
USACE / NAVFAC / AFCEA / NASA UFGS-26 56 20.00 10 (April 2006)

Preparing Activity: USACE Replacing without change
UFGS-16526A (December 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 18 July 2006

Latest change indicated by CHG tags

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS

04/06

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SUBMITTALS
- 1.3 SYSTEM DESCRIPTION
- 1.4 GENERAL REQUIREMENTS
 - 1.4.1 Code Compliance
 - 1.4.2 Standard Product
 - 1.4.3 Prevention of Corrosion
 - 1.4.3.1 Metallic Materials
 - 1.4.3.2 Ferrous Metal Hardware
 - 1.4.3.3 Luminaires Fabricated from Ferrous Metals
 - 1.4.4 Unusual Service Conditions
 - 1.4.4.1 Altitude
 - 1.4.4.2 Other
 - 1.4.5 Verification of Dimensions
 - 1.4.6 As-Built Drawings
 - 1.4.7 Protection Plan
 - 1.4.8 Qualifications

PART 2 PRODUCTS

- 2.1 MATERIALS
 - 2.1.1 Electrical Tape
 - 2.1.2 Nameplates
 - 2.1.3 Conduit, Conduit Fittings, and Boxes
 - 2.1.3.1 Rigid Steel or Intermediate Metal Conduit (IMC) and Fittings
 - 2.1.3.2 Flexible Metal Conduit
 - 2.1.3.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible
 - 2.1.3.4 Plastic Duct for Concrete Encased Burial
 - 2.1.3.5 Plastic Conduit for Direct Burial
 - 2.1.3.6 Frangible Couplings and Adapters
 - 2.1.3.7 Low-Impact-Resistant Towers
 - 2.1.3.8 Semi-Frangible Supports

- 2.1.4 Wire and Cable
 - 2.1.4.1 Conductor Sizes
 - 2.1.4.2 Low Voltage Wire and Cable
 - 2.1.4.3 Power Cables for Airfield and Heliports
 - 2.1.4.4 Wire and Cable for Airfield and Heliports
 - 2.1.4.5 Cable Tags
 - 2.1.4.6 Concrete Markers for Direct Buried Cable Systems
- 2.1.5 Ground Rods
- 2.1.6 Lightning Arresters
- 2.1.7 Surge Protection
- 2.1.8 Cable Connectors and Splices
- 2.1.9 Transformers
 - 2.1.9.1 Encapsulated Isolation Transformers
 - 2.1.9.2 Power Transformers
- 2.1.10 Light Bases
- 2.1.11 Sealant for Fixtures and Wires in Drilled Holes or Saw Kerfs
- 2.1.12 Constant Current Regulator
- 2.1.13 Lamps and Filters
- 2.1.14 Sump Pumps for Manholes and Vaults
- 2.1.15 Circuit Breakers and High-Voltage Switches
- 2.1.16 Transformer, Substations and Switchgear
- 2.1.17 Emergency Generator and Automatic Transfer Switch System
- 2.1.18 Circuit Selector Cabinet
- 2.1.19 Pilot Relay Panel
- 2.1.20 Control Panel
- 2.1.21 Lighting Fixtures
- 2.1.22 Painting
- 2.2 AIRFIELD AND HELIPORT MARKINGS
- 2.3 BEACON
 - 2.3.1 Airfield Rotating Beacon
 - 2.3.2 Heliport Beacon
 - 2.3.3 Airfield Identification/Code Beacon
- 2.4 WIND DIRECTION INDICATOR
- 2.5 OBSTRUCTION LIGHTING AND MARKING
- 2.6 HIGH-INTENSITY APPROACH LIGHTING SYSTEMS
 - 2.6.1 Elevated High-Intensity Fixtures Except Flashing Units
 - 2.6.2 Sequence Flashing Lights (SFL) System
 - 2.6.3 Semiflush, High-Intensity Approach Lights
- 2.7 MEDIUM-INTENSITY APPROACH LIGHTING SYSTEMS
 - 2.7.1 Elevated, Medium-Intensity, Steady-Burning Fixtures
 - 2.7.2 Sequence Flashing Lights (SFL) for Medium Intensity Lights
- 2.8 RUNWAY ALIGNMENT INDICATOR LIGHTS (RAIL)
- 2.9 OMNIDIRECTIONAL APPROACH LIGHT SYSTEM (ODALS)
- 2.10 RUNWAY END IDENTIFIER LIGHTS (REIL)
- 2.11 RUNWAY LIGHTING SYSTEM
 - 2.11.1 Runway Edge Lights
 - 2.11.2 Runway Threshold and End Lights
 - 2.11.3 Runway Centerline Lights, Tailhook Operations
 - 2.11.4 Standard Duty Centerline Lights
 - 2.11.5 Runway Touchdown Zone Lights
 - 2.11.6 Runway Distance Markers
 - 2.11.7 Arresting Gear Markers
- 2.12 TAXIWAY LIGHTING SYSTEMS
 - 2.12.1 Taxiway Edge Lights
 - 2.12.2 Taxiway Centerline Lights
 - 2.12.3 Taxiway Guidance Signs
 - 2.12.4 Hold Position Lights and Signs
- 2.13 HELIPAD LIGHTING SYSTEMS
 - 2.13.1 General

- 2.13.2 Hoverlane Lights
- 2.14 EXPLOSION-PROOF FIXTURES FOR HAZARDOUS LOCATIONS
- 2.15 GLIDE SLOPE INDICATOR
 - 2.15.1 PAPI
 - 2.15.2 CHAPI
- 2.16 LIMIT LIGHTS
- 2.17 OTHER LIGHTING SYSTEMS AND VISUAL AIDS
- 2.18 HELIPAD LIGHTING SYSTEMS
- 2.19 FACTORY COATINGS

PART 3 EXECUTION

- 3.1 GENERAL INSTALLATION REQUIREMENTS
- 3.2 CABLES, GENERAL REQUIREMENTS
 - 3.2.1 Duct Line Installation
 - 3.2.2 Direct-Burial Installation
 - 3.2.2.1 Trenching
 - 3.2.2.2 Cable Installation
 - 3.2.2.3 Other Requirements
 - 3.2.2.4 Medium-Voltage Cable Joints or Low-Voltage Cable Splices
 - 3.2.2.5 Surface Markers
 - 3.2.3 Connection to Buildings
- 3.3 MEDIUM-VOLTAGE CABLES
 - 3.3.1 Cable Joints
 - 3.3.1.1 Types
 - 3.3.1.2 Requirements
 - 3.3.2 Terminations
 - 3.3.2.1 Factory Preformed Type
 - 3.3.2.2 Taped Terminations
- 3.4 LOW-VOLTAGE CABLES
- 3.5 DUCT LINES
 - 3.5.1 Requirements
 - 3.5.2 Treatment
 - 3.5.3 Concrete Encasement
 - 3.5.4 Non-encased Direct-Burial
 - 3.5.5 Installation of Couplings
 - 3.5.5.1 Asbestos-Cement and Bituminized-Fiber Ducts
 - 3.5.5.2 Plastic Duct
- 3.6 MANHOLES AND HANDHOLES
- 3.7 WELDING
- 3.8 CABLE MARKERS
- 3.9 FRANGIBLE REQUIREMENTS
- 3.10 ELEVATED AIRFIELD AND HELIPORT LIGHTS
- 3.11 SEMIFLUSH AIRFIELD AND HELIPORT LIGHTS
- 3.12 WIRES, FIXTURES, AND ENCLOSURES IN SAW KERFS AND DRILLED HOLES
 - 3.12.1 Holes for Light Fixtures
 - 3.12.2 Holes for Transformer Enclosures
 - 3.12.3 Saw Kerfs and Splice Chambers
 - 3.12.4 Sandblasting
 - 3.12.5 Cleaning
 - 3.12.6 Lighting Fixture Installation
 - 3.12.7 Installation of Circuit Wires in Pavement
- 3.13 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE
 - 3.13.1 Connectors
 - 3.13.2 Splicing Fixtures to the Wires in Pavement Saw Kerfs
- 3.14 GROUNDING SYSTEMS
 - 3.14.1 Counterpoise Installation
 - 3.14.2 Fixture Grounding
- 3.15 MARKING AND LIGHTING OF AIRWAY OBSTRUCTIONS

- 3.15.1 Painting of Airway Obstructions
- 3.15.2 Obstruction Marker Lights
- 3.16 AIRFIELD ROTATING LIGHT BEACON
 - 3.16.1 Beam Adjustment
 - 3.16.2 Power Supply and Wiring
- 3.17 HELIPORT LIGHT BEACON
 - 3.17.1 Beam Adjustment
 - 3.17.2 Power Supply and Wiring
- 3.18 WIND DIRECTION INDICATORS
- 3.19 ISOLATION TRANSFORMERS
- 3.20 RUNWAY AND TAXIWAY LIGHTING SYSTEMS
 - 3.20.1 Runway and Taxiway Edge Lights
 - 3.20.2 Runway and Taxiway Centerline Lights
 - 3.20.3 Touchdown Zone Lighting Installation
- 3.21 APPROACH LIGHTING SYSTEMS
 - 3.21.1 Frangible Requirements
 - 3.21.2 Alignment of Lights
- 3.22 FIELD QUALITY CONTROL
 - 3.22.1 Operating Test
 - 3.22.2 Distribution Conductors, 600-Volt Class
 - 3.22.3 Counterpoise System Test and Inspection
 - 3.22.4 Progress Testing for Series Lighting Circuits
 - 3.22.5 Electrical Acceptance Tests
 - 3.22.5.1 Low-Voltage Continuity Tests
 - 3.22.5.2 High-Voltage Insulation Resistance Tests
 - 3.22.6 Constant Current Regulators
 - 3.22.7 Regulator Electrical Tests
 - 3.22.8 Final Operating Tests
- 3.23 FINISHING
- 3.24 POSTED INSTRUCTIONS
- 3.25 TRAINING

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-26 56 20.00 10 (April 2006)

Preparing Activity: USACE Replacing without change
UFGS-16526A (December 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 18 July 2006

Latest change indicated by CHG tags

SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS 04/06

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

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

NOTE: If the 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 [airfield] [heliport] [helipad] lighting systems shall 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 shall be assembled to permit completing the work within the scheduled time interval. Under no circumstances shall any of the existing airfield or heliport 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 shall be restored in such a manner that they will be operational at dusk each day. The Contractor shall submit a 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 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.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C119.1

(2002) Sealed Insulated Underground Connector Systems Rated 600 Volts

ANSI C57.12.50

(1981; R 1998) Sealed Dry-Type Distribution Transformers 1 to 500 kVA, Single-Phase; and 15 to 500 kVA, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8 (2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 780 (2001) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings

ASTM B 117 (2002) Operating Salt Spray (Fog) Apparatus

ASTM D 1248 (2005) Polyethylene Plastics Extrusion Materials for Wire and Cable

ASTM D 1654 (1992; R 2000) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

ASTM D 709 (2001) Laminated Thermosetting Materials

FM GLOBAL (FM)

FM P7825a (2005) Approval Guide Fire Protection

FM P7825b (2005) Approval Guide Electrical Equipment

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2 (2005) National Electrical Safety Code

IEEE C62.11 (1999) Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1KV)

IEEE C62.41 (1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

IEEE Std 48 (1996; R 2003) Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 1 (2002) Molded-Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures

NEMA ICS 2 (1996; R 2004) Standard for Industrial Control and Systems: Controllers,

Contractors, and Overload Relays Rated Not
More than 2000 Volts AC or 750 Volts DC:
Part 8 - Disconnect Devices for Use in
Industrial Control Equipment

NEMA ICS 6 (1993; R 2001) Industrial Control and
Systems: Enclosures

NEMA LA 1 (1992; R 1999) Surge Arresters

NEMA PB 1 (2000) Panelboards

NEMA RN 1 (2005) Polyvinyl Chloride (PVC) Externally
Coated Galvanized Rigid Steel Conduit and
Intermediate Metal Conduit

NEMA TC 2 (2003) Electrical Polyvinyl Chloride (PVC)
Tubing and Conduit

NEMA TC 3 (2004) Polyvinyl Chloride PVC Fittings for
Use with Rigid PVC Conduit and Tubing

NEMA TC 6 & 8 (2003) Polyvinyl Chloride PVC Plastic
Utilities Duct for Underground
Installations

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005) National Electrical Code

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20 (2002; R 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 AC 150/5345-10 (Rev E) Constant Current Regulators
Regulator Monitors

FAA AC 150/5345-12 (Rev C) Airport and Heliport Beacon

FAA AC 150/5345-13 (Rev A) L-841 Auxiliary Relay Cabinet
Assembly for Pilot Control of Airport
Lighting Circuits

FAA AC 150/5345-26 (Rev C) L-823 Plug and Receptacle, Cable
Connectors

FAA AC 150/5345-27 (Rev C) Wind Cone Assemblies

FAA AC 150/5345-28 (Rev D; Change 1) Precision Approach Path
Indicator (PAPI) Systems

FAA AC 150/5345-3	(Rev E) L-821 Panels for Control to Airport Lighting
FAA AC 150/5345-42	(Rev C; change 1) Airport Light Bases, Transformer Houses, Junction Boxes and Accessories
FAA AC 150/5345-43	(Rev E) Obstruction Lighting Equipment
FAA AC 150/5345-44	(Rev F; Change 1) Taxiway and Runway Signs
FAA AC 150/5345-45	(Rev A) Lightweight Approach Light Structure
FAA AC 150/5345-46	(Rev B) Runway and Taxiway Light Fixtures
FAA AC 150/5345-47	(Rev A) Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-5	(Rev A) Circuit Selector Switch
FAA AC 150/5345-51	(Basic; Change 1) Discharge-Type Flasher Equipment
FAA AC 150/5345-7	(Rev E) L-824 Underground Electrical Cable for Airport Lighting Circuits
FAA AC 150/5370-10	(Rev A; Changes 1-13) Specifying Construction of Airports
FAA AC 70/7460-1	(Rev K; Change 1) Obstruction Marking and Lighting
FAA DWG C-6046	(1978) Frangible Coupling Type 1 and Type 1A, Details
FAA E-2159	(Rev D; Am 1) Runway End Identifier Lighting System (REIL) with Remote Monitoring Subsystem
FAA E-2325	(Rev D) Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR)
FAA E-2628	(Rev B) Sequenced Flashing Lighting System, Elevated and Semiflush with Dimming and Monitoring
FAA E-2702	(Rev A) Low Impact Resistant Structures
FAA E-2756	(Rev A) Four-Box Precision Approach Path Indicator
FAA E-982	(Rev H; Notice 1) PAR-56 Lampholder

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005) Flexible Metal Conduit
------	-------------------------------

UL 1242	(2000; Rev thru May 2003) Electrical Intermediate Metal Conduit -- Steel
UL 360	(2003) Liquid-Tight Flexible Steel Conduits
UL 44	(2005) Thermoset-Insulated Wires and Cables
UL 486A-486B	(2003; Rev thru Apr 2004) Wire Connectors
UL 489	(2002; Rev thru May 2003) Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 510	(2005) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 514A	(2004) Metallic Outlet Boxes
UL 6	(2000; Rev thru May 2003) Rigid Metal Conduit
UL 797	(2004) Electrical Metallic Tubing -- Steel
UL 83	(2003; Rev thru Mar 2004) Thermoplastic-Insulated Wires and Cables
UL 854	(2004) Service-Entrance Cables
UL Elec Const Dir	(2003) 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. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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.

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.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting and Visual Navigation Aids

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.

As-Built Drawings

Drawings, as specified.

SD-03 Product Data

Materials and Equipment

1) 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.

2) 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 shall be included.

Protection Plan

Protection plan as specified.

Training

Requirements of training shall be provided [_____] weeks before training is scheduled to begin.

Special Tools

List of special tools and test equipment required for maintenance and testing of the products supplied by the Contractor.

List of Parts

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.

Maintenance and Repair

Instructions necessary to check out, troubleshoot, repair, and replace components of the systems, as specified.

Posted Instructions[; G][; G, [_____]]

Proposed diagrams, instructions, and other sheets shall be submitted prior to posting.

SD-06 Test Reports

Field Quality Control

a. 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.

b. 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.

Visual Inspection

Inspection reports shall be prepared and provided 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.

SD-07 Certificates

Qualifications

Certified documentation of qualifications, as specified.

Materials and Equipment

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, proof that the items furnished under this section of the specifications conform to the specified requirements shall be included. The label or listing in [UL Elec Const Dir](#) or in

FM P7825a, FM P7825b 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.

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures

[Six] [_____] copies of operation and [six] [_____] copies of maintenance manuals 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. Maintenance manuals shall list 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.

1.3 SYSTEM DESCRIPTION

The airfield and heliport lighting and visual navigation aids shall consist 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, and [_____].

1.4 GENERAL REQUIREMENTS

Items of the same classification shall be identical including equipment, assemblies, parts, and components.

1.4.1 Code Compliance

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

1.4.2 Standard Product

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.4.3 Prevention of Corrosion

1.4.3.1 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, fittings conforming to [UL 486A-486B](#) shall be used.

1.4.3.2 Ferrous Metal Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with [ASTM A 123/A 123M](#) and [ASTM A 153/A 153M](#).

1.4.3.3 Luminaires Fabricated from Ferrous Metals

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.

1.4.4 Unusual Service Conditions

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

1.4.4.1 Altitude

Any equipment shall be suitable for operation up to an altitude of [\[3,000 m 10,000 ft\]](#) [\[_____\]](#).

1.4.4.2 Other

Material or equipment to be installed [\[underground\]](#); [\[in handholes, manholes, or underground vaults\]](#); [\[or\]](#) [\[in light bases\]](#), [\[_____\]](#) shall be suitable for submerged operation.

1.4.5 Verification of Dimensions

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.4.6 [As-Built Drawings](#)

The Contractor shall 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, shall be provided 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.

1.4.7 [Protection Plan](#)

The Contractor shall 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.

1.4.8 [Qualifications](#)

- a. The Contractor shall 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, the Contractor shall 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. The Contractor shall submit [_____] copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators prior to welding operations.

PART 2 PRODUCTS

2.1 MATERIALS

Equipment and materials shall be new unless indicated or specified otherwise. **Materials and equipment** shall be labelled 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.

2.1.1 Electrical Tape

Electrical tape shall be **UL 510** plastic insulating tape.

2.1.2 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 D 709** 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 provided as indicated. Nameplates shall be fastened to the device with a minimum of two sheet metal screws or two rivets.

2.1.3 Conduit, Conduit Fittings, and Boxes

2.1.3.1 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](#).

2.1.3.2 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.

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

These outlet boxes shall be [UL 514A](#), cast metal with gasket closures.

2.1.3.4 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 70 02.00 10](#), ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.]

2.1.3.5 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 70 02.00 10](#), ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.]

2.1.3.6 Frangible Couplings and Adapters

These frangible couplings shall be in accordance with [FAA DWG C-6046](#). Upper section of frangible coupling shall be provided 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.

2.1.3.7 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.

2.1.3.8 Semi-Frangible Supports

Lights supported more than [12 m 40 feet](#) above the ground shall have a two-element structure, the lower element being a rigid structure and the

upper element being a 6.1 m 20 foot LIR structure in accordance with
FAA E-2702.

2.1.4 Wire and Cable

Conductors shall be copper except as otherwise indicated.

2.1.4.1 Conductor Sizes

NOTE: Refer to Article 310-5 of NFPA 70 for minimum conductor sizes. Require insulation thickness for 28 kV and 35 kV cables to be in accordance with AEIC specifications since NEMA specifications do not give an insulation thickness for the 133 percent level. When specifying 28 and 35 kV cables, add the requirements for not exceeding IEEE STD since this requirements is necessary as indicated by reference to the normal industry test values give in the table below.

15 MINUTE DRY WITHSTAND DC TEST VOLTAGES (kV)

Cable, Rates Voltage	133 Percent Insulation		Terminations	Joints on Extruded Dielectric Cable
Phase to Phase	NEMA WC 7 WC 8	AEIC CS5 CS8	IEEE Std 48	IEEE STD 404
2.5	25	--	40	--
5.0	25	--	50	25
8.7	35	--	65	35
15	65	--	75	55
25	100	--	105	75
28	--	125	115	85
34.5	--	155	140	100

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

2.1.4.2 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.

[UL 854, Type USE, 600 volts shall be used for underground low voltage power cables.] [UL 83, Type [_____] [THW] [THWN]] [UL 44, Type [XHHW] [_____] shall be used for secondary series lighting circuits to be installed in pavement.]

2.1.4.3 Power Cables for Airfield and Heliports

Power cables shall be rated [5] [_____] kV, [133 percent] [_____] insulation level, with shield and jacket conforming to [_____] for [[crosslinked polyethylene] [or] [_____] for ethylene-propylene rubber] insulated cables.

2.1.4.4 Wire and Cable for Airfield and Heliports

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. Airfield and heliport lighting cable shall be FAA AC 150/5345-7, Type L-824 for [crosslinked polyethylene Type C] [Type B] [600] [5000]-volt cable. Series airfield and heliport 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 [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] [[_____] for crosslinked polyethylene insulation] [or] [[_____] 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] [_____]].

2.1.4.5 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.

2.1.4.6 Concrete Markers for Direct Buried Cable Systems

Concrete markers shall be as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

2.1.5 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 not more than 3.048 m 10 feet long, unless indicated otherwise.

2.1.6 Lightning Arresters

These lightning arresters shall be in accordance with IEEE C62.11 and IEEE C62.41 as applicable with ratings as indicated.

2.1.7 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.

2.1.8 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.

2.1.9 Transformers

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

2.1.9.1 Encapsulated Isolation Transformers

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

2.1.9.2 Power Transformers

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

2.1.10 Light Bases

NOTE: Use FAA AC 150/5345-42 Type L-867 bases for applications not subject to aircraft or vehicle loading. Use Type L-868 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.

2.1.11 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.

2.1.12 Constant Current Regulator

The regulator shall be FAA AC 150/5345-10, [Type L-828, without monitoring] [Type L-829 with monitoring] 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] [_____] brightness steps shall be provided. [Monitors shall be provided as indicated.]

2.1.13 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.

2.1.14 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] [_____] [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 shown.

2.1.15 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 NEMA AB 1 type or approved by UL 489. Switchgear for use in manholes and underground vaults shall be subway type. Cutouts shall be rated 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.

2.1.16 Transformer, Substations and Switchgear

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

2.1.17 Emergency Generator and Automatic Transfer Switch System

NOTE: UFGS 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 airfield or heliport installation. Airfield or heliport 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 airfield or heliport 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 airfields. Time delay to override momentary normal source outages to delay all transfer switch and engine starting signals shall be set at three seconds.

The automatic transfer switch shall be in accordance with Section [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.

2.1.18 Circuit Selector Cabinet

NOTE: Circuit selector cabinets were previously referred to as distribution boxes and may be provided to select one of two circuits 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].

2.1.19 Pilot Relay Panel

NOTE: Type I pilot relay panel has 24 double-pole, single-throw relays and is used for systems including the approach lighting systems. Specify a Type II relay panel if 16 double-pole, single-throw relays and 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, and NEMA PB 1 for 120-volt control systems; and FAA AC 150/5345-13, Type L-841, for 48-V dc control systems.

2.1.20 Control Panel

NOTE: Refer to FAA AC 150/5345-3 for type, class, and style.

The panel 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.

2.1.21 Lighting Fixtures

NOTE: The airfield and heliport lighting systems and other visual aids equipment, including the fixtures and auxiliary equipment needed to make the visual aids operational should be specified in the drawings or other specification requirements. Select only items applicable to the installation of the contract.

See Army Standard Detail No. 40-06-05 for the lighting fixtures for specific airfield and heliport

lighting applications.

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

2.1.22 Painting

As specified in [Section 09 90 00 PAINTS AND COATINGS] [and] [Section 32 17 24.00 10, PAVEMENT MARKINGS].

2.2 AIRFIELD AND HELIPORT MARKINGS

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

2.3 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.

2.3.1 Airfield Rotating Beacon

NOTE: For operation down to minus 30 degrees C (-22 degrees F), a Class 1 beacon shall be provided. For operation down to minus 50 degrees C (-58 degrees F), specify a Class 2 beacon with a low temperature heater package.

The rotating beacon for fixed wing aircraft shall be FAA AC 150/5345-12, Type L-802A, Class [1] [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 [3R] [_____] enclosure of zinc-coated steel.

2.3.2 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] [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.

2.3.3 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.

2.4 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 to 2438 mm 1 to 8 feet] [609 to 3658 mm 2 to 12 feet]. The wind cones shall be of the size and color as shown on the contract drawings.

2.5 OBSTRUCTION LIGHTING AND MARKING

Obstructions on or near the [airfield] [heliport] 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]. 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 in the contract drawings. The obstruction lights shall be energized from [multiple] [series] [series or multiple] circuits as shown on the contract drawings or other contract documents.

2.6 HIGH-INTENSITY APPROACH LIGHTING SYSTEMS

NOTE: High-intensity approach systems may be either ALSF-2 or SALS lights. The system may include centerline barrette lights, crossbar lights, sequence flashing lights, side row barrettes, threshold lights, frangible supports, and associated equipment and circuits as shown on the contract drawings.

These lights shall be as shown on the contract drawings.

2.6.1 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] [with aviation red] [and/or] [with 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.

2.6.2 Sequence Flashing Lights (SFL) System

The SFL system shall be [**FAA E-2159**] [and/or] [**FAA AC 150/5345-51**, Type L-849] [**FAA E-2628**] lights provided as an integrated part of the approach system. The SFL system shall include the [21] [_____] elevated 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.

2.6.3 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] [Type L-850E for unidirectional] lights with lamps and filters as shown.

2.7 MEDIUM-INTENSITY APPROACH LIGHTING SYSTEMS

NOTE: Medium-intensity approach lighting systems may be either MALSR, MALSF, or MALS lights. The system may include centerline barrettes, crossbar lights, SFL, frangible supports and associated equipment and circuits as shown.

The medium-intensity approach lights shall be as shown on the contract drawings.

2.7.1 Elevated, Medium-Intensity, Steady-Burning Fixtures

The medium-intensity, elevated, steady-burning approach lights, shall be **FAA E-2325** PAR 38 lampholders with [150 watt] [_____] PAR-38 spotlight lamps frangibly mounted on [light bases] [steel stakes] [and/or] [low-impact-resistant supports] [frangible supports].

2.7.2 Sequence Flashing Lights (SFL) for Medium Intensity Lights

These elevated SFL fixtures (RAIL) shall meet the requirements of [**FAA E-2159**] [**FAA AC 150/5345-51**, Type L-849] with [eight] [_____] 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.

2.8 RUNWAY ALIGNMENT INDICATOR LIGHTS (RAIL)

The RAIL fixtures shall meet the requirements of [**FAA E-2159**] [**FAA AC 150/5345-51**, Type L-849] with [eight] [_____] lights and shall include the individual power supplies the master timer and power supply, remote control, [support structures,] and interconnecting wiring.

2.9 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 [7] [_____] 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.

2.10 RUNWAY END IDENTIFIER LIGHTS (REIL)

The REIL fixtures shall meet the requirements of **FAA AC 150/5345-51**, Type L-849, Style [A], [B] [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.

2.11 RUNWAY LIGHTING SYSTEM

NOTE: Use FAA fixtures where appropriate. Fixtures in a unique airfield lighting system shall be of a similar type. Do not mix military and FAA fixture types in unique systems.

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 22,680 kg 50,000 pounds.

2.11.1 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.

2.11.2 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 on the contract drawings].

2.11.3 Runway Centerline Lights, Tailhook Operations

NOTE: The fixtures are a sole-source item developed on a Navy contract and available only from Crouse Hinds Company, Cooper Industries. The fixtures are identified as FAA AC 150/5345-46 Type L-852 Class N (Navy) which are a stainless steel top conforming to Rockwell hardness of C 40 to resist damage from aircraft tailhooks.

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 12.7 mm 1/2 inch above pavement in lieu of 9.5 mm 3/8 inch. Optical assembly shall be secured with [410] [or] [416] stainless steel bolts.

2.11.4 Standard Duty Centerline Lights

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

2.11.5 Runway Touchdown Zone Lights

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

2.11.6 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 1.9 kPa 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] [Class 2] [as indicated] [as recommended by the sign manufacturer].

2.11.7 Arresting Gear Markers

The arresting gear markers shall be the same as Runway Distance Markers, except markers shall have a 990.6 mm 3.25 foot translucent yellow circle in place of numerals as specified above.

2.12 TAXIWAY LIGHTING SYSTEMS

NOTE: Use FAA fixtures where appropriate. Fixtures
in a unique taxiway lighting system shall be of a
similar type. Do not mix military and FAA fixture
types in unique 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.

2.12.1 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,] [Type L-852E, semiflush,] lights.

2.12.2 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]

[Type L-852B on curved sections].

2.12.3 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]. The size and information on the signs shall be as shown on contract drawings. The power supply to connect to [series] [multiple] circuits shall be as [indicated on the contract drawings] [approved by the manufacturer].

2.12.4 Hold Position Lights and Signs

The hold positions shall be marked by painted lines [and] [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 on the contract drawings.]

2.13 HELIPAD LIGHTING SYSTEMS

2.13.1 General

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

2.13.2 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] [light bases]. 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] [L-857] light bases. The hoverlane lights shall be energized from a [6.6 ampere series circuit through isolation transformers] [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.

2.14 EXPLOSION-PROOF FIXTURES FOR HAZARDOUS LOCATIONS

NOTE: Only fixtures that are listed by U.L. or an equivalent lab shall be used in explosion-hazardous locations. The listing must reflect the installed configuration. The lights referenced in Standard Detail No. 40-06-05 have not been approved for the purpose.

Fixtures to be installed in explosive hazardous locations shall meet the requirements of and be listed by [UL Elec Const Dir](#) or [FM P7825a](#), [FM P7825b](#) 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.

2.15 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 on the contract drawings.

2.15.1 PAPI

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

2.15.2 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.

2.16 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] [light bases if in paved areas].

2.17 OTHER LIGHTING SYSTEMS AND VISUAL AIDS

NOTE: The designer will rename this paragraph as appropriate for a specific project or delete if not required. Air Force Regulation AFR 88-14 will be used to specify lighting systems and visual aids for which there are no Army or FAA standards.

2.18 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.

2.19 FACTORY COATINGS

NOTE: A 200-hour test should 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 finish shall be provided with corrosion-resistant finishes which shall withstand [200] [500] hours of exposure to the salt spray test specified in ASTM B 117 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 D 1654 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 A 780.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Circuits installed underground shall conform to the requirements of Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND, 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 31 00.00 10 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.2 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.

3.2.1 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 [6] [] inches above the uppermost duct containing electrical cable. Electrical metallic tubing shall not be installed underground or enclosed in concrete.

3.2.2 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,] [[950] [900] mm [30] [36] inches for 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 but not less than the depth of the frost line.

3.2.2.1 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.

3.2.2.2 Cable Installation

NOTE: Where a buried cable warning is necessary, the requirement for a type of 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.]

3.2.2.3 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.

3.2.2.4 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.

3.2.2.5 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.

3.2.3 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.

3.3 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. 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 [100] [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.

3.3.1 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.

3.3.1.1 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. 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.

3.3.1.2 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.

3.3.2 Terminations

Terminations shall be IEEE Std 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.

3.3.2.1 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 318 mm (12-1/2 inches) for cable rated 5 kV, 508 mm (20 inches) for cable rated 15 kV, 635 mm (25 inches) for cable rated 25 kV, and 889 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 meters (46 inches) for 28 kV or 35 kV cables.

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 Std 48 for the next higher BIL level.

3.3.2.2 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.

3.4 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.

3.5 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.]

3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of [100 mm per 30 m](#) [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 [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 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 [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.

3.5.2 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 shall have diameters 6.2 mm 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.

3.5.3 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.

3.5.4 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 but in the earth and shall be installed with a minimum of 77 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.

3.5.5 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.

3.5.5.1 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 -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.

3.5.5.2 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.

3.6 MANHOLES AND HANDHOLES

NOTE: When preparing Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND for a project specification, the designer will edit the guide specification as necessary to suit the specific airfield or heliport installation. Note that airfield type manholes, vaults, handholes, and their associated frames and covers require a design for a maximum single wheel load of 22,680 kg (50,000 pounds) or dual wheel load of 40,820 kg (90,000 pounds). Use steel conforming to ASTM A 36/A 36M, for covers to airfield manholes, vaults, and handholes. Use ductile iron for frames conforming to ASTM A 536, grade 65-45-12.

The manholes and handholes shall be as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

3.7 WELDING

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

3.8 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. 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.

3.9 FRANGIBLE REQUIREMENTS

Frangible supports, couplings, and adapters shall be installed as indicated or specified. At the 300 m 1000 foot cross bar and beyond, approach lights shall be mounted up to 1.8 m 6 feet above concrete foundation on threaded frangible couplings and 53 mm 2 inch electrical metallic tubing (EMT). For mounting heights greater than 1.8 m 6 feet, approach lights shall be mounted on low-impact resistant frangible towers as indicated.

3.10 ELEVATED AIRFIELD AND HELIPORT LIGHTS

Elevated lights shall be frangibly mounted, not to exceed 350 mm 14 inches in height except where higher mounting is permitted in snow accumulation areas. Equipment exceeding 350 mm 14 inches in height shall be frangibly mounted as indicated.

3.11 SEMIFLUSH AIRFIELD AND HELIPORT 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 the concrete, adhesive, or sealant can provide permanent support.

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

3.12.1 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 25 mm 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.

3.12.2 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.

3.12.3 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 600 mm 2 feet each side of the joint.

3.12.4 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 621 kPa 90 psi.

3.12.5 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.

3.12.6 Lighting Fixture Installation

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

3.12.7 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 600 mm 24 inch length of flexible tubing of polyethylene material conforming to ASTM D 1248, 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.

3.13 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE

3.13.1 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.

3.13.2 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.

3.14 GROUNDING SYSTEMS

NOTE: The preferred method of grounding is to have grounding circuits 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. In areas with low thunderstorm frequency and good ground conductance, the counterpoise ground rods may be spaced up to 600 meters (2000 feet) apart but other areas may require grounding at less than 300 meters (1000 feet) separation.

3.14.1 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 150 mm 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 [600] [] m [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.

3.14.2 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.

3.15 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 information on 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 in or required otherwise.

3.15.1 Painting of Airway Obstructions

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

3.15.2 Obstruction Marker Lights

Obstruction marker lights shall be installed on radio towers, elevated water tanks, smokestacks, buildings, and similar structures with **25 mm 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.

3.16 AIRFIELD ROTATING LIGHT BEACON

NOTE: Provide foundation and supports drawings for the beacon.

Beacon shall be installed in accordance with the manufacturer's instructions and other contract requirements and shall include cleaning, lubrication, adjustment, and other special instructions. Foundations and supports shall be provided as indicated.

3.16.1 Beam Adjustment

Beam shall be adjusted during hours of darkness. Beam shall be aimed to provide a minimum of 5.5 degrees above the horizontal, but not higher than necessary to clear principal obstructions.

3.16.2 Power Supply and Wiring

Panelboard shall be installed 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. Conduit riser shall be installed on tower in a corner angle and not near ladder.

3.17 HELIPORT LIGHT BEACON

NOTE: Provide foundation and support drawings for the beacon.

Beacon shall be installed in accordance with the manufacturer's instructions and other contract requirements and shall include cleaning, lubrication, and adjustment. Foundations and supports shall be provided as indicated.

3.17.1 Beam Adjustment

Beam shall be adjusted during hours of darkness. Beam shall be aimed to provide 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

Panelboard shall be installed 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. Conduit riser shall be installed 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.

3.18 WIND DIRECTION INDICATORS

Installation shall include a black circle constructed on the ground with center at center of the base. Circle shall be constructed using 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 wind cone illumination lights and obstruction lights shall be energized from [multiple] [series] [series or multiple] circuits as shown by the contract drawings or as required otherwise.

3.19 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.

3.20 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

3.20.1 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] [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.

3.20.2 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.

3.20.3 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.

3.21 APPROACH LIGHTING SYSTEMS

Approach lighting system shall be installed as indicated or as required otherwise. Nameplates shall be provided for equipment, controls, devices, and for each lighting circuit.

3.21.1 Frangible Requirements

At the 300 meter 1,000 foot crossbar and beyond, overrun lights shall be mounted up to 1.8 m 6 feet above concrete foundations on threaded frangible couplings and 53 mm 2 inch rigid steel conduit. For mounting heights greater than 1.8 m 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 6 m 20 feet above the rigid structure with this support unit being frangible.

3.21.2 Alignment of Lights

The approach lights shall be aligned 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 150 m 500 foot interval into the approach area from the threshold. The tolerance for vertical aiming is plus or minus 0.5 degree.

3.22 FIELD QUALITY CONTROL

The Contracting Officer shall be notified [five] [_____] working days prior to [each] [_____] test. Deficiencies found shall be corrected and tests repeated.

3.22.1 Operating Test

Each completed circuit installation shall be tested for operation. Equipment shall be demonstrated to operate in accordance with the requirements of this Section. [[One] [_____] day and [one] [_____] night test shall be conducted for the Contracting Officer.]

3.22.2 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.

3.22.3 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.

3.22.4 Progress Testing for Series Lighting Circuits

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

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.

3.22.5 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.

3.22.5.1 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.

3.22.5.2 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.

- a. 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 **300 mm 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.

Series	Test Voltage, dc	
	First Test on New Circuits	Test on Existing Circuits
Lighting 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	600

When additions are made to existing circuits, only new sections shall be tested in accordance with "First Test on New Circuits" in table above. To ensure reliable operation, complete circuit shall be tested at reduced voltages indicated above.

- b. 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:

- (1) Three microamperes for each 300 m 1000 feet of cable.
- (2) Two microamperes for each 200 watt and each 500 watt 5,000-volt series transformer.
- (3) Two microamperes for each 30/45-Watt 5,000 volt series transformer.

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.

3.22.6 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.

3.22.7 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.

3.22.8 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.

3.23 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.

3.24 POSTED INSTRUCTIONS

The Contractor shall 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.

3.25 TRAINING

The Contractor shall provide training on the proper operation and maintenance procedures for the system. The Contractor shall 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.

-- End of Section --