2016 TITLE 24, PART 6

Residential Lighting

Best practices in lighting design to comply with California’s Title 24 energy code

NICOLE GRAEBER · Senior Development Engineer · California Lighting Technology Center, UC Davis
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Learning Objectives

- Effectively apply the mandatory residential Title 24 Building Energy Efficiency Standards requirements specific to lighting.
- Understand the lighting-related requirements in the 2016 Title 24 Building Energy Efficiency Standards code.
- Identify current lighting technologies, including LED luminaires, that are available to fulfill code requirements.
- Access resources through utility and lighting technology training centers for continued professional development.
- Understand how to participate in the 2019 Title 24 Building Energy Efficiency Standards code and standards enhancement process.
CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS

CLTC’s Mission: To stimulate, facilitate and accelerate the development, application and commercialization of energy-efficient lighting and daylighting technologies in partnership with utilities, manufacturers, occupants, builders, designers, researchers, academicians, and government agencies.

Mission-driven Activities:

- Research & Development
- Demonstration & Outreach
- Education & Training
<table>
<thead>
<tr>
<th>FOUNDING ORGANIZATIONS</th>
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<tbody>
<tr>
<td>UC Davis</td>
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<td>Pier</td>
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<td>NEMA</td>
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<th>UTILITIES</th>
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<tr>
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<td>Southern California Edison</td>
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<td>SDG Energy Solutions</td>
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<td>SMUD</td>
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<td>Roseville Electric</td>
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<td>Silicon Valley Power</td>
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<tr>
<th>MANUFACTURERS</th>
<th>LARGE END-USERS</th>
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<tr>
<td>Acuity Brands</td>
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<td>ENTECH Solar</td>
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<td>Cooper Lighting</td>
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<td>FINE LITE</td>
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<td>INTERMATIC</td>
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<td>Lumenetix</td>
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<td>SHARP</td>
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<td>Daintree Networks</td>
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<tr>
<td>Sai Lighting</td>
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<td>Dii Lighting</td>
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<td>LUMENRA</td>
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<td>SORAA</td>
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<td>Universal Lighting Technologies</td>
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<td>WattStopper</td>
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<td>HONDA</td>
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<td>The Power of Dreams</td>
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<td>National Forest Service</td>
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<td>CSU California State University</td>
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<td>LACCD</td>
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<td>Walmart</td>
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<td>Marines</td>
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</table>
Residential Lighting Design Guide

Provides a simplified and practical approach to lighting code compliance and design.

Topics include:

• Explanation of the code
• Technical guidelines
• Steps to compliance
• Lighting design examples

Available online for download!

www.cltc.ucdavis.edu
Background & Policy
Why Title 24, Part 6?

**Efficiency before generation**
The California Energy Commission has found energy efficiency and demand response as the preferred means of meeting the energy needs of a growing population.
Standards Development Obligations

- Technically feasible
- Cost-effective
- Performance-based and prescriptive compliance paths
## California’s Policy Goals

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Goal</th>
<th>Now</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2050</th>
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<td>Residential Buildings</td>
<td>New Construction ZNE¹</td>
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<td>100%</td>
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<td></td>
<td>Existing Homes (reduction relative existing stock)²</td>
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<td>Commercial Buildings</td>
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<td>100%</td>
<td></td>
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<tr>
<td></td>
<td>Existing ZNE¹</td>
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<td>50%</td>
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<td>State Buildings</td>
<td>New Construction &amp; Major Retrofit ZNE²</td>
<td>50%</td>
<td>100%</td>
<td></td>
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<tr>
<td></td>
<td>Existing ZNE (by square footage)²</td>
<td></td>
<td></td>
<td>50%</td>
<td></td>
<td></td>
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<tr>
<td>SB 350</td>
<td>Increase energy efficiency in existing buildings</td>
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<td></td>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Existing Buildings</td>
<td>New and enhanced codes &amp; standards, code simplification, increased compliance, asset ratings, purchase agreements, etc.³</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>GHG Emissions</td>
<td>Statewide GHG Emissions (all sources)⁴</td>
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<td></td>
<td>1990 Levels</td>
<td>40% Below 1990</td>
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<tr>
<td>Water Efficiency</td>
<td>25 percent reduction in urban water use⁵</td>
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<td></td>
<td>X</td>
</tr>
</tbody>
</table>

1. California’s *Long Term Energy Efficiency Strategic Plan*.
2. Executive Order B-18-12
3. Assembly Bill 758; Existing Buildings Action Plan
4. Assembly Bill 32 for 2020; Executive Order B-30-15 for 2030 and 2050
5. Executive Order B-29-15
Title 24 Code Cycle Timeline

The most recent revision, the 2016 *Title 24 Building Energy Efficiency Standards*, is effective now! Any application for a Building Permit submitted on or after January 1, 2017 must meet the 2016 standards.

The 2019 *Title 24 Building Energy Efficiency Standards* are currently being researched and developed. If you are interested in following the Codes and Standards Enhancement (CASE) process please participate in public events and docketing of comments on the California Energy Commission’s website.

http://www.energy.ca.gov/title24/2019standards/

http://title24stakeholders.com/

**Note:** This presentation is not intended to be used in lieu of the *Title 24 Building Energy Efficiency Standards*. Please visit [www.energy.ca.gov/title24](http://www.energy.ca.gov/title24) to download the official *Title 24 Building Energy Efficiency Standards* as well as the *Nonresidential Compliance Manual*. 
California's 2016 — Residential Building Energy Efficiency Standards

California Energy Commission

The state's energy efficiency standards for new buildings and appliances have saved consumers billions in reduced electricity and natural gas bills. The building standards include better windows, insulation, lighting, air conditioning systems and other features that reduce energy consumption in homes and businesses. Since 1978 these standards have helped protect the environment by reducing more than 260 million metric tons of greenhouse gas emissions (or the equivalent of removing 37 million cars of California roads).

High Efficacy Lighting

All lighting in new homes must be efficient. Installation of high quality lighting with controls that nearly halve the energy required for lights in new homes.

High Performance Walls

Increased wall insulation keeps the sun's heat out of your home during hot summer months and warm air in during winter months, improving comfort and reducing energy consumption.

High Performance Attics

Attics with additional insulation at the roof deck keep attic temperatures closer to ambient, improving the home's heating and cooling performance. Extra insulation at the roof deck, in addition to the ceiling insulation, will reduce the attic temperature by 35 degrees or more during hot summer days.

Improved Water Heating System Efficiency

Installing tankless water heating technology and better distribution systems reduces the energy needed to provide hot water to the home by about 35 percent.

These are cost effective measures that home builders may consider to achieve new levels of efficiency. They can be traded for other efficient technologies such as higher efficiency HVAC units, higher efficiency water heaters, etc.
Compliance Requirements
Does my project trigger code?

New Construction
New construction refers to construction of entirely new structures. New residential construction must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.

Additions
Additions are any change that increases the floor area and volume of a building of an occupancy group or type regulated by the Energy Standards. Additions are also any change that increases the illuminated area of an outdoor lighting application regulated by the Standards. New residential additions must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.

Alterations
Alterations involve replacing any lighting component, system, or equipment regulated by the Standards. Alterations to existing residential lighting systems must comply with the mandatory lighting measures contained in §150.0 (k) and Table 150.0-A.
The Compliance Process

Design
Architects, engineers and designers must understand both the requirements and the underlying intent of the standards if they are to design buildings and systems that are inherently energy efficient and cost effective.

Permit Application
Design teams must make sure that the plans contain all the information that the building official will need to verify that the building or system satisfies the requirements.

Plan Check
The plans examiner of the local building department must verify that the building or system satisfies the requirements of the standards and that the plans (not just the compliance forms) contain the information to be verified during field inspection.

Construction
Contractors must carefully follow the approved plans and specifications, and the building department field inspector(s) must verify that the building or system is constructed according to the plans and specifications.

Acceptance Commissioning
After completion of construction, the contractor and/or the design team must properly commission the building and its systems and provide information and/or training to the building operators on maintenance and operation of the building and its equipment.

Operation
After occupancy, the building and its systems must be correctly operated and properly maintained. The builder must provide new homeowners with a luminaire schedule that includes a list of installed lamps and luminaries. This ensures that homeowners know what lighting products they are entitled to when they take possession of a new home.
Locally Adopted Energy Standards

Local governmental agencies, primarily cities and counties, may adopt and enforce standards for newly constructed and existing buildings that are more stringent than Title 24. These can include:

- Shorter timeframes
- Additional energy conservation measures
- More stringent energy budgets
- CALGreen or GreenPoint Rated

It is critical to check with your local building agency for additional requirements.

A list of all local ordinances exceeding the standards is located at: [http://www.energy.ca.gov/title24/2016standards/ordinances/](http://www.energy.ca.gov/title24/2016standards/ordinances/)
Prescriptive vs. Performance Standards

Title 24, Part 6 compliance is achievable through two approaches:

**Prescriptive Standards**
- Simpler, but does not allow as much flexibility in design
- Each individual component of the proposed building must meet a prescribed minimum energy requirement
- Applicant needs only to show that a building meets each minimum or maximum level prescribed in the set of requirements contained in a package

**Performance Standards**
- Allows the builder more freedom, but the standards are more complex and involved
- Detailed accounting of energy trade-offs between measures is possible
- Uses Energy Commission-approved computer software to calculate energy trade-offs based on Title 24 guidelines

“Which technology is appropriate for my project?”

“What is available, and how can I piece together the building I want while complying with Title 24?”
# 2016 Approved Compliance Programs

## Residential Buildings, 2016 Standards

<table>
<thead>
<tr>
<th>Program Name</th>
<th>Approved versions usable for permit</th>
<th>Contact Information</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBECC-Res</td>
<td>CBECC-Res 2016.2.1 (888) was approved 9/14/2016 for demonstrating performance compliance with the residential provisions of the 2016 California Building Energy Efficiency Standards (effective date January 1, 2017). When demonstrating compliance with the 2016 standards, CBECC-Res 2016.2.1 must be used for permit applications made on or after December 19, 2016. Please review the resolutions for details of the public domain Compliance Software and associated Compliance Manager (CM). All CBECC-Res 2016 resolutions can be found here.</td>
<td>California Energy Commission Building Standards Office 1516 9th Street, MS 37 Sacramento, CA 95814 ATTN: Dee Anne Ross 916-654-5600 <a href="mailto:deeanne.ross@energy.ca.gov">deeanne.ross@energy.ca.gov</a></td>
<td>CBECC-Res Website FAQ Approval/Expiration Dates Reported Software Issues Support: <a href="mailto:cbecc.res@gmail.com">cbecc.res@gmail.com</a></td>
</tr>
<tr>
<td>EnergyPro</td>
<td>EnergyPro Version 7.1 was approved 9/27/2016 as an alternative calculation method for demonstrating performance compliance with the residential provisions of the 2016 California Building Energy Efficiency Standards. All 2016 EnergyPro (Residential) resolutions can be found here.</td>
<td>EnergySoft, LLC. 1025 5th Street, Suite A Novato, CA 94945-2413 415-897-6400</td>
<td>EnergyPro Website Approval/Expiration Dates FAQs Support: <a href="mailto:support@energysoft.com">support@energysoft.com</a></td>
</tr>
<tr>
<td>Right-Energy Title 24</td>
<td>Wrightsoft Right-Energy Title 24 v2.1, using the simplified geometry two-dimensional (2D) option of the CBECC-Res API, was approved 12/14/2016 as an alternative calculation method for demonstrating performance compliance with the residential provisions of the 2016 California Building Energy Efficiency Standards for newly constructed single family buildings.</td>
<td>Wrightsoft Corporation 131 Hartwell Avenue Lexington, MA 02421 800-225-8697 <a href="mailto:sales@wrightsoft.com">sales@wrightsoft.com</a></td>
<td>Wrightsoft Website Approval/Expiration Dates FAQs Support: <a href="mailto:support@energysoft.com">support@energysoft.com</a></td>
</tr>
</tbody>
</table>

Mandatory Measures

Mandatory measures required by both prescriptive and performance approaches include the following areas:

- Building envelope
- Space conditioning, water heating and plumbing
- Ducts and fans
- Pools and spas
- Fireplaces
- Lighting
What forms apply?

**CF2R-LTG-01-E**
for single-family dwellings

**CF2R-LTG-02-E**
for multi-family dwellings

Download Forms here:

The appropriate CF2R form must be posted on site and provided to the home owner *once the lighting project has been completed.*
## A. Installed Lighting and Controls

Select Yes or No according to whether your work on the project includes each of the following types of lighting and controls. See Sections B through H for applicable requirements.

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Y or N</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>High Efficacy luminaires installed in any interior rooms. (See Section B.)</td>
<td>Y</td>
</tr>
<tr>
<td>02</td>
<td>JA8 compliant luminaires and controls installed in any interior rooms. (See Section B.)</td>
<td>Y</td>
</tr>
<tr>
<td>03</td>
<td>Recessed downlight luminaire in ceilings in any interior rooms. (See Section C.)</td>
<td>Y</td>
</tr>
<tr>
<td>04</td>
<td>Screw-based luminaires installed in any interior rooms. (See Section D.)</td>
<td>Y</td>
</tr>
<tr>
<td>05</td>
<td>Lighting and controls in bathrooms. (See Section E.)</td>
<td>Y</td>
</tr>
<tr>
<td>06</td>
<td>Lighting and controls in laundry rooms. (See Section E.)</td>
<td>Y</td>
</tr>
<tr>
<td>07</td>
<td>Lighting and controls in utility rooms. (See Section E.)</td>
<td>Y</td>
</tr>
<tr>
<td>08</td>
<td>Lighting and controls in garage. (See Section E.)</td>
<td>Y</td>
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<tr>
<td>09</td>
<td>Outdoor lighting and controls. (See Section H.)</td>
<td>Y</td>
</tr>
<tr>
<td>10</td>
<td>Blank electrical boxes installed more than 5 feet from finished floor. (See Section F.)</td>
<td>NA</td>
</tr>
<tr>
<td>11</td>
<td>Internally illuminated address signs. (See Section G.)</td>
<td>Y</td>
</tr>
</tbody>
</table>

## B. High Efficacy Luminaires and Controls

All luminaires are installed with:

- Light sources of one of the light source technologies under the “High Efficacy” column of Table 150.0-A; or
- JA8 compliant light sources and the light sources are marked with a label reading “JA8-2016” or “JA8-2016-E”.

02 150.0(k)2K: Dimmers or vacancy sensors control all luminaires required to have JA8 compliant light sources.

03 150.0(k)2A: Forward phase cut dimmers used shall comply with NEMA SSL 7A.

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.
### C. Recessed Downlight Luminaires in Ceilings

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>150.0(k)1Cv: Contain JA8 compliant light sources that are marked with a label reading “JA8-2016-E”.</td>
</tr>
<tr>
<td>02</td>
<td>150.0(k)1C: Listed for zero clearance insulation contact (IC).</td>
</tr>
<tr>
<td>03</td>
<td>150.0(k)1Ci: Has label certifying air tight.</td>
</tr>
<tr>
<td>04</td>
<td>150.0(k)1Cii: Sealed with a gasket or caulk between the luminaire housing and ceiling, and all air leakage paths between conditioned and unconditioned spaces are sealed with a gasket or caulk.</td>
</tr>
<tr>
<td>05</td>
<td>150.0(k)1Civ: Allows ballast maintenance and replacement to be readily accessible to building occupants from below the ceiling without requiring the cutting of holes in the ceiling.</td>
</tr>
<tr>
<td>06</td>
<td>150.0(k)1Cv: Do not contain screw based sockets.</td>
</tr>
</tbody>
</table>

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.

### D. Additional Luminaire Requirements

<table>
<thead>
<tr>
<th></th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>150.0(k)1G: Screw based luminaires are installed with all of the following requirements:</td>
</tr>
<tr>
<td></td>
<td>• The luminaire is not recessed downlight luminaire in ceilings; and</td>
</tr>
<tr>
<td></td>
<td>• The luminaire contains JA8 compliant lamps</td>
</tr>
<tr>
<td>02</td>
<td>150.0(k)1H: No light sources marked “not for use in enclosed fixture” or “not for use in recessed fixture” are installed in enclosed luminaires.</td>
</tr>
<tr>
<td>03</td>
<td>150.0(k)1D: Ballasts for fluorescent lamps rated 13 Watts or greater are electronic.</td>
</tr>
<tr>
<td>04</td>
<td>150.0(k)1E: Night lights are rated to consume no more than 5 Watts of power.</td>
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<tr>
<td>05</td>
<td>150.0(k)1F: Lighting integral to exhaust fans meets all applicable requirements of Section 150.0(k).</td>
</tr>
</tbody>
</table>

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.
### E. Additional Lighting Controls

|   | 150.0(k)2J: In bathrooms, garages, laundry rooms, and utility rooms, at least one luminaire in each of these spaces are controlled by a vacancy sensor. |
|   | 150.0(k)2A: Forward phase cut dimmers used shall comply with NEMA SSL 7A. |
|   | 150.0(k)2B: Exhaust fans are switched separately from lighting systems, or can be switched OFF in accordance with EXCEPTION. |
|   | 150.0(k)2C: Luminaires are switched with readily accessible controls that permit luminaires to be manually switched ON and OFF. |
|   | 150.0(k)2D: Lighting controls and equipment are installed in accordance with manufacturer’s instructions. |
|   | 150.0(k)2E: No controls are installed that bypass a dimmer or vacancy sensor function where that dimmer or vacancy sensor has been installed to comply with Section 150.0(k). |
|   | 150.0(k)2F: Lighting control devices have been Certified to the Energy Commission as applicable; lighting control systems comply with the applicable requirements in Section 110.9. |
|   | 150.0(k)2G: Energy Management Control Systems used to comply with dimmer requirements provide the functionality of a dimmer in accordance with Section 110.9, meet the installation certificate requirements in Section 130.4, the EMCS requirements in Section 130.5, and comply with all other applicable requirements in Section 150.0(k). |
|   | 150.0(k)2H: Energy Management Control Systems used to comply with vacancy sensor requirements in Section 150.0(k) provide the functionality of a vacancy sensor in accordance with Section 110.9, meet the installation certificate requirements in Section 130.4, the EMCS requirements in Section 130.5, and comply with all other applicable requirements in Section 150.0(k). |
|   | 150.0(k)2I: A multi-scene programmable controller used to comply with dimmer requirements provides the functionality of a dimmer in accordance with Section 110.9, and complies with all other applicable requirements in Section 150.0(k). |
|   | 150.0(k)2L: Undercabinet lighting is switched separately from other lighting system. |

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.

### F. Blank Electrical Boxes

|   | 150.0(k): The number of blank electrical boxes installed more than five feet above the finished floor, are not greater than the number of bedrooms. The blank boxes are served by dimmer, vacancy sensor, or fan speed control. |

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.
### F. Blank Electrical Boxes

| 01 | 150.0(k)2: The number of blank electrical boxes installed more than five feet above the finished floor, are not greater than the number of bedrooms. The blank boxes are served by dimmer, vacancy sensor, or fan speed control. |

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.

### G. Address Signs

| 01 | 150.0(k)4: Internally illuminated address signs. Internally illuminated address signs shall either:  
| | a. Comply with Section 140.8. Applicable nonresidential sign lighting compliance forms shall also be submitted; or  
| | b. Consume no more than 5 Watts of power, determined according to Section 130.0(c). |

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.

### H. Single Family Outdoor Lighting

| 01 | 150.0(k)1A: High efficacy outdoor lighting is installed. |
| 02 | 150.0(k)3A: Outdoor lighting is controlled by a manual ON and OFF switch and one of the following automatic control types:  
| | • Photocontrol and motion sensor;  
| | • Photocontrol and automatic time switch control;  
| | • Astronomical time clock that automatically turns the lighting OFF during daytime hours;  
| | • Energy management control system (EMCS) that provides the functionality of an astronomical clock, does not have an override that allows the luminaire to be always ON, and is programmed to automatically turn outdoor lighting off during daytime hours. |

The responsible person’s signature on this compliance document affirms that all applicable requirements in this table have been met.
DOCUMENTATION AUTHOR’S DECLARATION STATEMENT

1. I certify that this Certificate of Installation documentation is accurate and complete.

   Documentation Author Name: ____________________________
   Documentation Author Company Name: _________________________
   Address: ____________________________
   City/State/Zip: ____________________________
   Date Signed: ____________________________
   CEA/HERS Certification Identification (if applicable): ____________________________
   Phone: ____________________________

   Documentation Author Signature: ____________________________

RESPONSIBLE PERSON’S DECLARATION STATEMENT

I certify the following under penalty of perjury, under the laws of the State of California:

1. The information provided on this Certificate of Installation is true and correct.

2. I am either: a) a responsible person eligible under Division 3 of the Business and Professions Code in the applicable classification to accept responsibility for the system design, construction, or installation of features, materials, components, or manufactured devices for the scope of work identified on this Certificate of Installation, and attest to the declarations in this statement, or b) I am an authorized representative of the responsible person and attest to the declarations in this statement on the responsible person’s behalf.

3. The constructed or installed features, materials, components or manufactured devices (the installation) identified on this Certificate of Installation conforms to all applicable codes and regulations and the installation conforms to the requirements given on the Certificate of Compliance, plans, and specifications approved by the enforcement agency.

4. I will ensure that a registered copy of this Certificate of Installation shall be posted or made available with the building permit(s) issued for the building, and made available to the enforcement agency for all applicable inspections. I understand that a registered copy of this Certificate of Installation is required to be included with the documentation the builder provides to the building owner at occupancy.

   Responsible Builder/Installer Name: ____________________________
   Responsible Builder/Installer Signature: ____________________________
   Address: ____________________________
   Address: ____________________________
   City/State/Zip: ____________________________
   Phone: ____________________________
   Date Signed: ____________________________

   Company Name: (Installing Subcontractor or General Contractor or Builder/Owner)
   Position With Company (Title): ____________________________
   CSLB License: ____________________________
Modernized Appliance Efficiency Database System (MAEDBS)

http://www.appliances.energy.ca.gov/AdvancedSearch.aspx
Construction & Inspection

• Starting 2016 code cycle, the builder must now provide new homeowners with a luminaire schedule that includes a list of installed lamps and luminaires.

• Lighting inspections are made easier since all luminaires are high efficacy and there is a completed luminaire schedule for the owner.

In the 2016 code: 10-103 (b) 2
Concepts & Principles
Lighting & Energy Efficiency

Light Sources
- One-time, long-term change
- Reduction of baseline
  - Light Source Efficacy
  - Luminaire Efficacy
  - Application Efficacy

Light Controls
- Continuous, real-time change
- Fluctuations from baseline
  - Dimming
  - Occupancy / Vacancy
Select the Appropriate Source + Luminaire + Controls (for the application)
Spectral Power Distribution

- **SPD**: The radiant power emitted by a light source over a range of specified wavelengths, typically the visible range (approximately 360 nm to 830 nm)

- Which electric light source’s spectral power distribution (SPD) is most similar to the sun’s SPD?

- Why does this matter?
Integrating Sphere
Terminology

**Luminous flux**: rate of flow of visible light emitted from a light source over time, measured in lumens (lm).

Luminous intensity of the measured solid angle (lm), where 1 lumen = 1 candela * 1 steradian

**Illuminance**: the amount of luminous flux that covers a surface (measured in lux or footcandles).

**Footcandle**: equal to one lumen per square foot (1 footcandle = 10 lux).
Luminous Flux (Lumen)

- Total amount of light emitted
- Measured in all directions
- Unit is lumen (lm)
- Used to quantify the output of lamps
Goniophotometer
Luminous Intensity (Candela)

The green and blue lines represent light intensity distribution patterns in the axial and transverse planes, respectively.

0° plane or “II” or “along” or “parallel”

90° plane or “⊥” or “across” or “normal”
Luminous Intensity (Candela)

- Intensity of light emitted in a specific direction
- Unit is candela (cd)
- Used to rate the output of directional lamps and light distribution of luminaires
- The luminous intensity of a source expressed in candelas is called its candlepower (cp)
**Luminous Intensity:** the concentration of light emitted from a given source in a particular direction, measured in candela (cd) \((1 \text{ cd} = 1 \text{ lm per steradian})\).
Luminance (Candela per Meter$^2$)

- Light emitted, reflected, or transmitted from or through a surface
- Specific to the direction of travel of the light
- US Unit is candela per square foot
- SI Unit is candela per square meter
Illuminance (Footcandle or Lux)

Density of light incident on a surface
Surface can be real or imaginary
  – A plane or a point in space
US Unit is *footcandle (fc)*
  – One Lumen per one square foot
SI Unit is *lux (lx)*
  – One lumen per one square meter

Horizontal and/or vertical levels may be critical depending on the application and type of task

10.76 lux = 1 foot-candle,
~10 lux = 1 foot-candle
# IES Illuminance Recommendations

<table>
<thead>
<tr>
<th>Category</th>
<th>Building Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (3fc)</td>
<td>Public spaces  (Movie theater, observatory)</td>
</tr>
<tr>
<td>B (5fc)</td>
<td>Orientation for short visits (Public auditorium, night club, arcade)</td>
</tr>
<tr>
<td>C (10fc)</td>
<td>Working spaces for simple visual tasks (Art gallery, restaurant, parking garage, public restroom)</td>
</tr>
<tr>
<td>D (30fc)</td>
<td>Performance of visual tasks of high contrast and large size (Coliseum/arena, school gymnasium, chapel, grocery store, commercial building)</td>
</tr>
<tr>
<td>E (50fc)</td>
<td>Performance of visual tasks of high contrast and small size or tasks of low contrast and large size (School, medical laboratory, computer processing office, vehicle repair center)</td>
</tr>
<tr>
<td>F (100fc)</td>
<td>Performance of visual tasks of low contrast and small size (Hospital facilities, veterinary clinic)</td>
</tr>
<tr>
<td>G (800fc)</td>
<td>Performance of visual tasks near threshold (Operating table)</td>
</tr>
</tbody>
</table>

*fc = footcandle
Electrical Characteristics

**Efficiency**: the ratio between the useful output of energy and the input of energy.

**Luminous Efficacy** compares the amount of light produced by a lamp (lumens), to amount of power consumed to produce it (watts).
Correlated Color Temperature (CCT)

A specification of the color appearance of light emitted by a lamp, relating its color to the color of light from a source when heated to a particular temperature.

CCT rating for a lamp is a general **warmth** or **coolness** measure of its appearance.
Correlated Color Temperature (CCT)
Color Rendering Index

- Color rendering is defined as “Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant” (CIE 17.4–1987)
- It is the only color rendering metric with wide spread acceptance
- It is calculated by comparing the color appearance of the test source to a reference source for 8 reflective samples (Score from 1–100)
- All other aspects of the source for a true comparison should be the same
Color Rendering Index
**Lighting Facts Label**

**Light Output/Lumens**
Measures light output. The higher the number, the more light is emitted. Reported as “Total Integrated Flux (Lumens)” on LM-79 test report.

**Watts**
Measures energy required to light the product. The lower the wattage, the less energy used. Reported as “Input Power (Watts)” on LM-79 report.

**Lumens per Watt/Efficiency**
Measures efficiency. The higher the number, the more efficient the product. Reported as “Efficacy” on LM-79 test report.

**IESNA LM-79-2008**
Industry standardized test procedure that measures performance qualities of LED luminaires and integral lamps. It allows for a true comparison of luminaires regardless of the light source.

**Brand & Model Number**

---

**Lighting Facts**
A Program of the U.S. DOE

<table>
<thead>
<tr>
<th>Light Output (Lumens)</th>
<th>315</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watts</td>
<td>9.3</td>
</tr>
<tr>
<td>Lumens per Watt (Efficacy)</td>
<td>33</td>
</tr>
</tbody>
</table>

**Color Accuracy**
Color Rendering Index (CRI)
Measures color accuracy. Color rendition is the effect of the lamp’s light spectrum on the color appearance of objects.

**Correlated Color Temperature (CCT)**
Measures light color. “Cool” colors have higher Kelvin temperatures (3600-5500K); “Warm” colors have lower color temperatures (2700-3500K).

---

Additional information:
- Registration Number: 10545-AUJD77V
- Model Number: FJ.5X2.3-KK
- Type: OTW

---

CONCEPTS & PRINCIPLES
Technology Requirements
Two Strategies, Three Main Technologies

High Efficacy Light Source
These light sources are designed and built to operate only high-efficacy light sources, as defined by the California Energy Commission. Select sources are automatically considered high-efficacy, while others must meet criteria.

Sensors
Occupancy/vacancy sensors and daylight sensors are all devices that automatically turn lights off (or dim them) in response to conditions that they “sense” or “see.”

Dimmers
Dimmers, which are already common in many residential applications, allow room occupants to lower lighting levels (and thus energy use) as desired.
Modernized Appliance Efficiency Database System (MAEDBS)

http://www.appliances.energy.ca.gov/AdvancedSearch.aspx
Light Sources
2016 Luminaire Requirements

- Luminaire Efficacy
- Blank Electrical Boxes
- Recessed Downlight Luminaires
- Electronic Ballasts
- Night Lights
- Lighting Integral to Exhaust Fans
- Screw Based Luminaires
- Enclosed Luminaires

In the 2016 code: 150(k)1
TABLE 150.0-A  CLASSIFICATION OF HIGH EFFICACY LIGHT SOURCES

<table>
<thead>
<tr>
<th>High Efficacy Light Sources</th>
<th>Light sources in this column shall be certified to the Commission as High Efficacy Light Sources in accordance with Reference Joint Appendix JA8 and be marked as meeting JA8.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminaires installed with only the lighting technologies in this table shall be classified as high efficacy</td>
<td></td>
</tr>
<tr>
<td>Light sources in this column other than those installed in ceiling recessed downlight luminaires are classified as high efficacy and are not required to comply with Reference Joint Appendix JA8</td>
<td></td>
</tr>
<tr>
<td>1. Pin-based linear or compact fluorescent light sources using electronic ballasts.</td>
<td></td>
</tr>
<tr>
<td>2. Pulse-start metal halide.</td>
<td></td>
</tr>
<tr>
<td>3. High pressure sodium.</td>
<td></td>
</tr>
<tr>
<td>4. GU-24 sockets containing light sources other than LEDs. ( ^a^b )</td>
<td></td>
</tr>
<tr>
<td>5. Luminaires with hardwired high frequency generator and induction lamp.</td>
<td></td>
</tr>
<tr>
<td>6. Inseparable SSL luminaires that are installed outdoors.</td>
<td></td>
</tr>
<tr>
<td>7. Inseparable SSL luminaires containing colored light sources that are installed to provide decorative lighting.</td>
<td></td>
</tr>
<tr>
<td>8. All light sources in ceiling recessed downlight luminaires. Note that ceiling recessed downlight luminaires shall not have screw bases regardless of lamp type as described in Section 150.0(k)1C.</td>
<td></td>
</tr>
<tr>
<td>9. GU-24 sockets containing LED light sources.</td>
<td></td>
</tr>
<tr>
<td>10. Any light source not otherwise listed in this table and certified to the Commission as complying with Joint Appendix 8.</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- \( ^a \) GU-24 sockets containing light sources such as compact fluorescent lamps and induction lamps.
- \( ^b \) California Title 20 Section 1605(k)3 does not allow incandescent sources to have a GU-24 base.
2016 High Efficacy Lighting

Light Sources that are *always* considered ‘high-efficacy’ by Title 24:

1. Pin-based linear or compact fluorescent light sources paired with electronic ballasts
2. Pulse-start metal halide
3. High pressure sodium
4. GU-24 sockets containing light sources other than LED (CFL, induction, etc.)
   - Title 20 does not permit *incandescent* GU-24 lamps
5. Luminaires with hardwired high-frequency generator and induction lamp
6. Inseparable solid state lighting luminaires that are installed outdoors
7. Inseparable solid state lighting luminaires containing colored light sources that are installed to provide decorative lighting

In the 2016 code: 150(k)1 A
### High Efficacy Light Sources

Luminaires installed with only the lighting technologies in this table shall be classified as high efficacy.

<table>
<thead>
<tr>
<th>Light sources in this column other than those installed in ceiling recessed downlight luminaires are classified as high efficacy and are not required to comply with Reference Joint Appendix JA8</th>
<th>Light sources in this column shall be certified to the Commission as High Efficacy Light Sources in accordance with Reference Joint Appendix JA8 and be marked as meeting JA8.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pin-based linear or compact fluorescent light sources using electronic ballasts.</td>
<td>8. All light sources in ceiling recessed downlight luminaires. Note that ceiling recessed downlight luminaires shall not have screw bases regardless of lamp type as described in Section 150.0(k)1C.</td>
</tr>
<tr>
<td>3. High pressure sodium.</td>
<td>10. Any light source not otherwise listed in this table and certified to the Commission as complying with Joint Appendix 8.</td>
</tr>
<tr>
<td>4. GU-24 sockets containing light sources other than LEDs. (a) (b)</td>
<td></td>
</tr>
<tr>
<td>5. Luminaires with hardwired high frequency generator and induction lamp.</td>
<td></td>
</tr>
<tr>
<td>6. Inseparable SSL luminaires that are installed outdoors.</td>
<td></td>
</tr>
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<td>7. Inseparable SSL luminaires containing colored light sources that are installed to provide decorative lighting.</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

- \(a\) GU-24 sockets containing light sources such as compact fluorescent lamps and induction lamps.
- \(b\) California Title 20 Section 1605(k)3 does not allow incandescent sources to have a GU-24 base.
2016 High Efficacy Lighting

Light Sources that are considered ‘high-efficacy’ by Title 24 when they comply with JA8 requirements:

1. All light sources in ceiling recessed downlight luminaires.
   - Note that ceiling recessed downlight luminaires shall not have screw-bases regardless of lamp type
2. GU-24 sockets containing LED light sources
3. Any light source not otherwise listed in Table 150.0-A and certified to the Commission as complying with JA8

In the 2016 code: 150(k)1 A
2016 High Efficacy Lighting – JA8

- High efficacy products include any luminaire that contains a JA8-compliant lamp or other approved light source (Section 150.0 (k) and Joint Appendix JA8)

- Manufacturers must test their products at an accredited test laboratory and submit the results to the California Energy Commission to gain JA8 certification

- Must be certified and marked as either JA8-2016 or JA8-2016-E

- Compliant products may be found at http://www.appliances.energy.ca.gov/AdvancedSearch.aspx

### Appendix JA8: Qualification Requirements for High Efficacy Light Sources – Partial List

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Efficacy</td>
<td>≥ 45 lumens/Watt</td>
</tr>
<tr>
<td>Power Factor at Full Rated Power</td>
<td>≥ 0.90</td>
</tr>
<tr>
<td>Correlated Color Temperature (CCT)</td>
<td>For inseparable SSL luminaires, LED light engines and GU24 LED lamps, ≤4000 Kelvin. For all other sources, ≤3000 Kelvin.</td>
</tr>
<tr>
<td>Color Rendering Index (CRI)</td>
<td>≥90</td>
</tr>
<tr>
<td>R9</td>
<td>≥50</td>
</tr>
<tr>
<td>Rated Life</td>
<td>≥15,000 hours</td>
</tr>
<tr>
<td>Minimum Dimming Level</td>
<td>≤10%</td>
</tr>
<tr>
<td>Flicker</td>
<td>&lt;30% for frequencies of 200 Hz or below, at 100% and 20% light output.</td>
</tr>
</tbody>
</table>

In the 2016 code: 150(k)1 A
Modernized Appliance Efficiency Database System (MAEDBS)

http://www.appliances.energy.ca.gov/AdvancedSearch.aspx
**Blank Electrical Boxes**

**Applies to the entire residence:**

- What does ‘blank electrical box’ mean?

  Electrical box that does not contain a luminaire or other device

  AND

  Higher than 5 feet above the finished floor

- Number of blank electrical boxes shall be no greater than the number of bedrooms in the residence.

- How many blank electrical boxes is this residence allowed?

  - 3 Bedrooms = **Up to 3 blank electrical boxes!**

  **Additionally:** Blank electrical boxes must be controlled by dimmer, vacancy sensor control, or fan speed control.

In the 2016 code: 150(k)1 B
TECHNOLOGY REQUIREMENTS

Recessed Downlight Luminaires in Ceilings

Must be:

- Approved for insulation contact (IC) by UL or equivalent laboratory
- Labeled certifying airtight (AT) according to ASTM E283
  - Air leakage is <2.0 CFM at 75 Pascals
  - Does not apply to exhaust fans!
- Sealed with gasket or caulking between housing and ceiling – all air leak paths through luminaire assembly or ceiling opening must be sealed!
- For luminaires with hardwired ballasts/drivers, allow for readily accessible maintenance from below ceiling without cutting holes.
- NO SCREW BASES (E26)
- Only paired with JA8 compliant light sources marked JA8-2016-E
  - E means it was tested and approved for elevated temperatures

In the 2016 code: 150(k)1 C
Electronic Ballasts

• Certified to the Energy Commission
• Mandated for fluorescent lamps rated 13 Watts or greater
• Output frequency no less than 20 kHz

In the 2016 code: 150(k)1 D
Night Lights

Applicable to:
• Permanently installed night lights
• Night lights integral to installed luminaires or exhaust fans

Shall be:
• 5 Watts or less

No controls required:
• Not required to be controlled by vacancy sensor.

In the 2016 code: 150(k)1 E
Lighting Integral to Exhaust Fans

• Required to meet all applicable residential lighting requirements
• Exception:
  • Lighting installed by the manufacturer in kitchen exhaust hoods

In the 2016 code: 150(k)1 F
Screw Based Luminaires

Applicable to:
• Any screw base luminaires

Must:
• Not be recessed downlight luminaires in ceilings
• Contain lamps that comply with JA8
• Contain lamps that are marked with JA8-2016 or JA8-2016-E
  • JA8-2016 lamps are appropriate for open fixtures
  • JA8-2016-E lamps are appropriate for fixtures that experience elevated temperatures, i.e. enclosed

Exception:
• Luminaires with hard-wired ballasts for high intensity discharge (HID)
Enclosed Luminaires

• Light sources not marked with JA8-2016-E shall not be installed in enclosed luminaires

• ENCLOSED LUMINAIRES are luminaires which contain enclosed lamp compartments where ventilation openings are less than 3 square inches per lamp in the lamp compartment as defined by UL 1598

• What are some examples of enclosed luminaires?
Interior Controls
Dimmer and Vacancy Sensor Requirements

Dimmers OR vacancy sensors are required to control all JA8 compliant light sources.

Exceptions:
- Luminaires in closets less than 70 square feet
- Luminaires in hallways

Additionally:
In **bathrooms, garages, laundry rooms, and utility rooms** at least one **luminaire** must be controlled by a **vacancy sensor**.

In the 2016 code: see 150(k)2 J and K
Exhaust Fans

- Exhaust fans shall be switched separately from lighting system
  - *Exception:* Lighting can be on the same switch as long as the fan stays on for an extended period of time after light is switched off.

In the 2016 code: 150(k)2 B
Undercabinet Lighting

• Undercabinet lighting shall be switched separately from lighting system

In the 2016 code: 150(k)2 L
Indoor Vacancy Sensor Requirements

Requirements

- Must be manual-on/automatic-off (can also be turned off manually)
- Time delay cannot be greater than 20 minutes
- Cannot be locked in a permanent “on” state (no “on” override)

Optional features to consider

- Energy-efficient LED night-light
- Impact-resistant lens and switch

In the 2016 Title 24 code: 110.9 (b) 4 F; In Title 20: 1605.3 (g) 8
Switching Devices and Control Requirements

- Controls shall be readily accessible
- Shall have the capability of manually switching lighting ON and OFF
- All forward phase dimmers used with LED light sources must comply with NEMA SSL 7A*
- Shall be installed according to manufacturer’s instructions
- Shall not bypass any dimmer or vacancy sensor functionality installed to comply with 150(k)2 requirements
- Energy Management Control Systems (EMCS) can be used to comply with 150(k)2 requirements assuming it provides the same functionality and is certified

*NEMA SSL 7A is an industry standard that provides compatibility requirements for dimmers and LED light sources

In the 2016 code: 150(k)2 A, 150(k)2 C, 150(k)2 D, 150k(2) F, 150(k)2 G, 150(k)2 H
Dimmer Requirements

- Comply with Title 20
- Very subtle differences in language
- The dimmer shall:
  - reduce power consumption by a minimum of 65% percent at its lowest level;
  - include an off position which produces a zero lumen output; and not consume more than 1 W per lighting dimmer switch leg when in the off position.
  - Reduce flicker through dimming range to be no greater than 30 percent flicker
  - For 3-way, do not override level set by dimmer and all switches should turn light off

In the 2016 code: 150 (k) F; In Title 20: 1605.3 (f)
Dimmer Specifications Recommendations

**Specify the correct load amount**

- Line voltage
- Low voltage
- 3-way dimmers (ex. hallway applications)

**Pair LED luminaires and lamps carefully with dimmers, check manufacturer websites and spec sheets for compatibility**

In the 2016 code: 150 (k) 2D
## Control Requirements by Space

### 2016 Indoor Residential Lighting Requirements: Spaces & Lighting Controls

<table>
<thead>
<tr>
<th>Residential Space</th>
<th>Manual ON/OFF Controls</th>
<th>Vacancy Sensor or Dimmer&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Separate Switching: Exhaust Fans</th>
<th>Separate Switching: Undercabinet Lighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallways &amp; Closets&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Required for all spaces</td>
<td>Not required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchens</td>
<td>Required for all spaces</td>
<td>Based on installed luminaire or lamp type&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Exhaust fans must be switched separate from lighting or utilize a device where lighting can be turned OFF while the fan is running. Excludes kitchen exhaust hoods.</td>
<td>Undercabinet lighting must be switched separate from all other lighting.</td>
</tr>
<tr>
<td>Bathrooms</td>
<td></td>
<td>At least one luminaire controlled by a vacancy sensor and all other based on installed lamp or luminaire type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laundry Rooms/Utility Rooms</td>
<td></td>
<td>Based on installed luminaire or lamp type&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> May be achieved with an EMCS or programmable scene controller with required functionality.  
<sup>2</sup> Closets less than 70 ft². For all other closets, requirements based on installed lamp or luminaire type.  
<sup>3</sup> See page 3 for a list of requirements by lamp and luminaire type.
Overview of Interior Lighting Requirements

<table>
<thead>
<tr>
<th>Mandatory Measure</th>
<th>Screw-Base Luminaire</th>
<th>Pin-Base Luminaire</th>
<th>Recessed Downlight</th>
<th>Inseparable SSL(^5) Luminaire (LED)</th>
<th>Night Lights(^2)</th>
<th>All Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Efficacy (required)</td>
<td>Yes—All</td>
<td>Yes—All</td>
<td>Yes—All</td>
<td>Yes—All</td>
<td>No</td>
<td>Yes—All</td>
</tr>
<tr>
<td>High Efficacy Qualification via JAB lamps and luminaires(^4)</td>
<td>All, excluding hard-wired ballasted HID</td>
<td>Only GU-24 LED lamps</td>
<td>All types, and certified compliant for elevated temperatures</td>
<td>All, except colored-decorative</td>
<td>No</td>
<td>All types</td>
</tr>
<tr>
<td>Automatic Qualification as High Efficacy: Listed in Table 150.0-A, Column 1 (JAB compliance not required)</td>
<td>Hard-wired, ballasted HID only</td>
<td>All types, excluding GU-24 LED</td>
<td>None</td>
<td>Colored-decorative</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>Dimmer, Vacancy Control or EMCS(^4)</td>
<td>Yes—All</td>
<td>Not mandatory, except for GU-24 LED</td>
<td>Yes—All</td>
<td>All, except colored-decorative</td>
<td>No</td>
<td>All</td>
</tr>
<tr>
<td>Other Requirements</td>
<td>Cannot be a recessed downlight</td>
<td>Must use an electronic ballast</td>
<td>Airtight, I-C-rated and maintenance per §150I/1.C</td>
<td>None</td>
<td>Must consume 5W or less</td>
<td>None</td>
</tr>
</tbody>
</table>

1 Excludes recessed downlights
2 Permanently installed or integral to luminaire or exhaust fan
3 Enclosed luminaires must use JAB lamps certified for use at elevated temperatures
4 Excludes luminaires in closets less than 70 ft\(^2\) and hallways
5 Solid-state lighting such as LED where the LED source is permanently attached to the luminaire
Exercise Your Indoor Lighting Knowledge!

Is this design compliant?

1. All high efficacy?
2. Manual on/off controls?
3. If JA8 listed, is it controlled by a dimmer or vacancy sensor?
4. Undercabinet lighting switched separately?

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Luminaire Type</th>
<th>Lamp</th>
<th>Quantity</th>
<th>CRI</th>
<th>CCT</th>
<th>Watts</th>
<th>Total Watts</th>
<th>Efficacy (Im / W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LED undercabinet</td>
<td>Dedicated LED</td>
<td>21'</td>
<td>94</td>
<td>2,150 K</td>
<td>1.4 W/ft.</td>
<td>29.4</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>LED tape light</td>
<td>Dedicated LED</td>
<td>41'</td>
<td>90</td>
<td>2,200 K</td>
<td>4 W/ft.</td>
<td>164</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>Pendant</td>
<td>Dedicated LED</td>
<td>4</td>
<td>90</td>
<td>2,700 K</td>
<td>15</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>

**CONTROLS**

- Switch
- Switch with vacancy sensor
- Dimmer switch
- 3-way switch
Outdoor Light Source Requirements

Must meet the requirements in Table 150.0-A

<table>
<thead>
<tr>
<th>Light sources in this column other than those installed in ceiling recessed downlight luminaires are classified as high efficacy and are not required to comply with Reference Joint Appendix JA8.</th>
<th>Light sources in this column shall be certified to the Commission as High Efficacy Light Sources in accordance with Reference Joint Appendix JA8 and be marked as meeting JA8.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pin-based linear or compact fluorescent light sources using electronic ballasts.</td>
<td>8. All light sources in ceiling recessed downlight luminaires. Note that ceiling recessed downlight luminaires shall not have screw bases regardless of lamp type as described in Section 150.0(k)1C.</td>
</tr>
<tr>
<td>3. High pressure sodium.</td>
<td>10. Any light source not otherwise listed in this table and certified to the Commission as complying with Joint Appendix 8.</td>
</tr>
<tr>
<td>4. GU-24 sockets containing light sources other than LEDs. a, b</td>
<td></td>
</tr>
<tr>
<td>5. Luminaires with hardwired high frequency generator and induction lamp.</td>
<td></td>
</tr>
<tr>
<td>6. Inseparable SSL luminaires that are installed outdoors.</td>
<td></td>
</tr>
<tr>
<td>7. Inseparable SSL luminaires containing colored light sources that are installed to provide decorative lighting.</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- GU-24 sockets containing light sources such as compact fluorescent lamps and induction lamps.
- California Title 20 Section 1605(k)3 does not allow incandescent sources to have a GU-24 base.

In the 2016 code: 150(k)3
Outdoor Control Requirements

Lighting for single family homes and lighting mounted to any building on the lot must be controlled by:

Manual On/Off switch and paired with one of the following combinations:

1. Photocell and motion sensor
2. Photocell and automatic time switch control
3. Astronomical time clock
4. EMCS with features:
   1. Astronomical time clock,
   2. Does not allow the luminaire to be ON during the day, and
   3. May be programmed to automatically turn lighting OFF at night
Exercise Your Outdoor Lighting Knowledge!

Is this design compliant?

1. All high efficacy?
2. Manual on/off controls?
3. Does it meet one of the following control strategy requirements?
   - Photocell/motion sensor,
   - Automatic time switch, or
   - Astronomical time clock

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Luminaire Type</th>
<th>Lamp</th>
<th>Quantity</th>
<th>CRI</th>
<th>CCT</th>
<th>Watts</th>
<th>Total Watts</th>
<th>Efficacy (lm/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATIO</td>
<td>Outdoor wall sconce</td>
<td>Dedicated LED</td>
<td>4</td>
<td>90</td>
<td>2,700K</td>
<td>13</td>
<td>52</td>
<td>64</td>
</tr>
</tbody>
</table>

with photocell & motion sensor

CONTROLS

$ Switch
$ Switch with vacancy sensor
$ Dimmer switch
$ 3-way switch
Internally Illuminated Address Signs
Internally Illuminated Address Signs

Consume no more than 5 watts of power

OR

Comply with the nonresidential sign lighting Standards in §140.8:

- Cannot exceed 12 watts per sq. ft. internal illumination
- Cannot exceed 2.3 watts per sq. ft. external illumination

Alternatives when equipped only with one or more of the light sources

- High-pressure sodium
- Select metal halide lamps
- Select neon or cold cathode lamps
- Fluorescent lamps with a minimum 80 CRI OR paired with electronic ballasts
- Compact fluorescent lamps with no screw-base sockets
- LEDs

In the 2016 code: see 150(k)4
Large Residential Garages
Parking Lots and Garages

**Residential Lots and Garages**
- Residential standards apply to parking lots, carports and parking garages (attached and detached from dwelling unit) for **seven or fewer vehicles** per site
- Parking lots and carports must meet the residential **outdoor** lighting requirements or the non-res requirements
- Parking garages must meet the residential **indoor** lighting requirements: high efficacy and controlled by a vacancy sensor

**Non-residential Lots and Garages**
- Non-residential standards apply to parking lots, carports and parking garages (attached and detached from dwelling unit) for **eight or more vehicles**
- Must meet the power density limits for non-residential lighting standards
- Luminaires must be controlled by a photocontrol or time switch that turns lights off when daylight is present
- New construction or major alterations are required to comply with Backlight, Uplight, Glare ratings per IES TM-15-11
- Pole mounted luminaire > 75W and < 24 ft must include motion sensors that reduce lighting levels on vacancy.
- Other conditions apply, see sections: 110.9, 130.0, 130.2, 130.4, 140.7 & 141.0

In the 2016 code: see 150(k) 5
Multi-Family Residential Buildings
Low-rise Multi-family Common Areas

A multi-family complex consists of four or more dwelling units. A low-rise is considered a building with three or fewer stories.

If the building has more than three stories the common areas must comply with the non-residential code.

In the 2016 code: see 150(k) 6
Low-rise Multi-family Common Areas

In buildings where common areas constitute > 20% of the floor space:

- Lighting must comply with the non-res standards
- Lighting in corridors and stairwells **must** be controlled by occupancy sensors that reduce lighting power by at least 50%

In buildings with common areas that are ≤ 20% of the floor space:

- All hardwired lighting must be high efficacy **or** controlled by an occupancy sensor

In the 2016 code: see 150(k) 6
Multi-Family Outdoor Control Requirements

Low-rise, multifamily residential buildings, outdoor for private patios, balconies, entrances, and porches must meet these requirements:

Manual On/Off switch paired with one of the following combinations:

1. Photocell and motion sensor
2. Photocell and time switch
3. Astronomical time clock
4. EMCS with features of astronomical time clock, does not allow the luminaire to be ON during the day, and may be programmed to automatically turn lighting OFF at night

Carports, parking garages and parking lots with eight or more spaces must comply with nonresidential standards. Smaller parking areas may comply with either the residential or nonresidential standards.

In the 2016 code: see 150(k) 3C
www.energy.ca.gov/title24/2016standards

2016 Building Energy Efficiency Standards

California’s Building Energy Efficiency Standards are updated on an approximately three-year cycle. The 2016 Standards will continue to improve upon the 2013 Standards for new construction of, and additions and alterations to, residential and nonresidential buildings. The effective date of the 2016 Standards is January 1, 2017.

2016 Energy Standards

  - CEC-2016-003-20-CMF (PDF File, 239 Pages, 2.3 mb)
- Table 100.2-A Quick Links to Sections.
- 2016 Reference Appendices.
  - CEC-2016-038-CMF (PDF File, 494 Pages, 8.8 mb)

Compliance Manuals and Compliance Documents

- 2016 Residential Compliance Manual and Documents
  - CEC-2016-032-CMF
- 2016 Nonresidential Compliance Manual and Documents
  - CEC-2016-033-CMF

Worksheets

- Open and Closed Circuit Cooling Towers - Maximum Achievable Cycles Calculator
  - [LS File]
- Solar Reflectance Index Calculator (SRI)
Blueprint Newsletter

Compiled Blueprints (1989 to Current) File date: December 28, 2016 (PDF File, 38.7 MB)

Issue 117, November - December 2016

The Lighting Issue

- Title 24's JA8 and Title 20's State Regulated Lamp Requirements
- 2016 Prescriptive Indoor Lighting Alteration Options
- Q&A

Issue 116, September 2016 - October 2016

- Are You Ready for January 1, 2017?
www.energycodeace.com

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Ace + Training™
Targeted classroom and online training on Title 24, Part 6 and Title 20 addressing a variety of stakeholders and measures.

Ace + Resources™
Application Guides, Facts Sheets, Trigger Sheets and Checklists to help you understand how and when to comply with California’s building codes.
EnergyCodeAce.com/resources
When in Doubt...

The California Energy Commission provides contacts for energy efficiency programs related to the Energy Standards:

**Contacts for Energy Efficiency Programs**

**Energy Standards Hotline**

Phone Numbers
- Toll-Free in California: 800-772-3300
- Outside California: 916-654-5106

Fax Numbers
- Appliance Efficiency: 916-654-4304
- Building Energy Efficiency: 916-654-4304

Emails
- Appliances@energy.ca.gov
- Title24@energy.ca.gov
Thank You

FOR MORE INFORMATION AND RESOURCES ABOUT TITLE 24, PART 6: cltc.ucdavis.edu/title24