JOINT BASE LEWIS-McCHORD DESIGN STANDARDS
DIVISION 26 - ELECTRICAL

SECTION 26 51 00

INTERIOR LIGHTING

05/2022

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.

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

ASTM INTERNATIONAL (ASTM)

ASTM A580/A580M (2016) Standard Specification for Stainless Steel Wire

ASTM A641/A641M (2019) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire

ASTM A653/A653M (2020) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

ASTM A1008/A1008M (2021a) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

ASTM B164 (2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire

ASTM B633 (2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel

ASTM D4674 REV A (2002; R 2010) Standard Practice for Accelerated Testing for Color Stability of Plastics Exposed to Indoor Office Environments

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 LS-1 (2020) Lighting Science: Nomenclature and Definitions for Illuminating Engineering

ANSI/IES TM-15 (2020) Technical Memorandum: Luminaire Classification System for Outdoor Luminaires

ANSI/IES TM-21 (2019) Technical Memorandum: Projecting Long-Term Lumen, Photon, and Radiant Flux Maintenance of LED Light Sources

ANSI/IES TM-30 (2020) Technical Memorandum: IES Method for Evaluating Light Source Color Rendition 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 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

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C78.54 (2019) Specification Sheet for Tubular Fluorescent Replacement and Retrofit LED Lamps

NEMA 77 (2017) Temporal Light Artifacts: Test Methods and Guidance for Acceptance Criteria

NEMA 250 (2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA ANSLG C78.377 (2017) Electric Lamps— Specifications for the Chromaticity of Solid State Lighting Products

NEMA C82.77-10 (2020) Harmonic Emission Limits – Related Power Quality Requirements

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 SSL 1 (2016) Electronic Drivers for LED Devices, Arrays, or Systems

NEMA SSL 3 (2011) High-Power White LED Binning for General Illumination

NEMA SSL 7A (2015) Phase-Cut Dimming for Solid State Lighting: Basic Compatibility

NEMA WD 1 (1999; R 2020) Standard for General Color Requirements for Wiring Devices

NEMA WD 7 (2011; R 2016; R 2021) Occupancy Motion Sensors Standard

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA

20-4) National Electrical Code
NFPA 101 (2021) Life Safety Code

NFPA 110 (2022) Standard for Emergency and Standby Power Systems

U.S. DEPARTMENT OF ENERGY (DOE)

Energy Star (1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

UNDERWRITERS LABORATORIES (UL)

UL 20 (2018; Reprint Jan 2021) UL Standard for Safety General-Use Snap Switches

UL 94 (2013; Reprint May 2021) UL Standard for Safety Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

UL 508 (2018; Reprint Jul 2021) UL Standard for Safety Industrial Control Equipment

UL 844 (2012; Reprint Oct 2021) UL Standard for Safety Luminaires for Use in Hazardous (Classified) Locations

UL 916 (2015; Reprint Sep 2021) UL Standard for Safety Energy Management Equipment

UL 917 (2006; Reprint Aug 2013) UL Standard for Safety Clock-Operated Switches

UL 924 (2016; Reprint May 2020) UL Standard for Safety Emergency Lighting and Power Equipment

UL 1472 (2015) UL Standard for Safety Solid-State Dimming Controls

UL 1598 (2021; Reprint Jun 2021) Luminaires

UL 1598C (2014) Standard for Light-Emitting Diode (LED) Retrofit Luminaire Conversion Kits

UL 1993 (2017) Self-Ballasted Lamps and Lamp Adapters

UL 2043 (2013) Fire Test for Heat and Visible Smoke Release for Discrete products and Their Accessories Installed in Air-Handling Spaces

UL 8750 (2015; Reprint Sep 2021) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.2 RELATED REQUIREMENTS
Materials not considered to be luminaires or luminaire accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires and accessories mounted on exterior surfaces of buildings are specified in Section 26 56 00 EXTERIOR LIGHTING. Cybersecurity requirements are specified in Section 25 05 11 CYBERSECURITY FOR FACILITY-RELATED CONTROL SYSTEMS. Commissioning requirements for Army and Air Force projects are specified in Section 01 91 00.15 10 TOTAL BUILDING COMMISSIONING. Emergency lighting requirements are specified in Section 26 52 00.00 40 EMERGENCY LIGHTING.

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 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.

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
Interior Lighting (Energy Efficiency); S

SD-02 Shop Drawings
Luminaire Drawings; G
Occupancy/Vacancy Sensor Coverage Layout; G

SD-03 Product Data
Luminaires; G
Light Sources; G
LED Drivers; G
LED Luminaire Warranty; G
Vacancy Sensors; G
Dimming Controllers (Dimmers); G
Lighting Contactor; G
Timeswitch; G
Power Hook Luminaire Hangers; G
Exit Signs; G
Emergency Lighting Unit (EBU); G
LED Emergency Drivers; G
Occupancy Sensors; G
Ambient Light Level Sensor; G
Lighting Control Panel; G

SD-05 Design Data
Luminaire Design Data; G
Photometric Plan; G

SD-06 Test Reports
LED Luminaire - IES LM-79 Test Report; G
LED Light Source - IES LM-80 Test Report; G
LED Light Source - IES TM-21 Test Report; G
ANSI/IES TM-30 Test Report; G
Occupancy/Vacancy Sensor Verification Tests; G
Energy Efficiency; G
Photosensor Verification Test; G

SD-07 Certificates
Luminaire Useful Life Certificate; G
LED Driver and Dimming Switch Compatibility Certificate; G

SD-10 Operation and Maintenance Data
Lighting System, Data Package 5; G
Lighting Control System, Data Package 5; G
Maintenance Staff Training Plan; G
End-User Training Plan; G

SD-11 Closeout Submittals
Interior Lighting (Energy Efficiency); S

1.5 QUALITY CONTROL

1.5.1 Luminaire Drawings
Include dimensions, accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data must accompany shop drawings.

1.5.2 Occupancy/Vacancy Sensor Coverage Layout
Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.3 LED Driver and Dimming Switch Compatibility Certificate. Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices.

1.5.4 Luminaire Design Data

a. Provide safety certification and file number for the luminaire family that must be listed, labeled, or identified per the 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).

b. Provide long term lumen maintenance projections for each LED luminaire in accordance with IES TM-21. Data used for projections must be obtained from testing in accordance with IES LM-80.

1.5.5 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Include all applicable and required data as outlined under "14.0 Test Report" in IES LM-79.

1.5.6 LED Light Source - IES LM-80 Test Report
Submit report on manufacturer's standard production LED light source (package, array, or module). Include all applicable and required data as outlined under "8.0 Test Report" in IES LM-80.

1.5.7 LED Light Source - IES TM-21 Test Report
Submit test report on manufacturer's standard production LED light source (package, array or module). Include all applicable and required data, as well as required interpolation information as outlined under "7.0 Report" in IES TM-21.

1.5.8 ANSI/IES TM-30 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.

1.5.9 Occupancy/Vacancy Sensor Verification Tests
Submit test report outlining post-installation coverage and operation of sensors.

1.5.10 LED Driver and Dimming Switch Compatibility Certificate
Submit certification from the luminaire, driver, or dimmer switch manufacturer that ensures compatibility and operability between devices without flickering and to specified dimming levels.

1.5.11 Occupancy/Vacancy Sensor Coverage Layout
Provide floor plans showing coverage layouts of all devices using manufacturer's product information.

1.5.12 Test Laboratories
Test laboratories for the IES LM-79 and 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 for both LM-79 and LM-80 testing.

b. One of the qualified labs listed on the Department of Energy - LED Lighting Facts Approved Testing Laboratories List at for LM-79 testing.

c. One of the EPA-Recognized Laboratories listed at for LM-80 testing.

1.5.13 Regulatory Requirements
In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "must" 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 must be in accordance with the mandatory and advisory provisions of NFPA 70, unless more stringent requirements are specified or indicated.

1.5.14 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 two years prior to bid opening. The two-year 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 two-year 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.

1.5.14.1 Alternative Qualifications
Products having less than a 2-year 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.

1.5.14.2 Material and Equipment Manufacturing Date
Products manufactured more than six months prior to date of delivery to site must not be used, unless specified otherwise.

1.5.14.3 Energy Efficiency

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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. Submit data indicating lumens per watt efficacy and color rendering index of light source.

1.6 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.

1.6.1 LED Luminaire Warranty

a. Provide a written 5 year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

(1) Include finish warranty to 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.

(c) Replacement when more than 15 percent of LED sources in any lightbar or subassembly(s) show a color shift greater than 0.003 delta u'v' from the zero hour measurement stated in the ANSI/IES LM-79 Test Report

b. Warranty period must begin on date of beneficial occupancy. Provide the Contracting Officer with signed warranty certificates prior to final payment.

1.6.2 LED Lighting Controls Warranty

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 occupancy sensors, photosensors, and manual wall station control devices.

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

1.6.3 Provide Luminaire Useful Life Certificate
Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life must 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 must be taken into consideration.

PART 2 PRODUCTS

Provide products in accordance with paragraph ENERGY EFFICIENCY in this section.

2.1 PRODUCT COORDINATION
Products and materials not considered to be luminaires, luminaire controls, or associated equipment are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Luminaires, luminaire controls, and associated equipment for exterior applications are specified in Section 26 56 00 EXTERIOR LIGHTING.

2.2 LUMINAIRES
UL 1598, NEMA C82.77-10, and UL 8750. Provide luminaires as indicated in luminaire schedule and NL plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. Provide all luminaires of the same type by the same manufacturer. Luminaires must be specifically designed for use with the driver, ballast or generator and light source provided.

2.2.1 LED Luminaires
Provide luminaires complete with power supplies (drivers) and light sources.

Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires. LED luminaires must meet the minimum requirements in the following table:

LUMINAIRE TYPE	MINIMUM LUMINAIRE EFFICACY (LE)	MINIMUM COLOR RENDERING INDEX (CRI)
LED TROFFER - 1 x 4300 x 1200 2 x 2600 x 600 2 x 4600 x 1200	90 LPW	80
LED Downlight	50 LPW	90
LED Track or Accent	40 LPW	80
LED Low Bay/High Bay	80 LPW	70
LED Linear Ambient	80 LPW	80

LED luminaires must also meet the following minimum requirements:

a. Luminaires must have a minimum 5 year manufacturer's warranty.

b. Luminaires must have a minimum 70 [_____] lumen maintenance value of 50,000[_____] hours as calculated by IES TM-21, with data obtained per IES LM-80 requirements.

c. Luminaire drive current value must be identical to that provided by test data for luminaire in question.

d. Luminaires must be tested to IES LM-79 and IES LM-80 standards, with the results provided as required in the Submittals paragraph of this specification.

e. Luminaires must be listed with the DesignLights Consortium 'Qualified Products List' when falling into category of "General Application" luminaires, i.e. Interior Directional, Display Case, Troffer, Linear Ambient, or Low/High Bay. Requirements are shown in the Designlights Consortium "Technical Requirements Table" at https://data.energystar.gov/dataset/EPA-Recognized-Laboratories-For-Lighting-Products/jgwf-7qrr.
f. Provide Department of Energy 'Lighting Facts' label for each luminaire.

2.2.2 Fluorescent Luminaires UL 1598. Provide linear and compact fluorescent luminaires complete with housing, ballast and light source. All fluorescent luminaires must be equipped with electronic ballasts.

2.2.3 Not using

2.2.4 Induction Luminaires
UL 1598. Provide induction luminaires complete with housing, generator and light source.

2.2.5 Luminaires for Hazardous Locations
In addition to requirements stated herein, provide LED, fluorescent, induction luminaires for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.

2.3 DRIVERS, BALLASTS and GENERATORS

2.3.1 LED Drivers

NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type and comply with the following requirements:

a. Output power (watts) and luminous flux (lumens) as shown in luminaire schedule for each luminaire type to meet minimum luminaire efficacy (LE) value provided.

b. Power Factor (PF) greater than or equal to 0.9 over the full dimming range when provided.

c. Current draw Total Harmonic Distortion (THD) of less than 20 percent.

d. Class A sound rating.

e. Operable at input voltage of 120-277 volts at 60 hertz.

f. Minimum 5 year manufacturer's warranty.

g. RoHS compliant.

h. Integral thermal protection that reduces or eliminates the output power if case temperature exceeds a value detrimental to the driver.

i. UL listed for dry or damp locations typical of interior installations.

j. [Non-dimmable], [step-dimmable to 50 percent output], or fully-dimmable using 0-10V control as indicated in luminaire schedule.

2.3.2 Fluorescent Electronic Ballasts
NEMA ANSLG C82.11, UL 935, CEC Title 24. Fluorescent ballasts must not contain any magnetic core and coil components, and must meet the following requirements:

a. Provide with transient protection as recommended by IEEE C62.41.1 and IEEE C62.41.2.

b. Provide UL listed Class P, "A" sound rating, with minimum power factor rating of 0.98 and minimum ballast factor rating of 0.95.

c. Be designed for the wattage and type of light source provided in the luminaire specified, and have circuit diagrams and light source connection information printed on the exterior of the ballast housing.

d. Contain no PCB's and be RoHS compliant.

e. Be manufactured in an ISO 9001 certified facility.

f. Operate at a frequency greater than 20 kHz, and have a Lamp Current Crest Factor less than 1.7.

g. Have a light regulation of plus or minus 10 percent of lumen output when operating within a plus or minus 10 percent range of input voltage.

h. Have a full replacement warranty of five years from date of manufacture.

2.3.2.1 T8 Programmed-Start Fluorescent Ballasts
Provide programmed-start T8 electronic fluorescent ballasts with the following

characteristics:

a. Total harmonic distortion (THD): Must be 20 percent[_____percent] (maximum).

b. Input wattage at 120/277 volts.

(1) 29/28 watts (maximum) when operating one F32T8 light source
(2) 55/54 watts (maximum) when operating two F32T8 light sources
(3) 84/82 watts (maximum) when operating three F32T8 light sources
(4) 109/107 watts (maximum) when operating four F32T8 light sources

c. Where indicated on project drawings, provide multi-light source luminaires with two or more ballasts to accomplish the switching scenario indicated.

2.3.2.2 T5 (long twin tube) and T5HO Fluorescent Ballasts

a. Total harmonic distortion (THD): Not greater than 25 percent when operating one light source, 15 percent when operating two light sources, and 20 percent when operating three light sources.

b. Input wattage:

(1) 45 watts (maximum) when operating one F40 T-5 light source
(2) 74 watts (maximum) when operating two F40 T-5 light sources
(3) 105 watts (maximum) when operating three F40 T-5 light sources

c. Provide three and four light source luminaires with two ballasts per luminaire where multilevel switching is indicated.

2.3.2.3 Compact Fluorescent Ballasts
Provide programmed-start ballasts for compact fluorescent luminaires.

2.3.2.4 Fluorescent Electronic Dimming Ballasts
Provide fluorescent electronic dimming ballasts with the following characteristics:

a. Comply with NEMA ANSLG C82.11, UL 935, and NFPA 70, unless specified otherwise. Provide ballast with transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Provide dimming capability range from 100 to 5 percent (minimum range) of light output, flicker free. Ballast must start lamp at any preset light output setting without first having to go to full light output. Provide ballasts designed for the wattage of the light sources used in the indicated application. Provide ballasts designed to operate on the voltage system to which they are connected.

b. Provide power factor of 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

c. Provide ballasts designed to operate at a frequency of 20,000 Hertz (minimum). Ballast must be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. When available, provide higher operating frequency of 40,000 hertz or above.

d. Ballast factor at full light output must be between 0.85 (minimum) and 1.00 (maximum). Current crest factor must be a maximum of 1.7.

e. Provide ballast with Class P UL listing and with a sound rating of "A".

f. Provide ballast with circuit diagrams displayed on the ballast exterior.

g. Provide programmed-start ballast. Ballast may operate light sources in a series circuit configuration. Provide series/parallel wiring for programmed-start ballasts where available.

h. Ballast must be capable of starting and maintaining operation at a minimum of minus 17 degrees C 0 degrees F unless otherwise indicated.

i. Provide ballast with total harmonic distortion (THD) of 20 percent (maximum) over the entire dimming range.

j. Ballasts for T-5 and smaller light sources must have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

2.3.2.4.1 T-8 Lamp Ballast
Input wattage:

a. 35 watts (maximum) when operating one F32T8 light source.

b. 70 watts (maximum) when operating two F32T8 light sources.

c. 104 watts (maximum) when operating three F32T8 light sources.

2.3.3 Not using

2.3.4 Induction Generators
Generator must be connected, and operate in conjunction with an inductive power coupler or coil(s). Provide solid-state, high-frequency (200 kHz - 2.67 MHz) type, with power factor greater than 0.95, Class A sound rating, maximum input current THD of 15 percent, operating voltage of 120-277V, and a minimum starting temperature of minus 30 degrees F. Provide generator dimmable to a minimum of 50 percent light output.

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

2.4.1 LED Light Sources

a. Correlated Color Temperature (CCT) of 4000 or greater degrees K.

b. Minimum Color Rendering Index (CRI) R9 value of 80.

c. High power, white light output utilizing phosphor conversion (PC) process or mixed system of colored LEDs, typically red, green and blue (RGB).

d. RoHS compliant.

e. Provide light source color consistency by utilizing a binning tolerance within a 4[_____] step McAdam ellipse.

2.4.1.1 LED Retrofit T8 Tubes

Provide linear T8 tubular LED light sources to replace fluorescent light sources in renovation or energy conservation projects. Provide only where entire luminaires are not being replaced. Light sources must be compatible with

existing instant-start or programmed-start ballasts and have the following requirements:

a. Correlated Color Temperature (CCT) of 4000 degrees K.

b. Total Harmonic Distortion (THD) less than 20 percent, with Power Factor (PF) greater than 90 percent.

c. Minimum lumen per watt efficacy greater than 120.

d. Minimum beam angle of 180 degrees.

e. Minimum 5 year warranty.

f. Minimum Color Rendering Index (CRI) of 80.

2.4.2 Fluorescent Light Sources
NEMA C78.376. Fluorescent light sources must be low-mercury, energy-savings type and be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at the time of manufacture.

2.4.2.1 Linear Fluorescent Light Sources
NEMA ANSLG C78.81. Provide linear fluorescent light sources with minimum CRI of 80[_____] and CCT of 4000[_____] degrees K.

2.4.2.1.1 T8 Linear Fluorescent Light Sources
Provide T8 light sources with medium bi-pin base, rated 32[_____] watts (maximum), 3100[_____] initial lumens (minimum), and with an average rated life of 30,000[_____] hours using an average three hour burn time and programmed-start ballast.

2.4.2.1.2 T5HO (High-Output) Linear Fluorescent Light Sources
Provide T5HO light sources with miniature bi-pin base, rated 54[_____] watts (maximum), 5000[_____] initial lumens (minimum), and with an average rated life of 30,000[_____] hours using an average three hour burn time and programmed start ballast.

2.4.2.2 Compact Fluorescent (CFL) Light Sources
ANSI C78.901. Provide compact fluorescent (CFL) light sources with minimum CRI of 80[_____] and CCT of 4000[_____] degrees K.

2.4.3 Not using

2.4.4 Induction Light Sources
Provide induction light sources consisting of an electrodeless, inductively-coupled, phosphor-coated fluorescent envelope, with an average rated life of 100,000 hours minimum rated using three hours operation per start. Light sources must be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at the time of manufacture.

2.4.4.1 Circular or Rectangular Tube Style Induction Light Sources Rated at 100, 150 or 200watts, with a CCT of 3500 4100 degrees K, a minimum CRI of 80, and an initial output at 25 degrees C of 8600, 13,000 or 15400 lumens.

2.4.4.2 Globe or 'A' Lamp Style Induction Light Sources
Rated at 165 watts, with a CCT of 4000 degrees K, a minimum CRI of 80, and a Luminous Lamp Efficacy (LLE) of 86 lumens per watt for 4000 degrees K source.

2.5 LIGHTING CONTROLS
ASHRAE 90.1 - IP ASHRAE 189.1. Provide network certification for all networked lighting control systems and devices per requirements of DOD 8500.01 and DOD 8510.01.

2.5.1 Toggle Switches
Provide line-voltage toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.5.2 Dimming Controllers (Dimmers)
UL 1472, UL 20, IEEE C62.41, NEMA SSL 7A. 120/277 V[0-10 V] dimmers must provide flicker-free, continuously variable light output throughout the dimming range. Provide radio frequency interference suppression integral to device. Provide dimmers utilizing pulse width modulation (PWM) or constant current reduction (CCR) technology. Provide device with a vertical slider, paddle, rotary button, or toggle (with adjacent vertical slider) type control, with finish to match switches and outlets in same area. Provide back box in wall with sufficient depth to accommodate body of switch and wiring. Devices must be capable of operating at their full rated capacity regardless of being single or ganged-mounted, and be compatible with three-way and four-way switching scenarios. Dimmers must be capable of controlling three-wire 0-10 volt fluorescent ballasts or LED drivers. Ensure compatibility of dimmer with separate power packs when utilized for lighting control. Dimmers and the ballasts or drivers they control, must be provided from the same manufacturer, or tested and certified as compatible for use together. Provide NEMA SSL 7A -compliant devices.

2.5.3 Sensors for Lighting Control
IEEE C62.41, NEMA WD 1, UL 94, UL 916, UL 508, ASTM D4674 REV A.

2.5.3.1 Occupancy Sensors
Provide occupancy sensors with coverage patterns as indicated on project plans. Provide no less quantity of sensors as shown on plans, but add additional sensors when required to fulfill coverage requirement for the specific model sensor provided. Sensor must be provided with an adaptive learning function that automatically sets sensor in optimum calibration in a set period of time after installation and a non-volatile memory that saves settings after a power outage. Provide sensors designed for ceiling, wall or wall-box installation as indicated. Operating voltage must be 120[277] volts. Operating voltage must be 24V in conjunction with a control system or separate power pack which interacts with luminaire being controlled. Provide housing of high-impact, injection-molded thermoplastic with a multi-segmented lens for PIR and dual technology sensors. Sensor operation requires movement to activate luminaires controlled, and turns luminaires off after a set time of inactivity. Provide integral photocell mounted in occupancy sensor housing when indicated.

2.5.3.1.1 Passive Infrared (PIR) Sensors
Provide ceiling or wall-mounted PIR sensors meeting the following requirements:

a. Temperature compensated, dual element sensor and a multi-element fresnel lens (Poly IR4 material).

b. Technology to optimize automatic time delay to fit occupant usage patterns.

c. No minimum load requirement for line voltage sensors and be capable of switching from zero to 800 W at 120 VAC, 50/60 Hz and from zero to 1200 W at

277 VAC, 50/60 Hz. Control voltage sensors must not exceed a maximum load requirement of 20 mA at 24VDC.

d. Time delay of five to 30 minutes in increments of five minutes with a walk through and test mode set by DIP switch.

e. LED indicator that remains active during occupancy.

f. Built-in light level sensor that is operational from 0.8 to 18 lux 8 to 180 foot-candles.

g. Coverage pattern tested to NEMA WD 7 standards.

h. Standard five year warranty and be UL listed

i. No leakage current to load when in the off mode.

2.5.3.1.2 Ultrasonic Sensors
Provide ceiling-mounted ultrasonic sensors meeting the following requirements:

a. Operate at an ultrasonic frequency of 25 kHz [40 kHz][_____].

b. LED on exterior of device to indicate occupant detection.

c. Adjustable time delay period of 15 seconds to 15 minutes [_____].

d. UL listed with minimum five year warranty.

2.5.3.1.3 Dual Technology Sensors
Provide dual technology sensors that meet the requirements for PIR sensors and ultrasonic sensors indicated above. If either the passive infrared or ultrasonic sensing registers occupancy, the luminaires must remain on.

2.5.3.1.4 High/Low-Bay Sensors
Provide occupancy sensors specifically designed for high/low-bay mounting application using passive infrared (PIR) technology, with the following characteristics:

a. Input voltage of 120/277 volts, at 50/60 hertz.

b. High-impact, injection-molded thermoplastic housing with interchangeable lenses for 360 degree open area coverage or narrow rectangular, warehouse aisle coverage.

c. Utilize zero-crossing circuitry to prevent damage from high inrush current and to promote long life operation.

d. Be designed to mount directly to or adjacent to high or low-bay luminaires.

e. UL listed, CEC Title 24 and ASHRAE 90.1 - IP compliant.

2.5.3.1.5 Power Packs for Sensors
UL 2043, CEC Title 24, ASHRAE 90.1 - IP. Power packs used to provide power to one or more lighting control sensors must meet the following requirements:

a. Input voltage - 120-277 VAC; output voltage - 24 VDC at 225 mA.

b. Plenum-rated, high-impact thermoplastic enclosure.

c. Utilizes zero-crossing circuitry to prevent damage from inrush current.

d. Maximum load rating of 16[_____] amps for electronic [_____] lighting loads.

e. RoHS compliant.

2.5.3.2 Vacancy Sensors
Provide vacancy sensors as indicated above under paragraph OCCUPANCY SENSORS, but with requirement of a manual operation to activate luminaires controlled. Provide automatic operation to turn luminaires off after a set period of inactivity.

2.5.4 Lighting Contactor
NEMA ICS 2. Provide an electrically-held lighting contactor housed in a NEMA 1[12][3R][4][4X][_____] enclosure conforming to NEMA ICS 6. Provide contactor with one[_____] normally-open(NO), single or double pole contacts, rated 600 volts, 30 amps. Provide coil operating voltage of [24][120][277][480][_____] volts.]

2.5.5 Not using

2.5.6 Not using

2.5.7 Lighting Control Panel
Provide an electronic, programmable lighting control panel, capable of providing lighting control with input from internal programming, digital switches, time clocks, and other low-voltage control devices. Enclose panel hardware in a surface[flush]-mounted, NEMA 1[3R], painted, steel enclosure, with hinged, 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. Input voltage - 120/277 V, 60 Hz, with internal 24 VDC power supply. Provide 8[16][32][_____] single-pole latching[return to close] relays rated at [20][30] amps, [120][277] volts. Relay control module must operate at 24 VDC and be rated to control a minimum of 8[16][32][_____] relays.

2.5.8 Local Area Lighting Controller
CEC Title 24 and ASHRAE 90.1 - IP compliant. Provide controller designed for single area or room with the following requirements:

a. [120][277] volt input, designed for fluorescent or LED lighting loads.

b. 2[_____] zone, with 1[2][_____] relay[s] rated 20 amps[each].

c. Provide daylight harvesting capability with full-range dimming control.

d. Inputs for occupancy sensor, photocell, and low-voltage wall switch.

2.6 EXIT AND EMERGENCY LIGHTING EQUIPMENT
UL 924, NFPA 101, and NFPA 70 compliant.

2.6.1 Exit Signs

Provide exit signs consuming a maximum of five watts total.

2.6.1.1 LED Self-Powered Exit Signs
Provide in UV-stable, thermo-plastic painted, die-cast aluminum or painted

steel housing with UL damp label, UL wet label, using clear polycarbonate housing, configured for ceiling[wall][end] mounting. [Provide edge-lit type with clear acrylic, edge-lit face and aluminum trim having clear aluminum [white][chrome][brass][_____] finish.] Provide 150 mm 6 inch high, 19 mm 3/4 inch stroke red[green][_____] lettering on face of sign. Provide chevrons on either side of lettering to indicate direction. Provide single[double] face. Equip with automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free nickel-cadmium type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1 1/2 hours. LEDs must have a minimum rated life of 10 years.

2.6.1.2 LED Remote-Powered Exit Signs. Provide as indicated above for self-powered type, but without battery and charger. Exit sign must contain provision for 120/277 VAC or 6-48 VDC input from remote source.

2.6.2 Emergency Lighting Unit (EBU)
Provide in UV-stable, thermo-plastic, painted, die-cast aluminum or painted steel housing with [UL damp label][UL wet label] as indicated. Emergency lighting units must be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted light sources may be rated six volts. Equip units with brown-out sensitive circuit to activate battery when input voltage falls to 75 percent of normal. Equip with two[_____] LED, MR-16[_____] type light sources, automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack. Battery must be sealed, maintenance free [lead-calcium][nickel-cadmium][_____] type, and must operate unattended for a period of not less than five years. Emergency run time must be a minimum of 1 1/2 hours. LEDs must have a minimum rated life of 10 years.

2.6.3 LED Emergency Drivers
Provide LED emergency driver with automatic power failure detection, test switch and LED indicator (or combination switch/indicator) located on luminaire exterior, and fully-automatic solid-state charger, battery and inverter integral to a self-contained housing. Provide self-diagnostic function integral to emergency driver.]Integral nickel-cadmium [_____] battery is required to supply a minimum of 90 minutes of emergency power at 10[_____] watts, [10-50][_____] VDC[compatible with LED forward voltage requirements], constant output. Driver must be RoHS compliant, rated for installation in plenum-rated spaces and damp locations, and be warranted for a minimum of five years.

2.6.4 Self-Diagnostic Circuitry for LED and Fluorescent Emergency Drivers/Ballasts
Provide emergency lighting unit with fully-automatic, integral self-testing/diagnostic electronic circuitry. Circuitry must provide for a one minute diagnostic test every 28 days, and a 30 minute diagnostic test every six months, minimum. Any malfunction of the unit must be indicated by LED(s) visible from the exterior of the luminaire. A manual test switch must also be provided to perform a diagnostic test at any given time.

2.6.5 Central Emergency Lighting System
Provide integrally-housed emergency system rated at [_____] VA/watts, 120[277] volts (input and output), for a minimum period of 90 minutes. Output frequency must be a pure sine wave at 60 hertz, with maximum 5 percent total harmonic distortion. Provide system with minimum short circuit rating required for protection against available fault current.

2.6.5.1 System Operation
During normal power operation, system charges batteries as needed and allows normal power to pass through to load. Upon loss of normal power, system automatically transfers to emergency mode without interruption of connected loads. Internal batteries provide a minimum of 90 minutes of emergency power at this time. Upon normal power being restored, system switches back to normal power mode and fully charges batteries within UL-approved time period.

2.6.5.2 Battery Charger
Solid state, monitored, three step float charging type, keeping batteries in a fully charged state. Provide circuitry to prevent deep discharge of batteries in prolonged power outage conditions.

2.6.5.3 Batteries
Provide sealed, lead calcium type, designed to operate unattended without maintenance, for a minimum of 10 years.

2.6.5.4 Enclosure
Provide system in NEMA 1[3R] painted steel [aluminum] enclosure with exterior-mounted "push-to-test" button and LED indicator.

2.7 LUMINAIRE SUPPORT HARDWARE

2.7.1 Wire
ASTM A641/A641M; Galvanized, soft tempered steel, minimum 2.7 mm 0.11 inches in diameter, or galvanized, braided steel, minimum 2 mm 0.08 inches in diameter.

2.7.2 Wire for Humid Spaces
ASTM A580/A580M; Composition 302 or 304, annealed stainless steel, minimum 2.7 mm 0.11 inches in diameter.
ASTM B164; UNS NO4400, annealed nickel-copper alloy, minimum 2.7 mm 0.11 inches in diameter.

2.7.3 Threaded Rods
Threaded steel rods, 4.76 mm 3/16 inch diameter, zinc or cadmium coated.

2.7.4 Straps

Galvanized steel, 25 by 4.76 mm one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

2.8 POWER HOOK LUMINAIRE HANGERS
UL 1598Provide an assembly consisting of through-wired power hook housing, interlocking plug and receptacle, power cord, and luminaire support loop. Power hook housing must be cast aluminum having two 19 mm 3/4 inch threaded hubs. Support hook must have safety screw. Fixture support loop must be cast aluminum with provisions for accepting 19 mm 3/4 inch threaded stems. Power cord must include 410 mm 16 inches of 3 conductor No. 16 Type SO cord. Assembly must be rated 120 volts or 277 volts, 15 amperes.

2.9 EQUIPMENT IDENTIFICATION

2.9.1 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.

2.9.2 Labels
Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires must be clearly marked for operation of specific light sources and ballasts, generators or drivers. Note the following light source characteristics in the format "Use Only _____":

a. Light source diameter code (T-4, T-5, T-8), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

b. Light source type, wattage, envelope type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

c. Start type (programmed start, instant start) for fluorescent and compact fluorescent luminaires.

d. ANSI ballast type (M98, M57, etc.) for HID luminaires.

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

All 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. Ballasts, generators or drivers must have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.10 FACTORY APPLIED FINISH
Provide all luminaires and lighting equipment with factory-applied painting system that as a minimum, meets requirements of NEMA 250 corrosion-resistance test.

2.11 RECESS- AND FLUSH-MOUNTED LUMINAIRES
Provide access to lamp and ballast from bottom of luminaire. Provide trim and lenses for the exposed surface of flush-mounted luminaires as indicated on project drawings and specifications.

2.12 SUSPENDED LUMINAIRES
Provide hangers capable of supporting twice the combined weight of luminaires supported by hangers. Provide with swivel hangers to ensure a plumb installation. Provide cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers must allow fixtures to swing within an angle of 0.79 rad 45 degrees. Brace pendants 1219 mm 4 feet or longer to limit swinging. Single-unit suspended luminaires must have twin-stem hangers. Multiple-unit or continuous row luminaires must have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Provide rods in minimum 4.57 mm 0.18 inch diameter.

PART 3 EXECUTION

3.1 INSTALLATION
Electrical installations must conform to IEEE C2, NFPA 70, and to the requirements specified herein. Install luminaires and lighting controls to meet the requirements of ASHRAE 90.1 - IP and ASHRAE 189.1. To encourage consistency and uniformity, install luminaires of the same manufacture and model number when residing in the same facility or building.

3.1.1 Light Sources
When light sources are not provided as an integral part of the luminaire, deliver light sources of the type, wattage, lumen output, color temperature, color rendering index, and voltage rating indicated to the project site and install just prior to project completion, if not already installed in the luminaires from the factory.

3.1.2 Luminaires
Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent luminaires and secure in accordance with manufacturers' directions and approved drawings. Installation must meet requirements of NFPA 70. Mounting heights specified or indicated must be to the bottom of the luminaire for ceiling-mounted luminaires and to center of luminaire for wall-mounted luminaires. Obtain approval of the exact mounting height on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed luminaires must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire and located near each corner of the luminaire. Ceiling grid clips are not allowed as an alternative to independently supported luminaires. Round luminaires or luminaires smaller in size than the ceiling grid must be independently supported from the building structure by a minimum of four wires, straps or rods per luminaire, spaced approximately equidistant around. Do not support luminaires by acoustical tile ceiling panels. Where luminaires of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support each independently and provide at least two 19 mm 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the luminaire. Provide wires, straps, or rods for luminaire support in this section. Luminaires installed in suspended ceilings must also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

3.1.3 Suspended Luminaires
Provide suspended luminaires with 0.79 rad 45 degree swivel hangers so that they hang plumb and level. Locate so that there are no obstructions within the 0.79 rad 45 degree range in all directions. The stem, canopy and luminaire must be capable of 0.79 rad 45 degree swing. Pendants, rods, or chains 1.2 meters 4 feet or longer excluding luminaire must be braced to prevent swaying using three cables at 2.09 rad 120 degree separation. Suspended luminaires in continuous rows must have internal wireway systems for end to end wiring and must be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Utilize aligning splines on extruded aluminum luminaires to assure minimal hairline joints. Support steel luminaires to prevent "oil-canning" effects. Luminaire finishes must be free of scratches, nicks, dents, and warps, and must match the color and gloss specified. Match supporting pendants with supported luminaire. Aircraft cable must be stainless steel. Canopies must be finished to match the ceiling and must be low profile unless otherwise shown. Maximum distance between suspension points must be 3.1 meters 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 Ballasts, Generators and Power Supplies
Typically, provide ballasts, generators, and power supplies (drivers) integral to luminaire as constructed by the manufacturer.

3.1.5 Exit Signs and Emergency Lighting Units
Wire exit signs and emergency lighting units ahead of the local switch, to the normal lighting circuit located in the same room or area.

3.1.5.1 Exit Signs
Connect exit signs on separate circuits and serve from [an emergency panel][a separate circuit breaker][a fused disconnect switch]. Provide only one source of control, which would be [the circuit breaker in the emergency panel][the separate circuit breaker][the fused disconnect switch]. Paint source of control red and provide lockout capability.

3.1.5.2 Emergency Lighting from Central Emergency System
Connect emergency lighting from a central emergency system as indicated on the project drawings.

3.1.6 Photocell Switch Aiming
Aim switch according to manufacturer's recommendations.

3.1.7 Occupancy/Vacancy Sensors
Provide testing of sensor coverage in all spaces where sensors are placed. This should be done only after all furnishings (carpet, furniture, workstations, etc.) have been installed. Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage must provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage.

3.1.8 Daylight or Ambient Light Level Sensor
Locate sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 300 lux 30 foot-candles or for the indicated light level measured at the work plane for that particular area.

3.2 FIELD APPLIED PAINTING
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.

-- End of Section --