Handout for: The Hidden Cost Of Light: Specifying Controllable Low CCT And Amber Outdoor Lighting To Combat Light Pollution

Specification Additions and Changes Examples

In The American Institute of Architects (AIA) MasterSpec Format

Spec Editor Note additions are blue text with gray highlight

Spec text is bold black text with gray highlight

SECTION 265000 - LIGHTING

PART 1 - GENERAL

1.1 DEFINITIONS

When including non-white light sources in the project edit requirements for each characteristic for each included type accordingly. Some non-white sources have CCT definitions in Kelvin defined in ANSI C78.377-2024 and others are not defined in that standard and require the specifier to state color and/or specific wavelength. For more information on specifying non-white light sources see Annex F, Specifications for 2000K and 1800K (Informative) in ANSI C78.377-2024. It is recommended that specifiers refer to *Specifying Non-White Light Sources in Outdoor Applications to Reduce Light Pollution* by Esposito and Radetsky (2023) to fully appreciate the factors involved when using non-white sources. The editors notes in this section related to non-white light are sourced from that paper.

A. Direct-emission amber LED (DE-Amber): A DE Amber LED is based on an Aluminum-Indium-Gallium-Phosphide chip (AlInGaP) directly emitting long wavelength radiation with a peak wavelength of 590 nm to 605 nm, and a FWHM of approximate 15 nm to 20 nm.

B. Direct-emission other: Other direct-emission narrowband LEDs (e.g., "DE Red"): These non-white LEDs, such as direct emitting AlInGaP red LEDs, emit narrowband radiation directly (FWHM from approximately 15 nm to 20 nm). They have saturated color appearances and chromaticity coordinates very near the spectrum locus.

C. **Phosphor-converted amber LED (PC-Amber): A PC Amber LED is based on a blue-emitting Indium Nitride-Gallium Nitride chip (InGan) paired with a reddish phosphor that fully, or nearly fully, down-converts the short wavelength radiation into longer wavelength broadband emission with a peak wavelength occurring near approximately 595 nm to 605 nm, and a full-width at half-maximum (FWHM) range of 80 nm to 90 nm.**

D. **Non-White Light: Sources without an ANSI C78.377-2024 defined CCT or with a CCT less than 2200K as defined by that standard.**

E. **White Light: Sources with a defined CCT quadrangle in ANSI C78.377-2024 of 2200K or higher.**

PART 2 - PRODUCTS

2.1 LUMINAIRES

A. Luminaire

1. Source Limitations:

a. **White-light defined by ANSI C78.377-2024:** [Bin LEDs for this luminaire type within seven-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type].

b. **Non-white Light defined by ANSI C78.377-2024 CCT: [1800K] [2000 K]** [Bin LEDs for this luminaire type within seven-step MacAdam Ellipse to ensure consistent chromaticity for all luminaires of this type].

Efficacy of non-white light sources varies widely depending on type. The specifier is referred to the above cited paper for a thorough discussion. Use caution when selecting efficacy limits and consider using DesignLights Consortium qualified product requirements to establish lower efficacy limits.

Non-white light sources without a definition in ANSI C78.377-2024 require defining the desired color characteristic in different ways depending on the source type.

PC Amber implies an SPD with a broadband spectral component generated by a reddish phosphor and may have a noticeable short wavelength "hump". The chromaticity boundary coordinates are provided in Table 3 of the referenced paper (reproduced below). When there is no overlap with Expanded Quadrangles choose "PC Amber". When there is overlap with one of the Expanded quadrangles of ANSI C78.377-2024 you must choose either "PC Amber – 1800 K" or Or "PC Amber – 2000 K"

x	*y*
0.5400	0.4590
0.5280	0.4430
0.5478	0.4260
0.5469	0.4249
0.5700	0.4100
0.5715	0.4099
0.5730	0.4089
0.5787	0.4033
0.5926	0.4074

Table 3 CIE 1931 xy chromaticity coordinates for the boundary of real PC Amber LED products from Esposito and Radeteky, 2023.

DE Amber LEDs are narrowband with a peak wavelength near approximately 590 nm. They emit light directly—they do not use phosphor—and have no broadband spectral component. You specify Color Name & Peak Wavelength "DE Amber – Peak WLnm" Example: "DE Amber – 590 nm".

Other narrowband DE LEDs that have SPDs with chromaticities near the spectrum locus and peak wavelengths longer than approximately 595 nm should be specified by Color Name & Peak Wavelength. "DE Color Name – Peak WL nm" Example: "DE Red – 640 nm".

2. Listing Criteria:

a. LED Luminaires:

1) Efficacy **for light defined by ANSI C78.377-2024**: [**75 lm/W**] [**80 lm/W**] [**85 lm/W**] <**Insert lm/W**>.
2) Efficacy **for light not defined by ANSI C78.377-2024**: Not less than [30 lm/W] <Insert lm/W>.
3) Rated Life: [35 000] [50 000] <Insert number> hours to L70.
4) **White-light defined by ANSI C78.377-2024** CCT: [**2700-2200 K (flame)**] [**Three-step selectable 2700-2500-2200 K**] **[2200 K]** [**2700 K**] [**3000 K**] [**3500 K**] [**4000 K**] [**5000 K**] [**6500 K**] [**Five-step selectable 3000-6500 K**] [**Three-step selectable 3000-4000-5000 K**] <**Insert kelvins**>.
5) **Non-white Light defined by ANSI C78.377-2024 CCT: [1800K] [2000 K]**
6) **Non-white Light not defined by ANSI C78.377-2024: [PC Amber] [PC Amber – 1800K] [PC Amber – 2000K]** [**DE Amber – <insert Peak WL nm>] [DE <insert Color Name> – <insert Peak WL nm>]**
7) CRI:
   a) **White-light defined by ANSI C78.377-2024: [70+]** [80+] [90+]
   b) **Non-white light defined by ANSI C78.377-2024: [50+] [70+] [<insert number>+]**
   c) **Non-white Light not defined by ANSI C78.377-2024: [PC-Amber: 40+]**

3. Sustainable Design Features:
   a. Energy Efficiency of LED Luminaires: Luminaire is certified by: [Energy Star] [and] [Design Lights Consortium] **[DesignLights Consortium LUNA].**

END OF SECTION 265000.

In the UFGS Format

Additions are red text with gray highlight

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USACE / NAVFAC / AFCEC **UFGS-26 56 00 (August 2021)**

Preparing Activity: NAVFAC **Superseding**
UFGS-26 56 00 (May 2020)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2025
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-- End of Section Table of Contents --

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****

SECTION 26 56 00

EXTERIOR LIGHTING

08/21

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*** NOTE: This guide specification covers lighting and lighting control 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) 'Lighting Handbook, 10th Edition' 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).
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*** NOTE: For supplemental information regarding UFGS 26 56 00, including PDF and CAD downloads of luminaire plates, go to:**
http://www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs/uf
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*** NOTE: This section contains the following luminaire plates (also referred to as 'sketches' or 'details'.) These are available in metric (SI) and U.S. Customary (IP) system dimensions. Plate titles and style numbers are unchanged for both units.**

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

PLATE NUMBER	Title
XL-1	LED ROADWAY LUMINAIRE
XL-2	LED AREA LUMINAIRE
XL-3	LED PEDESTRIAN LUMINAIRE
XL-4	LED ILLUMINATED BOLLARD
XL-5	LED PARKING LOT LUMINAIRE
XL-6	LED PARKING GARAGE LUNINAIRE
XL-7	LED EXTERIOR STEP LIGHT
XL-8	LED EXTERIOR WALL SCONCE
XL-9	LED EXTERIOR DECORATIVE WALL SCONCE
XL-10	LED WALL PACK
XL-11	EXTERIOR RECESSED DOWNLIGHT
XL-12	LED LINEAR WALL WASH
XL-13	AVIATION OBSTRUCTION LUMINAIRE
XL-14	LED FLOOD LUMINAIRE
XL-15	DIRECT-SET FIBERGLASS POLE
XL-16	DIRECT-SET CONCRETE POLE
XL-17	DIRECT-SET STEEL/ALUMINUM POLE

PLATE NUMBER	Title
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XL-19	ANCHOR BASE STEEL/ALUMINUM POLE
XL-20	ANCHOR BASE CONCRETE POLE
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XL-24	LUMINAIRE MOUNTING ARM DETAILS
XL-25	LUMINAIRE MOUNTING BRACKET DETAILS
XL-26	LUMINAIRE MOUNTING BRACKET DETAILS
NOTE: Do not include this index in project specification.	

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*** NOTE: Include the following information on the project drawings:**

1. Luminaire schedule indicating luminaire symbol; luminaire type; XL plate number and type designation; light source; voltage; input watts; delivered lumen output; efficacy; CCT; CRI; LED driver; dimming; mounting; NEMA distribution if applicable; BUG rating if applicable; and any other applicable options or notes.

2. Location and mounting height of all luminaires and required accessories such as, mounting brackets and poles.

3. Referenced XL plate number or detail (if no XL plate is available) for each luminaire type provided.

4. All accessories required, such as mounting hardware, mounting brackets, arms, NEMA 7-pin receptacles, remote drivers, emergency back-up, sensors and control equipment, and central emergency system components.

5. Control strategy description for each given area.

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

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*** 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.**
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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 within the text by the basic designation only.

ALLIANCE FOR TELECOMMUNICATIONS INDUSTRY SOLUTIONS (ATIS)

ATIS ANSI O5.1	(2017) 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 CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

AMERICAN WOOD PROTECTION ASSOCIATION (AWPA)

AWPA U1	(2024) Use Category System: User

	Specification for Treated Wood

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2024) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2023) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM B108/B108M	(2019) Standard Specification for Aluminum-Alloy Permanent Mold Castings
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM C1089	(2013) Standard Specification for Spun Cast Prestressed Concrete Poles
ASTM G154	(2023) Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2016) Building Energy Efficiency Standards For Residential and Nonresidential Buildings

EUROPEAN UNION (EU)

Directive 2011/65/EU	(2011) Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

ILLUMINATING ENGINEERING SOCIETY (IES)

ANSI/IES LM-79	(2019) Approved Method: Electrical and Photometric Measurements of Solid State Lighting Products
ANSI/IES LM-80	(2020) Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules
ANSI/IES LP-11	(2020) Lighting Practice: Environmental Considerations for Outdoor Lighting
ANSI/IES LS-1	(2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering
ANSI/IES RP-8	(2018; Addenda 1 2020; Errata 1-2 2021) Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting
ANSI/IES TM-15	(2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires

ANSI/IES TM-21	(2021) Technical Memorandum: Projecting Long-TermLuminous, Photon, and Radiant Flux Maintenance of LED Light Sources
ANSI/IES TM-27	(2020) Technical Memorandum: IES Standard Format For The Electronic Transfer Of Spectral Data
IES Lighting Library	IES Lighting Library

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
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 C136.3	(2020) Roadway and Area Lighting Equipment - Luminaire Attachments
ANSI C136.13	(2020) Roadway and Area 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 C136.41	(2013) Roadway and Area Lighting Equipment-Dimming Control Between an External Locking Type Photocontrol and Ballast or Driver
NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.377	(2024) Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products
NEMA C82.77-10	(2020) Harmonic Emission Limits - Related Power Quality Requirements
NEMA C136.10	(2023) 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; R 2021) Roadway and Area Lighting Equipment - Fiber Reinforced Composite (FRC) Lighting Poles
NEMA C136.31	(2023) Roadway and Area Lighting

	Equipment - Luminaire Vibration
NEMA ICS 2	(2000; R 2020) 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 SSL 1	(2016) Electronic Drivers for LED Devices, Arrays, or Systems
NEMA SSL 3	(2011) High-Power White LED Binning for General Illumination
NEMA WD 7	(2011; R 2016; R 2021) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023; ERTA 1 2024; TIA 24-1) 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

UL SOLUTIONS (UL)

UL 773	(2016; Reprint Jul 2020) UL Standard for Safety Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2016; Reprint Jan 2024) UL Standard for Safety Nonindustrial Photoelectric Switches for Lighting Control
UL 916	(2015; Reprint Oct 2021) UL Standard for Safety Energy Management Equipment
UL 924	(2016; Reprint Dec 2022) UL Standard for Safety Emergency Lighting and Power Equipment
UL 1310	(2018; Reprint Jun 2022) UL Standard for Safety Class 2 Power Units
UL 1598	(2021; Reprint Jan 2024) UL Standard for Safety Luminaires
UL 8750	(2020; Reprint Aug 2024) UL Standard for Safety Light Emitting Diode (LED)

1.2 RELATED REQUIREMENTS

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

For the purpose of this document, exterior luminaires include luminaires mounted in exterior environments that are not attached to the building. Luminaires attached to the exterior of the building are specified in Section 26 51 00 INTERIOR LIGHTING.
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Materials not considered to be luminaires, luminaire accessories, or lighting equipment are specified in Section(s) [33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION] [33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION]. Luminaires and accessories installed in interior of buildings or attached to the exterior of a building are specified in Section 26 51 00 INTERIOR LIGHTING. Cybersecurity requirements are specified in Section 25 05 11.[_____] CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.Commissioning requirements are specified in Section 01 91 00.15 BUILDING COMMISSIONING.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications and on the drawings must be as defined in IEEE 100 and ANSI/IES LS-1.

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 ANSI/IES LM-80.

c. For LED luminaires, "Luminaire Efficacy" (LE) is the appropriate measure of energy efficiency, measured in lumens/watt. This is gathered from LM-79 data for the luminaire, in which absolute photometry is used to measure the lumen output of the luminaire as one entity, not the source separately and then the source and housing together.

d. Total Harmonic Distortion (THD) is the Root Mean Square (RMS) of all the harmonic components divided by the total fundamental current.

e. 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.

f. Direct-emission amber LED (DE-Amber): A DE Amber LED is based on an Aluminum-Indium-Gallium-Phosphide chip (AlInGaP) directly emitting long wavelength radiation with a peak wavelength of 590 nm to 605 nm, and a FWHM of approximate 15 nm to 20 nm.

g. Direct-emission other: Other direct-emission narrowband LEDs (e.g., “DE Red”): These non-white LEDs, such as direct emitting AlInGaP red LEDs, emit narrowband radiation directly (FWHM from approximately 15 nm to 20 nm). They have saturated color appearances and chromaticity coordinates very near the spectrum locus.

h. Phosphor-converted amber LED (PC-Amber): A PC Amber LED is based on a blue-emitting Indium Nitride-Gallium Nitride chip (InGan) paired with a reddish phosphor that fully, or nearly fully, down-converts the short wavelength radiation into longer wavelength broadband emission with a peak wavelength occurring near approximately 595 nm to 605 nm, and a full-width at half-maximum (FWHM) range of 80 nm to 90 nm.

i. Non-White Light: Sources without an ANSI C78.377-2024 defined CCT or with a CCT less than 2200K as defined by that standard.

j. White Light: Sources with a defined CCT quadrangle in ANSI C78.377-2024 of 2200K or higher.

k. SPDX: SPDX documents contain spectral data for a luminaire and are formatted per ANSI/IES TM-27. TM-27 specifies the method for sharing radiometric power as a function of wavelength, typically represented as a table of wavelengths and corresponding radiometric power. The SPDX XML document is separated into a header element and a spectral distribution element. The header element contains all the generic information about the dataset; the spectral distribution element contains the specific data. SPDX files can be imported into spreadsheets to allow analysis of the spectral distribution and generate values such as scotopic/photopic (S/P)ratios.

1.4 SUBMITTALS

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*** NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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*** NOTE: Luminaire shop drawings are required for custom luminaires, luminaires specified to a specific custom length, or linear luminaires with lengths greater than 2.5 meters 8 feet.**

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Luminaire Drawings; G, [_____]

Pole Drawings; G, [_____]

Control System One-Line Diagram; G, [_____]

Sequence of Operation for Exterior Lighting Control System; G, [_____]

SD-03 Product Data

Luminaires; G, [

_____]

Light Sources; G, [__

_____]

LED Drivers; G, [____]

Luminaire Warranty; G, [_____]

Lighting Controls Warranty; G, [_____]

Pole Warranty; G, [_____]

Dimming Panel; G, [_____]

Motion Sensors; G, [____]

Photosensors; G, [_____]

Time Clock; G, [_____]

Lighting Contactor; G, [_____]

Poles; G, [_____]

Brackets

Obstruction Marker Luminaires; G, [_____]

[SD-04 Samples

Luminaire Samples; G, [_____]

] SD-05 Design Data

Luminaire Design Data; G, [_____]

Photometric Plan; G, [_____]

SD-06 Test Reports

ANSI/IES LM-79 Test Report; G, [_____]

ANSI/IES LM-80 Test Report; G, [_____]

ANSI/IES TM-21 Test Report; G, [_____]

ANSI/IES TM-27 Spectral Power Distribution

(SPDX); G, [_____]

Pressure Treated Wood Pole Quality; G, [_____]

Tests for Fiberglass Poles; G, [ ]

SD-08 Manufacturer's Instructions

Poles

SD-10 Operation and Maintenance Data

Lighting System, Data Package 5; G, [_____]

Exterior Lighting Control System, Data Package 5; G, [_____]

Maintenance Staff Training Plan; G, [_____]

End-User Training Plan; G, [______________]

1.5 QUALITY ASSURANCE

Data, drawings, and reports must employ the terminology, classifications and methods prescribed by the IES Lighting Library as applicable, for the lighting system specified.

1.5.1 Drawing Requirements

1.5.1.1 Luminaire Drawings

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NOTE: EPA and weight must be included in the luminaire drawings for pole-mounted luminaires.

Aiming diagrams are required for applications with directional luminaires, such as adjustable landscape and tree lighting, sports lighting, and wallwash applications.

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Include dimensions,[effective projected area (EPA), weight,] accessories, and installation and construction details. Photometric data, including CRI, CCT, TM-15-11 BUG rating, LED driver type,[aiming diagram,] zonal lumen data, and candlepower distribution data per LM-79 must accompany shop drawings.

1.5.1.2 Pole Drawings

****
*** NOTE: Wind loads for roadway luminaires are defined by AASHTO LTS. For other non-roadway poles, use ASCE 7-16.**
****

Include dimensions, wind load determined in accordance with [AASHTO LTS][ASCE 7-16], 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 Luminaire Design Data

a. Provide distribution data according to IES classification type as defined in IES Lighting Library and ANSI/IES RP-8.

b. B.U.G. rating for the installed position as defined by ANSI/IES TM-15 and shielding as defined by ANSI/IES RP-8.

c. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification in accordance with 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 ANSI/IES TM-21. Data used for projections must be obtained from testing in accordance with ANSI/IES LM-80.

e. Provide wind loading calculations for luminaires mounted on poles. Weight and effective projected area (EPA) of luminaires and mounting brackets must not exceed maximum rating of pole as installed in particular wind zone area.

1.5.3 ANSI/IES LM-79 Test Report

Submit test report on manufacturer's standard production model of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in ANSI/IES LM-79.

1.5.4 ANSI/IES LM-80 Test Report

Submit report on manufacturer's standard production LED light source (package, array, or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data as outlined under "8.0 Test Report" in ANSI/IES LM-80.

1.5.5 ANSI/IES TM-21 Test Report

Submit test report on manufacturer's standard production LED light source (package, array or module) of specified luminaire. Testing must be performed at the same operating drive current as specified luminaire. Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in ANSI/IES TM-21.

1.5.6 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 must be as a cantilever beam with pole butt as fixed end and a force simulating wind load at the free end.

1.5.7 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 AWPA 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 AWPA treatment standards.

[1.5.8 Photometric Plan

****

*** NOTE: Require photometric plans and design criteria to be submitted if the project is a Design-Build project and will not have an engineer or designer producing photometrics during design.**

Select ANSI/IES RP-8 for roadway and parking facilities photometric plans and ANSI/IES LP-11 for all other exterior environment scenarios.

For roadway designs, require average maintained luminance.

****

For [roadways][parking lots][intersections][_____] include computer-generated photometric analysis of the "designed to" values in accordance with [ANSI/IES RP-8][ANSI/IES LP-11] for the "end of useful life" of the luminaire installation using a light loss factor of 0.81. Provide photometric plans that meet criteria in the Basis of Design in the project plans. Include the following in the submittal:

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

b. Vertical illuminance measurements at 1500 mm 5 feet above finished grade at all sidewalks and crosswalks, taken at a maximum of 3050 mm 10 feet.

c. Minimum and maximum lux footcandle levels.

d. Average maintained lux footcandle level.

e. Maximum to minimum ratio for horizontal illuminance only.

[f. Average maintained luminance in candela per square meter.

]]1.5.9 Test Laboratories

Test laboratories for the ANSI/IES LM-79 and ANSI/IES LM-80 test reports must 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. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.10 Regulatory Requirements

Equipment, materials, installation, and workmanship must be in accordance with the mandatory provisions of NFPA 70 unless more stringent requirements are specified or indicated. Provide luminaires and assembled components that are approved by and bear the label of UL for the applicable location and conditions unless otherwise specified.

1.5.11 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 must have been in satisfactory commercial or industrial use for six months prior to bid opening. The six-month period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the six-month period. Where two or more items of the same class of equipment are required, these items must 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.

1.5.11.1 Alternative Qualifications

Products having less than a six-month field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.11.2 Material and Equipment Manufacturing Date

Do not use products manufactured more than six months prior to date of delivery to site, unless specified otherwise.

1.6 DELIVERY, STORAGE, AND HANDLING OF POLES

1.6.1 Aluminum 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.

1.6.2 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.

1.6.3 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 must 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.

1.6.4 Fiberglass 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.

1.6.5 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.

1.7 WARRANTY

Support all equipment items 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 Luminaire Warranty

Provide and transfer to the government the original LED luminaire manufacturers standard commercial warranty for each different luminaire manufacturer used in the project.

a. Provide a written five year minimum replacement warranty for material, luminaire finish, and workmanship. Provide written warranty document that contains all warranty processing information needed, including customer service point of contact, whether or not a return authorization number is required, return shipping information, and closest return location to the luminaire location.

   (1) Finish warranty must include failure and substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

   (2) Material warranty must include:

      (a) All LED drivers and integral control equipment.

      (b) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) are defective, non-starting, or operating below 70 percent of specified lumen output.

b. Warranty period must begin in accordance with the manufacturer's standard warranty starting date.

c. Provide replacements that are promptly shipped, without charge, to the using Government facility point of contact and that are identical to or an improvement upon the original equipment. All replacements must include testing of new components and installation.

1.7.2 Lighting Controls Warranty

Provide and transfer to the government the original lighting controls

manufacturers standard commercial warranty for each different lighting controls manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Warranty service must be performed by a factory-trained engineer or technician.

a. Unless otherwise noted, provide a written five year minimum warranty on the complete system for all systems with factory commissioning. Provide warranty that covers 100 percent of the cost of any replacement parts and services required over the five years which are directly attributable to the product failure. Failures include, but are not limited to, the following:

(1) Software: Failure of input/output to execute switching or dimming commands.

(2) Damage of electronic components due to transient voltage surges.

(3) Failure of control devices, including but not limited to photosensors and motion sensors.

b. Provide a written five year minimum warranty on all input devices against defect in workmanship or materials provided by device manufacturer.

c. Provide a written five year minimum warranty on all control components attached to luminaires against defect in workmanship or materials.

1.7.3 Pole Warranty

****
*** NOTE: Three year pole warranty is preferred. Select one year when three years is not available.**
****

Provide and transfer to the government the original pole manufacturers standard commercial warranty for each different pole manufacturer used in the project. Warranty coverage must begin from date of final system commissioning or three months from date of delivery, whichever is the earliest. Provide a written [3] [one] year minimum replacement warranty for material, luminaire finish, and workmanship. Warranty service must be performed by a factory-trained engineer or technician.

1.8 OPERATION AND MAINTENANCE MANUALS

1.8.1 Lighting System

Provide operation and maintenance manuals for the lighting system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the lighting system. Additional O&M Manual requirements for the Army are provided in Section 01 78 24.00 10 FACILITY DATA REQUIREMENTS. Additional requirements for the Navy are provided in Section 01 78 24.00 20 FACILITY DATA WORKBOOK (FDW). Include the following:

a. Manufacturers' operating and maintenance manuals.

b. Luminaire shop drawings for modified and custom luminaires.

c. Luminaire Manufacturers' standard commercial warranty information as specified in paragraph LUMINAIRE WARRANTY.

1.8.2 Exterior Lighting Control System

Provide operation and maintenance manuals for the exterior lighting control system in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA that provide basic data relating to the design, operation, and maintenance of the exterior lighting control system. Include the following:

a. Control System One-Line Diagram

b. Product data for all devices, including installation and programming instructions.

c. Training materials, such as videos or in-depth manuals, that cover basic operation of the lighting control system and instructions on modifying the control system. Training materials must include calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

[d. Motion sensor coverage layout.

]PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

2.2 LUMINAIRES

****
*** NOTE: Only require the acquisition of samples for luminaire installations that warrant mock-ups, such as wall grazing unique materials, or for applications where aesthetics are of high priority.**
****

UL 1598, NEMA C82.77-10. Provide luminaires as indicated in the luminaire schedule and XL plates or details on project plans, complete with light source, wattage, and lumen output indicated. All luminaires of the same type must be provided by the same manufacturer. Luminaires must be specifically designed for use with the LED driver and light source provided.

[2.2.1 Luminaire Samples

****
*** NOTE: Only require the acquisition of samples for luminaire installations that warrant mock-ups, such as wall grazing unique materials, for custom luminaires, or for applications where aesthetics are of high priority.**
****

Submit one sample of each luminaire type [_____], complete with light source and LED driver rated for 120 V operation, and 2 meters 6 feet pigtail with 3-prong Edison plug. Sample will be returned to the Contractor for installation in the project work.

]2.2.2 Luminaires

****
*** 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.**

Provide design information including delivered lumen output, L70 lumen maintenance data, and luminaire efficacy in luminaire schedule on project plans.
****

UL 8750, ANSI/IES LM-79, ANSI/IES LM-80. For all luminaires, provide:

a. Complete system with LED drivers and light sources.

b. Housing constructed of non-corrosive materials. All new aluminum housings must be anodized or powder-coated. All new steel housings must be treated to be corrosion resistant.

c. ANSI/IES TM-21, ANSI/IES LM-80. Minimum L70 lumen maintenance value of 50,000 hours for light defined by ANSI C78.377 and 35,00 hours for non-white light not defined by ANSI C78.377 unless otherwise indicated in the luminaire schedule. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Minimum efficacy as specified in the luminaire schedule. Theoretical models of initial lamp lumens per watt are not acceptable. If efficacy values are not listed in the luminaire schedule, provide luminaires that meet the following minimum values:

Luminaire Style	Minimum Luminaire Efficacy
Area and Roadway (pole mounted, arm mounted)	119 LPW
Pedestrian Post-Top (pole mounted, arm mounted)	97 LPW
Bollard	45 LPW
Accent (adjustable landscape, sign lighting)	35 LPW
Linear Accent (facade, wallwash)	80 LPW
Exterior Wall Sconce	50 LPW
Steplight	30 LPW
Parking Garage Luminaire	113 LPW
Efficacy for light defined by ANSI C78.377 at 1800K and 2000K	90 LPW
Efficacy for de-Amber LED luminaires not defined by ANSI C78.377	30 LPW
Efficacy for pc-Amber LED luminaires not defined by ANSI C78.377	70 LPW

e. Product 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].

f. UL listed for wet locations.[Optical compartment for LED luminaires must be sealed and rated a minimum of IP65 per NEMA IEC 60529.]

g. IES Lighting Library. Light distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans.

h. Housing finish that is baked-on enamel, anodized, or baked-on powder coat paint. Finish must be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.

i. LED driver and light source package, array, or module are accessible for service or replacement without removal or destruction of luminaire.

j. ANSI/IES TM-15. Does not exceed the BUG ratings as listed in the luminaire schedule. If BUG ratings are not listed in the luminaire schedule, provide luminaires that meet the following minimum values for each application and mounting conditions:

Lighting Application	Mounting Conditions	BUG Rating
Area and Roadway	All	B3-U0-G3
Pedestrian Post-Top	All	B2-U1-G1
Exterior Wall Sconce	Above 1.2 meters 4 feet AFF	B1-U0-G2
Exterior Wall Sconce	Below or at 1.2 meters 4 feet AFF	B4-U0-G4
Steplight	Above 1.2 meters 4 feet AFF	B1-U1-G2
Steplight	Below or at 1.2 meters 4 feet AFF	B4-U1-G4
Parking Garage Luminaire	Ceiling mounted	B4-U4-G3

k. Fully assembled and electrically tested prior to shipment from factory.

l. Finish color is as indicated in the luminaire schedule or detail on the project plans.

m. Lenses constructed of [clear][frosted] tempered glass or UV-resistant acrylic.[Provide polycarbonate vandal-resistant lenses.]

n. All factory electrical connections are made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

o. NEMA C136.31. Comply with 3G vibration testing.

[p. Luminaire arm bolts constructed from 304 stainless steel or zinc-plated steel.]

[c

luminaires is accessible without the use of hand tools to manipulate small screws, bolts, or hardware.]

[r. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks,
LED drivers, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.][s. ANSI C136.3. For all roadway and area luminaires, provide products with an integral tilt adjustment of plus or minus 5 degrees to allow the unit to be leveled.]

[2.2.3 Obstruction Marker Luminaires

****
*** NOTE: 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 AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS.

]2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type, lumen rating, and wattage as indicated in luminaire schedule on project plans.

2.3 .1 LED Light Sources

****
*** NOTE: A color temperature of 3000 K is standard for most applications. When specifically desired by the designer, a nominal color temperature of 2700 K, 3500 K, or 4000 K may be selected. The highest allowable CCT is 4100 K.**

For area and roadway projects where color detection is not of high importance, select a CRI of 70.

When including non-white light sources in the project edit requirements for each characteristic for each included type accordingly. Some non-white sources have CCT definitions in Kelvin defined in ANSI C78.377-2024 and others are not defined in that standard and require the specifier to state color and/or specific wavelength. For more information on specifying non-white light sources see Annex F, Specifications for 2000K and 1800K (Informative) in ANSI C78.377-2024. It is recommended that specifiers refer to Specifying Non-White Light Sources in Outdoor Applications to Reduce Light Pollution by Esposito and Radetsky (2023) to fully appreciate the factors involved when using non-white sources. The editors notes in this section related to non-white light are sourced from that paper.

Efficacy of non-white light sources varies widely depending on type. The specifier is referred to the above cited paper for a thorough discussion. Use

caution when selecting efficacy limits and consider using DesignLights Consortium qualified product requirements to establish lower efficacy limits.

Non-white light sources without a definition in ANSI C78.377-2024 require defining the desired color characteristic in different ways depending on the source type.

PC Amber implies an SPD with a broadband spectral component generated by a reddish phosphor and may have a noticeable short wavelength "hump". The chromaticity boundary coordinates are provided in Table 3 of the referenced paper (reproduced below). When there is no overlap with Expanded Quadrangles choose "PC Amber". When there is overlap with one of the Expanded quadrangles of ANSI C78.377-2024 you must choose either "PC Amber – 1800 K" or Or "PC Amber – 2000 K"

x	*y*
0.5400	0.4590
0.5280	0.4430
0.5478	0.4260
0.5469	0.4249
0.5700	0.4100
0.5715	0.4099
0.5730	0.4089
0.5787	0.4033
0.5926	0.4074

Table 3 CIE 1931 xy chromaticity coordinates for the boundary of real PC Amber LED products from Esposito and Radeteky, 2023.

DE Amber LEDs are narrowband with a peak wavelength near approximately 590 nm. They emit light directly—they do not use phosphor—and have no broadband spectral component. You specify Color Name & Peak Wavelength "DE Amber – Peak WLnm" Example: "DE Amber – 590 nm".

Other narrowband DE LEDs that have SPDs with chromaticities near the spectrum locus and peak wavelengths longer than approximately 595 nm should be specified by Color Name & Peak Wavelength. "DE Color Name – Peak WL nm" Example: "DE Red – 640 nm".

****

Provide LED light sources that meet the following requirements:

a. NEMA ANSLG C78.377. Emit white light and have a nominal Correlated Color Temperature (CCT) of [1800][2000][3000][2700][3500][4000]

Kelvin.

b. For light not defined by ANSI C78.377 refer to luminaire schedule on project plans.

c. For light defined by ANSI C78.377: Minimum Color Rendering Index (CRI) of [80][70].

d. For light not defined by ANSI C78.377 refer to luminaire schedule on project plans.

e. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

f. Light source color consistency by utilizing a binning tolerance within a [4-step][7-step] McAdam ellipse for light defined by ANSI C78.377.

2.4 LED DRIVERS

****

*** 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.**

Require a dimmable driver for all exterior lighting that

will be reduced at curfew in accordance with the lighting control strategies in the project plans.

****

NEMA SSL 1, UL 1310. Provide LED Drivers that are electronic, UL Class 1 or Class 2, constant-current type and meet the following requirements:

a. The combined LED driver and LED light source system is greater than or equal to the minimum luminaire efficacy values as listed in the luminaire schedule provided.

b. Operate at a voltage of [120-277][120][277] volts at 50/60 hertz, with input voltage fluctuations of plus or minus 10 percent.

c. Power Factor (PF) greater than or equal to 0.90 at full input power and across specified dimming range.

d. Maximum Total Harmonic Distortion (THD) less than or equal to 20 percent at full input power and across specified dimming range.

e. Operates for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.

f. Meets the "Elevated" (10kV/10kA) requirements per IEEE C62.41.2 -2002. Manufacturer must indicate whether failure of the electrical immunity system can possibly result in disconnect of power to luminaire. Provide surge protection that is integral to the LED driver.

g. Contains integral thermal protection that reduces the output power to protect the driver and light source from damage if the case temperature approaches or exceeds the driver's maximum operating temperature.

h. Complies with the requirements of the Federal Communications

Commission (FCC) rules and regulations, Title 47 CFR part 15, Non-Consumer (Class A) for EMI/RFI (conducted and radiated).

i. Class A sound rating for all drivers mounted under a covered structure, such as a canopy, or where otherwise appropriate.

j. Directive 2011/65/EU. Restriction of Hazardous Substances (RoHS) compliant.

k. UL listed for wet locations typical of exterior installations.

l. [Dimmable, and compatible with a standard dimming control circuit of 0 - 10V][Non-dimmable].

m. 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].

2.4.1 Remote LED Drivers

****

*** NOTE: Do not allow use of remote drivers unless specifically noted on the lighting plate and luminaire schedule.**

****

Provide remote LED Drivers that are [UL listed for wet locations typical of exterior installations][located in an IP68 direct burial enclosure listed for wet location].

2.5 LIGHTING CONTROLS

****

*** NOTE: Include a version of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS edited specifically for the lighting control system where a control system is specified.**

****

[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.]Provide network certification for all networked lighting control systems and devices in accordance with the requirements of Section 25 05 11.[_____] CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS.

2.5.1 System

Provide exterior lighting control system that operates the exterior lighting system as described in the exterior lighting control strategies in the project plans. Submit Sequence of Operation for Exterior Lighting Control System describing the operation of the proposed exterior lighting control system and devices. Sequence of Operation must provide the strategies identified in the exterior lighting control strategies.

2.5.1.1 Relay Panel

****

*** NOTE: Select NEMA 1 enclosure if panel will be**

located indoors with normal conditions, NEMA 3R for indoor or outdoor use when weather resistance is necessary, and NEMA 4 if a watertight enclosure is necessary.

****

Enclose panel hardware in a [surface][flush]-mounted, NEMA [1][3R][4], painted, steel enclosure with lockable access door and ventilation openings. Internal low-voltage compartment must be separated from line-voltage compartment of enclosure with only low-voltage compartment accessible upon opening of door. Provide additional remote cabinets that communicate back to main control panel as required. Provide relay panel that meets the following criteria:

a. Input voltage of [120][277][120-277] at 50/60 Hz, with internal low voltage power supply as required.

b. UL 924. [8][16][32][_____] single-pole latching relays rated at [20][30] amps, [120-277][120][277] volts. Provide provision for relays to close upon power failure. Provide relays designed for 10 years of use at full rated load.

c. Relay control module operates at 24 VDC and is rated to control a minimum of [8][16][32][_____] relays.

d. Dimming Panel

****

*** Select NEMA 1 enclosure if panel will be located indoors with normal conditions, NEMA 3R for indoor or outdoor use when weather resistance is necessary, and NEMA 4 if a watertight enclosure is necessary.**

For projects in the state of California, require compliance with CEC Title 24.

****

UL 916, 47 CFR 15[, CEC Title 24]. Provide dimming panel that is designed as a [a standalone][an automated control system interface] type. Provide panel that meets the following criteria:

e. Consists of a single NEMA [1][3R][4] [flush][surface]-mounted enclosure with two separate interior sections; one for Class 1 (branch circuit) and one for Class 2 (low voltage) wiring.

f. Panel enclosure is constructed of [16][14] gauge cold-rolled steel with baked-on enamel finish.

g. Class 1 section contains the load side of all relays and the incoming branch circuit wiring.

h. Class 2 section contains a 24 VDC control power transformer, relays, relay control modules, and control wiring[, and [BACnet compatibility in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] [LONworks compatibility in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS] field-programmable application controller for panels connected to the facility automated control system].

i. Contains inputs for signals from photosensors, time clocks, and motion

sensors.

j. Capable of 0-10V dimming.

2.5.1.2 Networked Lighting Control System

****

*** NOTE: When providing a control panel that interfaces with the building automated control systems, reference IES Technical Memorandum ANSI/IES LP-6-20 for technical information on various protocols, architectures and topologies for such systems. Include Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION for UMCS and integration requirements. Coordinate read access points and write access points with BAS specifier.**

Select requirements for a wired system if possible. If a wired control system is not available, select requirements for a wireless system. If a wireless system is not a viable option due to security concerns, a powerline carrier system may be used.

****

Provide a networked exterior lighting control system that meets the following requirements:

a. [Wired network][Wireless mesh network][Powerline carrier] system.

b. ANSI C136.41. [Communicates via gateway with [_____] nodes per gateway and a maximum of [_____] meters feet between gateways.] [Gateway-less system with wireless node compatible with 7-pin dimming receptacle. Wireless node must have a communication frequency of [_____][kHz][MHz][GHz] and must be located no greater than [_____] meters feet apart.]

c. Capable of [0-10V][DALI] dimming.

d. Capable of astronomic time clock functions, programmable luminaire grouping, [motion detection][programmable motion detection grouping], light source monitoring, LED driver monitoring, energy monitoring in kilowatt-hours, [remote monitoring with read-only access][remote control and programming with read and write access].

2.5.1.3 Gateway

****

*** NOTE: When specifying BAS interface, coordinate with HVAC specifier to ensure the requirements are described in both specifications. Include Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION for UMCS and integration requirements.**

****

Provide gateway in accordance with Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION. Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports. Provide [BACnet communication interface in accordance with Section 23 09 23.02 BACNET DIRECT DIGITAL CONTROL FOR HVAC

AND OTHER BUILDING CONTROL SYSTEMS][LONworks communication interface in accordance with Section 23 09 23.01 LONWORKS DIRECT DIGITAL CONTROL FOR HVAC AND OTHER BUILDING CONTROL SYSTEMS][_____] that enables remote control and monitoring of lighting from a workstation according to read access points and write access points listed in the paragraph NETWORKED LIGHTING CONTROL SYSTEM. Control features and monitoring points displayed locally at lighting panel must be available through the Gateway. Provide Gateway that meets the following requirements:

a. Microprocessor-based communications device that perform bi-directional protocol translation.

b. Support full bi-directional communication and translation.

c. Contain its own microprocessor, RAM, battery, communication ports, and power supply.

[d. Support an additional 5 percent points for future expansion.

]2.5.2 Devices

2.5.2.1 Time Clock

NEMA ICS 6. House time clock in a surface-mounted, lockable NEMA [1][3R] enclosure constructed of painted steel or plastic polymer. Provide electronic type time clock that meets the following criteria:

a. [24 hour][7 day][astronomic] programming function, providing a total of 56 [_____] on/off set points.

b. [12 hour AM/PM][24 hour] type digital clock display format.

c. Power outage back-up for switch utilizing [a capacitor][alkaline batteries][lithium battery] which provides coverage for a minimum of [seven days][three years][eight years].

d. Capable of controlling a minimum of [1][2][4][_____] channels or loads.

e. Contacts are rated for [30] [_____] amps at 120-277 VAC resistive load in a [SPST][DPST][SPDT][DPST] [normally open (NO)][normally closed (NC)] configuration.

f. Contains [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].

2.5.2.2 Photosensors

****
*** NOTE: 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.**
****

UL 773, UL 773A. Provide Photosensors that meet the following requirements:

a. Hermetically sealed, [cadmium sulfide][silicon diode] light sensor type, rated at [_____] watts, [_____] volts, 50/60 Hz with single-pole, [single][double]-throw contacts.

b. Turns ON at 10 to 30 lux 1 to 3 footcandles and turns OFF at 30 to 150 lux 3 to 15 footcandles.

c. Designed to fail to the ON position.

d. Housing is 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.

e. Time delay that prevents accidental switching from transient light sources.

[f. Directional lens in front of the cell to prevent fixed light sources

from creating a turnoff condition.

] g. Designed for 20-year service to match life expectancy of long-life LED fixtures and exceed 15,000 operations at full load. Provide photosensors with zero-cross technology to withstand severe in-rush current and extend relay life.

[h. [Fixed][Swivel] base type housing with 12.7 mm 1/2 in threaded base for mounting to a junction box or conduit.

]| NEMA C136.10. Twist-lock receptacle type. Provide with solid brass prongs and voltage markings and color coding on exterior of housing.

]|

protection.

]2.5.2.3 Motion Sensors

****

*** NOTE: Select requirement for motion sensors to work with bi-level controllers if required by the Sequence of Operations.**

****

NEMA WD 7, UL 773A. Provide sensors that meet the following requirements:

a. Operating voltage of [12-24][120-277][120][277] volts.

b. [Passive infrared][Microwave][Dual technology passive infrared/microwave] type sensors with [270][_____] degree coverage.

c. Time delay that can be adjusted from 15 seconds to 15 minutes.

d. Default state is "Fail to ON position."

e. Sensors installed integral to the luminaire must be provided by the luminaire manufacturer.

f. Sensor contains an integral light level sensor that does not allow luminaires to operate during daylight hours

g. [Equipped with a threaded base for mounting to a weatherproof junction

box][Mounted directly to luminaire].

[h. Operates in conjunction with bi-level controllers that reduce the connected lighting power by 50 percent.

]2.5.2.4 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 must have [2][4][6][_____] poles, configured as [normally open (NO)][normally closed (NC)]. Contacts must be rated [600] [_____] volts, [30][_____] amperes for a resistive load. Coil operating voltage must be [24][120][277][_____] volts. Contactor must have silver cadmium oxide double-break contacts [and coil clearing contacts for mechanically held contactors] and must 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.]

2.6 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.**

Wind loads for roadway luminaires are defined by AASHTO LTS. For other, non-roadway poles, use ASCE 7-16.

****

[AASHTO LTS][ASCE 7-16]. Provide round [straight][tapered] poles designed for wind loading of [161][_____] km/hr [100][_____] miles per hour while supporting luminaires and all other appurtenances indicated. The effective projected areas (EPA) of luminaires and appurtenances used in calculations must be specific for the actual products provided on each pole. Provide poles that are[embedded][anchor]-base type designed for use with[underground][overhead] supply conductors.[Poles[, other than wood poles,] must have oval-shaped hand hole having a minimum clear opening of 80 by 130 mm 3 by 5 inches. Secure hand hole covers by stainless steel captive screws.][Provide metal poles with an internal grounding connection accessible from the hand hole near the bottom of each pole. Install a means of wire disconnection accessible from the hand hole.] Do not install square poles. Provide poles from a Manufacturer with a standard provision for protecting the finish during shipment and installation. Do not install scratched, stained, chipped, or dented poles.

2.6.1 Aluminum Poles

Provide aluminum poles with [uniform satin][anodized][_____] finish unless otherwise noted in luminaire schedule on project plans. Do not paint aluminum poles. Provide poles that meet the following requirements:

a. AASHTO LTS. Manufactured of corrosion resistant aluminum alloys for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3,5) for cast alloys.

b. Seamless extruded or spun seamless-type with minimum 4.8 mm 0.188 inch wall thickness.

c. Top of shaft is fitted with a round or tapered cover.

d. ASTM B108/B108M. Pole base is mounted by anchor bolts, made of cast 356-T6 aluminum alloy. Base must be machined to receive the lower end of shaft. Joint between shaft and base is welded.

e. ASTM B108/B108M. Base cover is cast 356-T6 aluminum alloy.

f. All hardware other than anchor bolts are either 2024-T4 anodized aluminum alloy or stainless steel.

g. Grounding connection is designed to prevent electrolysis when used with copper ground wire.

2.6.2 Steel Poles

Provide steel poles with[hot-dipped galvanized in accordance with ASTM A123/A123M][iron-oxide primed] factory finish. Provide poles that meet the following requirements:

a. Minimum 11-gage steel with minimum yield/strength of 331 MPa 48,000 psi

b. Pole is [mounted by anchor bolts][direct set].

c. Consists of tapered tubular members, either round in cross section or polygonal.

d. Pole shaft is one piece and is of welded construction with no bolts, rivets, or other means of fastening except as specifically approved.

e. Base covers are of structural quality hot-rolled carbon steel plate, with a minimum yield of 248 MPa 36,000 psi.

f. Markings are approximately 900 to 1270 mm 3 to 4 feet above grade and includes manufacturer, year of manufacture, top and bottom diameters, and length.

g. Grounding connection is designed to prevent electrolysis when used with copper ground wire.

2.6.3 Wood Poles

****

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

****

ATIS ANSI O5.1, RUS Bull 1728F-700. Provide wood poles of[Southern Yellow Pine][Douglas Fir][_____]. Provide poles that meet the following requirements:

a. AWPA U1. RUS Bull 1728F-700. Treated full length with chromated

copper arsenate (CCA) or ammoniacal copper arsenate (ACA). Poles must be gained, bored, and roofed before treatment.

b. 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].

2.6.4 Fiberglass Poles

NEMA C136.20. Provide fiberglass poles with resin color of [dark bronze][_____] with uniform pigment coloration throughout entire wall thickness. Provide poles that meet the following additional requirements:

a. Poles are designed specifically for supporting luminaires and have factory-formed cable entrance and hand hole.

b. Finish surface is 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.

c. Minimum fiberglass content is 65 percent with resin and pigment comprising the other 35 percent material content.

2.6.5 Concrete Poles

ASTM C1089. Cross-sectional shape must be round.

2.6.5.1 Steel Reinforcing

Provide prestressed concrete pole shafts that are reinforced with steel prestressing members. Provide internal longitudinal loading by either pre-tensioning or post-tensioning longitudinal reinforcing members.

2.6.5.2 Tensioned Reinforcing

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

2.6.5.3 Coating and Sleeves for Reinforcing Members

Where minimum internal coverage cannot be maintained next to required core opening, such as hand holes and wiring inlet, protect reinforcing with a vapor proof noncorrosive sleeve over the length without the 1/2 inch concrete coverage. Apply a nonmigrating slipper coating to each steel reinforcing member which is to be post-tensioned prior to the application of concrete to ensure uniformity of stress throughout the length of each member.

2.6.5.4 Strength Requirement

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

2.6.5.5 Shaft Preparation

Provide completed prestressed concrete pole shaft with a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water and frost, and must be clean, smooth, and free of surface voids and internal honeycombing. Do not install poles within 15 days of manufacture.

2.6.6 Brackets and Supports

ANSI C136.3, ANSI C136.13, and ANSI C136.21. Provide pole brackets that are 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 must be coordinated to luminaires provided, and brackets for use with one type of luminaire must be identical. Brackets for pole-mounted street lights must correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 7320 mm 24 feet above street. Provide special mountings or brackets as indicated and of metal which will not promote galvanic reaction with luminaire head.

2.6.7 Pole Foundations

Provide anchor bolts consisting of a steel rod with a minimum yield strength of 344.5 MPa 50,000 psi; the top 305 mm 12 inches of the rod must be galvanized in accordance with ASTM A153/A153M. Concrete must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.7 EQUIPMENT IDENTIFICATION

2.7.1 Manufacturer's Nameplate

Each item of equipment must 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.

2.7.2 Labels

UL 1598. Luminaires must be clearly marked for operation of specific light sources and drivers according to proper light source type. Note the following luminaire characteristics in the format "Use Only _____":

a. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

b. Driver and dimming protocol.

Markings related to light source type must be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when light sources are in place. LED drivers must have clear markings indicating dimming type and indicate proper terminals for the various outputs.

2.8 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.**
****

NEMA 250. Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum meets requirements of corrosion-resistance testing.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Luminaires

****
*** NOTE: Require luminaires to be installed per aiming diagram in applications with directional luminaires, such as adjustable landscape and tree lighting, sports lighting, and wallwash applications.**
****

Install all luminaires in accordance with the luminaire manufacturer's written instructions. Install all luminaires at locations and heights as indicated on the project plans. Level all luminaires in accordance to manufacturer's written instructions.[Aim all luminaires in accordance with aiming diagram.]

[3.1.2 LED Drivers

Provide LED drivers integral to luminaire as constructed by the manufacturer.

[3.1.2.1 Remote LED Drivers

Locate Remote LED Drivers within the maximum distance allowed to reduce voltage drop. Do not locate remote LED drivers further from the light source than specified by the manufacturer. Locate remote LED drivers in dry, well-ventilated, and accessible location, or in accessible IP68-rated enclosure. Provide separate compartments for Class 2 wiring connections and for Class 1 wiring connections. Separation must be barrier-type within the same box or separate boxes with close connector conduit fittings. Field connections must be inside housing or junction box or secured by a quick disconnect wire connector suitable for wet-location. Remote LED drivers must be electronically grounded in accordance with NFPA 70.

]]3.1.3 Field-Applied Painting

****
*** NOTE: Use and coordinate paint and coating requirements with Section 09 90 00 PAINTS AND COATINGS when provided in the job. If Section 09 90 00 PAINTS AND COATINGS is not provided or when requirements are beyond what is specified in Section 09 90 00 PAINTS AND COATINGS, specify the requirements in this paragraph.**
****

Provide field applied painting for luminaire type [_____]. Paint lighting equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Provide painting as specified in Section 09 90 00 PAINTS AND COATINGS.

3.1.4 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.

Delete setting information for pole lengths not required.

****

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

a. Setting depth: Provide pole setting depths 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 must 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 must 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.

3.1.5 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.

3.1.6 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.

3.1.7 Aluminum and 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 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 bells, and ground rods must be as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE and 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 is not allowed.]

3.1.8 Pole Setting

[Set pole to depth as indicated.][Poles in straight runs must 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.]

3.1.9 Lighting Controls

****
*** NOTE: Include a version of Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS edited specifically for the lighting control system where a control system is specified.**
****

Refer to Section 25 05 11.[_____] CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS for additional lighting control installation requirements.

3.1.9.1 Photosensors

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

3.1.9.2 Motion Sensors

Locate sensors in accordance with the manufacturer's recommendation. Locate sensors to achieve coverage of areas as indicated on project plans. Coverage patterns must 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.

3.1.10 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.

3.2 FIELD QUALITY CONTROL

3.2.1 Tests

****
*** NOTE: Coordinate commissioning requirements with Section 01 91 00.15 BUILDING COMMISSIONING.**

****

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Perform initial operational test, consisting of the entire system energized for 72 consecutive hours without any failures of any kind occurring in the system. All circuits must test clear of faults, grounds, and open circuits.

3.2.1.1 Lighting Control Verification Test

Verify lighting control system and devices operate according to approved sequence of operations. Verification tests are to be completed after commissioning.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Training

Provide on-site training to the Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide training that includes calibration, adjustment, troubleshooting, maintenance, repair, and replacement.

3.3.1.1 Maintenance Staff Training

Submit a Maintenance Staff Training Plan at least 30 calendar days prior to training session that describes training procedures for Owner's personnel in the operation and maintenance of lighting and lighting control system. Provide on-site training which demonstrate full system functionality, assigning schedules, calibration adjustments for light levels and sensor sensitivity, integration procedures for connecting to third-party devices, and manual override including information on appropriate use. Provide protocols for troubleshooting, maintenance, repair, and replacement, and literature on available system updates and process for implementing updates.

3.3.1.2 End-User Training

Submit a End-User Training Plan at least 30 calendar days prior to training session that describes training procedures for end-users on the lighting control system. Provide demonstration for each type of user interface. Provide users with the curfew schedule as currently commissioned, including conditional programming based on astronomic time clock functionality. Provide users with the correct contact information for maintenance personnel who will be available to address any lighting control issues.

-- End of Section --