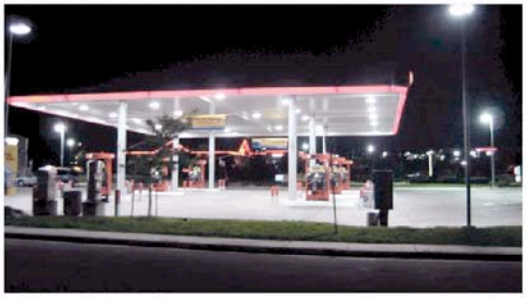
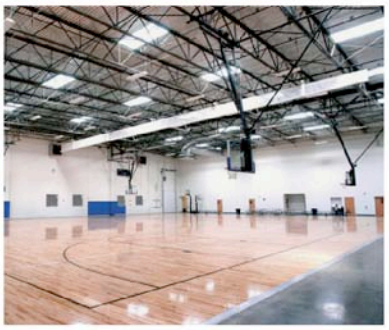
2005 BUILDING ENERGY EFFICIENCY STANDARDS

CALIFORNIA ENERGY COMMISSION






NONRESIDENTIAL COMPLIANCE MANUAL

COMMISSION CERTIFIED MANUAL

CEC-400-2005-006-CMF
Revision 3

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4Q-05

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Abstract

The Nonresidential Compliance Manual includes compliance method descriptions, calculation procedures, technical data, examples, and sample compliance forms for meeting the energy efficiency *Standards* for Nonresidential Buildings, High-Rise Residential Buildings, and Hotels/Motels. This compliance manual is not a substitute for the Standards, and it should be used in conjunction with a current copy of the *2001 Energy Efficiency Standards*.

Section 25402.1 of the Public Resources Code requires that the California Energy Commission make compliance materials available, including an energy conservation manual. The *Nonresidential Manual for Compliance with the 2005 Energy Efficiency Standards* (*Manual*) is provided to meet this requirement. This compliance manual supersedes *the Nonresidential Manual for Compliance with the 2001 Energy Efficiency Standards*, and all other previous manuals, notices, and interpretations explaining compliance with the *Energy Efficiency Standards* (*Standards*) for Nonresidential Buildings, High-Rise Residential Buildings and Hotels/Motels.

Acknowledgments

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The Nonresidential Compliance Manual has evolved over the years with contributions made by many persons along the way. The 2005 Nonresidential Manual was adapted from earlier versions in response to changes to the Standards made through the 2005 update. This most recent version was developed by Architectural Energy Corporation, with assistance from Mark Hydeman of Taylor Engineering and Jon McHugh of HMG. Charles Eley of Architectural Energy Corporation was the technical editor. From the California Energy Commission, Maziar Shirakh, PE was the project manager, as well as a contributor of technical content. Bill Pennington served as both the office manager and a technical contributor. Other technical contributors from the CEC included Suzie Chan, Tav Commins, Gary Flamm, Elaine Hebert, Rob Hudler, Bruce Maeda, Nelson Peña, and Ram Verma, PE. Special thanks goes to Jon Leber, PE for his invaluable and detailed comments on both the residential and nonresidential manuals.

Technical contributors from Architectural Energy Corporation include John Arent, Larry Ayers, and Charles Eley. Editing, layout and graphics were done by Zelaikha Akram, Tom Bergstrom, Kyra Epstein and Kimberly Got.

Technical Assistance

The authors are grateful to many people and organizations that contributed to the development and production of this manual. The manual reflects, to a large extent, the comments made by the many people who took time to carefully review earlier versions. Reviewers who contributed to the content include Gary Farber and Mike Gabel of CABEC; Martyn Dodd of EnergySoft; Don Little of the Farnsworth Group; Lynn Benningfield, Charles Ehrlich and Nehemiah Stone of the Heschong Mahone Group; Jeff Johnson of the New Buildings Institute, Inc; and Larry Luskay of Portland Energy Conservation, Inc.

Lastly, so many others contributed helpful suggestions, comments and criticism that are impossible to show a complete list. However, their assistance is acknowledged and greatly appreciated.

In spite of all our efforts, omissions and errors are certain to occur. These, of course, are attributed to the authors alone. If a Manual user discovers an error or has a suggestion, we request that it be brought to the attention of the Energy Efficiency Hotline at 1-800-772-3300 (California) or 916-654-5106.

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5. Indoor Lighting

This chapter covers the requirements for indoor lighting design and installation, including controls. It is addressed primarily to lighting designers or electrical engineers and to building department personnel responsible for lighting and electrical plan checking and inspection. Chapter 6 addresses outdoor lighting applications.

Indoor lighting is one of the single largest consumers of energy (kilowatt-hours) in a commercial building, representing about a third of electricity use. The objective of the Standards is the effective reduction of this energy use, without compromising the quality of lighting or task work. The Standards are the result of the involvement of many representatives of the lighting design and manufacturing community, and of building departments across the state. A great deal of effort has been devoted to making the lighting requirements practical and realistic.

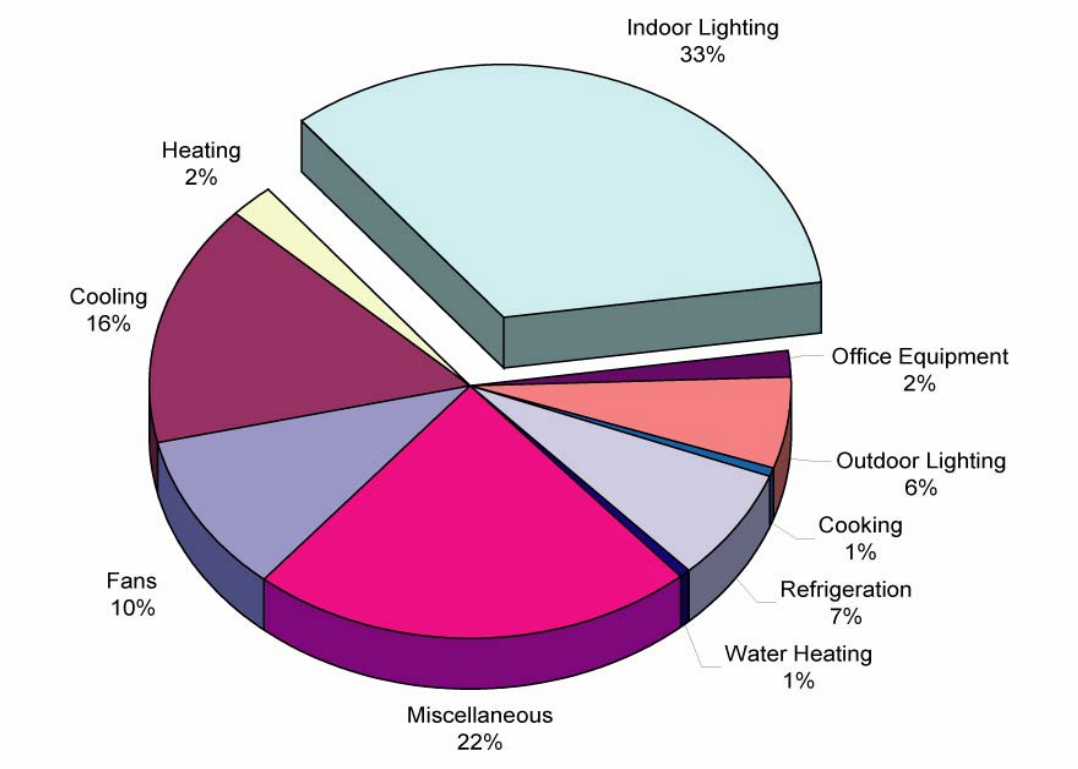


Figure 5-1– Lighting Energy Use
Lighting accounts for about one third of commercial building electricity use in California. Source IEQ RFP, December 2002, California Energy Commission No. 500-02-501

5.1 Overview

The primary mechanism for regulating indoor lighting energy under the Standards is to limit the allowable lighting power (watts) installed in the building. Other mechanisms require basic equipment efficiency, and require that the lighting is controlled to permit efficient operation.

Mandatory measures apply to all lighting systems and equipment (§119, §130, and §131). These requirements may include manual switching, daylit area controls, and automatic shut-off controls. The mandatory requirements must be met under either the prescriptive or performance approach.

§146(a)

Allowed lighting power for a building is determined by one of four methods:

- *Complete building method:* applicable when the entire building's lighting system is designed and permitted at one time, and when at least 90% of the building is one primary type of use (for retail or wholesale stores, at least 70% of the building must be merchandise sales function area). In some cases, the complete building method may be used for an entire tenant space in a multi-tenant building. A single lighting power value governs the entire building [§146(b)1].

- *Area category method:* applicable for any permit situation, including tenant improvements. Lighting power values are assigned to each of the major function areas of a building (offices, lobbies, corridors, etc.). See Section 5.2.2.
- .Area Category Method
- *C. Tailored method:* applicable when additional flexibility is needed to accommodate special task lighting needs in specific task areas. Lighting power allowances are determined room-by-room and task-by-task, with the area category method used for other areas in the building. See Section 5.2.2 Tailored Method.
- *Performance approach:* applicable when the designer uses an Energy Commission certified computer program to demonstrate that the proposed building's energy consumption, including lighting power, meets the energy budget. The performance approach incorporates one of the three previous methods which sets the appropriate Allowed Lighting Power Density used in calculating the building's custom energy budget. The performance approach may only be used to model the performance of lighting systems that are covered under the building permit application. See Section 5.3.

Actual lighting power (adjusted) is based on total design wattage of lighting, less adjustments for any qualifying automatic lighting controls, such as occupant-sensing devices or automatic daylighting controls.

The actual lighting power (adjusted) must not exceed the allowed lighting power for the lighting system to comply.

5.1.1 Lighting Trade-offs

The Standards restrict the overall installed lighting power in the building, regardless of the compliance approach. However, there is no general restriction regarding where or how general lighting power is used. This means that installed lighting may be greater in some areas of the building and lower in others, as long as the total does not exceed the allowed lighting power.

There is another type of lighting tradeoff available under the Standards. This is the ability to make tradeoffs under the performance approach between the lighting system and the envelope or mechanical systems. Tradeoffs can only be made when permit applications are sought for those systems involved. For example, under performance compliance, a building with an envelope or mechanical system that is more efficient than the prescriptive efficiency requirements might be able to meet the allowed performance energy budget with more lighting power than allowed under the prescriptive approach. When a lighting power allowance is calculated using the performance approach, the allowance is treated exactly the same as an allowance determined using one of the other compliance methods. No tradeoffs are allowed between indoor lighting and outdoor lighting or with lighting that is in unconditioned spaces.

Example 5-1

Question

Under the area category method, a mixed-use building is determined to have an allowed lighting power of 23,500 W. As part of this determination, an office area within the building is found to have an allowance of 1.2 W/ft^2. One of the private offices within this area is designed with an actual lighting power density of 2.0 W/ft^2. Is this permitted?

Answer

Yes. Provided the actual lighting power of the entire building does not exceed the 23,500 W limit, there is no limit on the individual office.

This is true for general lighting no matter what method is used to determine the allowed lighting power.

Note that it is not necessary to specify precisely where the watts come from when a trade-off occurs. These details are not needed for compliance; any individual trade-offs are included in the totals. It is only necessary to demonstrate that the actual total watts for the building does not exceed the total allowable. Trade-offs are not allowed with so-called use-it-or-lose-it categories of lighting. These are specific task or display lighting applications, such as chandeliers under the area category method or display lighting under the tailored method, where the allowable lighting power for the application is determined from:

1. Wattage allowance specified by the Standards.
2. Actual wattage of the fixture(s) assigned to the application.

For use-it-or-lose it applications, the allowable lighting power is the lesser of these two wattages. This means that the allowance cannot exceed the actual lighting wattage. If the actual lighting watts are lower than the allowance, the remaining watts in the allowance are not available for trade-off to other areas of the building.

Example 5-2

Question

A display lighting application (one of the use-it-or-lose-it applications) is determined to have a lighting power allowance of 350 W. The actual luminaires specified for the display total 300 W. How does this affect the allowed watts and the actual watts (adjusted if applicable) for the building?

Answer

The lower value, 300 W, is shown as total allowed watts for the building. The actual lighting power is also 300 W. There are no watts available for use through trade-offs elsewhere in the building.

Example 5-3

Question

A display lighting application is determined to have a lighting power allowance of 500 W. The actual luminaires specified for the display total 600 W. How does this affect the allowed watts and the actual watts (adjusted if applicable) for the building?

Answer

As before, the lower value, 500 W in this case, is shown as the total allowed watts for the display. The proposed lighting power will include the full 600 W. For the building lighting to comply, the extra 100 W used by the display fixtures must be traded-off against eligible lighting systems such as general lighting from elsewhere in the building.

Lighting control credits reduce the actual installed watts, making it easier to meet the allowed watts. The specific calculations involved in the trade-offs discussed in this section are carried out on the compliance forms.

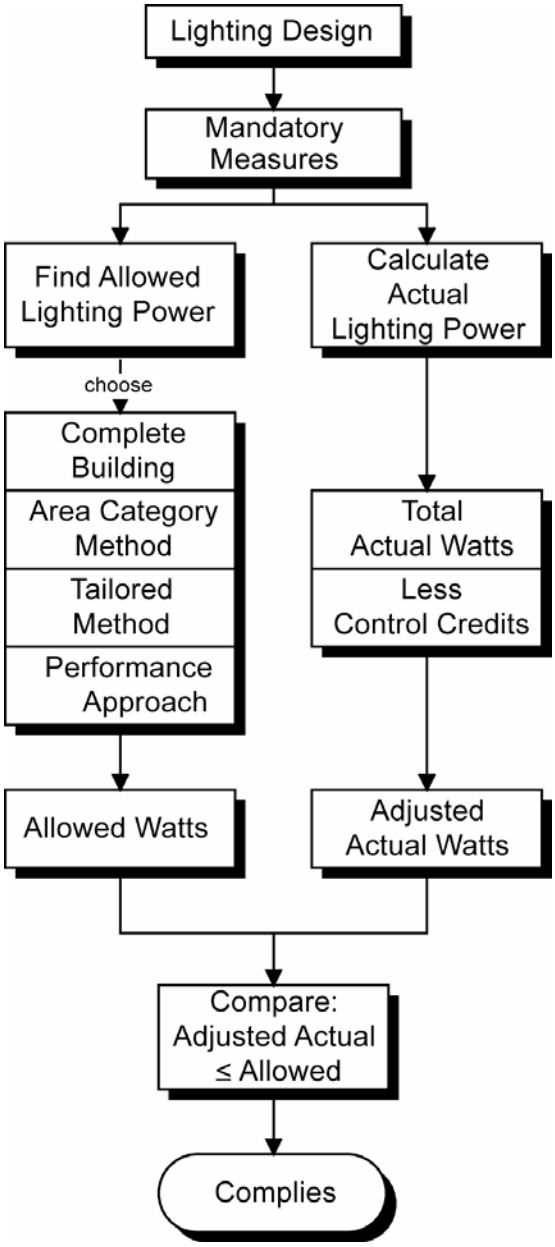


Figure 5-2 – Lighting Compliance Flowchart

5.1.2 Forms, Plan Check, Inspection and Acceptance Tests

Chapter 2 of this manual provides an overview of the documentation requirements and the process of complying with the energy standards. This process includes providing documentation that shows a building complies with all of the pertinent requirements of the Standards. After this is reviewed and

approved during plan check, construction may begin. During and after construction, there are periodic inspections to assure that all required energy features are installed. At the end of construction, acceptance tests are performed on HVAC and lighting controls to assure they are installed and work correctly.

If inspections or acceptance testing uncover systems that are not installed as shown in the plans and documentation, or are found not to be operating correctly through acceptance testing, these defects have to be fixed before the building is approved. Once approved by the code official as complying with all the building code requirements including the energy code, the building receives a certificate of occupancy.

5.2 Lighting Design Procedures

This section discusses how the requirements of the Standards affect lighting system design. For procedures on documenting the lighting design, including compliance forms, see Section 5.2.1.1 on Lighting Equipment Certification.

5.2.1 Mandatory Measures

The mandatory features and devices must be included in the building design whether compliance is shown by the prescriptive or the performance approach. These features have been proven cost-effective over a wide range of building occupancy types.

Many of the mandatory features and devices are requirements for manufacturers of building products, who must certify the performance of their products to the Energy Commission. It is the responsibility of the designer, however, to specify products that meet these requirements. Code enforcement officials, in turn, check that the mandatory features and specified devices are installed.

Lighting Equipment Certification

§119

The mandatory requirements for lighting control devices specify minimum features for automatic time switch controls, occupant-sensing devices, automatic daylighting controls, and indoor photosensors. Many of these requirements are part of standard practice in California and should be well understood by those responsible for designing or installing lighting systems.

All automatic lighting control devices that are installed to comply with mandatory requirements or to obtain control credits must be certified by the manufacturer before they can be installed in a building. The manufacturer must certify the devices to the Energy Commission. Once a device is certified, it will be listed in the Directory of Automatic Lighting Control Devices, which is available from the link below:

http://www.energy.ca.gov/appliances/appliance/excel_based_files/controls/

Call the Energy Hotline at 1-800-772-3300 to obtain more information. All devices must have instructions for installation and start-up calibration, must be

installed in accordance with such directions, and must have a status signal (visual or audio) that warns of failure or malfunction. Photoswitches and other devices may be considered exempt from this requirement if the status signal is infeasible because of inadequate power.

A. Automatic Time Switches

§119(c)

Automatic time switches, sometimes called time clocks, are programmable switches that are used to automatically shut-off the lights according to pre-established schedules depending on the hours of operation of the building. The device should have the capability to store two separate daily programs (for weekdays and weekends). To prevent losing the time of day and the programmed schedules, the time switch must contain back-up power for at least 10 hours during power interruption. Most building automation systems can meet these requirements, provided they are certified to the Energy Commission.

B. Occupant-Sensors

§119(d)

Occupant-sensing devices shall be capable of automatically turning off all of the lights in an area no more than 30 minutes after the area has been vacated.

Additionally, the following sensors must meet special requirements:

- The ultrasonic type must meet certain minimum health requirements, and have the built-in ability for sensitivity calibration (to reduce false signals for both on and off).
- The microwave devices must have emission controls, permanently affixed installation requirements, and built-in sensitivity adjustment. Microwave devices are rarely used in occupant sensors.

C. Automatic Daylighting Controls

§119(e)

Daylighting controls consist of photosensors that compare actual illumination levels with a reference illumination level and reduce the electric lighting until the reference level has been reached. These controls may be used to apply for power adjustment factor (PAF) lighting credits in the daylit areas near windows. If one wishes to use automatic daylighting controls to satisfy the mandatory requirements for controls under skylights and associated power adjustment factor (PAF) credits, additional multi-level requirements must be met [see §131(c), §119(i)].

When automatic daylighting control devices and systems are used, they must be certified to the Energy Commission that they meet the following requirements:

- The ability to reduce the general lighting power of the controlled area by at least 50% uniformly (either by separate control of multiple lamps or by dimming).

- When a dimmer is used, provide reduced flicker operation (see definitions) over the dimming range without causing premature lamp failure.
- For stepped dimming, provide a time delay that prevents cycling of the lights in less than 3 minutes. This is typically accomplished by a time delay of 3 minutes before electric lighting is reduced but usually a much shorter delay before electric lighting is increased.
- For single or multiple-stepped switching controls with distinct on and off settings for each step, include sufficient separation (dead-band) between points to prevent cycling. Such a control requires a higher light level to turn lights off than is required to turn the lights on.
- For single or multi-stepped switching controls that incorporate a time delay, include a method to override that delay for setup. The override must automatically return to normal after no more than 60 minutes.
- Have a sensitivity adjustment that easily distinguishes settings to within 10% of full scale adjustment.
- The light sensor in a daylight control must exhibit a linear response within 5% for the whole range of illuminance sensitivity. In general, photodiode sensors meet this requirement whereas photoconductive cells do not.
- A stepped switching control device must show the status of lights in the controlled zones by an indicator on the control device.
- The control must incorporate an indication device that shows the currently selected step for a switched control or the relative illumination level on the sensor for a continuously dimming control located where a user can easily see the controlled lighting. If the control is part of a networked system with central display, which displays of the status of lights in each controlled zone, and where setpoint adjustments are implemented, the standard allows an exception to this indication device requirement.

D. Interior Photosensor Device

§119(f)

Daylighting control systems incorporate a photosensor that measures the amount of light at a reference location. The photosensor provides light level information to the controller so it can decide when to increase or decrease the electric light level.

Photosensor devices must be certified to the Energy Commission as not having mechanical slide covers or other means that allow easy unauthorized adjusting or disabling of the photosensor. In addition, they shall not be combined in a wall mounted occupant-sensing device. (This means that wall-mounted occupant-sensing devices with photosensor controls can be certified as occupant-sensing devices but not interior photosensor devices.)

E. Multi-level Astronomical Time Switch Controls

§119(h)

Although skylight requirements are prescriptive (§143(c)), once skylights are installed, there are mandatory automatic controls that must be installed to reduce electric lighting when sufficient daylight is available. Multi-level Astronomical Time Switch Controls or automatic multi-level daylighting controls will meet the mandatory requirements for automatic controls under skylights when the daylit zone is greater than 2,500 sf (§131(c)2). The purpose of these controls is to turn off lights where there is sufficient daylight available. This is done by keeping track of the time since sunrise and amount of time remaining before sunset. Since the control is multi-level, there must be at least two steps (relays) per control zone with independent schedules (i.e. the steps turn on and off at different times).

When sky conditions are atypical (overly cloudy or overly bright), it may be necessary to manually override the system. This is accomplished by manual switches in the zone that are configured so that lights will revert to OFF within two hours unless the astronomical time switch schedule calls for the lights on (§131(c)2, 131(d)2)).

To comply with §131(c)2, the power consumption of lights on this control is no greater than 35% at its step of minimum electric light output. The space must have close to the design illuminance when the control has turned off most of the lights. As a result, the astronomical time switch is required to have the capability of offsetting a switching event by as much as 4 hours from sunrise and sunset.

To assure that the device is configured correctly, the time switch must be able to display, date/time, sunrise and sunset times, and switching times for each step of control. To prevent loss of settings due a temporary loss of power, the schedules must be protected for a loss of power as long as 10 hours. Time zone, longitude and latitude are stored in non-volatile memory.

F. Automatic Multi-level Daylighting Controls

§119(i)

Although skylight requirements are prescriptive (§143(c)), once skylights are installed, there are mandatory automatic controls that must be installed to reduce electric lighting when sufficient daylight is available. Automatic multi-level controls are used to comply with the mandatory requirements for automatic daylighting controls when the daylit area under skylights is greater than 2,500sf (§131(c)2). These controls also qualify for a power adjustment factor (PAF) in the daylit area under skylights (§146(a)4E). Automatic multi-level controls must meet all of the requirements for automatic daylighting controls [§119(e)] and the following additional requirements:

- The control has at least two control steps so that electric lighting can be uniformly reduced. One of the control steps will reduce lighting power to between 70% and 50% of full rated power.
- The light sensor is physically separated from where setpoint adjustments are made. This eliminates the problem of the technician obstructing light on the sensor while trying to calibrate the control setpoint.

- The controls for calibration adjustments are “readily accessible” to authorized personnel. This means that the controls are accessible without climbing a ladder or removing obstacles. These controls can be behind a switch plate cover, touch plate cover, or in an electrical box with a lock because they are accessible to authorized personnel (with a key).
- When the control is used under skylights with a daylit area greater than 2,500 ft^2 (§131(c)2), the power consumption of lights on this control can be no greater than 35% at its step of minimum electric light output. This can be achieved with a control that automatically turns all of its lights off, or 2/3’s of its lights off, in response to high daylight levels. A fluorescent dimming control will usually meet the minimum power requirements. Usually dimming control of HID (High Intensity Discharge) lamps will not be able to meet the power requirements at minimum dimming levels. However, a multi-stage HID switching control can meet these requirements.

G. Outdoor Astronomical Time Switch Controls

§119(j)

Section 132(c) requires automated multi-level switching of outdoor lighting. This creates the opportunity to have all, half or none of the lights on for different times of day, for different days of the week, while making sure that the lights are off during the day.

Section 119(j) specifies the capabilities of an outdoor astronomical time switch control. The requirements for this control are very similar to the indoor multi-level astronomical control (§119(h)) except this control has a less stringent requirement for the offset from sunrise or sunset. This control is required to have the capability of independently offsetting on or off settings up to 120 minutes from sunrise or sunset.

H. Installation in Accordance with Manufacturer’s Instructions

§119(g)

If an automatic time switch control device, occupant sensor, automatic daylighting control device, or interior photosensor is installed, it must comply with both items 1 and 2 below.

1. The device must be installed in accordance with the manufacturer’s instructions; and,

2. Automatic daylighting control devices must be installed so that the device controls only luminaires within the daylit areas, and must have photosensors that are either ceiling mounted or located so that they are accessible only to authorized personnel, and that are located so that they maintain adequate illumination in the area in accordance with the designer’s or manufacturer’s instructions.

I. Certified Ballasts and Luminaires

Fluorescent lamp ballasts and luminaires with fluorescent lamp ballasts are regulated by the Appliance Efficiency Regulations. Those certified to the Energy Commission are listed in the efficiency database. See http://www.energy.ca.gov/appliances/appliance/excel_based_files/ballasts/ or call the Energy Hotline at 1-800-772-3300 to obtain more information. All standard wattage four-foot and eight-foot lamp and ballast combinations commonly installed in nonresidential buildings are included in the ballast efficiency database.

5.2.1.2 Area Controls

§131(a)

The simplest way to improve lighting efficiency is to turn off the lights when they are not in use. All lighting systems must have switching or control capabilities to allow lights to be turned off when they are not needed.

Room Switching

§131(a)1

Independent lighting controls are required for each area enclosed by ceiling height partitions. In the simplest case, this means that each room must have its own switching; gang switching of several rooms is not allowed. The switch may be manually operated or automatically controlled by an occupant-sensing device that meets the requirements of §119 (d).

Accessibility

§131(a)1A & B

All manually operated switching devices must be located so that personnel can see the controlled area when operating the switch(es). When not located within view of the lights or areas, the switch shall be annunciated to indicate the status of the lights (on or off).

Security or Emergency

§131(a) Exception No. 1

Lighting in areas within a building that must be continuously illuminated for reasons of building security or emergency egress are exempt from the switching requirements for a maximum of 0.5 W per square foot along the path of egress. These lights must be installed in areas designated as security or emergency egress areas on the plans, and must be controlled by switches accessible only to authorized personnel. The remaining lighting in the area, however, is still subject to the area switching requirements.

Public Areas

§131(a) Exception No. 2

In public areas, such as building lobbies, concourses, etc., the switches may be located in areas accessible only to authorized personnel.

Other Devices

§131(a)2

If the room switching operates in conjunction with any other kind of lighting control device, there are two other requirements: 1) the other control device must allow the room switching to override its action, and 2) if the other control device is automatic, it must automatically reset to its normal operation mode without any further action.

For example, if there is an automatic control system that sweeps all the lights off in a group of offices at a certain hour, the room switch in any individual office must be able to override the sweep and turn the office's lights back on. The next time the automatic control sweeps the lights off, however, the override for that individual office must not remain in effect but must return to automatic mode and shut the lights off.

Example 5-4

Question

A 5,000 square foot building will be equipped with an automatic control device to shut off the lights, in compliance with §131(b) multi-level controls. How are the local switches supposed to respond when an occupant wishes to turn on lights after the lights are shut off?

Answer

The local switch (as specified in §131(a)) must allow the occupant to override the shut off and turn on the lights in their area (§131(a)2.A.). Following the override, the automatic function of the shut-off must resume, so that when the automatic control sweeps the lights off, these lights will be shut off unless the local switch again overrides the shut-off (§131(a)2.B.).

Example 5-5

Question

The card access system of a proposed building will automatically turn on the lobby and corridor lights when activated by someone entering the building after hours. In addition, the lobby and corridor lights are on an automatic time switch control. Are manual switches required for the lobby and corridor?

Answer

Yes. The manual switch is still required under the area control mandatory measure requirement. Furthermore, the manual switch must be able to turn off the lights when either the automatic time switch control or card access system has turned them on. The automatic devices must be automatically reset.

Multi-Level Switching

§131(b)

Most areas in buildings must be controlled so that the connected lighting load may be reduced by at least 50% while maintaining reasonably uniform illumination. The intent of this requirement is to achieve the reduction without losing use of any part of the space. A multi-level lighting control is a lighting control that reduces lighting power by either continuous dimming, stepped dimming, or stepped switching while maintaining a reasonably uniform level of illuminance throughout the area controlled. Multilevel controls shall have at least one control step that is between 50% and 70% of design lighting power and at least one step of minimum light output operating at less than 35% of full rated lighting system power (this control step could be completely off, creating a bi-level control). A reasonably uniform level of illuminance in an area shall be achieved by any of the following:

- Using dimming controls to dim all lamps or luminaires,
- Switching the middle lamps of three lamp luminaires independently of outer lamps,
- Separately switching "on" alternate rows of luminaires,
- Separately switching "on" every other luminaire in each row (checkerboard), or
- Separately switching lamps in each luminaire.

Multi-level switching is not required when:

- The lighting power density is less than 0.8 W/ft^2,
- The area has only one light source (luminaire),
- The area is less than 100 square feet, or
- The area is a corridor.

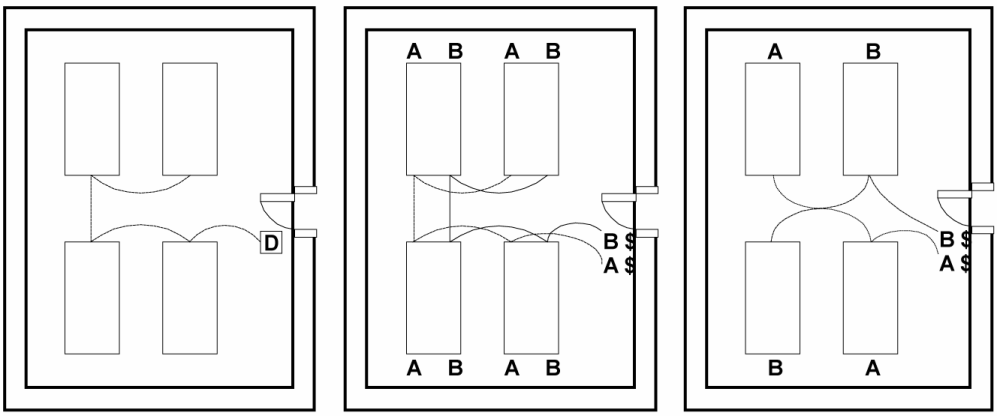


Figure 5-3 – Multi-Level Switching Options

Shut-Off Controls

§131(d)

The Standards require that lights on each floor of a building be controlled by a separate automatic control device (or control point with multiple point control systems).

The areas exempted from automatic shut-off are:

- Areas that must be continuously lit, such as hotel lobbies and 24-hour, 365 day per year grocery stores where lights are never turned off.
- Security or emergency egress lighting that must be continuously on, provided it does not exceed 0.5 W/ft^2 and the area is controlled by switches accessible only to authorized personnel (the security or egress area must be documented on the plans).
- Corridors, guest rooms, and lodging quarters of high-rise residential buildings or hotel/motels.

The shut-off control need not be a single control, but may include automatic time switches, occupancy sensors, or other automatic controls (see Sections 5.2.1.1 A. Automatic Time Switches and B. Occupant-Sensors).

When an occupant-sensing device is used to meet the automatic shut-off requirement, it must be installed in accordance with manufacturer's instructions with regard to placement of the sensors.

Automatic time switches with programmable solid state perpetual calendar control devices can also be used to meet the shut-off requirement. These devices are typically available with multiple channels of control, and may also be used to meet the mechanical system automatic time switch control requirements.

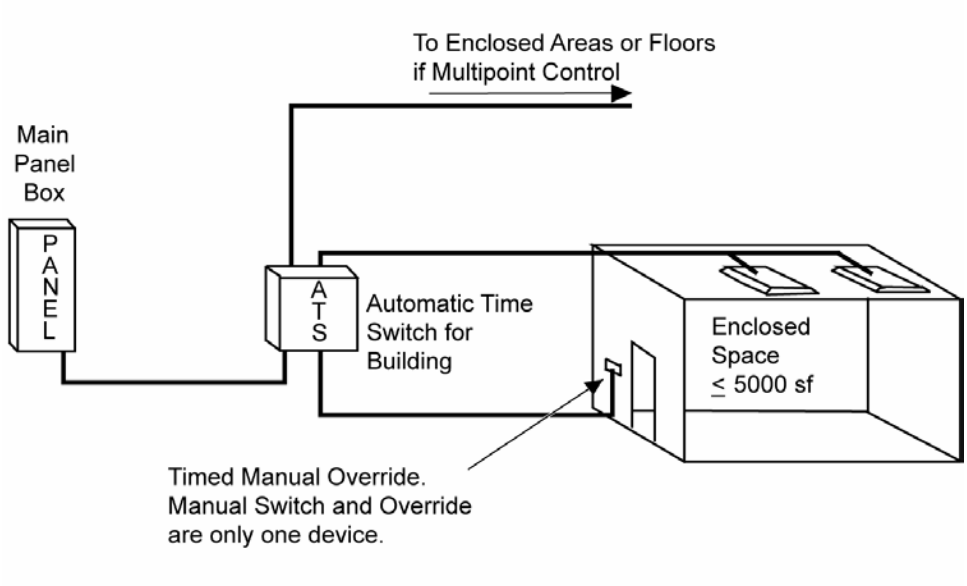


Figure 5-4 – Timed Manual Override

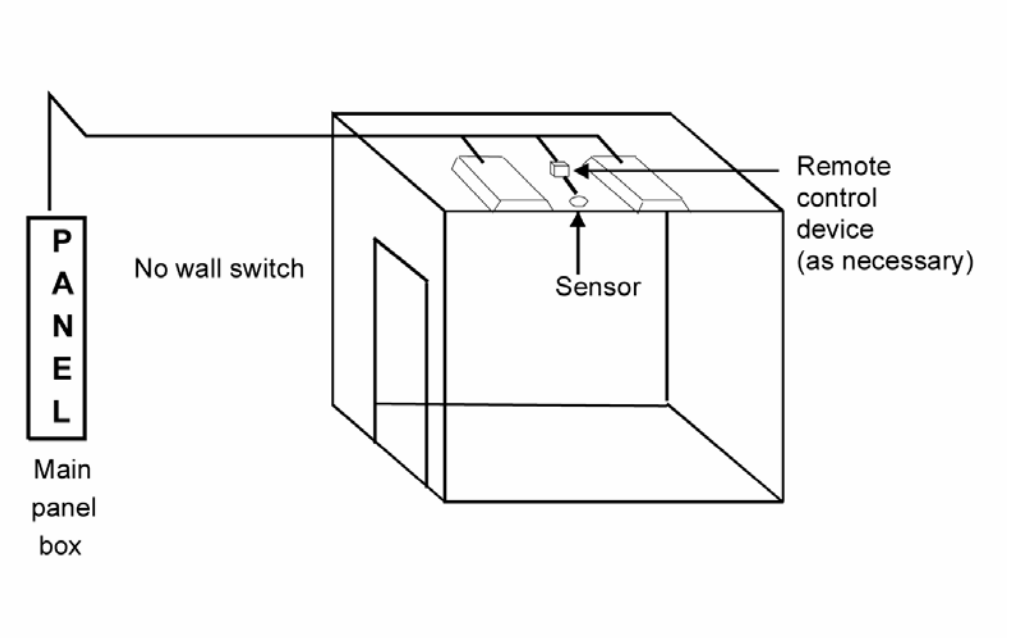


Figure 5-5 – Occupant-Sensing Device Shut-off

If an automatic time switch control device is used for shut-off control, it must be certified, and incorporate an automatic holiday shut-off that turns off all lighting loads for at least 24 hours, and then resumes normal scheduled operation. Holiday scheduling is not required for: retail stores and associated malls, restaurants, grocery stores, churches, and theaters.

Local Override

If an automatic time switch control device is used for shut off, the control must be designed with override switching devices. The override switching devices shall:

- Controls an area enclosed by ceiling height partitions not exceeding 5,000 ft^2 on a single floor. For malls and arcades, auditoriums, single tenant retail spaces, industrial facilities, and arenas, the area controlled may not exceed 20,000 ft^2.
- Be readily accessible.
- Be manually operated.
- Allow the operator to see the lights or area controlled or be annunciated.
- Provide an override for not more than 2 hours. In malls and arcades, auditoriums, single tenant retail spaces, industrial facilities, and arenas where captive-key override is utilized, a 2-hour override limit is not required.

Display Lighting

§131(e)

Display lighting shall be separately switched on circuits that are 20 amps or less. Display lighting for wall display, floor display, and lighting external to display cases and cabinets may be on the same circuit so long as each circuit does not exceed 20 amps. Ornamental/special effect lighting, lighting that is internal to display cases and cabinets, and general lighting must each be separately switched and not exceed 20 amps per circuit.

Display lighting circuits rated up to 20 amps may use local subpanels to separate the final circuits from a single higher rated circuit. These subpanels should use switch-rated breakers (rated to comply to UL-SWD), and the subpanel location must be so that the controlled lighting is visible from the switch. These switches must be located where a user would reasonably expect to find a lighting control for the display lighting, and must be readily accessible (they can not be locked).

For example, a benefit of general lighting being on a separate switch is that it can be operated without having to turn on the display lighting (as, for example, when the cleaning crew is working at night and there is no need for the displays to be lit).

5.2.1.3 High Rise Residential Living Quarters and Hotel/Motel Guest Rooms - General

§130(b), §150(k)
Chapter 6, Residential Manual

The *Standards* require that lighting in high-rise residential living quarters and in hotel/motel guest rooms comply with all applicable lighting requirements of the low-rise residential standards. For hotel/motel guest rooms, up to 10% of the rooms (this refers to the number of the rooms, including suites and not the areas of the guestrooms) are exempt from the low-rise residential lighting requirements.

The low-rise residential standards changed considerably with the 2005 update. High efficacy luminaires are required for almost all rooms in the dwelling unit or hotel room. Exceptions are made in some rooms if the fixtures are on a separate circuit or are controlled by occupancy switches or dimmers. The specific language for these requirements can be found in §150(k) of the 2005 standards.

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

The requirements are 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. Wattage shall be determined according to § 130 (c).

- *Lighting in Bathrooms, Laundry Rooms and Utility Rooms.* All luminaires shall either be high efficacy or shall be controlled by a manual-on occupant sensor.
- *Other Rooms (other than Kitchens, Bathrooms, Laundry Rooms and Utility Rooms).* All luminaires shall either be high efficacy or shall be controlled by a manual-on occupant sensor or dimmer.
- *Outdoor Lighting.* All luminaires mounted to the outside of the nonresidential buildings must meet the requirements of §147 of the Standards. See Chapter 6, Outdoor Lighting and Signs, of this Manual for more details.
- *Common Areas of Low-Rise Multifamily Buildings*. All luminaires in the common areas of low-rise multifamily buildings shall either be high efficacy or shall be controlled by an occupant sensor. All high efficacy luminaires must meet the requirements of §150(k). See Section 5.13 of this chapter for more details.
- All High Rise Residential Living Quarters lighting need to comply with §150(k).
  - Hotel/Motel garages must meet the requirements of the Area Category Method of §146, Table 146-C.

5.2.1.4 Daylighting Controls

§131(c)

A substantial fraction of electric lighting energy can be saved if lights are turned off whenever there is sufficient daylight. §131(c) has a series of mandatory requirements for the control of electric lighting in daylit areas. These control requirements range from separate manual switching of lights near windows to skylights when the daylit area is greater than 250 ft^2.

There are mandatory control requirements for prescriptive measures such as the requirement for automatic controls when the daylit area under skylights is greater than 2,500 ft^2.

Although prescriptive compliance requires skylights in large spaces, this requirement can be traded-off against other building features using the performance method.

If skylights are installed to meet prescriptively requirements or where skylights with automatic daylighting controls are modeled for compliance under the performance method, there are mandatory automatic daylighting control requirements that must be met to assure energy savings are realized. In those spaces where skylights are not required but are installed for other reasons and the daylit areas are less than 2,500 square feet, there are no mandatory control requirements for automatic daylighting controls; however, if automatic daylighting controls are installed in the space, those controls must meet the mandatory requirements of §119, §130, and §132. If the daylit area is greater than 2,500 square feet, the automatic daylighting controls must be installed

Automatic daylight control devices include stepped dimming, continuous dimming, and stepped switching devices. For definitions of these terms see §101 of the standards or the definitions in the Joint Appendix I.

A. The "Daylit Area" near Windows and under Skylights

The daylit area near a window extends back a distance of 15 ft perpendicular to the glazing, or to the nearest 60-inch or higher permanent partition, whichever is less. The width of the daylit area is the width of the window plus either 2 feet on each side, the distance to a permanent partition, or one half the distance to the closest skylight or vertical glazing, whichever is least.

The daylit zone under skylights is the "footprint" of the skylight opening with the edge of the daylit area expanding by 70% of the ceiling height from each edge of the skylight footprint outward, unless it impinges upon: the daylit area under another skylight, the daylit zone from vertical glazing or the light is blocked by a permanent partition that is 5 ft tall or taller (see Figure 1-6). See special skylight cases Question 5-11 and 5-12.

The architect in cooperation with the electrical engineer or lighting designer should draw the daylit area on the lighting plans so that it is easy to see which luminaires must be on separate daylit area circuits.

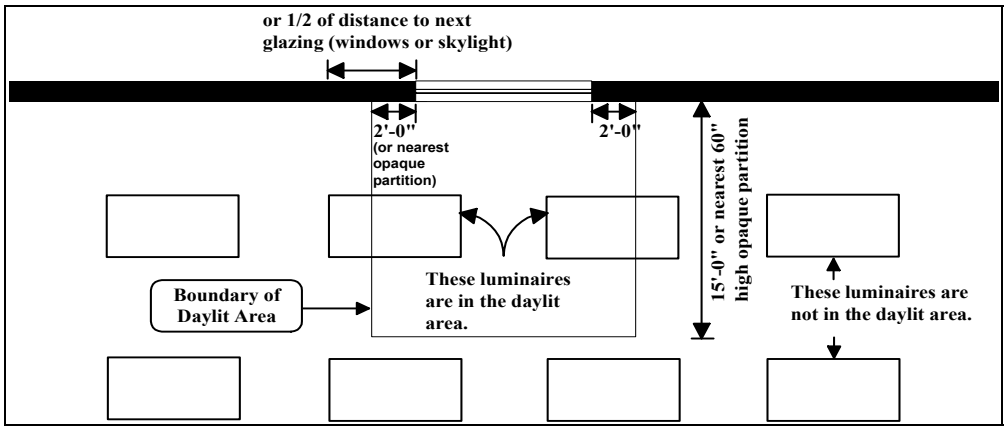


Figure 5-6 – Plan View of Daylit Area near Window

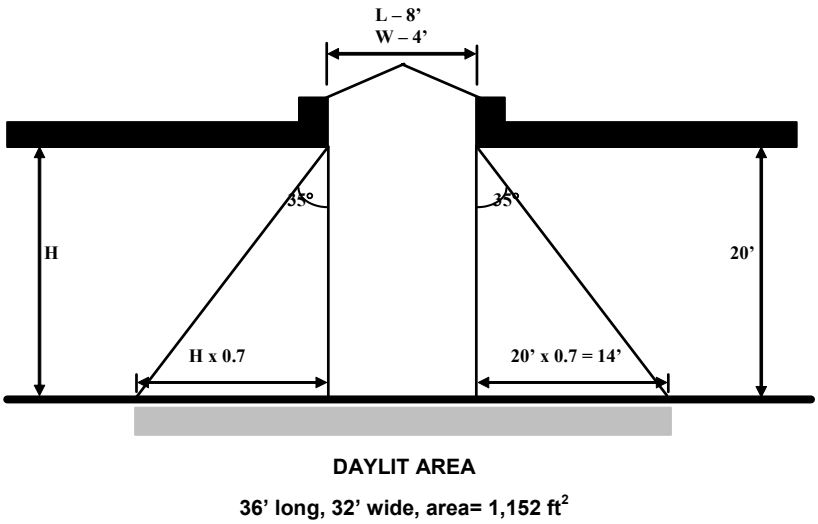


Figure 5-7 – Elevation View of Daylit Area under Skylight

The only exception to the requirement of providing the separate control to daylit areas is when there is not enough daylight. This is decided in one of two ways:

1. When the daylight to a window or skylight is so obstructed by adjacent structures or natural objects that the effective use of daylighting is not reasonable. This determination must be made by the local enforcement agency.

2. When the effective aperture of the window is less than 0.1 (or of the skylight is less than 0.006). A low effective aperture prevents usable daylight from entering the area; it is caused by small glazing area, low transmission glazing materials, or a combination of both.

Calculation of the effective aperture is necessary only if you have a very small window or skylight area and you don't want to put in separate control of lights in the daylit area. The skylight effective aperture is used to calculate the credit when multilevel daylighting controls are used (see Section 5.4.4 Automatic Lighting Control Credits).

Effective Aperture (EA) for windows equates to the visible light transmittance (VLT) times the window wall ratio. The EA for windows is calculated for each room with daylighting. For the purpose of calculating effective aperture and calculating the Power Adjustment Factor for photocontrols in daylit areas sidelit by windows, the window to wall area ratio (WWR) is the window area divided by the area of that portion of the wall containing windows adjacent to the daylit area as seen from inside the room. This wall area includes the window areas in the wall and is calculated as the floor to ceiling height (as opposed to floor-to-floor as used in envelope calculations) multiplied by the horizontal length of the wall(s) containing window(s) adjacent to the daylit area. The effective aperture for a window, EA_{Window}, is:

EA_{Window} = Glazing VLT x WWR

Effective Aperture (EA) for a Skylight System

$EA_{Skylight}$, is the product of the well efficiency (WE), the transmittance of the glazing and accessories (Glazing VLT), an 85% dirt factor and the skylight area to daylit area ratio. The Glazing VLT is the product of the visible light transmittance of the skylight glazing and all components in the light well that might reduce light transmission such as louvers, diffusers etc. The visible light transmittance of movable accessories (such as louvers, shades, etc.) is rated in the full open position.

Equation 5-4 – Effective Aperture of Skylights

$$\text{Effective Aperture} = \frac{0.85 \text{ x Total Skylight Area x Glazing Visible Light Transmittance x Well Efficiency}}{\text{Daylit Area Under Skylights}}$$

Visible Light Transmittance (VLT)

Visible Light Transmittance (VLT) is a property of the glass or plastic glazing material. It is the ratio of the light transmitted to the light incident on the glazing at normal incidence. The value of VLT for a given material is found in the manufacturer's literature, or ASHRAE Handbook, Fundamentals Volume, Chapter 30, Table 24. VLT is the property of the glazing material and does not include the effects of the framing. By contrast, NFRC ratings are based on Visible Transmittance (VT), which includes the effects of the framing; consequently, VT values are always lower than VLT values. For power adjustment factor (PAF) calculations (Table 146-A), VT values may be substituted for VLT. However, for daylit area calculations of §131(c) only VLT values must be used.

Well Efficiency

Well efficiency, as used to calculate effective aperture of skylights, is shown in the nomograph in Figure 146-A of the Standards. This figure is reproduced below. It is the ratio of the amount of visible light leaving a skylight well to the amount of visible light entering the skylight well and shall be determined from the nomograph in Standards Figure 146-A based on the weighted average reflectance of the walls of the well and the well cavity ratio (WCR), or other test method approved by the Energy Commission. The overall well efficiency is the product of the vertical well efficiency and the splayed well efficiency.

The area weighted average reflectance [of the walls of the well (R)] is the average calculated by the area of reflectance of all surfaces associated with a skylight. Typical reflectance values are given in Table 5-1 below. However, the submission shall use reflectances of the surfaces from the product manufacturer if they are available. Both paint and acoustic tile manufacturers publish reflectance values for their products. For skylight wells that are a combination of a splayed well and a vertical wall well, the overall well efficiency is the product of the vertical well efficiency and the splayed well efficiency, where each well efficiency is based on the dimensions at the bottom portion with similar wall angles.

Table 5-1 – Reflectance of Light Well Surfaces

Material	Reflectance %
white plaster	90
Aluminum sheet, polished	82
acoustic tile	80
white paint	70-85
pastel color paint	45 - 60
Saturated colors	25 - 35
galvanized sheet metal	50
unpainted concrete	30
unpainted wood	30
black tar paper	7

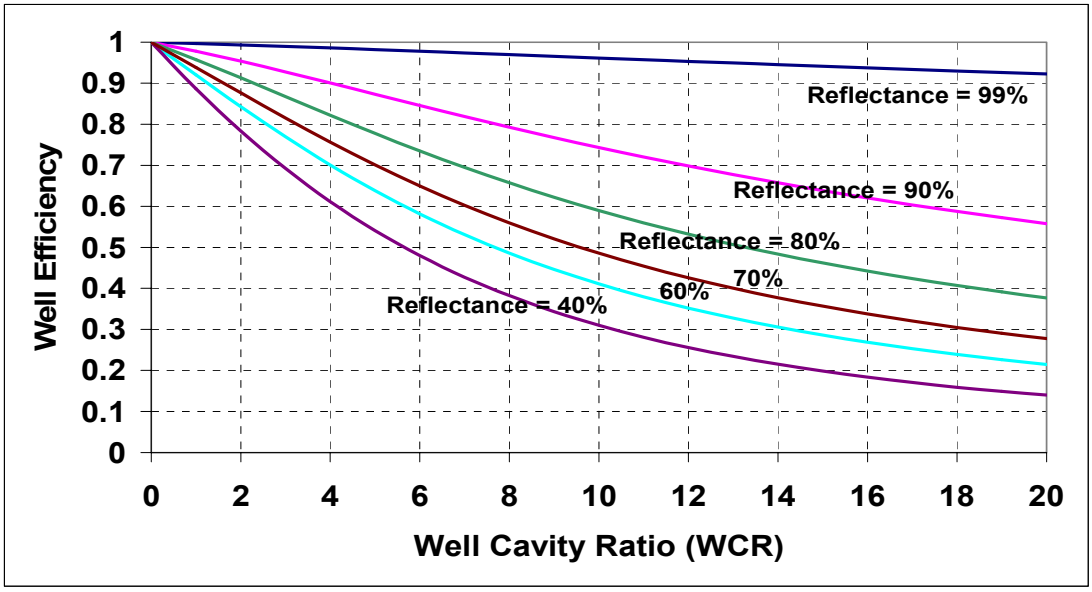


Figure 5-8 – Well Efficiency Nomograph

Well Cavity Ratio (WCR)

The well cavity ratio (WCR) is determined by the geometry of the skylight well and shall be determined using either equation below.

Equation 5-5 – Well Cavity Ratio for Rectangular Wells

$$\text{WCR} = \left(\frac{5 \times [\text{well height} \left(\text{well length} + \text{well width}\right)]}{\text{well length} \times \text{well width}} \right) \textit{;or}$$

Equation 5-6 – Well Cavity Ratio for Non-rectangular-shaped Wells:

$$\text{WCR} = \left(\frac{2.5 \times \text{well height} \times \text{well perimeter}}{\text{well area}} \right)$$

Where the length, width, perimeter, and area are measured at the bottom of the well.

Example 5-6

Question

What is the daylit area associated with the skylight shown in Figure 5-7?

Answer

The daylit area of the skylight is calculated from the length and width of the skylight footprint, and from 70% of the ceiling height (there are no permanent partitions or nearby windows/skylights). The length of the daylit area is the length of the skylight (8') plus the floor-to-ceiling height on each end times 70% (70% of 20=14; 14’ + 14’), for a total daylit area length of 36’. The width of the daylit area is the width of the skylight (4') plus 70% of the floor-to-ceiling height on each end (14’+ 14’) for a total daylit area length of 32’. The daylit area is its length times its width, or 36’ x 32’ =1,152 ft².

Example 5-7

Question

A room has a window area of 80 ft². The exterior wall that is adjacent to the daylit area has an area of 260 ft² (wall vertical height measured floor to ceiling; wall area includes openings). The window glazing has a visible light transmittance (VLT) of 0.50. Do the daylit area switching requirements apply in this room?

Answer

Yes. The window wall ratio (WWR) for the room is 80 ft² / 260 ft² = 0.31. The effective aperture, EA = 0.31 x 0.50 = 0.155, which is greater than 0.1 (exception for inadequate daylight does not apply). Daylighting control credits are available for the room if automatic daylighting controls are installed (see §146).

Example 5-8

Question

A large room has 4’ by 8’ skylights spaced on 40-foot centers. The skylight glazing has a visible light transmittance of 50% and has 3-foot deep vertical light wells with a surface reflectance of 80%. The ceiling height is 20 feet. What is the effective aperture of the skylighting system?

Answer

As shown in question 4-6, the daylit area under a single skylight is 36 by 32 feet, for a daylit area under a single skylight of 1,152 ft^2. Since the spacing is greater than the daylit area dimensions, there is no overlap of daylit areas under skylights and calculations of effective aperture can be performed on a single representative skylight. From the equation below, the remaining piece of information is the well efficiency.

$$\text{Effective Aperture} = \frac{0.85 \text{ x Total Skylight Area x Glazing Visible Light Transmittance x Well Efficiency}}{\text{Daylit Area Under Skylights}}$$

To calculate the well efficiency, first calculate the well cavity ratio (WCR):

$$\text{WCR} = \left(\frac{5 \times [\text{well height} \left(\text{well length} + \text{well width}\right)]}{\text{well length} \times \text{well width}} \right) = \left(\frac{5 \times 3 \left(8 + 4\right)}{8 \times 4} \right) = 5.6$$

From looking at the nomograph in Figure 5-8 and plotting on the 80% reflectance line that corresponds to a 5.6 well cavity ratio, one finds that the light well has a 75% well efficiency. Thus the effective aperture of the skylights is:

$$\text{Effective Aperture} = \frac{0.85 \text{ x } 32 \text{ x } 0.5 \text{ x } 0.75}{1{,}152} = 0.0089$$

Since the effective aperture is greater than 0.006, requirements for skylighting controls will apply to this system.

Example 5-9

Question

How close together do the skylights in the previous question have to be to have an effective aperture of 0.011?

Answer

To have a higher effective aperture for the same skylight dimensions, ceiling height etc, the daylit area under skylights must overlap so there is more total skylight area per total daylit floor area under skylights. To solve this, calculate the previous effective aperture equation keeping constant skylight area, glazing transmittance and setting Effective aperture to 0.011.

$$\text{Effective Aperture} = \frac{0.85 \text{ x } 32 \text{ x } 0.5 \text{ x } 0.75}{\text{Daylit Area Under Skylights}} = 0.011$$

$$\text{Daylit Area Under Skylights} = \frac{0.85 \text{ x } 32 \text{ x } 0.5 \text{ x } 0.75}{0.011} = 927 \text{ ft}^2$$

Thus if the skylights are spaced 30 ft apart in one dimension and less than (927)/(30) = 30.9 ft in the other direction the effective aperture will be greater than 0.011.

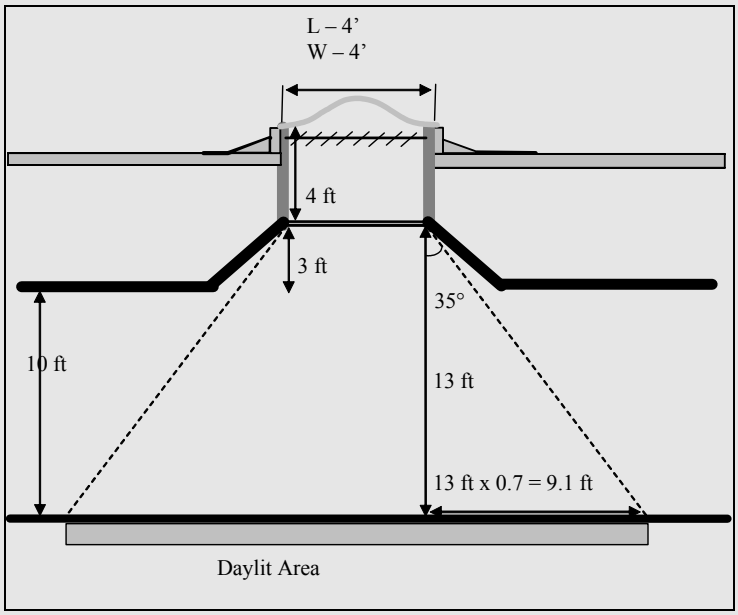
This calculation can be used to estimate maximum spacing of skylights in large open spaces to comply with the minimum effective apertures prescriptively required in §143(c).

Example 5-10

Question

A 4’ by 4’ skylight having a glazing transmittance of 82% is placed on top of a light well that has a 4 foot tall vertical section with a 95% reflectance which is above a diffuser with 92% transmittance and a 3’ deep 45° splayed light well with 80% reflectance. Also in the light well is a louver with an 85%

transmittance when it is full open. What is the overall well efficiency and the overall glazing VLT including accessories? What is the daylit area under the skylight if the suspended ceiling height is 10 feet?



Answer

The overall well efficiency is the product of the vertical well efficiency and the splayed well efficiency. The well cavity ratio (WCR) of the vertical well is calculated by:

$$\text{WCR} = \left(\frac{5 \times \text{well height} \left(\text{well length} + \text{well width} \right)}{\text{well length} \times \text{well width}} \right) = \left(\frac{5 \times 4 \left(4 + 4 \right)}{4 \times 4} \right) = 10$$

For a WCR of 10 and a reflectance of 95%, the well efficiency taken from the nomograph in Figure 146-A in the Standards is 85%. This nomograph is reprinted above in Figure 5-8.

The calculation of WCR of the splayed well is based upon the width and length at the bottom of the well which for a 45° splay is 10 ' by 10'. Thus the WCR for the splayed well is:

$$\text{WCR} = \left(\frac{5 \times \text{well height} \left(\text{well length} + \text{well width} \right)}{\text{well length} \times \text{well width}} \right) = \left(\frac{5 \times 3 \left(10 + 10 \right)}{10 \times 10} \right) = 3$$

For a WCR of 3 and a reflectance of 80%, the well efficiency taken from the nomograph in Figure 146-A in the Standards is 87%.

The overall well efficiency is 0.85 x 0.87 = 74%.

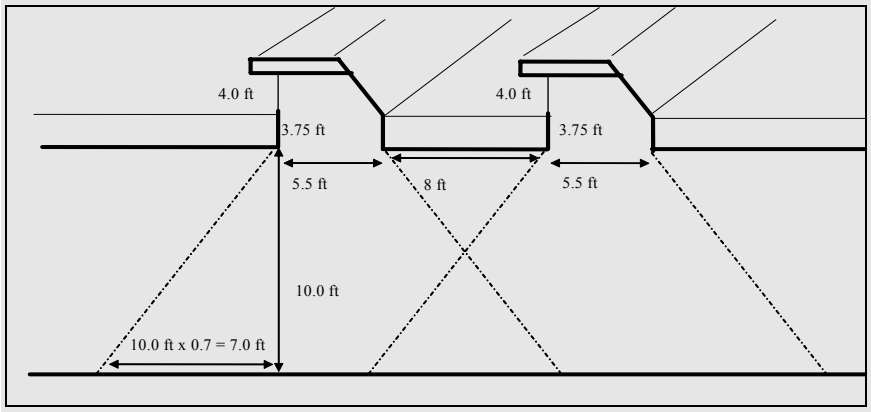
The overall glazing VLT is the product of the glazing, diffuser and louver transmittances. The louver transmittance is measured in the full open position. The overall transmittance is 0.82 x 0.92 x 0.85 = 64%.

Since the splay opens wider than 0.7 feet out for each foot of height, the daylit zone is measured from the transition between the vertical well and the splayed well. Since this transition is 13 feet above the floor the footprint of the skylight is increased on all sides by 0.7 x 13 ft = 9.1 feet. Thus the daylit area is 9.1+ 4 + 9.1 = 22.2 feet on a side for a total area of 492 ft^2.

Example 5-11

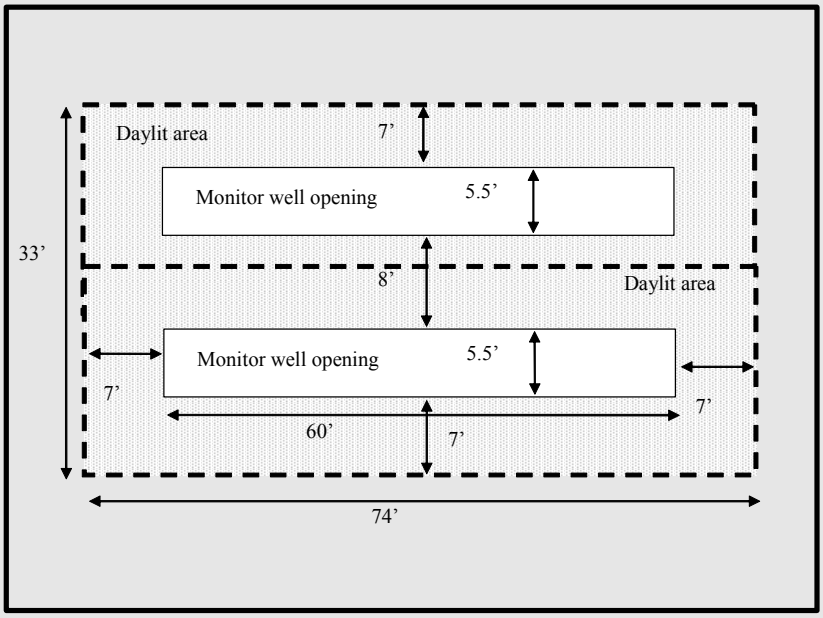
Question

Each of the two rooftop monitors as shown in the below figure, has four 14 ft long by 4 ft tall windows with a visible transmittance of 60%. Each monitor sits on top of a light well 60 ft long, 5.5 feet wide and 3.75 ft tall with surface reflectance of 80%. The two light wells are 8 feet apart and the ceiling height is 10 feet. The lighting power density of general lighting is 1.5 W/ft^2. What is the daylit area, effective aperture, well cavity ratio and the power adjustment factor (PAF) associated with the rooftop monitors?



Answer

Since the rooftop monitor sits on top of a light well, the monitor would be treated like a skylight. See plan view of skylights and daylit area below. In this case the light well opening beneath the monitor is 60 ft long, 5.5 ft wide and 3.75 ft tall.



Daylit Area

The daylit area is the footprint of the light well opening plus 70% of the ceiling height in each direction. Since the ceiling height is 10 feet, the daylit area is the light well opening plus an additional 7 feet in each of the four directions. The best way to evaluate the daylit area under skylights is to plot on a roof plan the skylight openings and then around these openings to designate

the daylit area. The dotted line designating the edge of the daylit area is offset from the skylight opening by 70% of the ceiling height, in this case 7 ft. This plan representation of the daylit area is also useful for electrical contractors so they can readily see which luminaires need to be on manual or automatic daylighting controls. In this example, the light wells are closer together than 14' and thus the daylit areas of the two light wells overlap. The overall area of this overlapping daylit area is given by the following:

Width = (0.7 x 10') + 5.5' + 8' + 5.5' + (0.7 x 10')

Width = 7' + 5.5' + 8' + 5.5' + 7' = 33 feet

Length = (0.7 x 10') + 60' + (0.7 x 10')

Length = 7' + 60' + 7' = 74ft

Daylit Area = 33 ft x 74ft

= 2,442 sf

Effective Aperture and Wall Cavity Ratio

The effective aperture is the fraction of light entering the space as compared to the amount of sunlight on the roof above the daylit area.

For this situation the total glazing area is equivalent to the total skylight area. The visible light transmittance of the glazing was given as 60% and the daylit area was calculated above as 2,442 sf. The remaining piece of information needed to calculate the effective aperture is the well efficiency. The well efficiency is obtained by looking it up on the nomograph in Figure 5-10 as a function of average well surface reflectance and the well cavity ratio of the light well. The well cavity ratio (WCR) is given by:

$$\mathrm{WCR} = \left(\frac{5 \times [\text{well height} \left(\text{well length} + \text{well width}\right)]}{\text{well length} \times \text{well width}} \right)$$

For the skylight well with a length of 60' a width of 5.5 feet and a height of 3.75 feet, the well cavity ratio is:

$$\mathrm{WCR} = \left(\frac{5 \times 3.75 \left(60 + 5.5\right)}{60 \times 5.5} \right) = 3.72$$

As shown in Figure 5-10, the well efficiency nomograph has well efficiency on the vertical axis, a series of curves for each well reflectance and the well cavity ratio on the horizontal axis. The skylight well is painted with white paint with a reflectance of 80%. Locating the point on the 80% reflectance curve directly above a well cavity ratio of 3.72 corresponds to a well efficiency of 0.82 on the vertical axis of the graph.

Given the well efficiency one can calculate the effective aperture for the daylit area underneath the two rooftop monitors.

$$\text{Effective Aperture} = \frac{0.85 \text{ x Total Skylight Area x Glazing Visible Light Transmittance x Well Efficiency}}{\text{Daylit Area Under Skylights}}$$

The total glazing area (skylight area) is the 4 pieces of glass 14 feet by 4 feet in each monitor times the two monitors for a total glazing area of:

Glazing area = (4 windows/monitor) (4 ft x 14 ft) (2 monitors) = 448 ft^2

Thus the effective aperture is:

$$\text{Effective Aperture} = \frac{0.85 \text{ x } 448 \text{ x } 0.60 \text{ x } 0.82}{2{,}442} = 0.077$$

Since the effective aperture is greater than 0.006, daylighting controls are required (§131(c) Exception 1). However, the daylit area is less than 2,500 ft^2, and automatic daylighting controls are not required, but separate control of lights in daylit areas from lights in non-daylit areas is required (§131(c)1. If daylighting controls are installed and the system meets certain criteria, a power adjustment factor (PAF) is available which treats the installed lighting as if there are less installed watts (see Section 5.4.4 of this manual).

Power Adjustment Factor

Calculating the Power Adjustment Factor (PAF) for Multi-level Daylighting Controls Under Skylights:

From the example above with the general lighting in the space having a lighting power density of 1.5 W/ft^2, the PAF is:

$$\text{PAF} = 10 \times 0.077 - \frac{1.5}{10} + 0.2 = 0.82$$

This power adjustment factor is very high and reflects that the space is fully daylit almost all daytime hours. The power adjustment factor cannot be greater than 1 as it reduces the installed lighting power of the controlled lighting by this fraction.

To obtain this Power Adjustment Factor (PAF) credit, the system must meet two criteria:

1) The control system must be an automatic multi-level daylighting control system as defined in §119(i), §131(b), and §131(c).

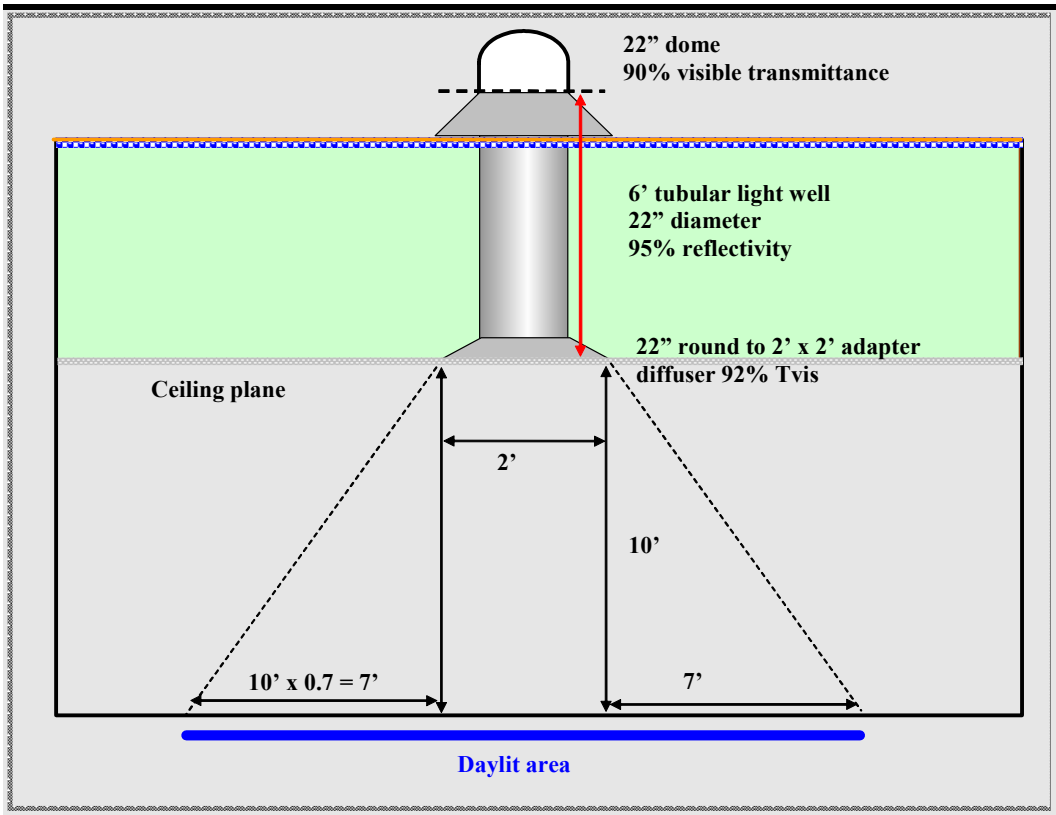
2) The glazing or diffuser must be diffusing as defined by having a haze rating greater than 90% as defined in §143(c). Products that have such a rating include prismatic diffusers, laminated glass with diffusing interlayers, pigmented plastics and the like. The purpose of this requirement is to assure the light is diffused over all sun angles.

Other methods of diffusion that result in sufficient diffusion of light over the course of the entire year would also be acceptable in lieu of using diffusing glazing. Acceptable alternatives are baffles or reflecting surfaces that ensure over all sun angles encountered during the course of a year that direct beam light is reflected off of a diffuse surface prior to entering the space. This alternative method of diffusion would have to be documented by the designer and approved by the code authority in your jurisdiction.

Example 5-12

Question

An office space with a 10-foot ceiling height is daylit with tubular skylights, also known as tubular daylighting devices or TDD's. These TDD's have a an acrylic dome with 90% visible transmittance and a 6 ft deep light shaft, The light shaft is 22" in diameter, has a 95% reflectance and terminates into a 2 ft by 2 ft square adapter with a 92% transmissive lens. This lens has a haze rating greater than 90% (i.e. it is sufficiently diffusing). The eight skylights are placed in two rows with 10 ft by 20 ft on center spacing. This office space has a general lighting power density of 1.1 W/ft^2 and the lights that are in the daylit area under skylights are on multi-level daylighting controls. What PAF should be applied?



Elevation Plan of Tubular Skylight

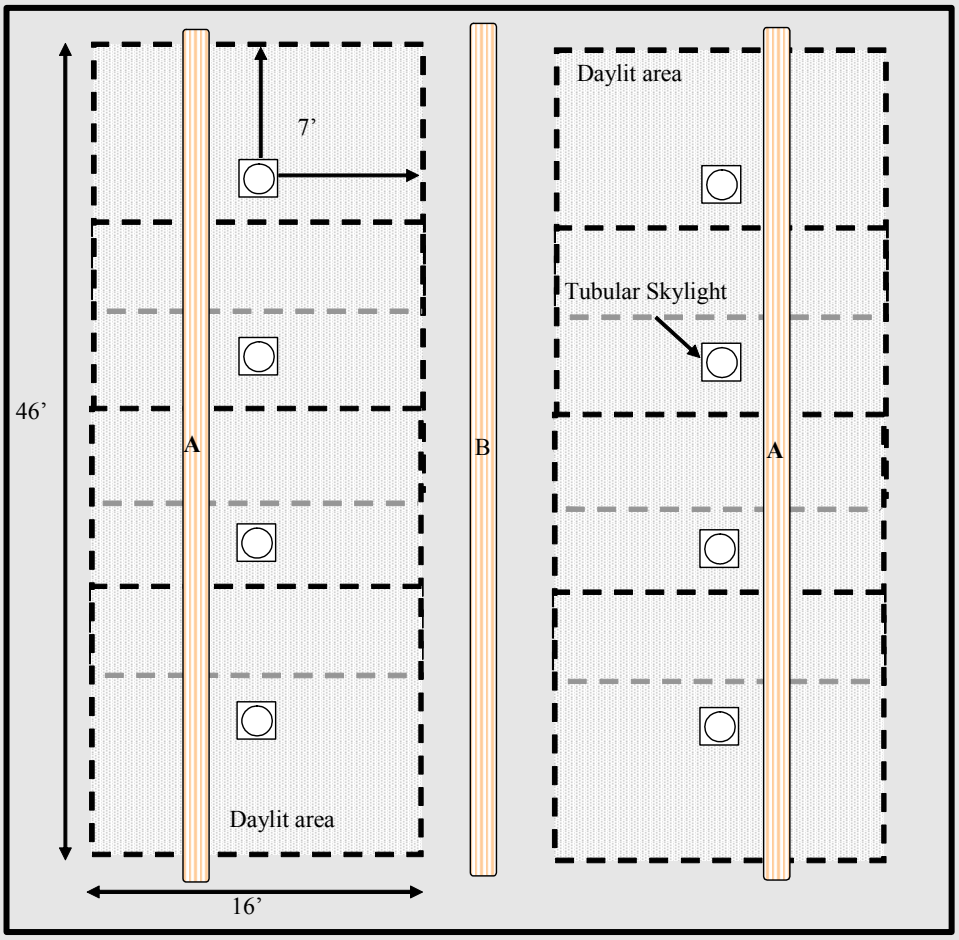
Answer:

The Power Adjustment factor is a function of the Effective Aperture of the skylighting system and the LPD of the general lighting in the space. The effective aperture in turn is a function of the skylight area, skylight glazing transmittances (including the transmittances of the diffuser), the well efficiency and the daylit area under skylights.

The skylight area per skylight is:

$$\text{Skylight area} = \frac{\pi \times D^2}{4} = \frac{\pi \times (22"/12")^2}{4} = 2.64\,\text{sf}$$

The daylit area under a skylight is the footprint of the bottom of the light well plus 70% of the ceiling height in each direction. As shown in Elevation Plan of Tubular Skylight above, the daylit area under a single 2 ft by
2 ft base of the light well is expanded by 7 feet (70% of the 10 ft ceiling height) in each direction for the total daylit area under a single skylight being 16 ft by 16 ft. However, the daylit areas overlap and must not be double counted. The calculation of daylit area under skylights is simplified by plotting on a roof plan the skylight openings and then around these openings to designate the daylit area as shown in Plan View of Tubular Skylight and Electric Lighting below. As shown on the plan, the daylit area under each row of skylights is 16 ft by 46 ft for a total of 736 ft^2. Since there are two rows of skylights, the total daylit area in the room is 1,472 ft^2.



Plan View of Tubular Skylight and Electric Lighting

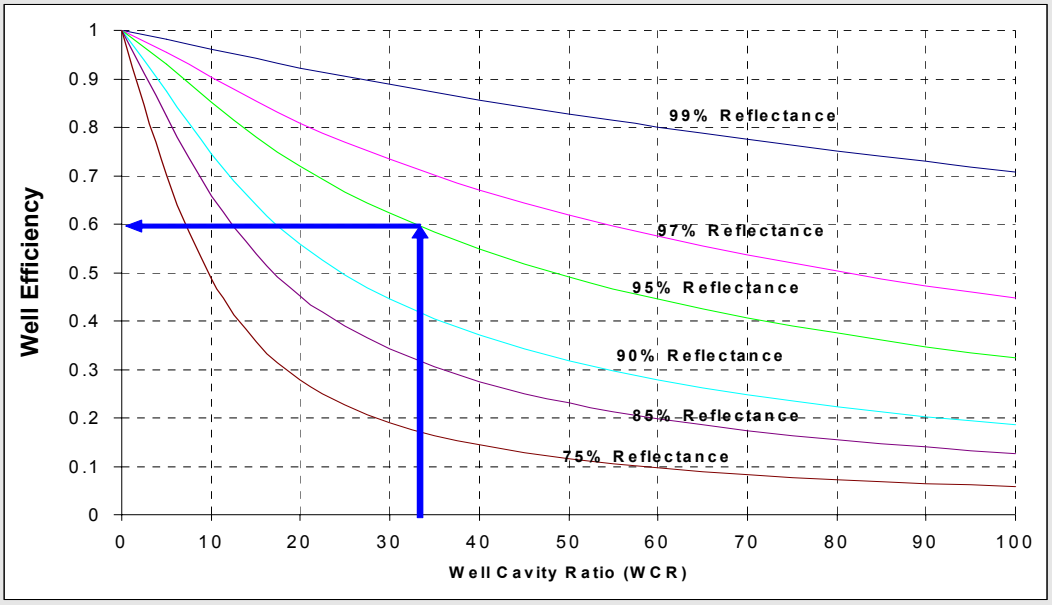
The well efficiency is calculated by using the well efficiency nomograph which has lines for various light well reflectances and well cavity ratios. The well cavity ratio (WCR) of all non-rectangular light wells is calculated by equation 146-C of the Standards:

$$\mathrm{WCR} = \left(\frac{2.5 \times \text{well height} \times \text{well perimeter}}{\text{well area}} \right)$$

This can be redefined in terms of the height over diameter ratio (H/D) of a tubular skylight as follows:

$$\mathrm{WCR} = \left(\frac{2.5 \times \text{well height} \times \text{well perimeter}}{\text{well area}} \right) = \left(\frac{2.5 \times \mathrm{H} \times \pi \times \mathrm{D}}{\pi \times \mathrm{D}^2 / 4} \right) = 10 \times \frac{\mathrm{H}}{\mathrm{D}}$$

For this example the 6 foot (72 inches) tall 22 inch diameter light well has a H/D ratio of 72/22 = 3.3 or a well cavity ratio of 10 x 3.3 = 33.0 The well efficiency nomograph in the Standards is for well cavity ratios up to 20. For this example the well cavity ratio in Extended Well Efficiency Nomograph below, is extended out to a WCR of 100. On this graph one can see that tubular skylight with a reflectance of 95% and with a WCR ratio of 33 (an H/D ratio of 3.3) has a well efficiency of approximately 60%.



Extended Well Efficiency Nomograph

Combining all of the information given or calculated above, the effective aperture can be calculated for this system.

$$\text{Effective Aperture} = \frac{0.85 \text{ x Total Skylight Area x Glazing Visible Light Transmittance x Well Efficiency}}{\text{Daylit Area Under Skylights}}$$

The glazing visible transmittance is the product of the glazing transmittance of 0.9 and the diffuser glazing transmittance of 0.92. The system effective aperture is:

$$\text{Effective Aperture} = \frac{0.85 \text{ x } 8 \text{ skylights x } 2.64 \text{ sf/skylight x } 0.90 \text{ x } 0.92 \text{ x } 0.6}{1{,}472} = 0.0061$$

This system just barely requires daylighting controls since Section 131(c) Exception 1 exempts systems with effective apertures less than 0.006. Since the daylit area is less than 2,500 ft^2, a separate manual control for lighting in the daylit area will suffice. In Plan View of Tubular Skylight and Electric Lighting above, the lights labeled “A” must be on a separate control from those labeled “B”.

The Power Adjustment Factor (PAF) for electric lighting in daylit areas under skylights and controlled by a multi-level daylighting control meeting the requirements of Section 119(i) is:

$$\text{PAF} = 10 \times \text{Effective Aperture} - \frac{\text{Lighting Power Density}}{10} + 0.2$$

Given that the general lighting power density is 1.1 W/ft^2 and the effective aperture is 0.0061, the PAF is:

$$\text{PAF} = 10 \times 0.0061 - \frac{1.1}{10} + 0.2 = 0.151$$

Alternatively, if the light wells of the tubular skylights have a 99% reflectance, the well efficiency would be 87% and the resulting effective aperture would be increased to 0.0088. Such a system would have a power adjustment factor of 0.178. One can also increase the effective aperture and thus the PAF by spacing the skylights closer together.

B. Separate Switching near Windows and under Skylights

The control of electric lighting in the area where daylighting enters a building through windows or skylights is addressed in the Standards. It falls under the mandatory requirement for separate switching in daylit areas, and may receive credit under the optional automatic controls credits. Under the mandatory measures, where an enclosed space is greater than 250 ft^2, the electric lighting within daylit area must be switched so that the lights can be controlled separately from the non-daylit areas. It is acceptable to achieve control in the daylit area by being able to shut off at least 50% of the lamps within the daylit area. This must be done by a control dedicated to serving only luminaires in the daylit area. If there are separate daylit areas for windows and skylights, they must be controlled separately.

Daylighting Controls and Multi-Level Switching

The daylit area switching requirements are in addition to the multi-level switching requirements. Taken together, there are at least three ways to comply. See Figure 5-9. Daylight switching must be applied to a fixture if any portion of that fixture is within the daylit area.

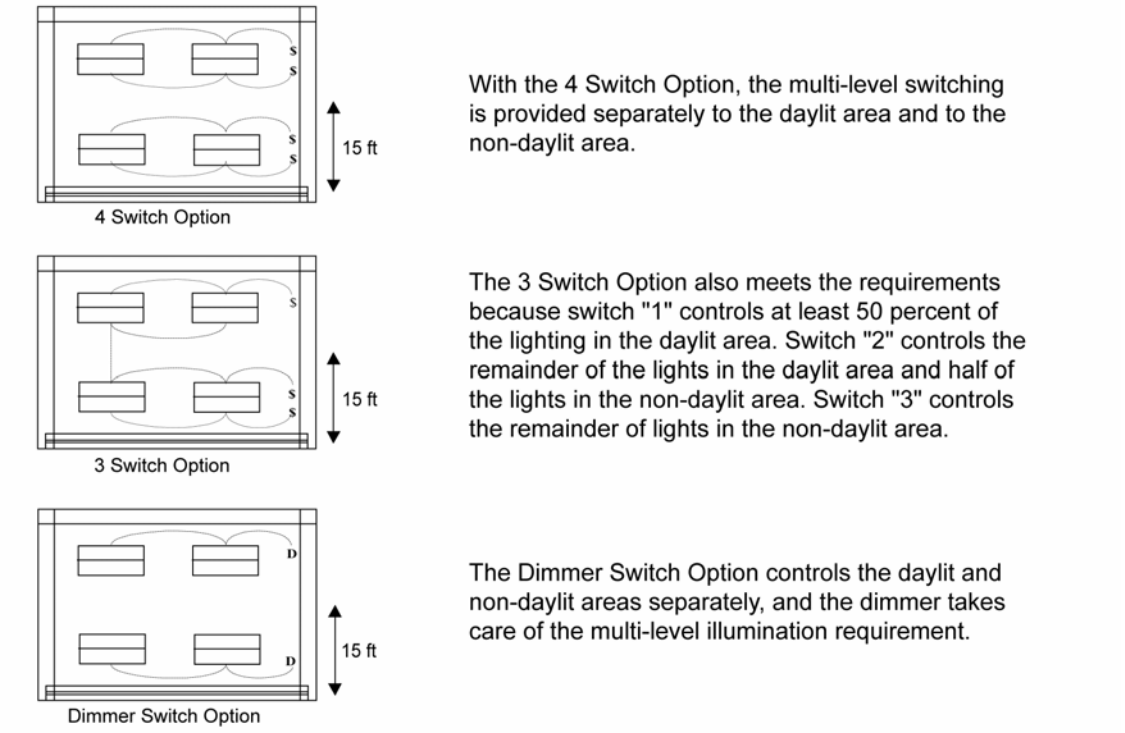


Figure 5-9 – Combined Multi-level and Daylit Area Switching

C. Daylit Areas under Skylights Exceeding 2,500 SF

Although the skylight requirements of §143 (c) are prescriptive, once skylights are installed, it triggers mandatory automatic controls for skylights. When the daylit area under skylights in any enclosed space (room) is greater than 2,500

ft^2, then the general lighting in the daylit area must be on an automatic multi-level control. The minimally compliant control is a multi-level astronomical time switch as described in §119(h). The alternative control is a multi-level photocontrol as described in §119(i) – this multi-level photocontrol can also qualify for a power adjustment factor in §146(a)4E in the Standards.

A multi-level time switch must reduce lighting power while maintaining a reasonable amount of lighting uniformity. This can be achieved by switching alternating lamps or luminaires or rows of luminaires in response to the amount of time that has elapsed since sunrise or the amount of time remaining before sunset. The automatic switching control must have at least one step that is between 50% and 70% of rated power and a minimum step that is less than 35% of rated power. Complying controls include but are not limited to a 2/3's controlled on/off or ½ + off controls as shown in Figure 5-11.

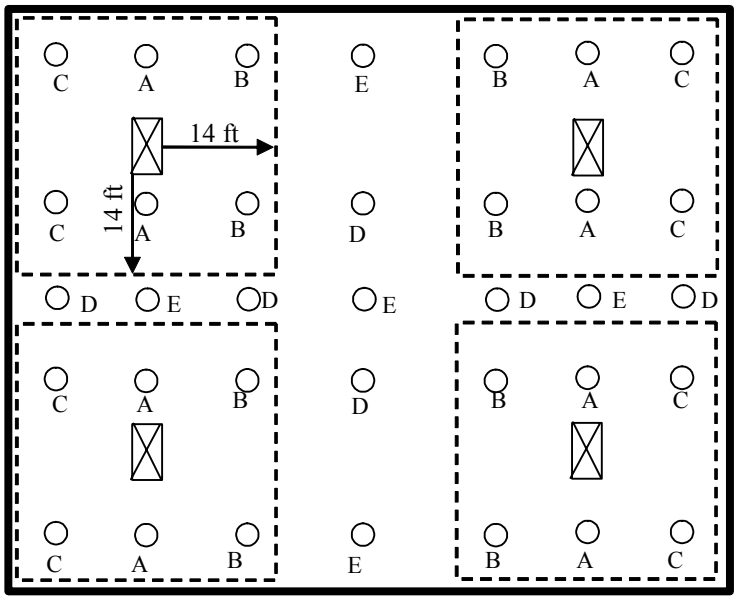


Figure 5-10 – Lighting Plan Showing Daylit Areas and Circuits (20 ft ceiling height)

The designer should designate on the reflected lighting plan, the location of skylights and their associated daylit areas as shown in Figure 5-10 (rectangles with diagonals are skylights, circles are low bay fixtures, lettering designates circuits for each luminaire and dotted lines indicate the daylit areas). This helps prevent fixtures from being wired to the wrong circuit, something that is expensive to correct after the fact. Note that there are three circuits in the daylit areas as designated by circuits A, B and C. The circuiting has been organized so that the luminaires on circuit A are closer than the luminaires on circuits B and C. At relatively low daylight levels circuit A can be switched off. Since 2/3's (67%) of the luminaires in the daylit zone will still be on when circuit A is switched off, this meets the requirement of §131(b) that lighting can be reduced to be between 70% and 50% of rated power. At higher daylight levels circuits B and C can be shut off. In this diagram if conduit is running from top to bottom, the conduit only carries two circuits of wiring (C&D, A&E, and B&D).

Note that the areas outside of the daylit areas have two circuits. This is required by multi-level control requirements of §131(b). If skylight spacing is reduced so that the entire space is in the daylit area, less lighting circuits are needed.

The astronomical time switch must have separate offsets from sunrise and sunset for the minimum of two channels that are needed to implement the control. The astronomical time switch must have the capability to offset the switch times as much as 4 hours from sunrise or sunset. When specifying an astronomical time switch, have the control manufacturer document that i the switch meets all the requirements of §119(h) of the Standards. The astronomical time switch system must also have manual timed over-ride controls in the controlled space that override the time switch for no more than 2 hours as described in §131(d)2. These manual switches may control no more than 5,000 sf of lighting except in large single spaces such as warehouses, industrial spaces, retail etc where no greater than 20,000 sf can be controlled on a single switch.

The automatic multi-level daylighting controls can either be switching or dimming. If they are the switching type, they must have the power and uniformity requirements as described above for the astronomical time switch. If they are the dimming type, all of the general lighting in the daylit area can be on a single control and continuously dimmed. In general the minimum power requirements will prohibit the use of dimming HID controls because these controls typically consume more than 35% at minimum light output.

Even when dimmed to 25% of light output, the example HID (metal halide) dimming system shown in Figure 5-12 consumes approximately 60% of full power. In contrast the fluorescent dimming system consumes approximately 15% of full power when fully dimmed. Thus HID systems will likely need to be controlled by a switching control to comply.

If a switching control is used, there are at least two stages of control. When circuiting these stages, predict or visualize which lights would be turned off first as daylight levels rise – these lights should be the lights that are closest to the skylights. The next stage of lights to be turned off should be further away. The lighting controls manufacturer should be able to advise on the layout of circuits and how the equipment should be commissioned upon start-up.

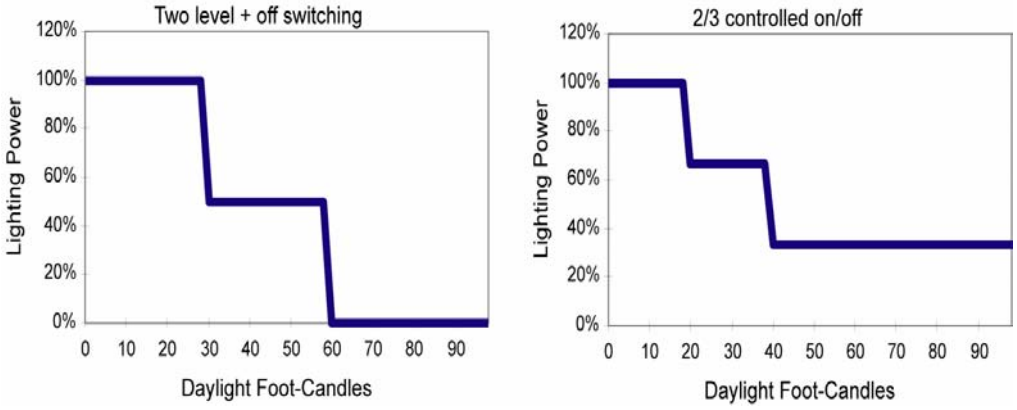


Figure 5-11 – Complying Switching Controls Strategies

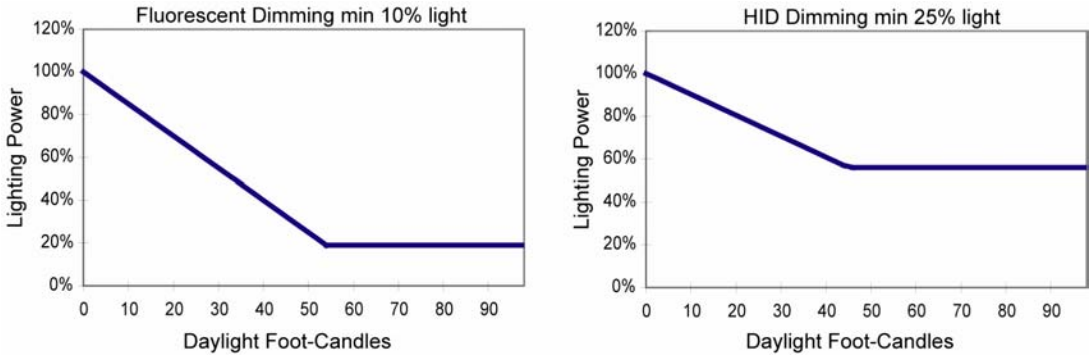


Figure 5-12 – Fluorescent and HID Power Draw in Response to Daylight

5.2.2 Prescriptive Approach

5.2.2.1 Allowed Lighting Power

The prescriptive approach for lighting involves a comparison of the building's allowed lighting power with its actual lighting power (as adjusted for controls). The actual power shall be less than the allowed power.

There are three methods to determine the allowed lighting power using the prescriptive approach: the complete building, the area category, and the tailored method. The lighting allotment must be based on area intended only for occupancy, or complete lighting plans must be submitted.

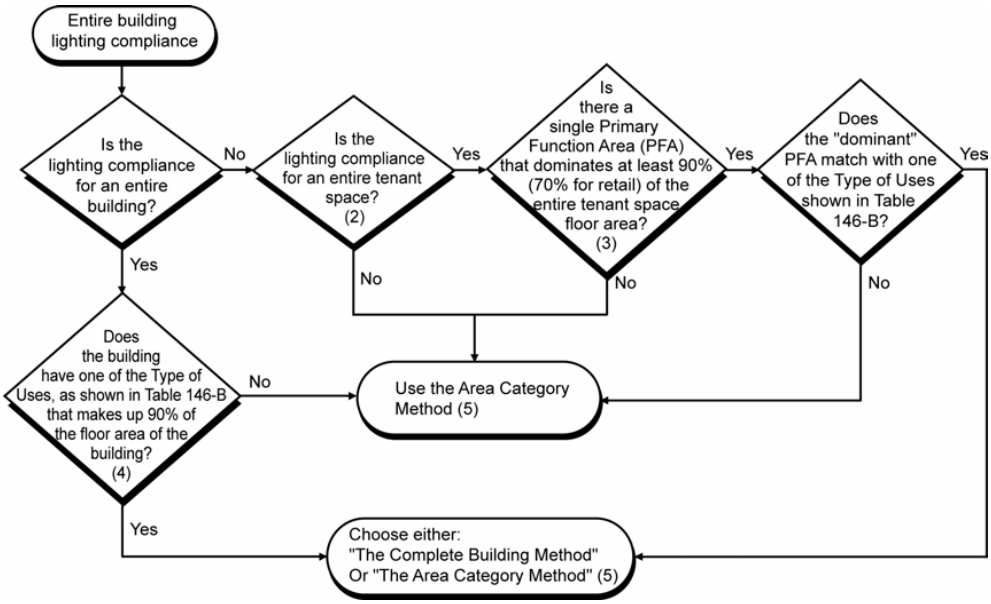


Figure 5-13 – Lighting Power Density Calculation Flowchart.
Complete Building Method and Area Category Method (1)

A. Complete Building Method

§146(b)1
Table 146-B

The complete building method can only be applied when all areas in the entire building are complete (i.e., lighting will be installed throughout the entire building under the permit for which the Title 24 compliance is prepared). The building must consist of one type of use for a minimum of 90% of the floor area of the entire building (in determining the area of the primary type of use, include the following areas if they serve as support for the primary type of use: lobbies, corridors, restrooms and storage closets). Retail and wholesale store buildings shall use this method only if the merchandise sales function area is 70% or greater of the building area. There cannot be any unfinished areas. The retail and wholesale store type of use lighting power allowance shall be used only for single tenant retail and wholesale buildings, or for buildings with multiple tenants if it is known at the time of permit application that the buildings will be entirely made up of retail and wholesale stores. To qualify for retail and wholesale power allowances, documentation must be provided at the time of permitting indicating that the actual tenants are Retail Merchandise Sales and/or Wholesale Showroom tenants.

The allowed indoor lighting power density for conditioned and unconditioned spaces, such as parking garages and conditioned spaces, shall be separate allotments, which shall be met separately without tradeoffs between the separate allotments.

To determine the allowed lighting power, multiply the complete building conditioned floor area (see definition of conditioned floor area in §101 of the Standards) times the lighting power density for the specific building type, as found in Standards Table 146-B.

Note: High-rise residential and hotel/motel buildings cannot use the complete building method.

Table 5-2 – Standards Table 146-B Complete Building Method Lighting Power Density Values (Watts/ft²)

TYPE OF USE	ALLOWED LIGHTING POWER
Auditoriums	1.5
Convention centers	1.3
Financial institutions	1.1
General commercial and industrial work buildings	
High bay	1.1
Low bay	1.0
Grocery stores	1.5
Hotel	1.4
Industrial and commercial storage buildings	0.7
Medical buildings and clinics	1.1
Office buildings	1.1
Parking Garages	0.4
Religious facilities	1.6
Restaurants	1.2
Retail and wholesale stores*	1.5
Schools	1.2
Theaters	1.3
All others	0.6
* For retail and wholesale stores, the complete building method may only be used when the sales area is 70% or greater of the building space.	

Example 5-13

Question

A 10,000-ft² medical clinic building is to be built. What is its allowed lighting power under the complete building approach?

Answer

From Table 146-B in the Standards, medical buildings and clinics are allowed 1.1 w/ft^2. The allowed lighting power is 10,000 x 1.1 = 11,000 W.

B. Area Category Method

§146(b)2
Table 146-C

The area category method is more flexible than the complete building method because it can be used for multiple tenants or partially completed buildings. For purposes of the area category method, an "area" is defined as all contiguous spaces that accommodate or are associated with a single primary function as listed in Standards Table 146-C. Areas not covered by the current permit are ignored. When the lighting in these areas is completed later under a new permit the applicant may show compliance with any of the lighting options except the complete building method.

The area category method divides a building into primary function areas. Each function area is defined under occupancy type in §101 in the Standards and in Joint Appendix I. The allowed lighting power is determined by multiplying the area of each function times the lighting power density for that function. Where areas are bounded or separated by interior partitions, the floor space occupied by those interior partitions shall be included in any area. The total allowed watts is the summation of the allowed lighting power for each area covered by the permit application.

When using this method, each function area in the building must be included as a separate area. Boundaries between primary function areas may or may not consist of walls or partitions. For example, kitchen and dining areas within a fast food restaurant may or may not be separated by walls. Also, it is not necessary to separate aisles or entries within primary function areas. However, when the area category method is used to calculate the allowed total lighting power for an entire building, the main entry lobbies, corridors, restrooms, and support functions shall be treated as separate areas.

When using this method, the public and common areas of Multifamily refers to exercise rooms, hallways, lobbies, corridors, and stairwells. The Transportation Function refers to the ticketing area, waiting area, baggage handling areas, concourse, or other areas not covered by primary functions in Table 146-C in an airport terminal, bus or rail terminal or station, subway or transit station, or a marine terminal.

If at the time of permitting a tenant is not identified for a multi-tenant space, the tenant leased space allowance from Standards Table 146-C must be used. For example, in a strip mall or other malls, if at the time of permitting a tenant is not identified for a space, the tenant lease space allowance and not the retail merchandise sales must be used. To qualify for a power allowance other than Tenant Lease Space, documentation must be provided to indicate the actual tenant and their type of business at the time of permitting.

Transferring lighting power from one area to another is acceptable only for areas for which lighting plans are being submitted and lighting is being installed as part of the same approved permit. Areas not proposed for lighting improvements are left out both on the allowance side and the installed power side. Allowed and proposed lighting calculations for unconditioned and conditioned spaces must be kept separate, with no trade-offs between the two.

Figure 5-14 shows a function area that has interior, non-bounding partitions (dotted) and bounding partitions (solid). The area is calculated by multiplying the width times the depth, as measured from the center of the interior bounding partitions. If the function area is bounded by exterior walls on one or more sides, the area is calculated by multiplying the width times the depth, as measured from the inside surface of the exterior walls to the center of the interior bounding partitions. If there are no partitions separating the boundary of the function areas on one or more sides, the boundary of the area is determined by a line separating the function areas where no bounding partitions exist. Examples of interior bounding partitions are permanent full height partitions and walls. Movable partitions such as office cubicles partitions and temporary partitions in retail sales areas are not considered interior bounding partitions.

Note that no tradeoffs are allowed between areas that are located within the conditioned floor area of a building and areas that are located in unconditioned areas or outdoor areas. For example, from Standards Table 146-C, the lighting power allowance for an unconditioned parking garage is 0.4 w/ft^2, and no tradeoffs with the conditioned areas or outdoor lighting are available to increase the lighting power allowance above 0.4 w/ft^2.

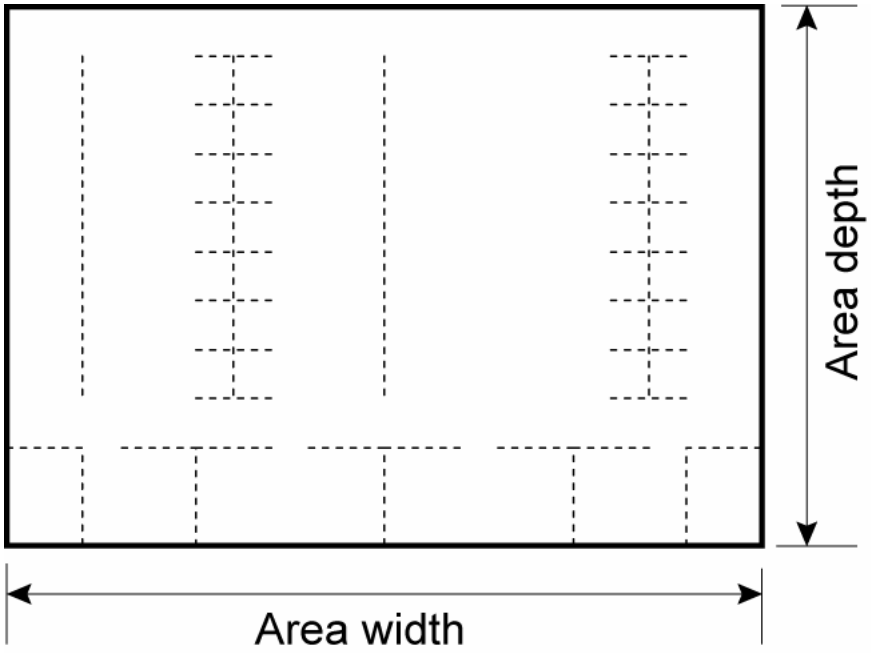


Figure 5-14 – Calculating Lighting Area

Chandeliers and Sconces (*)

§146(b)3H

Certain function areas use decorative lighting in the form of ornamental chandeliers or sconces. Areas shown in Table 146-C in the Standards, with a single asterisk (*) qualify for an additional lighting allotment of up to 1.0 w/ft². The additional power for chandeliers and/or sconces is a use-it-or-loose-it allowance that may be added to the allowed lighting power under the area category method. Ornamental chandeliers are ceiling-mounted or suspended decorative luminaires that use glass crystal, ornamental metal or other decorative materials. Sconces are wall mounted decorative lighting fixtures.

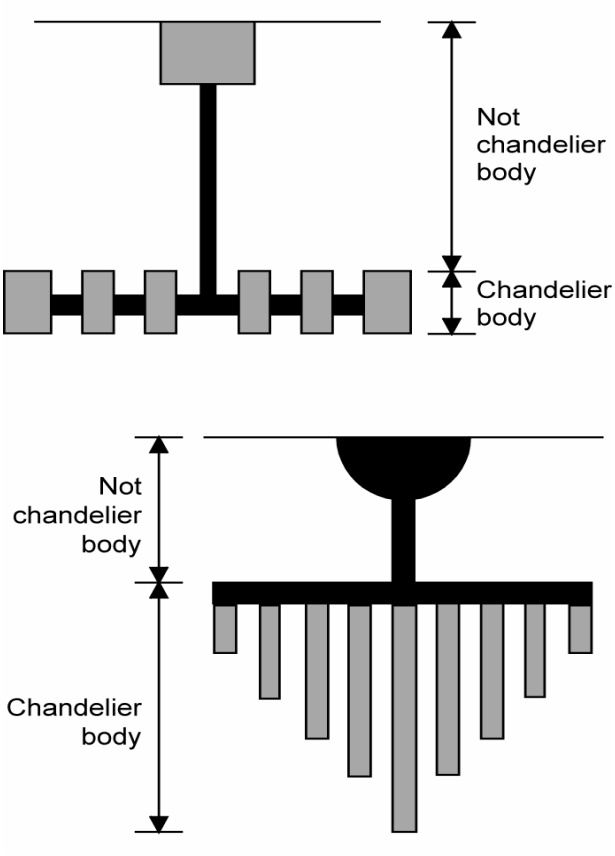


Figure 5-15 – Chandelier Dimensions

Specialized Work Tasks (**)

The spaces in Table 146-C in the Standards that are marked with two asterisks (**) may qualify for additional lighting power if the plans clearly identify special visual tasks and special lighting equipment is shown on the plans to provide illumination for these tasks. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for this specialized task work allowance.

The additional allowance is either 0.5 w/ft² times the area of the task space required for an art, craft assembly or manufacturing operation; or the actual design wattage of the luminaire(s) providing illuminance to the specialized task area. The area or location of each specific task must be shown on the plans. This is a use-it-or-lose-it allowance.

Precision Commercial and Industrial Work (***)

The spaces in Table 146-C in the Standards that are marked with three asterisks (**) may qualify for additional lighting power if the plans clearly identify special visual tasks and special lighting equipment to provide illumination for these tasks. Tasks that are performed less than two hours per day or poor quality tasks that can be improved are not eligible for this specialized task work allowance.

The additional allowance is either 1.0 W/ft² times the area of the task space required for the precision work or the actual design wattage of the luminaire(s) providing illuminance to the specialized task area. The area or location of each specific task must be shown on the plans. This is a use-it-or-lose-it allowance.

Example 5-14

Question

A small bank building has the following area distribution:

Corridors	800 ft^2
Main Entry Lobby	200 ft^2
Financial Transactions	1,200 ft^2
Manager's Office	200 ft^2

What is the allowed lighting power for this building under the area category method?

Answer

The following Lighting Power Densities apply (from Table 146-C in the Standards):

Space	LPD	Area	Allowed Watts
Corridors	0.6 W	800 ft^2	480
Main Entry	1.5 W	200 ft^2	300
Financial Transactions	1.2 W	1200 ft^2	1440
Manager's Office	1.2 W	200 ft^2	240
Total			2460 W

Financial Transactions in this example are assumed to include all the spaces in which financial transactions for the public are taking place. The allowed lighting power for this building is 2460 W.

Example 5-15

Question

A 10,000-ft^2 multi-use building is to be built consisting of:

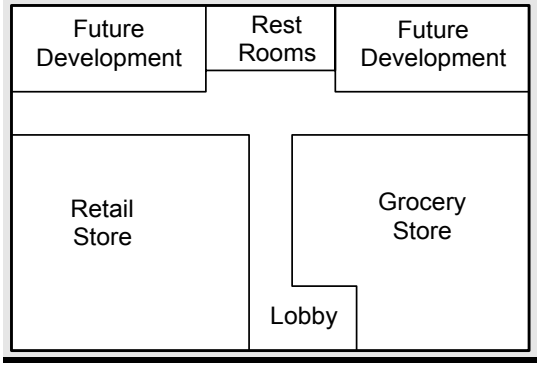
A) 500 ft^2 main entry lobby,

B) 2,000 ft^2 corridors and restroom,

C) 3,000 ft^2 grocery store,

D) 2,500 ft^2 retail, and

E) 2,000 ft^2 future development.



What is the allowed lighting power under the area category method?

Answer

Space		LPD	Area	Allowed Watts
A)	Main Entry	1.5 W/ft²	500 ft²	750
B)	Corridors and Restrooms	0.6 W/ft²	2,000 ft²	1,200
C)	Grocery Sales	1.6 W/ft²	3,000 ft²	4,800
D)	Retail Store	1.7 W/ft²	2,500 ft²	4,250
	TOTAL		8,000 ft²	11,000

with 2,000 ft² for future development.

Example 5-16

Question

What is the wattage allowance for a 10 cubic foot chandelier with 5-50 W lamps in a 300 ft² bank entry lobby?

Answer

The wattage based on the task space is 1 W/ft² x 300 ft² = 300 W

The wattage based on actual design watts is 250 W.

The wattage allowance for the chandelier is the smaller of the two values, or 250 W.

Table 5-3 – Standards Table 146-C Area Category Method - Lighting Power Density Values (Watts/ft²)

PRIMARY FUNCTION	ALLOWED LIGHTING POWER
Auditorium	1.5*
Auto repair	1.1 **
Classrooms, lecture, training, vocational room	1.2
Civic Meeting Place	1.3*
Commercial and industrial storage	0.6
Convention, conference, multipurpose and meeting centers	1.4*
Corridors, restrooms, stairs and support areas	0.6
Dining	1.1*
Electrical, mechanical rooms	0.7 **
Exercise center, gymnasium	1.0
Exhibit, museum	2.0
Financial transactions	1.2*
General commercial and industrial work	
High bay	1.1**
Low bay	1.0 **
Precision	1.3 ***
Grocery sales	1.6
Housing, Public and Commons Areas	

PRIMARY FUNCTION	ALLOWED LIGHTING POWER
Multi-family	1.0
Dormitory, Senior Housing	1.5
Hotel function area	1.5*
Kitchen, food preparation	1.6
Laundry	0.9
Library	
Reading areas	1.2
Stacks	1.5
Lobbies	
Hotel lobby	1.1*
Main entry lobby	1.5*
Locker/dressing room	0.8
Lounge/recreation	1.1
Malls and atria	1.2*
Medical and clinical care	1.2
Office	1.2
Parking garage	0.4
Religious worship	1.5*
Retail merchandise sales, wholesale showrooms	1.7
Tenant lease space	1.0
Transportation function	1.2
Theaters	
Motion picture	0.9*
Performance	1.4*
Waiting area	1.1*
All other	0.6

** The smallest of the following values may be added to the allowed lighting power for ornamental chandeliers and sconces that are switched or dimmed on circuits different from the circuits for general lighting:*

a. One watt per square foot times the area of the task space that the chandelier or sconce is in; or

b. The actual design wattage of the chandelier or sconce.

*** The smallest of the following values may be added to the allowed lighting power for specialized task work.*

a. One half watt per square foot times the area of the task space required for an art, craft assembly or manufacturing operation is performed). For spaces employing this allowance, submit plans under §10-103 of Title 24, Part 1 clearly identifying all task spaces for using this task and the lighting equipment designed to illuminate them. Tasks that are performed less than two hours a day, or poor quality tasks that can be improved shall not be employed to justify use this allowance.

b. The actual design wattage of the luminaire (s) providing illuminance to the task area(s).

**** The smallest of the following values may be added to the allowed lighting power for precision commercial or industrial work*

a. One watt per square foot times the area of the task space required for the precision work. For spaces employing this allowance, submit plans under §10-103 of Title 24, Part 1 clearly identifying all task spaces for using this task and the lighting equipment designed to illuminate them. Tasks that are performed less than two hours a day, or poor quality tasks that can be improved shall not be employed to justify use this allowance.

b. The actual design wattage of the luminaire (s) providing illuminance to the task area(s)

C. Tailored Method

§146(b)3

For occupancies such as retail merchandise sales and exhibit/museum, the maximum allowed lighting power is determined for each space or activity when the tailored method is used. In general, the tailored method can only be used for spaces whose combined area does not exceed 30% of the entire building that is otherwise using the area category method. However, the tailored method may be used for up to 100% of the entire building area of retail merchandise sales and exhibit/museum. Also, if a single function area within the building exceeds 30% of the floor area of the entire building, the tailored method may be used for that entire function area alone, with the remaining spaces using the area category method. To qualify for a tailored power allowance, documentation must be provided at the time of permitting to indicate the actual building or tenant space occupant and their type of business or activity.

The tailored method and the area category method cannot be used for the same floor area. The floor area for calculations based on the tailored method must be subtracted from the floor area for the remainder of the building lighting calculations. Trade-offs of lighting power between the tailored method and area category methods are not allowed.

The difference between the tailored method and the area category method is that the tailored method takes into account each task activity in each enclosed space or task area as the basis for determining the lighting power allotment (as opposed to functional areas, which may have several different tasks). Because the tailored method is based on task activities, this method requires the most detail on the plans, and in some cases, requires documentation of the actual lighting tasks. The tailored method may allow more lighting power than the other two methods.

The task allotments are defined in terms of the illuminance category for each task. The Illuminating Engineering Society of North America (IESNA) uses illuminance category and foot-candle levels for determining design lighting levels. Because the task allotments are based on the same categories as the IESNA design lighting levels, this method allows designers to translate their design parameters directly into allowed lighting power levels.

When using this method, the public and common areas of high-rise Multifamily buildings refer to exercise rooms, hallways, lobbies, corridors, and stairwells. The Transportation Function refers to the ticketing area, waiting area, baggage handling areas, concourse, or other areas not covered by primary functions in Table 146-C in an airport terminal, bus or rail terminal or station, subway or transit station, or a marine terminal.

Note: In many buildings the tailored method may actually result in less allowed lighting power than other methods. Larger allowances generally result from special lighting needs in a substantial portion of the building or from control credits.

Determining Illuminance Categories

§146(b)3
Table 146-D

The first step in identifying the allowed lighting power when using the tailored method is to determine the illumination category for each task. Illumination categories are determined according to the task activity that will be performed. For each task, the appropriate illuminance category is found either in Table 146-D in the Standards or in tables and procedures found in the IESNA Handbook, Ninth Edition.

Some primary functions in column 2 are assigned a specific illumination category, while others are referred to the IESNA HB. For the primary functions that refer to IESNA HB, use the IESNA HB to determine the illumination category. If there are more than one IESNA illumination categories for a given primary function, use the one that most closely matches the actual function of the space.

Selection of each illumination category not listed in Standards Table 146-D (ones that refer to IESNA HB) must be supported by a justification on the plans.

Note that the primary functions that are assigned a specific illumination category in column 2 are those that are generally allowed one or more special allowances, such as wall, floor, ornamental, and very valuable display allowances. By contrast, there are no special display lighting allowances in Table 146-D for those primary functions that are referred to the IESNA HB.

Note: All categories E and higher require special consideration. See explanatory sections on following pages.

Determining LPD Values

After determining the illuminance category, the next step is to find the lighting power density (LPD), in watts per square foot (w/ft²) or watts per linear foot (w/lf), for each category. The LPD is selected from Table 146-F in the Standards and depends on the illuminance category, which is defined either in Standards Table 146-D or in the IESNA Handbook and the room cavity ratio (RCR) of the space (see below).

Room Cavity Ratio (RCR)

For the tailored method, the maximum adjusted LPD assigned to illuminance categories A through G depends on the RCR of the space. See Table 146-F in the Standards.

The lighting level in a room is affected by the amount of light its fixtures provide and by the configuration of the room, expressed as the room cavity ratio (RCR). Small cramped rooms are more difficult to light and have a high RCR. Large open rooms are easier to light and have a low RCR. Since lighting fixtures are not as effective in a room with a high RCR, the Standards allow a greater LPD to compensate for this effect.

The RCR is based on the entire space bounded by floor-to-ceiling partitions. If a task area within a larger space is not bounded by floor to ceiling partitions, the RCR of the entire space must be used for the task area.

The RCR is calculated from one of the following formulas:

Rectangular Shaped Rooms

$$RCR = \frac{5 \times H \times (L + W)}{A}$$

Where:

RCR = The room cavity ratio

H = The room cavity height, vertical distance measured from the work plane to the center line of the lighting fixture

L = The room length

W = The room width

A = The room area

Non-Rectangular Shaped Rooms

$$RCR = \frac{[2.5 \times H \times P]}{A}$$

Where:

RCR = The room cavity ratio

H = The room cavity height (see equation above)

A = The room area

P = The room perimeter

A = The room area

These two methods yield the same result and the second more general form of calculating RCR may be used in all instances, if desirable.

It is not necessary to calculate RCR values for rooms with an RCR less than 3.5. Rooms with a RCR higher than 3.5 are allowed higher LPDs under the tailored method. Table 5-4 gives typical RCR values calculated for rooms with the task surface at desk height (2.5 ft above the floor). This table is useful in assessing whether or not a room is likely to have an RCR greater than 3.5.

A special situation occurs when illuminating stacks of shelves in libraries, warehouses, and similar spaces. In this situation, the lighting requirements are to illuminate the vertical stack rather than the horizontal floor area (see example below). In stack areas the RCR is assumed to be greater than seven. The non-stack areas are treated normally.

Table 5-4 – Typical RCRs

(Task Height 2.5 ft Above Floor, for Flush/Recessed Luminaires)

Room Length (ft)	Room Width (ft)				
	8	12	16	20	24
5	8.9	7.8	7.2	6.9	6.6
8	6.9	5.7	5.2	4.8	4.6
12	. . .	4.6	4.0	3.7	3.5
16	. . .	. . .	3.4	3.1	3.0
20	. . .	. . .	. . .	2.8	2.5
24	. . .	. . .	. . .	. . .	2.3
Room Cavity Height = 5.5 ft (eight feet from floor to luminaire)					
5	12.2	10.6	9.8	9.4	9.1
8	9.4	7.8	7.0	6.6	6.3
12	. . .	6.3	5.5	5.0	4.7
16	. . .	. . .	4.7	4.2	3.9
20	. . .	. . .	. . .	3.8	3.4
24	. . .	. . .	. . .	. . .	3.1
Room Cavity Height = 7.5 ft (ten feet from floor to luminaire)					

C.1. General Lighting Power Allowance

There are two types of lighting power allowances under the tailored method: the general lighting power allowance (column 2 of Standards Table 146-D or IESNA Handbook) and specific lighting power allowances (columns 3-5 of Standards Table 146-D).

The general power lighting power allowance is determined in accordance with paragraphs 1-6 below:

1. If a specific IESNA Illuminance Category is listed in Column 2 of Standards Table 146-D, then such illuminance category must be used. Otherwise, determine the category for each lighting task according to categories specified in the IESNA Lighting Handbook (IESNA HB), using the “Design Guide” for illuminance. It is permissible to have more than one task type in a space. For spaces employing tasks E, F, or G, submit plans under §10-103 of Title 24, Part 1 clearly identifying all task spaces for such categories and the lighting equipment designed to illuminate them. Tasks that are performed less than two hours a day, or poor quality tasks that can be improved cannot be employed to justify use of E, F, or G.

2. Determine the area of each task. Areas without tasks shall be identified as non-task. The total of all task areas and non-task areas must be equal to the area of the space.

3. Determine the room cavity ratio (RCR) and area of each space. The RCR must be calculated using either Standards Equation 146-D or Equation 146-E.

4. Multiply the area of each task by the allowed lighting power density for the task according to Standards Table 146-F. The product, or the actual installed

lighting power for the task, whichever is less, is the allowed lighting power for the task.

5. For non-task areas, the allowed lighting power density shall be 50% of the adjacent task area or that permitted for Category D, whichever is lower. Multiply the non-task area by the allowed lighting power density.

Add the allowed lighting power of all tasks and non-task areas. This is the allowed general lighting power for the space.

C.2. Specific Lighting Power Allowance

Specific lighting power allowances include wall display power (W/ft), allowed floor display power (W/ft²), allowed ornamental/special effect lighting and allowed very valuable display power (W/ft^2) (columns 3-6 of Standards Table 146-D).

Wall Display Power

Some of the primary functions listed in Table 146-D in the Standards are allowed additional lighting power for wall displays. The allowance is determined by multiplying the value in Standards Table 146-D (in watts per linear foot) by the length of display walls (in feet) that surround the space. This is a use-it-or-lose-it allowance so the allowance is the lesser of the allowed power or the installed power.

The length of display walls may include perimeter walls, including closable openings and permanent full height interior partitions. The wall display allowance may be adjusted for luminaire mounting heights that are greater than 13 ft above the finished floor (see Table 146-E in the Standards).

Qualifying wall lighting systems shall be mounted within 6 ft of the wall and shall be of a lighting system type appropriate for wall lighting. Suitable lighting systems include lighting tracks, wallwashers, valance lights, cove lighting, or adjustable accent light.

Allowed Floor Display Power

Some of the primary functions listed in Table 146-D in the Standards are allowed additional lighting power for floor displays. The allowance is determined by multiplying the power allowance in Standards Table 146-D (w/ft²) by the total area of the space. This is a use-it-or-lose-it allowance so the allowance is the lesser of the allowed power or the installed power.

The floor display allowance may be adjusted for luminaire mounting heights that are greater than 13 ft above the finished floor (see Table 146-E in the Standards).

Qualifying floor display lighting systems shall be mounted no closer than 6 ft to a wall and shall be a lighting system type such as track lighting, adjustable or fixed luminaires with PAR, R, MR, AR, or other projector lamp types or employing optics providing directional display light from non-directional lamps. Except for lighting for very valuable merchandise as defined below, lighting mounted inside of display cases shall also be considered floor display lighting.

Allowed Ornamental/Special Effect Lighting

Some of the primary functions listed in Table 146-D in the Standards are allowed additional lighting power for ornamental or special effects lighting. The allowance is determined by multiplying the power allowance in Standards Table 146-D (w/ft²) by the total area of the space. This is a use-it-or-lose-it allowance so the allowance is the lesser of the allowed power or the installed power.

Qualifying ornamental luminaires include chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes, theatrical projectors, moving lights, and light color panels when used in a decorative manner that does not serve as display lighting. Ornamental/special effects lighting shall not be the only light source in the space.

Allowed Very Valuable Display Power (W/ft^2)

Some of the primary functions listed in Table 146-D in the Standards are allowed additional lighting power for the display of very valuable merchandise. Typical spaces are in museums, religious facilities and retail stores. The allowance is the smaller of the product of power allowance in Standards Table 146-D (w/ft²) and the area of the space, or multiplying the area of the display case by 20 w/ft². This is a use-it-or-lose-it allowance so the allowance is the lesser of the allowed power or the installed power.

Qualifying lighting includes internal display case lighting or external lighting employing highly directional luminaires specifically designed to illuminate the case without spill light. To qualify for this allowance, cases shall contain jewelry, coins, fine china or crystal, precious stones, silver, small art objects and artifacts, and/or valuable collections the selling of which involves customer inspection of very fine detail from outside of a locked case.

Mounting Height Adjustment

When a space requires that luminaires for wall or floor display lighting be mounted at a height of 13 ft or higher, additional lighting power is permitted. Table 146-E in the Standards lists mounting height adjustments for various mounting heights. The appropriate multiplier is applied to the power allowance for wall or floor display lighting shown in Standards Table 146-D.

When there is more than one mounting height condition, they should be separated into different task areas for purposes of applying the mounting height adjustments. The boundaries of these separate areas should be clearly shown on the plans, and the mounting height in each should also be shown with a section diagram.

Determining Area of a Task

In order to determine the allowed lighting power, the task areas need to be identified. For illuminance categories A, B, C D, E, F, and G, the task areas are the areas of each task space that has a separate illuminance requirement. If the task area in bounded by walls or partitions, then the area of each task space is determined by measuring the dimensions from inside the bounding partitions. The area is calculated by multiplying the width times the depth, as measured

from the inside of the bounding partitions. The floor area occupied by the interior partitions is not included in the floor area of the function area. However, if the task area is not bounded by walls and partitions, then the actual area of the task may be used to determine the allowable power.

Determining Allowed Watts

After the LPD and task area assigned to each space or task is established, the allowed watts may be calculated. There are two cases:

- For illuminance categories A through D and for the gross sales floor area, the allowed watts are calculated simply by multiplying the LPD (w/ft²) by the area of the space (ft²).
- For illuminance categories E through I, gross sales wall areas and feature displays, the allowed watts are the lesser of: the LPD (w/ft²) multiplied by the area of the task (ft²) to obtain allotted watts, or the design watts of the luminaires assigned to the task.

The sum of the allowed watts for all spaces and tasks is the building allowed lighting power, in watts, as determined by the tailored method.

Tradeoffs

Only the general portion of the lighting power determined in §146 (b) 3 A in the Standards above can be used for tradeoffs among the various occupancy or task types of the permitted space. The allowed wall display lighting power, the allowed floor display lighting power, the allowed ornamental/special effect lighting power, and the allowed lighting power for very valuable displays are “use-it-or-lose-it” power allowances that shall not be traded off.

Allocation Restrictions of Task Lighting

When using the tailored method, the determination of task lighting is based on need. Therefore, lighting plans must be submitted that show the actual task lighting application. Task lighting allotments from walls, floors or special applications cannot be traded off for use as general lighting.

Table 5-5 – Standards Table 146-D Tailored Method Special Lighting Power Allowances

Primary Function	Illumination Category	Wall Display Power (W/ft)	Allowed Floor Display Power (W/ft²)	Allowed Ornamental/ Special Effect Lighting	Allowed Very Valuable Display Power (W/ft^2)
Auditorium	D	2.5	0.3	0.5	0
Civic Meeting Place	D	3.5	0.2	0.5	-
Classrooms, lecture, training, vocational room	D	7	0	0	0
Commercial and industrial storage	IESNA HB	0	0	0	0
Convention, conference, multipurpose and meeting centers	D	2.5	0.4	0.5	0
Corridors, restrooms, stairs and support areas	IESNA HB	0	0	0	0
Dining	B	1.5	.6	0.6	0
Exercise center, gymnasium	IESNA HB	0	0	0	0
Exhibit, museum	C	20.0	1.4	0.7	1.3
Financial Transactions	D	3.5	0.2	0.6	0
Grocery store	D	11	1.2	0	0
Housing, Public and Commons Areas	D	0	0	1.0	0
Multi-family Dormitory, Senior Housing	D	0	0	1.0	0
Hotel function area	D	2.5	0.2	0.5	0
Kitchen, food preparation	IESNA HB	0	0	0	0
Laundry	IESNA HB	0	0	0	0
Library					
Reading areas	D	0	0	0.7	0
Stacks	D	0	0	0.7	0
Lobbies:					
Hotel lobby	C	3.5	0.2	0.7	0
Main entry lobby	C	3.5	0.2	0	0
Locker/dressing room	IESNA HB	0	0	0	0
Lounge/recreation	C	7	0	0.7	0
Malls and atria	D	3.5	0.5	0.7	0
Medical and clinical care	IESNA HB	0	0	0	0
Office	IESNA HB	0	0	0	0
Jail	IESNA HB	0	0	0	0
Police or fire stations	IESNA HB	0	0	0	0
Religious worship	D	1.5	0.5	0.5	03
Retail merchandise sales, wholesale showrooms	D	21.0	1.5	0.7	1.3
Tenant lease space	C	0	0	0	0
Transportation Function	D	3.5	0.3	0.7	0

Primary Function	Illumination Category	Wall Display Power (W/ft)	Allowed Floor Display Power (W/ft²)	Allowed Ornamental/ Special Effect Lighting	Allowed Very Valuable Display Power (W/ft^2)
Theaters:					
Motion picture	C	3	0	0.6	0
Performance	D	6	0	0.6	0
Waiting area	C	3.5	0.2	0.7	0
All other	IESNA HB	0	0	0	0

Table 5-6 – Standards Table 146-E Adjustments for Mounting Height above Floor

Height in feet above finished floor and bottom of luminaire(s)	Multiply by
12 or less	1.0
13	1.05
14	1.10
15	1.15
16	1.21
17	1.47
18	1.65
19	1.84
20 or more	2.04

Table 5-7 – Standards Table 146-F Illuminance Categories A Through G Lighting Power Density Values (Watts/ft^2)

IESNA Illuminance Category	RCR<3.5	3.5<RCR<7.0	RCR>7.0
A	0.2	0.3	0.4
B	0.4	0.5	0.7
C	0.6	0.8	1.1
D	0.9	1.2	1.4
E	1.3	1.8	2.5
F	2.7	3.5	4.7
G	8.1	10.5	13.7

Example 5-17

Question

A private office is 12 ft wide, by 12 ft long, by 9 ft high. The lighting system uses recessed ceiling fixtures. The task surface is at desk height (2.5 ft above the floor). What is the room cavity ratio?

Answer

The room cavity height is the distance from the ceiling (center line of luminaires) to the task surface (desk height). This is 9 ft – 2.5 ft = 6.5 ft.

RCR = [5 x H x (L + W)] / Area

RCR = [5 x 6.5 x (12 + 12)] / (12 x 12) = 5.42

Example 5-18

Question

The private office in the above example is to comply under illuminance category E (found in the IESNA Lighting Handbook). What is the allowed lighting power?

Answer

The RCR is 5.4 and the area of the office is 144 ft². The allowed LPD for task E from the IESNA Lighting Handbook illuminance is 1.8 w/ft² (RCR of 5.4) Therefore, the allowed power for this office is 1.8 w/ft² X 144 ft² = 259 watts.

Example 5-19

Question

A 5,500-ft² retail store with an RCR of 4.0 has:

5,000 ft² of gross sales floor area.

200 ft² of restrooms with a RCR of 6.0.

300 ft² of corridors with a RCR of 6.5.

100 ft² of very valuable merchandize case top with 1,200 W of actual lighting.

300 linear ft of parameter wall including closeable openings.

What is the allowed general lighting, wall display, floor display, ornamental/special effect, and very valuable display wattage in this store using the tailored method?

Answer

From Standards Table 146-D, column 2, the general power illumination category for retail is category D. From Standards Table 146-F, the LPD for illumination category of D and RCR of 4.0 is 1.2 w/ft². Therefore, the allowed general lighting power is 1.2 w/ft² X 5,000 ft² = **6,000 W**.

From IESNA Handbook, restrooms are at illuminance category C. From Table 146-F in the Standards, at illuminance category C and RCR of 6.0, the LPD is 0.8 w/ft², therefore, the allowed power for the restrooms is 200 ft² x 0.8 W/ft² = **160 W.**

From IESNA Handbook, corridors are at illuminance category C. From Table 146-F in the Standards, at illuminance category C and RCR of 6.5, the LPD is 0.8 w/ft², therefore, the allowed power is 300 ft² x 0.8 W/ft² = **240 W.**

The wall display lighting is computed from the entire wall parameter including all closeable openings times the wall display power allowance. Therefore, the allowed wattage is 300 ft x 21 w/ft = **6,300 W**. The allowance is taken from column three of Standards Table 146-D.

The floor display allowance is computed from the area of the entire space with floor displays times the floor display lighting power density. Therefore, the allowed wattage is 5,000 ft² x 1.5 w/ft² = **7,500 W**. The allowance is taken from column four of Table 146-D in the Standards.

The ornamental/special effect allowance is computed from the area of the entire space with floor displays times the ornamental/special effect lighting power density. Therefore, the allowed wattage is 5,000 ft² x 0.7 w/ft² = **3,500 W**. The allowance is taken from column five of Table 146-D in the Standards.

The allowed wattage for very valuable display case top is smaller of the 1.3 w/ft² (from column five of Standards Table 146-D) and the gross sales area (5,000 ft²), or 20 /ft² times the actual area of the

case tops (100 ft²). The maximum allowed power is the smaller of 1.3 w/ft² X 5,000 ft² = 6,500 watts, or 20 w/ft² X 100 ft² = 2,000 watts. Therefore, the maximum allowed power is **2,000 W**.

Therefore, the total allowed lighting wattage is 6,000 + 160 + 240 + 7.500 + 3,500 + 2,000 = **19,400 W**. Please note that in tailored method, the allowed wattage for each lighting task activity is of the use-it-or-lose-it kind, which prohibits tradeoffs between different tasks.

Example 5-20

Question

If in the question above, the actual design wattages for floor display and very valuable display are 5,000 and 1,000 W respectively, what are the maximum allowed floor display and very valuable display power allowances?

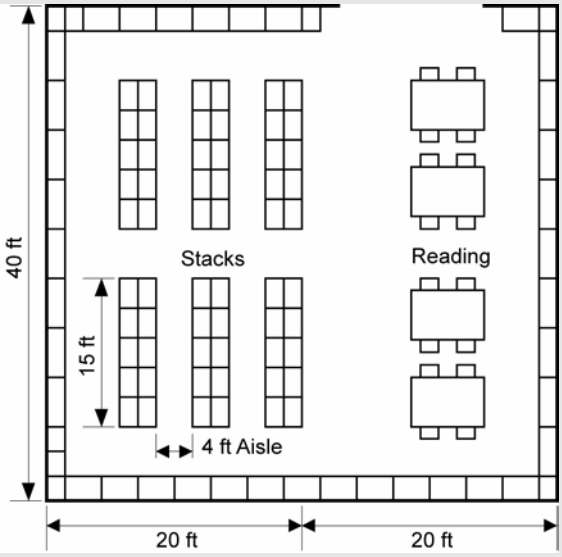
Answer

Since the floor display and very valuable display allowances are use-it-or-lose-it allowances, the maximum power allowed is the smaller of allowed watts for floor display (7,500 W) and very valuable display (2,000 W) or the actual design watts for floor display (5,000 W) and very valuable display (1,000 W). Therefore, the maximum allowed watts for floor display and very valuable display are 5,000 and 1,000 W respectively.

Example 5-21

Question

How is the RCR determined for the library reading room/stack area shown in below?



Answer

A RCR value of 7 may be assumed for the stack area. The reading area RCR is calculated based on the reading area room dimensions (20 ft x 40 ft) and on the room cavity height.

5.3 Performance Approach

The performance approach provides an alternative method to the prescriptive approach for establishing the allowed lighting power for the building.

Under the performance approach, the energy use of the building is modeled using a computer program approved by the Energy Commission. In this energy analysis, the standard lighting power density for the building is determined by the computer program based on occupancy type, in accordance with either the complete building, area category, or tailored rules described above. This standard lighting power density is used to determine the energy budget for the building.

When a lighting permit is sought under the performance approach, the applicant uses a proposed lighting power density to determine whether or not the building meets the energy budget. If it does, this proposed lighting power density is automatically translated into the allowed lighting power for the building (by multiplying by the area of the building).

If the building envelope or mechanical systems are included in the performance analysis (because they are part of the current permit application), then the performance approach allows energy trade-offs between systems that can let the allowed lighting power go higher than any other method. Alternatively, it allows lighting power to be traded away to other systems, which would result in a lower allowed lighting power. This flexibility in establishing allowed lighting power is one of the more attractive benefits of the performance approach.

If the common lighting system (Section 5.9) is used in the performance approach then the standard design will be based on the area category method and the proposed design will be the actual proposed power density (not to exceed 1.0 watts per square foot).

When tailored lighting is used to justify increases in the lighting load, a lower lighting load cannot be modeled for credit. The standard design building uses the lesser of allowed w/ft^2, or actual lighting power, to be installed in the building. The proposed design building uses the actual lighting power to be installed as detailed on the lighting plans. This value must be equal to, or greater than, the allowed w/ft^2.

5.4 Calculating the Lighting Power

Once the allowed lighting power is determined by one of the prescriptive methods or the performance approach, it is compared to the actual lighting power (adjusted for controls). The designed or actual lighting power is simply the sum of the wattages of all planned permanent and portable lighting fixtures in the building, based on the same floor area as was used to calculate the allowed lighting power. The actual lighting power may be adjusted through lighting control credits if optional automatic lighting controls are installed.

The actual lighting power does not necessarily include every light in the building. There are a number of lighting applications that are exempted from the Standards limits on lighting power.

5.4.1 Exempt Lighting

§146(a)5

The following lighting applications are exempt from the actual lighting power used to compare with the allowed lighting power.

- In theme parks: lighting for themes and special effects. Regular spaces such as administrative offices and retail areas are *not* exempt.
- Lighting for film, video or photography studios.
- Lighting for dance floors and lighting for theatrical and other live performances, provided that these lighting systems are additions to a general lighting system and are controlled by a multiscene or theatrical cross-fade control station accessible only to authorized operators.
- In civic facilities, transportation facilities, convention centers, and hotel function areas: lighting for temporary exhibits if the lighting is an addition to a general lighting system and is separately controlled from a panel accessible only to authorized operators.
- Lighting installed by the manufacturer in refrigerated cases, walk-in freezers, vending machines, food preparation equipment, and scientific and industrial equipment.
- In medical and clinical buildings: examination and surgical lights, low-level night lights, and lighting integral to medical equipment.
- Lighting for plant growth or maintenance equipped with an automatic 24-hour time switch with program backup capabilities to prevent the loss of the switch's program and time setting for at least 10 hours if power is interrupted.
- Lighting equipment that is for sale.
- Lighting demonstration equipment in lighting education facilities.
- Lighting that is required for exit signs subject to the California Building Code with a maximum lamp input power rating of five watts per illuminated face or less. (Exit signs shall meet the requirements of the Appliance Efficiency Regulations.)
- Exitway or egress illumination that is normally off and that is subject to the California Building Code.
- Lighting in guestrooms in hotel/motel buildings.
- Living quarters in high-rise residential buildings, except that such lighting shall comply with the requirements for low-rise residential buildings (see Chapter 6 of the Residential Manual).
- Temporary lighting systems.
- Lighting in occupancy group U buildings less than 1,000 ft^2.
- Lighting in unconditioned agricultural buildings less than 2,500 ft^2.

- Lighting systems in qualified historic buildings, as defined in the State Historic Building Code (Title 24, Part 8), are exempt from the lighting power allowances if they consist solely of historic lighting components or replicas of historic lighting components. All other lighting systems in qualified historic buildings, or non-historic parts of those lighting systems, shall comply with the lighting power allowances.
- Parking garages for seven or less vehicles.
- Internally illuminated, externally illuminated, and unfiltered signs. (These signs are exempt from the actual lighting power used to compare with the allowed lighting power. However, sign energy requirements in §148 apply to all internally illuminated and externally illuminated signs, whether they are used indoors or outdoors.)

5.4.2 Actual Lighting Power Calculation

§146(a)

For calculating the actual lighting power, wattages of all planned permanent, and portable (including planned portable), including hard wired and plug-in lighting systems shown on the plans at the time of permitting, must be considered (except those exempt under §146(a)3). This includes track lighting systems, chandeliers, portable free standing lights, lights attached to workstation panels, movable displays and cabinets, and internally illuminated case work for task or display purposes. Sufficient supporting evidence (from manufacturer's catalogs or values from independent testing lab reports) must be submitted to and accepted by the building authority. The individual signing the lighting plans must clearly indicate on the plans the actual power for the portable lighting systems in the area (§146(a)2).

The calculation of actual lighting power is accomplished with the following steps:

1. Determine the watts for each type of fixture. This includes both the lamp and the ballast wattage. These are interdependent, so the wattage of a particular lamp/ballast combination is best determined from reputable manufacturer's test data. Default values from ACM Manual Appendix NB may be used for standard lamp and ballast combinations.

2. Determine the number of each fixture type in the design.

3. Multiply the fixture wattages by the numbers of fixtures and sum to obtain the building total actual lighting power in watts (this includes wattages of portable lighting systems for office spaces).

4. Adjust for lighting control credits, if applicable.

Portable Lighting Systems

§146(a)1

For all spaces, the actual wattage of all planned permanent and portable lighting shown on the plans at the time of permitting must be included in determining the actual lighting power density. The individual signing the lighting plans must clearly indicate the actual power for the portable lighting systems in the area.

Portable lighting fixtures are often added to office spaces after the building is occupied. If the actual wattage of portable lighting is not known at the time of permitting, then the Standards require that an additional lighting power of 0.2 w/ft^2 be included in determining the actual lighting power density. Enclosed office spaces with areas equal to or less than 250 ft^2 enclosed by floor-to-ceiling permanent partitions are exempt from this requirement. Note that the portable lighting requirement applies to all office spaces regardless of the primary function area of the building. This requirement will apply to most buildings with typical open office type of layouts. However, once portable lighting systems have been installed in the space, the building official may require that the actual lighting power of the space be recalculated and resubmitted taking into account the actual wattage of the installed portable systems.

If portable lighting is shown on the plans, the documentation must include information on luminaire layout (accompanied by furniture layout including modular furniture walls, shelves and cabinets), location, brand, model, and performance characteristics of all luminaires in the space. The designer is responsible for providing all of the information that the building inspector may need to clearly understand that less than 0.2 w/ft^2 of portable lighting will be needed.

Example 5-22

Question

A retail building has two enclosed office spaces (120 ft^2 each) with floor-to-ceiling permanent partitions, for store managers. Should calculations for installed lighting power include an additional 0.2 w/ft^2 to account for portable lighting for these spaces?

Answer

No. The enclosed spaces are exempt from the additional 0.2 w/ft^2 requirement because their area does not exceed 250 ft^2.

Example 5-23

Question

An 8,000-ft^2 office building is to be built. At the time of permit application, the actual wattage of planned portable lighting for the office area is not known and no portable lighting is shown on the plans. Further, the percentage of office areas versus support areas is not known at the time of permitting. Using the complete building method, how does this affect the installed lighting power calculation for the building?

Answer

The Standards require that a portable lighting power of 0.2 w/ft^2 be included in the calculation of installed lighting power for office buildings with areas greater than 250 ft^2. However, since the percentage of office areas versus support areas is not known in the building, the 0.2 w/ft^2 should be added to the installed lighting power of the permanent fixtures installed in the entire 8,000 ft^2 of office space.

Example 5-24

Question

An 8,000-ft^2 office building is to be built. The building contains 2,000 ft^2 of corridors, restrooms, and storage rooms. At the time of permit application, the actual wattage of planned portable lighting for

the office area is not known and no portable lighting is shown on the plans. Using the complete building method, how does this affect the installed lighting power calculation for the building?

Answer

The Standards require that a portable lighting power of 0.2 w/ft^2 be included in the calculation of installed lighting power for office buildings with areas greater than 250 ft^2. 0.2 w/ft^2 should be added to the installed lighting power of the permanent fixtures installed in the 6,000 ft^2 of office space. All other spaces (2,000 ft^2 of corridors, restrooms, and storage rooms) are exempt from this requirement.

Example 5-25

Question

A small 200-ft^2 office building is to be built. At the time of permit application, the actual wattage of the planned portable lighting is not known and no portable lighting is shown on the plans. How does this alter the installed lighting power calculation?

Answer

The installed lighting power calculation remains unaltered. No portable lighting power is required to be included in the calculation of installed lighting power for office buildings with areas equal to or less than 250 ft^2.

Example 5-26

Question

A 5,000-ft^2 retail building, which includes a 300 ft^2 administrative office space and other spaces (as listed below), is to be built. At the time of permit application, the actual wattage of planned portable lighting is not known and no portable lighting is shown on the plans. How will the installed lighting power for the building be calculated?

Function	Area
Office	300
Common Restrooms	200
Common Corridors	500
Retail Function	3,000
Total Building Area	4,000

Answer

Although office is *not* the primary function of the building, an additional 0.2 w/ft^2 must be added to the installed lighting power because the area of the space is greater than 250 ft^2. The remaining area is exempt from this requirement.

5.4.3 Determining Luminaire Wattage

§130(d)
ACM Manual Appendix NB

For most fixture types, determining the luminaire wattage is straightforward. ACM Manual Appendix NB shows typical luminaire power for a wide range of lamp and ballast types and these values may be used as a default. There are,

however, a few types that require special consideration. The Standards determine the luminaire wattage to be counted towards calculating installed indoor lighting power based on lamps, ballasts, and luminaire type.

Medium Screw Base Sockets

§130(c)1

The wattage of incandescent or tungsten-halogen luminaires with medium screw base sockets and not containing permanently installed ballasts shall be the maximum relamping rated wattage of the luminaire, as listed on a permanent factory-installed label, as specified by UL 1598. Medium screw base sockets are typically found in fixtures that require a screw-in type lamp. They are the most common lamp bases for incandescent lamps (the ordinary type of light bulb that generates light from a glowing filament). These bases are used for a wide range of lamp wattages. These fixtures present a special situation when calculating actual lighting power, because the wattage of the lamps can be easily changed at any time. 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. The plans should specify the maximum allowed lighting power for each luminaire so that installers understand not to install luminaires with higher ratings.

Luminaires with Permanently or Remotely Installed Ballasts

§130(c)2

The wattage of luminaires with permanently installed or remotely installed ballasts shall be the operating input wattage of the rated lamp/ballast combination based on values published in manufacturer's catalogs based on values from independent testing lab reports as specified by UL 1598. 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 used for determining the luminaire wattage.

Track Lighting

§130(c)3, §130(c)4

There are two types of track lighting systems: tracks on line-voltage, and low-voltage tracks. Line-voltage tracks include tracks that operate on 90 through 480 volts. Low-voltage tracks include tracks that operate on less than 90 volts

Line-Voltage Tracks

The wattage for track lights on line-voltage tracks - including plug in busways used for lighting - shall be determined by one of the following two methods:

1. Volt-ampere (VA) rating of the branch circuit(s) feeding the tracks, or the higher of:

- Wattage (or VA) rating of an integral current limiter controlling the track system, or
- 15 watts per linear foot of the track

For branch circuits with multiple tracks, with every track equipped with an integral current limiter, the rating shall be the higher of 15 watts per linear foot or the sum of the wattage (or VA) rating of all current limiters controlling the tracks. For branch circuits that have a mix of tracks with and without current limiters, the wattage of the tracks without integral current limiters shall be determined by method 2 below.

2. The higher of 45 W per linear foot of the track or total wattage of all of the luminaires included in the system. Determine the wattage of each luminaire (track head) according to § 130 (c) of the Standards. Luminaire wattage for incandescent track heads shall meet the requirements of S § 130 (c) 1, based on the maximum relamping rated wattage as listed on a permanent factory-installed label. Luminaire wattage for fluorescent and high intensity discharge (HID) track heads shall meet the requirements of § 130 (c) 2, based on the operating input wattage of the rated lamp/ballast combination. Luminaire wattage for low-voltage track heads (when mounted on line-voltage track) shall meet the requirements of § 130 (c) 5, based on the maximum rated wattage of the transformer on each track head. This method applies to single and multi circuit track.

When using an integral current limiter, such device shall be permanently attached to or an integral part of the track. The VA rating of the current limiter shall be clearly marked on the device and readily available for the building officials' field inspection without opening coverplates, fixtures or panels. Access to wiring connections shall employ tamper resistant hardware and a conspicuous label shall be permanently affixed to the wiring compartment warning against removing, tampering with, rewiring, or bypassing the device.

If a current limiter is used to achieve compliance for tracks, the manufacturer of the current limiting device must certify to the commission that the device complies with all of the applicable requirements of Standards §130 (c) 3 and Section 5.4.3 of this manual, Determining Luminaire Wattage.

Low-Voltage Tracks

Low-voltage tracks, cable conductors, rail conductors, and other low voltage flexible lighting systems which are serviced through permanently installed transformers must use the specified rated wattage of the transformer feeding the system, as shown on a permanent factory-installed label per UL-1574 or UL-1598, as the actual lighting power of the track.

In some situations, extra length of track is desired to provide greater flexibility in locating lighting fixtures. In these cases, the designer can limit the actual lighting power by providing interlock switching that limits the circuits (and therefore the electric capacity) of track lighting that can be operated simultaneously.

Other Lighting

§130(c)5

The wattage for all other lighting equipment (lighting systems that are not addressed in §130 (c) 1-4) shall be the maximum rated wattage of that lighting system, or operating input wattage of the system, 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.

Example 5-27

Question

What is the wattage of a 6 ft length of track lighting that has three 150 W listed fixtures with 60 W, medium base lamps proposed, assuming this track is not equipped with a current limiter?

Answer

Based on medium base socket fixtures the total wattage is 450 W (three fixtures at 150 listed W each).

Based on the length of track the wattage is 270 W (6 ft x 45 w/ft).

Therefore, the actual lighting power of the track is the larger of the two, or 450 W.

Example 5-28

Question

What is the wattage of a 20-foot track system that is equipped with an integral current limiter rated at 400 watts?

Answer

The wattage of the track is the higher of:

15 w/lf X 20 ft of track = 300 watts, or

the wattage rating of the current limiter which is 400 watts.

Therefore, the wattage of this track is the greater of the two, or 400 watts.

Example 5-29

Question

If in the example above, the track is not equipped with a current limiter and is equipped with 350 watts of track heads, what would be the wattage of the track?

Answer

In the absence of a current limiter, the wattage of the track is the higher of:

the maximum relamping rated wattage of all of the luminaires included in the system (350 watts), or

45 watts per linear foot of the track which is 45 w/lf X 25 ft = 1,125 watts.

Therefore, the wattage of the track is 1,125 watts.

Example 5-30

Question

A 20-amp branch circuit is supplying two line-voltage tacks. Only one of the tracks is equipped with an integral current limiter. How are the wattages of the tracks on this branch circuit is determined?

Answer

The wattage of the track may be calculated using one of the following options:

Option 1. The wattage of the current limiter (or15W /ft if greater), plus 45W/ft of the second track, or

Option 2. The VA of the branch circuit that supplies both tracks.

5.4.4 Automatic Lighting Control Credits

§146(a)4

The controlled watts of connected lighting within the building may be adjusted to take credit for the benefits of certain types of automatic lighting controls. A list of the controls that qualify for these credits is shown in Table146-A in the Standards.

The lighting control credits set out "Power Adjustment Factors." These are multipliers that allow the actual lighting power to be reduced, giving a lower adjusted lighting power. This makes it easier to meet the allowed lighting power requirement. A credit is only permitted when the control types indicated in Table146-A are used.

In order to qualify for the power savings adjustment, the control system or device must be certified (see Section 5.2.1 Lighting Equipment Certification), and must control all of the fixtures for which credit is claimed; only controlled luminaires are eligible for lighting control credit. Exit way, emergency, egress and other lighting systems that are on a separate circuit and are not controlled by a qualifying control device, are not eligible for these credits.

At least 50% of the light output of the controlled luminaire must fall within the applicable type of space listed in Standards Table146-A. Additionally, credits may not be combined, with the exception of those listed as combined controls in Standards Table 146-A.

Occupant Sensors

An occupant sensor used in some spaces may qualify for the power adjustment factor. Eligible spaces include any space ≤ to 250 square feet enclosed by floor to ceiling partitions, any size classrooms, corridors, conference rooms, or waiting rooms. The occupant sensor shall meet the multi-level lighting control requirements of §131(b) in the Standards:

- The sensor shall have an automatic OFF function that turns off all the lights.
- The sensor shall have either an automatically or manually controlled ON function.

- The sensor shall have wiring capabilities so that each switch function activates a portion of the lights.
- One control step must activate between 50-70% of the design lighting power, and one step must activate less than 35% of the design lighting power. The multi-level control can be accomplished by switches "downstream" of the occupancy sensor.
- The lighting shall achieve a reasonably uniform level of illuminance.

In addition, the occupant sensor must meet the "multi-level circuitry" requirements described in the following section.

Occupant Sensors with multi-level circuitry

An occupant sensor used in a small office (less than or equal to 250 ft^2) shall have the following features (§146 E):

- Upon entering the room, a first stage of control activates between 50-70% of the lights in the space automatically or by manually turning on a switch.

After that action occurs, the following actions must be able to occur based upon manual control by the occupant:

- Activating the alternate set of lights.
- Activating 100% of the lights.
- Deactivating all lights.

When the room is unoccupied, all of the lights must automatically turn off.

When the room is reoccupied, no more than 70% of the lights can be turned back on automatically or from a single switch action. This prevents the use of standard line voltage switches to perform this type of control. This control can be accomplished by special bi-level occupancy sensors or by the use of a standard occupancy sensor and a sentry switch that defaults back to the off position when it is de-energized.

Non-qualifying Circuit for Occupancy Sensor Credit Example

Figure 5-16 shows an occupant sensor wired in series with a conventional double wall switch. This circuit meets the mandatory lighting control requirements including multi-level control in §131(b) and the shut-off requirements in §131(d). But in this circuit does not qualify for the control credits for a occupancy sensor with "multi-level circuitry" as described in §146(a)4 because if the occupant leaves the room with all of the lights on, the next time she comes back into the room the occupant sensor will turn all of the lights back on. The requirement in §146(a)4 says that the first level of lighting to come back on must "activate between 50% -70% of the lights."

If the conventional switches were replaced with sentry switches which return both switches to the off position each time power is interrupted for an extended periods of time, this would then quality for the compliance credit for occupancy sensors with "multi-level circuitry" as described in §146(a)4.

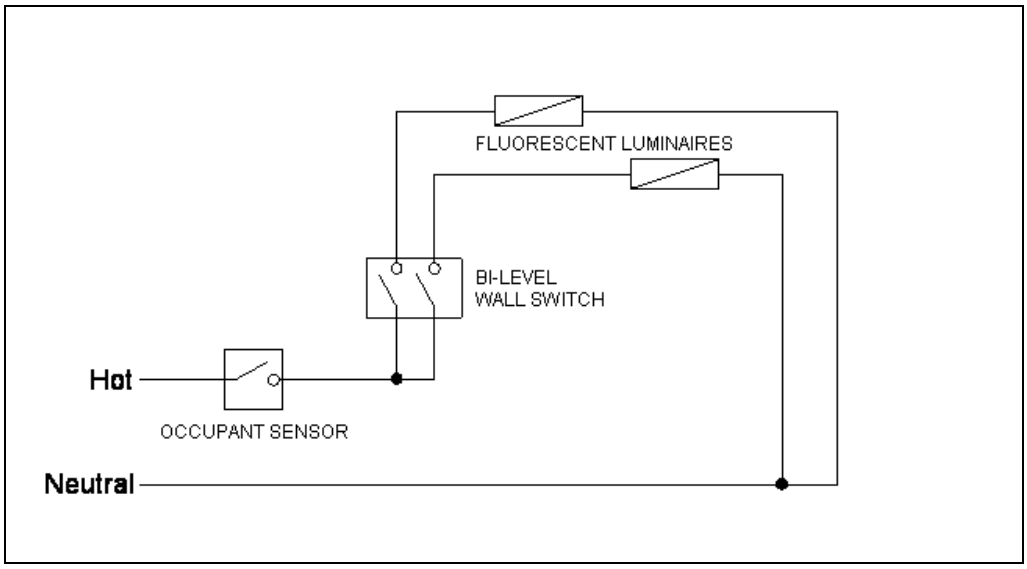


Figure 5-16 – Occupancy Sensor with Manual Multi-level Switches

Private Office with an Occupant Sensor and Multi-Level Controls Example

The schematic in Figure 5-17 shows a private office with an occupant sensor and multi-level controls. The luminaires remain off unless manually switched on by the occupant either through a manual action by the occupant or automatically to between 50-70% of the design lighting power; and switch off automatically shortly after the occupant has left the space. This time delay can be varied but must be 30 minutes or less. The occupant sensor is integrated into the switch faceplate. A double wall switch is required, to allow override of each circuit separately. Each luminaire has three lamps powered by two ballasts in an "inboard/outboard" arrangement; the control system supplies each luminaire with two switched hot wires and one neutral. This system qualifies for a power adjustment factor of 0.20. Occupant sensing systems should be set to manual-on wherever possible to maximize energy savings.

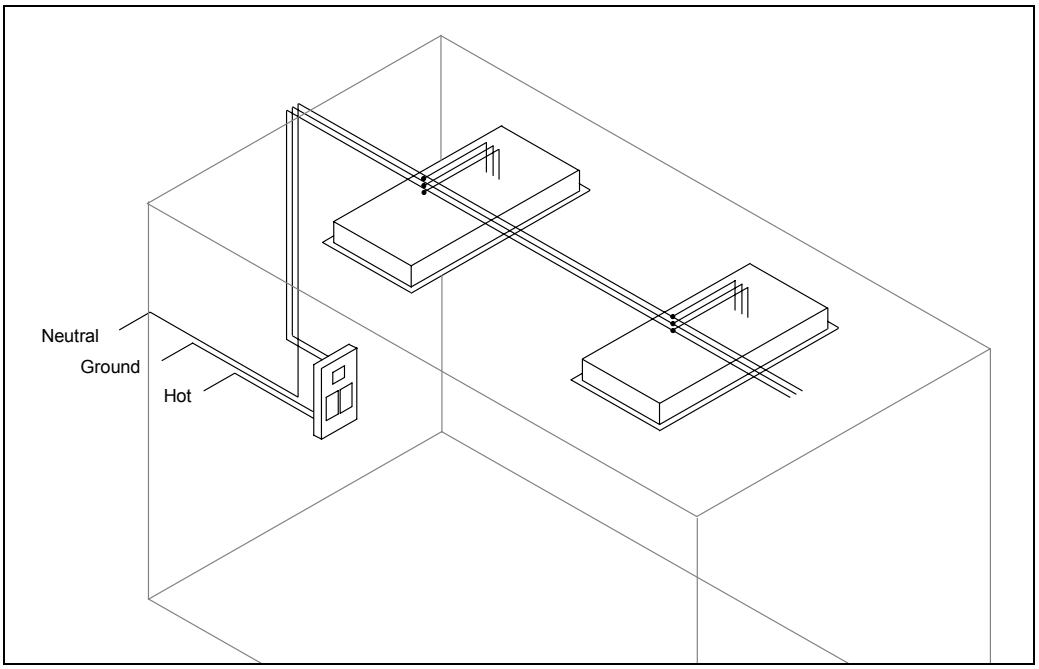


Figure 5-17 – Occupant Sensors with Multi-Level Control: "Inboard/Outboard" Approach.

Other Control Credits

Table 146-A of the Standards also provides control credits for the following technologies and spaces:

- Occupant sensor controlled multi-level switches or dimming systems that reduce the lighting power at least 50% in hallways of hotel/motels, commercial and industrial storage stack areas (maximum two aisles per sensor), and library stacks (maximum two aisles per sensor). This can be accomplished by placing half of the lighting in these areas on an occupancy sensor and the remainder on a manual switch. Only the fraction of the lighting that is on the occupancy sensor qualifies for the credit (§146(a)4 "controlled watts of any luminaire…").
- Dimming systems including manual and multi-scene programmable systems in hotels/motels, restaurants, auditoriums, and theaters.
- Manual dimming with automatic load control of dimmable electronic ballasts in all building types. This control system allows load shedding (dimming lights) initiated by the utilities or other grid system operators in the event of an electricity shortage. To qualify for this credit the dimming system in the building must have a control system that is ready to respond to a load curtailment or real time pricing signal. Such a system is enabled to dim all lights receiving the control credit below a fixed setting or to a fraction of their setting at the time the signal is received.
- Combined controls (either an occupancy sensor with daylighting controls or an occupancy sensor with manual dimming) for any space

less than or equal to 250 ft^2 within a daylit area and enclosed by floor-to-ceiling partitions, or any size classroom, corridor, conference or waiting room.

The power adjustment factors in Standards Table 146-A may not be combined, with the exception of those allowed under the "combined controls" section.

Hotel Corridor with Occupant Sensors and Multi-Level Controls Example

The schematic in Figure 5-18 shows a hotel corridor with occupant sensors and multi-level controls. Hotel/motel corridors are eligible for lighting power control credits if they are equipped with occupant sensor controlled multi-level switches or dimming systems that reduce the lighting power at least 50% when no people are present. Luminaires are wired on alternate circuits so that half remain on permanently, and the other half switch on automatically when an occupant is detected. Two occupant sensors are mounted in opposite corners of the ceiling and operate at low voltage supplied by a power pack behind the switch faceplate. The occupant sensors are connected, to ensure that the system can detect hotel guests at either end of the corridor. The control system supplies each luminaire with one switched hot wire and one neutral. A double wall switch is provided, although it is not required in public areas (§131(a) in the Standards). This system qualifies for a power adjustment factor of 0.25. Note that external staircases and corridors are classified as outdoor lighting and so are required to be controlled by a photoelectric switch or time clock.

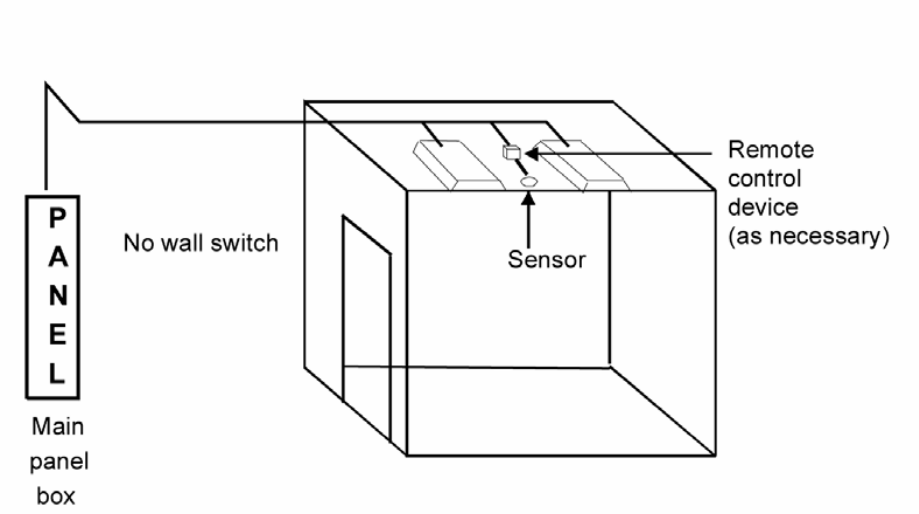


Figure 5-18 – Occupant Sensors with Multi-Level Control: Alternate Luminaire Approach

Daylighting Control Credits

§146(a)4. E.

Control credits as defined by §146(a)4 in the Standards permit a reduction in the computed lighting power in a building based on special allowances for installing controls that save more energy than the basic mandatory controls required by

§131. These credits are based upon power adjustment factors (PAFs) which when multiplied by the wattage of the controlled lighting, is subtracted from the installed lighting power to yield the calculated lighting power. A lighting system prescriptively complies when the calculated lighting power is less than or equal to the allowed indoor lighting power.

Automatic daylighting control credits for side-lighting and skylights, listed Table 146-A, are NOT available when automatic daylighting controls are installed as a result of mandatory requirements, prescriptive requirements or performance approach compliance. These credits are only available in spaces where daylighting and controls are not already required by mandatory requirements or prescriptive or performance approach requirements. For example, if performance approach is used to install skylights in addition to what is prescriptively required and the daylit area is greater than 2500 square feet, control credits are not available for the automatic daylighting controls associated with additional skylights since there are mandatory requirements for these controls.

Automatic daylight control devices include stepped dimming, continuous dimming, and stepped switching devices. For definitions of these terms see §101 of the standards or the definitions in the Joint Appendix I.

Installing controls that have power adjustment factors increases the efficiency of the lighting system and this efficiency is captured in both the prescriptive and performance documentation of lighting system wattage. The control credits can be used when more installed lighting capacity is required, or for exceeding the requirements of the energy code to gain credit for building rating systems such as LEED[9] or CHPS[10].

For controlled lighting to receive a reduction in its calculated wattage from a daylighting control power adjustment factor, it must be in the daylit area and comply with the restrictions associated with the specific power adjustment factor.

For automatic daylighting controls with windows, the PAF is a function of dimming versus switching controls, the glazing VLT (Section 3.2.8) and the window to wall ratio (WWR) [Section 5.2.1.4

A. The “Daylit Area” near Windows and under Skylights].

For automatic multi-level daylighting controls with skylights, the power adjustment factors are only applied to controlled general lighting in the daylit area under skylights. To qualify for the power adjustment credits, the control must conform to the requirements of §119(i) automatic multi-level daylighting controls, and the skylight glazing or diffuser must have a haze rating greater than 90%. The haze rating greater than 90% indicates that the glazing is diffusing. Ask the manufacturer for documentation of the haze rating of the skylight glazing or diffuser before specifying their product.

[9] LEED stands for Leadership in Energy and Environmental Design and is a rating program of the U. S. Green Building Council.

[10] CHPS is the Collaborative for High Performance Schools, which has a rating program for K-12 schools, which is based in part on exceeding the Title 24 standards.

The power adjustment factors for automatic multi-level daylighting controls with skylights are a function of the effective aperture, EA, and the lighting power density of the controlled lighting, LPD, as given by the following equation:

PAF = 10 x EA – (LPD/10) + 0.2

The calculation of effective aperture, EA, is described in Section 5.2.1.4

A. The “Daylit Area” near Windows and under Skylights.

Daylighting control credits are only available for luminaires within daylit zones, as defined in Section 5.2.1.4 Daylighting Controls. The daylight control system shall comply with §119(e), §119(f), and §119(g). The power adjustment factor is a function of the lighting power density of the general lighting in the space, and the effective aperture of the windows or skylights.

Bookstack Area with an Automatic Daylight Dimming System

The schematic in Figure 5-19 shows a library bookstack area with an automatic daylight dimming system. The luminaires remain off when the space is daylit, and dim up progressively when daylight levels are low. The photocell is mounted in the ceiling, looking out of the window to provide open-loop control. Each luminaire has a dimming ballast; the control system supplies each luminaire with one switched hot, one neutral and one control wire (consisting of a low voltage twisted pair). A double wall switch is provided, although it is not required in public areas [§131(a) in the Standards]. This system is installed in a room with a 30% window wall ratio and clear double-pane windows with 65% visible light transmittance; it therefore qualifies for the maximum power adjustment factor of 0.40.

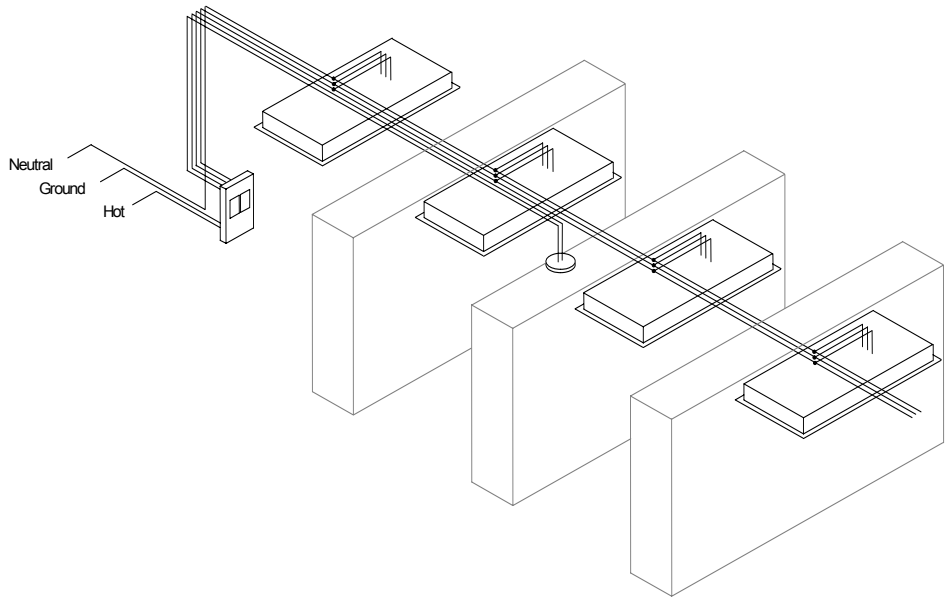


Figure 5-19 – Photocell Dimming

Table 5-8 – Standards Table 146-A Lighting Power Adjustment Factors

TYPE OF CONTROL	TYPE OF SPACE	FACTOR
Occupant sensor with "manual ON" or bi-level automatic ON combined with multi-level circuitry and switching	Any space ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room	0.20
Occupant sensor controlled multi-level switching or dimming system that reduces lighting power at least 50% when no persons are present	Hallways of hotels/motels	0.25
	Commercial and Industrial Storage stack areas (max. 2 aisles per sensor)	0.15
	Library Stacks (maximum 2 aisles per sensor)	0.15
Dimming system		
Manual	Hotels/motels, restaurants, auditoriums, theaters	0.10
Multiscene programmable	Hotels/motels, restaurants, auditoriums, theaters	0.20
Manual dimming with automatic load control of dimmable electronic ballasts.	All building types	0.25
Combined controls		
Occupant sensor With "manual ON" or bi-level automatic ON combined with multi-level circuitry and switching in conjunction with daylighting controls	Any space ≤ 250 square feet within a daylit area and enclosed by floor-to-ceiling partitions, any size classroom, corridor, conference or waiting room.	0.10 (may be added to daylighting control credit)
Manual Dimming with Dimmable Electronic Ballasts and Occupant sensor with "manual ON" or automatic ON to less than 50% power and switching	Any space ≤ 250 square feet enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room	0.25
Automatic Daylighting Controls with Windows (Stepped Switching or Stepped Dimming/Continuous Dimmed) (Numbers on the left side of a slash apply to Stepped Switching or Stepped Dimming. Numbers on the right side of a slash apply to Continuous Dimming)		
	WINDOWS – Window Wall Ratio	
Glazing Type	< 20%	20% to 40%	> 40%
VLT ≥ 60%q	0.20/0.30	0.30/0.40	0.40/0.40
VLT ≥ 35 and < 60%	0/0	0.20/0.30	0.30/0.40
VLT < 35%	0/0	0/0	0.20/0.40
Automatic Multi-Level Daylighting Controls with Skylights		
Glazing Type - Skylights	Factor	
Glazing material or diffuser with ASTM D1003 haze measurement greater than 90%	$10 \times \text{Effective Aperture} - \frac{\text{Lighting Power Density}}{10} + 0.2$ WHERE Effective Aperture is as calculated in the Equation 146-A. Lighting Power Density is the lighting power density of general lighting	

Example 5-31

Question

A lot of occupant sensors can be set to "manual-on" or "automatic-on" – which one is better?

Answer

The Standards allow either manual- or automatic-on, although best practice guidance recommends manual on to avoid nuisance switching, for instance during daylight hours when lights are not

required, or when someone enters a room only briefly, or when someone passes the open doorway of a room with an occupant sensor. Manual-on also maximizes energy savings. Automatic-on may offer added convenience in storerooms, restrooms and similar spaces.

Example 5-32

Question

A multi-scene programmable controller is used to control display lighting in a store. Can a power adjustment factor be applied?

Answer

The 0.2 power adjustment factor for multiscene programmable controllers is only available for the general lighting of hotels/motels, restaurants, auditoriums and theaters. However, special lighting power allowances are available for retail display lighting under the tailored compliance method.

Example 5-33

Question

Can I provide multi-level control with occupant sensors just by wiring an occupant sensor in series with a wall switch? Will such a combination qualify for a power adjustment factor?

Answer

This arrangement will meet the mandatory requirements for multi-level control in §131(b) and automatic shut-off control in §131(d). But this configuration does not qualify for a power adjustment factor credit because if one leaves the room with all of the lights on, the next time the lights are turned on, all the lights will be on. Special circuitry is required. Many control system manufacturers offer products specifically for bi-level occupant sensing systems, many of which use a double wall switch with an occupant sensor integrated into the switch faceplate, or an integrated power pack that supplies an occupant sensor in the ceiling. See Section 5.4.4 Non-qualifying Circuit for Occupancy Sensor Credit Example.

Example 5-34

Question

Where can I find guidance on how to commission lighting controls? I need information on where to position sensors, how to set time delays and how to get the best performance from my system.

Answer

Many manufacturers provide comprehensive guidance on the design and commissioning of systems; this guidance is often tailored to the characteristics of their own products and is therefore the best advice available. More general information can be obtained from best practices guidance such as The Advanced Lighting Guidelines which can be downloaded free of charge at http://www.newbuildings.org, or from the Lighting Controls Association website http://www.aboutlightingcontrols.org.

5.5 Theme Parks

Specialty lighting within theme parks are exempt from the lighting power density calculations. However, all other lighting must comply with the Standards. The Standards must be enforced for primary function areas that are included in Standards Table 146-C. The primary function areas in theme parks must be quantified in Title 24 lighting documentation, and are not exempt from the lighting power density requirements. These include, retail, restrooms, restaurants, lobbies, ballrooms, theaters and other primary function areas in theme parks. The treatment of these primary function areas is no different for theme parks than for other building projects. However, the lighting that is used strictly for entertainment in theme parks, such as the entertainment production lighting related only to presenting the theme of the theme park, may be exempted from Title 24 lighting power density compliance. An example of a theme park may be a large amusement park, which includes carnival rides, shows, and exhibits.

5.6 Exit Way and Egress Lighting

Lighting that is required for exit signs subject to the California Building Code and has an input power rating of five watts per illuminated face or less, and exit way or egress illumination that is normally off and that is subject to the California Building Code, is exempt from lighting power calculations. Exit way and egress lighting systems are regulated by Article 700 of the State Electricity Code (Title 24, Part 3), which specifies that:

- Emergency systems are those systems legally required and classed as emergency by municipal, state, federal, other codes, or by any governmental agency having jurisdiction.
- These systems are intended to automatically provide illumination to designated areas in the event of failure of normal power supply.
- These systems must be separately switched from the general lighting systems.
- These systems shall be so arranged that only authorized persons have control of the emergency lighting.
- These systems have an emergency power supply independent of the general lighting power supply, or are equipped with two or more separate and complete systems with independent power supply, each system providing sufficient current for emergency lighting purposes.

Note that §131(a) in the Standards, the area controls of the mandatory measures, specifies that lighting in areas within a building that must be continuously illuminated for reasons of building security or emergency egress are exempt from the switching requirements of the area controls of the mandatory measures for a maximum of 0.5 w/ft^2. These lights must be installed in areas designated as security or emergency egress areas on the plans, and must be controlled by switches accessible only to authorized personnel. The

remaining lighting in the area, however, is still subject to the area switching requirements.

When applying lighting power adjustment factors to luminaires in a space, exit way, emergency, and egress lighting systems that are on a separate circuit and are not controlled by a qualifying control device, are not eligible for these credits.

5.7 Historic Buildings

Exception 1 to §100(a) states that qualified historic buildings, as defined in the California Historical Building Code (Title 24, Part 8 or California Building Code, Title 24, Part 2, Volume I, Chapter 34, Division II) are not covered by the Standards. However, non-historical components of the buildings, such as new or replacement mechanical, plumbing, and electrical (including lighting) equipment, additions and alterations to historic buildings, and new appliances in historic buildings may need to comply with Building Energy Efficiency Standards and Appliance Standards, as well as other codes. For more information about energy compliance requirements for Historic Buildings, see Section 1.7.1, Building Types Covered, in Chapter 1, the Overview of this manual.

5.8 Signs

The sign energy requirements in §148 apply to all internally illuminated (cabinet) and externally illuminated signs, whether they are used indoors or outdoors. Examples include, but are not limited to, internally illuminated and externally illuminated signs in theaters, convention centers, and lobbies. These requirements do not apply to unfiltered signs (see definitions in Joint Appendix I) or exit signs. The power consumed by signs regulated by §148 is not included total building lighting power budget for compliance purposes. Detailed requirements for sign compliance are discussed in Chapter 6 of this manual, Outdoor Lighting and Signs.

5.9 Common Lighting Systems

This section describes a simplified application of the area category method that can be used for compliance. This method can only be used for area category method function areas for which the lighting power densities are 1.0 watts per square foot and higher. This easy method allows 1.0 W/ft² or less for installing common lighting systems like those described in Table 5-9. Designing systems to these specifications will result in a system that uses less than 1.0 W/ft².

One type of Luminaire: Luminaires must consist of any one type of luminaire, plus exit signs, installed as described in Table 5-9. Spacing measurements are taken from the plan view center of the luminaire. Luminaires must be mounted at least 1/3 of the indicated mounting distance away from any ceiling-high partition.

More than One Type of Luminaire: If there is more than one type of luminaire (excluding exit signs) located within one space enclosed with ceiling high

partitions, the spacing between different luminaires shall be the larger of the required spacing for the two luminaires in Table 5-9.

This method is cannot be used if any of the following luminaire types exists in the building:

- Luminaires employing Edison base line voltage sockets.
- Luminaires exceeding 75 W designed for low voltage lamps, incandescent or halogen.
- Track lighting systems or other flexible lighting systems which allows the addition or relocation of luminaires without altering the wiring of the system of any kind or voltage.
- Line voltage monopoints permitting the installation of track luminaires.

Normally off emergency lighting systems required by code and not used except under a power outage or in emergency conditions are not included in power allowance computations.

Up to 5% of the total luminaires of the project (by count) may be hardwired luminaires of any type (except track lighting, which is not appropriate) rated not more than 150 W.

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 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.

Permanent Lighting: A complete and permanent lighting system must be installed. Additional lighting, such as lighting within furniture systems, shall not be installed in the space. Undercabinet luminaires are allowed, however, when attached to the underside of modular furniture overhead cabinets, bins or shelves and complying with the requirements for undercabinet luminaires in Table 5-9.

Table 5-9 – Common Lighting Systems

Luminaire Type	Maximum Watts (lamp watts unless otherwise noted)	Spacing between luminaires in plan view (o.c. = on centers)
Single lamp fluorescent with electronic ballast	35 luminaire W (including ballast or transformer loss)	One luminaire in a closet, electric room, or other small space
Two lamp fluorescent with electronic ballast	60 luminaire W (including ballast or transformer loss)	One luminaire per vanity in a toilet room or locker room; or one luminaire per landing in a stairwell.
Nominal 4ft recessed or surface mounted fluorescent troffer, wraparound, strip lights, with electronic ballast	60 luminaire W (including ballast or transformer loss)	No less than 8 ft o.c.
Recessed, surface or suspended fluorescent uplights, industrials, wraparounds, strip lights, consisting of nominal 4ft sections in continuous rows with electronic ballast(s)	1 or 2 lamps totaling 64 W or less	Continuous rows no closer than 15 ft apart
High intensity discharge or induction lamp lighting systems (or multiple compact fluorescent lamp systems of equivalent lamp watts with electronic ballasts)	1 lamp 100 W or less 1 lamp 150 W or less 1 lamp 250 W or less 1 lamp 400 W or less	No less than 12 ft o.c. No less than 15 ft o.c. No less than 18 ft o.c. Not less than 22 ft o.c.
Compact fluorescent (including twin tube) or metal halide downlights, wallwashers, monopoints and similar directional luminaires	1 lamp 40 W or less 1 lamp 60 W or less 1 lamp 80 W or less 1 lamp 100 W or less	No less than 6 ft o.c. No less than 8 ft o.c. Not less than 10 ft o.c. No less than 12 ft o.c.
Hardwired undercabinet or undershelf fluorescent luminaires nominal 2 ft, 3 ft or 4 ft in length and employing an electronic ballast	No greater than 8.5 W/ft of luminaire	
Low-voltage downlights, accent lights or monopoint lights having an integral transformer	50 W	No less than 8 ft o.c.
Sconces, pendants and other decorative lighting employing compact fluorescent, metal halide or fluorescent lamps and electronic ballasts	Total of all lamps 90 W Total of all lamps 175 W	No less than 10 ft o.c. No less than 15 ft o.c.
Exit signs	5 W	As required
Notes: The on-center (o.c.) spacing dimensions apply in both directions. Luminaires shall be mounted at least 1/3 of the specified mounting distance away from any ceiling-high partition.		

Example 5-35

Question

What is the easiest way to comply with Title 24 lighting power requirements?

Answer

Use the common lighting system recommendations, which will ensure compliance and a lighting power density less than 1 W/ft^2 for almost any appropriate area. Although this method will only work for some building types, these types make up a large part of buildings under construction.

5.10 Simplification for Tenant Spaces

As an option, an entire tenant space can use the Complete Building Method when at least 82% of the permitted space is one of the primary functions listed in Standards Table 146-C (see Figure 5-20 and Examples 5-30 through 5-32).

A tenant space is part of a building leased or used by a single tenant that is separated from other tenants by demising partition(s).

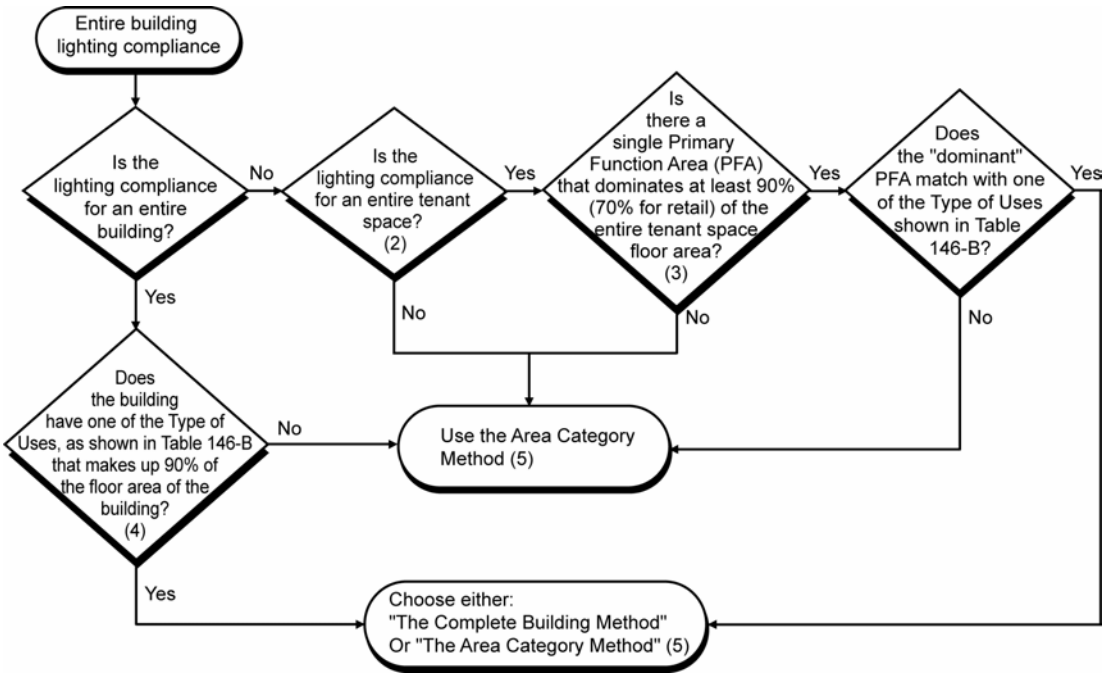


Figure 5-20 – Lighting Power Density Calculation Flowchart For Simplified Tenant Spaces

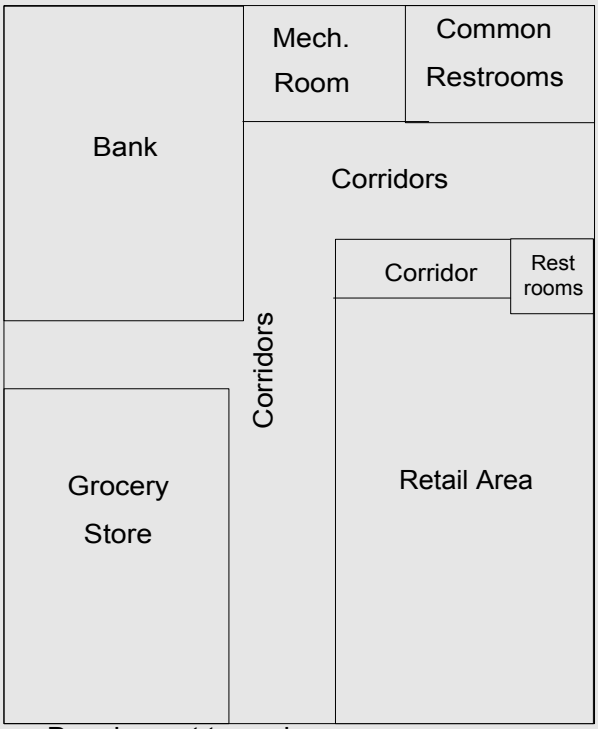
- Lighting compliance can also be achieved using the Tailored Method or the Performance Method. The lighting power portion of the Performance allowed budgets is determined by selecting the appropriate Complete Building or Area Category uses or function types, in accordance with the modeling rules shown in the flowchart above. The Tailored method may also be used to establish the lighting portion of the Performance Method allowed budget.
- A tenant space is a part of the building leased or used by a single entity that is separated by demising partitions from other tenants. The Complete Building Method may not be used for permits issued for partial tenant spaces. Multiple tenant spaces, when making up less than an entire building but permitted together, may each use the Complete Building Method by showing that EACH space meets the requirements of the Complete Building Method.
- PFA = Primary Function Area. All Primary Function Areas are listed in Standards Table 146-C. The "dominant" PFA refers to the Function Area with the largest floor area among all Function Areas contained within a tenant space.

- Type of Use (TOU) is defined as a single type of use, as used in this Manual and listed in Standards Table 146-B. To determine the AREA of the TOU, the following areas shall be included, provided they serve the primary use function: Lobbies, Corridors, and Restrooms.
- When using the Area Category Method, breakout separate Function areas into separate area categories, such as Retail Function, Corridor, Restroom, and Commercial Storage Functions.

Example 5-36

Question

If the figure below is a new building, what is the allowed lighting power for the entire building?



Drawing not to scale

Function	Area	%of Area
Non-Retail:		
Bank (Financial Transactions)	4,000	28%
Grocery Store	3,500	24%
Mechanical Room	200	1%
Common Restrooms	300	2%
Common Corridors	1,000	7%
Total Non-Retail	9,000	62%
Retail:		
Retail Area	4,700	32%
Retail Restrooms	200	1%
Retail Corridors	600	4%
Total Retail	5,500	38%
Total Building	14,500	100%

Procedure

Using the flowchart in Figure 5-20:

1. Is the lighting compliance for an entire building? *Yes.*

2. Does the building have one of the types of uses that makes up 90% of the floor area of the building? No (the largest type of use category is Retail which occupies 38% of the floor area of the entire building).

Calculate the allowed lighting power by the area category method.

Area Category Method:

Function	Area	W/ft^2	Watts
Bank (Financial Transactions)	4,000	1.2	4,800
Grocery Store	3,500	1.6	5,600
Mechanical Room	200	0.7	140
Common Restrooms	300	0.6	180
Common Corridors	1,000	0.6	600
Retail Function	4,700	1.7	7,990
Retail Restrooms	200	0.6	120
Retail Corridor	600	0.6	360
Total Building Lighting Power			19,790 W

Answer

The allowed lighting power is 19,790 W.

Example 5-37

Question

If the figure in the example above is an existing building and the retail store is being renovated, what is the allowed lighting power for the retail store?

Procedure

Using the flowchart in Figure 5-20:

1. Is the lighting compliance for an entire building? *No.*

2. Is the lighting compliance for an entire tenant space? *Yes.*

3. Is there a single PFA that dominates at least 90% of the entire tenant space floor area (at least 70%/single tenant for retail spaces)? *Yes. The permit is for one tenant (retail store), and the retail function area is greater than 70% of the entire retail store (4,700/5,500 = 0.855).*

4. Does the dominant PFA match with one of the primary types of uses shown in Table 146-B in the Standards? *Yes.*

Calculate the allowed lighting power by either the complete building method, or the area category method.

Complete Building Method:

Allowed lighting power is 5,500 x 1.5 = 8,250 W.

Area Category Method:

Function	Area	W/ft^2	Watts
A) Retail	4,700	1.7	7,990

B) Restrooms	200	0.6	120
C) Retail Corridor	600	0.6	360
Total Allowed Lighting Power			8,470W

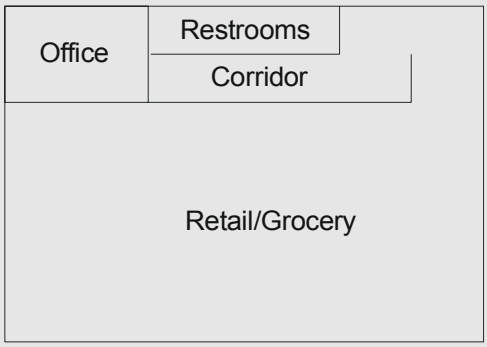
Answer

The allowed lighting power is 8,250 W using the complete building method and 8,470 W using the area category method.

Example 5-38

Question

What is the allowed lighting power for the Retail Grocery store combination in the figure below?



Drawing not to scale

Function	Area	% of Area
Retail	5,750	63%
Grocery	2,150	23%
Retail Office	450	5%
Restrooms	300	3%
Corridors	550	6%
Total	9,200	100%

Answer

Procedure

Using the flowchart in Figure 5-20:

1. Is the lighting compliance for an entire building? *Yes*.

2. Does the building have one of the types of uses that makes up 90% of the floor area of the building (at least 70%/single tenant for retail)? No. (There are several Primary Function Areas including retail, grocery, office, restroom and storage. However, the office function is a separate tenant and therefore excluded from the Complete Building Method.)

Calculate the allowed lighting power by the area category method.

Function	Area	W/ft2	Watts
Retail	5,750	1.7	9,775
Grocery	2,150	1.6	3,440
Office	450	1.2	540
Restrooms	300	0.6	180

Corridor	550	0.6	330
Total Allowed Lighting Power			14,265 W

The allowed lighting power is 14,265 W.

5.11 Minimum Skylight For Large Enclosed Spaces

Minimum Skylight Area for Large Enclosed Spaces is discussed in [§143 (c)] applies to low-rise conditioned or unconditioned enclosed spaces that meet the following conditions:

- Greater than 25,000 ft^2
- Directly under a roof
- Ceiling heights greater than 15 feet
- A lighting power density for general lighting equal to or greater than 0.5 w/ft^2

At least half of the floor area must be daylit under skylights. Minimum Skylight Area is defined in Table 143-F.

Additional discussions about Minimum Skylight Area can be found in Chapter 3 of the Manual, Building Envelope (Section 3.2.4 Skylights in Large Enclosed Spaces), and this chapter in Section 5.13.2, Prescriptive Measures, Additions, Lighting Systems Installed for the First Time. Discussions about requirements for Effective Aperture, Skylight Characteristics, and Controls can be found in Section 5.2.1.4, Daylighting Controls.

Though Section 143(c) requires that at least half of the floor space be daylit and that the ratio of skylight area to daylit area be 3%, there are maximum skylight area requirements whenever the skylights are above conditioned spaces. Section 43(a) 6 limits skylight area to 5% of the gross roof area in most cases and to 10% of the roof area for atria over 55 feet. The thermal transmittance (U-factor) and solar heat gain (SHGC) of skylights are also limited to the appropriate climate zone specific values in Tables 143(a-c). In general these requirements require the use of double glazed skylights. See Section 3.2.4 Skylights in Large Enclosed Spaces of this manual for more details of skylight area and skylight properties requirements. When the skylights are above unconditioned spaces there is no limitation placed on skylight area or its U-factor or SHGC. In such cases, single glazed skylights will comply with the code requirements as long as they are sufficiently diffusing [i.e. the glazing or diffuser material has a haze rating greater 90% as defined in §143(c)]. Products that have such a rating include prismatic diffusers, laminated glass with diffusing interlayers, pigmented plastics etc. The purpose of this requirement is to assure the light is diffused over all sun angles.

Other methods of diffusion that result in sufficient diffusion of light over the course of the entire year would also be acceptable in lieu of using diffusing glazing. Acceptable alternatives are baffles or reflecting surfaces that ensure over all sun angles encountered during the course of a year that direct beam light is reflected off of a diffuse surface prior to entering the space. This

alternative method of diffusion would have to be documented by the designer and approved by the code authority in your jurisdiction.

5.12 Acceptance Requirements

Acceptance tests are used to verify that lighting controls were installed and calibrated correctly. These tests require that a responsible party certify that controls are installed and calibrated properly. This responsible party is typically the contractor who installed the lighting controls. To verify that they are calibrated properly, the responsible party must conduct a test and make modifications to the control until it passes the test. The test results must be recorded on acceptance test forms and are part of the building documentation. These forms must be filled out before the building authority grants a certificate of occupancy.

The Standards have acceptance test requirements for:

- Manual daylighting controls
- Automatic daylighting controls.
- Occupancy sensors.
- Automatic time-switch controls.

A detailed description of each acceptance test can be found in Chapter 8 of this manual, Acceptance Requirements.

5.13 High Efficacy Luminaires

High efficacy luminaires are defined by §150(k) for residential buildings. However, high efficacy luminaires that are installed in nonresidential buildings must also meet the definition of §150(k) for high efficacy. These luminaires must meet the following requirements:

- Ballasts for lamps rated 13 watts or greater shall be electronic and shall have an output frequency no less than 20 kHz.
- Luminaires shall not contain medium screw base sockets

EXCEPTION: Outdoor high intensity discharge (HID) luminaires with HID rated medium screw base sockets and factory-installed hardwired HID ballast which meet the minimum lumens per watt in Table 150-C. HID Ballasts for this application may be electromagnetic (magnetic).

- Luminaires must contain only lamps with the following minimum efficacies

Table 5-10 – Standards Table 150-C

Lamp Power Rating	Minimum Lamp Efficacy
15 watts or less	40 lumens per watt
Over 15 watts to 40 watts	50 lumens per watt
Over 40 watts	60 lumens per watt

To determine minimum lamp efficacy category only the watts of the lamp (not the ballast) are to be considered.

5.14 Additions and Alterations

§149

New additions must meet the all mandatory measures for both the prescriptive and performance method of compliance. Prescriptive requirements, including the lighting power densities must be met if prescriptive method of compliance is used. If performance approach is used, the lighting power densities may be traded-off against other prescriptive building features.

Altered lighting components must also meet applicable mandatory measures described below. Prescriptive requirements apply if in a permitted space (The Basis for the Alteration Area is discussed in Section 5.12.3, Prescriptive Measure – Alterations below) more than 50% of the fixtures are replaced, or if the connected lighting load is increased. These requirements are discussed in the following sections.

Lighting alterations generally refers to replacing the entire luminaire, which includes the housing, lamps, ballasts, and louvers or lenses. Simply replacing the lamps and ballasts in an existing fixture is not considered a lighting alteration. Replacing or installing new wiring that connects the luminaires to switches, relays, branch circuits, and other control devices represents a lighting alteration and therefore must meet the applicable mandatory requirements as described below.

5.14.1 Mandatory Measures – Additions and Alterations

New additions and lighting systems that are installed for the first time in an existing space must comply with mandatory requirements of §119, §130, §131, and §132.

All “altered” lighting components in alterations must comply with applicable mandatory requirements of §119, §130, §131, and §132. Although these mandatory requirements apply only to altered lighting components, it is recommended that mandatory measures be considered for the entire space to achieve maximum energy savings.

Compliance requirements vary with the details and extent of the alterations. The mandatory requirements include certification of any new lamps and ballasts that are installed if they are the type regulated by the Appliance Efficiency Regulations. Any new lighting controls must meet minimum performance

requirements. In addition, control and circuiting requirements apply to the altered lighting components as follows:

- Independent switching within a space or room is required if ceiling height partitions are installed or moved, creating a new enclosed space.
- Multi-level lighting controls requirements apply if the alteration consists of rewiring, and any individual enclosed space within the altered area exceeds 100 ft^2, has more than 0.8 w/ft^2, and has more than one luminaire [§131 (b)] (corridor lighting is exempt from this alteration requirement).
- Separate switching for daylit areas is required if the alteration involves rewiring, and any individual enclosed space within the altered area exceeds 250 ft^2. See §131 (c).
- Alterations in spaces with existing skylights must comply with the daylit area mandatory requirements of §131 (c).
- All altered luminaires in a space must meet the automatic shut-off controls requirements of §131 (d).
- Altered display lighting systems that involve rewiring must meet the requirements of §131 (e).

For lighting alterations purposes, rewiring refers to replacement or installation of new wires that serve the circuit between the switches, relays, branch circuits, other control devices, and rewired luminaire(s). In the case where only the wiring in a circuit that connects the switch and the luminaire(s) is being replaced without any alterations to the luminaire(s), the wiring system itself is considered the altered component and must therefore meet the lighting control requirements.

For more information on mandatory requirements, see Sections 5.1 Overview, 5.2 Lighting Design Procedure, Lighting Equipment Certification, and Daylighting Control.

5.14.2 Prescriptive Measures – Additions

All additions must comply with the prescriptive requirements of

- §143 (c) – Minimum Skylight Area for Large Enclosed Spaces in Low-rise Buildings, and
- §146 – Prescriptive Requirements for Indoor Lighting

Additions must also meet the mandatory requirements discussed in Section 5.12.1 above. For more information on these requirements, refer to Section 5.2.2 Prescriptive Approach.

5.14.3 Prescriptive Measures – Alterations

Alterations that involve the following must comply with §146:

- Replacing more than 50% of the luminaires, or

- An increase in the connected lighting load.

When it is necessary to calculate the existing wattage to demonstrate that the alteration does not result in an increased lighting level, use the same methodology used for new lighting installations found in this chapter.

The Basis for the Alteration Area

Only those areas of the building enclosed by floor-to-ceiling partitions in which lighting fixtures are being replaced or the connected lighting load is being increased, need to meet lighting requirements of the Standards. Areas of the building enclosed by floor-to-ceiling partitions in which no lighting is being altered do not need to meet lighting requirements of the Standards. The basis for determining if more than 50% of fixtures are being replaced is the permitted space (not the building space), excluding any enclosed areas that are not receiving new light fixtures. Enclosed areas are areas that are surrounded by permanent floor-to-ceiling partitions. For alterations, the permitted space is usually not an entire building, and may not be an entire tenant space. Building departments will often define "permitted space" to include only those areas where alterations are proposed.

Lighting Systems Installed for the First Time

Spaces with lighting systems that are installed for the first time must comply with the applicable prescriptive requirements of §143 (c) and §146. *"Installed for the first time"* refers to when the first lighting permit has been issued for a lighting system in a given space. This means skylights will be required in all large open spaces (greater than 25,000 ft^2) with ceiling heights greater than 15 feet, where a lighting system is being installed for the first time even if the building shell was constructed without any skylights, or with minimal lights. For example: If the building shell is built with a minimal lighting system for exit, egress, and emergency and later a general lighting system is installed in the building, all lighting other than the exit, egress, and emergency lighting is considered a lighting system installed for the first time for the purposes of the §143 (c) of the Standards.

If it is likely that the building will ultimately be finished as a big box retail space, warehouse, exhibition hall etc. where a room can be larger than 25,000 ft^2 and with ceiling heights greater than 15 feet, it is recommended to consider skylights and skylight controls as an integral part of the design and construction phase of the building shell, early in the design process. If skylights are impractical, the performance approach may be used to show overall compliance for the entire building by installing other energy savings features that save as much energy as skylights with multi-level astronomical time switch control of lighting.

Note that alterations must also meet the mandatory requirements discussed in Section 5.12.1 above.

Example 5-39

Question

There are 30 lighting fixtures in an existing office space. We are replacing five fixtures without increasing the connected lighting load or rewiring any of fixtures. Which Standards requirements must we comply with?

Answer

All altered lighting components must meet the mandatory measures of §119, §130 and §131. However, since the luminaires are not being rewired, only independent room switching controls, daylit area under skylight controls (if applicable), and the automatic shut-off control requirements apply, if the luminaires are not already controlled by these devices.

Since less than 50% of the luminaires are being replaced without increasing the connected lighting load, no prescriptive requirements apply to this space.

Example 5-40

Question

If in the example above, the five replaced luminaries are also being rewired, then which Standards requirement must be complied with?

Answer

In addition to the mandatory measures that are discussed in the example above, the luminaires must also meet the requirements for multi-level controls, daylit area controls (if applicable), and display lighting controls, if the luminaires are not already controlled by these devices. As in the example above, there are no prescriptive requirements that apply to this space.

Example 5-41

Question

If in the example above, 20 fixtures were being replaced, then which Standards requirements must be complied with?

Answer

Since more than 50% of the fixtures are being replaced, in addition to all the mandatory requirements discussed above, all prescriptive requirements of §146 must also be complied with.

Example 5-42

Question

There are 10 luminaires on the same circuit controlled by a single switch. Two of these luminaires are being replaced without rewiring. How would the automatic shut-off control requirement apply to these luminaires?

Answer

All altered (or replaced)) luminaires must comply with the automatic shut-off control requirements regardless of rewiring. Since the two altered luminaires are on the same circuit as the remaining eight unaltered luminaires, the simplest and most energy efficient option is to apply the automatic shut-off control device to all 10 luminaires that are on the same circuit. An automatic shut-off control may be a programmable time clock, a light swiping device, an occupant sensor, or any other device capable of turning off the light automatically. A second choice may be to isolate and apply to control device only to the two altered luminaires.

Example 5-43

Question

All light fixtures are being replaced in one enclosed room of a commercial tenant space. The entire tenant space currently has a total of 25 light fixtures. The altered room will receive a total of eight new light fixtures. How much lighting power is allowed for the new lighting?

Answer

Since all lighting fixtures within the enclosed area (room) are being replaced, then more than 50% of the lighting in the applicable space (the enclosed room) is new. Therefore, the lighting power in this space must meet the requirements for new construction.

Example5-44

Question

All light fixtures in one enclosed room of a commercial tenant space are being replaced. The permitted space however, covers the entire tenant space due to a proposed replacement HVAC system. How much lighting power is allowed for the new lighting?

Answer

Though the entire tenant space is the permitted space, only the room where new lighting is proposed is evaluated for determining whether more than 50% of the light fixtures are new. In this case, 100% of the lighting in this room is being altered, so the lighting power in this room must meet the requirements for new construction.

Example 5-45

Question

All light fixtures in a men's clothing department are being replaced. The men’s clothing department covers one-third of main open sales floor of the department store. The permit space covers only the men’s clothing department floor area. How much lighting power is allowed for the new lighting?

Answer

Although the men’s clothing department covers only one-third of the entire enclosed floor area, it still constitutes 100% of the permitted space. Only this area should be considered for the basis of determining if more than 50% of fixtures are being replaced. In this case, 100% of the lighting in area is being altered, so the lighting power in this area must meet the requirements for new construction.

Example 5-46

Question

In a 30,000 sf unconditioned warehouse, a 10,000 sf portion is supposed to be converted into an office space, with 1 w/sf for lighting with 16 foot ceilings. Do skylights have to be installed in the office portion of the building?

Answer

No. The portion of the buildings with lighting power density of 1 W/sf is less than 25,000 sf, so there will be no requirements for skylights.

Example 5-47

Question

In the example above, 26,000 sf of the area is converted into 26 office areas of 1,000 sf each. Do skylights have to be installed in the office portion of the building?

Answer

No. §143 (c) the Standards require skylights in "enclosed spaces that are greater than 25,000 sf…". In this example since each enclosed area is only 1,000 sf, there will be no skylight requirements.

Example 5-48

Question

A 30,000 sf building has a 16,000 sf area with an 18-foot high ceiling and another 14,000 sf area with 13-foot high ceiling. The lighting power density in this building is 1 w/sf. Do skylights have to be installed in the portion of the building with 18-foot ceiling?

Answer

No. §143 (c) of the Standards require skylights in "enclosed spaces that are greater than 25,000 sf directly under a roof with ceiling height greater than 15 ft…". In this example the area with ceiling of greater than 15 foot is only 16,000 sf, therefore there are no skylight requirements.

Example 5-49

Question

If in the example above the area under the 18-foot ceiling is 26,000 sf and the area under the 13-foot ceiling is 4,000 sf, must skylights be installed in the 26,000 sf portion of the building.

Answer

Yes. The 26,000 sf portion of the building meets all three criteria for skylights specified in §143 (c); 1) the enclosed area is greater than 25,000 sf, 2) the ceiling height for the whole area is greater than 15-foot, and 3) the lighting power density exceeds 0.5 w/sf.

Example 5-50

Question

A 30,000 sf speculative building shell with a 30 foot ceiling height is built.

A minimal lighting system is installed for exit lighting resulting in a lighting power density of 0.1 w/sf. No general lighting has been installed. Are skylights required?

Answer

No. Since the LPD is less that 0.5 W/sf, skylights are not required even though the other criteria of Section 143(c) are met (a low rise open space greater than 25,000 sf and ceiling heights greater than 15 feet).

Example 5-51

Question

In the example above, the space is sold to a big box retailer who is going to add a 1.5 W/sf general lighting system but no suspended ceiling so that the building will retain 30 foot ceiling heights. Will skylights be required for the tenant finish?

Answer

Yes, skylights are prescriptively required. Section 149(b)1F says that when lighting systems are installed for the first time, the lighting system must comply with the requirements of new lighting systems and the building must meet the skylighting requirements of section 143(c). Thus speculative buildings designed for the warehouse or big box retail market will be more salable with skylights pre-installed.

Example 5-52

Question

A pre-existing air-conditioned 30,000 sf warehouse with 30 foot ceiling and no skylights will have its general lighting system replaced as part of a conversion to a big box retail store. Are skylights prescriptively required?

Answer

No. The general lighting system is being replaced and is not “installed for the first time.” Thus Section 149(b)1F does not apply and therefore does not trigger the requirements in Section 143(c) for skylighting.

Example 5-53

Question

A pre-existing unconditioned 30,000 sf warehouse with 30 foot ceiling and no skylights has a 1.5 W/sf lighting power density and will have air conditioning added as part of a conversion to a big box retail store. Are skylights prescriptively required?

Answer

Yes. Since the space is defined as “newly conditioned,” all of the requirements of Section 149 (a) apply to the space. This includes the prescriptive skylighting requirements in Section 143(c) when there is an enclosed space larger than 25,000 sf, with a ceiling height greater than 15 feet and a lighting power density greater than 0.5 w/sf.

5.15 Lighting Plan Check Documents

At the time a building permit application is submitted to the building department, the applicant also submits plans and energy compliance documentation. This section describes the recommended forms and procedures for documenting compliance with the lighting requirements of the Standards. It does not describe

the details of the requirements. The following discussion is addressed to the designer preparing construction and compliance documents, and to the building department plan checkers who are examining those documents for compliance with the Standards.

The use of each form is briefly described below, and complete instructions for each form are presented in the following subsections. These forms may be included in the lighting equipment schedules on the plans, provided the information is in a similar format as the suggested form.

- *LTG-1-C: Certificate of Compliance*:
  This form is required for every job, and it is required to appear on the plans.
- *LTG-2-C: Interior Lighting Schedule:*
  This form is required for all submittals.
- *LTG-3-C: Portable Lighting Worksheet:*
  This form is required for all submittals.
- *LTG-4-C: Lighting Controls Credit Worksheet:*
  This form should only be required when calculating control credit watts. See Standards Table 146-A for lighting control credits.
- *LTG-5-C: Interior Lighting Power Allowance Worksheet:*
  This form is required when calculating the Lighting Power Allowance using the Complete Building, Area Category, or Tailored Method for compliance.
- *LTG-6-C: Tailored Method Worksheet:*
  This form should only be required when calculating the Lighting Power Allowance using the Tailored Method.
- *LTG-7-C: Room Cavity Ratio Worksheet:*
  This form should only be required when using the Tailored Method. The Room Cavity Ratio is required in the Tailored Method Worksheet.
- *LTG-8-C: Common Lighting Systems Method:*
  This form is only used when showing compliance using the Common Lighting Systems Method.
- *LTG-9-C: LINE VOLTAGE TRACK LIGHTING WORKSHEET:*
  This form is only used when line voltage track lighting is used.
- *OLTG-4-C: Worksheet for Signs:*
  See instructions for OLTG-4-C, Sign Worksheet in Chapter 6, Outdoor Lighting and Signs Chapter.

5.15.1 LTG-1-C: Certificate of Compliance

The LTG-1-C Certificate of Compliance form is in three parts. Each part; if required below must appear on the plans (usually near the front of the electrical drawings). A copy of these forms should also be submitted to the building department along with the rest of the compliance submittal at the time of building permit application. With building department approval, the applicant may use alternative formats of these forms (rather than the official Energy Commission forms), provided the information is the same and in a similar format.

LTG-1-C, Part 1 of 4 and 2 of 4 are required for all submittals. LTG-1-C, Part 3 of 4 submittal is only required if control credits are claimed.

LTG-1-C Part 1 of 4

Project Description

1. PROJECT NAME is the title of the project, as shown on the plans and known to the building department.
2. DATE is the date of preparation of the compliance submittal package. It should be on or after the date of the plans, and on or before the date of the building permit application.
3. PROJECT ADDRESS is the address of the project as shown on the plans and as known to the building department.
4. PRINCIPAL DESIGNER - LIGHTING is the person responsible for the preparation of the lighting plans, one of two people who sign the STATEMENT OF COMPLIANCE (see below). The person's telephone number is given to facilitate response to any questions that arise.
5. DOCUMENTATION AUTHOR is the person who prepared the energy compliance documentation. This may or may not be the principal designer (it may be a person specializing in energy standards compliance work). This person is not subject to the Business and Profession's Code. The person's telephone number is given to facilitate response to any questions that arise.
6. ENFORCEMENT AGENCY USE is reserved for building department record keeping purposes.

General Information

1. DATE OF PLANS is the last revision date of the plans. If the plans are revised after this date, it may be necessary to resubmit the compliance documentation to reflect the altered design. The building department will determine whether or not the revisions require this.
2. BUILDING CONDITIONED FLOOR AREA has specific meaning under the Standards. Refer to Joint Appendix I for a discussion of this definition.
3. The number entered here should match the floor area entered on form ENV-1-CC-05.
4. CLIMATE ZONE of the building. Refer to Joint Appendix I.
5. BUILDING TYPE is specified because there are special requirements for high-rise residential and hotel/motel guest room occupancies. All other occupancies that fall under the Nonresidential Standards are designated "Nonresidential" here. It is possible for a building to include more than one building type. See §149 in the Standards for the formal definitions of these occupancies.
6. CONDITIONED SPACE is a space that is directly or indirectly air-conditioned. Check this box if the building includes conditioned spaces where lighting systems are being installed. Tradeoffs are not allowed between conditioned and unconditioned spaces.
7. UNCONDITIONED SPACE is a space that is not directly or indirectly air-conditioned. Check this box if the building includes unconditioned spaces where lighting systems are being installed. Tradeoffs are not allowed between conditioned and unconditioned spaces.

8. INDOOR AND OUTDOOR SIGNS are internally illuminated signs that are located either indoor or outdoor. If these signs are present, the Form OLTG-4-C must be filled out along with either LTG-1-C or OLTG-1-C.
9. PHASE OF CONSTRUCTION indicates the status of the building project described in the documents. Refer to Joint Appendix I for detailed definitions.

    - NEW CONSTRUCTION should be checked for all new buildings, newly conditioned space (see §149 in the Standards) or for new construction in existing buildings (tenant improvements, see Section **1.7.10**) that are submitted for envelope compliance.
    - ADDITION should be checked for an addition which is not treated as a stand-alone building, but which uses Option 2 described in §149 in the Standards.
    - ALTERATION should be checked for alterations to existing building lighting systems. See Section 5.13.
    - METHOD OF COMPLIANCE indicates which method is being used and documented with this submittal:
    - PERFORMANCE should be checked when the performance method is used to show compliance. All required performance documentation must be included in the plan check submittal when this method is used.
    - COMPLETE BUILDING should be checked if the lighting system complies using the complete building method, as documented on the LTG-2-C Form
    - AREA CATEGORY should be checked if the lighting system complies using the area category method, as documented on the LTG-2-C form
    - TAILORED should be checked if the tailored method of lighting compliance, with supporting documentation (LTG-6-CC-05 and LTG-7-C) is submitted.
    - COMMON LIGHTING should be checked if the common lighting method of lighting compliance, with supporting documentation (LTG-8-C) is submitted.

Lighting Mandatory Measures

This portion requests the location of notes clarifying the inclusion of the mandatory requirements. Notes should be included on the plans to demonstrate compliance with mandatory requirements of the Standards.

Following are prototype examples of the notes that should be rewritten to actual conditions. A note for each of the items listed should be included, even if the note states “not applicable”.

Building Lighting Shut-off

The building lighting shut-off sys consists of an automatic time switch, with a zone for each floor.

Override for Building Lighting Shut-off

The automatic building shut-off system is provided with a manual accessible override switch in sight of the lights. The area of override is not to exceed 5,000 square feet.

Automatic Control Devices Certified

All automatic control devices specified are certified; all alternate equipment shall be certified and installed as directed by the manufacturer.

Fluorescent Ballast and Luminaires Certified

All fluorescent fixtures subject to certification and specified for the projects are certified.

Individual Room/Area Controls

Each room and area in this building is equipped with a separate switch or occupancy sensor device for each area with floor-to-ceiling walls.

Uniform Reduction for Individual Rooms

All rooms and areas greater than 100 square feet and more than 0.8 watts per square foot of lighting load shall be controlled with Multi-level switching for uniform reduction of lighting within the room.

Daylit Area Control

All rooms that are greater than 250 square feet and contain windows and skylights, that allow for the effective use of daylight in the area shall have 50% of the lighting power in each daylit area controlled by a separate switch; or

The effective use of daylight throughout cannot be accomplished because the windows are continuously shaded by a building on the adjacent lot. Diagram of shading during different times of year is included on plans.

The above notes are only examples of wording. Each mandatory measure that requires a separate note should be listed on the plans.

To verify certification, use one of the following options:

The Energy Hotline (1-800-772-3300) can verify certification of appliances not found in the above directories.

- The Energy Commission's Web Site includes listings of energy efficient appliances for several appliance types. The web site address is http://www.energy.ca.gov/efficiency/appliances/.
- The complete appliance databases can be downloaded from the California Energy Commission's Internet

(http://www.energy.ca.gov/appliances/appliance/excel_based_files/). This requires database software (spreadsheet programs cannot handle some of the larger files). To use the data, a user must download the database file (or files), download a brand file and a manufacturer file and then decompress these files. The data can be sorted and manipulated.

Documenting the mandatory measures on the plans is accomplished through a confirmation statement, notes and actual equipment location as identified on the plans. The plans should clearly indicate the location and type of all mandatory control devices; such as manual switches, reduced level control, daylit area, controls, building shut-off and overrides, and exterior light controls.

Lighting Worksheet

Check the appropriate boxes to indicate which worksheet(s) are being included with the certificate of compliance.

LTG-1-C Part 2 of 4

Part 2 of LTG-1-C is used to indicate compliance by showing that the installed indoor lighting power is lower than the lighting power allowance.

Installed Indoor Lighting Power for Conditioned and Unconditioned Spaces:

- Indicate the installed lighting for conditioned spaces from form LTG-2-C
- Indicate installed lighting power from LTG-2-C, portable lighting from LTG-2-C, and any lighting controls credits from LTG-4-C. Sum to determine total installed lighting power.
- Indicate lighting control credit for conditioned spaces form LTG-4-C
- Indicate the conditioned space adjusted installed lighting power
- Indicate the installed lighting for unconditioned spaces from LTG-2-C
- Indicate lighting control credit for unconditioned spaces from LTG-4-C
- Indicate the unconditioned space adjusted installed lighting power

Allowed Indoor Lighting Power

- Indicate which method of compliance is being used and indicate the total allowance from the corresponding worksheet.

Alternate Compliance

- Check the appropriate box if the performance or area category method is being used for compliance.

- Indicate the allowed indoor lighting power for unconditioned spaces from LTG-5-C

Mandatory Lighting Measures for Indoor Lighting and Daylit Areas

The Mandatory Automatic Controls portion is where those devices that meet the mandatory control requirements are listed, that would include devices for building shut-off, individual room control and control of exterior lights.

1. CONTROL LOCATION lists the location(s), room number(s), area number(s), or description of the controls and should match the plans.
2. CONTROL IDENTIFICATION lists the symbol of the control and should match the plans.
3. CONTROL TYPE lists the type of certified control device used to meet the mandatory automatic control requirement, such as automatic time switch, dimming, photosensor, etc.
4. SPACE CONTROLLED lists the location of controlled lights.

Check the box(s) if the controls are used for daylighting.

Notes to Field -This space is for use by the building department plans examiner to alert the field inspector to look for important inspection items.

Typical controls may be covered by general notation.

LTG-1-C Part 3 of 4

LTG-1-C, Part 3 of 4 submittal is only required if control credits are claimed. Controls for Credit in Conditioned and Unconditioned Spaces

The Controls for Credit portion is similar to the Mandatory Automatic Controls portion. The only difference is in the last column, LUMINAIRES CONTROLLED.

1. CONTROL LOCATION lists the location(s) or room number(s) of the controls and should match the plans.
2. CONTROL IDENTIFICATION lists the symbol of the control and should match the plans.
3. CONTROL TYPE lists the type of certified control device used to meet the automatic control requirement. Such controls are, occupant, daylight, dimming sensors etc.
4. LUMINAIRES CONTROLLED should list the luminaire type and quantity controlled for credit.
5. TYPE should use the same name as on the plans.
6. # OF LUMINAIRES should indicate the number of luminaires of that type that are controlled by the control type. A general plan notation on the plans may cover all typical controls.

This space is for use by the building department plans examiner to alert the field inspector to look for important inspection items.

LTG-1-C Part 4 of 4

Acceptance Requirements

The Designer is required to check the box for each type of lighting system in the building when an acceptance test is required. Below each box that is checked the Designer is required to list the equipment that must be tested and the number of systems to be tested in parentheses. The Designer should think abut who will be conducting the tests and list this person in the section titled "Test Performed By". Those who are allowed to conduct the tests are the installing contractor, design professional or an agent selected by the owner.

Statement of Compliance

The Statement of Compliance is signed by the person responsible for preparation of the plans for the building. This person is also responsible for the energy compliance documentation, even if the actual work is delegated to someone else (the Documentation Author described above). It is necessary that the compliance documentation be consistent with the plans. The Business and Professions Code governs who is qualified to prepare plans, and therefore to sign this statement; check the appropriate box that describes the signer's eligibility.

Applicable sections from the Business and Professions Code (based on the edition in effect as of August 2000), referenced on the Certificate of Compliance, are provided below.

5.15.2 LTG-2-C: Indoor Lighting Schedule

LTG-2-C, Part 1 of 2, is used to describe the lighting fixtures and control devices designed to be installed in the building. The Installed Lighting Power for Conditioned Spaces is calculated by completing this form.

1. LUMINAIRE NAMES shall be listed by name or symbol.
2. DESCRIPTION should indicate a short list of the technical features.
3. LAMP TYPE is the type of lamps such as T-8, T-5, high output (HO), etc.
4. NUMBER OF LAMPS PER LUMINAIRE is the number of lamps per luminaire.
5. WATTS PER LAMP is watts per lamp including ballast losses and ballast factor. This is not the nominal lamp wattage published by the manufacturer.
6. NUMBER OF BALLASTS PER LUMINAIRE is the number of ballasts per each luminaire.
7. WATTS PER LUMINAIRE is the total watts per luminaire including lamps, ballasts, and all loses and ballast factors. This number is equal to WATTS PER LAMPS multiplied by NUMBER OF LAMPS PER LUMINAIRE.
8. If CEC DEFAULT is checked, this indicates the wattage is a standard value from the data in ACM Manual Appendix NB. If this column is not

checked, nonstandard values must be substantiated with manufacturer's data sheets.

9. NUMBER OF LUMINAIRES is the number of similar luminaires in the space.
10. INSTALLED WATTS is total installed watts for similar luminaire installed in the space, which is the product of WATTS PER LUMINAIRE and NUMBER OF LUMINAIRES.

Subtotal the total watts for each luminaire, add portable lighting watts, if any from Ltg-3-C, and subtract the control credits, if any, from form LTG-4-C. The results are the actual lighting power (adjusted) for conditioned spaces of the building. This total cannot be greater than the lighting power allowance calculated below.

LTG-2-C, Part 2 of 2, is used to describe the lighting fixtures and control devices designed to be installed in the building. The Installed Lighting Power for Unconditioned Spaces is calculated by completing this form.

The instructions for filling LTG-2-C, Part 2 of 2 are similar to instructions LTG-2-C, Part 2 of 1 described above, except this form is to be used for unconditioned spaces.

5.15.3 LTG-3-C: Portable Lighting Worksheet

LTG-3-C should be used to identify and account for all portable lighting fixtures in office areas in buildings, both planned and unplanned. Note that this applies to all office spaces with planned portable lighting systems regardless of the primary function area of the building and does not apply to enclosed (floor-to-ceiling permanent partition) office spaces with floor areas less than 250 ft^2. Use Table 1 for unspecified portable lighting systems. Most buildings with typical open office type of layouts should use this approach. Use Table 2 if the specific portable lighting systems to be installed in the office space are known and documented on the plans. The documentation must include specific features of the portable lighting, and identify the specific task areas that each portable lighting equipment will illuminate. Use Table 3 if no portable lighting fixtures are planned for the office space(s) and if detailed documentation of the lighting levels by overhead lighting are provided to show that they meet the lighting requirements of that space.

If lighting system documentation shows less than 0.2 W/ft^2 of portable lighting, the designer must demonstrate that the lighting design meets lighting needs without additional portable lighting. This must be demonstrated by a detailed point calculation method analysis using a lighting simulation tool. Average illuminance calculations are not acceptable for determining that a lighting system meets lighting requirements of the space. All assumptions used in the simulation model of the lighting design must be submitted as an attachment to Form LTG-3-C. This documentation must include information on luminaire layout (accompanied by furniture layout including modular furniture walls, shelves and cabinets), location, brand, model, and performance characteristics of all luminaires in the space. In addition, the documentation must include the coefficient of utilization (CU) for the luminaires, luminaire spacing, surface reflectance, ballast factors, lamp lumens, various loss factors, and all lighting

design calculations. The resultant minimum-to-maximum or minimum-to-average ratios (typically generated by lighting simulation tools) must also be included in the submittal. The designer is responsible for providing all of the information that the building inspector may need to clearly understand that less than 0.2 W/ft^2 of portable lighting will be needed, including describing the Design Intent (based on IESNA recommended design criteria) and including the target illumination ratios for comparison to the proposed lighting design.

Table 1 Portable Lighting not Shown on Plans

1. ROOM # OR ZONE ID - Enter the name of the room number or zone ID for space(s) that have more than 250 square feet of floor area B. The DEFAULT lighting power density for this space is 0.2 w/ft^2.
2. DEFAULT – 0.2 w/ft^2 is the default lighting power density for portable lighting.
3. AREA (ft^2) – Enter room or zone office area for the floor area of the space identified in COLUMN A.
4. TOTAL WATTS (B x C) – Enter the total watts for each room or zone by multiplying the values in COLUMNS B and C.
5. COLUMN TOTALS – Sum the values in each of COLUMNS C and D and enter the result in the boxes at the bottom of Table 1A.

Table 2 Detailed Lighting Design - Portable Lighting Shown on Plans

1. ROOM # OR ZONE ID – Enter the name of the room number or zone ID for the space(s) that contains the task area(s) for which specific portable lighting system(s) and associated task areas have been shown on the plans. Use a separate line for each task area.
2. PORTABLE LIGHTING DESCRIPTION(S) PER TASK AREA – Enter the type of lamp and fixture used for portable task lighting to illuminate each task area and include a detailed lighting design demonstrating how the lighting design meets the illumination needs throughout the space. Note that supporting documents include output forms from lighting software and drawings that clearly show the location, brand, model, and performance characteristics of all luminaires in the space. In addition, all properties of the space that effect lighting performance (like surface reflectance and furniture layout) must be clearly summarized on documentation attached to Form LTG-1-C Part 3 of 3. The information needs to be traceable to specific types of portable lighting products that will be installed.
3. LUMINAIRE(S) WATTS PER TASK AREA – Enter the total number of watts for all portable lighting used to illuminate each task area.
4. TASK AREA (ft^2) is the surface area in the space that will be served by the portable light. This may not be the same as the actual partition-to-partition area of the cubicle. It may be limited to the actual area served by the task lighting, or be limited to the desk area in the cubicle. There may be more than one task area in each ROOM # OR ZONE ID identified in COLUMN A. Each task area must be identified on the plans in a fashion that can be matched to the list of portable lighting.
5. NUMBER OF TASK AREAS – Enter the number of task areas in column D for each room or zone identified in COLUMN A.
6. TOTAL AREA (ft^2) [D x E] – Enter the results of COLUMN D multiplied times COLUMN E.

7. TOTAL WATTS (C x E) – Enter the results of COLUMN C multiplied times COLUMN E.
8. COLUMN TOTALS – Sum up the values in each of COLUMNS F and G and enter the result in the boxes at the bottom of Table 2.
9. ROOM # OR ZONE ID – Enter the name of the room number or zone ID for space(s) for which no portable lighting is required (as established by supporting documents and drawings). Note that supporting documents include output forms from lighting software and drawings that clearly show the location, brand, model, and performance characteristics of all luminaires in the space. In addition, all properties of the space that effect lighting performance (like surface reflectance and furniture layout) must be clearly summarized on documentation attached to Form LTG-3-C.
10. TOTAL AREA (ft^2) – Enter the areas of the spaces listed in A.

Building Summary – Portable Lighting

- TOTAL AREA (ft2) – Enter the sum of the total areas from Tables 1, 2, and 3.
- TOTAL WATTS - Enter the total watts of portable lighting from Tables 1 and 2. This number is entered on forms LTG-1-C under portable lighting.

5.15.4 LTG-4-C: Lighting Controls Credit Worksheet

1. LTG-4-C, Part 1 of 2, is used to report the control credits for conditioned spaces. When certain types of automatic lighting controls listed in Table 146-A in the Standards are used, a credit is permitted. This table also lists some restrictions that must be met in order to take credit for the controls.
    - Lighting control credits are documented on form LTG-4-C. This requires a specific listing of each device that is used for credit and listing those luminaires controlled by that device.
    - ROOM – List the room where the control device is controlling luminaires.
    - DESCRIPTION – List a description of that device.
    - PLANS – Indicate where on the plan set the controls are shown.
    - ROOM AREA – Indicate the area of the room in which the controls are located.
    - WWR – Indicate the window wall ratio for determining the daylighting control credit and described in the section on Effective Aperture. The window wall ratio for the window in the room should be used for vertical daylighting configurations.
    - VLT – Indicate the visible light transmittance of the aperture. The visible light transmittance is discussed in the section on Visible Light Transmittance (VLT)

2. SKYLIGHT EFFECT APERTURE – Show the skylight effective aperture as computed from Standards Equation 146-A (§146 in the Standards) for horizontal daylighting configurations.
3. WATTS OF CONTROL LIGHTING – The total watts of controlled lighting in each room.
4. ADJUSTMENT FACTOR – Indicate the power adjustment factor for that specific control device from Table 146-A in the Standards.
5. CONTROL CREDIT – The product of COLUMN G (Watts of Control Lighting) and COLUMN H (Lighting Adjustment Factor).
6. The total control credit watts (entered on LTG-4-C) is the sum of the control credit watts in COLUMN J. This credit is subtracted from the total installed watts to determine the actual lighting power (adjusted).
7. LTG-4-C, Part 2 of 2, is used to report the control credits for unconditioned spaces. The instructions for filling LTG-4-C, Part 2 of 2 are similar to LTG-4-C; Part 1 of 2 described above, except this form is to be used for unconditioned spaces.

5.15.5 LTG-5-C5: Indoor Lighting Power Allowance

Allowed Lighting Power

The lighting power allowance is determined by calculating the maximum total watts of lighting that may be installed. There are four different methods that may be used. These methods may not be mixed in the same building permit application.

Complete Building Method

This method may only be used when plans and specifications for the entire building are included in the permit application.

Area Category Method

This method may be used when different primary function areas of a building are included in the permit application.

1. AREA CATEGORY is taken from Table 146-C in the Standards for the primary function of the area. If the building has a mixture of areas, each function area must be listed separately.
2. WATTS PER SF for that building type is taken from Standards Table 146-C and entered here.
3. AREA (SF) is the floor area of the primary function area, which is calculated by multiplying the width times the depth, as measured from the center of the interior bounding partitions. If the function area is bounded by exterior walls on one or more sides, the area is calculated by multiplying the width times the depth, as measured from the inside surface of the exterior walls to the center of the interior bounding partitions. If there are no partitions separating the boundary of the function areas on one or more sides, the boundary of the area is determined by a line separating the function areas where no bounding partitions exist.

4. ALLOWED WATTS is the product of the watts per square foot times the primary function area. This becomes the lighting power allowance for the area.

The sum of the lighting power allowance for each primary function area is the lighting power allowance for the building.

Tailored Method

When the tailored method is used, the LTG-6-C form, or a similar form, must be included in the compliance submittal.

Unconditioned Spaces

This method may be used when different unconditioned areas complete building method type of uses and the area category method primary function areas of a building are included in the permit application.

1. AREA CATEGORY is taken from Table 146-C in the Standards for the primary function of the area. If the building has a mixture of areas, each function area must be listed separately.
2. WATTS PER SF for that building type is taken from Standards Table 146-C and entered here.
3. AREA (SF) is the floor area of the primary function area measured from the inside of bounding partitions (see the section B. Area Category Method).
4. ALLOWED WATTS is the product of the watts per square foot times the primary function area. This becomes the Lighting Power Allowance for the area.

The sum of the Lighting Power Allowance for each primary function area is the Lighting Power Allowance for the building.

Tailored Method - Unconditioned Spaces

When the Tailored Method is used for unconditioned areas of the building, the LTG-6-C form, or a similar form, must be included in the compliance submittal.

5.15.6 LTG-6-C: Tailored Method Worksheet

The tailored method is the most detailed method of calculation for the lighting power allowance. The lighting power allowance is determined based on the individual needs of each task. This method is appropriate for buildings that have unusual lighting needs and in some cases, may increase the lighting power allowance to meet those needs. For a complete description of this method, refer to Section 5.2.2.1

C. Tailored Method.

If there are both conditioned and unconditioned spaces in a building and the tailored method is used to determine the allowed lighting power for both types of spaces, separate tailored method worksheets (LTG-6-C) must be filled out, one for conditioned spaces and one for unconditioned spaces. Each form must clearly indicate if it is used for conditioned or unconditioned spaces. Note that unconditioned spaces are all those areas that are not directly or indirectly

conditioned. The conditioned and unconditioned allowances must be kept separated because when the performance method is used to show compliance for the entire building, the tailored LPD lighting for only the conditioned space must be entered for both the standards and proposed buildings. Inclusion of the unconditioned LPD would result in erroneous HVAC load calculations.

LTG-6-C: Part 1 of 3

This form should be submitted with all tailored method applications. It summarizes the results of the different parts of LTG-6-C, and includes the lighting power allowance calculations for illuminance categories A through G.

Tailored Method Summary

1. The ALLOWED WATTS is the summation for the building, included at the top of Part 1 of form LTG-6-C.
2. LINE 1 is the BUILDING TOTAL ALLOWED WATTS for illuminance categories A through G. This value is obtained from the bottom right corner of this form.
3. LINE 2 is the BUILDING TOTAL ALLOWED WATTS for display and ornamental/special effects lighting. This value is obtained from the total watts entries on LTG-6-C, Part 2, and Part 3. Each allotment is separately calculated and entered into the appropriate box on this form.
4. LINE 3 is the sum of lines 1, 2, and 3. The TOTAL ALLOWED WATTS is the lighting power allowance using the tailored method.

Tailored LPD- Illuminance

To complete the lower portion of Part 1 of this form, complete the following steps.

5. COLUMN A - lists the room number of space designation and should correspond with the plans.
6. COLUMN B - lists the task or activity that will occur in the room or space. If a space also contains a non-task area, this area should be entered on a separate line from the task area.
7. COLUMN C - lists the illuminance category for the room or space. This is determined by using the IES Handbook, Ninth Edition, 2000.
8. COLUMN D - lists the room cavity ratio (RCR) of each room or space. A RCR of less than 3.5 may be assumed for any room. Table 5-4 includes the RCR of simple spaces. The LTG-7-C form may be used to calculate an RCR greater than or equal to 3.5.
9. COLUMN E - lists the actual floor area of the room or space from the plans. The area is determined by measuring from the inside of the partitions that bound the task area.
10. COLUMN F - lists the lighting Power allowance density from Table 146-F in the Standards using the illuminance category (COLUMN C) and room cavity ratio (COLUMN D) for each room.
11. COLUMN G - is the product of the floor area times lighting power allowance density. The total for all rooms or spaces that contain task activities that fall within illuminance categories A through G is entered in line 1 at the top of LTG-6-C, Part 1.

LTG-6-C: Part 2 of 3

Display Lighting: Walls

When public areas include feature display lighting, it must be documented according to the display lighting procedure. To complete Part 2 of LTG-6-C, complete the following steps.

1. COLUMN A - lists the name of the task.
2. COLUMN B - lists the mounting height for display luminaires. Section 5.2.2.1 C.2. Specific Lighting Power Allowance contains a discussion on how to determine the mounting height.
3. COLUMN C - lists the mounting height adjustment factor for display luminaires. Select the proper factor from Standards Table 146-E and show in this column.
4. COLUMN D - lists the wall length of the display from the plans. This length must be totaled at the bottom of the column.
5. COLUMN E lists the lighting power allowance from Standards Table 146-D for wall display luminaires.
6. COLUMN F - is the product of the mounting height adjustment factor (COLUMN C) times the lighted display wall length (COLUMN D) times lighting power allowance density (COLUMN E).
7. COLUMN G - lists the luminaire name (consistent with LTG-1-C and LTG-2-C) that is illuminating the display. If more than one luminaire type is used to illuminate the display, each type must be listed separately. Multiple lines on this form may be used for this list.
8. COLUMN H - lists the quantity of luminaires used to illuminate the display. If track lighting is used, and the plans do not indicate the number of fixtures to be used on the track, the actual length of track is entered in this column.
9. COLUMN I - lists the total wattage of each luminaire type (including ballasts for fluorescent or high intensity discharge fixtures). For track and incandescent medium base socket fixtures, see Section 5.2.2.1 Allowed Lighting Power for how to determine the watts of these types of luminaires. If track lighting is used and the fixtures are not shown on the plans, enter 45 watts per foot of track in this column.
10. COLUMN J - is the product of the quantity of luminaires (COLUMN H) times the watts per luminaire (COLUMN I). If more than one luminaire type is used to illuminate the task or activity, the subtotal for all the luminaires illuminating the task should be indicated in this column on a separate line of the form.
11. COLUMN K - is the lesser of either the allotted watts (COLUMN F) or the design watts (COLUMN J).
12. The sum of the allowed watts in COLUMN K is entered on Line 2, Part 1 of LTG-6-C.

Display Lighting - Floors

When retail spaces include sales floor display lighting, the lighting must be documented according to the display lighting procedure established in the section above on Determining Allowed Watts.

Complete the upper portion of Part 3 of this LTG-6-C, using the following steps.

1. COLUMN A - lists the name of the sales floor display. See the section above on Determining Allowed Watts for more information on the definition of Sales Floor Display Lighting.
2. COLUMN B - lists the mounting height of the display luminaires. Section 5.1.2.2 C.2. Specific Lighting Power Allowance contains a discussion on how to determine the mounting height of floor display luminaires.
3. COLUMN C - lists the mounting height adjustment factor for floor display luminaires, found in Table146-D in the Standards.
4. COLUMN D - lists the area of each space with floor displays from the plans. This area must be totaled at the bottom of the column.
5. COLUMN E - lists the Lighting Power Allowance density from Standards Table 146-D using the mounting height adjustment factors (COLUMNS C and D) for display luminaires. This allowance will always be based on illuminance category G.
6. COLUMN F - is the product of the mounting height adjustment factor (COLUMN C), the task area (COLUMN D) and the lighting power density (COLUMN E).
7. COLUMN G - lists the luminaire name (consistent with LTG-1-C and LTG-2-C) that is illuminating the display. If more than one luminaire type is used to illuminate the display, each type must be separately listed. Multiple lines on this form may be used for this list.
8. COLUMN H - lists the quantity of luminaires used to illuminate the display. If track lighting is used, and the plans do not indicate the number of fixtures to be used on the track, the actual length of the track is entered in this column.
9. COLUMN I - lists the total wattage of each luminaire type (including ballasts for fluorescent or high intensity discharge fixtures). For track and incandescent medium base socket fixtures, see the section above on Track Lighting for how to determine the watts of these types of luminaires. If track lighting is used, and the fixtures are not shown on the plans, enter 45 watts per foot of track in this column.
10. COLUMN J - is the product of the quantity of luminaires (COLUMN H) times the watts per luminaire (COLUMN I). If more than one luminaire type is used to illuminate the task or activity, the subtotal for all the luminaires illuminating the task should be indicated in this column on a separate line of the form.
11. COLUMN K - is the lesser of either the allotted watts (COLUMN F) or the design watts (COLUMN J).
12. The sum of the allowed watts for floor display lighting in COLUMN K is entered on Line 2, Part 1 of LTG-6-C.

LTG-6-C: Part 3 of 3

Ornamental and Special Effects Lighting includes chandeliers, sconces, lanterns, neon and cold cathode, light emitting diodes (LEDs), theatrical projectors, moving lights and light color panels (used decoratively, not as display lighting). If allowed in Standards Table 146-D column 5, use this form to compute the power allowance.

1. COLUMN A - lists the name of the luminaire or lighting type.
2. COLUMN B - lists area of the space that contains the chandelier or special effects lighting.

3. COLUMN C - lists the lighting power allowance density from COLUMN 5 of Standards Table 146-D.
4. COLUMN D - is the product of the area (COLUMN B) and the lighting power density (COLUMN C).
5. COLUMN E - lists the luminaire name (consistent with LTG-1-C and LTG-2-C). Multiple lines on this form may be used to list multiple luminaires.
6. COLUMN F - lists the quantity of luminaires used for ornamental or special effects lighting. If track lighting is used, and the plans do not indicate the number of fixtures to be used on the track, the actual length of track is entered in this column.
7. COLUMN G - lists the total wattage of each luminaire type (including ballasts for fluorescent or high intensity discharge fixtures). For track, and incandescent medium base socket fixtures, see the section above on Track Lighting for how to determine the watts of these types of luminaires. If track lighting is used, and the fixtures are not shown on the plans, enter 45 Watts per foot of track in this column.
8. COLUMN H - is the product of the quantity of luminaires (COLUMN F) times the watts per luminaire (COLUMN G). If more than one luminaire type is used to illuminate the task or activity, the subtotal for all the luminaires illuminating the task should be indicated in this column on a separate line of the form.
9. COLUMN I - is the lesser of either the allotted watts (COLUMN D) or the design watts (COLUMN H).

The sum of the allowed watts for ornamental/special effects lighting in COLUMN I is entered on Line 2, Part 1 of LTG-6-C.

Very Valuable Merchandise Display Cases that contain jewelry and other valuable merchandise are Lighting Power Allowance for each square foot of lighted display case counter top, as shown in Table 146 D in the Standards. These displays may include jewelry, coins, fine china or crystal, precious stones, silver or other precious metal, small art objects and artifacts, or other valuable collections that require inspection of fine detail from outside a locked case.

1. COLUMN A - lists the name of the luminaire or location.
2. COLUMN B - lists area of the space.
3. COLUMN C - lists the Lighting Power Allowance density from Column 5 of Standards Table 146-D.
4. COLUMN D - is the product of the area (COLUMN B) and the lighting power density (COLUMN C).
5. COLUMN E - lists area of the display case.
6. COLUMN F - is already listed and is 20 watts per square foot.
7. COLUMN G - is the product of the area (COLUMN E) and the lighting power density (COLUMN F = 20 watts per square foot).
8. COLUMN H - lists the luminaire code (consistent with LTG-1-C and LTG-2-C). Multiple lines on this form may be used to list multiple luminaires.
9. COLUMN I - lists the quantity of luminaires used for very valuable display lighting. If track lighting is used, and the plans do not indicate the number of fixtures to be used on the track, the actual length of track is entered in this column.

10. COLUMN J - lists the total wattage of each luminaire type (including ballasts for fluorescent or high intensity discharge fixtures). For track and incandescent medium base socket fixtures, see the section on Track Lighting for how to determine the watts of these types of luminaires. If track lighting is used, and the fixtures are not shown on the plans, 45 watts per foot of track is entered in this column.
11. COLUMN K - is the product of the quantity of luminaires (COLUMN I) times the watts per luminaire (COLUMN J). If more than one luminaire type is used to illuminate the task or activity, the subtotal for all the luminaires illuminating the task should be indicated in this column on a separate line of the form.
12. COLUMN L - is the lesser of either the allotted watts for the space area (COLUMN D), the allotted watts for the very valuable display area (Column G), or the design watts (COLUMN K).

The sum of the allowed watts for ornamental/special effects lighting in COLUMN L is entered on Line 2, Part 1 of LTG-6-C.

As with all applications in illuminance category G, the allowed lighting watts for feature displays may not exceed the actual installed wattage. This prevents unused display lighting allotments from being used in other areas of the store.

5.15.7 LTG-7-C: Room Cavity Ratio Worksheet (>3.5)

Form LTG-7-C is an optional form to be used only in conjunction with the Tailored Method and form LTG-6-C. LTG-7-C documents the calculation of room cavity ratios (RCRs) that are greater than or equal to 3.5 for spaces in illuminance categories A-G.

Rooms in a building which are relatively large generally have a high RCR. If the RCR is greater than or equal to 3.5, a higher LPD is allowed. If the RCR is less than 3.5, it does not need to be included on this form.

The form has two sections: **Rectangular Spaces** is for rooms with four 90° walls, and **Non-rectangular Spaces** is for all other room types (including oblique four walled and circular rooms).

Rectangular Spaces

1. COLUMN A - lists each room's number, and should correspond to the plans.
2. COLUMN B - lists the task/activity description for the room. If the room has multiple tasks or activities, use the dominant activity for the room in this column.
3. COLUMN C - lists the length (L) of the room, measured in feet, from the interior surfaces of opposing walls. The length is typically the longest distance between two parallel walls in the room.
4. COLUMN D - lists the width (W) of the room, measured in feet, from the interior surfaces of opposing walls. The width is typically the smallest distance between two parallel walls in the room.
5. COLUMN E - lists the vertical distance, measured in feet, from the work plane to the center line of the lighting fixture. This measurement is called the room cavity height (H).

6. COLUMN F - is 5 times the product of the room cavity height H (from COLUMN E) and the sum of the room length and width (L from COLUMN C plus W from COLUMN D), all divided by the room area L (from COLUMN C) times room width (W from COLUMN D). This quantity is the RCR and should be entered in COLUMN D of Part 1 of LTG-6-C for tasks with illuminance categories A-G.

Non-rectangular Spaces

7. COLUMN A - lists each room's number, and should correspond with the plans.
8. COLUMN B - lists the area or activity description for the room. If the room has multiple tasks or activities, use the dominant activity for the room in this column.
9. COLUMN C - lists the interior area (A) of the room in square feet. This should be determined by whatever means appropriate for the shape of the room.
10. COLUMN D - lists the room perimeter (P) measured in feet along the interior surfaces of the walls that define the boundaries of the room. For rooms with angled walls, this is the sum of the interior lengths of each wall in the room. For circular rooms, this is the interior radius of the room, squared, times pi (3.413).
11. COLUMN E - lists the vertical distance, measured in feet, from the work plane to the center line of the lighting fixture. This measurement is called the room cavity height (H).
12. COLUMN F - is 2.5 times the product of the room cavity height H (from COLUMN E) and room perimeter P (from COLUMN D), all divided by the room area A (from COLUMN C). This quantity is the RCR and should be entered in COLUMN D of Part 1 of LTG-6-C for tasks with illuminance categories A-G.

5.15.8 LTG-8-C: Common Lighting Systems Method Worksheet

Complete and submit form LTG-8-C (Common Lighting Systems) only if selecting the Common Lighting Systems method of allowed lighting power to determine if an indoor lighting system complies with the prescriptive requirements (§146 in the Standards). This method is only for building types shown in Standards Table 146-B, Complete Building Method Lighting Power Density Values. In addition, the lighting power density listed in Standards Table 146-B for that building type must be at least 1.0 w/ft^2.

1. SPACE NAME -- Insert the name or number of the space. Use a new row for each space in the building area.
2. SPACE AREA -- Insert the area (square feet) of the space.
3. LUMINAIRE TYPE OR CODE -- Insert the luminaire type, or the luminaire code shown in the luminaire schedule on the plans.
4. LUMINAIRE POWER -- Insert the power used by each luminaire of the type shown on this line, in watts. This is the total power including the ballast or transformer (or lamp, if no ballast or transformer is required to operate that lamp) when operating the lamp.

5. Energy Commission DEFAULT -- Check the "Y" box if the luminaire power in the previous column is from Appendix NB in the Nonresidential ACM Manual, or check the "N" box if the power shown is from the ballast manufacturer's literature. Include a copy of the ballast manufacturer's specification sheet if that is the source for the luminaire power shown in the previous column.
6. LUMINAIRE SPACING OR LAYOUT -- Indicate the distance between luminaire centers in rows and columns, similar to the method used in column 3 of the Standards Table for common lighting systems.

5.15.9 LTG-9-C: Line Voltage Track Lighting Worksheet

LTG-9-C should be used to identify and account for all line voltage track lighting. (Line voltage track typically operates around 120 volts or greater). Completing this form and entering the results on LTG-2-C calculate the installed lighting power for line voltage track lighting.

To determine luminaire wattage incorporated into the installed lighting power for line voltage track lighting, use one of the two Methods described in 5.4.3 of the Nonresidential Manual.

Method 1 - Volt-Ampere (VA) Rating of the Branch Circuit(s) Feeding the Tracks or the Wattage of Integral Current Limiters

1. COLUMN A - list the name or number that identifies the branch circuit feeding the track. This column must be filled for all branch circuits feeding track lighting systems.
2. COLUMN B - list the volt-ampere rating of the branch circuit identified in column A. Fill out this column only when you are using the VA of the branch circuit to determine the wattage of the track(s). If integral current limiters are used to determine the wattage of the tracks, leave this column blank.
3. COLUMN C - Check the boxes to indicate if integral current limiters are used. Columns (C) thru (G) must only be filled out if the current limiter option is used to determine the wattages of all or some of the tracks connected to the branch circuit. These columns may be left blank if the branch circuit option is used to determine the wattage of the track(s)
4. COLUMN D – If the box(es) in column (C) is checked, list the wattage of the current limiter.
5. COLUMN E – List the length of the track.
6. COLUMN F – If the track is equipped with an integral current limiter, multiply the value in column (E) by 15 watts per linear foot. If the track is not equipped with an integral current limiter, multiply the value in column (E) by 45 watts per linear foot.
7. COLUMN G – List the wattage of the track, which is the higher of columns (D) or (F)
8. SUB-TOTALS –Sub-totals are the sum of all track watts listed in column (G). If the branch circuit option is used to determine the wattage of the track(s), sub-total is the value listed in column (B).
9. TOTAL WATTS – Total watts are the sum of all sub-totals.

Method 2 - Use The Higher Of:

45 watts per linear foot of track, or the maximum relamping rated wattage of all luminaires.

1. COLUMN A - list the name or number that identifies the track lighting.
2. COLUMN B - list the linear feet of track lighting identified in column A
3. COLUMN C - is 45 watts per linear feet. This number is required for using Method 2.
4. COLUMN D - Multiply the number in column B by the number in column C.
5. COLUMN E - Determine the rated wattage of each luminaire (track head) that will be installed on the line voltage track identified in column A according to
   §130 (c) of the Standards. Luminaire wattage for incandescent track heads shall be the maximum relamping rated wattage as listed on a permanent factory-installed label according to §130 (c) 1. Luminaire wattage for fluorescent and high intensity discharge (HID) track heads shall be the operating input wattage of the rated lamp/ballast combination according to §130 (c) 2. Luminaire wattage for low-voltage track heads (when mounted on line-voltage track) shall be the maximum rated wattage of the transformer on each track head according to §130 (c) 5. Add up the wattage for every luminaire that will be installed on the identified track and enter the total amount as the rated wattage.
6. COLUMN F - list the larger number from column D or column E. This is the installed lighting power for the track listed in column A. Add up all of the numbers in column F and list the total at the bottom. Enter this number in LTG-2-C for the installed lighting power of the track lighting systems determined by this method.

5.15.10 OLTG-4-C: Indoor Signs Worksheet

Complete and submit OLTG-4-C to show compliance for all indoor and outdoor signs. Refer to OLTG-4-C Worksheet and Plan Check Documents instructions in this manual's Chapter 6, the Outdoor Lighting and Signs Chapter. For indoor and outdoor Signs, either LTG-1-C or OLTG-1-C Certificate of Compliance may be used in conjunction with OLTG-4-C.