

**REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY**

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## ***REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY***

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# REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

## SECTION 16500 - LIGHTING

### PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Environmental Issues: Work includes special environmental considerations related to energy efficiency, indoor air quality, and resource efficiency; refer to Section 01350 – Special Environmental Requirements.

#### 1.2 DEFINITIONS

- A. Normal Light Output (NLO) ballasts: Ballasts with a ballast factor between 0.85 and .95.
- B. Reduced Light Output (RLO) ballasts: Ballasts with a ballast factor of 0.85 or less.
- C. High Light Output (HLO) ballasts: Ballasts with a ballast factor between 0.95 and 1.20.
- D. NVLAP: National Voluntary Laboratory Accreditation Program, administered by National Institute of Standards and Technology (NIST) for commercial laboratories. One of the NVLAP areas of accreditation is for energy efficient lighting products.

#### 1.3 SUBMITTALS (*Note 1.2*)

- A. Submit in accordance with the procedures listed in Division 1 the following:
  1. Data sheets for all luminaires, lamps, and ballasts listed on the Fixture Schedule.
  2. Lamp submittals shall include data for rated lamp life, initial light output and lumen depreciation ratings at 40% and 80% of rated lamp life. Lamp submittals for directional lamps shall list center beam candle power and beam angle. (*Note 1.3*)
  3. Ballast submittals shall be provided as part of the luminaire submittal. The submittal shall include the specific ballast manufacturer and model number and pertinent ballast data to demonstrate compliance with the ballast specifications.
  4. A photometric test report for each luminaire type and lamp combination listed on the fixture schedule. Test reports shall be based on Illuminating Engineering Society published test procedures and shall contain all relevant candlepower distribution data as well as luminaire luminance data necessary to ensure compliance with design intent.

#### 1.4 TESTING:

- A. Test Reports: Certified Test Reports showing compliance with specified performance characteristics and physical properties. Testing by an independent lighting laboratory may be designated. Lamp tests from a NVLAP accredited laboratory may be designated. (*Note 1.4*)

#### 1.5 OWNER'S INSTRUCTIONS

- A. Product Record Documents shall include a copy of any owner's instructions available from the manufacturer of lighting equipment.

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### 1.6 COMMISSIONING

- A. All lighting controls shall be commissioned to ensure optimal performance and compliance with design intent. Commissioning shall be performed by (Commissioning Agent Identification) prior to occupancy but after all furnishings and finishes have been installed. *(Note 1.5)*
  - 1. Either the manufacturer's representative or a trained technician shall implement the initial commissioning. *(Note 1.6)*
- B. Energy management systems and other comprehensive control networks shall be commissioned as indicated by the system manufacturer, before accepting building spaces for occupancy.

### 1.7 MAINTENANCE

- A. Replace lamps as a group after an interval specified by the lighting designer between 70 and 80% or rated lamp life. *(Note 1.7)*
- B. Recycle spent fluorescent and HID lamps. *(Note 1.8)*

## **PART 2 - PRODUCTS**

### 2.1 MATERIALS

- A. Lamps:
  - 1. General:
    - a. Refer to Fixture Schedule for a list of all lamps.
    - b. Lamps are specified by manufacturer name and model number for specific performance and environmental criteria. Only lamps of equal or better performance criteria will be acceptable.
    - c. Directional lamps are specified by their center beam candlepower values, beam spreads, and wattages.
  - 2. Linear Fluorescent Lamps:
    - a. Linear fluorescent lamps shall comply with the latest state environmental laws for new lamps. *(Note 1.8)*
    - b. Linear fluorescent lamps shall have a minimum Color Rendering Index (CRI) of 80. The color temperature (CCT) shall be \_\_\_\_\_°K. *(Fill in 3000, 3500, 4100, or 5000) (Note 1.9)*
    - c. Linear fluorescent lamp efficacy shall be minimum 85 lumens per Watt (excluding ballast) based on rated initial lamp lumens.
    - d. Lamp Lumen Depreciation (LLD) for linear fluorescent lamps shall result in a mean lumen value of at least 92% of the initial lamp lumens at 40% rated life and 89% of the initial lamp lumens at 80% rated lamp life.
    - e. Mortality curves at 3 operating hours per start shall show that less than 15% of lamps fail before 70% of rated life.
    - f. 32W F32T8 lamps shall have a minimum initial rated light output of 3100 lumens. *(Note 1.10)*
    - g. T8 Linear 2', 3', 4', and 5' lamps shall have a minimum rated lamp life of 24,000 hours. *(Note 1.1)*
    - h. T5 Linear 2', 3', 4', and 5' (nominal length) lamps shall have a minimum rated

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lamp life of 20,000 hours.

3. Compact Fluorescent Lamps:
    - a. Compact fluorescent lamps incorporating three twin tubes and four-pin bases shall contain amalgam.
    - b. Compact fluorescent lamps shall have a minimum CRI of 80. The color temperature shall be \_\_\_\_\_°K. (*Fill in 2700, 3000, 3500, 4100, or 5000*) (*Note 1.9*)
    - c. Compact fluorescent lamp efficacy, based on initial lamp rating, shall be minimum 60 lumens per Watt (excluding ballast).
    - d. Lamp Lumen Depreciation (LLD) for linear fluorescent lamps shall result in a mean lumen value of at least 82% of the initial lamp lumens at 40% rated life and 75% of the initial lamp lumens at 80% rated lamp life.
    - e. Mortality curves at 3 operating hours per start shall show that less than 20% of lamps fail before 70% of rated life.
    - f. T5 Compact twin tube lamps shall have a minimum rated lamp life of 20,000 hours for 18 and 40 Watt lamps and 12,000 hours for 27 and 50 Watt lamps.
    - g. T4 Compact twin, triple, quad and helical lamp types shall have a minimum rated lamp life of 10,000 hours.
  4. HID Lamps:
    - a. HID lamp bases shall either be welded or use lead-free solder. Pay particular attention to lamp starting method and ballast compatibility. (*Note 1.12*)
  5. Halogen Lamps:
    - a. Halogen lamps shall comply with the latest state environmental laws. If no state laws are in place, the minimum criteria shall be that the lamp bases shall only use solder that is lead-free.
    - b. Halogen lamps shall employ Halogen Infrared Reflecting(IR) technology. Exceptions will be made for lamps that can demonstrate the same level of performance at identical or lower power (wattage). (*Note 1.13*)
- B. Ballasts:
1. Refer to Fixture Schedule for a list of all ballasts used on projects.
  2. Ballasts shall not contain polychlorinated biphenyls (PCB's) and shall be labeled "NO PCB's" if they contain an internal capacitor. (*Note 1.14*)
  3. Electronic Fluorescent High Frequency Ballasts:
    - a. All Fluorescent ballasts (linear and compact) for lamps rated 15 Watts and above shall be electronic operating at a frequency of 20 KHz or greater. (*Note 1.15*)
    - b. Fluorescent electronic ballasts shall be Normal Light Output, Reduced Light Output, or High Light Output, as noted in the fixture schedule.
    - c. Total Harmonic Distortion shall not exceed 20%. (*Note 1.16*).
    - d. Power Factor shall be 0.9 or greater. (*Note 1.17*)
    - e. Lamp Current Crest Factor shall not exceed 1.7. (*Note 1.18*)
    - f. Ballasts shall be regulated to maintain light output which does not vary more than  $\pm 5\%$  for all fluorescent lamps within operating ranges of  $\pm 10\%$  of rated system voltage.
    - g. Ballasts shall have a warranty of not less than 5 years. (*Note 1.1*)

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- h. Compact fluorescent and T5 fluorescent ballasts shall employ end-of-life (EOL) circuitry to shut down the circuit at the end of the lamp life. (*Note 1.20*)
- 4. HID Ballasts:
  - a. Use electronic ballasts where specified, and any specific manufacturer if designated.
  - b. HID ballasts for indoor applications shall meet any sound rating specifications.
  - c. Total Harmonic Distortion shall not exceed 35 %. (*Note 1.16*)
  - d. Power Factor shall be 0.9 or greater. (*Note 1.17*)
  - e. Lamp Current Crest Factor shall not exceed 1.7. (*Note 1.18*)

### **2.2 EQUIPMENT**

#### **A. Luminaires:**

- 1. Refer to Fixture Schedule for a list of all project luminaires.
- 2. For fluorescent luminaires, follow specified ballast wiring and switching arrangements to lamps. Tandem wiring, where specified, shall be provided as factory assembled whips in specified lengths. (*Note 1.21*)

#### **B. Lighting Controls:**

- 1. Refer to Lighting Control Schedule for a list of all project lighting control devices.
- 2. All lighting controls and associated equipment shall comply with applicable State, UL and National Electrical Code requirements, and shall be installed to conform with manufacturer's and code specifications.
- 3. All switching devices that control fluorescent ballasts shall employ zero-crossing switching technology, or otherwise be designed to withstand high inrush current that may be caused by electronic ballasts.
- 4. All occupancy (motion) sensors shall be approved by the California Energy Commission.
- 5. Any specified dimming ballasts shall be electronic (solid state).
- 6. Any photocells that control lighting equipment shall be compatible with the ballasts they control, and shall be installed as directed by the photocell and ballast manufacturers. Photocells shall comply with applicable State requirements.
- 7. Photocell and other sensors shall be installed with five feet of slack wire to permit subsequent relocation without the need for rewiring.
- 8. Occupancy sensors intended for use with HID systems (typically high-low operation) shall be designated by the manufacturer to be compatible with such dimming systems.
- 9. Control systems that include both occupancy sensors and photocells shall be installed as indicated by the control manufacturer to assure compatibility.
- 10. Before calibrating a dimming control system, all lamps shall be operated at full output for at least 100 hours to assure stable dimming operation.
- 11. Passive infrared occupancy sensors shall be "masked" as required to prevent sensors from detecting motion outside the area they are controlling. The masking material shall be provided by the occupancy sensor manufacturer expressly for this purpose.

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12. Ultrasonic occupancy sensors shall be calibrated so that they detect motion only in the intended control space.

### **2.3 FINISHES**

- A. Painted finishes for luminaire housings and white painted reflectors shall be powder coat finishes. White painted reflector surfaces shall have reflectivity of 90% or higher.

### **2.4 SOURCE QUALITY CONTROL: RECYCLABILITY**

- A. Project goal is to provide products that are readily recyclable.

## **PART 3 - EXECUTION**

### **3.1 COORDINATION**

- A. Architectural Plans shall govern exact ceiling construction and mounting conditions for all fixtures. Contractor shall be responsible for coordination of fixture mounting and compatibility with ceiling construction.
- B. Fixtures in areas where exposed or concealed pipe and ductwork prevents direct access to the structural ceiling shall be provided with appropriate support system to suspend fixture below obstructions to avoid conflicts with same.
- C. The contractor shall coordinate the locations of light fixtures in exposed construction areas with mechanical ductwork. Any conflicts shall be coordinated through the Architect.
- D. Coordinate circuiting of the lighting with the electrical plans. Electrical connections and wiring methods shall conform to Division 16.

### **3.2 INSTALLATION**

- A. The contractor shall be responsible for handling and installation of fixtures including all supports, hangers and hardware necessary for a complete installation. Fixtures shall be clean, plumb, level, square, in straight lines, and without distortion. Remedy light leaks that may develop after installation of recessed or enclosed fixtures.
- B. Lighting plans show conduit connections to all specified luminaires. However contractor may, at his discretion, use existing flexible wiring harnesses in lieu of conduit connections, provided all applicable code provisions are met.
- C. Turn over project with all lamps in new and operating condition. Exception: for dimming system lamp seasoning requirements, refer to part 2.2-B-10.

### **3.3 FIXTURE SUPPORTS**

- A. Physical Supports:
  1. Surface mounted fixtures solely supported by recessed boxes in a gypsum board ceiling shall have a 1 1/8" steel bar screwed or welded to the back of the box. This steel bar must be long enough to span two ceiling support channels and shall be attached to the channels by twisting wire around the bar and the support channel. For fixtures weighing over 50 pounds, provide fixture studs in recessed box.
  2. Support surface mounted fixtures more than 18" wide at or near each corner, in addition to support from outlet box. Recessed downlights manufactured with

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built-in brackets shall be supported by twisting wire around the bracket and two adjacent ceiling support channel runners on either side of fixture.

3. Recessed downlights manufactured with built-in brackets shall be supported by twisting wire around the bracket and two adjacent ceiling support channel runners on either side of fixture.
4. Where ceiling and/or wall construction or pipe and/or ductwork is such that mounting channels, strongbacks, trapezes, brackets, etc., are required to properly support fixtures, provide these supports under this Section, unless otherwise shown.
5. Support outlet boxes as specified in Section 16130: Boxes. Provide all boxes with grounding pigtail.
6. On concrete ceilings, use one of the following for supporting fixtures other than by outlet box:
  - a. Preset concrete inserts, provided inserts are completely covered by the fixture canopy.
  - b. 1/4" x appropriate length wedge type anchor.

### **B. Seismic Supports:**

1. Recessed fluorescent fixtures in suspended ceilings shall be supported by connecting two fixture support wires to the fixture at diagonal opposite corners for fixtures weighing 56 pounds or less. Connect four wires, one at each corner for fixtures weighing more than 56 pounds.
2. Recessed incandescent or compact fluorescent downlight fixtures in suspended ceilings shall be supported by connecting at least one fixture support wire to the fixture housing.
3. All suspended fixtures shall be able to swing 45 degrees from vertical in any direction without obstruction.
4. All recessed fluorescent fixtures shall be furnished with earthquake clips where installed in tee bar ceiling.

### **3.4 IDENTIFICATION SYSTEM**

- A. All junction box cover plates for the lighting branch circuit system shall be clearly marked with a permanent black ink felt pen identifying the branch circuit (both panel designation and circuit number) contained in the box.

### **3.5 FIELD AIMING**

- A. The contractor shall allow time in the bid, and be responsible upon the installation of the light fixtures, for aiming and lamping fixtures as described in the fixture schedule. This aiming will be required to be performed at night under the direction of the owner's representative and the architect or engineer. The contractor shall be responsible for providing the labor and materials for field aiming including, but not limited to, special rigging or scaffolding, adjusting fixtures in field, testing of various lamps with each fixture, and/or testing of various lenses or louvers with fixtures, as directed by the architect or engineer.

### **3.6 CLEANING AND PROTECTION**

- A. Environmental Protection: Refer to Section 01350 – Special Environmental Requirements.

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**END OF SECTION**

**REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY****SECTION 16500 - LIGHTING - NOTES****JUSTIFICATION**

- 1.1 *Guidelines for Specification Integrity* provides useful information for design professionals on how to write specifications with clarity and precision. It is also instructional about communicating with clients, manufacturers and manufacturers' agents concerning their standards of quality for lighting equipment to ensure that recommendations apply to every phase of a project's development.
- 1.2 Submittals must be coordinated with Division 1 specifications; otherwise they will most likely be dropped for existing Division 1 priorities.
- 1.3 Lamp lumen ratings at 40% of rated life are called "mean lumens". Ratings at 80% of rated life correspond to typical end-of-life for group lamp replacement cycles.
- 1.4 To verify any questionable claims, independent laboratory testing can show actual performance. If there is any doubt that a product could achieve performance claims, or if any product might not exhibit the quality of prior samples, laboratory tests will prove performance or lack thereof.
- 1.5 Occupancy sensors, dimming systems and other automatic lighting controls require commissioning to adjust and verify proper operation and programming for user compatibility and energy savings. Untuned lighting controls can actually create higher lighting energy use than simple on/off switching. In addition, poorly commissioned lighting controls will distract and annoy building occupants, leading to complaints and decommissioning of expensive lighting equipment. Initial commissioning should occur before accepting building spaces for occupancy, but after important furniture or other items that might influence control response have been placed in each space. Should any remedial commissioning become necessary, it should specifically avoid times that are inconvenient for the space occupants. Also, any expenses incurred by remedial commissioning will be the responsibility of the commissioning agent.
- 1.6 The commissioning agent shall instruct and train at least one permanent maintenance technician for the building in control adjustment procedures.; this may be part of the Systems Demonstration.
- 1.7 Group relamping is the most labor and cost saving method to replace the lamps in a lighting system. Group relamping should occur between 70 and 80% of rated lamp life. Spot relamping should replace failed lamps before the group relamping, as necessary for task and aesthetic requirements. All lamps used for spot replacement should have installation month and year prominently marked, so they can be reused for spot relamping after the group relamping. The date information is useful to ascertain the probable remaining life of the substitute lamp, a factor in selecting spot replacement lamps.
- 1.8 Special environmental considerations for lamps that contain mercury:
  - a. Almost all arc (fluorescent and HID) lamps contain mercury. Just a few high pressure sodium lamps are mercury-free, and these have limited applications. Compared to using incandescent mercury-free lamps, the

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- increased efficacy from arc lamps more than compensates for the internal lamp mercury by saving power plant emissions.
- b. Lighting equipment that contains mercury is not prohibited. However, when it is discarded it must either meet California EPA requirements for unregulated disposal or must be disposed or recycled in compliance with the California Universal Waste Rule (until California EPA prohibits disposal in 2006). Small toxic waste generators (less than 220 pounds per month) are allowed to put items such as fluorescent or HID lamps into landfills. Larger toxic waste generators must track and dispose of their Universal Waste at proper sites.
  - c. All lamp manufacturers and the Cal EPA recommend recycling spent lamps to minimize environmental effects. Using a California-authorized lamp recycler eliminates other waste disposal requirements.
  - d. The US EPA uses a Toxicity Characteristic Leaching Procedure (TCLP) test to determine if a lighting waste can be discarded without using toxic waste procedures. Only some fluorescent lamps, a group of HPS lamps and a very few metal halide lamps meet TCLP requirements. Since Cal EPA requirements are more stringent, they supercede US EPA requirements in California.
  - e. California EPA uses a Total Threshold Limit Concentration (TTLC) test instead of the TCLP test. Only a few fluorescent lamps, from one manufacturer, and a couple of HPS lamps pass this test. Cal EPA recommends recycling for all commercial spent lamps that contain mercury, weather they meet TTLC test requirements or not.
  - f. Since both Cal EPA and lamp manufacturers recommend recycling spent lamps, there is no restriction on buying or using non-TTLC complying lamps. The lamps become universal waste when discarded, so the recycling question becomes a maintenance need rather than a specifying or purchasing item.
- 1.9 Specifier should indicate the best CCT for fluorescent lamps. 3000K works well with incandescent lamps or if illuminance levels are low (such as 5 footcandles). 3500K is a neutral white; without other light sources it seems neither warm nor cool. 4100K seems cool and crisp, and implies a business atmosphere; it works well with higher illuminance levels such as 100 footcandles. 5000K seems similar to noontime daylight with blue sky. While 5000K seems too cool for many applications, some research suggests that the high scotopic output of these very cool lamps may enhance visual acuity.
  - 1.10 Lighting specifiers are encouraged to use "2<sup>nd</sup> Generation" or "premium" F32T8 lamps. These lamps produce more light and render colors better than standard F32T8 lamps. Since they produce higher lumens, the specifier can use RLO electronic ballasts to produce equivalent light output as standard electronically-ballasted F32T8 systems with an associated energy savings of 19%-20%.
  - 1.11 Linear fluorescent lamps should be T8 (unless other types perform better, such as T5 in small optical systems) and should be rated for long life. The 24,000 hour rated T8 lamps have better overall life-cycle cost than 20,000 hour rated 2, 3, and 4 foot lamps.
  - 1.12 Ballast compatibility is an important issue, especially with both pulse and probe

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- start metal halide lamps available. ANSI codes, often listed in lamp and ballast catalogs can show lamp-ballast compatibilities.
- 1.13 Halogen Infrared lamps are typically more efficient than non-infrared lamps, so they are cost effective in the long run. A few non-infrared halogen lamps use advanced optical techniques to provide performance equal to infrared types.
  - 1.14 Toxic PCB insulating oil-filled capacitors were discontinued as ballast components about 1978. Since then, ballasts that contain capacitors state that they contain "no PCBs".
  - 1.15 All ballasts that operate at frequencies of 20kHz and above use electronics (they usually contain small inductors as part of their electronic circuitry). Small fluorescent lamps (less than 15 watts, compact or linear) may use 60 Hz magnetic ballasts, with low power factor acceptable, since electronic ballast availability for these lamp types is still poor.
  - 1.16 Total harmonic distortion (THD) above 0.3 (30%) might cause overheating in the wiring of some buildings. Almost all electronic fluorescent ballasts offer THD of 20% or better, while magnetic fluorescent ballasts may range up to about 30% THD. HID ballasts display THD up to 30%.
  - 1.17 Power factor indicates how efficiently an electrical device uses the energy provided. A low power factor may complicate the wiring needs of an electric system, since the current would exceed the anticipated amount based on the power of the load. High power factor means 0.90 and above, and is often required by electric utilities to avoid a special charge. This measure is usually determined at the electric meter, but keeping ballasts' power factor high tends to minimize complications of compliance.
  - 1.18 Lamp current crest factor, a typical ballast performance specification, may have detrimental effect on lamp life if it exceeds 1.7.
  - 1.19 Electronic ballasts have wide acceptance, so ballast manufacturers no longer offer a cash credit to replace a ballast that fails prematurely.
  - 1.20 T5 and smaller diameter lamps need a ballast circuit to shut down the lamp if an electrode fails; this prevents overheating the glass near the electrode. Overheating often causes separation of the lamp base from the glass, allowing toxic lamp materials to escape. Modern electronic ballasts for these lamps include this circuit, and usually so state in their specifications.
  - 1.21 Rapid start and instant start connections for electronic ballasts have historically caused occasional problems, since the options are many. Factory luminaire pre-wiring can decrease some problems, but clear specification and communications is very important.

**REFERENCES**

- 2.1 Illuminating Engineering Society of North America. Lighting Handbook, Ninth Edition. New York, NY: IESNA. 2000.
- 2.2 New Buildings Institute, Advanced Lighting Guidelines 2001. White Salmon, WA: NBI. 2001.
- 2.3 International Association of Lighting Designers. Guidelines for Specification Integrity. Chicago, IL. 2000. (*Note 1.1*)