JOINT BASE LEWIS-McCHORD DESIGN STANDARDS
DIVISION 26 - ELECTRICAL

SECTION 26 56 00

EXTERIOR LIGHTING

08/18

PART 1 GENERAL

1.1 REFERENCES
The publications listed below form a part of this specification to the extent referenced. The publications are referred to 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

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM 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 (2016) Building Energy Efficiency Standards For Residential and Nonresidential Buildings

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 (2017) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing

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; TIA 17-4; TIA 17-5; TIA 17-6; TIA 17-7; TIA 17-8; TIA 17-9; TIA 17-10; TIA 17-11; TIA 17-12; TIA 17-13; TIA 17-14) National Electrical Code

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 (2016; Reprint Nov 2017) UL Standard for Safety 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 Feb 2018) 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

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. Luminaires and accessories installed in interior of buildings are specified in Section 26 51 00 INTERIOR LIGHTING.

1.3 DEFINITIONS

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 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.

c. 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

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NOTE: If 01 33 29 is incorporated in the specifications, select that
option below.  If not, select the option for 01 57 19.  Include items
noted at SD-01 and SD-11 as applicable, based on project scope.
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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are 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 with Section 01 33 29 SUSTAINABILITY REPORTING][Environmental Records Binder, in conformance to Section 01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS]. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals
Photometric Plan; G
LED Luminaire Warranty; G
Exterior Lighting (Energy Efficiency); S
Exterior Lighting (Light Pollution Reduction); S

SD-02 Shop Drawings
Luminaire drawings; G
Poles; G

SD-03 Product Data
LED and Induction Luminaires; G
Luminaire Light Sources; G
Luminaire 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
Brackets
Obstruction Marker 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
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.
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.

SD-11 Closeout Submittals
Exterior Lighting (Energy Efficiency); S
Exterior Lighting (Light Pollution Reduction); S

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 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.

1.5.3 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.

1.5.4 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.

1.5.5 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.

1.5.5.1 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.

1.5.6 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.

1.5.7 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.

1.5.7.1 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.

1.5.7.2 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 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
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
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
Coordinate with manufacturer for maintenance agreement. Collect information from the manufacturer about maintenance agreement 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

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NOTE: If 01 33 29 is incorporated in the specifications, select that
option below.  If not, select the option for 01 57 19.
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Provide lighting and documentation in conformance with

Section [01 33 29 SUSTAINABILITY REPORTING][01 57 19 TEMPORARY ENVIRONMENTAL CONTROLS] paragraph ENERGY EFFICIENT PRODUCTS. See https://sftool.gov/greenprocurement/green-products/22/lighting-ceiling-fans/0, https://www.energystar.gov/products?s=mega, and https://www.energy.gov/eere/femp/search-energy-efficient-products for more information.

Provide lighting in conformance with the Reduction of Light Pollution requirements in the current Assistance Secretary of the Army for Installations, Energy and Environment (ASA IE&E) Sustainable Design and Development (SDD) policy.

2.1 PRODUCT COORDINATION
Products and materials not considered to be luminaires, equipment or accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, Section 33 71 01.00 40 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 LED and INDUCTION LUMINAIRES
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.

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.

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.

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 tempered glass or UV-resistant acrylic.

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

2.2.2.1 LED Light Sources

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 80 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.

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

2.2.3 Luminaire Power Supply Units (Drivers)

2.2.3.1 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.

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.

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.

l. 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.

2.2.3.3 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.

2.3 OBSTRUCTION MARKER LUMINAIRES
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.

2.4 EXTERIOR LUMINAIRE CONTROLS
Controls shall comply with Section 9 of ASHRAE 90.1 - SI ASHRAE 90.1 - IP. 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
UL 773 or UL 773A. Photocells shall be hermetically sealed, silicon diode light sensor type, rated at [_____] watts, [_____] volts, 50/60 Hz with single-pole, single-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of 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 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 photocell with metal oxide varistor (MOV) type surge protection.

2.4.2 Lighting Contactor
NEMA ICS 2. Provide a electrically-held lighting contactor housed in a NEMA 3R or 4[_____] enclosure conforming to NEMA ICS 6. Contactor shall have 2, [4][6][_____] poles, configured as normally open (NO). Contacts shall be rated [600] [_____] volts, 30[_____] amperes for a resistive load. Coil operating voltage shall be 120, 277[_____] volts. Contactor shall have silver cadmium oxide double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic on-off selector switch.

2.4.3 Lighting Control Relay Panel
Panel shall consist of a single NEMA 3R flush-mounted enclosure with two separate interior sections; one for Class 1 (branch circuit) and one for Class 2 (low voltage) wiring. Provide panel with [16][32][_____] relays. Panel shall be designed as 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 LONworks field-programmable application controller for panels connected to the facility automated control system]. Panel enclosure shall be constructed of 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).

2.4.4 Motion Sensor
NEMA WD 7, UL 773A. Provide 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. Sensor shall be equipped with a threaded base for mounting to a weatherproof junction box][mounted directly to luminaire.

2.5 POLES
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 or anchor-base type designed for use with underground or 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 silver 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 factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be 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
ATIS ANSI O5.1 and RUS Bull 1728F-700 of 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 AWPA 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.

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.

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
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 _____":

a. 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.

2.9 FACTORY APPLIED FINISH
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
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.

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
Install according to pole manufacturer's instructions.

3.1.4 Aluminum Steel Poles
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

3.1.5 Pole Setting
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
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 --