6. Lighting

6.1 Overview

6.1.1 Introduction and Scope

This chapter is a one-stop place where a builder, contractor, or lighting designer can get the information they need about residential lighting in low-rise buildings and in the dwelling units of high-rise buildings.

For residential buildings, all of the lighting requirements are mandatory measures. Therefore, lighting energy is not part of the energy budget for the whole building performance method, except as part of the standard assumption on internal heat gains that is assumed to be the same for all buildings. There are no tradeoffs between lighting and other building features.

The lighting requirements apply to alterations and additions (including replacements) as well as newly-constructed buildings. All new luminaires that are permanently installed must be high efficacy, but existing luminaires may stay in place.

The Standards apply only to permanently installed luminaires (i.e., plug-in luminaires are not required to meet these requirements).

6.1.2 What's New for 2005

The lighting requirements have been simplified and expanded for the 2005 update of the Standards with particular emphasis on efficiency measures that are easily inspected and verified by building inspectors on the job site. The concepts of "general lighting" and "task lighting" have been eliminated as a basis for code compliance.

The most dramatic change since the previous Standards is that high efficacy luminaires are required for almost all rooms in residential buildings. Exceptions are made in kitchens for a limited percentage of watts if the luminaires are on a separate circuit, or in other specified rooms if the luminaires are controlled by occupant sensors or dimmers[7]. In addition, trade-offs between the high efficacy requirement in specific rooms is removed, and all exterior luminaires attached to a building are required to be either high efficacy luminaires or controlled by both a photocontrol and motion sensor as well. The specific language for these requirements can be found in §150(k) of the proposed 2005 Standards.

[7] A manual-on occupant sensor turns lighting off automatically when no one is present. When lighting is needed it must be turned on manually with a switch.

The requirements apply only to permanently installed luminaires, i.e., luminaires that are part of the house, as opposed to portable luminaires such as torchieres or table lamps that are provided by the occupant. Permanently installed luminaires include ceiling luminaires, chandeliers, vanity lamps, wall sconces and any other type of luminaire that is a permanent part of the house.

The new requirements may be summarized as follows:

- Kitchens. At least half the installed wattage of luminaires in kitchens shall be high efficacy and the ones that are not must be switched separately.
- Lighting in Bathrooms, Garages, Laundry Rooms and Utility Rooms. All luminaires shall either be high efficacy or shall be controlled by an occupant sensor.
- Other Rooms. All luminaires shall either be high efficacy or shall be controlled by an occupant sensor or dimmer. Closet that are less than 70 square foot are exempt from this requirements.
- Outdoor Lighting. All luminaires mounted to the building or to other buildings on the same lot shall be high efficacy luminaires or shall be controlled by a photocontrol/motion sensor combination.
- Common Areas of Multifamily Buildings. All luminaires in the common areas of multifamily buildings shall either be high efficacy or shall be controlled by an occupant sensor.

Luminaires that are recessed into insulated ceilings are required to be rated for insulation contact ("IC-rated") so that insulation can be placed over them. The housing of the luminaire shall be airtight to prevent conditioned air escaping into the ceiling cavity or attic, unconditioned air infiltrating from the ceiling or attic into the conditioned space.

An additional set of requirements apply to parking lots or garages with space for eight or more cars, which are typically for multifamily buildings. The nonresidential Standards for parking lots and/or garages apply in these cases (§132, §147).

6.1.3 Related Documents

There are a number of publications and documents available from the California Energy Commission and others that provide additional information about residential lighting. A summary of these is listed below:

- The Nonresidential Manual should be consulted for more details on the requirements for parking lots and parking garages.
- The Advanced Lighting Guidelines, available from the New Buildings Institute (http://www.newbuildings.org) is an informative resource for energy efficient lighting design, luminaires, and controls. While the document is mostly oriented for nonresidential lighting applications, it has generic information

about lamps, ballasts, luminaires, and controls that is applicable to low-rise residential buildings.

- Professionally qualified lighting designers can be quickly located via the website of the International Association of Lighting Designers (http://www.iald.org/index). Many designers are ready to offer informal advice as well as undertake commissioned work.
- Many books on residential lighting design are available. The best books explain the principles of good lighting design as well as showing examples of luminaires. The fast pace of lamp development makes recently written books much more useful.
- Guidance on the selection and use of lighting technologies is available from the Lighting Research Center's National Lighting Product Information Program, at www.lrc.rpi.edu/programs/nlpip. Additional resources for energy efficient lighting and other building systems are available from the California Building Industry Institute at http://www.thebii.org.

6.2 High Efficacy Luminaires

A luminaire is the lighting industry's term for light fixture. A luminaire consists of the housing, power supply (ballast), lamp, reflector, and in some cases a lens. A lamp is the lighting industry's term for a light bulb. Luminaires can be designed to be recessed into the ceiling, suspended by a rod or chain, or surface mounted on the wall or ceiling.

A high efficacy luminaire is one that contains only high efficacy lamps and must not contain a conventional (medium) screw-based socket. Typically, high efficacy luminaires contain, pin-based sockets, like compact or linear fluorescent lamp sockets, though other types such as screw sockets specifically rated for high intensity discharge lamps (like metal halide lamps) may also be eligible for exterior use. Luminaires with modular components that allow conversion between screw-based and pin-based sockets without changing the luminaire housing or wiring shall not be considered high efficacy luminaires. These requirements prevent low efficacy lamps being retrofitted in high efficacy luminaires. Also, compact fluorescent luminaires with permanently installed ballasts that are capable of operating a range of lamp wattages, the highest operating input wattage of the rated lamp/ballast combination must be use for determining the luminaire wattage.

There are two qualifying requirements for a high efficacy luminaire: that the lumens per watt for the lamp be above a specified threshold and that electronic ballasts be used in certain applications.

6.2.1 Lumens per Watt

The lumen is the unit of visible light. To be rated as high efficacy, a lamp must produce a certain number of lumens for each watt of electrical power it consumes. Efficacy is therefore measured in lumens per watt.

Almost all fluorescent lamps equipped with electronic ballasts qualify as high efficacy light sources; incandescent lamps (including any screw-in incandescent lamps, like regular 'A' or reflector lamps, or quartz halogen lamps, or low voltage lamps, like halogen MR lamps) do not. To be classified as high efficacy, a lamp must meet the requirements listed in Table 6-1 (documented in Table 150-C of the Standards):

For simplicity, the power used by the ballast is ignored when determining the lumens per watt for purposes of compliance with the residential lighting requirements.

Table 6-1 – High Efficacy Lamps

Lamp power	Required lamp efficacy
< 15 W	40 lm/W
15-40 W	50 lm/W
>40 W	60 lm/W
Note: the wattage of the ballast is not included when determining lamp efficacy.	

Mercury vapor lamps do not usually meet the requirements; metal halide or compact fluorescent lamps (CFLs) are good replacements. For other lamp types such as LEDs you should check with the lamp manufacturer and provide documents showing that the lamp meets the requirements.

To calculate the efficacy of a lamp, find out from the manufacturer how many lumens it produces, then divide this number by the rated wattage of the lamp. Do not include any watts consumed by the ballast.

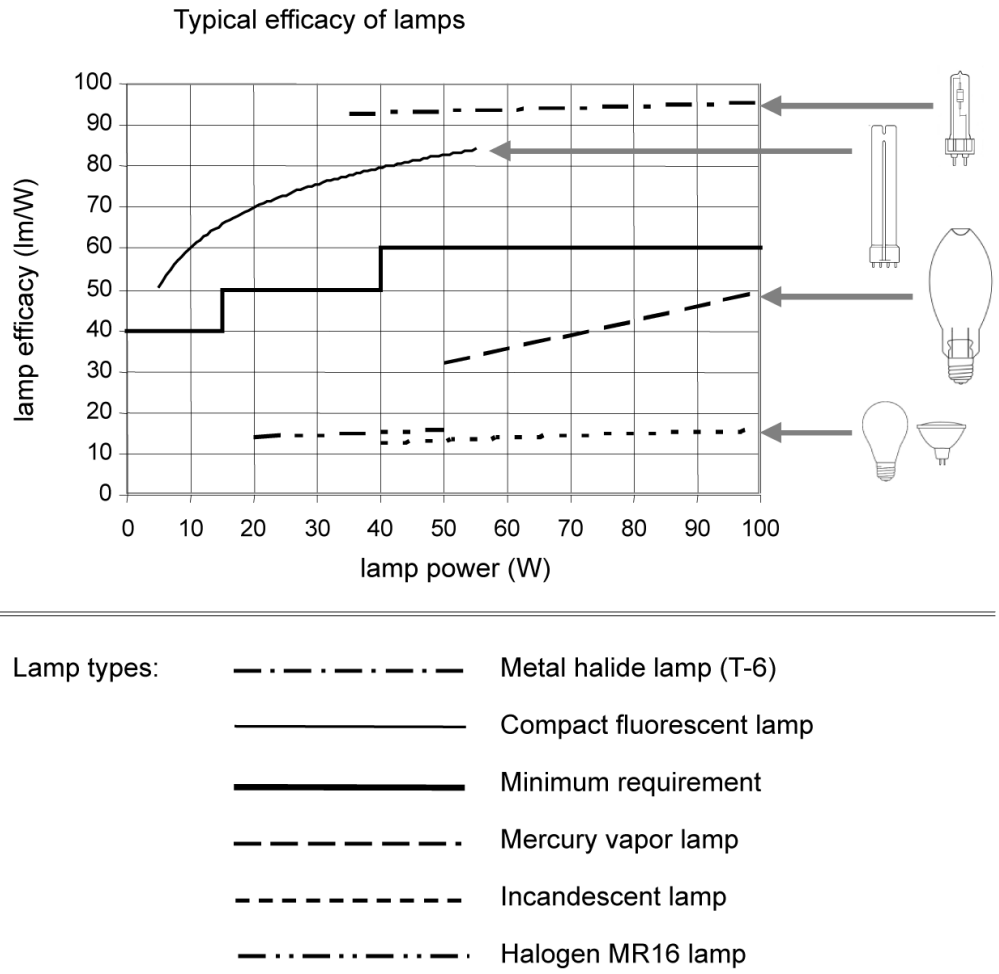

Figure 6-1 – Typical Lamp Efficacies

6.2.2 Electronic Ballasts

Additionally, fluorescent lamps with a power rating of 13 W or more shall have an electronic ballast that operates the lamp at a frequency of 20 kHz or more. All commonly available electronic ballasts meet this requirement. Outdoor luminaires with high intensity discharge (HID) lamps (like metal halide or high-pressure sodium) containing hardwired electromagnetic HID ballasts with HID rated medium base sockets and lamps meeting the minimum efficacy requirements in Table 6-1 are considered high efficacy.

At the present time, pin based compact fluorescent lamps that are operated with electronic ballasts typically have four-pin lamp holders. Pin-based compact fluorescent lamps with two-pin lamp holders typically will indicate that the ballast is magnetic. However, there are new compact fluorescent lamp holders being considered by the lighting industry.

6.2.3 Permanently Installed Luminaires

The Standards require that all permanently installed luminaires be high efficacy as defined by the Standards, with some exceptions described later in this chapter. Permanently installed luminaires include, but are not limited to those luminaires installed in, on, or hanging from the ceilings or walls (including ceiling fan lights); in or on built-in cabinets (including kitchen, nook, wet bar, and other built-in cabinets); and those mounted to the outside of the buildings. Permanently installed luminaires do not include lighting that is installed in appliances by the manufacturers including refrigerators, stoves, microwave ovens, or exhaust hoods.

6.3 Kitchens

§150(k)2.

The Standards define a residential kitchen to be “a room or area used for food storage and preparation and washing dishes including associated counter tops and cabinets, refrigerator, stove, oven, and floor areas.” The definition goes on to say, “Adjacent areas are considered kitchen if the lighting for the adjacent areas is on the same switch as the lighting for the kitchen”.

The intent of the kitchen lighting Standard is to insure the builder provides the occupant with energy efficient lighting. The permanently installed lighting should provide sufficient light levels for basic kitchen tasks without the need for augmenting with portable (plug-in) lighting.

A design recommendation may be to utilize the Illuminating Engineering Society of North America (IESNA) guidelines that at least 30 footcandles of light be provided for seeing tasks in kitchens. Seeing tasks include, but are not limited to, the basic kitchen tasks as preparing meals and washing dishes. These tasks typically occur on accessible kitchen countertops, the tops of ranges and in sinks, where food preparation, recipe reading, cooking, cleaning and related meal preparation activities take place, as well as at the front of kitchen cabinets so that the contents of the cabinet are discernable. Although the design should achieve 30 footcandles on most counter-height, horizontal work surfaces, there may be a few work surfaces where the lighting levels fall below this value and the fronts of kitchen cabinets may also be below this value. Even in these locations, the lighting level provided should not fall below the IESNA-recommended lower value for non-critical seeing tasks of 20 footcandles. Parts of counters that are not work surfaces, such as a corner underneath a cabinet, may have a lighting level below 20 footcandles and still meet the requirements of the standard, because meal preparation is unlikely to occur in those areas.

The Standards require that at least half the lighting watts in a kitchen must be consumed by high efficacy luminaires (remember that low-voltage halogen MR lamps do not count as high efficacy). Because high efficacy luminaires typically consume less power than other luminaires, about three-fourths of the luminaires in the kitchen are likely to be high efficacy. See Form WS-5R, Residential Kitchen Lighting Worksheet, Appendix A, which is completed to determine if kitchen lighting complies with the Standards.

High-efficacy fixtures and non-high efficacy fixtures are required to be switched separately. Our recommendation is to also separately switch different layers of the kitchen lighting. Each layer that can serve a unique function should have the ability to operate independent.

The following are some examples of layers that code allows to be switched together but are recommended to be switched separately:

- Recessed Downlights
- Linear fluorescent luminaires mounted on the ceiling.
- Under-cabinet lighting.

Under-cabinet lighting using 14W and 28W T5 linear fluorescent lamps
Source: www.gelighting.com

Figure 6-2 – Kitchen Work Surface Lighting

- In uplights (mounted on walls or on top of cabinets). Uplights are effective at making rooms less gloomy, so if an uplight is provided people may choose not to switch on the other lights in the room.

Non-high efficacy luminaires must be switched on a separate circuit from the high efficacy luminaires. These could include low-voltage halogen MR lamps or reflector lamps used to provide decorative spotlighting.

Lighting in areas adjacent to the kitchen, such as dining and nook areas and even family rooms, is considered to be kitchen lighting if it is not separately switched from the kitchen lighting. The switches may be mounted on the same faceplate, but as long as the lights can be switched independently, these areas do not count as being in the kitchen.

Recessed cans with 18W CFLs light specific task areas

Wall-mounted uplighters using 32W CFLs increase the sense of space

Figure 6-3 – General Kitchen Lighting

For incandescent luminaires including, but not limited to those with medium screw base sockets that can accept lamps of many different types and wattages, the wattage of the luminaire used in calculations and shown on the building plans is to be its maximum rated relamping wattage as marked on the luminaire, on a permanent factory-installed label. For luminaires with modular components that allow conversion between screw-based and pin-based sockets without changing the luminaire housing or wiring, it shall be assumed that an incandescent lamp of the maximum relamping wattage available for that system will be used. For compact fluorescent luminaires with permanently installed ballasts that are capable of operating a range of lamp wattages, the highest

operating input wattage of the rated lamp/ballast combination must be use for determining the luminaire wattage. For low voltage track lighting, use the rated wattage of the transformer listed on a permanent factory-installed label. For line voltage track lighting, use the volt-ampere rating of the branch circuit feeding the track, or the volt-ampere of a current limiter integral to the track if there is one, or the higher of the rated wattage, as listed on a permanent factory-installed label, of all the luminaires installed, or 45W per ft of track.

All other miscellaneous lighting equipment not addressed in §130 (c) 1 through 4, shall be the maximum rated wattage (for incandescent lamps) of the lighting equipment, or operating input wattage (for miscellaneous lighting systems with ballasts or transformers), as listed on a permanent factory-installed label, or published in manufacturer's catalogs, based on independent testing lab reports as specified by UL 1574 or UL 1598.

The wattage of the lamp as actually installed or as marked on the building plans shall not be used to determine if compliance has been met at site inspection. Compliance shall be determined by verifying that the wattage marked on the luminaires is consistent with the wattage used to determine compliance.

Example 6-1

Question

I am using an incandescent luminaire over the sink that is capable of housing a 150-watt lamp. I plan to install a 26-watt compact fluorescent lamp in the socket. Does this qualify as a high efficacy luminaire and what wattage should I use in determining if half the lighting power in the kitchen is high efficacy?

Answer

The luminaire does not count as high efficacy because it is capable of being lamped with an incandescent lamp. Use the maximum rated power (150 W) for determining the percent of high efficacy lighting.

Example 6-2

Question

If I use track lighting in a kitchen, how do I calculate the power?

Answer

See §130(c). For line voltage track, use the maximum relamping wattage of all of the installed luminaires as listed on permanent factory-installed labels, or 45 watts per linear foot of track, whichever is larger. An alternate method is to calculate the power based on the volt-ampere rating of the branch circuit feeding the track, or the volt-ampere of a current limiter integral to the track. For low-voltage tracks, use the rated watts of the transformer as listed on a permanent factory-installed label.

Example 6-3

Question

I am doing minor renovations to my kitchen that has six recessed incandescent cans and I am adding a new luminaire over the sink. Does this luminaire have to be a high efficacy luminaire?

Answer

Yes, all new luminaires must be high efficacy until at least 50% of the total lighting wattage comes from high efficacy luminaires (§152 (b) 1 and §152 (b) 2).

Example 6-4

Question

I am completely remodeling my kitchen and putting in an entirely new lighting system. How do the Standards apply to this case?

Answer

At least half the lighting watts must be high efficacy luminaires. This is treated like new construction.

Example 6-5

Question

Where does the kitchen lighting stop and the other lighting begin in the case of a large family room with the kitchen on just one side of an approximately 24-ft by 24-ft room. Is the kitchen nook part of the kitchen? Lighting over the eating counter? Lighting in an adjacent pantry?

Answer

Lighting over food preparation areas is kitchen lighting, including areas used for cooking, food storage and preparation and washing dishes, including associated countertops and cabinets, refrigerator, stove, oven, and floor areas. Any other lighting on the same switch is also kitchen lighting, whether or not the luminaires are in the kitchen area. Lighting for areas not specifically included in the definition of a kitchen, like the nook or the family room, is not kitchen lighting, as long as it is switched separately.

Example 6-6

Question

I am installing an extraction hood over my stove, it has lamps within it. Do these lamps have to be high efficacy?

Answer

This lighting is part of an appliance, and therefore does not have to meet the Standards for permanently installed lighting. This lighting is ignored in determining if half the kitchen lighting is high efficacy.

Example 6-7

Question

Am I still required to control the general lighting by a switch on a readily accessible lighting control panel at an entrance to the Kitchen as required in the 2001 and earlier versions of the Standards?

Answer

No. In the 2005 Standards there are no constraints on where the control for high efficacy Kitchen lighting is located, only that the high efficacy lighting must be switched separately from the low efficacy lighting.

6.4 Bathrooms, Garages, Laundry Rooms and Utility Rooms

§150(k)3

Lighting in bathrooms, garages, laundry rooms and/or utility rooms must be high efficacy, or must be controlled by a manual-on occupant sensor.

A bathroom is a room containing a shower, tub, toilet, or a sink that is used for personal hygiene.

If a sink used for personal hygiene is in a room other than a bathroom, such as bedroom, where no doors, walls, or other partitions separate the sink area from the rest of the room, and the lighting for the sink area is switched separately from room area lighting, only the luminaire(s) that are lighting the sink area must meet the bathroom lighting requirements. In this case, lighting of the sink area includes lighting of associated counters, cabinets, and mirrors.

More than one circuit of luminaires may be attached to the same manual-on occupant sensor. At least one high-efficacy luminaire should be installed so that it can be left off the occupant sensor circuit to ensure that all of the luminaires don't switch off while someone is in the bath. Even dual technology sensors may not detect a motionless and silent occupant.

Garages, laundry rooms and utility rooms can be lit entirely by high efficacy lighting. Linear fluorescent luminaires are typically between 1.5 and 4 times as efficient as CFLs, and should be used unless there is insufficient space. Luminaires should be mounted close to washer/dryer hookups and over work surfaces to ensure shadow-free illumination.

Garages present an opportunity to reduce energy use by providing task lighting. The end of the garage furthest from the door to the house is often used as a work area, and can be provided with high efficacy luminaires switched separately from the rest of the space.

Although not required, occupant sensors can be used in conjunction with high efficacy lighting to achieve the lowest possible energy use.If there are any concerns about safely using occupant sensors in conjunction with low-efficacy luminaires in a space, consider the following two options:

- In addition to the low efficacy luminaires controlled by a manual-on occupant sensor, leave one high efficacy luminaire on a separate manual switch.
- Install all high efficacy luminaires in the space; high efficacy luminaires do not require an occupant sensor to meet the requirements of the Standards.

Example 6-8

Question

What types of occupant sensors qualify for controlling low efficacy lights in bathrooms, garages and utility rooms?

Answer

Eligible occupant sensors are those that do not allow the luminaire to be turned on automatically and do not have an override that allows it to remain on.

Sensors including microwave, ultrasonic and passive infra-red (PIR) must comply with section 119 (d)

Example 6-9

Question

Is it good lighting practice to have all the lighting in a room controlled by a single occupant sensor?

Answer

Occupant sensors may fail to detect people who aren't making large movements, and their sensitivity is reduced in hot environments. Occupant sensors may cause the lights to switch off while someone is using a hazardous device. Where safety is an issue, high efficacy luminaires should be installed. High efficacy luminaires do not require an occupant sensor to meet the Standards.

Example 6-10

Question

Is the factory installed lighting system in a bathroom mounted medicine cabinet required to be either high-efficacy or controlled by a manual-on occupant sensor?

Answer

If the factory installed lighting in a medicine cabinet is designed to only illuminate the inside of the medicine cabinet, and the lighting is controlled only by a door activated switch where the lights turn off automatically when the cabinet door is closed, then the factory installed lighting is not regulated by the Standards. However, if the factory installed lighting is connected to a manually operated switch that can be turned on regardless of the position of the cabinet door, and/or the lighting is designed to illuminate and/or display the contents of the cabinet when the door is closed, then it is considered permanently installed lighting that must comply with the Standards. Also, any factory installed "bath bar" or other general lighting system is considered permanently installed lighting that must comply with the Standards.

Example 6-11

Question

Is the factory installed lighting in a built-in ironing board device required to be either high-efficacy or controlled by a manual-on occupant sensor when it is installed in a laundry room?

Answer

Yes, if the lighting is permanently wired it must be either high-efficacy or controlled by a manual-on occupant sensor. However, if the lighting plugs directly into an electrical receptacle, it is not regulated by the Standards.

6.5 Other Rooms

§150(k)4

Permanently installed lighting in other rooms must be high efficacy, or a manual-on occupant sensor or a dimmer must control it.

"Other rooms" includes hallways, dining rooms, family rooms and bedrooms – the rooms in which people are most aware of interior design both in terms of fashion and the usability of their living space.

Exception 3 to §150 (k) 4 specifies that permanently installed luminaires that are not high efficacy luminaires can be allowed in closets less than 70 square feet. These luminaires may be controlled by a simple toggle switch, manual-on occupant sensor, or an automatic-on occupant sensor.

Many people commonly add their own portable lighting. Unfortunately, portable lighting often means highly inefficient incandescent floor-standing luminaires that can consume 190 watts or more for older lamps.

Permanently installed lighting should reduce the need for such high wattage portable sources by creating variations of light throughout the room, and by reducing areas of shadow. To achieve this, use several luminaires rather than a single luminaire; wall-mounted uplights are a good choice because they are design-neutral and can be repainted. For high-end properties, linear fluorescent cove lighting and other forms of concealed lighting may increase marketability.

People like to control the appearance of their rooms; providing separate switches for each luminaire will make the space more attractive to tenants and will allow them to reduce their energy use.

Although occupant sensors can be used in living spaces, there are limitations in those living spaces where people are expected to sit still for long periods of time and not move around enough to keep the sensor activated, resulting in lights going off prematurely.

Example 6-12

Question

Can a ceiling fan with integrated lighting be a high efficacy luminaire?

Answer

Yes. Ceiling fans with integral CFL ballasts are available. Occupants are likely to prefer obscured lamps to visible lamps. A less efficient alternative, when the ceiling fan is installed in a room other than a kitchen, bathroom, garage, laundry room and/or utility room, is to use incandescent lamps on a dimming circuit separate to the fan circuit.

Example 6-13

Question

Are high-efficacy spotlights available, to replace halogen MR16s?

Answer

Some CFLs resemble spotlights, and manufacturers may describe them as spotlights, but they produce the same diffuse light as regular CFLs. Metal halide spotlights with 35W T-6 high efficacy lamps are available, and LEDs can be used as spotlights.

6.6 Outdoor Lighting

§150(k)6

Outdoor lighting attached to a building must be high efficacy, or controlled by a motion sensor with integral photocontrol. Motion sensors used in conjunction with outdoor lighting luminaires should have the capability of turning the lights on automatically. Lighting around swimming pools, water features, or other locations subject to Article 680 of the California Electric Code are exempt.

Section 119 (b) requires control devices, including motion sensors and photocontrols, to have an indicator that visibly or audibly informs the operator that the controls are operating properly, or that they have failed or malfunctioned. A light emitting diode (LED) status signal is typically used to meet this requirement. The LED status signal is also practical for use as a commissioning tool. Another option is to use the lamp in the luminaire as the status signal, as long as the lamp fails in the off position. The intention of this requirement is that if the photocell or motions sensor fails the luminaire will not turn on until the control is fixed.

Amalgam CFLs perform better at both very high and very low temperatures than non-amalgam versions, so are appropriate for outdoor lighting, although they can take a few minutes to reach full output. If instant start is important and temperatures may be low, specify a cold-weather-rated ballast. Alternatively, an incandescent source (fitted with a combination photocontrol/motion sensor) may be a good choice.

Decorative landscape lighting that is not permanently attached to buildings is not regulated by the Standards. Even though it is not required by the Standards, using a time clock or photocontrol on outdoor lighting not attached to buildings will help to prevent people accidentally leaving these lights on during the day and reduce energy use.

Example 6-14

Question

Do all residential outdoor luminaires have to be “cutoff” rated, or “flat glass” types?

Answer

Typical residential outdoor lighting does not have to be “cutoff” rated. However, residential parking lots for eight or more vehicles are required to meet the Nonresidential Standards, which do include cutoff requirements for luminaries greater than 175 watts. Even though not required for most residential outdoor lighting, cutoff luminaires are usually more efficient at providing light in the required area, so a lower wattage lamp and ballast can be used. Cutoff luminaires also reduce stray light and glare problems which can be a source of legal dispute between tenants or with neighboring property owners.

Example 6-15

Question

My house has a row of small incandescent bollards along the walk way to the front door. Do these have to be high efficacy?

Answer

No. The high efficacy requirement only applies to lighting mounted to the building.

Example 6-16

Question

I would like to install low-voltage landscape lighting in my yard. Are these required to be on a motion sensor and photocontrol?

Answer

No. Even though low-voltage lighting does not qualify as high efficacy lighting, lighting not attached to a building, like landscape lighting, is exempt from this requirement.

Example 6-17

Question

If I install high efficacy lighting on the exterior of the building, can I then install lighting that is not high efficacy in the bathrooms?

Answer

No, the provisions for "tradeoff" between exterior lighting and certain interior rooms have been eliminated in the 2005 Standards. However, you now have the option of using a manual-on occupant sensor in conjunction with outdoor luminaires that are not high efficacy.

6.7 Parking Lots and Parking Garages

§150(k)7

§132

§147

§148

Parking lots for eight or more cars must meet the nonresidential lighting requirements (see §148). A maximum lighting power of 0.08 W/ft² is permitted if you are in a rural area and 0.15 W/ft² if you are in an urban area, as defined by the U.S. Census. For more details, see the *2005 Nonresidential Manual*.

Parking garages that house eight or more cars shall meet the interior lighting power requirements of the Nonresidential Standards (see §147). A maximum lighting power of 0.4 W/ft² is permitted.

Parking lots and garages for eight or more cars are generally associated with multifamily housing.

For parking lots and parking garages that accommodate eight or more vehicles the following requirements apply:

- Lamps rated over 100W must have a lamp efficacy of at least 60 lumens per watt, or be controlled by a motion sensor;
- Lamps rated over 175 watts shall be designated "cutoff" in a photometric test report.

- Luminaires shall be controlled by a photocontrol, or an astronomical time switch that turns the lighting off when daylight is available.

Residential parking lots should be lighted uniformly to provide a sense of safety; this means that lighting should fill in shadows and dark corners. Two or more less powerful luminaires in different places are preferable to a single luminaire.

6.8 Common Areas of Multifamily Buildings

§150(k)8.

Lighting for common areas of low-rise residential buildings with four or more dwelling units shall be high efficacy, or shall be controlled by an occupant sensor. Occupant sensors used in common areas may have the capability of turning the lights on automatically.

The quality of light provided in common areas of apartments, condominiums, and townhouses must be particularly high, because older or visually impaired residents must be able to find their way safely through spaces that may contain unexpected obstacles. Providing a sufficient level of light is essential.

The lighting of staircases and stairwells is a particular safety concern; the best way to light stairs is with directional light from above, to maximize the contrast between treads and risers. CFL luminaires with reflectors provide this type of light with great efficiency.

Buildings of three stories or less are classified as low-rise. For buildings higher than three stories the Nonresidential Standards apply. The local fire code may limit the options for the use of occupant sensors in corridors and stairways.

6.9 Luminaires in Insulated Ceilings

§150(k)5

Luminaires recessed in insulated ceilings can create a thermal bridge through the insulation. Not only does this degrade insulation performance, but it can also permit condensation on the cold surface of the luminaire if exposed to moist air, for instance in a bathroom.

Luminaires recessed in insulated ceilings must meet three requirements:

- They must be rated for direct insulation contact (IC) by Underwriters Laboratories or other testing/rating laboratories recognized by the International Conference of Building Officials. This enables insulation to be packed in direct contact with the luminaire.
- They must be certified as airtight construction. Airtight construction means that leakage through the luminaire will not exceed 2.0 cubic feet per minute when exposed to a 75 Pascals

pressure difference, when tested in accordance with ASTM E283.

- They must have a sealed gasket or caulking between the housing and ceiling to prevent the flow of heated or cooled air out of the living areas and into the ceiling cavity.

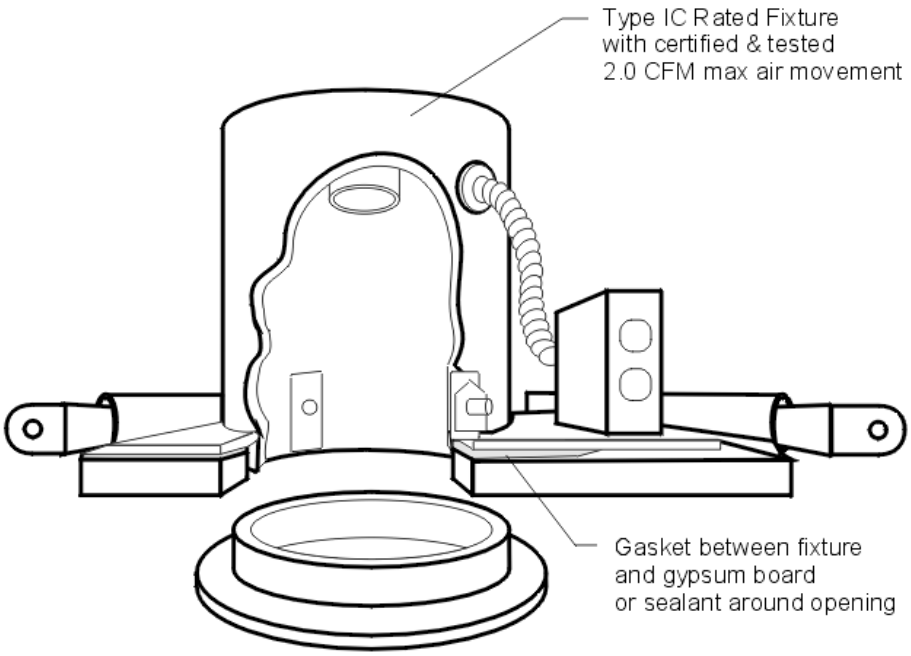

Figure 6-4 – Airtight, Type IC Luminaire

6.10 Inspection Protocol for Recessed Luminaires in Insulated Ceilings

§150(k)5.

Luminaires recessed in insulated ceilings must be IC rated and have a gasket or caulking between the housing and ceiling to prevent the flow of heated or cooled air between conditioned and unconditioned spaces. The luminaire must include a label certifying airtight or similar designation to show air leakage less than 2.0 CFM at 75 Pascals when tested in accordance with ASTM E283. The label must be clearly visible for the building inspector. The building inspector may verify the IC and ASTM E283 labels at a rough inspection. If verified at final inspection the building inspector may have to remove the trim kit to see the labels.

The ASTM E283 certification is a laboratory procedure intended to measure only leakage of the luminaire housing or, if applicable, of an airtight trim kit, and not the installation. Luminaire housings labeled as airtight, airtight ready or other airtight designation do not establish that the luminaire has been installed airtight. The luminaire manufacturer must provide instructions that explain the entire assembly required to achieve an airtight installation.

There are several different methods used by manufacturers to meet the airtight standards. The Energy Commission does not recommend one airtight method over another.

The primary intent is to install a certified airtight luminaire so that it is sufficiently airtight to prevent the flow of heated or cooled air between conditioned and unconditioned spaces. All air leak paths through the luminaire assembly or through the ceiling opening must be sealed. Leak paths in the installation assembly that are not part of the ASTM E283 testing must be sealed with either a gasket or caulk. One example may apply for assemblies where a certified airtight luminaire housing is installed in an adjustable mounting frame; all air leak paths between the certified airtight luminaire housing and the adjustable mounting frame must be sealed, either with a gasket or caulk.

Following is the process for verifying that the requirements for an airtight installation are met.

- Manufacturer specifications (a "cut sheet") of the certified airtight luminaire housing(s) and installation instructions must be made available with the plans to show all components of the assembly that will be necessary to insure an airtight installation consistent with §150 (k) 5 of the Standards. This allows the building inspector to know what method the luminaire manufacturer specifies to achieve airtight installation, and therefore, at what phase of construction the building inspector must inspect the luminaire for airtight compliance.
- One of the following primary methods is specified by the luminaire manufacturer to insure an airtight seal of the certified airtight housing to the ceiling:

1. A gasket is attached to the bottom of the certified airtight housing prior to the installation of the ceiling (i.e. drywall or other ceiling materials) to create an airtight seal. The gasket may be preinstalled at the factory, or may need to be field installed. For field installed gaskets, instructions on how the gasket is to be attached must be provided by the manufacturer. The luminaire must be installed so that the gasket will be sufficiently compressed by the ceiling when the ceiling is installed.

2. A gasket is applied between the certified airtight housing and the ceiling opening after the ceiling has been installed. The gasket creates the airtight seal. The cut sheet and installation instructions for achieving the airtight conditions must show how the gasket is to be attached.

3. Caulk is applied between the certified airtight housing and the ceiling after the ceiling has been installed. The caulk creates the airtight seal. The cut sheet or installation instructions for achieving the airtight conditions must specify the type of caulk that must be used and how the caulk must be applied.

4. A certified airtight trim kit is attached to the housing after the ceiling has been installed. The certified airtight trim kit in combination with the luminaire housing makes the manufactured luminaire airtight. Note that a decorative luminaire trim that is not ASTM E283 certified does not make the manufactured luminaire airtight. Most decorative luminaire trims are not designed to make a luminaire airtight. Rather, these trims are used to provide a finished look between the

ceiling and luminaire housing, and may include a reflector, baffle, and/or lens. However, some trim kits are specifically designed to be a critical component used to make a luminaire installation airtight. These trim kits must be certified airtight in accordance with ASTM E283. Certified airtight trim kits typically consist of a one-piece lamp-holder, reflector cone, and baffle.

The cut sheet and installation instructions for achieving the airtight conditions must show which certified airtight trim kits are designed to be installed with the luminaire housing, and how the certified airtight trim kits must be attached. A gasket must be installed between the certified airtight trim kit and the ceiling.

- The following methods for insuring an airtight seal between the certified airtight housing or certified airtight trim and the ceiling must be field verified at different phases during construction.

1. Gasket attached to the bottom of the certified airtight housing must be inspected prior to the installation of the ceiling when the rough-in electrical work is visible. The inspector must review the cut sheet or installation instructions to make sure the housing and gasket have been installed correctly. All gaskets shall be permanently in place at the time of inspection. It is important that once the ceiling material is installed the gasket will be in continuous, compressed contact with the backside of the ceiling and that the housing is attached securely to avoid vertical movement. The housing must be installed on a plane that is parallel to the ceiling plane to assure continuous compression of the gasket.

2. Gasket applied between the certified airtight housing and the ceiling after the ceiling has been installed must be inspected after the installation of the ceiling. The inspector must review the cut sheet or installation instructions to make sure the housing and gasket have been installed correctly. The gasket shall be permanently in place at the time of inspection. It is important that the gasket is in continuous, compressed contact with the ceiling, and that the housing is attached securely to avoid vertical movement.

3. Caulk applied between the certified airtight housing and the ceiling after the ceiling has been installed must be inspected after the installation of the ceiling. The inspector must review the cut sheet or installation instructions to make sure the housing has been installed correctly and the caulk has been applied correctly. It is important and that the housing is attached securely to avoid vertical movement.

4. Certified airtight trim kit must be inspected after the installation of the ceiling and the installation of the trim. The inspector must review the cut sheet or installation instructions to make sure the luminaire housing and the certified airtight trim kit have been installed correctly. It is important that the housing and the certified airtight trim kit are attached securely to avoid vertical movement. The ASTM E283 certification is a laboratory procedure where the trim kit is tested on a smooth mounting surface. However, it is common for certified airtight trim kits to be installed against a textured ceiling or other irregular ceiling surface. It is important that the gasket is in continuous, compressed contact with the ceiling and the certified airtight trim kit. Therefore, it is important to visually inspect the certified airtight trim kit and gasket next to the ceiling to assure that a continuous seal has been produced.

Certified airtight trim kits may be installed on luminaire housings that may or may not be certified airtight. If the trim kit is certified airtight, it must also have a sealed gasket between the trim kit and ceiling.

6.11 Recommendations for Luminaire Specifications

It is important that luminaires are described fully in the specifications and on drawings so that contractors and subcontractors provide and install residential lighting systems that comply with the Title 24 Residential Lighting Standards. The specifications should be clear and complete so that contractors understand what is required to comply with Standards.

Following are a few suggestions to help reduce the chance that there may be costly change orders required to bring a non-complying building into compliance.

1. Include all applicable Title 24 residential lighting requirements in the general notes on the drawings and other bid documents

2. Include the Title 24 residential lighting requirements with each luminaire listed in the lighting schedule text and details, for example:

Recommendations for Luminaire Specifications	
Luminaire Type	Notes for luminaire schedule
Bath Bar	Bath bar, incandescent lamps, must be controlled by a manual-on occupant sensor per Section 150(k)
Ceiling fixture (i.e., for a bathroom application)	Fluorescent surface-mounted ceiling luminaire, with one F32-T8 fluorescent lamp and electronic ballast, meeting the requirements of Section 150 (k)
Fluorescent Recessed Can (i.e., for a Kitchen application)	Fluorescent recessed can, with one 26 watt pin-based compact fluorescent lamp, meeting the electronic ballast, minimum efficacy, IC, and Airtight requirements of Section 150 (k)
Incandescent Recessed Can (i.e., for a Kitchen application)	Incandescent recessed can with a maximum relamping wattage of 75 watts, meeting the labeling, IC, and Airtight requirements of Section 150 (k)
Incandescent Recessed Can (i.e., for a Dining Room application)	Incandescent recessed can, meeting the IC, and Airtight requirements of Section 150 (k), and controlled by a dimmer switch meeting the requirements of Section 150 (k)
Chandelier	Chandelier, controlled by a dimmer switch meeting the requirements of Section 150 (k)
Occupant Sensor	Manual-on occupant sensor meeting the requirements of Section 150 (k)

6.12 Residential Manual-On Occupant Sensors

In bathrooms, garages, laundry rooms, and utility rooms, manual-on / automatic-off occupant sensors are allowed as an alternate compliance option to high efficacy lighting. Manual-on / automatic-off occupant sensors automatically turn lights off if an occupant forgets to turn them off when a room is unoccupied. Additionally, these sensors should readily provide the occupant with the option of turning the lights off manually upon leaving the room. This option should be available without having to remove the switchplate or any other modifications to the sensor. The manual–off feature is critical because it provides the occupants with the flexibility to control the lighting environment to their satisfaction, and

results in greater energy savings by allowing the occupants to turn off the lights when they are not needed.

Occupant sensors must be “manual-on”, i.e., the sensors must not have the ability to turn the lights on automatically and must not have a setting that can leave the lights in a permanent-on position. If a manual-on occupant sensor has an on/off switch to put the sensor into a temporary programming mode, the on/off programming switch must automatically switch off (for example, within 15 minutes) in the event the end user or installer leaves it in the programming mode.

Some models of occupant sensors have the capability to be changed by the occupant to "automatic-on" by removing the switchplate or touchplate and changing switch settings. These occupant sensors are acceptable as long as the mechanism to switch settings is not visible to the occupant, cannot be easily accessed without the removal of a switchplate or touchplate, and as long as they are delivered to the building site and installed with the "manual-on" setting.

Occupant sensors usually have built-in switches or dials that allow adjustment of the time delay between the last sensing of occupancy and when the lights are turned off. This built-in delay must be 30 minutes or less. Occupant sensors must meet the various requirements of section 119 (d); most commercially available products meet these requirements.

Some occupant sensors have minimum load requirements. For example, an occupant sensor may require that bulbs rated over 25 watts be installed before the sensor will work. However, if an occupant later installs a screw-in compact fluorescent lamp that is rated less than 25 watts, the sensor will no longer work. It is critical to select a sensor that has a low enough minimum load requirement to accommodate however small a load the occupant may install into the socket. Another solution would be to install an occupant sensor that does not have minimum load requirements.

The sensors that have a minimum load requirement are typically the ones that are designed to operate without a groundwire in the switch box which were common wiring scheme in the older residential units. Commercial grade sensors and all other sensors that are designed to take advantage of the groundwire in the switch box typically do not have a minimum load requirement and are the preferred choice to meet the requirements of the Standards.

If you are trying to control a lighting fixture from two different switches you will want to use a ceiling mounted rather than a wall switch occupant sensor. For example, if you are trying to control the lighting in a hallway with a switch at each end of the hallway a wall mounted occupant sensor will not work.

Example 6-18

Question

We would like to use incandescent lighting in a bathroom along with an occupant sensor. Although the sensor has the “manual-on” capability, it also has the capability of turning the lights on automatically by flipping a switch that is located under the switchplate cover. Does this sensor meet the requirements of the Standards?

Answer

Yes, this occupant sensor meets the requirements of the Standards, so long as the controls to switch between manual-on and automatic-on are not visible to the occupant, cannot be easily accessed without the removal of a switchplate or touchplate, and the sensor is shipped from the factory in the manual-on mode. To pass inspection, the occupant sensor must be installed with the control in manual-on.

Example 6-19

Question

Must the sensor in the example above give the occupant the option of turning the light off manually upon leaving the bathroom?

Answer

Yes. The sensors must provide the occupant with the option to turn the lights off manually upon leaving the space. If the occupant forgets to turn the lights off when a room is left unoccupied then the occupant sensor must turn the lights off automatically within 30 minutes. The lights must then be manually switched back on when the lights are needed again. This option provides the occupants with the flexibility to control the lighting environment to their satisfaction, and results in greater energy savings by allowing the occupants to turn off the lights when they are not needed.

Example 6-20

Question

What are our options if we want to use an automatic-on occupant sensor in a bathroom, garage, laundry room, or utility room?

Answer

You can use automatic-on sensors in conjunction with high efficacy luminaires. With high efficacy luminaires you may use a toggle switch, manual-on sensor, or automatic-on sensor. With luminaires in these rooms that are not high efficacy you must use a manual-on occupant sensor.

6.13 Residential Dimmers

One of the alternate options to high efficacy lighting in rooms other than kitchens, bathrooms, garages, laundry rooms, and utility rooms is the use of dimmers.

It is important to correctly match the dimmer with the type of lighting load that is being dimmed. Failure to correctly match the dimmer with the electrical lighting load may result in early equipment failure, including the dimmer, transformer, ballast, or lamp.

Dimmer manufacturers typically offer three basic types of incandescent dimmers: Line voltage (120 volt), low-voltage for use with a magnetic transformer, and low-voltage for use with an electronic transformer. Line voltage incandescent lamps, including tungsten-halogen lamps, can easily be dimmed over their full range of output with voltage control or phase control (electronic) dimmers. Tungsten-halogen lamps can be dimmed with conventional

incandescent dimmers, generally without any special considerations. When dimming a low voltage load, additional components are required in the dimmer to avoid overheating the transformer. UL has separate requirements for 120-volt and low-voltage dimmers due to the heat concern with transformers.

All fluorescent lamps 13 watts or greater, with electronic ballasts, and meeting the minimum lumens per watt already comply with Standards. Even though high efficacy fluorescent lamps with electronic ballasts do not require dimmers to meet Standards, dimmers are permitted to be used with fluorescent lighting systems. Most fluorescent lamps cannot be properly dimmed with the same simple wallbox devices typically used for dimming incandescent lamps. A special control and dimming ballast must be used. Some types of screw-in compact fluorescent lamps with integral ballasts can be dimmed by simple controls. However, many screw-in compact fluorescent lamps cannot be dimmed at all.