SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1654	(2008; R 2016; E 2017) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 48	(2009) Standard for Test Procedures and Requirements for Alternating-Current Cable

	Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C57.12.50	(1981; R 1998) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Volt 601 to 34,500 Volts
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2016) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LA 1	(2009) Standard for Surge Arresters
NEMA PB 1	(2011) Panelboards
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2016) Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20	(2002; E 2004) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 345-67	(1998) REA Specification for Filled Telephone Cables, PE-39

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA 6850.19	(1978) Frangible Coupling
FAA AC 150/5345-10	(2014; Rev H) Specification for Constant Current Regulators Regulator Monitors
FAA AC 150/5345-12	(2005; Rev E) Specification for Airport and Heliport Beacon
FAA AC 150/5345-13	(2007; Rev B) Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits
FAA AC 150/5345-26	(2008; Rev D) FAA Specification for L-823 Plug and Receptacle, Cable Connectors
FAA AC 150/5345-27	(2013; Rev E) Specification for Wind Cone Assemblies
FAA AC 150/5345-28	(2005; Rev F) Precision Approach Path Indicator (PAPI) Systems
FAA AC 150/5345-3	(2007; Rev F) Specification for L-821 Panels for Control to Airport Lighting
FAA AC 150/5345-42	(2013; Rev G) Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories
FAA AC 150/5345-43	(2016; Rev H) Specification for Obstruction Lighting Equipment
FAA AC 150/5345-44	(2007; Rev H) Specification for Runway and Taxiway Signs
FAA AC 150/5345-45	(2007; Rev C) Low-Impact Resistant (LIR) Structures
FAA AC 150/5345-46	(2016; Rev E) Specification for Runway and

	Taxiway Light Fixtures
FAA AC 150/5345-47	(2005; Rev B) Specification for Series to Series Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-5	(2006; Rev B) Specification for Airport Lighting Circuit Selector Switch
FAA AC 150/5345-51	(2005; Rev A) Specification for Discharge-Type Flashing Light Equipment
FAA AC 150/5345-7	(2013; Rev F) Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
FAA AC 150/5370-10	(2014; Rev G; Errata 1 2015; Errata 2 2016) Standards for Specifying Construction of Airports
FAA AC 70/7460-1	(2015; Rev L) Obstruction Marking and Lighting
FAA E-2159	(2004; Rev E) Runway End Identifier Lighting System (REIL)
FAA E-2519	(1972; Rev A) Types I and II
FAA E-2628	(1979; Rev B) Sequenced Flashing Lighting System, Elevated and Semiflush with Dimming and Monitoring
FAA E-2702	(2007; Rev A)Low Impact Resistant (LIR) Structures
FAA E-2756	(2004; Rev B) Four Box Precision Approach Path Indicator (PAPI) without Remote Monitoring Subsystem (RMS)
FAA E-2980	(2005) Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR)
FAA E-982	(2003; Rev J) PAR-56 Lampholder

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Aug 2017) UL Standard for Safety Flexible Metal Conduit
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 360	(2013; Reprint Jan 2015) Liquid-Tight Flexible Steel Conduit
UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables

UL 486A-486B	(2013; Reprint Jan 2016) Wire Connectors
UL 489	(2016) UL Standard for Safety Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures
UL 510	(2017) UL Standard for Safety Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013; Reprint Aug 2017) UL Standard for Safety Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Mar 2017) UL Standard for Safety Electrical Metallic Tubing -- Steel
UL 83	(2017) UL Standard for Safety Thermoplastic-Insulated Wires and Cables
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES as identified in the project documents.

SD-02 Shop Drawings

Lighting and Visual Navigation Aids; G
As-Built Drawings; G

SD-03 Product Data

Materials and Equipment; G
Protection Plan; G
Training; G
Special Tools; G
List of Parts; G
Maintenance and Repair; G
Posted Instructions; G

SD-06 Test Reports

Field Quality Control; G
Visual Inspection; G

SD-07 Certificates

Qualifications; G
Materials and Equipment; G

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G

1.3 QUALITY ASSURANCE

1.3.1 Code Compliance

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 and local codes where required.

1.3.2 Qualifications

a. Submit certification containing the names and the qualifications of persons recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and termination has been adequately trained in the proper techniques and has had at least 3 recent years of experience in splicing and terminating the same or similar types of cables approved for installation. Any person recommended by the Contractor may be required to perform a dummy or practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, provide short sections of the approved types of cables with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types. The certification shall be prepared in conformance with paragraph CERTIFICATES OF COMPLIANCE in the SPECIAL CONTRACT REQUIREMENTS, and shall be accompanied by satisfactory proof of the training and experience of persons recommended by the Contractor as cable installers.

b. The SF sub 6 gas pressurized cable and conduit system installer must be trained and certified in installation of this type of system and must be approved by the manufacturer of the system.

c. Submit 1 electronic copy of qualified procedures and lists of names and identification symbols of qualified welders and welding operators prior to welding operations.

1.3.3 Protection Plan

Submit detailed procedures to prevent damage to existing facilities or infrastructures. If damage does occur, the procedures shall address repair and replacement of damaged property at the Contractor's expense.

1.3.4 Prevention of Corrosion

1.3.4.1 Metallic Materials

Protect metallic materials against corrosion as specified. Aluminum shall

not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, use fittings conforming to UL 486A-486B.

1.3.4.2 Ferrous Metal Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

1.3.5 As-Built Drawings

Submit as-built drawings that provide current factual information including deviations from, and amendments to the drawings and changes in the work, concealed and visible, as instructed. The as-built drawings shall show installations with respect to fixed installations not associated with the systems specified herein. Cable and wire shall be accurately identified as to direct-burial or in conduit and shall locate the connection and routing to and away from bases, housings, and boxes.

1.4 PROJECT/SITE CONDITIONS

Items furnished under this section shall be specifically suitable for the following unusual service conditions:

1.4.1 Altitude

Any equipment shall be suitable for operation up to an altitude of 10,000 ft, or as specified.

1.4.2 Other

Material or equipment to be installed underground; in handholes, manholes, or underground vaults; or in light bases, and shall be suitable for submerged operation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide airfield and heliport lighting and visual navigation aids consisting of airfield and heliport lighting, airfield and heliport marking, obstruction lighting and marking, beacon, wind direction indicator, approach lights, runway lights, taxiway lights, apron lights, visual glide slope indicator, runway end identifier lights, runway distance markers, taxiway signs and the lighting power supply and control as specified.

a. Submit composite drawings showing coordination of work of one trade with that of other trades and with the structural and architectural elements of the work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between the various trades.

b. Luminaires fabricated from ferrous metals, unless hot-dip galvanized or of porcelain enamel finish, shall be factory finished with a weather-resistant finish in accordance with paragraphs FACTORY COATING and FINISHING, except exposure shall be 200 hours. Finish color shall be the manufacturer's standard, unless otherwise indicated.

2.2 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

a. Submit a complete itemized listing of equipment and materials proposed for incorporation into the work. Each itemization shall include an item number, the quantity of items proposed, and the name of the manufacturer.

b. Submit data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents.

c. When equipment or materials are specified to conform to the standards or publications and requirements of AASHTO, ANSI, ASTM, AEIC, FM, IEEE, IES, NEMA, NFPA, or UL, or to an FAA, FS, or MS, submit proof that the items furnished under this section conform to the specified requirements.

d. The label or listing in UL Electrical Constructn or in FM APP GUIDE or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards, or publications and with the manufacturer's standards will be acceptable evidence of such compliance.

e. Certificates shall be prepared by the manufacturer when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

2.3 NAMEPLATES

Each major component of equipment shall have as a minimum the manufacturer's name, address, and catalog or style number on a nameplate securely attached to the item of equipment. Laminated plastic nameplates shall be provided for equipment, controls, and devices to identify function, and where applicable, position. Nameplates shall be 1/8 inch thick laminated cellulose paper base phenolic resin plastic conforming to ASTM D709 sheet type, grade ES-3, white with black center core. Surface shall be a matte finish with square corners. Lettering shall be engraved into the black core. Size of nameplates shall be 1 by 2-1/2 inches minimum with minimum 1/4 inch high normal block lettering. Nameplates provided as indicated. Nameplates shall be fastened to the device with a minimum of two sheet metal screws or two rivets.

2.4 ADDITIONAL REQUIREMENTS

Equipment and materials shall be new unless indicated or specified otherwise. Materials and equipment shall be labeled when approved by Underwriters Laboratories (UL) or Factory Mutual (FM) System. Askarel and insulating liquids containing polychlorinated biphenyls (PCB's) will not be allowed in any equipment. Equipment installed below grade in vaults, manholes, and handholes shall be the submersible type.

2.4.1 Electrical Tape

Electrical tape shall be UL 510 plastic insulating tape.

2.4.2 Conduit, Conduit Fittings, and Boxes

2.4.2.1 Rigid Steel or Intermediate Metal Conduit (IMC) and Fittings

The metal conduit and fittings shall be UL 6 and UL 1242, respectively, coated with a polyvinylchloride (PVC) sheath bonded to the galvanized exterior surface, nominal 40 mils thick, conforming to NEMA RN 1.

2.4.2.2 Flexible Metal Conduit

Flexible metal conduit shall be UL 1, zinc-coated steel. UL 360 liquid-tight flexible metal conduit shall be used in wet locations.

2.4.2.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible

These outlet boxes shall be UL 514A, cast metal with gasket closures.

2.4.2.4 Plastic Duct for Concrete Encased Burial

These ducts shall be PVC conforming to NEMA TC 6, Type EB provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4.2.5 Plastic Conduit for Direct Burial

This plastic conduit shall be PVC conforming to NEMA TC 2 (conduit) and NEMA TC 3 (fittings) Type EPC-80 PVC provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4.2.6 Frangible Couplings and Adapters

These frangible couplings shall be in accordance with FAA 6850.19 and FAA E-2519. Provide upper section of frangible coupling with one of the following:

a. Unthreaded for slip-fitter connections.

b. 2-13/32 inch 16N-1A modified thread for nut and compression ring to secure 2 inch EMT.

c. 2 inch 11-1/2-N.P.T. (tapered) with 7/32 inch nominal wall thickness to accept rigid conduit coupling.

d. Frangible Couplings for specialized applications as approved.

e. Electrical Metallic Tubing UL 797, where indicated for use with frangible couplings and adapters.

2.4.2.7 Low-Impact-Resistant Towers

Fiberglass reinforced low-impact resistant (LIR) towers shall conform to [FAA E-2702] [FAA AC 150/5345-45]. Anchor bolts, lowering devices and fixture mounting accessories shall be provided as required by tower manufacturer.

2.4.2.8 Semi-Frangible Supports

Lights supported more than 40 feet above the ground shall have a two-element structure, the lower element being a rigid structure and the upper element being a 20 foot LIR structure in accordance with FAA E-2702.

2.4.3 Wire and Cable

Conductors shall be copper except as otherwise indicated.

2.4.3.1 Conductor Sizes

Conductor size shall conform to American Wire Gage (AWG). Conductor sizes larger than No. 8 AWG shall be stranded. No. 8 AWG and smaller shall be stranded.

2.4.3.2 Low Voltage Wire and Cable

UL 83, Type THW, THWN, or UL 44, Type XHHW shall be used for secondary series lighting circuits to be installed in pavement, as specified.

2.4.3.3 Power Cables for Airfield and Heliports

Power cables shall be rated 5 kV, with shield and jacket conforming to NEMA WC 7 for crosslinked polyethylene or NEMA WC 8 for ethylene-propylene rubber insulated cables.

2.4.3.4 Wire and Cable for Airfield and Heliports

a. Airfield and heliport lighting cable shall be FAA AC 150/5345-7, Type L-824 for crosslinked polyethylene Type C or Type B 600 to 5000-volt cable. Series airfield and heliport lighting cable shall be unshielded. Lighting cable for multiple type lighting circuits shall be shielded, or as specified.

b. Cable for pavement slot installation shall be UL 83 Type THWN THW or UL 44 Type XHHW, except as indicated otherwise.

c. Counterpoise Wire. No. 4 AWG bare stranded copper, annealed or soft drawn.

d. Control Cable. Multiconductor type [FAA AC 150/5345-7, Type A, B, or C for 120 volt AC control, rated 600 volts, No. 12 AWG, and conforming to the following unless indicated otherwise. Conductors shall be color coded. The cable shall have an overall jacket of heavy-duty neoprene rated for direct burial. FAA AC 150/5345-7, Type A, B or C rubber insulation NEMA WC 7 for crosslinked polyethylene insulation] or NEMA WC 8 for ethylene-propylene rubber insulation. For 48 volt DC control, multi-conductor, 300 volts, No. 19 AWG cable shall be in accordance with RUS Bull 345-67.

e. Fused Cable Connectors. Connector shall consist of a line-side receptacle and a load-side plug, each in a molded rubber form and including crimp-on fittings for the cable ends to accommodate a 250-volt cartridge-type fuse with fuse rating as indicated. Connectors in kit form shall be properly sized for the specific cable diameter involved. Completed connection shall be watertight.

f. Cable for sequence flashing trigger circuits shall be RUS Bull 345-67.

2.4.3.5 Cable Tags

Install cable tags for each cable or wire at duct entrances entering or leaving manholes, handholes, and at each terminal within the lighting vault. Cable tags shall be stainless steel, bronze, lead strap, or copper strip, approximately 1/16 inch thick or hard plastic 1/8 inch thick suitable for immersion in salt water and impervious to petroleum products and shall be of sufficient length for imprinting the legend on one line using raised letters. Cable tags shall be permanently marked or stamped with letters not less than 1/4 inch in height as indicated. Two-color laminated plastic is acceptable. Plastic tags shall be dark colored with markings of light color to provide contrast so that identification can be easily read. Fastening material shall be of a type that will not deteriorate when exposed to water with a high saline content and to petroleum products.

2.4.3.6 Concrete Markers for Direct Buried Cable Systems

Concrete markers shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4.4 Ground Rods

Ground rods shall be sectional copper-clad steel with diameter adequate to permit driving to full length of the rod, but not less than 3/4 inch in diameter and not more than 10 feet long, unless indicated otherwise.

2.4.5 Lightning Arresters

These lightning arresters shall be in accordance with IEEE C62.11, IEEE C62.41.1 and IEEE C62.41.2 as applicable with ratings as indicated.

2.4.6 Surge Protection

Surge protection shall be metal oxide varistors (MOV) in accordance with NEMA LA 1 for power and signal circuits with ratings as recommended by the system manufacturer.

2.4.7 Cable Connectors and Splices

Cable connectors in accordance with FAA AC 150/5345-26, Item L-823 shall be used for connections and splices appropriate for the type of cable. Other types of cable connectors and splices shall be of copper alloys for copper conductors, aluminum alloys for aluminum-composition conductors and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. For FAA Type L-824 lighting cable, connectors shall be FAA AC 150/5345-26, Type L-823.

2.4.8 Transformers

2.4.8.1 Encapsulated Isolation Transformers

These transformers shall be FAA AC 150/5345-47, Type L-830. Each transformer shall be provided with rating appropriate for the device being supported, as shown on the contract drawings.

2.4.8.2 Power Transformers

These transformers shall be in accordance with IEEE C57.12.50 as indicated.

2.4.9 Light Bases

Light bases shall be FAA AC 150/5345-42 Type L-867, L-868, L-869 as required. Steel bases, Class 1, Size A, B, or C shall be provided as indicated or as required to accommodate the fixture or device installed thereon if diameter is not shown. Base plates, cover plates, and adapter plates shall be provided to accommodate various sizes of fixtures. Bolts shall be Brass.

2.4.10 Sealant for Fixtures and Wires in Drilled Holes or Saw Kerfs

The sealant shall be in accordance with FAA AC 150/5370-10, Type P-606. Use FAA AC 150/5370-10, Type P-606 sealant for use in asphaltic concrete (AC) or Portland cement concrete (PCC) pavement compatible with AC pavement and having a minimum elongation of 50 percent. Formulations of Type P-606 which are compatible with PCC pavement only are prohibited.

2.4.11 Constant Current Regulator

The regulator shall be FAA AC 150/5345-10, Type L-828, without monitoring or Type L-829 with monitoring system and with ratings as indicated. Regulators shall operate on 60 Hz, have internal primary switch included, have input voltage of 240 or 2400 and be controlled by 120-volt external control voltage. Three, Five or as specified brightness steps shall be provided. Monitors shall be provided as indicated.

2.4.12 Lamps and Filters

Lamps shall be of size and type indicated, or as required by fixture manufacturer for each lighting fixture required under this contract. Filters shall be of colors as indicated and conforming to the specification for the light concerned or to the standard referenced.

2.4.13 Sump Pumps for Manholes and Vaults

Sump pumps shall be submersible type with a capacity for not less than the specifed gal/min at a total dynamic head of specified feet. The motor shall include automatic thermal overload protection. Each pump shall have an internal magnetic float switch, stainless steel shaft, bronze impeller, and cast iron motor housing and volute. The cable shall be continuous and of a waterproof type with watertight plug of sufficient length to include slack and allow connection to receptacle shown.

2.4.14 Circuit Breakers and High-Voltage Switches

Circuit breakers and high-voltage switches shall be UL 489 type or approved by UL 489. Switchgear for use in manholes and underground vaults shall be subway type. Cutouts shall be rated for as specified. Hermetically sealed cutouts shall be provided with expansion chambers for full rating. Cutout shall be mounted on galvanized steel junction boxes with bolted-on covers, unless indicated otherwise.

2.4.15 Transformer, Substations and Switchgear

The transformer substations and switchgear shall be as specified.

2.4.16 Emergency Generator and Automatic Transfer Switch System

The automatic transfer switch shall be in accordance with 26 36 00.00 10 AUTOMATIC TRANSFER SWITCH AND BY-PASS/ISOLATION SWITCH and as required by the contract drawings or contracting documents. The emergency generator shall be in accordance with Section 26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 kW, WITH AUXILIARIES, 26 32 14.00 10, DIESEL-GENERATOR SET, STATIONARY 15-300 kW, STANDBY APPLICATIONS and as required by the contract drawings or contracting documents.

2.4.17 Circuit Selector Cabinet

The circuit selector cabinet shall be FAA AC 150/5345-5, Type L-847, for one, two, three, or four circuit control as indicated, Class A, indoor or B, outdoor, Rating 1, for 6.6 amperes 2, for 20 amperes.

2.4.18 Pilot Relay Panel

The pilot relay panel shall be NEMA 250, NEMA ICS 2, and NEMA PB 1 for 120-volt control systems; and FAA AC 150/5345-13, Type L-841, for 48-V dc control systems.

2.4.19 Control Panel

The panel shall be FAA AC 150/5345-3, as specified. Quantity and color of lenses shall conform to FAA AC 150/5345-3 and shall correspond to the actual circuits indicated.

2.4.20 Lighting Fixtures

Provide lighting fixtures for the airfield and heliport lighting as shown in the contract drawings or as required in other contract documents.

2.4.21 Painting

As specified in Section 09 90 00 PAINTS AND COATINGS and Section 32 17 23 PAVEMENT MARKINGS.

2.5 AIRFIELD AND HELIPORT MARKINGS

The airfield and heliport markings shall be installed as shown on the contract drawings.

2.6 BEACON

The rotating beacons for airfield and heliport beacons are omnidirectional and color coded and are provided by rotating the beams in sequence to provide the color and intensity. For military facilities the beacon has a double-peaked white beam. The beacon flashes shall be visible through 360 degrees.

2.6.1 Airfield Rotating Beacon

The rotating beacon for fixed wing aircraft shall be FAA AC 150/5345-12, Type L-802A, Class 1 or 2. A duplex type beacon with alternating green and white beams shall be provided. Beacons used on military airfields shall have a double-peaked white beam. Cabinet shall be provided with a

NEMA ICS 6 type as specified enclosure of zinc-coated steel.

2.6.2 Heliport Beacon

The heliport rotating beacon, shall be FAA AC 150/5345-12, Type L-801H, Class 2. Except for military facilities the white beam shall be a double-peaked white flash. The beacon shall flash the three color sequence 10 to 15 times per minutes. The colors white, green, and yellow for a heliport and white, green, and red for a medical facility. The effective intensity of the white flash shall be not less than 25,000 candelas for vertical angles between 2 and 8 degrees and not less than 12,500 candelas between 0 and 10 degrees.

2.6.3 Airfield Identification/Code Beacon

If an identification or code beacon is required, the fixture shall be in accordance with FAA AC 150/5345-43, Type L-866 with green filters and code flashing device. The beacon flashes shall be visible through 360 degrees. The effective intensity of the green flash shall be not less than 2,000 candelas. The code shall be as indicated on the contract drawings and shall flash 6 to 8 codes per minute.

2.7 WIND DIRECTION INDICATOR

The wind direction indicator shall be an FAA AC 150/5345-27, Type L-806, low mass supporting structure or L-807, rigid supporting structure, Style I-lighted or II-unlighted as specified, Size 1 to 8 feet or 2 to 12 feet as specified. The wind cones shall be of the size and color as indicated.

2.8 OBSTRUCTION LIGHTING AND MARKING

Obstructions on or near the airfield or heliport shall be marked and/or lighted as shown on the contract drawings. Obstruction marker lights shall emit aviation red flashing and/or steady burning light as required. The light fixtures, shall be multiple-socket assembly or series socket assembly FAA AC 150/5345-43, Type L-810 or Type L-864 as indicated. For multiple flashing lights on a circuit, the lights shall flash in unison. Obstruction marker lights shall be single- or double-unit type as shown in the contract drawings. The obstruction lights shall be energized from series or multiple circuits as shown on the contract drawings or other contract documents.

2.9 HIGH-INTENSITY APPROACH LIGHTING SYSTEMS

These lights shall be as indicated.

2.9.1 Elevated High-Intensity Fixtures Except Flashing Units

The elevated approach light fixtures shall be FAA E-982 frangible mounted lights with PAR-56 200 W, 300 W, and 500 W lamps as specified, and without or with aviation red and/or aviation green filters as indicated. Elevated bidirectional threshold lights shall be FAA AC 150/5345-46, Type L-862 with aviation green filters on the approach side and aviation red filters on the runway side. The side row barrettes shall emit aviation red lights.

2.9.2 Sequence Flashing Lights (SFL) System

The SFL system shall be FAA E-2159 and/or FAA AC 150/5345-51, Type L-849 or FAA E-2628 lights provided as an integrated part of the approach

system. The SFL system shall include the elevated fixtures as specified, the individual power supplies, master timer and power supply, remote control and monitor, support structures, and interconnecting wiring. The SFL shall flash twice per second in sequence towards the runway threshold.

2.9.3 Semiflush, High-Intensity Approach Lights

The approach lights in the overrun area, inner section of threshold bar, and paved areas with traffic, shall be semiflush, high-intensity, base-mounted lights as shown. These semiflush approach high-intensity fixtures shall be FAA AC 150/5345-46, Type L-850D for bidirectional or Type L-850E for unidirectional lights with lamps and filters as shown.

2.10 MEDIUM-INTENSITY APPROACH LIGHTING SYSTEMS

The medium-intensity approach lights shall be as indicated.

2.10.1 Elevated, Medium-Intensity, Steady-Burning Fixtures

The medium-intensity, elevated, steady-burning approach lights, shall be FAA E-2980 PAR 38 lampholders with PAR-38 spotlight lamps frangibly mounted on light bases, steel stakes, and/or low-impact-resistant supports or frangible supports as specified.

2.10.2 Sequence Flashing Lights (SFL) for Medium Intensity Lights

These elevated SFL fixtures (RAIL) shall meet the requirements of FAA E-2159 or FAA AC 150/5345-51, Type and number of lights shall be as indicated on the contract drawings as an integrated part of the approach system. The SFL system shall include the fixtures, the individual power supplies, master timer and power supply, remote control and monitor, support structures, and interconnecting wiring. The SFL shall flash twice per second in sequence towards the runway threshold.

2.11 RUNWAY ALIGNMENT INDICATOR LIGHTS (RAIL)

The RAIL fixtures shall meet the requirements of FAA E-2159 or FAA AC 150/5345-51, Type and number of lights as specified, and shall include the individual power supplies the master timer and power supply, remote control, support structures, and interconnecting wiring.

2.12 OMNIDIRECTIONAL APPROACH LIGHT SYSTEM (ODALS)

The ODALS fixtures shall meet the requirements of FAA AC 150/5345-51, Type L-859 Style F. The ODALS shall include the specified fixtures, the individual power supplies, the master timer and power supply, remote control, support structures and interconnecting wiring. The ODALS shall flash twice per second in sequence towards the runway threshold.

2.13 RUNWAY END IDENTIFIER LIGHTS (REIL)

The REIL fixtures shall meet the requirements of FAA AC 150/5345-51, Type L-849, Style A, B, or E. The REIL shall include the master and slave fixture, the power supply, remote control, frangible mounts, and interconnecting wiring. The REIL units shall flash in unison twice per second.

2.14 RUNWAY LIGHTING SYSTEM

Runway lights include runway edge lights, runway threshold lights, runway centerline lights, runway touchdown zone lights, runway distance and arresting gear markers, mounting structures, controls, and the associated equipment and interconnecting wiring to provide complete systems as indicated and specified herein. In-pavement light fixtures shall be able to withstand a minimum static single wheel load of 50,000 pounds.

2.14.1 Runway Edge Lights

The runway edge light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-862, elevated high-intensity, Type L-861, elevated medium-intensity, airfield and heliport, Type L-850C, semiflush, high-intensity, Type L-852E, semiflush medium-intensity, white lights as specified.

2.14.2 Runway Threshold and End Lights

The threshold lights shall use aviation green filter and the end lights shall use aviation red filters. These lights shall be combined in a single bidirectional fixture with the appropriate color filters if so indicated on the contract drawings. The runway threshold/end light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-862, elevated high-intensity, bidirectional, Type L-861 SE, elevated, medium-intensity, bidirectional, Type L-861, elevated, medium-intensity, omnidirectional Type L-852E, semiflush, medium-intensity, omnidirectional Type L-850D, semiflush, high-intensity, bidirectional, Type L-850C, semiflush, high-intensity, unidirectional, FAA E-982, PAR-56, elevated unidirectional outboard of runway edges, airfield and heliport lights as indicated.

2.14.3 Runway Centerline Lights, Tailhook Operations

The fixtures shall be similar to FAA AC 150/5345-46, Type L-852, and identified as Class N (Navy). The fixtures are available from Crouse Hinds Company, Cooper Industries. The fixtures shall be unidirectional, narrow beam, Type V, VI, VII, VIII, with shorting device for failed lamp, modified to resist damage from aircraft tailhooks. The stainless steel top assembly shall have a Rockwell hardness of C40 plus or minus 5. Height of fixture shall be 1/2 inch above pavement in lieu of 3/8 inch. Optical assembly shall be secured with 416 stainless steel bolts.

2.14.4 Standard Duty Centerline Lights

The fixtures shall be FAA AC 150/5345-46, Type L-850A, Class 1 for insetting directly into pavement, Class 2 for installation on mounting bases. Filters shall be provided as indicated and conforming to requirements of fixture specifications.

2.14.5 Runway Touchdown Zone Lights

The fixtures shall be FAA AC 150/5345-46, Type L-850B.

2.14.6 Runway Distance Markers

Runway distance markers shall conform to FAA AC 150/5345-44, Type L-858B, Size 4, Style 3 with white or yellow numerals on a black background. Markers shall be provided, to withstand a static wind load of 0.28 psi,

and suitable for connection to the secondary of the isolation transformers specified. Internally illuminated markers shall be provided with illumination of the face not less than 50 percent of that at rated current when the series lighting circuit is operated at the lowest brightness step. Marker housing shall be fiber reinforced epoxy, with information faces of high-impact acrylic or ultraviolet stabilized polycarbonate. The power supply and lamps shall be Style 3, Class 1 or Class 2 as indicated or as recommended by the sign manufacturer.

2.14.7 Arresting Gear Markers

The arresting gear markers shall be the same as Runway Distance Markers, except markers shall have a 3.25 foot translucent yellow circle in place of numerals as specified above.

2.15 TAXIWAY LIGHTING SYSTEMS

Taxiway lighting systems shall include edge lights, centerline lights, guidance signs, and hold position lights and signs. These systems shall also include the associated equipment, power supplies and controls, mounting devices, and interconnecting wiring to provide complete systems as specified.

2.15.1 Taxiway Edge Lights

Taxiway edge light shall emit aviation blue light provided by filters or globes for both airfields and heliports. The edge lights shall meet the requirements of FAA AC 150/5345-46, Type L-861, elevated, or Type L-852E, semiflush, lights.

2.15.2 Taxiway Centerline Lights

Taxiway centerline lights shall be semiflush fixtures using filters to provide aviation green light. These centerline light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-852A on straight sections and Type L-852B on curved sections.

2.15.3 Taxiway Guidance Signs

The taxiway guidance signs shall meet the requirements of FAA AC 150/5345-44, Type L-858Y for information and Type L-858R for mandatory signs as specified. The size and information on the signs shall be as shown on contract drawings. The power supply to connect to series or multiple circuits shall be as indicated and/or approved by the manufacturer.

2.15.4 Hold Position Lights and Signs

The hold positions shall be marked by painted lines, lights, and/or signs as specified or indicated on the contract drawings. The lights shall meet the requirements of FAA AC 150/5345-46, Type L-852A, semiflush, unidirectional, with aviation yellow filter toward the taxiway approach to the runway. In some confusing locations FAA AC 150/5345-46, Type L-804, elevated flashing lights may be required. Hold position signs shall meet the requirements of FAA AC 150/5345-44, Type L-858R, with the size and information as indicated.

2.16 HELIPAD LIGHTING SYSTEMS

2.16.1 General

Helipad lighting, when required, shall be in accordance with Section 26 54 21.00 10 HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS.

2.16.2 Hoverlane Lights

The hoverlane lights shall be alternating aviation green and aviation yellow lights along the centerline of the hoverlane path. The fixtures shall be FAA AC 150/5345-46, Type L-861, for elevated lights with alternating yellow and green globes as required or indicated on the contract drawings. These lights shall be frangibly mounted on stakes or light bases as indicated. For hoverlanes across paved areas, the fixtures shall be FAA AC 150/5345-46, Type L-852E mounted on FAA AC 150/5345-42, Type L858 or L-857 light bases. The hoverlane lights shall be energized from a 6.6 ampere series circuit through isolation transformers or 120/240-volt multiple circuit power source as indicated on the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1.

2.17 EXPLOSION-PROOF FIXTURES FOR HAZARDOUS LOCATIONS

Fixtures to be installed in explosive hazardous locations shall meet the requirements of and be listed by UL Electrical Constructn or FM APP GUIDE as defined in NFPA 70 for the hazard and application. The explosion-proof fixtures are located as indicateds or otherwise specified herein.

2.18 GLIDE SLOPE INDICATOR

The glide slope indicator for airfields shall be the Precision Approach Slope Indicator (PAPI). For the heliports the glide slope indicator unit shall be the PAPI or the CHAPI as indicated.

2.18.1 PAPI

The light units for the PAPI shall meet the requirements of FAA AC 150/5345-28, Type L-880 or FAA E-2756. The system consists of four light units.

2.18.2 CHAPI

The light units for the CHAPI systems for heliport glide slope indicators, if required, shall consist of two units which meet the basic requirements of FAA AC 150/5345-28, Type L-880, except the on-glide-slope indication has been replaced by a two degree wide green lens.

2.19 LIMIT LIGHTS

The fixtures for limit lights shall be FAA AC 150/5345-46, Type L-861 with red globes and 45-watt lamps. These lights shall be frangibly mounted on steel stakes, or light bases if in paved areas.

2.20 OTHER LIGHTING SYSTEMS AND VISUAL AIDS

2.21 HELIPAD LIGHTING SYSTEMS

Where helipad lighting interfaces with airfield and heliport lighting

systems, the helipad lighting as required shall be in accordance with Section 26 54 21.00 10 HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS.

2.22 FACTORY COATINGS

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finish shall be provided with corrosion-resistant finishes which shall withstand 500 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with zinc rich paint conforming to SSPC Paint 20 in accordance with ASTM A780/A780M.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 GENERAL INSTALLATION REQUIREMENTS

Circuits installed underground shall conform to the requirements of Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, except as required herein. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 31 00 00 EARTHWORK. Concrete work shall conform to the requirements of Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE.

3.3 CABLES, GENERAL REQUIREMENTS

The type of installation, size and number of cables shall be as indicated. Conductors larger than No. 8 AWG shall be stranded. Loads shall be divided as evenly as practicable on the various phases of the system. Furnish manufacturer's written recommendations for each type of splice and medium-voltage cable joint and termination, and for fireproofing application methods, approved before any work is done. Medium-voltage cable joints and terminations shall be the standard product of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Medium-voltage cable joints shall be made by qualified cable splicers. Compounds and tapes shall be electrical grade suitable for the cable insulation provided and shall use design materials and techniques recommended by the manufacturer. Maximum length of cable pull and cable pulling tensions shall not exceed the cable manufacturer's recommendations.

3.3.1 Duct Line Installation

Install medium-voltage cables, low-voltage cables, cables in duct lines where indicated. Cable splices in low-voltage cables shall be made in manholes and handholes only, except as otherwise noted. Cable joints in

medium-voltage cables shall be made in manholes only. Neutral and ground conductors shall be installed in the same duct with their associated phase conductors. Counterpoise cable shall be installed in a separate duct or direct-burial not less than 6 inches above the uppermost duct containing electrical cable. Electrical metallic tubing shall not be installed underground or enclosed in concrete.

3.3.2 Direct-Burial Installation

Medium-voltage cables and Low-voltage cables shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be 24 inches for low-voltage cables, and 36 inches for medium-voltage cables but not less than the depth of the frost line. Counterpoise cable shall be not less than 6 inches above the uppermost electrical cable but not less than the depth of the frost line.

3.3.2.1 Trenching

Trenches for direct-burial cables shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 3 inch layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil.

3.3.2.2 Cable Installation

Cables shall be unreeled along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position will not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Where cables cross or are installed in layers at different depths, a separation of at least 3 inches vertically and 2 inches horizontally shall be provided, unless each cable circuit is protected by a nonmetallic conduit sleeve at the crossing. Where single-conductor cable is installed for three-phase circuits, all three phases and the neutral shall be installed in the same sleeve. Bend radius of any cable shall be not less than 10 times the diameter of the cable. In no case shall cables be left under longitudinal tension. The first 4 inch layer of backfill shall be of sand or stone-free earth. A 5 mil, brightly colored plastic tape not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers, or other approved dig-in warning indication, shall be placed approximately 12 inches below finished grade levels of trenches. Selected backfill of sand or stone-free earth shall be provided to a minimum depth of 3 inches above cables.

3.3.2.3 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 5 feet in width, such cables shall be installed in concrete-encased ducts. Where direct-burial cables cross under railroad tracks, such cables shall be installed in reinforced concrete encased ducts. Ducts shall extend at least 1 foot beyond each edge of any paving and at least 5 feet beyond each side of any railroad tracks. Cables may be pulled into conduit from a fixed reel where suitable rollers are provided in the trench. Direct-burial cables shall be centered in duct entrances. A suitable waterproof nonhardening mastic compound shall be used to facilitate such centering. If paving or railroad tracks are in place where cables are to be installed, coated rigid steel conduits driven under the paving or

railroad tracks may be used in lieu of concrete-encased ducts. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by suitable predrilling. Where cuts are made in any paving, the paving and sub-base shall be restored to their original condition.

3.3.2.4 Medium-Voltage Cable Joints or Low-Voltage Cable Splices

Cable joints or splices in direct-burial cables are not permitted in runs of 1000 feet or less, nor at intervals of less than 1000 feet in longer runs, except as required for taps. Locations of cable joints or splices in shorter intervals, where required to avoid obstructions or damage to cables, shall be approved. Cable joints or splices shall be installed in cable boxes, except that medium-voltage separable connectors or low-voltage sealed insulated connectors do not require cable boxes.

3.3.2.5 Surface Markers

Locate markers near the ends of cable runs, at each cable joint or splice, at approximately every 500 feet along cable runs, and at changes in direction of cable runs. Markers shall be constructed as indicated.

3.3.3 Connection to Buildings

Cables shall be extended into the various buildings as indicated, and shall be properly connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 5 feet outside of a building and 2 feet below finished grade as specified and provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.4 MEDIUM-VOLTAGE CABLES

Medium-voltage cables shall be suitable for a rated circuit voltage of 5 kV, 15 kV, 25 kV, 28 kV, or 35 kV as specified. Other parts of the cable system such as joints and terminations shall have ratings not less than the rating of the cables on which they are installed. Separable insulated connectors shall have nominal voltage ratings coordinated to associated apparatus ratings rather than cable ratings when used to connect cable to apparatus. Cables shall be provided with 133 percent insulation level [and 28 kV and 35 kV insulation thicknesses shall be in accordance with either AEIC CS8 as applicable]. Neutral conductors of grounded neutral systems shall be of the same insulation material as phase conductors, except that a 600-volt insulation rating is acceptable.

3.4.1 Cable Joints

Apply shields as required to continue the shielding system through each entire cable joint. Shields may be integrally molded parts of preformed joints. Shields shall be grounded at each joint.

3.4.1.1 Types

Separable insulated connectors of suitable construction or standard splice kits shall be used for single-conductor and two-conductor cables. The connectors shall be of FAA AC 150/5345-26 factory preformed, resin pressure-filled as specified. Cable joints for which acceptable separable connector kits are not available may use factory preformed, vulcanized,

taped joint, resin pressure-filled over-case taped splices if approved.

3.4.1.2 Requirements

Cable joints shall provide insulation and jacket equivalent to that of the associated cable. Lead sleeves shall be provided for lead-covered cables. Armored cable joints shall be enclosed in compound-filled, cast-iron or alloy, splice boxes equipped with stuffing boxes and armor clamps of a suitable type and size for the cable being installed.

3.4.2 Terminations

Terminations shall be IEEE 48, Class 1 or Class 2, of the molded elastomer, wet-process porcelain, prestretched elastomer, heat-shrinkable elastomer, or taped type. Acceptable elastomers are track-resistant silicone rubber or track-resistant ethylene propylene compounds, such as ethylene propylene rubber or ethylene propylene diene monomer. Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations shall be of the outdoor type, except that where installed inside outdoor equipment housings which are sealed against normal infiltration of moisture and outside air, indoor, Class 2 terminations are acceptable. Class 3 terminations are not acceptable. Terminations, where required, shall be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, and armor.

3.4.2.1 Factory Preformed Type

Molded elastomer, wet-process porcelain, prestretched, and heat-shrinkable terminations shall utilize factory preformed components to the maximum extent practicable rather than tape build-up. Terminations shall have basic impulse levels as required for the system voltage level. Leakage distances shall pass the wet withstand voltage test required by IEEE 48 for the next higher BIL level.

3.4.2.2 Taped Terminations

Taped Terminations are not allowed.

3.5 LOW-VOLTAGE CABLES

Cable shall be rated 600 volts, except that secondaries of isolation transformer to in-pavement lights installed in pavement saw kerf and 48 volt DC control cables may be 300 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices in wires No. 8 AWG single conductor cable shall be made with FAA AC 150/5345-26 Type L-823 connectors noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

3.6 DUCT LINES

Duct lines shall be concrete-encased, thin-wall type, non-encased direct-burial, thick-wall type, or, concrete-encased, thin-wall type for duct lines between manholes for other medium-voltage lines as specified. Low-voltage lines run elsewhere may be non-encased direct-burial, thick-wall type. Communication lines run elsewhere may be direct-burial, thick-wall type.

3.6.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 4 inches per 100 feet. Depending on the contour of the finished grade, the high point may be at a terminal, a manhole, a handhold, or between manholes or handholes. Manufactured 90 degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 18 inches for ducts of less than 3 inches diameter, and 36 inches for ducts 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 25 feet shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends as required, but the maximum curve shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells when duct lines terminate in manholes or handholes. Duct line markers shall be provided as indicated at the ends of long duct line stubouts or for other ducts whose locations are indeterminate because of duct curvature or terminations at completely below-grade structures. In lieu of markers, a 5 mil brightly colored plastic tape not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers with a continuous metallic backing and a corrosion-resistant 1 mil metallic foil core to permit easy location of the duct line, shall be placed approximately 12 inches below finished grade levels of such lines.

3.6.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. After a duct line is completed, a standard flexible mandrel shall be used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 12 inches long and shall have diameters 1/4 inch less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used to draw in lead wires. A coupling recommended by the duct manufacturer shall be used when an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.6.3 Concrete Encasement

Each single duct shall be completely encased in concrete with a minimum of 3 inches of concrete around each duct, except that only 2 inches of concrete are required between adjacent electric power or adjacent communication ducts, and 4 inches of concrete shall be provided between adjacent electric power and communication ducts. Duct line encasements shall be monolithic construction. Where a connection is made to a

previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. At any point, except railroad crossings, tops of concrete encasements shall be not less than 18 inches below finished grade or paving. At railroad crossings, duct lines shall be encased with concrete, reinforced as indicated. Tops of concrete encasements shall be not less than 5 feet below tops of rails, unless otherwise indicated. Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not further apart than 4 feet on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 6 inches vertically.

3.6.4 Non-encased Direct-Burial

Top of duct lines shall be below frost line but not less than 24 inches below finished grade. Ducts shall be buried below frost line but in the earth and shall be installed with a minimum of 3 inches of earth around each duct, except that between adjacent electric power and communication ducts, 12 inches of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 3 inch layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts in direct-contact tiered fashion. Joints in adjacent tiers of duct shall be vertically staggered at least 6 inches. The first 4 inch layer of backfill cover shall be sand or stone-free earth compacted as previously specified. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling. Selected earth at duct banks shall be thoroughly tamped in 4 to 6 inch layers.

3.6.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved. In the absence of specific recommendations, various types of duct joint couplings shall be made watertight as specified.

3.6.5.1 Bituminized-Fiber Ducts

To ensure a watertight joint, tapered ends or joints of the same material as the ducts shall be swabbed with bituminous or joint-sealing compound before couplings are applied. Plastic or nonmetallic couplings shall be tightly driven onto unswabbed ducts. Due to the brittleness of plastic couplings at low temperatures, such couplings shall not be installed when temperatures are below 0 degrees F. Couplings shall be warmed in hot water or by another approved method when installed at temperatures below 32 degrees F.

3.6.5.2 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick one-quarter-turn twist to set the joint tightly.

3.7 MANHOLES AND HANDHOLES

The manholes and handholes shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.8 WELDING

Perform the welding of supports and metallic ducts and welding or brazing of electrical connections by using qualified welders.

3.9 CABLE MARKERS

Provide cable markers or tags for each cable at duct entrances entering or leaving manholes or handholes and at each termination within the lighting vault. Cables in each manhole or handhole shall have not less than two tags per cable, one near each duct entrance hole. Immediately after cable installation, tags shall be permanently attached to cables and wires so that they cannot be accidentally detached.

3.10 FRANGIBLE REQUIREMENTS

Install frangible supports, couplings, and adapters as indicated or specified. At the 1000 foot cross bar and beyond, approach lights shall be mounted up to 6 feet above concrete foundation on threaded frangible couplings and 2 inch electrical metallic tubing (EMT). For mounting heights greater than 6 feet, approach lights shall be mounted on low-impact resistant frangible towers as indicated.

3.11 ELEVATED AIRFIELD AND HELIPORT LIGHTS

Elevated lights shall be frangibly mounted, not to exceed 14 inches in height except where higher mounting is permitted in snow accumulation areas. Equipment exceeding 14 inches in height shall be frangibly mounted as indicated.

3.12 SEMIFLUSH AIRFIELD AND HELIPORT LIGHTS

Remove water, debris, and other foreign substances prior to installing semiflush light base and light. Use positioning jigs to hold the light bases and/or lights to ensure correct orientation and leveling until the concrete, adhesive, or sealant can provide permanent support.

3.13 ENCLOSURES IN SAW KERFS AND DRILLED HOLES

3.13.1 Holes for Light Fixtures

Holes shall be bored in existing pavement to the dimensions indicated with a diamond-edged bit to provide a smooth, straight cut. Bottom of hole shall be flat or slightly concave, except that an area at least 1 inch wide around the perimeter shall be flat. Surfaces deeper than the prescribed depth shall be filled with sealant to the level of the flat area and allowed to cure before further placement.

3.13.2 Holes for Transformer Enclosures

Holes shall be drilled or excavated through concrete pavement and loose material removed. Hole shall be filled with concrete to depth indicated. A minimum of 3 inches of concrete shall be provided at bottom of hole.

3.13.3 Saw Kerfs and Splice Chambers

Saw kerfs and splice chambers shall be cut in pavements where indicated. Saw cuts shall be in straight lines with vertical sides. Width and depth of saw cuts shall be adequate for the required number of wires. Saw kerfs shall have the vertical edges chamfered at intersections. Where a saw kerf crosses a construction joint, the depth shall be increased sufficiently to allow for slack wire under the joint. The wire shall be enclosed in flexible tubing which extends not less than 2 feet each side of the joint.

3.13.4 Sandblasting

Saw kerfs, grooves, and holes shall be sandblasted to remove foreign or loose material. Sandblasting shall use approved equipment maintained in good working order. Sand for blasting shall be proper size and quality to perform the work. Nozzles for sandblasting shall be of the proper size in relation to the groove or holes to be cleaned. Nozzles enlarged by wear shall be replaced as necessary. Sandblast air pressure shall be not less than 90 psi.

3.13.5 Cleaning

Immediately prior to installation of wire or light fixtures, saw kerfs and holes shall be flushed with a high velocity water jet or steam, and then cleaned and dried with a high velocity air jet to remove dirt, water, and foreign material.

3.14 FIXTURES AND WIRES INSTALLATION

3.14.1 General

Sides and bottom of each light base shall be sandblasted immediately prior to installation. Inside faces of bored hole and bottom and sides of light base shall be covered with a coating of sealant that will completely fill the void between concrete and base. A jig or holding device shall be used when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixture shall be oriented with the light beams parallel to the runway or taxiway centerline and facing in the required direction. Outermost edge of fixture shall be level with the surrounding pavement. Surplus sealant or flexible embedding material shall be removed. The holding device shall remain in place until sealant has reached its initial set. Fixture lead wires shall be properly arranged with respect to their connecting position. The wireway entrance into the light recess shall be blocked to retain the sealant material during curing.

3.14.2 Installation of Circuit Wires in Pavement

Place wires in saw kerfs and anchor them at bottom by means of rubber or plastic wedges or noncorrosive metal clips placed every 2 or 3 feet or as often as necessary to hold the wire down. Wires crossing existing joints shall be encased in a 24 inch length of flexible tubing of polyethylene material conforming to ASTM D1248, Type II or Type III, to break the bond between the wires and the sealing material. Flexible tubing shall be centered on the joint and of sufficient size to accommodate the wires to allow for movement of the wires as the joint opens and closes. Ends of tubing shall be wrapped with tape to prevent entrance of sealing materials. The adjacent joint area shall be packed temporarily with

roving material, such as hemp, jute, cotton or flax, to prevent sealing material from flowing into the open joint. Sealing materials shall be carefully mixed and applied in accordance with the manufacturer's instructions and at the recommended temperature. Surplus or spilled material shall be removed.

3.15 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE

3.15.1 Connectors

Kit type connectors shall be used to splice 5 kV single-conductor series lighting cables. During installation and prior to covering with earth, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, heat shrinkable tubing shall be installed with waterproof sealant with two half-lapped layers of tape over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.15.2 Splicing Fixtures to the Wires in Pavement Saw Kerfs

Splices shall have preinsulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed. Splice shall be taped with plastic insulating tape.

3.16 GROUNDING SYSTEMS

3.16.1 Counterpoise Installation

Counterpoise wire shall be laid for entire length of circuits supplying airfield lighting. Wire shall be in one piece, except where distance exceeds the length usually supplied. Counterpoise shall be installed on top of the envelope of concrete-encased duct and approximately 6 inches above direct burial cables and duct lines. Where trenches or duct lines intersect, counterpoise wires shall be electrically interconnected by exothermic welding or brazing. Counterpoise to earth ground shall be connected at every 2,000 feet of cable run, at lighting vault, and at feeder connection to light circuit by means of ground rods as specified. Counterpoise shall be installed in a separate duct under roads, railroads, and paved areas above the highest duct containing electrical or communications circuits.

3.16.2 Fixture Grounding

Each fixture or group of adjacent fixtures shall be grounded by a grounding circuit separate from the counterpoise system unless required otherwise or by driven ground rods if permitted. Fixtures, steel light bases or grounding bushings on steel conduits shall be connected to an independent ground rod by a No. 6 AWG bare stranded copper wire. Semiflush fixtures for direct mounting in pavement need not be grounded. Copper wire shall be connected to ground rods by exothermic weld or brazing.

3.17 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

Towers, poles, smokestacks, buildings of certain shapes and sizes, and other obstructions shall be marked and lighted in accordance with FAA AC 70/7460-1 and as indicated in or required otherwise.

3.17.1 Painting of Airway Obstructions

Patterns and colors to mark obstructions shall conform to FAA AC 70/7460-1 and shall be as indicated.

3.17.2 Obstruction Marker Lights

Obstruction marker lights shall be installed on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with 1 inch zinc-coated rigid steel conduit stems using standard tees and elbows, except that lowering devices, when required, shall be installed in accordance with equipment manufacturer's recommendations.

3.18 AIRFIELD ROTATING LIGHT BEACON

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, adjustment, and other special instructions. Provide foundations and supports as indicated.

3.18.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.18.2 Power Supply and Wiring

Install panelboard at top of structure to provide separately protected circuits for beacon lamps, heaters, motor, and obstruction lights. Install cabinet on side of platform opposite ladder. Conduit riser shall be installed on tower in a corner angle and not near ladder.

3.19 HELIPORT LIGHT BEACON

Install beacon in accordance with the manufacturer's instructions and other contract requirements including cleaning, lubrication, and adjustment. Provide foundations and supports as indicated.

3.19.1 Beam Adjustment

Adjust beam during hours of darkness. Aim beam to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.19.2 Power Supply and Wiring

Install panelboard at top of structure to provide separately protected circuits for beacon lamps, [heaters,] motor, and obstruction lights. Cabinet shall be installed on side of platform opposite ladder. Install conduit riser on tower in a corner angle and shall not be located near ladder. The terminal cabinet shall be in accordance with NEMA ICS 6 Type 3R or as required otherwise.

3.20 WIND DIRECTION INDICATORS

Include in the installation a black circle constructed on the ground with center at center of the base. Construct the circle using an emulsified asphalt-sand mixture or of a cut-back asphalt-sand mixture not less than 5

inches in thickness. Asphalt-sand mixture shall contain not less than 6 percent bitumen. Sand shall be well-graded with not more than 10 percent material which will pass through a No. 200 mesh sieve. Asphalt-sand mixture shall be compacted thoroughly and sloped for drainage from center to outer rim from one side to the other. Wind cone direction indicator shall be guyed as indicated. The wind cone illumination lights and obstruction lights shall be energized from series or multiple circuits as shown by the contract drawings or as required otherwise.

3.21 ISOLATION TRANSFORMERS

Transformer lead connections shall conform to FAA AC 150/5345-26. Transformer secondary connectors shall plug directly into a mating connector on the transformer secondary leads. During installation, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, heat shrinkable tubing shall be installed with waterproof sealant or with two half-lapped layers of tape over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.22 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

3.22.1 Runway and Taxiway Edge Lights

Edge lights shall be elevated type lights except in paved areas where semiflush lights are required. Threshold and runway end lights shall be elevated or semiflush type as indicated on the contract drawings. Elevated lights shall be frangibly mounted and each light supplied power through an isolation transformer. The taxiway lights shall be omnidirectional and only require leveling. The runway lights require leveling and alignment of the beams for the correct toe-in of the beams.

3.22.2 Runway and Taxiway Centerline Lights

These lights may be mounted on light bases or in drilled holes as indicated on contract drawings. A transformer shall be provided for each group of four 45-watt or three 65-watt centerline lights and installed in a handhole as indicated on the contract drawings. Each light shall be provided with lamp failure shorting device to allow the other lights to operate if one lamp fails. Lights shall be connected to secondary circuit wires at fixture leads using preinsulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed. Connection shall be at staggered locations and wrapped with one layer of half-lapped plastic electrical insulating tape. Light fixtures shall be installed in holes drilled in the pavement as indicated.

3.22.3 Touchdown Zone Lighting Installation

A light base shall be provided for each light and transformer as indicated. In making cable connections, sufficient slack cable shall be provided in each base to permit connection to the upper part of the base or as indicated.

3.23 APPROACH LIGHTING SYSTEMS

Install approach lighting system as indicated or as required otherwise. Provide nameplates for equipment, controls, devices, and for each lighting circuit.

3.23.1 Frangible Requirements

At the 1,000 foot crossbar and beyond, overrun lights shall be mounted up to 6 feet above concrete foundations on threaded frangible couplings and 2 inch rigid steel conduit. For mounting heights greater than 6 feet, light shall be installed on low impact-resistant (LIR) frangible supports. When rigid towers, trestles, and similar structures are required, the light unit shall be installed at least 20 feet above the rigid structure with this support unit being frangible.

3.23.2 Alignment of Lights

Align the approach lights with the axes of the beams directed towards the approach area parallel to the runway centerline. Vertically, they shall be aimed above the horizontal at the threshold of 5.5 degrees and increasing the elevation angle 0.5 degree for each 500 foot interval into the approach area from the threshold. The tolerance for vertical aiming is plus or minus 0.5 degree.

3.24 FIELD QUALITY CONTROL

Notify the Contracting Officer as specified prior to each test. Submit performance test reports, upon completion and testing of the installed system, in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria. Each test shall indicate the final position of controls. Deficiencies found shall be corrected and tests repeated. Field test reports shall be written, signed and provided as each circuit or installation item is completed. Field tests shall include resistance-to-ground and resistance between conductors, and continuity measurements for each circuit. For each series circuit the input voltage and output current of the constant current regulator at each intensity shall be measured. For multiple circuits the input and output voltage of the transformer for each intensity setting shall be measured. A visual inspection of the lights operation, or of the markings appearance, or of the installation of fixtures or units installed shall be reported.

3.24.1 Operating Test

Test each completed circuit installation for operation. Equipment shall be demonstrated to operate in accordance with the requirements of this Section. Testing as specified shall be conducted for the Contracting Officer.

3.24.2 Distribution Conductors, 600-Volt Class

Test shall verify that no short circuits or accidental grounds exist using an instrument which applies a voltage of approximately 500 volts providing a direct reading in resistance.

3.24.3 Counterpoise System Test and Inspection

Continuity of counterpoise system shall be checked by visual inspection at accessible locations. Continuity of counterpoise system to the vault grounding system shall be tested in manhole closest to the vault.

3.24.4 Progress Testing for Series Lighting Circuits

A megger test shall be conducted on each section of circuit or progressive

combinations of sections as they are installed. Each section or progressive combination of sections shall be tested with a megohmmeter providing a voltage of approximately 1000 volts, a direct reading in resistance. Results shall be documented. Faults indicated by these tests shall be eliminated before proceeding with the circuit installation.

3.24.5 Electrical Acceptance Tests

Acceptance tests shall be performed for series and multiple airfield and heliport lighting circuits only on complete lighting circuits. Each series and multiple lighting circuit shall receive a high voltage insulation test.

3.24.5.1 Low-Voltage Continuity Tests

Each series circuit shall be tested for electrical continuity. Faults indicated by this test shall be eliminated before proceeding with the high-voltage insulation resistance test.

3.24.5.2 High-Voltage Insulation Resistance Tests

Each series lighting circuit shall be subjected to a high-voltage insulation resistance test by measurement of the insulation leakage current with a suitable high-voltage test instrument which has a steady, filtered direct current output voltage and limited current. High-voltage tester shall include an accurate voltmeter and microammeter for reading voltage applied to the circuit and resultant insulation leakage current. Voltages shall not exceed test values specified below.

3.24.5.2.1 Test Procedure

Both leads shall be disconnected from regulator output terminals and support so that air gaps of several inches exist between bare conductors and ground. Cable sheaths shall be cleaned and dried for a distance of 1 foot from ends of cables and exposed insulation at ends of cables. Ends of both conductors of the circuit shall be connected together and to high-voltage terminals of test equipment, and test voltage applied as specified in the following tabulation between conductors and ground for a period of 5 minutes.

	Test Voltage, dc	
Series Lighting Circuits	First Test on New Circuits	Test on Existing Circuits
High Intensity Series Lighting Circuits (5,000-Volt Leads, 500- and 200-Watt Transformers)	9000	5000
Medium Intensity Series Lighting Circuits (5,000-Volt Leads, 30/45-Watt Transformers)	6000	3000
600-Volt Circuits	1800	6000
When additions are made to existing circuits, only new sections shall be tested in accordance with "First Test on New Circuits" in this table. To ensure reliable operation, complete circuit shall be tested at reduced voltages indicated.		

3.24.5.2.2 Leakage Current

Insulation leakage current shall be measured and recorded for each circuit after a 1 minute application of the test voltage. If leakage current exceeds values specified below, the circuit shall be sectionalized and retested and the defective parts shall be repaired or replaced. Leakage current limits include allowances for the normal number of connectors and splices for each circuit as follows:

a. Three microamperes for each 1000 feet of cable.

b. Two microamperes for each 200 watt and each 500 watt 5,000-volt series transformer.

c. Two microamperes for each 30/45-Watt 5,000 volt series transformer.

d. If measured value of insulation leakage current exceeds calculated value, the circuit shall be sectionalized and tested as specified for each section. Defective components shall be repaired or replaced until repeated tests indicate an acceptable value of leakage current for the entire circuit.

3.24.6 Constant Current Regulators

Each constant current regulator shall be examined to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and liquid level of liquid-filled regulators is correct. Relay panel covers shall be removed only for this examination; it is not necessary to open the main tank of liquid-filled regulators. The instructions on the plates attached to the regulators shall be followed. Covers shall be replaced tightly after completing examinations and tests.

3.24.7 Regulator Electrical Tests

Supply voltage and input tap shall correspond. With the loads disconnected, regulator shall be energized and the open circuit protector observed to ensure that it de-energizes the regulator within 3 seconds. After testing circuits for open circuit and ground fault and corrections, if any, and after determining that lamps are serviceable and in place, the loads shall be connected for each circuit or combination of circuits to be energized by the regulator and the voltage and current measured simultaneously for each brightness tap. Voltmeter and ammeter shall have an accuracy of plus or minus 1 percent of meter full scale. Readings shall be recorded during the day and night in order to obtain the average supply voltage. Output current on each brightness tap shall be within plus or minus 2 percent full scale of the nameplate values after making necessary correction in the supply voltage. Late model regulators have automatic supply voltage correction in lieu of input taps, and output current does not change as supply voltage varies. When output current on highest intensity setting deviates from nameplate value by more than 2 percent of meter full scale and the regulator is not overloaded, internal adjustment shall be checked as described on regulator instruction plate. Since adjustment may be rather delicate, a deviation of up to plus or minus 5 percent of meter full scale is allowed for lower intensity settings before attempting to readjust the regulator.

3.25 FINISHING

Painting required for surfaces not otherwise specified and finish painting of items only primed at the factory shall be as required in Section 09 90 00 PAINTS AND COATINGS.

3.26 TRAINING

Submit requirements of training 3 weeks before training is scheduled to begin. Submit information describing training to be provided, training aids to be used, samples of training materials, and schedules; a list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays; instructions necessary to checkout, troubleshoot, repair, and replace components of the systems, including integrated electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting after acceptance of the system.

a. Provide training on the proper operation and maintenance procedures for the system. Submit a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

b. Submit 6 copies of operation for the equipment furnished. One complete set shall be furnished prior to performance testing and the remainder shall be furnished upon acceptance. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

c. Submit 4 copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include conduit and equipment layout and simplified wiring and control diagrams of the system as installed.

3.27 FINAL OPERATING TESTS

After completion of installations and the above tests, circuits, control equipment, and lights covered by the contract shall be demonstrated to be in acceptable operating condition. Each switch in the control tower lighting panels shall be operated so that each switch position is engaged at least twice. During this process, lights and associated equipment shall be observed to determine that each switch properly controls the corresponding circuit. Telephone or radio communication shall be provided between the operator and the observer. Tests shall be repeated from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Each lighting circuit shall be tested by operating the lamps at maximum brightness for not less than 30 minutes. At the beginning and at the end of this test the correct number of lights shall be observed to be burning at full brightness. One day and one night operating test shall be conducted for the Contracting Officer.

3.28 POSTED INSTRUCTIONS

Submit a typed copy of the proposed posted instructions showing wiring,

control diagrams, complete layout and operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system.

-- End of Section --