
USACE / NAVFAC / AFCEC / NASA UFGS-26 56 00 (May 2013)

Preparing Activity: NAVFAC Superseding
UFGS-26 56 00 (July 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2017

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EXTERIOR LIGHTING

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NOTE: This guide specification covers lighting system requirements for exterior installations.

This specification does not cover all possible methods or requirements for exterior lighting; therefore, designer should add special information required to suit a specific project. Industry publications exist to aid the designer in choosing the best lighting system for the project. Publications include, but are not limited to, the Illuminating Engineering Society (IES) HB-10, LIGHTING HANDBOOK and RP-8, RECOMMENDED PRACTICE FOR ROADWAY LIGHTING.

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

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

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

NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to <http://www.wbdg.org/FFC/NAVGRAPH/graphtoc.pdf>

NOTE: This section contains the following sketches (plates) and are available in metric (SI) and U.S. Customary (IP) system dimensions. Sketch titles and

style numbers are unchanged for both types.

Do not include list of sketches, or sketches themselves, in project specifications. Use luminaire sketches as details (plates) on drawings whenever possible. If special features are required, do not modify sketches, but indicate these changes as notes in luminaire schedule. The "XL" style numbers and dates should remain on the drawing details. If additional luminaire types are needed that are not covered in sketches, provide additional sketches or details on drawings, but do not label as XL sketch type.

<u>Sketch No.</u>	<u>Title</u>
XL-1	LED Roadway Luminaire
XL-2	HID/Induction Roadway Luminaire
XL-3	LED Area Luminaire
XL-4	HID Area Luminaire
XL-5	Induction Area Luminaire
XL-6	Low Pressure Sodium Area Luminaire
XL-7	HID High Mast Luminaire
XL-8	HID Apron/Large Sports Field Luminaire
XL-9	HID Sports Field Luminaire
XL-10	LED Pedestrian Post Top Luminaire
XL-11	HID/CFL/Induction Pedestrian Post Top Luminaire
XL-12	Decorative Bollard
XL-13	LED Parking Garage Luminaire
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XL-15	Exterior Recessed Downlight
XL-16	LED Linear Wall Wash
XL-17	LED Wall Pack
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<u>Sketch No.</u>	<u>Title</u>
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XL-24	Direct-Set Concrete Pole
XL-25	Direct-Set Steel/Aluminum Pole
XL-26	Anchor Base Fiberglass Pole
XL-27	Anchor Base Steel/Aluminum Pole
XL-28	Anchor Base Concrete Pole
XL-29	Anchor Base Pole Foundation
XL-30	Direct Set Pole Grounding Detail
XL-31	Luminaire Mounting Arm Details
XL-32	Luminaire Mounting Arm Details
XL-33	Luminaire Mounting Bracket Details
XL-34	Luminaire Mounting Bracket Details
NOTE: Do not include this index in project specification.	

NOTE: The following information shall be shown on the project drawings or specified in the project specifications:

- a. Luminaire schedule indicating luminaire type, mounting, and light source type and quantity;
- b. Accessories required, such as photocell, mounting brackets or arms and pole type;
- c. Wattage, operating voltage and frequency;
- d. Location and mounting height of poles or standards;
- e. Referenced XL sketch or detail;

f. NEMA distribution type and BUG rating when applicable; and

g. Extent and location of the work to be accomplished with wiring and equipment necessary for a complete installation.

NOTE: Demolition work that involves disposal of fluorescent and HID light sources and ballasts will require the use of Section 02 84 16 HANDLING OF LIGHTING BALLASTS AND LAMPS CONTAINING PCBs AND MERCURY.

PART 1 GENERAL

1.1 REFERENCES

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

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

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

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

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1 (2008) Wood Poles -- Specifications & Dimensions

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO LTS (2013; Errata 2013) Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING
ENGINEERS (ASHRAE)

ASHRAE 189.1	(2014) Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - IP	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 90.1 - SI	(2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA U1	(2017) Use Category System: User Specification for Treated Wood
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ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2015) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B108/B108M	(2015) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1089	(2013) Standard Specification for Spun Cast Prestressed Concrete Poles
ASTM G154	(2016) Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings
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ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011; Errata 2015) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2015) Measuring Lumen Maintenance of LED Light Sources
IES RP-16	(2010; Addendum A 2008; Addenda B 2009;

Addendum C 2016) Nomenclature and
Definitions for Illuminating Engineering

IES RP-8	(2014) Roadway Lighting
IES TM-15	(2011) Luminaire Classification System for Outdoor Luminaires
IES TM-21	(2011; Addendum B 2015) Projecting Long Term Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2017; Errata 1-2 2017; INT 1 2017) National Electrical Safety Code
IEEE C62.41	(1991; R 1995) Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.41	(2016) Electric Lamps--Guidelines for Low-Pressure Sodium Lamps
ANSI ANSLG C78.42	(2009; R 2016) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C136.13	(2004; R 2009) American National Standard for Roadway Lighting Equipment, Metal Brackets for Wood Poles
ANSI C136.21	(2014) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
ANSI C136.3	(2014) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
ANSI C82.4	(2017) Lamp Ballasts - Ballasts for High- Intensity-Discharge and Low-Pressure Sodium Lamps

ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
ANSI/NEMA C78.LL 1256	(2003; R 2015) Procedures for Fluorescent Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure (TCLP)
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2017) Electric Lamps- Specifications for the Chromaticity of Solid State Lighting Products
NEMA ANSLG C78.380	(2007) Electric Lamps - High Intensity Discharge Lamps, Method of Designation
NEMA ANSLG C78.44	(2008) For Electric Lamps - Double-Ended Metal Halide Lamps
NEMA ANSLG C82.11	(2017) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
NEMA ANSLG C82.14	(2016) Lamp Ballasts Low-Frequency Square Wave Electronic Ballasts -- for Metal Halide Lamps
NEMA C136.10	(2010) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA C136.20	(2012) American National Standard for Roadway and Area Lighting Equipment - Fiber Reinforced Composite (FRC) Lighting Poles
NEMA C136.31	(2010) American National for Roadway and Area Lighting Equipment - Luminaire Vibration
NEMA C78.LL 3	(2003; R 2015) Electric Lamps - Procedures for High Intensity Discharge Lamp Sample Preparation and the Toxicity Characteristic Leaching Procedure
NEMA C82.77	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2016) Industrial Control and

Systems: Enclosures

NEMA IEC 60529 (2004) Degrees of Protection Provided by Enclosures (IP Code)

NEMA WD 7 (2011; R 2016) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2017; ERTA 1-2 2017; TIA 17-1; TIA 17-2; TIA 17-3) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1728F-700 (2011) Specification for Wood Poles, Stubs, and Anchor Logs

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

47 CFR 15 Radio Frequency Devices

47 CFR 18 (2011) Industrial, Scientific, and Medical Equipment

UNDERWRITERS LABORATORIES (UL)

UL 1029 (1994; Reprint May 2017) UL Standard for Safety High-Intensity-Discharge Lamp Ballasts

UL 1310 (2011; Reprint Dec 2014) UL Standard for Safety Class 2 Power Units

UL 1598 (2008; Reprint Oct 2012) Luminaires

UL 773 (1995; Reprint Jul 2015) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting

UL 773A (2016) Standard for Nonindustrial Photoelectric Switches for Lighting Control

UL 8750 (2015; Reprint Aug 2017) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

UL 916 (2007; Reprint Aug 2014) Standard for Energy Management Equipment

UL 935 (2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

NOTE: Select applicable tri-service, Army, Navy,
Air Force or NASA specification section reference(s).

Materials not considered to be luminaires or lighting equipment are specified in Section(s) [33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION] [33 71 01.00 40 OVERHEAD TRANSMISSION AND DISTRIBUTION] [33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION]. Luminaires and accessories installed in interior of buildings are specified in Section [26 51 00 INTERIOR LIGHTING] [26 51 00.00 40 INTERIOR LIGHTING].

1.3 DEFINITIONS

NOTE: Delete definitions that are not applicable to project.

- a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings shall be as defined in IEEE 100 and IES RP-16.
- [b. For HID, fluorescent, and induction luminaire light sources, "Average Rated Life" is the time after which 50 percent of a large group of light sources will have failed and 50 percent will have survived under normal operating conditions.]
- [c. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.]
- [d. The "Groundline Section" of wood poles is that portion of the pole between 305 mm one foot above, and 610 mm 2 feet below the groundline.]

1.4 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.

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

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Recommended codes for Army projects are "RE" for Resident Engineer approval, "ED" for Engineering approval, and "AE" for Architect-Engineer approval. Codes following the "G" typically are not used for

Navy projects.

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

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.

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

SD-01 Preconstruction Submittals

NOTE: Required for all area and roadway designs. Contractor shall provide calculations to verify luminaires and design layout meet required illumination and photometric values of the design. This requirement has been added as a quality assurance step. Absolute photometry of LED luminaires provided by IES LM-79 data should provide accurate values to assure contractor's luminaires meet the standards of the initial design.

Photometric Plan; G[, [____]]

LED Luminaire Warranty; G[, [____]]

SD-02 Shop Drawings

Luminaire drawings; G[, [____]]

Poles; G[, [____]]

SD-03 Product Data

[[HID,] [LPS,] [Fluorescent,] [Induction] [and LED] Luminaires; G[, [____]]]

Luminaire Light Sources; G[, [____]]

NOTE: Choose "Ballasts" for HID, LPS and fluorescent; "Generators" for induction; and "Power Supply Units (Drivers)" for LED applications.

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Luminaire[ Ballasts,][ Generators][ and][ Power Supply Units
(Drivers)]; G[, [____]]

Lighting contactor; G[, [____]]

Time switch; G[, [____]]

Lighting Control Relay Panel; G[, [____]]

Motion Sensor; G[, [____]]

Bi-level HID Controller; G[, [____]]

Photocell; G[, [____]]

Concrete poles; G[, [____]]

Aluminum poles; G[, [____]]

Steel poles; G[, [____]]

Fiberglass poles; G[, [____]]

Brackets

Obstruction Marker Luminaires; G[, [____]]

[ SD-04 Samples

*****
NOTE: Samples involve additional shipping cost.
Use only for special luminaires or for an item for
which a large quantity is required on a project.
*****

[HID,] [LPS,] [Fluorescent,] [Induction] [and] [LED] Luminaires; G
[, [____]]

Submit one sample of each luminaire type[, complete with light
source and ballast, generator or power supply unit].[ Submit one
sample for each item other than luminaires.] Sample will be
returned to the Contractor for installation in the project work.

] SD-05 Design Data

Design Data for luminaires; G[, [____]]

SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report; G[, [____]]

LED Light Source - IES LM-80 Test Report; G[, [____]]

[ Pressure treated wood pole quality

][ Tests for fiberglass poles; G[, [____]]

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] Operating test

Submit operating test results as stated in paragraph entitled "Field Quality Control."

SD-07 Certificates

Luminaire Useful Life Certificate; G[, [____]]

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life shall be directly correlated from the IES LM-80 test data using procedures outlined in IES TM-21. Thermal properties of the specific luminaire and local ambient operating temperature and conditions shall be taken into consideration.

SD-08 Manufacturer's Instructions

Concrete poles

Submit instructions prior to installation.

Fiberglass poles

Submit instructions prior to installation.

SD-10 Operation and Maintenance Data

Electronic Ballast Warranty

Operational Service

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

1.5 QUALITY ASSURANCE

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and[computerized] candlepower distribution data shall accompany shop drawings.

[1.5.1.2 Poles

Include dimensions, wind load determined in accordance with AASHTO LTS, pole deflection, pole class, and other applicable information.[For concrete poles, include: section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes; initial prestressing steel tension; and concrete strengths at release and at 28 days.]

]1.5.2 Pressure Treated Wood Pole Quality

Ensure the quality of pressure treated wood poles. Furnish an inspection report (for wood poles) of an independent inspection agency, approved by the Contracting Officer, stating that offered products comply with AWPAs U1 and RUS Bull 1728F-700 standards. The RUS approved Quality Mark "WQC" on each pole will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPAs treatment standards.

]1.5.3 Photometric Plan

For LED luminaires, include computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.7. For LED and all other types of luminaires, the submittal shall include the following:

Horizontal illuminance measurements at finished grade, taken at a maximum of every 3050 mm 10 feet.

Vertical illuminance measurements at 1500 mm 5 feet above finished grade.

Minimum and maximum lux footcandle levels.

Average maintained lux footcandle level.

Maximum to minimum ratio for horizontal illuminance only.

1.5.4 Design Data for Luminaires

- a. Provide distribution data according to IES classification type as defined in IES HB-10.
- b. Shielding as defined by IES RP-8 or B.U.G. rating for the installed position as defined by IES TM-15.
- c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification per NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratories).
- d. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections shall be obtained from testing in accordance with IES LM-80.
- e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets shall not exceed maximum rating of pole as installed in particular wind zone area.

1.5.5 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Submittal shall include all photometric and electrical measurements, as well as all other pertinent data outlined under "14.0 Test Report" in IES LM-79.

1.5.6 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED package, array, or module. Submittal shall include:

- a. Testing agency, report number, date, type of equipment, and LED light source being tested.
- b. All data required by IES LM-80.

1.5.6.1 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports shall be one of the following:

- a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.
- b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.
- c. A manufacturer's in-house lab that meets the following criteria:
 1. Manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires and the manufacturer's lab has been successfully certifying these fixtures for a minimum of 15 years.
 2. Annual equipment calibration including photometer calibration in accordance with National Institute of Standards and Technology.

[1.5.7 \[Tests for Fiberglass Poles

- a. Ultraviolet resistance tests: Perform according to ASTM G154 using a UV-B light source having a 313 nanometer wavelength, operated at 54 degrees C 130 degrees F, cycling the light source on for 4 hours and off for 4 hours for a total test period of 1500 hours minimum with the following results:

Fiber exposure:	None
Crazing:	None
Checking:	None
Chalking:	None
Color:	May dull slightly

- b. Flexural strength and deflection test: Test loading shall be as a cantilever beam with pole butt as fixed end and a force simulating wind load at the free end.

\]]1.5.8 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been

substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.9 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.9.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires for a minimum of 15 years. Products shall have been in satisfactory commercial or industrial use for 15 years prior to bid opening. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 15-year period.

1.5.9.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

[1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

[1.6.1 Wood Poles

Do not store poles on ground. Stack poles stored for more than 2 weeks on decay-resisting skids arranged to support the poles without producing noticeable distortion. Store poles to permit free circulation of air; the bottom poles in the stack shall be at least 305 mm one foot above ground level and growing vegetation. Do not permit decayed or decaying wood to remain underneath stored poles. Do not drag treated poles along the ground. Do not use pole tongs, cant hooks, and other pointed tools capable of producing indentation more than 25 mm one inch in depth in handling the poles. Do not apply tools to the groundline section of any pole.

][1.6.2 Concrete Poles

Do not store poles on ground. Support poles so they are at least 305 mm one foot above ground level and growing vegetation.

][1.6.3 [Fiberglass] [Aluminum] [Steel] Poles

Do not store poles on ground. Support poles so they are at least 305 mm one foot above ground level and growing vegetation. Do not remove

factory-applied pole wrappings until just before installing pole.

]1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

[1.7.1 LED Luminaire Warranty

NOTE: Choose this paragraph for LED applications.

Provide Luminaire Useful Life Certificate.

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

- a. Provide a written five year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.
 1. Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
 2. Material warranty shall include:
 - (a) All power supply units (drivers).
 - (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.
- b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

]1.7.2 Electronic Ballast Warranty

NOTE: Choose this paragraph for HID, LPS, and fluorescent applications.

Furnish the electronic ballasts manufacturer's warranty. The warranty period shall not be less than five (5) years from the date of manufacture. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed twelve (12) months, thereby permitting four (4) years of the five (5) year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

1.8 OPERATIONAL SERVICE

NOTE: Maintenance agreements are standard practice in the building industry. Take-back programs refer to programs in which the product manufacturer "takes-back" scrap material and/or packaging associated with its product. Under a green lease, when the customer no longer requires the use of the particular product or requires an updated model, the manufacturer is obligated to reclaim it and refurbish it or disassemble it for recycling as appropriate. Using one of these manufacturer's services contributes to the following LEED credit: MR2.

NOTE: This is optional for Army Projects.

Coordinate with manufacturer for [maintenance agreement] [take-back program]. Collect information from the manufacturer about [maintenance agreement] [green lease] options, and submit to Contracting Officer. Services shall reclaim materials for recycling and/or reuse. Services shall not deposit materials in landfills or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

NOTE: Choose bracketed options as applicable for Army, Navy or Air Force project.

Products and materials not considered to be luminaires, equipment or accessories are specified in [Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION,] [Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION,] [and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.] Luminaires and associated equipment and accessories for interior applications are specified in Section 26 51 00 INTERIOR LIGHTING.

2.2 [HID,] [LPS,] [FLUORESCENT,] [INDUCTION] [AND] [LED] LUMINAIRES

NOTE: XL series luminaire plates and details shown on project plans are provided for a visual perspective of the luminaire desired. Shapes, dimensions and other requirements shown are not intended to restrict selection to luminaires of a specific manufacturer. Luminaires producing comparable or competitive photometric results on a given plan area, and of similar or equal material, finish and craftsmanship will be considered for approval.

Choose appropriate bracketed options for type of

luminaires being used.

UL 1598, NEMA C82.77 and UL 8750. Provide luminaires as indicated in luminaire schedule and XL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. All luminaires of the same type shall be provided by the same manufacturer.

2.2.1 General Requirements

- a.[LED luminaire housings shall be die cast or extruded aluminum.][Housings for luminaires other than LED shall be die cast, extruded, or fabricated aluminum. Fabricated aluminum housings shall have all seams and corners internally welded to resist weathering, moisture and dust.]

NOTE: 40 degrees C 104 degrees F is "standard" upper level rating of most LED luminaires. Choose higher 50 degrees C 122 degrees F rating when an installation location warrants a higher ambient temperature rating and the additional cost it incurs.

- [b. LED luminaires shall be rated for operation within an ambient temperature range of minus 30 degrees C minus 22 degrees F to[40 degrees C 104 degrees F][50 degrees C 122 degrees F].
-] c. Luminaires shall be UL listed for wet locations per UL 1598.[Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.]
- [d. LED luminaires shall produce a minimum efficacy as shown in the following table, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.

Application	Luminaire Efficacy in Lumens per Watt
Exterior Pole/Arm-Mounted Area and Roadway Luminaires	65
Exterior Pole/Arm-Mounted Decorative Luminaires	65
Exterior Wall-Mounted Area Luminaires	60
Bollards	35
Parking Garage Luminaires	70

-] e. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans per IES HB-10.
- f. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving ASTM B117 salt fog

environment testing for 2500 hours minimum without blistering or peeling.

NOTE: Lighting zones referenced below are taken from the joint IDA/IES Model Lighting Ordinance, published in 2011. Zones included range from LZ-0 through LZ-4, and outline requirements for minimal to very high ambient light levels respectively.

- g. Luminaires shall not exceed the following IES TM-15 Backlight, Uplight and Glare (B.U.G.) ratings:
 - 1. Maximum Backlight (B) rating shall be determined by lighting zone in which luminaire is placed.
 - 2. Maximum Uplight (U) rating shall be U0.
 - 3. Maximum Glare (G) rating shall be determined by lighting zone in which luminaire is placed.
- h. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.
- i. The finish color shall be as indicated in the luminaire schedule or detail on the project plans.
- [j. Luminaire arm bolts shall be 304 stainless steel or zinc-plated steel.
-] k. Luminaire lenses shall be constructed of[clear][frosted] tempered glass or UV-resistant acrylic.[Provide polycarbonate vandal-resistant lenses as indicated.]
- [l. The wiring compartment on pole-mounted, street and area luminaires must be accessible without the use of hand tools to manipulate small screws, bolts, or hardware.
-] m. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.
- n. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.
- [o. Roadway and area luminaires shall have an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled in accordance with ANSI C136.3.
-] p. Luminaire must pass 3G vibration testing in accordance with NEMA C136.31.
- q. All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

2.2.2 Luminaire Light Sources

NOTE: The Energy Independence and Security Act (EISA) of 2007, Title III, Subtitle B, Section 324 limits the use of certain metal halide light sources and ballasts. Do not specify any of the light sources listed in that document.

[2.2.2.1 High Pressure Sodium (HPS) Light Sources

NOTE: For Army and Navy projects, high pressure sodium light sources are not recommended for new installations, but can be used where existing conditions and continuity of source type make their use necessary. For Air Force projects, high pressure sodium light sources should be avoided for new installations if possible and considered only when a more energy efficient alternative is not available to meet photometric and performance requirements.

ANSI ANSLG C78.42 and NEMA ANSLG C78.380. HPS light sources shall have a minimum average rated life of 24,000 hours, minimum color rendering index (CRI) of 21, and a minimum correlated color temperature (CCT) of 1900 degrees K. Provide type and wattage as indicated in luminaire schedule on project plans. Light sources shall be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of manufacture.

]2.2.2.2 Metal Halide (MH) Light Sources

NOTE: Metal halide light sources are available in a wide variety of configurations and wattages. Only a few typical examples are shown below. Utilize pulse-start technology for all wattages as they become available. They have longer life and better lumen maintenance. Some are rated for vertical use only, so be wary of light source orientation. Like other HID sources, re-strike time is a factor to consider. PAR envelopes are an efficient choice for lower wattage applications, but must be specified with beam type and angle. In most cases, choose light sources rated for use in an enclosed luminaire. Typically, choose sources with highest CRI and longest life, and closest CCT to match LED temperature of no greater than 4300 degrees K.

ANSI/ANSLG C78.43, NEMA ANSLG C78.44, ANSI C78.1381, and NEMA ANSLG C78.380. Provide type and wattage as indicated in luminaire schedule on project plans. Open fixtures are prohibited unless provided with a mechanism to utilize only Type O light sources and prohibit the use of Type E or S light sources. Light sources shall be specifically suited to operate in the burning position which they are installed, and shall be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of

manufacture.

- [a. All probe-start metal halide light sources shall utilize [a] [an] BT [ED][ET]-type envelope, with an E-39[_____] screw base. The arc tube shall be a ceramic[-fused quartz]-type, with a rating of [400][1000][_____] watts, having a minimum initial output of [35,000][105,000][_____] lumens. The correlated color temperature (CCT) shall be [3000][_____] degrees K, with a minimum color rendering index (CRI) of [65][_____]. The minimum average rated life shall be [15,000][12,000] hours, based on 10 hours operation per start.
-] [b. All pulse-start metal halide light sources shall utilize [a] [an] [Tube][PAR][ED][ET][BD]-type envelope, [G-12][E-26 Medium][E-39][mogul] base, ceramic[fused quartz] arc tube type, rated at [70][100][250][_____] watts, with a minimum initial output of [6300][6200][21,000][_____] lumens. Correlated color temperature (CCT) shall be [3000][_____] degrees K, minimum color rendering index (CRI) shall be [80] [_____], with a minimum average rated life of [12,000] hours, based on 10 hours operation per start.

]] [2.2.2.3 Low Pressure Sodium (LPS) Light Sources

**NOTE: Use low-pressure sodium light sources only in
unique applications such as sea turtle nesting
habitats and only when approved by the state or
local governing authority.**

ANSI ANSLG C78.41 and NEMA ANSLG C78.380. Low Pressure Sodium light sources shall have average rated life of 18,000 hours minimum and a correlated color temperature (CCT) of 1700 degrees K. Provide in a T17 or T21 type envelope with a D.C. Bayonet type base rated at [55][90][135][180] watts, with an initial output of [7800][14300][22600][32000] lumens.

] [2.2.2.4 Fluorescent Light Sources

- [a. T5HO fluorescent light sources shall have miniature bi-pin bases, be low-mercury type, in nominal length(s) of 1170 mm 46 in 1475 mm 58 in, rated at [54][80] watts, with minimum initial output of [4450] [6150] lumens. Light source correlated color temperature (CCT) shall be [3500] [4100] degrees K, with a minimum CRI value of 75, and a minimum average rated life of [25,000][_____] hours, based on 3 hours operation per start. Light sources shall be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at time of manufacture.
-] [b. T8 fluorescent light sources shall have medium bi-pin bases, be low-mercury type, in nominal length(s) of 1220 mm 48 in 2438 mm 96 in, rated at [32] [59] watts, with minimum initial output of [2800] [5700] lumens. Light source correlated color temperature (CCT) shall be [3500] [4100] degrees K, with a minimum CRI value of 75, and a minimum average rated life of [30,000][_____] hours, based on 3 hours operation per start. Light sources shall be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at time of manufacture.
-] [c. Compact fluorescent (CFL) light sources shall be 4-pin base, low-mercury, programmed-start, energy-savings type, rated at [26] [32] [42][57][70] watts, correlated color temperature of [3500] [4100]

degrees K, minimum CRI of 82, with an average rated life of [16,000][_____] hours minimum. Light sources shall be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at time of manufacture.

][2.2.2.5 Induction Light Sources

NOTE: Induction light sources have high efficiencies, superior color rendering, instant on/off switching ability, and extremely long lives. Relamping is typically in the 60,000 plus hour range and because of this, savings in maintenance make these a viable solution to certain outdoor applications. Typically select CCT of 4000 degrees K to match LED and other exterior light sources.

Induction light sources shall consist of an electrodeless, inductively-coupled, phosphor-coated fluorescent envelope rated at [55] [85] [100] [150] [165] watts, color temperature of [3000/3500] [4000/4100] [5000] degrees K, minimum CRI of 80, with an average rated life of 100,000 hours minimum based on 3 hours operation per start.

][2.2.2.6 LED Light Sources

NOTE: Typically, select a CCT in the range of 4000 degrees K. Some studies have shown that luminaires with higher CCT values approaching 6500 degrees K attribute to skyglow, cause erratic behavior in some animals, and possibly cause circadian rhythm abnormalities. Although all of these issues have not been fully documented, a lower color temperature is recommended.

- a. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

[Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K

- b. Color Rendering Index (CRI) shall be:

Greater than or equal to [70] [_____] for 4000 degrees K light sources.

- c. Color Consistency:

Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistency of LEDs used in luminaires.

][2.2.3 Luminaire[Ballasts,][Generators][and][Power Supply Units (Drivers)]

NOTE: Choose "Ballasts" for HID, LPS and fluorescent; "Generators" for induction; and "Power Supply Units (Drivers)" for LED applications.

[2.2.3.1 HID Ballasts

2.2.3.1.1 Electronic HID Ballasts

NEMA ANSLG C82.14, IEEE C62.41, 47 CFR 18 and shall meet the following requirements:

- a. Minimum power factor shall be greater than 90 percent.
- b. Input voltage shall be 120-277 volts plus or minus 10 percent.
- c. Shall have end of life circuitry to prevent ballast from operating if light source is inoperable.
- d. Shall have a sound rating of A and a lamp current crest factor less than 1.5.
- e. Input current total harmonic distortion shall be less than 15 percent.
- f. Minimum starting temperature shall be minus 30 degrees C minus 22 degrees F.
- g. Shall be thermally protected to prevent overheating.
- h. Shall be UL listed and RoHS compliant.

2.2.3.1.2 Magnetic HID and LPS Ballasts

NOTE: For metal halide luminaires, provide electronic ballasts whenever available. Otherwise, constant wattage autotransformer (CWA) or high reactance/high power factor (HX-HPF), pulse-start magnetic ballasts should be specified.

ANSI C82.4. Pulse-start constant wattage autotransformer (CWA) type shall be used when available. Probe-start constant wattage autotransformer (CWA), high reactance/high power factor (HX-HPF) or regulator type shall be used for metal halide light sources when pulse-start is not available, and for high and low pressure sodium light sources. Ballasts shall meet the following requirements:

- a. Shall have minimum Class "H" insulation rating.
- b. Shall be designed for 60,000 hours of operation at maximum rated temperature.
- c. Shall have minimum starting temperature for high and low pressure sodium shall be minus 40 degrees C minus 40 degrees F, and for metal halide minus 30 degrees C minus 22 degrees F.
- d. Nominal ballast factor shall be 1.0.
- e. Capacitors shall have a self-contained bleeder resistor as required by UL 1029.
- f. Oil-filled capacitors shall be housed in an aluminum or

corrosion-resistant steel can and be provided with 6 mm 0.25 in quick disconnect terminals.

- g. Capacitor maximum case temperature shall be 90 degrees C 194 degrees F for oil-filled and 105 degrees C 221 degrees F for dry film type.
- h. Starter/igniter shall provide six months of light source open circuit operation without failure and be designed to withstand 10,000 hours of continuous pulsing (not applicable for LPS).

][2.2.3.2 Fluorescent Ballasts

UL 935, NEMA ANSLG C82.11, NFPA 70 and CEC Title 24, with no magnetic core and coil components, and shall meet the following requirements:

- a. Shall provide transient protection as recommended by IEEE C62.41.1 and IEEE C62.41.2.
- b. Shall be programmed-start or instant-start type as indicated in luminaire schedule on project drawings elsewhere in this specification.
- c. Shall be UL listed Class P, have a Class A sound rating, and have a minimum power factor of 0.98.
- d. Shall be designed for the wattage and quantity of light sources powered in the luminaire specified, and have circuit diagrams and lamp connection information printed on the exterior of the ballast housing.
- e. Shall contain no PCBs and be RoHS compliant.
- f. Shall be manufactured in an ISO 9001-certified facility.
- g. Shall operate at a frequency greater than 20 kHz minimum, preferably greater than 40 kHz, and shall have a Lamp Current Crest Factor less than 1.7.
- h. Shall have a light regulation of plus or minus 10 percent of lumen output when operated within a plus or minus 10 percent range of input voltage.
- i. Shall have a full replacement warranty of 5 years from date of manufacture for a maximum case temperature of 70 degrees C 158 degrees F and 3 years for a maximum case temperature of 90 degrees C 194 degrees F.
- j. All ballasts provided to operate 1220 mm 48 in T8 light sources shall be NEMA Premium type.

2.2.3.2.1 T5HO Electronic Fluorescent Ballasts

Shall be programmed-start type with nominal ballast factor of 1.0, maximum input current THD of 10 percent, lamp end of life protection circuitry, and have a minimum starting temperature of minus 18 degree C 0 degree F.

Ballast efficacy factor (BEF), rated at 120 volts shall be:

- [Minimum 3.66 for one 24W light source.
-][Minimum 1.83 for two 24W light sources.
-][Minimum 2.23 for one 39W light source.

-][Minimum 1.11 for two 39W light sources.
-][Minimum 1.62 for one 54W light source.
-][Minimum 0.83 for two 54W light sources.
-][Minimum 0.57 for three 54W light sources.
-][Minimum 0.42 for four 54W light sources.
-]

Input power shall be:

- [Maximum 30 watts for one 24W light source.
-][Maximum 59 watts for two 24W light sources.
-][Maximum 47 watts for one 39W light source.
-][Maximum 90 watts for two 39W light sources.
-][Maximum 63 watts for one 54W light source.
-][Maximum 120 watts for two 54W light sources.
-][Maximum 184 watts for three 54W light sources.
-][Maximum 240 watts for four 54W light sources.
-]

2.2.3.2.2 T8 Electronic Fluorescent Ballasts

Shall be[programmed-start][instant-start] type, with minimum ballast factor of 0.87, maximum current THD of 10 percent, and have a minimum starting temperature of minus 18 degrees C 0 degrees F.

[For programmed-start ballasts:

Ballast efficacy factor (BEF), rated at 120 volts shall be:

- [Minimum 2.9 for one 32 W, 1220 mm 48 in light source (NEMA Premium).
-][Minimum 1.49 for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Minimum 1.03 for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Minimum 0.8 for four 32 W, 1220 mm 48 in light sources (NEMA Premium).

] Input power shall be:

- [Maximum 35 watts for one 32 W, 1220 mm 48 in light source (NEMA Premium).
-][Maximum 59 watts for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Maximum 85 watts for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Maximum 112 watts for four 32 W, 1220 mm 48 in light sources (NEMA Premium).

]][For instant-start ballasts:

Ballast efficacy factor (BEF), rated at 120 volts shall be:

- [Minimum 2.9 for one 32 W, 1220 mm 48 in light source (NEMA Premium).
-][Minimum 1.49 for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Minimum 1.03 for three 32 W, 1220 mm 48 in light sources (NEMA Premium).

-][Minimum 0.8 for four 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Minimum 1.36 for one 59 W, 2438 mm 96 in light source.
-][Minimum 0.77 for two 59 W, 2438 mm 96 in light sources.

] Input power shall be:

- [Maximum 35 watts for one 32 W, 1220 mm 48 in light source (NEMA Premium).
-][Maximum 59 watts for two 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Maximum 85 watts for three 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Maximum 112 watts for four 32 W, 1220 mm 48 in light sources (NEMA Premium).
-][Maximum 72 watts for one 59 W, 2438 mm 96 in light source.
-][Maximum 113 watts for two 59 W, 2438 mm 96 in light sources.

][2.2.3.2.3 Compact Fluorescent (CFL) Electronic Ballasts

Shall be programmed start type with ballast factor greater than or equal to 0.98, maximum input current THD of 10 percent, lamp end of life protection circuitry, and have a minimum starting temperature of minus 18 degrees C 0 degrees F for primary light source(s).

The ballast efficacy factor rated at 120 volts shall be:

- [Minimum 3.64 for one 26W CFL light source.
-][Minimum 2.72 for one 32W CFL light source.
-][Minimum 2.13 for one 42W CFL light source.
-][Minimum 1.56 for one 57W CFL light source.
-][Minimum 1.28 for one 70W CFL light source.
-]

The input power shall be:

- [Maximum 29 watts for one 26W CFL light source.
-][Maximum 36 watts for one 32W CFL light source.
-][Maximum 46 watts for one 42W CFL light source.
-][Maximum 59 watts for one 57W CFL light source.
-][Maximum 75 watt for one 70W CFL light source.
-]

][2.2.3.3 Induction Generators

Generator shall be connected to, and operate in conjunction with, an inductive power coupler or coil(s). These in turn activate a glass light source enclosure from either inside or outside of the enclosure. The generator shall be solid-state, high-frequency (200kHz - 2.67MHz) type, with a power factor greater than 0.9, a Class A sound rating, a maximum input current THD of 15 percent, an operating voltage of 120-277V and a minimum starting temperature of minus 40 degrees C minus 40 degrees F. Generator shall be dimmable to 50 percent of lumen output and be UL, CSA, and RoHS compliant.

][2.2.3.4 LED Power Supply Units (Drivers)

UL 1310. LED Power Supply Units (Drivers) shall meet the following requirements:

- a. Minimum efficiency shall be 85 percent.
- b. Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.

NOTE: 40 degrees C 104 degrees F is "standard" upper level rating of most LED luminaires. Choose higher 50 degrees C 122 degrees F rating when an installation location warrants a higher ambient temperature rating and the additional cost it incurs.

- c. Shall be rated to operate between ambient temperatures of minus 30 degrees C minus 22 degrees F and 40 degrees C 104 degrees F[50 degrees C 122 degrees F].
- d. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.
- e. Operating frequency shall be: 50 or 60 Hz.
- f. Power Factor (PF) shall be greater than or equal to 0.90.
- g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.
- h. Shall meet requirements of 47 CFR 15, Class B.
- i. Shall be RoHS-compliant.
- j. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.
- k. Power supplies in luminaires mounted under a covered structure, such as a canopy, or where otherwise appropriate shall be UL listed with a sound rating of A.
- [1. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.
-] m. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

]2.2.4 LED Luminaire Surge Protection

Provide surge protection integral to luminaire to meet C Low waveforms as defined by IEEE C62.41.2, Scenario 1, Location Category C.

[2.3 OBSTRUCTION MARKER LUMINAIRES

NOTE: If no other airfield lighting is required in project, cut and paste required paragraph on obstruction marker luminaires in this paragraph. If other airfield lighting is required, include entire section in project specifications as noted below. Designer shall also be aware of a conflict between LED obstruction luminaires and pilots using night

vision goggles (NVG). The output wavelength and low heat signature of LED luminaires render them invisible for pilots using NVG.

Do not use LED obstruction luminaires for Air Force projects. See Air Force ETL 11-29 "Use of Light-Emitting Diode (LED) Fixtures in Airfield Lighting Systems on Air Force Installations and Enduring/Contingency Locations" for more information.

Provide obstruction marker luminaires for facilities as required by the FAA and in accordance with [Section 26 56 20.00 10 AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS] [Section 26 54 21.00 10HELIPAD LIGHTING AND VISUAL NAVIGATION AIDS][Section 34 43 00.00 20 AIRFIELD LIGHTING].

]2.4 EXTERIOR LUMINAIRE CONTROLS

NOTE: Currently, policy for networked control of lighting systems are still being developed. Issues such as security and standard protocols need further review and certification. So, lighting control "systems" at this point shall be limited to stand-alone type, and wireless control strategies shall not be employed at this time.

Typically, controls shall be provided to turn luminaires on at dusk and off after a certain time period, when sufficient daylight is available, or when illumination is not required.

Provide control at each individual luminaire or by a single device or system controlling a group of luminaires.

Use reference to ASHRAE 189.1 in lieu of ASHRAE 90.1 for Army projects.

Controls shall comply with[Section 9 of ASHRAE 90.1 - SI ASHRAE 90.1 - IP] [ASHRAE 189.1]. [Provide a control system interface within each luminaire that is compatible with the energy management or control system used by the utility department in charge of the project area for control of site lighting.]

[2.4.1 Photocell

NOTE: Cadmium sulfide is the older of the two technologies. Silicon diode sensors are a solid state device and more resistant to higher temperatures and environmental contamination. Silicon diode type are usually specified when mounting directly to luminaires, but both types are proven, reliable technologies.

UL 773 or UL 773A. Photocells shall be hermetically sealed, [cadmium sulfide] [silicon diode] light sensor type, rated at [_____] watts, [_____] volts, 50/60 Hz with single-pole, [single] [double]-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of [polycarbonate] [die cast aluminum] [UV stabilized polypropylene], rated to operate within a temperature range of minus 40 to 70 degrees C minus 40 to 158 degrees F. Photocell shall have a 13 mm 1/2 in threaded base for mounting to a junction box or conduit. Provide [fixed] [swivel] base type housing. Photocell shall be twist-lock receptacle type conforming to NEMA C136.10. Provide with solid brass prongs and voltage markings and color coding on exterior of housing. Photocell shall turn on at 10-30 lux 1-3 footcandles and turn off at 30 to 150 lux 3 to 15 footcandles. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition. Provide photocell with metal oxide varistor (MOV) type surge protection.]

] [2.4.2 Timeswitch

[Timeswitch shall be electromechanical type with a [24 hour] [7 day] [astronomic] dial [that changes on/off settings according to seasonal variations of sunset and sunrise]. Switch shall be powered by an enclosed synchronous motor with a maximum 3 watt operating rating. Timeswitch contacts shall be rated for [40] [_____] amps at 120-277 VAC resistive load in a [SPST] [DPST] [SPDT] [DPST] [normally open (NO)] [normally closed (NC)] configuration. Switch shall have an automatic spring mechanism to maintain accurate time for up to 16 hours during a power failure. Provide switch with function that allows automatic control to be skipped on certain selected days of the week. Provide switch with manual bypass or remote override control.]]

[Timeswitch shall be an electronic type with a [24 hour] [7 day] [astronomic] programming function [that changes on/off settings according to seasonal variations of sunset and sunrise], providing a total of [56] [_____] on/off set points. Digital clock display format shall be [AM/PM 12 hour] [24 hour] type. Provide power outage backup for switch utilizing a [capacitor] [alkaline batteries] [lithium battery] which provides coverage for a minimum of [7 days] [3 years] [8 years]. Timeswitch shall provide control to [1] [2] [4] [_____] channels or loads. Contacts shall be rated for [30] [_____] amps at 120-277 VAC resistive load in a [SPST] [DPST] [SPDT] [DPST] [normally open (NO)] [normally closed (NC)] configuration. Provide switch with [function that allows automatic control to be skipped on certain selected days of the week] [manual bypass or remote override control] [daylight savings time automatic adjustment] [EEPROM memory module] [momentary function for output contacts] [ability for photosensor input]].]

Timeswitch shall be housed in a surface-mounted, lockable NEMA [1] [3R] enclosure constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

] [2.4.3 Lighting Contactor

NEMA ICS 2. Provide a [mechanically] [electrically]-held lighting contactor [housed in a NEMA [1] [3R] [4] [_____] enclosure conforming to NEMA ICS 6]. Contactor shall have [2] [4] [6] [_____] poles, configured as [normally open (NO)] [normally closed (NC)]. Contacts shall be rated [600] [_____] volts, [30] [_____] amperes for a resistive load. Coil operating voltage shall be

[24][120][277][_____] volts. Contactor shall have silver cadmium oxide double-break contacts [and coil clearing contacts for mechanically held contactors] and shall require no arcing contacts. [Provide contactor with hand-off-automatic [on-off] selector switch.] [Provide contactor as specified above along with [disconnect switch][circuit breaker] in integral NEMA [1][3R][_____] enclosure with flange-mounted handle to satisfy requirement for a "combination lighting contactor" when specified.]

][2.4.4 Lighting Control Relay Panel

NOTE: NOTE: When providing a control panel that interfaces with the building automated control system, reference IES Technical Memorandum IES TM-23-11 for technical information on various protocols, architectures and topologies for such systems.

Panel shall consist of a single NEMA [1][3R] [flush][surface]-mounted enclosure with two separate interior sections; one for Class 1 (branch circuit) and one for Class 2 (low voltage) wiring. Provide panel with [8][16][32][_____] relays. Panel shall be designed as [a stand alone][an automated control system interface] type. The Class 1 section shall contain the load side of all relays and the incoming branch circuit wiring. The Class 2 section shall contain the control power transformer (24 volt output), relays, relay control modules, and control wiring[, and native BACnet[LONworks] field-programmable application controller for panels connected to the facility automated control system]. Panel enclosure shall be constructed of [16][14] gauge cold-rolled steel with baked-on enamel finish. Panel shall meet requirements of UL 916, ASHRAE 90.1 - SI ASHRAE 90.1 - IP, CEC Title 24 and 47 CFR 15.

Relays shall be [1][2]-pole, rated at 20 amperes [300][480] VAC with rated life of 120,000 mechanical operations minimum.

Relay control module shall be 24 volt, electronic type and control up to 16 separate relays (16 channel) or programmed groups of relays. Provide with inputs for signals from devices such as photocells, timeclocks, and motion sensors. [Relay control module with integral timeclock function shall be 24 volt, electronic type with LCD display and control up to 8 separate relays (8 channel)].

][2.4.5 Motion Sensor

NEMA WD 7, UL 773A. Provide [passive infrared][microwave][dual technology passive infrared/microwave] type sensors with [270][_____] degree coverage, time delay that can be adjusted from 15 seconds to 15 minutes, and "fail to ON position" default state. Sensors shall be located to achieve coverage of areas as indicated on project plans. Coverage patterns shall be derated as recommended by manufacturer based on mounting height of sensor and any obstructions such as trees. Do not use gross rated coverage in manufacturer's product literature. Sensors installed integral to the luminaire must be provided by the luminaire manufacturer. Sensors shall have an integral light level sensor that does not allow luminaires to operate during daylight hours and shall be designed to operate on a voltage of [120/277 VAC][24 VDC]. [Provide sensors to operate in conjunction with bi-level controllers that lower HID or LED luminaires to a 50 percent

output.] Sensor shall be [equipped with a threaded base for mounting to a weatherproof junction box][mounted directly to luminaire].

][2.4.6 Bi-level HID Controller

UL 1598. Provide device to switch full lumen output of HID luminaires to 50 percent output upon receiving 24 VDC signal from motion sensor, photocell or control system circuit. Device shall be compatible with constant wattage autotransformer (CWA) ballasts only and have maximum load rating of 1000 watts. Provide controller in a weatherproof housing and mount adjacent to luminaire on pole or luminaire mounting structure. Controller requires separate bi-level capacitor[, supplied with luminaire][, supplied with controller] to operate.

][2.5 POLES

NOTE: This specification does not cover decorative poles or high-mast lighting systems. Poles, luminaire mounting assemblies, and lowering mechanisms for high-mast lighting are specially fabricated and should be individually designed to suit a specific project. Pole specifications for high-mast system should, as a minimum, include wind loading and ultimate strength meeting the loading requirements of AASHTO LTS. Do not specify embedded type metal poles for Army facilities.

Provide poles designed for wind loading of [161][_____] km/hr [100][_____] miles per hour determined in accordance with AASHTO LTS while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be[embedded][anchor]-base type designed for use with[underground][overhead] supply conductors.[Poles[, other than wood poles,] shall have oval-shaped handhole having a minimum clear opening of 65 by 130 mm 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws.][Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole.] Scratched, stained, chipped, or dented poles shall not be installed.

[2.5.1 Concrete Poles

Provide concrete poles conforming to ASTM C1089. Cross-sectional shape shall be[round][or][multi-sided].

2.5.1.1 Steel Reinforcing

Prestressed concrete pole shafts shall be reinforced with steel prestressing members. Design shall provide internal longitudinal loading by either pretensioning or post tensioning of longitudinal reinforcing members.

2.5.1.2 Tensioned Reinforcing

Primary reinforcement steel used for a prestressed concrete pole shaft shall be tensioned between 60 to 70 percent of its ultimate strength. The amount of reinforcement shall be such that when reinforcement is tensioned

to 70 percent of its ultimate strength, the total resultant tensile force does not exceed the minimum section compressive strength of the concrete.

2.5.1.3 Coating and Sleeves for Reinforcing Members

Where minimum internal coverage cannot be maintained next to required core openings, such as handhole and wiring inlet, reinforcing shall be protected with a vaporproof noncorrosive sleeve over the length without the 13 mm 1/2 inch concrete coverage. Each steel reinforcing member which is to be post-tensioned shall have a nonmigrating slipper coating applied prior to the addition of concrete to ensure uniformity of stress throughout the length of such member.

2.5.1.4 Strength Requirement

As an exception to the requirements of ASTM C1089, poles shall be naturally cured to achieve a 28-day compressive strength of 48.23 MPa 7000 psi. Poles shall not be subjected to severe temperature changes during the curing period.

2.5.1.5 Shaft Preparation

Completed prestressed concrete pole shaft shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost, and shall be clean, smooth, and free of surface voids and internal honeycombing. Poles shall not be installed for at least 15 days after manufacture.

2.5.2 Aluminum Poles

Provide aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 4.8 mm 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel. Aluminum poles and brackets for [walkway][] lighting shall have a [uniform satin][dark anodic bronze][] finish to match fixtures and shall not be painted. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape, and shipping small parts in boxes.

2.5.3 Steel Poles

AASHTO LTS. Provide steel poles having minimum 11-gage steel with minimum yield/strength of 331 MPa 48,000 psi and [hot-dipped galvanized in accordance with ASTM A123/A123M][iron-oxide primed] factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be [direct set][anchor bolt mounted] type. Poles shall have tapered tubular members, either round in cross section or polygonal. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening

except as specifically approved.] Pole markings shall be approximately 900 to 1270 mm 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length.[Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 248 MPa 36,000 psi.]

][2.5.4 Wood Poles

**NOTE: Other wood species which are covered by ATIS
ANSI 05.1 and AWPB may be specified, provided they
are available at the project location. Indicate
pole class and height on the drawings.**

ATIS ANSI 05.1 and RUS Bull 1728F-700 of[Southern Yellow Pine][Douglas Fir][____]. Poles shall be gained, bored, and roofed before treatment. Poles shall be treated full length with chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA) according to AWPB U1 as referenced in RUS Bull 1728F-700. Poles shall be branded by manufacturer with manufacturer's mark and date of treatment, height and class of pole, wood species, preservation code, and retention. Place the brand so that the bottom of the brand or disc is 3050 mm 10 feet from the pole butt for poles up to 15250 mm 50 feet long[and 4270 mm 14 feet from the butt for poles over 15250 mm 50 feet long].

][2.5.5 Fiberglass Poles

NEMA C136.20. Designed specifically for supporting luminaires and having factory-formed cable entrance and handhole. Resin color shall be[dark bronze][as indicated][____], and pigment shall provide uniform coloration throughout entire wall thickness. Finish surface shall be pigmented polyurethane having a minimum dry film thickness of 0.038 mm 1.5 mils. Polyurethane may be omitted if the surface layer of the pole is inherently ultraviolet inhibited. Minimum fiberglass content shall be 65 percent with resin and pigment comprising the other 35 percent material content.

]][2.6 BRACKETS AND SUPPORTS

ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 31.75 mm 1 1/4 inch[galvanized steel pipe][aluminum] secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 7320 mm 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

][2.7 POLE FOUNDATIONS

Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa 50,000 psi; the top 305 mm 12 inches of the rod shall be galvanized in accordance with ASTM A153/A153M. Concrete shall be as specified in[Section 03 30 00 CAST-IN-PLACE CONCRETE][Section 03 30 00.00 10 CAST-IN-PLACE CONCRETE].

2.8 EQUIPMENT IDENTIFICATION

2.8.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.8.2 Labels

NOTE: Labeling of lighting components is an inexpensive and effective method for helping facilities personnel properly operate and maintain the lighting systems. The labels shall be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Refer to the FEMP guidelines for lighting at

http://www.eere.energy.gov/femp/technologies/eep_lighting_guidance.cfm.

Provide labeled luminaires in accordance with UL 1598 requirements. Luminaires shall be clearly marked for operation of specific light sources and ballasts according to proper light source type. The following light source characteristics shall be noted in the format "Use Only _____":

NOTE: Choose requirements as applicable for project.

- [a. Light source tube diameter code (e.g. T-5, T-8), tube quantity configuration (e.g. twin, quad, triple), base type (e.g. G24q-2, GX 24 q-4), and nominal wattage for fluorescent and compact fluorescent luminaires.
-] [b. Light source type, wattage, bulb type (e.g. ED17, BD56) and coating (clear or coated) for HID luminaires.
-] [c. Start type (e.g. programmed-start, rapid-start, instant-start) for fluorescent and compact fluorescent luminaires.
-] [d. ANSI ballast type (e.g. M98, M57) for HID luminaires.
-] e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

Markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. [Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.]

2.9 FACTORY APPLIED FINISH

NOTE: This paragraph covers only the basic painting requirements for most electrical equipment. Include any special finishes for high or low temperatures

and corrosive atmospheres.

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

[3.1.1 Wood Poles

NOTE: Poles set in swampy or rocky soil will require different settings or foundations than those set in average bearing soils. Consult pole manufacturer and structural engineer for proper setting or foundation requirements for these and other unusual soil conditions.

Pole holes shall be at least as large at the top as at the bottom and shall be large enough to provide 100 mm 4 inches of clearance between the pole and the side of the hole.

NOTE: At the text below, delete setting information for pole lengths not required.

- a. Setting depth: Pole setting depths shall be as follows:

Length of Pole (mm)	Setting in Soil (mm)
6100	1575
7625	1575
9150	1575
10675	1830
12200	1830
13725	1985
12250	2135
16775	2285
18300	2440

Length of Pole (feet)	Setting in Soil (feet)
20	5.0
25	5.5
30	5.5
35	6.0
40	6.0
45	6.5
50	7.0
55	7.5
60	8.0

- b. Soil setting: "Setting in Soil" depths shall apply where pole holes are in soil, sand, or gravel or any combination of these.[At corners, dead ends and other points of extra strain, poles 12,200 mm 40 feet long or more shall be set 150 mm 6 inches deeper.]
- c. Setting on sloping ground: On sloping ground, measure the depth of the hole from the low side of the hole.
- d. Backfill: Tamp pole backfill for the full depth of the hole and mound the excess fill around the pole.

][3.1.2 Concrete Poles

NOTE: Poles set in swampy or rocky soil will require different settings or foundations than those set in average bearing soils. Consult pole manufacturer and structural engineer for proper setting or foundation requirements for these and other unusual soil conditions.

Install according to pole manufacturer's instructions.

][3.1.3 Fiberglass Poles

NOTE: Poles set in swampy or rocky soil will require different settings or foundations than those set in average bearing soils. Consult pole manufacturer and structural engineer for proper setting or foundation requirements for these and other unusual soil conditions.

Install according to pole manufacturer's instructions.

]3.1.4 [Aluminum][Steel] Poles

NOTE: Poles set in swampy or rocky soil will require different settings or foundations than those set in average bearing soils. Consult pole manufacturer and structural engineer for proper setting or foundation requirements for these and other unusual soil conditions.

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.[After installation, paint exposed surfaces of steel poles with two finish coats of[exterior oil paint of a color as indicated][aluminum paint]. Install according to pole manufacturer's instructions. Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed.]

]3.1.5 Pole Setting

[Depth shall be as indicated.][Poles in straight runs shall be in a straight line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 150 mm 6 inch maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.]

]3.1.6 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.[Mount switch on or beside each luminaire when switch is provided in cast weatherproof aluminum housing with swivel arm.][Set adjustable window slide for [_____] lux [_____] footcandles photocell turn-on.]

]3.1.7 GROUNDING

Ground noncurrent-carrying parts of equipment including[metal poles,] luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.1.8 FIELD APPLIED PAINTING

NOTE: Use and coordinate paint and coating requirements with Section 09 90 00 PAINTS AND COATINGS when provided in the job. When requirements are beyond what is specified in Section 09 90 00, specify the requirements in this paragraph.

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.2 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test after 100 hours of burn-in time to show that the equipment operates in accordance with the requirements of this section.

-- End of Section --