
USACE / NAVFAC / AFCEC / NASA UFGS-26 54 21.00 10 (October 2007)

Preparing Activity: USACE Superseding
UFGS-26 54 21.00 10 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2017

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DIVISION 26 - ELECTRICAL

SECTION 26 54 21.00 10

HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS

10/07

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SECTION 26 54 21.00 10

HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS
10/07

NOTE: This guide specification covers the requirements for lighting and visual navigation aids for helipads.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: If mission on an existing facility is to be operational during construction, a scheduling plan properly coordinated with the airfield or heliport users should be developed and included as part of the bid package. Maximum outage time allowed should be specified for critical lighting, visual navigational aids and utility systems. Minimum advance notice (48 hrs, 72 hrs, etc.) for proposed outages should be specified. Consider transfer of control from the control tower to the alternate control point (vault) to maintain the mission for limited times during construction and to minimize mission disruption and potential cost growth during construction. If this is not possible, the scheduling can be delegated to the construction

phase of the project by inserting the following text in Part 1.

"Existing helipad, airfield or heliport lighting systems must remain in operating condition except for minimum interruptions, as approved in writing by the Contracting Officer. Prior to each interruption, all necessary materials and a sufficient labor force will be assembled to permit completing the work within the scheduled time interval. Under no circumstances will any of the existing airfield, heliport, or helipad lighting circuits be left inoperative without making provisions for suitable temporary connections in the affected area or areas. All airfield, heliport, or helipad lighting circuits covered under this contract must be restored in such a manner that they will be operational at dusk each day. The Contractor must submit plan for outages and maintaining lighting and lighting control."

1.1 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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
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ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2015) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and
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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) Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D709	(2016) Standard Specification for Laminated Thermosetting Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/
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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) 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	(2011) 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 2011) Industrial Control and Systems: Enclosures
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	(2015) Standard for 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) National Electrical Code
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SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20	(2002; E 2004) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)
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U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 345-67	(1998) REA Specification for Filled Telephone Cables, PE-39
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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 150/5345-46	(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 150/5345-7	(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-2519	(1972; Rev A) Types I and II
FAA E-982	(2003; Rev J) PAR-56 Lampholder

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for 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	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 83	(2014) 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

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Use the "S" classification only in SD-11 Closeout Submittals. The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. 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:

SD-02 Shop Drawings

Lighting and Visual Navigation Aids; G[, [_____]]
As-Built Drawings

SD-03 Product Data

Materials and Equipment
Protection Plan
Training
Posted Instructions

SD-06 Test Reports

Field Quality Control
Final Operating Test
Inspections

SD-07 Certificates

Qualifications
Materials and Equipment

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 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 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 shall be trained and certified in installation of this type of system and approved by the manufacturer of the system.
- c. Submit [_____] copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators prior to welding operations.

1.3.2 Code Compliance

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

1.3.3 Protection Plan

Submit detailed procedures to prevent damage to existing facilities or infrastructures. If damage does occur, 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

Metallic materials shall be protected against corrosion as specified. Aluminum shall not be used in contact with earth or concrete. Where aluminum conductors are connected to dissimilar metal, suitable fittings shall be used.

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.

1.3.4.3 Luminaries Fabricated from Ferrous Metals

Luminaries 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.

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. 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 [3,000 m 9850 feet] [_____].

1.4.2 Other

All materials or equipment to be installed [underground]; [in handholes, manholes, or underground vaults]; [or] [in light bases], [_____] shall be suitable for submerged operation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

- a. The helipad lighting and visual navigation aids shall consist of [helipad perimeter lights,] [helipad marking,] [floodlights,] [in-pavement lights,] [[landing direction lights] and approach direction lights,] [obstruction lights and markings,] [beacon,] [wind direction indicator,] [visual glide slope indicator,] [[hoverlane lights] and markings,] [approach lighting system,] [refueling area lights,] [[helipad lighting power supply,] [and controls]] and [_____] as indicated on the contract Drawings.
- b. 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.
- c. Reports of inspections for the counterpoise system and other required inspections shall be prepared and provided to the Contracting Officer as each stage of installation is completed. These reports shall identify the activity by contract number, location, quantity of material placed, and compliance with requirements.

2.2 STANDARD PRODUCT

Provide material and equipment which are a 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.

2.3 MATERIALS

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.

- 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. 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.

2.3.1 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 3.2 mm 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 25.4 by 63.5 mm 1 by 2-1/2 inches minimum with minimum 6.4 mm 1/4 inch high normal block lettering. Nameplates shall be provided as indicated. Nameplates shall be fastened to the device with a minimum of two sheet metal screws or two rivets.

2.3.2 Electrical Tape

Electrical tape shall be UL 510 plastic insulating tape.

2.3.3 Conduit, Conduit Fittings, and Boxes

2.3.3.1 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 1.0 mm 40 mils thick, conforming to NEMA RN 1.

2.3.3.2 Flexible Metal Conduit

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

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

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

2.3.3.4 Plastic Duct for Concrete Encased Burial

These ducts shall be [PVC conforming to NEMA TC 6 & 8, Type EB] [provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION].

2.3.3.5 Plastic Conduit for Direct Burial

This plastic conduit shall be [PVC conforming to NEMA TC 2 (conduit) and NEMA TC 3 (fittings) Type [EPC-40 PVC] [EPC-80 PVC]] [provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION].

2.3.3.6 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. 61.1 mm 2-13/32 inch - 16N-1A modified thread for nut and compression ring to secure 50 mm 2 inch EMT.
- c. 50 mm 2 inch - 11 1/2-N.P.T. (tapered) with 5.6 mm 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.

2.3.4 Wire and Cable

Conductors shall be copper except as otherwise indicated.

2.3.4.1 Conductor Sizes

Conductor size shall conform to American Wire Gauge (AWG) and NFPA 70 for minimum size. Conductor sizes larger than No. 8 AWG shall be stranded. No. 8 AWG and smaller may be solid or stranded unless otherwise indicated.

2.3.4.2 Low Voltage Wire and Cable

NOTE: Type THW insulation can only be obtained in large quantity. Use of this type insulation is not recommended for small projects. Wire with "W" in the type is usually acceptable for wet locations.

Use [UL 854, Type USE, 600 volts for underground low voltage power

cables.] Use [UL 83, Type [_____] [THW] [THWN]] [UL 44, Type [XHHW] [_____] for secondary series lighting circuits to be installed in pavement.

2.3.4.3 Power Cables for Use in Helipad Lighting

Power cables for use in Helipad Lighting shall be [rated [5] [_____] kV,] [133 percent] [_____] insulation level, with shield and jacket provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.3.4.4 Wire and Cable for Helipad Lighting Systems

NOTE: FAA AC 150/5345-7 covers Type A (rubber), Type B (ethylene-propylene), and Type C (crosslinked polyethylene) cable. Each type has 600-volt and 5000-volt ratings with single and multiple conductors. Type A and B have overall jackets while C only has the overall jacket for the multiple conductor cables. Type C is recommended for single conductor cable. If soil conditions require a jacketed cable for protection of insulation, specify Type B.

- a. Helipad lighting cable shall be [FAA AC 150/5345-7, Type L-824, for crosslinked polyethylene Type C] [_____] [600] [5000]-volt cable. Series airfield lighting cable shall be unshielded. Lighting cable for multiple type lighting circuits shall be [shielded] [unshielded].
- b. Cable for pavement slot installation shall be [UL 83 Type [THWN] [THW]] [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 for 120 V 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. Cable shall conform to FAA AC 150/5345-7, Type [A] [B] [or] [C]]. [For 48 V dc control, multiconductor, 300 volts No. 19 AWG, conforming to RUS Bull 345-67] [_____]].
- e. Fused Cable Connectors. Provide connector consisting 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. Provide fuse with rating indicated. Provide connectors in kit form properly sized for the specific cable diameter involved. Completed connection shall be watertight.

2.3.4.5 Cable Tags

Cable tags for each cable or wire shall be installed 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 1.6 mm 1/16 inch thick or hard plastic 3.2 mm 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 6.4 mm 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.

2.3.4.6 Concrete Markers for Direct Buried Cable Systems

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

2.3.5 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 19.1 mm 3/4 inch in diameter and 3.048 m 10 feet long, unless indicated otherwise.

2.3.6 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.

2.3.7 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.

2.3.8 Transformers

NOTE: Occasionally, power transformers will be needed to support helipad systems. Prepare this paragraph as necessary to suit the specific helipad installation.

2.3.8.1 Encapsulated Isolating Transformers

These transformers shall be FAA AC 150/5345-47, Type L-830. Each transformer shall be provided with rating as indicated on the contract drawings.

2.3.8.2 Power Transformers

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

2.3.9 Light Bases

NOTE: Use Type L-867 bases for applications not subject to aircraft or vehicle loading. Use Type L-868 bases for applications subjected to aircraft

or vehicle loading. Use Type L-869 as a junction box in all pavements.

Light bases shall be FAA AC 150/5345-42 Type [L-867] [L-868] [L-869] [____]. Steel bases, Class 1, Size [A] [B] [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 stainless steel.

2.3.10 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.

2.3.11 Constant Current Regulator

The regulator shall be FAA AC 150/5345-10, Type L-828, [with] [without] monitor system and with ratings as indicated. [Regulators shall operate on [60] [50] Hz, have internal primary switch [included] [excluded], have input voltage of [240] [480] [2400] [____] and be controlled by 120-volt external control voltage. [Three] [Five] [Indicated number of] brightness steps shall be provided]. [Monitors shall be provided as indicated.]

2.3.12 Lamps and Filters

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

2.3.13 Sump Pumps for Manholes and Vaults

Sump pumps shall be submersible type with a capacity for not less than [____] L/min gal/min at a total dynamic head of [3.1 m] [____] m [10] [____] 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 as shown.

2.3.14 Circuit Breakers and High-Voltage Switches

NOTE: Circuit breakers and high-voltage switches should normally be rated at 150 percent of the full load current rating of the transformer or the device protected. Do not use manually operated fuse cutouts.

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 vaulted for [____] volts, [____] amperes,

[_____] kV BIL. 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.

2.3.15 Transformer, Substations and Switchgear

The transformer substations and switchgear shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.3.16 Emergency Generator and Automatic Transfer Switch System

NOTE: Sections 26 36 00.00 41 AUTOMATIC TRANSFER [AND BY-PASS/ISOLATION] SWITCHES, 26 32 15.00 10 DIESEL-GENERATOR SET STATIONARY 100-2500 KW, WITH AUXILIARIES, and 26 32 14.00 10 DIESEL-GENERATOR SET, STATIONARY 15-300 KW, STANDBY APPLICATIONS shall be edited and modified as necessary to suit the specific helipad installation. Helipad requirements include the following. Emergency generator sets shall be rated 0.8 power factor lagging, either 4160/2400 or 480/277 volts, 3-phase, 4-wire, grounded wye, 60 Hz. Installations for OCONUS usually require 50 Hz. Governor shall provide speed regulation of 5 percent from no load to full load. Provide manual voltage control, electromagnetic interference suppression, batteries, battery charger, and repair parts. Parallel operation and remote control speed adjustments are not required. Automatic transfer switch shall be specified for ratings needed for the helipad lighting installation. The generator and automatic transfer switch system shall accomplish a complete transfer to the emergency power supply within 15 seconds of interruption of the normal power supply for Category I helipads. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals shall be set at three seconds. Where climatic conditions warrant, cold starting capability suitable to the minimum temperature to be encountered shall be provided.

The automatic transfer switch shall be in accordance with Section [26 36 00.00 10 AUTOMATIC TRANSFER [AND BY-PASS/ISOLATION] SWITCHES] [_____] and as required by the contract drawings or contracting documents. The emergency generator shall be in accordance with [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.

2.3.17 Circuit Selector Cabinet

NOTE: Circuit selector cabinets were previously referred to as distribution boxes and may be provided to select one or a second circuit or to

select any combination of up to four circuits.

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

2.3.18 Pilot Relay Panel

NOTE: Type I pilot relay panel has 24 double-pole, single-throw relays and is used for systems including approach lighting systems. Specify a Type II relay panel if 16 double-pole, single-throw relay sand 8 double-pole, double-throw relays are required for a system. Specify L-841 panel only if 48 V dc control is required.

The pilot relay panel shall be NEMA 250, NEMA ICS 2, NEMA ICS 6, NEMA PB 1 and FAA AC 150/5345-13, Type L-841, for 48 V dc control systems.

2.3.19 Control Panel

NOTE: Refer to FAA AC 150/5354-3 for type, class, and style.

The control panel for helipad lighting shall be FAA AC 150/5345-3, Type L-821 Type [____], Class [____], Style [____]. Quantity and color of lenses shall conform to FAA AC 150/5345-3 and shall correspond to the actual circuits indicated.

2.3.20 Lighting Fixtures

NOTE: See Army Standard Detail No. 40-06-05 for the lighting fixtures for the specific helipad lighting application. Select fixtures and equipment for operation of visual aids and delete the unused items.

The lighting fixtures for the helipad lighting shall be as required in contract drawings or other contract documents.

2.3.21 Painting

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

2.4 HELIPAD MARKINGS

The helipad markings shall be [a large white "letter-H" at the center of the helipad with broken white edge markings] [a red "letter-H" centered on a white cross and the broken white edge markings]. The markings shall be [retroreflective] [non-retroreflective] with dimensions as shown on the contract drawings.

2.5 HELIPAD BEACON

The helipad 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 colors [white, aviation green, and aviation yellow for a non-medical facility helipad] [white, aviation green, and aviation red for a medical facility helipad.] The beacon flashes shall be visible throughout 360 degrees horizontally, and the effective intensity of the flashes shall be not less than 25,000 candelas for vertical angles between 2 and 8 degrees and not less than 12,500 candelas for vertical angles between 0 and 10 degrees. The flashes shall be uniformly spaced with the three-color sequence flashing 10 to 15 times per minute.

2.6 WIND DIRECTION INDICATOR

The wind direction indicator shall be an FAA AC 150/5345-27, Type [L-806, low mass supporting structure] [L-807, rigid supporting structure], Style [I-lighted] [II-unlighted], Size [304.8 - 2438 mm] [1 - 8 feet] [609.6 - 3658 mm] [2 - 12 feet] with the fabric cone color as required on the contract drawings.

2.7 OBSTRUCTION LIGHTING AND MARKING

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

2.8 HELIPAD GLIDE SLOPE INDICATOR

The glide slope indicator for helipads shall be Chase Helicopter Approach Path Indicator (CHAPI) two-unit system. The CHAPI shall meet the requirements of FAA AC 150/5345-28, Type L-881, with the addition of a filter that will provide a two-degree wide green sector in the center of the white over red beam.

2.9 HOVERLANE LIGHTS

The hoverlane lights shall be alternating green and yellow steady burning lights along the hoverlane centerline. The fixtures shall be [FAA AC 150/5345-46, Type L-861 for elevated lights with aviation yellow or aviation green globes] [as shown on the contract drawings]. The elevated lights shall be frangibly mounted on [steel stakes] [bases]. For hoverlane lights located in paved areas subjected to aircraft or vehicle traffic, the fixtures shall be [FAA AC 150/5345-46, Type L-852E with aviation yellow or aviation green filters mounted on FAA AC 150/5345-42, Type L-868 bases] [as required]. The hoverlane lights shall be energized from a [6.6 ampere series circuit through isolation transformers] [120-240 volt multiple circuit] power source as required by the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1, 6.6/6.6 amperes, 30/45 watts 60 hertz.

2.10 EXPLOSION-PROOF AVIATION LIGHT FIXTURE

NOTE: Only fixtures that are listed by U.L. or an equivalent lab shall be used in a hazardous location. Listing must reflect the installed configuration. A listing for the fixtures shown in Standard Detail No. 40-06-05, sheet 12 has not been obtained.

For lights located in explosion hazardous areas, the fixtures shall be approved and listed to meet the requirements of UL Electrical Constructn or FM APP GUIDE as defined in NFPA 70 for the hazard and application. The explosion-proof fixtures are located as shown on the contract drawings or otherwise specified herein.

2.11 HELIPAD LIGHTING, VISUAL METEOROLOGICAL CONDITIONS (VMC)

The VMC helipad lighting basically consists of the perimeter lights; but landing direction lights, approach direction lights, helipad floodlights, and helipad inset lights shall be provided as specified.

2.11.1 Perimeter Lights

The perimeter lights are used to mark the edges of helipads intended for operations at night. The fixtures shall be FAA AC 150/5345-46, Type L-861 with aviation yellow globes. These elevated lights shall be frangibly mounted on [steel stakes] [FAA AC 150/5345-42, Type L-867 bases]. For perimeter lights located in paved areas subject to aircraft or vehicular surface traffic, the fixtures shall be FAA AC 150/5345-46, Type L-852E with aviation yellow filters. These fixtures shall be mounted on FAA Type L-868 bases. These lights shall be energized from a [6.6 ampere circuit through isolation transformers] [120/240 volt multiple circuit] as required by the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1, 6.6/6.6 amperes, 30/45 watts, 60 hertz.

2.11.2 Landing Direction Lights

The landing direction lights mark the preferred direction for the approach to landing on the helipad. The light fixtures shall be FAA AC 150/5345-46, Type L-861 with aviation yellow globes. These elevated lights shall be frangibly mounted on [steel stakes] [FAA AC 150/5345-42, Type L-867 bases]. For landing direction lights located in paved areas subject to aircraft or vehicular surface traffic, the fixtures shall be FAA AC 150/5345-46, Type L-852E with aviation yellow filters. These fixtures shall be mounted FAA Type L-868 bases. These lights shall be energized from [6.6 ampere series circuit through isolating transformers] [120/240 volt multiple circuit] power source as required by the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type 1-830-1, 6.6/6.6 amperes, 30/45 watts, 60 hertz.

2.11.3 Approach Direction Lights

The approach direction lights emit white light to indicate the direction for approach to the helipad. The fixtures shall be FAA AC 150/5345-46, Type L-861 with aviation white globes. These elevated lights shall be frangibly mounted on [steel stakes] [FAA AC 150/5345-42, Type L-867 bases]. For approach direction lights located in paved areas subject to

aircraft or vehicular surface traffic, the fixtures shall be FAA AC 150/5345-46, Type L-852E without filters. These lights shall be mounted on FAA Type L-868 bases. These lights shall be energized from a [6.6 ampere series circuit through isolation transformers] [120/240 volt multiple circuit] power source as required by the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1, 6.6/6.6 amperes, 30/45 watts, 60 hertz.

2.11.4 Helipad Floodlights

Helipad floodlights provide texture on the helipad surface at night. The floodlight fixtures are as required in the contract drawings. These lights shall be [mounted on FAA AC 150/5345-42, [Type L-867] [Type L-858] bases] [[or] [as approved].] The lights shall be energized from 120/240 volt multiple circuits.

2.11.5 Helipad Inset Lights

Helipad inset shall be FAA AC 150/5345-46, Type L-852E [with aviation blue filters] [without filters]. These lights shall be mounted on FAA AC 150/5345-42, Type L-868 light bases. These lights shall be energized from a [6.6 ampere series circuit through isolation transformers] [120/240 volt multiple circuit] power source as shown on the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-1, 6.6/6.6 amperes, 30/45 watts, 60 hertz.

2.12 HELIPAD LIGHTING, INSTRUMENT METEOROLOGIC CONDITIONS (IMC)

The IMC helipad lighting consists of perimeter lights, approach lights, and landing direction lights.

2.12.1 Helipad IMC Perimeter lights

For IMC perimeter lights, shall be FAA AC 150/5345-46, Type L-861SE elevated, medium-intensity, bidirectional fixtures with aviation yellow filters. These lights shall be frangibly mounted on FAA AC 150/5345-42, Type L-867 bases. These lights shall be energized from a [6.6 ampere series circuit through isolation transformers] [120/240 volt multiple circuit] power source as required by the contract drawings. [The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-4 6.6/6.6 amperes, 100 watts, 60 hertz.]

2.12.2 Helipad IMC Approach Lights

The IMC helipad approach lights fixtures shall be [FAA specification FAA E-982 lampholder for Type PAR-56 lamps without filters]. The fixtures shall be frangibly mounted on [steel stakes] [FAA AC 150/5345-42, Type L-867 bases]. The lamps shall be as required by the contract drawings. The lights shall be energized by a [6.6 ampere] [20 ampere] series circuit through isolation transformers. The isolation transformers shall be FAA AC 150/5345-47, Type L-830-6, 6.6/6.6 ampere, 200 watt, 60 hertz transformers.

2.12.3 Helipad IMC Landing Direction Lights

The helipad IMC landing direction lights fixtures shall be FAA AC 150/5345-46, Type L-862 elevated, high-intensity, bidirectional, fixtures with aviation yellow filters. The lights shall be frangibly mounted on [FAA AC 150/5345-42, Type [L-868] [L-867]] bases. These lights

shall be energized from a [6.6 ampere series circuit through isolation transformers] [120/240 volt multiple circuit] power source as required by the contract drawings. The isolation transformers for series circuits shall be FAA AC 150/5345-47, Type L-830-6, 6.6/6.6 ampere, 200 watt, 60 hertz transformers.

2.13 AIRFIELD AND HELIPORT LIGHTING SYSTEMS

Lighting at airfield or heliport interfaces shall be as specified in [Section 26 56 20.00 10, AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS.]

2.14 FACTORY COATING

NOTE: A 200-hour test will be specified in a noncorrosive environment and a 500-hour test will be specified in a corrosive environment.

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand [200] [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 1.6 mm 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 a zinc rich paint conforming to SSPC Paint 20 in accordance with ASTM A780/A780M.

PART 3 EXECUTION

3.1 Verification of Dimensions

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 covered 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. Manufacturer's written recommendations shall be furnished for each type of splice and medium-voltage cable joint and termination, and for fireproofing

application methods, and shall be 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

[Medium-voltage cables] [Low-voltage cables] [Cables] shall be installed 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 [150 mm] [_____] mm [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

NOTE: Use 750 mm 30 inch back-fill cover for cable ratings up to 15 kV and 900 mm 36 inch cover for cable ratings above 15 kV and up to 35 kV.

[Medium-voltage cables] [Low-voltage cables] [Cables] shall be buried directly in the earth as indicated. Minimum cover from the top of a cable to finished grade shall be [600 mm 24 inches for low-voltage cables] [[750] [900] mm [30] [36] inches from medium-voltage cables,] but not less than the depth of the frost line. Counterpoise cable shall be not less than [150] [_____] mm [6] [_____] inches above the uppermost electrical cable or duct containing 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, 75 mm 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

NOTE: Where a buried cable warning is necessary, the requirement for a tape or approved warning indication will be provided. Where soil is known to be rocky, provide selected backfill for cable protection.

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 75 mm 3 inches vertically and 50 mm 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 100 mm 4 inch layer of backfill shall be of sand or stone-free earth. [A 0.127 mm 5 mil, brightly colored plastic tape not less than 75 mm 3 inches in width and suitably inscribed at not more than 3 m 10 feet on centers, or other approved dig-in warning indication, shall be placed approximately 300 mm 12 inches below finished grade levels of trenches.] [Selected backfill of sand or stone-free earth shall be provided to a minimum depth of 75 mm 3 inches above cables.]

3.3.2.3 Other Requirements

Where direct-burial cables cross under roads or other paving exceeding 1.5 m 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 300 mm 1 foot beyond each edge of any paving and at least 1.5 m 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 300 m 1000 feet or less, nor at intervals of less than 300 m 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

Markers shall be located near the ends of cable runs, at each cable joint or splice, at approximately every 150 m 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 1.5 m 5 feet outside of a building and 600 mm 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] [35 kV]. 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. Separate 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 [100] [133] percent insulation level [and 28 kV and 35 kV insulation thicknesses shall be in accordance with either AEIC CS8 or 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

Shields shall be applied 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] [_____] type. Cables joints for which acceptable separable connector kits are not available may use [factory preformed] [vulcanized] [taped joint] [resin pressure-filled overcast 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, pre-stretched 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

NOTE: In areas where heavy fog, salt air or medium to heavy industrial contamination occur, require that terminations pass the next higher wet withstand test for factory preformed terminations. For taped termination, use 320 mm 12-1/2 inches for cable rated 5 kV, 510 mm 20 inches for cable rated 15 kV, 635 mm 25 inches for cable rated 25 kV, and 890 mm 35 inches for cable rated 28 kV or 35 kV in normal atmospheres. Use next higher voltage level lengths in contaminated atmospheres which will require 1.2 m 46 inches for 28 kV or 35 kV cables.

Molded elastomer, wet-process porcelain, pre-stretched, 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 shall use standard termination kits providing suitable terminal connectors, [field-fabricated stress cones], [and rain hoods]. Terminations shall be at least [318] [508] [635] [889] [1200] mm [12 1/2] [20] [25] [35] [46] inches long from the end of the tapered cable jacket to the start of the terminal connector, or not less than the kit manufacturer's recommendations, whichever is greater.

3.5 LOW-VOLTAGE CABLES

Cable shall be rated 600 volts, except that secondaries of isolation transformer to in-pavement lights installed in pavement 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] [non-insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B]. They shall be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. All 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

NOTE: Communication lines run elsewhere will be provided with the type of wall thickness that is in accordance with the appropriate communication agency's policy. Electrical metallic tubing will not be installed underground or encased in concrete.

[Duct lines shall be concrete-encased, thin-wall type.] [Duct lines shall be non-encased direct-burial, thick-wall type.] [Duct lines shall be concrete-encased, thin-wall type for duct lines between manholes and for other medium-voltage lines]. [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 100 mm/30 m 4 inches/100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, 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 450 mm 18 inches for ducts of less than 78 mm 3 inches diameter, and 900 mm 36 inches for ducts 78 mm 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m 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 used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever 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 0.127 mm 5 mil brightly colored plastic tape not less than 76.2 mm 3 inches in width and suitably inscribed at not more than 3.0 m 10 feet on centers with a continuous metallic backing and a corrosion-resistant 0.025 mm 1 mil metallic foil core to permit easy location of the duct line, shall be placed approximately 300 mm 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 300 mm 12 inches long and have diameters 6.4 mm 1/4 inch less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used for draw-in lead wires. A coupling recommended by the duct manufacturer shall be used whenever 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 any 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 75 mm 3 inches of concrete around each duct, except that only 50 mm 2 inches of concrete are required between adjacent electric power or adjacent communication ducts, and 100 mm 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 450 mm 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 1.5 m 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 1.2 m 4 feet on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete and joints shall be staggered at least 150 mm 6 inches vertically.

3.6.4 Non-encased Direct-Burial

Top of duct lines shall be below frost line but not less than 600 mm 24 inches below finished grade. Ducts shall be buried below frost line in the earth and shall be installed with a minimum of 75 mm 3 inches of earth around each duct, except that between adjacent electric power and communication ducts, 300 mm 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, 75 mm 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 150 mm 6 inches. The first 100 mm 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 100 to 150 mm 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 Asbestos-Cement and 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 minus 18 degrees C 0 degrees F. Couplings shall be warmed in hot water or by another approved method when installed at temperatures below 0 degrees C 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

NOTE: When preparing Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION for a project specification, the designer will edit the guide specification as necessary to suit the specific helipad installation. Note that for helipads standard type manholes, vaults, manholes, vaults, handholes, and their associated frames and covers may be used. If one of these will be located on the helipad or surface subject to aircraft traffic loads, these features may require a design for a maximum single wheel load of 222 kN 50,000 pounds or dual wheel load of 400 kN 90,000 pounds. Use steel conforming to ASTM A36/A36M, "Structural Steel", for covers at helipad manholes, vaults, and handholes. Use ductile iron for frames conforming to ASTM A536, grade 65-45-12.

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

3.8 WELDING

The welding supports and metallic ducts and welding or brazing of electrical connections shall be by qualified welders.

3.9 CABLE MARKERS

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

3.10 FRANGIBLE REQUIREMENTS

Frangible supports, couplings, and adapters shall be installed as indicated or as specified.

3.11 ELEVATED HELIPAD LIGHTS

Elevated helipad lights shall be frangibly mounted, normally not exceeding 350 mm 14 inches in height, unless higher mounting is permitted in snow accumulation areas as indicated.

3.12 SEMIFLUSH HELIPAD LIGHTS

Water, debris, and other foreign substances shall be removed prior to installing semiflush light base and light. Positioning jigs shall be used to hold the light bases and/or lights to ensure correct orientation and leveling until concrete, adhesive, or sealant can provide permanent support.

3.13 WIRES, FIXTURES, AND ENCLOSURES IN SAW KERFS AND DRILLED HOLES

Sealant is specified in paragraph Sealing Fixtures and Wires in Drilled

Holes or Saw Kerfs.

3.13.1 Holes for Light Fixtures

Holes shall be bored in existing pavement to the dimensions indicated using 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 25 mm one 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 75 mm 3 inches of concrete shall be provided at bottom of hole.

3.13.3 Saw Kerfs and Splice Chambers

Kerfs and splice chambers shall be saw 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 in flexible tubing under the joint.

3.13.4 Sandblasting

Saw kerfs, grooves, and holes shall be sandblasted to remove foreign or loose material using approved equipment maintained in good working order at all times. Sand for blasting shall be proper size and quality as necessary to perform the work. Nozzles used 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 621 kPa 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 cleaned and dried with a high velocity air jet.

3.13.6 Lighting Fixture Installation

**NOTE: The designer shall provide details on the
project drawings showing the installed light fixture
with reference to the pavement.**

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. Sealant shall completely fill the void between concrete and base. A jig or holding device shall be used for installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixture shall be oriented with light beams parallel to the preferred direction of approach to the helipad. Level outermost edge of fixture with the surrounding pavement. Surplus sealant or flexible embedding material shall

be removed. The holding device shall be left in place until sealant has reached its initial set. Fixture lead wires shall be properly arranged with respect to their connecting position. The wire way entrance into the light recess shall be blocked to retain the sealant material during curing.

3.13.7 Installation of Circuit Wires in Pavement

Wires shall be placed in saw kerfs and anchored at bottom by means of rubber or plastic wedges or noncorrosive metal clips placed every 600 or 900 mm 2 or 3 feet or as often as necessary to hold the wire down. Wires crossing existing joints shall be encased in a 300 mm 12 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 mixed and applied in accordance with the manufacturer's instructions and at the recommended temperature. Surplus or spilled material shall be removed.

3.14 SPLICES FOR HELIPAD LIGHTING CABLE

3.14.1 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 cleaned when plugged together. At joint where connectors come together, install heat shrinkable tubing with waterproof sealant. Alternately, the Contractor may provide two half lapped layers of tape over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.14.2 Splicing Fixtures to the Wires in Pavement Saw Kerfs

Splices shall be made with pre-insulated watertight connector sleeves crimped with a tool that requires a complete crimp before tool can be removed.

3.15 GROUNDING SYSTEMS

NOTE: The preferred method of grounding is to have grounding circuit separate and not connected to the counterpoise. The light fixtures, equipment, and buildings are connected to the grounding circuit. If necessary, grounding to the counterpoise may be permitted.

3.15.1 Counterpoise Installation

Counterpoise wire shall be placed for entire length of circuits supplying helipad lighting. Wire shall be provided 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

150 mm 6 inches above direct burial cables and duct lines. Where trenches or duct lines intersect, counterpoise wires shall be electrically interconnected wires by exothermic welding or brazing. Counterpoise shall be connected to earth ground at every [600 m] [_____] m [2,000] [_____] feet of cable run, at lighting vault, and at feeder connection to light circuit by means of ground rods as specified. The counterpoise shall be installed in a separate duct under roads, railroads, and paved areas above the highest duct containing electrical or communications circuits.

3.15.2 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 base-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.

3.16 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

NOTE: If Section 09 90 00 PAINTS AND COATINGS is included, painting requirements should be transferred to it. Local conditions may necessitate modification to the following paragraph. Refer to FAA AC 70/7460-1 for further marking of 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.

3.16.1 Painting of Airway Obstructions

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

3.16.2 Obstruction Marker Lights

Install obstruction marker lights on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with 25 mm one-inch zinc-coated rigid steel conduit stems using standard tees and elbows, except that where lowering devices are required, equipment shall be installed in accordance with manufacturer's recommendations.

3.17 HELIPAD LIGHT BEACON

Install helipad light beacon in accordance with specifications and manufacturer's instructions, including those for cleaning, lubrication, adjustment, and other special instructions. Provide foundations and support as indicated.

3.17.1 Beam Adjustment

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

3.17.2 Power Supply and Wiring

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

3.18 WIND DIRECTION INDICATOR

Installation shall include a 7.5 m 25 foot black circle constructed on the ground with center at center of the wind cone base. Circle shall be constructed of an emulsified asphalt-sand mixture or of a cut-back asphalt-sand mixture not less than 125 mm 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 obstruction lights shall be energized from [multiple] [series] [series or multiple circuits] as required by the contract drawings.

3.19 HELIPAD GLIDE SLOPE INDICATOR

The helipad glide slope indicator, CHAPI, system shall be on an independently controlled power circuit.

3.20 ISOLATION TRANSFORMERS

Connect transformer primary leads to primary cables with connectors conforming to FAA AC 150/5345-26. Transformer secondary shall be connected with connectors conforming to FAA AC 150/5345-26 and plugged directly into a mating connector on the transformer secondary leads. During installation, mating surfaces of connectors shall be kept covered until connected and clean when plugged together. At joint where connectors come together, heat shrinkable tubing shall be installed with waterproof sealant. [Alternately, the Contractor may provide two half-lapped layers of tape over the entire joint.] Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.21 FIELD QUALITY CONTROL

Notify the Contracting Officer [5] [_____] working days prior to [each] [_____] test[s]. Deficiencies found shall be corrected and tests repeated.

3.21.1 Distribution Conductors, 600-Volt Class

Conductors shall be tested to verify that no short circuits or accidental grounds exist using an instrument which applies a voltage of approximately 500 volts to provide a direct reading in resistance.

3.21.2 Counterpoise System Test and Inspection

Continuity of counterpoise system shall be inspected at accessible locations. Continuity of counterpoise system to the vault grounding system in manhole closest to the vault shall be tested.

3.21.3 Progress Testing for Series Helipad Lighting Circuits

NOTE: Progress testing should be specified when replacing or modifying existing series airfield, heliport, or helipad lighting circuits since interruption time is usually critical; however, progress testing on completely new series helipad lighting circuits is not normally necessary.

Conduct a megger test on each section of circuit or progressive combinations of sections as they are installed. Each section or progressive combination of sections shall be checked with a megohmmeter providing a voltage of approximately 1000 volts to provide a direct reading in resistance, and document results. Faults indicated by these tests shall be eliminated before proceeding with the circuit installation.

3.21.4 Electrical Acceptance Tests

Perform acceptance tests for series and multiple helipad lighting circuits only on complete lighting circuits. Each series and multiple lighting circuit shall be tested for high voltage insulation resistance.

3.21.4.1 Low Voltage Continuity Tests

Test each series circuit for electrical continuity. Faults indicated by this test shall be located and eliminated before proceeding with the high voltage insulation resistance test.

3.21.4.2 High-Voltage Insulation Resistance Tests

Test each series lighting circuit for high-voltage insulation resistance by measuring the insulation leakage current using a suitable high-voltage test instrument with 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.

3.21.4.2.1 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 clean and dry for a distance of 300 mm one 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 between conductors and for a period of 5 minutes as follows:

Series Lighting Circuits	Test Voltage, dc	
	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

Series Lighting Circuits	Test Voltage, dc	
	First Test on New Circuits	Test on Existing Circuits
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.		

3.21.4.2.2 Leakage Current

Insulation leakage current shall be measured and recorded for each circuit after a one-minute application of the test voltage. If leakage current exceeds values specified below, the circuit shall be sectionalized and re-tested 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 300 m 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.

3.21.4.2.3 Sectionalized Testing

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

3.21.5 Constant Current Regulator

Examine each constant current regulator 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 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.

3.21.6 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 faults 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 to the regulator and the voltage and current measured simultaneously for each brightness tap. Voltmeter and ammeter shall have an accuracy of plus or minus one percent full scale. Readings shall be

recorded during the day and night in order to obtain the average supply voltage. Output current for each brightness tap shall be within plus or minus 2 percent of meter 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 full intensity 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 shall be allowed of up to plus or minus 5 percent of meter full scale on taps 1 through 4 before attempting to readjust the regulator.

3.22 FINISHING

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

3.23 TRAINING

Provide training on the proper operation and maintenance procedures for the system. Requirements of training shall be provided [_____] 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. Training shall include a list of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor; 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. Submit [6] [_____] copies of operation manuals as required 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.
- b. Submit [6] [_____] 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.

3.24 Final Operating Test

After completion of installations and the above tests, the circuits, control equipment, and lights covered by the contract shall be demonstrated to be in good operating condition. Each switch in the helipad and/or 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 corresponding circuit.

- a. Telephone or radio communication shall be provided between the operator and the observers. 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 conducted 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 burning at full brightness. [One] [_____] day and [one] [_____] night operating test shall be conducted for the Contracting officer.
- b. Submit field test reports 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.
- c. Upon completion and testing of the installed system, performance test reports are required 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.

3.25 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 prior to posting.

-- End of Section --