This is a guidance document with sample specification language intended to be inserted into project specifications on this subject as appropriate to the agency's environmental goals. Certain provisions, where indicated, are required for U.S. federal agency projects. Sample specification language is numbered to clearly distinguish it from advisory or discussion material. Each sample is preceded by identification of the typical location in a specification section where it would appear using the SectionFormat™ of the Construction Specifications Institute.

SECTION 16500 – LIGHTING

SPECIFIER NOTE:

resource management: The systems specified for energy use in a building can dramatically impact both the quantity of such resources used and the quality. Coordinating use of daylighting with requirements of artificial lighting and the associated heat loads of each can improve energy efficiency and the related environmental impacts.

toxicity/IEQ: Currently, products are not legally permitted to be manufactured with PCBs. Lead is commonly used in solder for ballasts oh HID lamps; however, many manufacturers now crimp ballasts rather than solder. Mercury is commonly used in fluorescent lamps; however, some manufacturers have developed low-mercury fluorescent lamp products.
Light quality is also a consideration for IEQ. Natural daylighting is preferred.
performance: Lighting accounts for 25 percent of the electricity used in the Federal sector. If advanced lighting technologies and designs were implemented throughout the Federal sector, electricity use for lighting would be cut by more than 50 percent, electrical demand dramatically reduced, and working environments significantly improved.
Refer to “Greening Federal Facilities: An Energy, Environmental, and Economic Resource Guide for Federal Facility Managers and Designers" http://www.eere.energy.gov/femp/pdfs/29267-0.pdf

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
1. Interior luminaires.
2. Exterior luminaires.
3. Lighting control devices.
4. Accessories.

B. Related Sections:
1. Section 01810 - Commissioning.

1.2 SUBMITTALS

A. Product data. Unless otherwise indicated, submit the following for each type of product provided under work of this Section:

SPECIFIER NOTE:
Specifying local materials may help minimize transportation impacts; however it may not have a significant impact on reducing the overall embodied energy of a building material because of efficiencies of scale in some modes of transportation.
Green building rating systems frequently include credit for local materials. Transportation impacts include: fossil fuel consumption, air pollution, and labor.

USGBC-LEED™ v2.2 includes credits for materials extracted/harvested and manufactured within a 500 mile radius from the project site. Green Globes US also provides points for materials that are locally manufactured.

1. Local/Regional Materials:
   a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
   b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.
   c. Product Value: Indicate dollar value of product containing local/regional materials; include materials cost only.
   d. Product Component(s) Value: Where product components are sourced or manufactured in separate locations, provide location information for each component. Indicate the percentage by weight of each component per unit of product.

SPECIFIER NOTE:
The EPA has developed minimum energy efficiency standards for Energy Star labeled products. EPA Energy Star categories include: appliances, HVAC, residential equipment, office equipment, and lighting.
USGBC-LEED™ v2.1 include credits for increasing levels of energy performance, referencing IESNA/ASHRAE 90.1 (without amendments) as the standard for establishing baseline performance. Energy systems addressed include: HVAC, service hot water, and interior lighting. Plug loads, exterior lighting, garage ventilation, and vertical transportation (elevators) are not included.

2. Energy Efficiency:
   a. Submit documentation for Energy Star qualifications for equipment provided under work of this Section.
   b. Submit data indicating lumens per watt efficiency of light source.
   c. Submit data indicating color rendition index of light source.

B. Submit environmental data in accordance with Table 1 of ASTM E2129 for products provided under work of this Section.

SPECIFIER NOTE:
Identify special maintenance agreements. Maintenance agreements are standard practice in the building industry. Take-back programs refer to programs in which the product manufacturer "takes-back" scrap material and/or packaging associated with its product. Green leasing is a new, but dramatic shift in the traditional perspective of leased equipment. Under a green lease, the product manufacturer is responsible for the disposition of the product at all times. Thus, when the customer no longer requires the use of the particular product or requires an updated model, the manufacturer is obligated to reclaim it and refurbish it or disassemble it for recycling as appropriate. This approach necessitates a revision of administrative services. It also requires a basic redesign of products in order to allow for future disassembly and upgrade. This has the potential to be cost effective for manufacturers and customers alike. It is also extremely resource efficient.

C. Documentation of manufacturer's **[maintenance agreement] [take-back program] [green lease]** for luminaires. Include the following:
   1. Appropriate contact information.
   2. Overview of procedures.
      a. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.
   3. Limitations and conditions, if any, applicable to the project.

1.3 QUALITY ASSURANCE

A. Energy Efficiency: Comply with National Energy Policy Act requirements for lighting products.

1.4 MAINTENANCE

A. Operational Service: Provide manufacturer's **[maintenance agreement] [take-back program] [green lease]** service for luminaires installed in project. Service shall reclaim materials for recycling and/or reuse. Service shall not landfill or burn reclaimed materials.

SPECIFIER NOTE:
For disposal information regarding mercury, refer to the EPA Mercury website http://www.epa.gov/mercury/index.html

1. Indicate procedures for compliance with regulations governing disposal of Mercury.

PART 2 PRODUCTS

2.1 INTERIOR LUMINAIRES

SPECIFIER NOTE:
The Federal Energy Management Program (FEMP) provides procurement guidelines with efficiency recommendations for products as indicated below. Decisions as to appropriateness of equipment design are dependent upon project goals and location. Refer to http://www.eere.energy.gov/femp/technologies/eeproducts.cfm
Lumen is a measure of light output.
Ballast efficacy factor (BEF) is the ratio of the ballast factor (BF) to input watts; it measures the efficiency of the lamp/ballast system relative to others using the same type and number of lamps.
Ballast factor (BF), also called relative light output (RLO), is the ratio of the light output of a lamp(s) operated by a ballast, to the light output of the same lamp(s) operated by a reference ballast at rated current and voltage.
Upward efficiency is the portion of light directed up. Both high-bay and low-bay luminaires are available with opaque reflectors, which direct all or most of the light downward, and with transparent refractors, which direct some light up.
LER, or luminaire efficacy rating, describes the efficiency of a luminaire in terms of rated light output (in lumens) per watt of electricity use. A lumen is a standard measure of light output.

A. Fluorescent Tube Lamp:

Lamp Type	Recommended
Four-Foot Lamps	
T8, 32 watts	2800 lumens or more
T12, 34 watts	2800 lumens or more
Eight-Foot Lamps	
T8,59 watts	5700 lumens or more
T12,60 watts	5600 lumens or more
U-Tube Lamps	
T8/U,31-32 watts	2600 lumens or more

T12/U,34 watts	2700 lumens or more

B. Fluorescent Ballast:

Lamp Type	# of Lamps	Recommended BEF
Four-Foot and U-Tube Lamps		
T8,32 Watts	1	2.54 or higher
	2	1.44 or higher
	3	0.93 or higher
	4	0.73 or higher
T12,34 Watts	1	2.64 or higher
	2	1.41 or higher
	3	0.93 or higher
Eight-Foot Lamps		
T8,59 Watts	2	0.80 or higher
T12,60 Watts	2	0.80 or higher

C. HID Luminaires:

Upward Efficiency	Lamp Wattage	Closed Fixture (HC) LER Recommended	Open Fixture (HO) LER Recommended
Metal Halide Lamps			
0%	150-399	41 or higher	insuff. data
	400-999	53 or higher	59 or higher
	≥1000	77 or higher	insuff. data
1%-10%	150-399	56 or higher	insuff. data
	400-999	62 or higher	64 or higher
	≥1000	insuff. data	88 or higher
>20%	150-399	62 or higher	77 or higher
	400-999	65 or higher	insuff. data
	≥1000	insuff. data	insuff. data
High Pressure Sodium Lamps			
0%	150-399	58 or higher	68 or higher
	400-999	63 or higher	84 or higher
	≥1000	insuff. data	insuff. data
1%-10%	150-399	64 or higher	63 or higher
	400-999	82 or higher	89 or higher
	≥1000	insuff. data	109 or higher
11%-20%	150-399	insuff. data	78 or higher
	400-999	insuff. data	94 or higher
	≥1000	insuff. data	insuff. data
>20%	150-399	75 or higher	77 or higher
	400-999	insuff. data	insuff. data
	≥1000	insuff. data	insuff. data

D. Downlight Luminaires;

Luminaire Type	Recommended LER

(NEMA designation)	
Compact Fluorescent Lamps (CFLs)	
Open Optics	29 or higher
Baffled Optics	21 or higher
Lensed Optics	24 or higher
Metal Halide Lamps	
Open Optics	35 or higher
Lensed Optics	30 or higher

E. Fluorescent Luminaires:

Luminaire Type (NEMA Designation)	Number of Lamps	Recommended LER
2' x 4' Recessed		
Lensed (FL)	2	62 or higher
	3	61 or higher
	4	61 or higher
VDT-Preferred Louvered (FP)	2	50 or higher
	3	51 or higher
	4	54 or higher
Plastic Wraparound		
Four-Foot (FW)	2	63 or higher
	4	62 or higher
Strip Lights		
Four-Foot (FS)	1	70 or higher
	2	70 or higher
Industrial		
Four-Foot (FI)	2	67 or higher
Eight-Foot (FI)	2	68 or higher
2' x 2' Recessed, for U-Tube Lamps		
VDT-Preferred	2	41 or higher
Lensed	2	49 or higher

F. Compact Fluorescent Lamps:

To Replace Incandescent Bulb Rated at	Necessary Light Output (Lumens)	Typical CFL Replacement Wattage	Recommended CFL Lumens per Watt (lpW)
Bare Bulbs			
40 watts	495 or more	11 - 14 watts	45 lpW or more
60 watts	900 or more	15 - 19 watts	60 lpW or more
75 watts	1200 or more	20 - 25 watts	60 lpW or more
100 watts	1750 or more	≥29 watts	60 lpW or more
Reflector Type Bulbs			
50 watts	550 or more	17 - 19 watts	33 lpW or more
60 watts	675 or more	20 - 21 watts	40 lpW or more
75 watts	875 or more	≥22 watts	40 lpW or more

G. Exit Sign: UL listed. Provide with automatic power failure device, **[test switch, pilot light,] [integral self-testing module]** and fully automatic high/low trickle charger in a self-contained power pack. Battery shall be sealed electrolyte type, shall operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years. LED exit sign shall have emergency run time of 1 1/2 hours (minimum). The light emitting diodes shall have rated lamp life of 70,000 hours (minimum).

Product Type	Recommended
All Fixtures	5 watts or less

2.2 EXTERIOR LUMINAIRES

A. Luminaire:

SPECIFIER NOTE:
USGBC-LEED™ v2.1 include credit for eliminating light trespass from the building and site; credit includes requirement that exterior luminaires with more than 1000 initial lamp lumens are shielded and all luminaires with more than 3500 initial lamp lumens meet the full cutoff IESNA Classification.

1. IESNA Cutoff Category: **[Cutoff] [Semicutoff]**.
2. Photometric Performance of installed units: Maximum initial horizontal illumination does not exceed **[xxxx]** footcandles at a point lighting level readings should be measured at **[grade] [xxxx].**

2.3 LIGHTING CONTROL DEVICES

A. Dimming Ballast Controls: Sliding-handle type with on/off control; compatible with ballast and having light output and energy input over the full dimming range.

B. Light Level Sensor: Detect changes in ambient lighting level and provide dimming range of 20 to 100 percent in response to change. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Adjustable Ambient Detection Range: **[10 to 100] [xxxx]** footcandles minimum. Sensor shall have a bypass function to electrically override sensor control.

C. Occupancy Sensors: Comply with GS-12. Provide adjustable sensitivity and off delay time range of 5 to 15 minutes.
1. **[Ultrasonic Sensors: Crystal controlled with circuitry that causes no detection interference between adjacent sensors.]**
2. **[Infrared Sensors: With daylight filter and lens to afford coverage applicable to space to be controlled.]**
3. **[Combination Sensors: Ultrasonic and infrared sensors combined].**
4. **[Microwave and audiophonic sensors.]**

D. Time Switch: Astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise.
1. Provide switch rated **[xxxx]** volts, having automatically wound spring mechanism or capacitor, to maintain accurate time for a minimum of 15 hours following power failure.
2. Provide time switch with a manual on-off bypass switch.
3. Housing: **[surface] [flush]**-mounted, NEMA **[1] [3] [xxxx]** enclosure conforming to NEMA ICS 6.

E. Photocell Switch: UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated **[xxxx]** volts ac, 60 Hz with **[single-throw contacts] [single pole double-throw contacts**] for control of mechanically held contactors, rated **[1000] [xxxx]** W.
1. Switch shall turn on at or below 32 lux (3 footcandles) and off at 22 to 107 lux (92 to 10 footcandles).
2. A time delay shall prevent accidental switching from transient light sources.
3. Provide switch:
   a. **[Integral to the luminaire. rated 1000W minimum.] [Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.]**
   b. **[In a U.V. stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA, minimum.]**
   c. **[In a high-impact-resistant, noncorroding and nonconductive molded plastic housing with a locking-type receptacle conforming to IEEE C136.10, rated 1800 VA, minimum.]**
   d. **[In a cast weatherproof aluminum housing with adjustable window slide, rated 1800 VA, minimum.]**

2.4 ACCESSORIES

SPECIFIER NOTE:
Labeling of lighting components is an inexpensive and effective method for helping facilities personnel properly operate and maintain the lighting systems. The labels should be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Refer to the FEMP guidelines for lighting http://www.eere.energy.gov/femp/technologies/eep_lighting_guidance.cfm

A. Labels: Provide labels luminaires. Include the following information on each label:
1. All luminaires shall be clearly marked for operation of specific lamps and ballasts and according to proper lamp type in accordance with UL 1570 or UL 1572 requirements, as applicable.
2. For maintenance purposes, the following lamp characteristics should be noted, as applicable, in the format "Use Lamps Only":
   a Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
   b Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
   c Start type (preheat, rapid 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.
3. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but invisible from normal viewing angles when lamps are in place.
4. Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

PART 3 - EXECUTION

3.X SITE ENVIRONMENTAL PROCEDURES

A. Resource Management:
   1. Energy Efficiency: Verify equipment is properly installed, connected, and adjusted. Verify that equipment is operating as specified.
      a. Electronic Dimming Ballast: Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.
      b. Occupancy Sensor: Test sensors for proper operation. Observe for light control over entire area being covered.
   2. Coordinate with manufacturer for **[maintenance agreement] [take-back program] [green lease]**.

END OF SECTION