

2013 TITLE 24, PART 6

RETAIL LIGHTING

*A guide to meeting, or exceeding,
California's 2013 Building Energy Efficiency Standards*



DEVELOPED BY THE CALIFORNIA LIGHTING TECHNOLOGY CENTER, UC DAVIS

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This guide is designed to help builders and lighting industry professionals become more familiar with the retail nonresidential lighting portion of California's 2013 Building Energy Efficiency Standards (Title 24, Part 6). The guide provides information on current lighting technologies, lighting design terms and principles, and best-practice recommendations. It is designed to complement lighting courses developed through CLTC and sponsored by Pacific Gas and Electric Company through its Energy Education program.



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PHOTO: SORAA

INTRODUCTION

THE BENEFITS OF EFFICIENCY

Bigger Energy Savings

Lighting is one of the largest electricity loads in commercial buildings, representing about a third¹ of commercial electricity use. The lighting requirements of California's Title 24, Part 6 Building Energy Efficiency Standards are aimed at reducing electricity use while maintaining high-quality lighting.

Smarter Lighting

Dimmable light sources paired with advanced lighting controls save energy while adding flexibility to lighting designs. Today's retail spaces often serve multiple functions and their merchandise displays may be constantly changing. Smart lighting systems allow retailers to adjust lighting quickly and easily, maximizing the impact of new displays while saving employee time.

Better Branding

Consumers have become increasingly concerned about their impact on the environment and aware of how their shopping habits affect the planet. Retailers have responded by increasing the sustainability of their products and business practices. Improving efficiency and reducing waste not only lowers overhead costs for retailers, but also provides an opportunity for business growth.²

Market analysis now indicates that companies with sustainability initiatives tend to profit more and perform better than competitors without these programs.³ Sustainability programs are increasingly recognized as a source of innovation and a way to improve the appeal of retail brands.⁴

¹ *California Commercial End-Use Survey (CEUS)*, March 2006, California Energy Commission No. 400-2006-005

^{2,3} *2013 Retail Sustainability Report: Fueling Continuous Development*, 2013, Retail Industry Leaders Association (RILA)

⁴ *The Innovation Bottom Line: Findings from the 2012 Sustainability and Innovation Global Executive Study and Research Report*, February 2013, MIT Sloan Management Review

ABOUT THIS GUIDE

This guide is designed to help builders, lighting designers, contractors, and other end users become more familiar with the lighting portion of California's 2013 Title 24, Part 6 nonresidential standards as they apply to retail spaces. It is designed to serve as a resource for lighting industry professionals involved in the construction, maintenance, or retrofit of California's retail buildings. The guide includes compliance requirements and recommendations for implementing the standards in new construction or renovation projects.

Compliance Process Overview

The guide begins with an overview of the compliance process including the responsibilities, requirements and documentation involved in each phase of a project, from design to final inspection.

Concepts & Principles

Chapter 2 is devoted to lighting concepts and principles such as color rendering, color temperature, light output, and lamp life. These concepts are vital for making informed decisions about lamps, luminaires and controls.

Technology Overview

This portion of the guide describes lamp types, luminaire classification under the standards, control strategies, and control systems most relevant to retail spaces.

Code Requirements & Recommendations

Mandatory code requirements related to electric lighting, daylighting and lighting controls in retail buildings are explained in Chapter 4. This chapter also examines the prescriptive requirements of Title 24, Part 6, including the available methods used to calculate allowed lighting power.

Requirements & Recommendations by Space Type

This section of the guide includes recommendations for meeting the lighting standards in different retail spaces, including outlet stores, mass merchandising spaces, boutique shops, and commercial restrooms. Floor plans with compliant lighting are provided as examples of successful designs.

NOTE: This guide is not intended to be used in lieu of California's Title 24 Building Energy Efficiency Standards, and it is not a substitute for the code itself. Please visit www.energy.ca.gov/title24 to download the official 2013 Title 24 Building Energy Efficiency Standards, Errata, Reference Appendices, and the Nonresidential Compliance Manual. To obtain a hard copy of the standards, contact the California Energy Commission's publications unit at (916) 654-5200.

THE COMPLIANCE PROCESS

The following is an overview of the compliance process for nonresidential lighting. Additional information and resources, including the 2013 Nonresidential Compliance Manual and forms may be found on the California Energy Commission website: energy.ca.gov/title24/2013standards

Step 1: Comply with All Mandatory Measures

All nonresidential buildings must be designed and built to comply with the **mandatory measures** of Title 24, Part 6.

Step 2: Comply with All Performance or Prescriptive Requirements

Commercial buildings must also meet lighting power density (LPD) requirements. There are two approaches to meet these requirements:

The **Performance Approach** provides one path to compliance. It requires using software approved by the Energy Commission and is best suited for use by experienced professionals familiar with Title 24. This method allows for energy trade-offs between building systems. For example, under the performance approach, very efficient lighting can allow for larger heating and cooling loads.

The **Prescriptive Approach** does not require software or the same level of building design expertise as the Performance Approach. This guide focuses on the Prescriptive Approach. With this approach, designers may use one of the following two methods to ensure each area of the retail store is in compliance:

Area Category Method: A single lighting power allowance (LPA) is applied to all lighting in a given space. Different retail areas or space types are allowed different LPA.

Tailored Method: This detailed method may be used with sales floors, show rooms, financial transaction areas, and malls. It provides separate lighting power allotments for general lighting, task lighting, ornamental lighting, and different types of display lighting in each space.

The **Complete Building Method** is not an option for retail projects, other than grocery store buildings in which a minimum of 90% of the building floor area is classified as sales floor for foodstuffs.

Step 3: Verify Compliance

After choosing a compliance method, calculate the actual LPD of the total project area by combining the LPDs for all areas. This value should not exceed the allowed, which is a sum of the lighting power allowances for individual areas. If the lighting design does not comply, then it will have to be revised to achieve a lower total LPD.

Step 4: Prepare and Submit Plans

Once the standards have been met, the design team must ensure that the plans include all the documents that building officials will require to verify compliance. Plans and compliance forms are submitted to the Authority Having Jurisdiction (AHJ) at the same time as a building permit application.



Step 5: Pass Inspection and Receive Permit

A building department plans examiner must check that the building or system satisfies Title 24 requirements and that the plans contain the information to be verified during field inspection. A building permit is issued after plans are approved.



Step 6: Complete Construction

The installation team must follow the approved plans and specifications during construction. The approved plans and specifications can be changed after the original plans have been approved by the Authority Having Jurisdiction (AHJ), provided the changes are resubmitted to the building department for re-approval.



Step 7: Commission Building Systems

Once construction is complete, the contractor and/or the design team must properly commission the building and its systems. The contractor and/or design team must also advise the building operators of their responsibilities to comply with Title 24 standards. They also must provide information or training on how to maintain and operate the building and its energy features.



Step 8: Pass Inspection by an Acceptance Test Technician

Title 24, Part 6 requires that Acceptance Test Technicians (CLCATTs) review and test lighting controls installations to ensure controls operate as required by the standards.

CLCATTs trained and certified through an approved curriculum provider will:

- Review installation certificates and associated documentation
- Test installations to ensure controls are positioned and calibrated to operate in compliance with the standards
- Check that all necessary set points or schedules are in place as required by the standards
- Fill out required Certificates of Acceptance and submit these to the enforcement agency

Visit energy.ca.gov/title24/attcp for information on acceptance test technicians (ATT) certification providers.



Step 9: Provide Documentation to Building Owners

Upon occupancy, the building owner must receive copies of the energy compliance documents, including Certificates of Acceptance, along with instructions for operation and maintenance.



CALCTP-AT Technician Training

calctp.org

CALCTP is one of two training and certification programs recognized and approved by the California Energy Commission to carry out lighting controls acceptance testing as required by Title 24, Part 6.

In order to be certified as a CALCTP Acceptance Test Technician, a person must:

- Be employed by a listed CALCTP-certified employer: calctp.org/tacceptance-technicians/contractors
- Have at least three years of experience with lighting controls
- Register on the CALCTP website: calctp.org/acceptance-technicians
- Take the training course offered at one of the CALCTP training centers: calctp.org/training-center-list

NEW IN 2013: AN OVERVIEW OF UPDATES

For those familiar with the 2008 standards for nonresidential indoor lighting, these are the most significant changes affecting retail lighting.

New controls required, dimmable steps expanded

Occupancy-based, automatic-shutoff controls are now required in more spaces, with an increased number of steps required for mandatory multi-level lighting controls. General and display lighting must automatically shut OFF when buildings are unoccupied. General lighting, floor and wall display, window display, case display, ornamental, and special effects lighting must be separately controlled.

Automatic daylighting controls now mandatory

Daylight harvesting is now mandatory in the primary daylit and skylit zones, except for areas with less than 24 ft² of glazing and less than 120 watts of total general installed lighting power in the combined primary daylit and skylit zones. Under the prescriptive approach, automatic daylighting controls are also required for the secondary sidelit zone.

More alterations trigger compliance upgrades

Alterations now include projects where at least 10% of all luminaires in the enclosed space are altered (the threshold was 50% in the 2008 standards). When at least 40 luminaires in a building (or on a floor if the building has multiple floors) are modified in the locations where they are currently installed in the course of a year, Title 24 requirements are also triggered. A new category, luminaire modifications-in-place, has been added for these projects.

Demand response required in buildings 10,000 ft² and larger

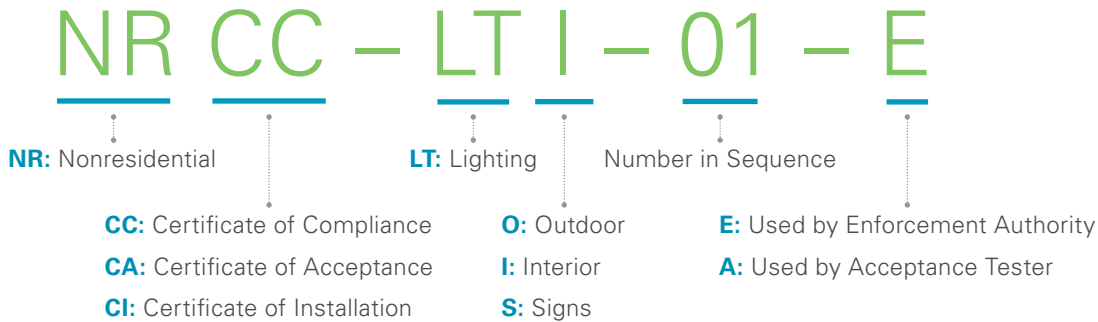
The 2008 code only required demand response (DR) capability in retail buildings with sales floors at least 50,000 ft² in size. The 2013 code expands this to require all commercial buildings 10,000 ft² in size or larger be capable of automatically reducing lighting energy use at least 15% in response to a DR signal.

Acceptance test requirements expanded

Acceptance tests must now be performed to verify compliance for automatic daylighting controls, shut-off controls (indoor and outdoor), and demand response controls. Lighting controls acceptance test technicians must be certified through a training program approved by the Energy Commission. Visit energy.ca.gov/title24/attcp for more information.

INDOOR LIGHTING COMPLIANCE DOCUMENTS

Instructions for completing compliance forms are provided in [Section 5.10](#) of the Energy Commission's Nonresidential Compliance Manual. The Energy Commission plans to have electronic documents replace paper documents for nonresidential building projects in 2015.



Certificates of Compliance

Compliance forms and plans are submitted at the same time that a building permit application is submitted to the enforcement agency (see Step 4 in the compliance overview).

NRCC-LTI-01-E	Indoor Lighting
NRCC-LTI-02-E	Indoor Lighting Controls
NRCC-LTI-03-E	Indoor Lighting Power Allowance
NRCC-LTI-04-E	Tailored Method Worksheets
NRCC-LTI-05-E	Line-Voltage Track Lighting Worksheet

NRCC-LTI-01-E, **NRCC-LTI-02-E** and **NRCC-LTI-03-E** are required for all projects.

Submit **NRCC-LTI-04-E** when the Tailored Method is followed for prescriptive compliance.

When line-voltage track lighting is installed, include **NRCC-LTI-05-E** in the package.

Because lighting power trade-offs are not allowed between conditioned and unconditioned spaces, most nonresidential indoor lighting compliance documents must be completed separately for conditioned and unconditioned spaces.

Certificates of Installation

These forms, signed by licensed individuals, certify that the lighting installed for the project corresponds with the lighting proposed on the Certificates of Compliance:

NRCI-LTI-01-E	Validation of Certificate of Compliance (All Buildings)
NRCI-LTI-02-E	Energy Management Control System or Lighting Control System
NRCI-LTI-03-E	Line-Voltage Track Lighting
NRCI-LTI-04-E	Two Interlocked Lighting Systems
NRCI-LTI-05-E	Power Adjustment Factors
NRCI-LTI-06-E	Video Conferencing Studio Lighting

Certificates of Acceptance

An ATT trained and certified through a state-approved program must complete forms **NRCI-LTI-02-A**, **NRCI-LTI-03-A** and **NRCI-LTI-04-A** when required. The forms are also signed by the responsible party and the document author, if different than the ATT. Information in these forms certifies that the lighting controls were tested and operate in compliance with the standards:

NRCA-LTI-02-A	Lighting Controls
NRCA-LTI-03-A	Automatic Daylighting Controls
NRCA-LTI-04-A	Demand Responsive Lighting Controls

FINDING COMPLIANT PRODUCTS

Certain devices must be certified to the Energy Commission as meeting California's Appliance Efficiency Standards (Title 20 of the California Code of Regulations). Others are regulated under the Building Energy Efficiency Standards (Title 24, Part 6).

Products Regulated Under Title 20

The following lighting appliances must be certified under Title 20:

- **Fluorescent lamp ballasts** ([Section 110.1](#))
- **Lighting control devices** ([Section 110.9](#))
 - Time-switch lighting controls: automatic time-switch controls, astronomical time-switch controls, multi-level astronomical time-switch controls, outdoor astronomical time-switch controls
 - Daylighting controls: automatic daylight controls, photo controls
 - Dimmers
 - Occupant sensing controls: occupant sensors, motion sensors, vacancy sensors, partial-ON sensors, partial-OFF sensors

Products Regulated Under Title 24

The following lighting control devices are regulated under [Section 110.9](#) of Title 24, instead of Title 20:

- Part-night outdoor lighting controls ([Section 100.1](#))
- Track lighting integral current limiter ([Section 110.9](#))
- Supplementary overcurrent protection panels for use with line-voltage track lighting
- Field-assembled lighting control systems

Lighting specifiers wishing to work with a product not yet listed in the Appliance Efficiency Database can encourage the manufacturer or a pre-approved third-party certifier to submit appliance certification data to the Energy Commission.

Appliance Efficiency Database

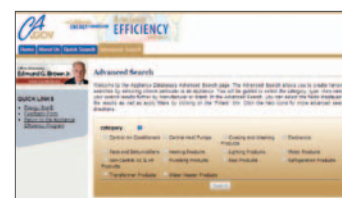
The Energy Commission's database lists a variety of products certified as meeting Title 20 or Title 24 requirements, including lamps, ballasts, and lighting controls.

ENERGY STAR®

While many Energy Star products meet California's efficiency requirements, not all Energy Star labeled products comply with Title 20 and Title 24 standards. In some cases, California's compliance requirements are more stringent.

DesignLights Consortium®

The DesignLights Consortium (DLC) maintains a Qualified Products List that provides information on available products for the commercial sector that passed a review of test results as verification of performance for listed products. Members of the DLC are comprised of regional, state, utility, and energy efficiency programs throughout the United States and Canada. Products on the list are often eligible for incentives through participating programs.



Appliance Efficiency Database

appliances.energy.ca.gov

This online database of products certified to the Energy Commission has a Quick Search function allowing users to search by product type, brand or model.



PHOTO: CLTC, UC DAVIS

Luminaires & Lamps

"Luminaire" is the lighting industry's term for what is also commonly described as a light fixture. A luminaire consists of the housing, power supply (ballast, transformer or driver), lamp, and optical components such as reflectors or lenses.

"Lamp" is the lighting industry's term for a light bulb. Table lamps and floor lamps — classified as portable luminaires under the standards — are regulated under California's Appliance Efficiency Standards.



A Prescription for Low-Maintenance Lighting *Walgreens, Buffalo Grove, IL*

Walgreens installed LED lighting for its sales floors, cooler doors, pharmacies, and parking lots to reduce energy use. The renovation also lowered maintenance from once every month to “nearly zero, overnight,” said former Walgreens Director of Energy and Sustainability Menno Enters. More information is at acuitybrands.com.

CONCEPTS & PRINCIPLES

LAYERS OF LIGHT

One of the most efficient and effective ways to light retail spaces is layering ambient, task and accent lighting. This layered approach to lighting design also provides variety and visual interest, attracting customers into the store and guiding their focus within the space. Most retail lighting designs are comprised of these layers:

Daylight

Where daylight is available in retail spaces, electric light levels can often be lowered. In addition to reducing energy use, daylighting is attractive to customers and offers excellent color rendering. Controls and window or skylight treatments can be used to prevent glare and unwanted heat from sunlight.

Ambient Lighting

Ambient lighting, referred to as general lighting by the standards, makes navigating a retail space visually comfortable. Per Illuminating Engineering Society (IES) recommendations and the Title 24, Part 6 Nonresidential Compliance Manual, 400 lux, or about 40 foot-candles (fc), is generally recommended for ambient horizontal lighting in retail applications.

Accent or Display Lighting

Conventional retail lighting practice relies on the most brightly lit areas and objects, usually displays and signs, to draw guests' attention. Maintaining contrast between ambient and display lighting creates visual interest and draws customers' eyes to the display items that are illuminated with more intensity. Ambient light levels can be lowered to increase contrast with display lighting, or the display lighting can be increased. Higher ratios may be needed to bring out detail in dark merchandise or to bring out sparkle in jewelry and crystal.

Task Lighting

Sales transaction areas require increased light levels and minimal glare for transactions and work tasks such as checking receipts and inspecting merchandise. Task lighting is one approach to reach these light levels.

Decorative Lighting

Chandeliers, pendants or other luminaires that provide visual interest or sparkle draw guests into a retail space. They can also provide attractive markers for checkout stations or seating areas. Decorative lighting contributes to other aspects of the lighting design. For example, pendants hung over registers supplement task and ambient lighting in that area.

LUMEN OUTPUT, EFFICACY & LIFE

Many consumers estimate the light output of lamps and luminaires based on the amount of power they draw, but it is lumens (lm), not watts (W), that indicate luminous output. More efficient sources can produce the same amount of light as legacy sources while consuming less energy.

Luminous Output

The amount of visible light emitted by a light source is measured in lumens (lm). The more lumens, the more light emitted, but other factors also affect visibility and perception of brightness, such as contrast ratios and color characteristics. In addition, the type of fixture or housing can greatly affect the amount of lighting reaching its intended target.

★ Recommendations





- Compare the light output, not the power rating, of existing and replacement light sources or luminaires to ensure adequate lighting is maintained.
- Consider other factors, such as contrast, distribution and color rendering; these also affect nighttime vision and perceived brightness.
- Install lighting controls, such as dimmers or motion sensors, to maximize energy savings while automatically tailoring light levels to occupants' needs.
- To avoid energy waste and excessive illumination, factor task lighting and ambient lighting into the overall lighting design for a space.



Lighting Facts Label

The Lighting Facts label helps consumers understand lamp performance and compare products. Information can also be found on manufacturers' websites and in product specification sheets. A simplified, black and white version of this label is required by the Federal Trade Commission for all general service, medium screw-base lamps.

Comparing Lumens vs. Watts

LUMENS →		450	800	1,100	1,600	
		← DIMMER → BRIGHTER				
LESS EFFICIENT ↑ ↓ MORE EFFICIENT		Standard Incandescent	40 W	60 W	75 W	100 W
		Halogen Incandescent	29 W	43 W	53 W	72 W
		CFLs	10 W	13 W	16 W	20 W
		LEDs	5 W	10 W	15 W	19 W

Sources: U.S. Department of Energy Building Technologies Office, "CALiPER Snapshot: Light Bulbs," October 1, 2013.
Natural Resources Defense Council, "Your Guide to More Efficient and Money-Saving Light Bulbs," October 30, 2013.

Luminous Efficacy

In lighting, the term efficacy refers to the ratio of luminous output produced by a light source to power rating of that source (lm/W).

Efficacy = Lumens/Rated Watts

Different source technologies provide different efficacy levels. For example, a 75 W A19 incandescent lamp, a 16 W A19 compact fluorescent lamp (CFL) lamp, and a 15 W A19 light-emitting diode (LED) lamp use different amounts of power to produce the same amount of light (approximately 1,100 lumens). Each type of lamp has a different rated efficacy, with the LED example being the most efficacious (producing the most lumens per watt).

When assessing the overall value of lamps or luminaires, efficacy and initial product costs are two factors to consider. It is also important to compare longevity, lifetime performance, and long-term energy and maintenance costs.

Life

Electric light sources have the potential to fail due to several factors, including faulty electrical components, corrosion inside the lamp, or lumen depreciation (the gradual decrease in lumen output that occurs over time).

Incandescent lamps typically last 1,000–2,000 hours and lose about 10–15% of their initial lumen output before burning out. A CFL lamp lasts about 12,000 hours and loses about 10–15% of its output before burning out. Linear fluorescent lamps typically last 25,000–40,000 hours, losing 5–10% of their original lumen output before failing.

LEDs do not burn out in the same way as many legacy sources, their lumen output decreases very gradually over time. Many LED A19 replacement lamps are rated to last 25,000 hours or more before they lose 30% of their initial light output, and recent testing indicates the diodes in these lamps may maintain useful light output longer than previously predicted. Capacitors or other components that provide power to the LED circuit are more likely to fail before the LEDs themselves. Basing LED product life on lumen depreciation (L_{70} or 70% of initial lumen output, for example) may not be the best way to measure the useful life of LED lamps and luminaires.

LED life testing methodologies are still evolving as the technology improves. Here are some best practices to maximize the life of LED lighting:

- Always follow manufacturer installation instructions, including references to base position for replacement lamps (e.g. base-up, base-down or horizontal)
- Pair LED lamps and luminaires with manufacturer recommended dimmers and other controls
- Observe manufacturers' recommendations on operating temperature to prevent heat-related performance degradation

Warranties

Manufacturers offer competitive warranties for lighting products. Energy Star® requires that luminaires and LED lamps carry a warranty of at least three years. LED replacement lamps must come with a minimum five-year free replacement warranty in order to meet the Voluntary California Quality LED Lamp Specification and qualify for utility rebates.

NOTE: Life and lumen maintenance information presented here comes from the The Lighting Handbook, Tenth Edition (sec. 7), published by the IES in 2011.



PHOTO: CLTC, UC DAVIS

Voluntary California Quality LED Lamp Specification

LED replacement lamps for residential applications must now meet certain performance criteria in order to qualify for utility incentive programs and rebates in California. These include:

- Minimum color rendering index of 90
- R9 greater than 50
- Color temperature of 2700 K or 3000 K
- Color consistency



Vision Needs Change with Age

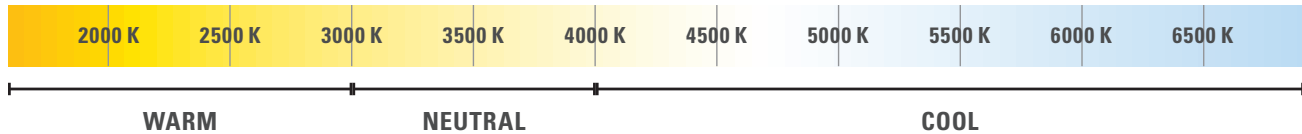
As we age, our eyes require more light to see clearly. The IES sets lowest average minimum maintained recommendations for light level (lux) requirements based on the needs of occupants under 25 years old. These illumination requirements doubled for those ages 26–65 and by quadrupled for those over age 65.

COLOR CHARACTERISTICS

Color Temperature (CCT)

Correlated color temperature (CCT) indicates the warmth or coolness of the light emitted by a given source. CCT is measured on the Kelvin scale (K). Light sources with a low CCT (2,700–3,000 K) give off light that is warm in appearance. Sources with higher CCT values (4,000–6,500 K) provide light with a cooler color appearance.

Selecting light sources with consistent CCTs helps maintain some consistency in the appearance of various light sources. Check the Lighting Facts label for information on CCT (or “light color”), lumen output, power consumption (watts), and efficacy.



Color Rendering (CRI)

The color rendering index (CRI) is the current industry standard for measuring how accurately a light source renders the colors of the objects it illuminates. The maximum CRI value is 100. Most indoor commercial applications should have a minimum CRI of 80. Light sources with a CRI of 90 or higher provide even better color rendering and should be considered for retail applications. Lighting for use in retail areas with color-critical products should be specified with a high CRI.

Specifying lamps and luminaires with similar color rendering properties helps ensure wall color, carpeting and other materials have a consistent appearance, especially in adjoining spaces. The full-color Lighting Facts label issued by the U.S. Department of Energy includes CRI, but the black-and-white Federal Trade Commission label does not. Most manufacturers can supply information on CRI if it is not on product packaging or literature.

R9

Fourteen reference colors are typically used to measure color rendition. CRI measures a light source against the first eight reference colors (R1 – R8). The ninth reference color, R9, is used to measure how a light source's spectral output renders vibrant reds. This measurement is especially critical to consider when illuminating items with saturated red elements, including clothing, jewelry, leather goods, and wood finishes. Cosmetics and customers' skin tones also appear more vibrant when illuminated by sources with an R9 measurement over 50. While the R9 value is not always printed on the lighting facts label, many manufacturers can provide spectrum measurements, including R9 values.



Comparing Color Quality

The LED MR16 lamps used for these photos both have a CCT of 3000 K and were produced by the same manufacturer. The difference is that the first-generation lamp on the left has a CRI of 80 while the lamp on the right has a CRI of 95.





PHOTO: CLTC, UC DAVIS; RALEY'S

TECHNOLOGY OVERVIEW

CHOOSING THE RIGHT LIGHT

An effective indoor lighting system combines the right source technology with the right luminaire and the appropriate lighting controls for the desired function and effect.

Selecting the right type of light source and lighting controls for different retail lighting needs means comparing a variety of factors, including:

- Luminous output
- Efficacy
- Distribution
- Color rendering
- Controls compatibility
- Product life
- Manufacturer warranties
- Long-term energy and cost savings

In many cases, a higher up-front investment in a more efficient, more functional lighting system yields a higher return in the long term. This is especially true in retail applications, where lighting quality can influence sales. This technology overview briefly describes the benefits and limitations of technologies currently on the market and offers guidance for selecting products that comply with Title 24, Part 6 and Title 20.



PHOTO: CLTC, UC DAVIS

PG&E Emerging Technologies Program Report: Directional LED Lamps – Laboratory Testing Program

LED replacement lamps have the potential to significantly reduce lighting energy use in the retail sector, where halogen PAR and MR lamps are among the most common choices. The Directional LED Lamps – Laboratory Testing Program was designed to verify manufacturers' product claims about life, lumen maintenance, and color maintenance of directional LED replacement lamps, based on a market cross-section of lamps commonly used in retail applications.

Read the final report at cltc.ucdavis.edu/publication/directional-led-lamps-laboratory-testing-program.

LIGHT SOURCES

A single luminaire can often accommodate different lighting technologies. For example, most screw-based lamp types are available using incandescent, CFL or LED sources. Selecting the best source type for a particular application means considering several factors, including light quality, intensity, efficiency, and longevity.



Incandescent

Incandescent lamps are highly inefficient. Initial costs for incandescent lamps are low. These lamps do have excellent color, but they burn out quickly compared to other sources. This can increase maintenance costs over time. They can provide unwanted heat in retail applications.



Halogen

Halogen lamps burn hotter and longer than standard incandescent lamps, producing a brighter, whiter light. Halogen lamps are also about 25% more efficacious than standard incandescent lamps.



CFL

With CFLs, the linear tube design of traditional fluorescent lights has been curved into a more compact shape, facilitating incandescent lamp replacement. An electronic ballast in the base of the CFL activates the lamp then regulates the electrical current. Not all CFLs are dimmable and some can have delayed start times, which can be problematic in some retail applications.



Linear Fluorescent

Linear fluorescent lamps provide uniform levels of illumination for long periods of time, making them ideal in stores that require bright, uniform ambient lighting. Linear fluorescent lamps also work well in break rooms, bathrooms, storage spaces, and other more utilitarian areas. In addition, these lamps are relatively inexpensive and can provide excellent color rendering.

- Linear fluorescent lamps are available in different wattages and sizes; the 32W T8 is the most common.
- Not all fluorescent lamps are compatible with dimmable ballasts—make sure the products selected are able to dim in accordance with the requirements in [Table 130.1-A](#) of Title 24, Part 6.

LED

LEDs are solid-state light sources capable of emitting colored light, white light or color-tunable light. The color quality of white light LEDs depends on the phosphors used in manufacturing the LED chip.

- Installing long-life LED luminaires in difficult-to-reach spaces can reduce maintenance costs and reduces time spent changing failed lamps
- LEDs' dimmability and compatibility with cold temperatures make them an excellent choice for pairing with occupancy-based controls, such as those used in adaptive freezer case lighting
- Color-tunable LEDs introduce a new element of flexibility and fascination into display lighting



PHOTO: LEOTEK

Metal Halide (MH)

Metal halide lamps are one type of high-intensity discharge (HID) light source. They are commonly used in retail lighting, particularly high-bay and low-bay applications. MH lamps are three to five times more efficient than incandescent lamps and last about 15–20 times as long. Full light output can take up to 10 minutes to achieve.



PHOTO: PHILIPS

Ceramic Metal Halide (CMH)

CMH lamps are a newer variation of MH technology commonly used in spot and track lighting applications. CMH lamps can produce white light with a CRI as high as 96, making them suitable for color-critical applications. Similar to standard MH lamps, CMH can take up to 10 minutes to reach maximum light output.

Induction

Induction lamps operate similarly to fluorescent lamps, but without the electrodes and filaments. By eliminating these points of failure, induction sources have very long lifetimes and seldom need replacing.

- These lamps are very efficient and compatible with many types of lighting controls
- Induction sources are suited to retail with a CRI of 80 or more
- Long life (60,000–100,000 hours) means easy maintenance



PHOTO: CLTC, UC DAVIS



PHOTO: CLTC, UC DAVIS

LED Options Let New Stores Shine *The Office BOSS, Truckee, California*

When the Office BOSS moved to a new location in 2011, the growing company seized an opportunity to improve its energy efficiency and cut overhead costs. The retailer partnered with the Truckee Public Utilities District, the California Lighting Technology Center (CLTC) and LED product manufacturers to install energy-efficient LED luminaires instead of the halogen and fluorescent sources that typically light retail spaces. The project was made possible with support from the Energy Commission's State Partnership for Energy Efficient Demonstrations (SPEED) program.

- The store has an attractive, comfortable solid-state lighting design that uses less than half the energy of older technologies and costs far less to operate and maintain.
- Energy savings: 56% compared to halogen and fluorescent sources
- Average annual energy cost savings: \$747 (average electricity rate of \$0.128/kWh)
- Positive feedback from customers and staff

General Lighting

Lunera's 65W 6800-series LED linear suspended pendant provides general lighting in the store's customer service areas. This pendant was installed where 1 x 8 two-lamp 128–130W fluorescent luminaires might typically be found.

Downlights

Six LED Halo downlights from Eaton's Cooper Lighting Business (13.8 watts each) were installed instead of halogen recessed downlights that use 65–75W each.

Accent Lighting

Sixteen PM series pendants by Philips Lightolier (some 20W, others 10W) were installed instead of 100W and 75W incandescent luminaires.

Track Lighting

The general merchandise area is illuminated by track lighting that uses 72 Cree 12W LBR-30 LED lamps. Each lamp delivers 600 lumens, equivalent to the output of a 60W incandescent lamp.

CONTROL STRATEGIES

Sensors and controls can achieve significant energy savings by automatically adjusting lighting based on time of day, available task needs, daylight, occupancy, and electricity supply or cost. The 2013 Title 24 standards introduce many new requirements for lighting controls in non-residential buildings, including retail spaces.

Tuning



◀ *Tuning Controls (left to right): Leviton Renoir II dimming control, Leviton Sapphire LCD Touch Screen*

Tuning, also known as high-end trim or institutional dimming, reduces the level of general lighting in an area. Luminaire layouts are designed using a light loss factor, so initial designed light levels are often brighter than necessary. Tuning allows the luminaires to be dimmed to the recommended light level initially and, later, restored to full output when lumen output has degraded. This strategy saves energy, maintains more consistent light levels over the life of the luminaire, and extends lamp life.

Occupancy and Vacancy Sensors



◀ *Occupancy Sensors (top row, left to right): Leviton OSSMT Occupancy Sensor, Lighting Control & Design xCella Wireless Occupancy Sensor, Lutron Radio Powr Savr Wireless Occupancy Sensor*
Vacancy Sensors (bottom row, left to right): Leviton Provolt Vacancy Sensor, WattStopper CU-250 Ultrasonic Multi-way Wall Switch Vacancy Sensor

These sensors automatically dim or switch lighting OFF when the field of view has been vacant for a period of time. Occupancy sensors automatically turn lights ON when an occupant is present in the sensor's field of detection. Occupancy sensors can often be programmed to turn only a portion of the controlled lights ON or OFF. This strategy is called Partial-ON or Partial-OFF control. Lights controlled by vacancy sensors, or manual-ON occupant sensors, must be turned ON manually. The occupant makes a conscious decision to add electric lighting. This strategy can result in significant energy reductions when general lighting subsequently remains OFF for the majority of the day.

Daylight Harvesting



◀ Daylight Harvesting Controls (left to right): Leviton ODC05-MDW, WattStopper LMS-600, Lutron Radio Powr Savr Wireless Daylight Sensor

Also called photocontrols, these devices utilize daylight sensors (photocells) to adjust lighting loads based on ambient light levels. Daylight controls are now required in all spaces that have skylights, windows or other daylight sources and at least 120 watts of electric lighting and 24 ft² of glazing.

Time Clocks



◀ Time Clocks (left to right): Leviton EZ-MAX Plus 8 Relay Panel, WattStopper LP8 Peanut Lighting Control Panels

Time clocks, commonly used in indoor and outdoor applications, switch lights ON or OFF based on daylight hours and geographical location. Some time clocks and curfew dimming controls can automatically adjust dimmable sources, such as LEDs or CMH lamps, to operate at different levels according to a schedule. Dimming lights during the least active hours of operation reduces energy waste and light pollution.

Automatic Demand Response



◀ Demand Response Controls (left to right): Leviton GreenMax Relay Panel, WattStopper Digital Lighting Management

Utilities initiate demand response events for a variety of reasons. Commercial electricity customers may choose to participate in utility demand response programs in exchange for financial incentives. Often, these events are issued when demand for electricity is expected to exceed generation capacity. Title 24 now requires all commercial buildings at least 10,000 ft² in size be capable of receiving and automatically responding to DR signals by reducing lighting energy use to a level at least 15% below the building's maximum lighting power.

CONTROL ARCHITECTURES

Control systems can be as simple as an ON/OFF switch or as complex as a building-level networked control system that integrates daylight harvesting, occupancy sensing, scheduling, and demand response. There are four control architectures most commonly used in commercial spaces: self-contained lighting control, luminaire-integrated control, circuit-level control and networked control.

Self-Contained Lighting Controls

This is the simplest category of control. This category includes ON/OFF switches, dimmers, photocontrols, and occupancy sensors. In the standards, each task area is required to be served by controls that allows occupants to adjust the lighting based on their needs.

Luminaire-Integrated Controls

Also known as on-board controls, these come integrated into the luminaire direct from the manufacturer. They can control individual lights locally. Luminaires can come with occupancy AND/OR daylight harvesting controls.

Circuit-Level Control

This control strategy automatically engages shut-off controls to circuits serving lighting and certain plug loads when those loads are not needed, typically based on a programmed schedule or area occupancy. The strategy is implemented through a timer, or time-clock feature, that enables ON/OFF control based on a schedule defined by hours of building operation.

Networked Control Systems

Interconnected lighting control systems can control select groups of luminaires or lighting for whole buildings, facilities, or campuses. There are centralized, panel-based wired systems and distributed intelligence systems (available in both wired and wireless forms). The number of lighting control networks and systems on the market has increased in recent years. Interfaces are increasingly user-friendly. These systems can integrate daylight harvesting, advanced scheduling, occupancy-based control, demand response, and data monitoring.

Lighting can also be controlled as part of a computerized building management system (BMS) or energy management control system (EMCS) that can address HVAC and other systems in addition to lighting. Networked control systems may not override manual controls under Title 24.



Keeping Energy Use on a Short Leash

Care-A-Lot Pet Supply, Virginia Beach, Virginia

When designing their new 20,000-square-foot location, Care-A-Lot Pet Supply needed lighting to serve a variety of space types, including the sales floor, office spaces, and veterinary exam rooms. The retailer worked with PM&E Design Group and Resource Lighting to install a total of 184 luminaires, including LED and high-output fluorescent high-bay (T5HO) sources by Acuity Brands. Digital lighting controls maximized the flexibility of the lighting design. Each area within the building is controlled separately, providing the right amount of light where and when it is needed and saving energy in spaces like the veterinary exam rooms, where bright, high-quality lighting is required when the rooms are in use. The energy-efficient lighting design saves the store \$5,000 every year on its energy bills. The long lifetimes of the LED luminaires also help reduce costly maintenance on the high ceilings. The T5HO luminaires provide improved light distribution over traditional HID high bays.

A case study is available at: acuitybrands.com/solutions/inspire-me/case-studies/care-alot-pet-supply.





COMPLIANCE REQUIREMENTS

There are three basic steps to comply with Title 24, Part 6:

1. **Meet all mandatory requirements** by installing required devices, including controls, and ensuring that they perform all functions required by the standards.
2. **Select your method** of compliance by choosing either the **Performance Approach** or the **Prescriptive Approach**.
3. **Meet lighting power density requirements** by ensuring that the actual lighting power installed in a space is less than or equal to the allowed lighting power for that space.

Mandatory Requirements

All nonresidential buildings must meet a set of mandatory standards for equipment efficiency and the use of lighting controls.

Performance Approach

The Performance Approach allows energy allotments to be traded between building systems, such as lighting, HVAC or the building envelope. It cannot be used for lighting alone. This compliance approach requires using energy analysis software that has been approved by the Energy Commission.

Prescriptive Approach

Title 24, Part 6 provides retail applications with two main methods of compliance under the Prescriptive Approach: the Area Category Method and the Tailored Method. These methods may be used in conjunction with one another, but each area must follow only one or the other. A third option, the Complete Building Method, is only available to grocery stores that meet the strict definition of a Grocery Store Building per [Section 100.1\(b\)](#), which requires a minimum of 90 percent of the building floor area to be sales floor for the sale of foodstuffs. This method cannot be used for other retail applications.

AREA CATEGORY METHOD

With this option, lighting power values are assigned to each of the major areas of a building (e.g. sales floor, storage rooms, restrooms, etc.), with some special tasks qualifying for more flexible lighting power allotments. This method can be used for any type of project, including alterations and modifications.

TAILORED METHOD

The Tailored Method is typically used in the retail space types listed in [Table 140.6-D](#) to customize illumination levels in specialized task areas, such as high-value displays. Space types include malls, showrooms and merchandise sales areas. Lighting power allowances provided for these areas through the Tailored Method are based on provided illuminance level values and the dimensions of the area the lighting serves.



PHOTO: CREE, INC.



NAVIGATING TITLE 24, PART 6

	MANDATORY	PRESCRIPTIVE	PERFORMANCE
ADDITIONS, ALTERATIONS AND REPAIRS	§ 141.0(b)2F – § 141.0(b)2K	§ 141.0(b)2F – § 141.0(b)2K	—
Additions	—	§ 141.0(a)1	§ 141.0(a)2
Alterations	§ 141.0(b)2Iii § 141.0(b)2Iv Table 141.0-E	§ 141.0(b)2Iii § 141.0(b)2Ivi § 140.6	§ 141.0(b)3A Table 141.0-D
Luminaire Modifications-in-Place	§ 141.0(b)2Iiii Table 141.0-F	§ 140.6 § 141.0(b)2Iiii § 141.0(b)2Ivi Table 141.0-F	—
Light Wiring Alterations	§ 130.1 § 130.4 § 141.0(b)2Iiv	—	—
Repairs	§ 110.9(c)	—	—
GENERAL LIGHTING CONTROLS AND EQUIPMENT	§ 130.0	—	—
Manual Area Controls	§ 130.1(a)	—	—
Multi-level Controls	§ 130.1(b)	—	—
Automatic Shut-Off Controls (Occupant-Sensing Controls)	§ 130.1(c)	—	—



	MANDATORY	PRESCRIPTIVE	PERFORMANCE
Automatic Daylighting Controls	§ 130.1(d) Skylit and Primary Sidelit Zones	§ 140.6(d) Secondary Sidelit Zones	—
Automated Demand Response	§ 130.1(e) Buildings over 10,000 ft ²	§ 140.6(a)2K Table 140.6-A PAFs for demand response buildings < 10,000 sq ft)	—
DAYLIGHTING / GLAZING REQUIREMENTS	—	§ 140.3	—
Fenestration: Minimum U-factor, Solar Heat Gain Coefficient (SHGC), Visible Transmittance	—	§ 140.3(a)5	—
Skylights: Maximum skylight to gross roof area, minimum SHGC, Visible Transmittance	—	§ 140.3(a)6	—
Minimum Daylight Requirements, spaces > 5,000 square feet with ceiling heights > 15 feet	—	§ 140.3(c)	—
CONTROL DEVICES AND SYSTEMS, BALLASTS, AND LUMINAIRES	§ 110.9	—	—
Time-Switch Lighting Controls	§ 110.9(b)1	—	—
Daylight Controls	§ 110.9(b)2	—	—
Dimmers	§ 110.9(b)3	—	—
Occupant-Sensing Controls	§ 110.9(b)b4	—	—
Track Lighting Integral Current Limiter	§ 110.9(c)	—	—
Track Lighting Supplementary Overcurrent Protection Panel	§ 110.9(d)	—	—



ADDITIONS, REPAIRS, ALTERATIONS & MODIFICATIONS-IN-PLACE

Section 141.0

When starting the Title 24 compliance process, the first step is to determine what sections of the standards apply to the project. For new construction and additions, the requirements are easier to determine: most, if not all, sections of standards will apply. It becomes more challenging to determine what applies with retrofits. For lighting retrofits, code-triggering projects will either be alterations or modifications-in-place, a new category for the 2013 standards. Once the project is declared an alteration or a modification-in-place, certain rules can be applied. Maintenance and repair activities can occur outside of the compliance process.

Maintenance & Repairs

No compliance measures required: Routine maintenance and repairs of lighting components, systems or equipment already installed in an existing building do not trigger Title 24.

The standards define maintenance tasks and repairs as:

- Replacement of lamps of the same technology type
- Replacement of lamp holders or lenses
- Replacement of a ballast or driver that is no longer functioning properly
- Maintenance measures that do not increase energy consumption of the equipment being serviced
- Alterations caused directly by the disturbance of asbestos
- Medium screw-based lamp replacements
- Tubular LED lamps that replace fluorescent lamps by changing the lamp only, and not any of the wiring (including the ballast)
- When less than 40 luminaires are upgraded or modified-in-place within a 12-month period in a building space, it is treated as a repair rather than an alteration. Refer to **Table 141.0-F** for a section-specific definition of "building space" to use for modifications-in-place.



Help with Forms

energycodeace.com

Energy Code Ace offers tools to support compliance with the 2013 Title 24 requirements. Select the forms tool and follow the instructions for a summary of the forms required for your specific project. Energy Code Ace fact sheets, checklists and other resources are also available.

Additions

Section 141.0(a)

New construction requirements apply: Lighting plans for building additions must meet the same mandatory and prescriptive or performance standards as lighting installed for a new construction project. If the performance approach is followed, the LPD for the general lighting systems may be traded off with other prescriptive building features.

Alterations

Section 141.0(b)2lii, 141.0(b)2liv, Table 141.0-E

Replacing any lighting component, system, or equipment regulated by Title 24 is considered an alteration, not a repair.

The following are considered lighting system or lighting wiring alterations:

- Luminaire replacement
- Luminaire removal and reinstallation
- Luminaire relocation
- Wiring alterations
- Connecting luminaires to switches, relays, branch circuits, and other controls

Alterations do not always require compliance with all of Title 24, Part 6. For certain types of alterations, compliance is required for only specific sections.

LIGHTING SYSTEM ALTERATIONS

Lighting system alterations that do not change the area of the enclosed space they are located in trigger certain compliance requirements, based on the quantity of existing affected luminaires.

Only areas involved in the lighting alteration must comply with the standards. Areas that are untouched are not required to be changed.

SPACE CHANGES

Any renovations or alterations that increase lighting energy use, change the space function type as a part of the retrofit project (e.g. dividing a stock room into two private offices), or an adjustment to the area of the enclosed space will trigger the following compliance requirements for lighting in the entire space:

- LPD maximum limits under the Area Category Method (**Section 140.6**)
- Manual area controls (**Section 130.1(a)**)
- Automatic shut-off controls (**Section 130.1(c)**)
- Automated demand response (in buildings over 10,000 ft²) (**Section 130.1(e)**)

LPD increases and space changes also trigger the following requirements—for the altered luminaires only:

- Multi-level lighting controls (**Section 130.1(b)**)
- Daylight controls (**Section 130.1(d)**)

Compliance Requirements for Lighting Alterations

Type of Change to Existing Lighting	Total Portion of Existing Luminaires Affected by Alterations per Enclosed Space	Resulting Lighting Power	Mandatory Control Provisions for Each Enclosed Space	Multi-level Lighting Control Requirements for Each Altered Luminaire
Luminaire Replacement Luminaire removal and reinstallation Luminaire relocation	LESS THAN 10%	Lowered or unchanged	No changes required for compliance	
	10% OR MORE	85% or less of allowed lighting power under the Area Category Method Section 140.6	Area Controls Section 130.1 (a) Automatic Shut-off Controls Section 130.1 (c)	Multi-level controls Section 130.1 (b) OR Bi-level controls with at least one step at 30–70% of design lighting power
		86%–100% of allowed lighting power under the Area Category Method Section 140.6	Area Controls Section 130.1 (a) Automatic Shut-off Controls Section 130.1 (c) Automatic Daylighting Controls Section 130.1 (d)	Multi-level controls Section 130.1 (b)

Based on Table 141.0-E in the standards

NOTE:

- Bi-level lighting controls must provide reasonably uniform illumination.
- Controls and equipment must comply with applicable mandatory requirements (per **Section 110.9**) and be installed according to manufacturers' instructions, per **Section 130.0(d)**.

Luminaire Modifications-in-Place

This new category allows lighting retrofit projects to take place with fewer requirements than alterations. If fewer than 40 luminaire modifications-in-place are undertaken within one year in a building space as defined by this section of the standards, then no changes are required for compliance. For luminaire modifications-in-place, a “building space” is defined as any of the following:

- A single-story building
- A complete floor of a multi-floor building
- The entire space in a building with a single tenant under a single lease
- All of the common, not leasable space in a single building

When more than 40 luminaire modifications-in-place are done in the course of a year, then areas where at least 10% of the luminaires are affected must comply with the applicable lighting requirements. Any areas that do not change 10% or more of the luminaires are not required to comply with **Table 141.0-F**.

Title 24, Part 6 defines the following as luminaire modifications-in-place:

- One-to-one luminaire replacements (disconnecting old and reconnecting new)
- Lamp and ballast replacements that preserve the original luminaire type and listing
- Whole-fixture retrofit kit installations
- Reflector or optical system modifications
- Changes to the number or type of light source used by a luminaire, including: socket renewal, removal or relocation of sockets/lamp holders, changes to wiring internal to the luminaire

The benefit of classifying a project as a modification-in-place is that 39 luminaires can be modified-in-place without triggering additional requirements. To qualify as luminaire modifications-in-place, lighting alterations cannot result from any general remodeling of the enclosed space in which they are located and cannot involve changes to panelboard or branch circuit wiring.

Compliance Requirements for Luminaire Modifications-in-Place

Type of Change to Existing Lighting	Total Portion of Existing Luminaires Affected by Modifications-in-Place, per Building, per Year	Resulting Lighting Power	Mandatory Control Provisions for Each Enclosed Space	Multi-level Lighting Control Requirements for Each Altered Luminaire
	FEWER THAN 40	Lowered or unchanged	No changes required for compliance	
Group lamp and ballast change-outs	40 OR MORE	85% or less of allowed lighting power under the Area Category Method Section 140.6	Area Controls Section 130.1 (a) Automatic Shut-off Controls Section 130.1 (c)	Multi-level controls Section 130.1 (b) OR Bi-level controls with at least one step at 30–70% of design lighting power
Reflector or optical system modifications		86–100% of allowed lighting power under the Area Category Method Section 140.6	Area Controls Section 130.1 (a) Automatic Shut-off Controls Section 130.1 (c) Automatic Daylighting Controls Section 130.1 (d)	Multi-level controls Section 130.1 (b)
Installation of whole-fixture retrofit kits				

Based on Table 141.0-F in the standards

NOTE:

- Bi-level lighting controls must provide reasonably uniform illumination.
- Controls and equipment must comply with applicable mandatory requirements (per **Section 110.9**) and be installed according to manufacturers' instructions, per **Section 130.0(d)**.



PHOTO: SORAA



MANDATORY LIGHTING CONTROL MEASURES



[energycodeace.com/
content/reference-ace](http://energycodeace.com/content/reference-ace)

The Reference Ace™ tool helps users navigate the Title 24, Part 6 Standards documents. Keyword search capabilities along with hyperlinks allow users to jump directly to related sections.

The current 2013 version of the Reference Ace links the relevant sections of the Building Energy Efficiency Standards, Reference Appendices and the Residential and Nonresidential Compliance Manuals.

New requirements for lighting controls constitute one of the biggest changes to the Title 24, Part 6 standards. The requirements for indoor lighting controls are included in **Section 130.1**. For new construction projects, including additions, all subsections within **Section 130.1** must be considered. Both alterations and modifications-in-place trigger controls requirements as well. However, not all measures will be implemented in every project.

Determining what controls measures will be required is connected to quantity of luminaires affected by the project, per enclosed space, and the actual lighting energy use calculations. Some measures may be bypassed if the lighting power density of a space is 85% or less than the maximum allowed. While most requirement triggers are based on a percentage of affected luminaires or a percentage of an allowed LPD, the demand response controls requirements are triggered by reaching an affected square footage threshold. Alterations that involve less than 10,000 ft² within a single building are not required to comply with **Section 130.1(e)**. To determine which measures affect a project, review **Table 141.0-E** for alterations and **Table 141.0-F** for modifications-in-place. These two tables are a valuable tool in this process.

All lighting equipment and control devices specified to meet the requirements must be installed according to manufacturer's instructions and lighting controls should follow the performance and certification requirements listed in **Section 110.9**.

CALIFORNIA ENERGY COMMISSION



[energy.ca.gov/
efficiency/blueprint](http://energy.ca.gov/efficiency/blueprint)

The Energy Commission's Blueprint Newsletter is published by the Standards Implementation Office. Each edition offers information that is helpful in interpreting the Building Energy Efficiency Standards in professional practice. Topics are selected based on needs identified by the energy standards hotline staff.

MANUAL AREA LIGHTING CONTROLS

Section 130.1(a)

Separate Manual Control of Different Areas

The luminaires in each area must be independently controlled from luminaires in other areas by manual lighting controls that provide:

- **ON/OFF functionality** AND
- **Dimming or multi-level control steps** for dimmable luminaires

Manual controls must be located in the same room as the controlled lighting, with some exceptions in retail applications such as malls, atria, and retail and wholesale sales floors. All other spaces such as offices, break rooms, stock rooms and non-public bathrooms must comply.

Specific requirements for continuous dimming or multi-level control steps apply to general lighting and are based on luminaire type, per [Table 130.1-A](#).

Malls and Sales Floors

Manual area lighting controls for sales floors and malls must be:

- **Readily accessible** to authorized personnel,
- **Located so users can monitor the controls' effect**, either by looking directly at the area OR using a device such as the interface of a lighting management system to monitor light levels and lighting loads

Other installed controls may not override manual controls.

Separate Control of Different Lighting Systems

Within each area enclosed by ceiling-height partitions:

- **General lighting** must be controlled separately from all other lighting systems.
- **Ornamental and display lighting**, including lighting for floor and wall displays, window displays, case displays, and special effects lighting, must each be separately controlled on circuits of 20 amps or less.
- **When track lighting is used**, general, display, ornamental, and special effects lighting must each be separately controlled. For this reason, it is helpful to designate the purpose of each track (general or display lighting, etc.) on the building plans.

Egress Lighting

Up to 0.2 watts per square foot (W/ft²) of lighting may remain ON during occupied hours for emergency egress, but only in building spaces designated for emergency egress on building plans. Control switches for the egress lighting must not be accessible to unauthorized personnel. Egress lighting that is part of the general illumination must be shut OFF along with other lighting when the building is not occupied.



PHOTO: ACUITY BRANDS

Annunciation

Malls and sales floors in retail and wholesale stores may be annunciated, meaning the status of lighting loads in these areas may be indicated by a visual signaling device, such as an EMS dashboard or lighting control system interface. This is an exception to [Section 130.1\(a\)2](#), which requires that most area light switches/dimmers be located in the same area as the lights they control, so those operating the controls can visually monitor the effect of the controls on the lighting in the space.



Public Restrooms

Restrooms with two or more stalls are not required to have a manual switch accessible to the public. An ON/OFF control should still be readily accessible to authorized personnel and located in the same room as the controlled lighting, and all other applicable lighting controls are still required.

MULTI-LEVEL CONTROLS FOR GENERAL LIGHTING

Section 130.1(b)

✓ **EXCEPTION: Multi-level Controls for General Lighting**

An area with only one luminaire that has just one or two lamps is exempt from the requirements for multi-level lighting controls.

This section of the standards sets the dimmability requirements, by source and socket type, for the general lighting in a retail space. Dimmable lighting provides the opportunity to reduce lighting energy use while allowing occupants to choose an appropriate light level for each area at any time. Decorative, accent and display lighting is not required to meet the dimming steps in this section. However, if these luminaires are used for general illumination, such as track lighting if it is the only electric lighting illuminating the space, then they must comply.

The standards require the general lighting in any area over 100 ft² with a connected lighting load over 0.5 W/ft² meet all of the multi-level steps described in this section. Full compliance with this section is required for alterations and modifications-in-place with a task area lighting power density greater than 85% of the allowed lighting power. If the lighting power density is less than or equal to 85% in projects that are not new construction or additions, there are some additional options to comply.

Requirements by Luminaire Type

Minimum control steps and illuminance uniformity requirements are based on luminaire type (see the facing-page table, based on [Table 130.1-A](#) of Title 24, Part 6).

All Luminaires Must Comply

Each luminaire must meet every step of the multi-level control requirements. Controlling alternating luminaires or rows of luminaires does not comply.

AUTOMATIC SHUT-OFF CONTROLS

Section 130.1(c)

Automatic shut-OFF controls turn lights OFF when a space is typically unoccupied. These controls are required in addition to manual area lighting controls and meeting the dimmability requirements in [Section 130.1\(b\)](#). In this code cycle, more lighting will be off after hours in spaces that were typically left on all night, such as corridors and stairwells. In retail applications, all lighting should be off when the building is unoccupied with rare exceptions. All lighting must be controlled by one or more of the following types of controls that automatically shut OFF all lights for vacant periods:

- Occupant-sensing control
- Automatic time clocks
- Energy management system (EMS)
- Lighting control system or another type of control mechanism

Multi-level Lighting Controls and Uniformity Requirements for General Lighting

Luminaire Type	Minimum Required Control Steps (% of full rated power ¹)	Uniform Level of Illuminance Achieved By:
Line-voltage sockets except GU-24	Continuous dimming 10–100%	
Low-voltage incandescent systems		
LED luminaires & LED source systems		
GU-24 rated for LED		
GU-24 sockets rated for fluorescent >20 W	Continuous dimming 20–100%	
Pin-based compact fluorescent >20 W²		
GU-24 sockets rated for fluorescent ≤20 W	Minimum one step between 30–70%	Stepped dimming; or continuous dimming; or switching alternate lamps in a luminaire.
Pin-based compact fluorescent ≤20 W²		
Linear & U-bent fluorescent ≤13 W		
Linear & U-bent fluorescent >13 W	Minimum one step in each range	Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of four lamps per luminaire, illuminating the same area and in the same manner.
	20–40%	
	50–70%	
	80–85%	
	100%	
Track Lighting	Minimum one step between 30–70%	Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.
HID >20 W	Minimum one step between 50–70%	Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of two lamps per luminaire, illuminating the same area and in the same manner.
Induction >25 W		
Other light sources		

Table 130.1-A in the standards

¹ Full rated input power of ballast and lamp, corresponding to maximum ballast factor² Includes only pin-based lamps: twin tube, multiple twin tube, and spiral lamps

NOTE: Multi-level controls must not override the functionality of other controls required for compliance.

Separate Control of Different Areas

Each room (or "area") on each building floor must separately automatically shut OFF during unoccupied times. Limits apply in terms of how much floor area can be covered by a single control in different types of spaces:

- **Single-tenant retail spaces and malls:** No more than 20,000ft² of floor area may be covered by a single control.
- **Other function areas:** No more than 5,000ft² of floor area may be covered by a single control.

✓ **EXCEPTION: Separate Control of Different Lighting Systems**

Buildings with lighting in continuous use (24 hours per day, 365 days per year) are not required to have automatic shut-off controls. Electrical equipment rooms are another exception.

Separate Control of Different Lighting Systems

Separate automatic shut-off controls are required for general, display, display case and ornamental lighting.

Countdown Timer Switches

If countdown timer switches are selected to comply with the shut-off requirements, they may only be used in the following specific applications:

- **Single-stall restrooms smaller than 70ft²:** Maximum setting: 10 minutes
- **Closets smaller than 70ft²:** Maximum setting: 10 minutes
- **Aisles in server rooms smaller than 500ft²:** Maximum setting: 30 minutes

As an alternative to countdown timer switches, these same spaces can also comply with the automatic shut-off requirements with occupancy sensors, automatic time clocks or through an energy management system.

Automatic Time-switch Control

Where time-switch controls are installed instead of occupant-sensing controls, occupants must have a manual override option that allows the lighting to remain ON outside the scheduled time for a maximum of two hours. Malls, single tenant retail and additional applications have an exception that allows for a longer override.

Occupancy Controls Required in Secondary Spaces

In the following spaces, separate controls must automatically reduce lighting energy use at least 50% when no occupants are detected during building hours of operation:

CORRIDORS AND STAIRWELLS

- Each space must be separately controlled
- Sensors must be activated from all potential entrances
- Minimum automatic 50% reduction in lighting power when vacant

WAREHOUSE AISLES AND OPEN AREAS

- Each aisle must be independently controlled
- Minimum automatic 50% reduction in lighting power when vacant
- In warehouses with metal halide or high-pressure sodium light sources, lighting power must be reduced by at least 40% when aisles or open areas are vacant

DAYLIGHTING CONTROLS

Section 130.1(d)

The standards address three types of daylit zones:

1. **Skylit zones:** Areas illuminated by one or more skylights
2. **Primary sidelit zones:** Daylit areas directly adjacent to one or more windows
3. **Secondary sidelit zones:** Areas not directly adjacent to a window but close enough to still receive some daylight

General Lighting in Daylit Zones

Automatic daylighting controls are required for luminaires that meet these criteria:

- Provide general lighting (as opposed to display lighting, decorative chandeliers or ornamental lighting)
- Are located at least partially in a skylit or primary sidelit zone
- Are installed in an area with a total installed general lighting power of 120 watts or more
- Are located in a room with at least 24 ft² of glazing
- Luminaires in skylit and primary sidelit zones must be controlled separately from each other. Luminaires installed where a skylit zone and primary sidelit zone overlap are controlled as part of the skylit zone, except for rooms with less than 24 ft² of glazing.

Daylighting Control Requirements

When compliance with this section is required, general lighting will be adjusted when enough daylight is available with automatic daylighting controls that must:

- Provide multi-level lighting in accordance with **Table 130.1-A** unless the lighting power density is less than 0.3 watts per square foot
- Maintain design light levels for each space, i.e., at or above those provided by electric lighting when no daylight is available
- Reduce general lighting power in a daylit zone at least 65% when the daylight contribution in that zone is more than 150% of the general lighting system's design light level at full power

In projects that qualify as alterations and modifications-in-place, the daylighting requirements in this section can often be bypassed if the actual lighting power is lower than 85% of the lighting power density required for that task area. Also, only altered luminaires need to comply with the daylight control requirements.

PRESCRIPTIVE REQUIREMENTS

When using the prescriptive compliance approach for a space, the requirements for automatic daylighting controls in primary sidelit zones also apply to general-lighting luminaires that are at least 50% in a secondary sidelit zone.

Floor plans for most buildings located in climate zones 2–15 that are over 5,000 ft² with a ceiling height of greater than 15 ft must have 75% of their total floor area in daylit zones, per **Section 140.3(c)**.



Daylight Commissioning

Proper calibration of daylighting controls enables these devices to maintain a proper balance between daylight and electric lighting contributions.

✓ EXCEPTION: Daylighting Control Requirements

General lighting in rooms with a total glazing area of less than 24 ft² are not required to meet the daylighting control requirements.

*Controlled lighting with a lighting power density less than 0.3 W/ft² does not have to meet the multi-level requirements in **Section 130.1(b)**.*

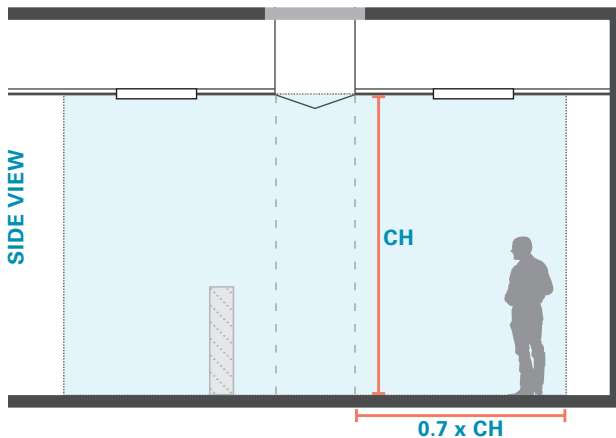
Determining Daylit Zones

All skylit zones and primary sidelit zones must be shown on building plans. The easiest way to determine the size of daylit zones is examining building plans.

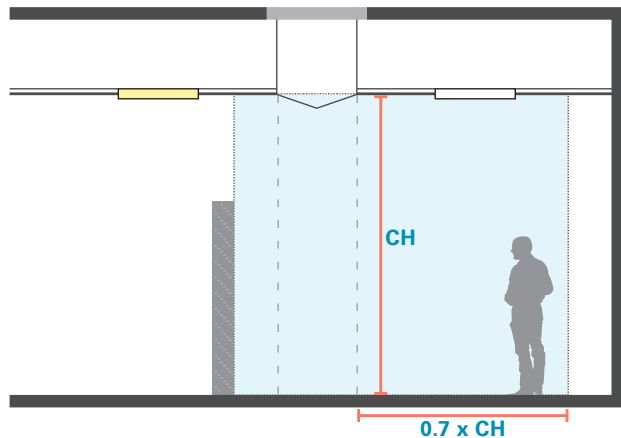
CALCULATING A SKYLIT ZONE

1. **Define the shape of the skylight.** A rectangular skylight produces a rectangular daylight zone, and a circular skylight produces a circular zone, etc.
2. **Determine the average ceiling height (CH) surrounding the skylight.**
The ceiling height is the vertical distance from the finished floor level to the ceiling.
3. **Multiply the CH by 0.7.**
4. **Add the value determined in Step 3 in all directions around the skylight**
(starting at the edges of the opening).
5. Subtract any area blocked from receiving daylight by a permanent obstruction taller than half the distance from the floor to the bottom of the skylight.

Obstruction height less than half the ceiling height

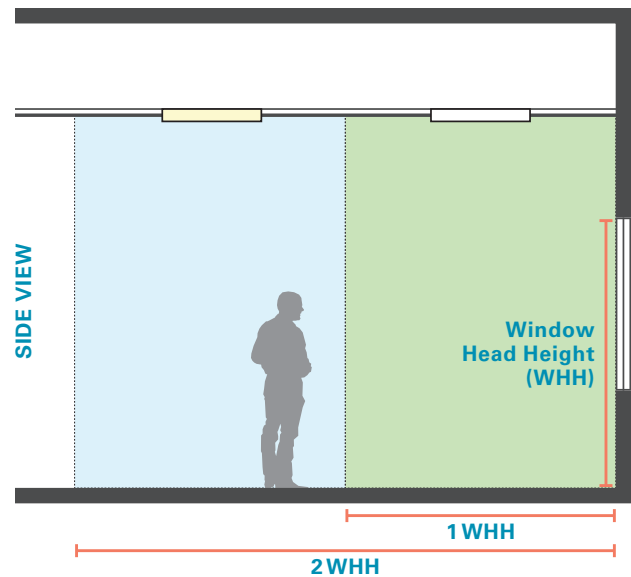


Obstruction height more than half the ceiling height



CALCULATING A PRIMARY SIDELIT ZONE

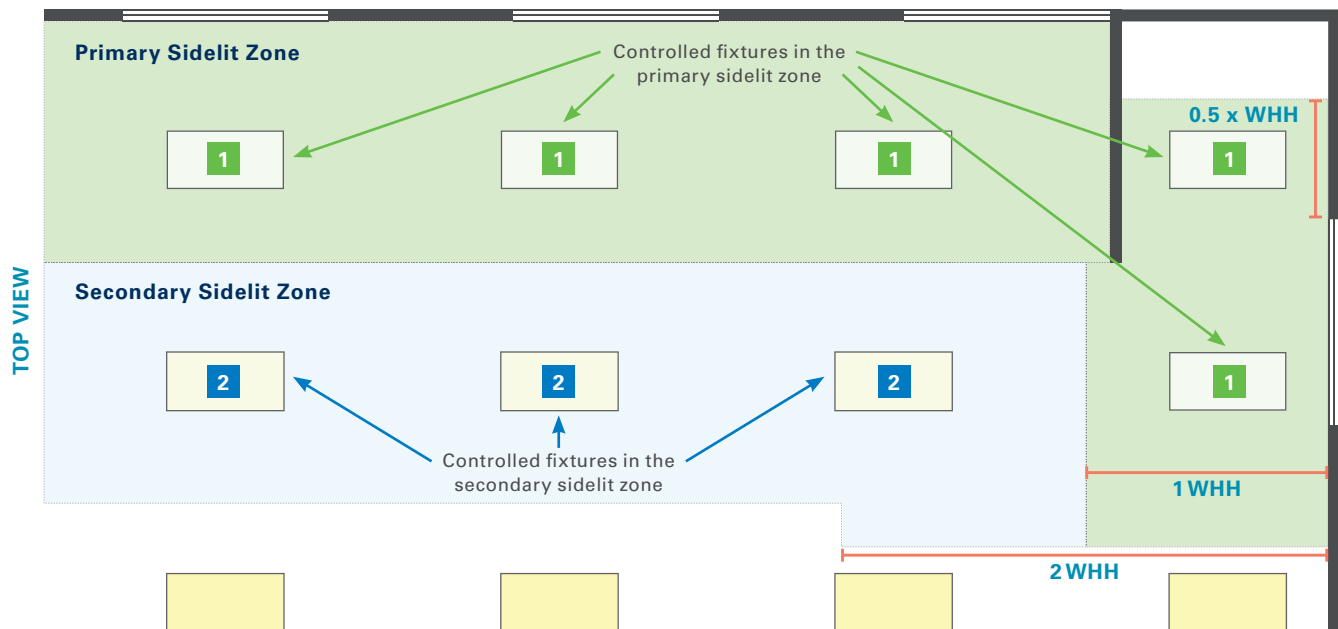
1. **Determine the window head height for each window.** The window head height (WHH) is the vertical distance from the finished floor level to the top of the glazing.
2. **Determine the depth of the zone.** The zone depth is one window head height into the area adjacent to the window.
3. **Calculate the width of the zone.** The zone width is the window's width added to half the window head height on each side of the window.
4. Subtract any area blocked from receiving daylight by a permanent obstruction that is six feet or taller. Modular furniture is not considered a permanent obstruction.



CALCULATING A SECONDARY SIDELIT ZONE

A secondary sidelit zone extends one additional window head height beyond the primary sidelit zone(s) adjacent to it.

1. Add one additional window head height to the same dimensions determined for primary sidelit zones, to determine the depth and width of the secondary sidelit zone.
2. Subtract any area that is blocked from receiving daylight by a permanent obstruction that is 6' or taller.



AUTOMATED DEMAND RESPONSE CONTROLS

Section 130.1(e)

Automated demand response (ADR) programs use energy management technologies and controls to respond to reduce peak demand and stabilize the grid more quickly and reliably than manual demand response (DR). An automated DR signal is sent from a utility, independent system operator or other power provider to energy management control systems enrolled in ADR programs. The automated systems then reduce electricity use temporarily, according to pre-programmed load shed strategies.

Buildings over 10,000ft²

Project work areas larger than 10,000ft² must be capable of automatically responding to a DR signal by:

- Reducing lighting power at least 15% below total installed lighting power AND
- Observing uniform level of illumination requirements consistent with the multi-level controls requirements listed in **Table 130.1-A**

A project work area can be comprised of various task areas and does not have to be continuous. If the total affected square footage of the project exceeds 10,000 ft², ADR compliance is likely required. It is important to note that per **Table 141.0-F** lighting retrofits that are classified as modifications-in-place will not trigger **Section 130.1(e)**, even if they exceed the square footage threshold.



Lighting Loads & ADR

Lighting is extremely well-suited to ADR since peak demand periods typically overlap daylight hours. Research shows illuminance levels can be reduced by as much as 20% without occupants detecting the change. Optimal light levels are also easily, immediately restored after a DR event. Heating and cooling loads require time and additional energy.

Spaces Not Included in the ADR Plan

Lighting load in the following space types is treated differently:

- Non-habitable spaces (such as storage closets) may not be counted toward the 15% reduction for compliance purposes, but they can be included in the DR plan when the facility is in operation for additional reductions
- Spaces using a sum total of less than 0.5 W/ft² may not be counted in the building's ADR plan, as these spaces rarely have spare lighting load to shed

Designers are responsible for specifying controls compatible with the local utility company's protocol. The lighting control system must be programmed to automatically respond to DR signals in compliance with Title 24, Part 6 before the project is considered ready for the ATT and the building inspector. The ATT will verify that the ADR system is capable of the appropriate reduction as part of the acceptance testing process.



PERFORMANCE APPROACH

The Performance Approach to compliance is a software-based method that uses energy modeling to plan for an energy efficient building. This method is commonly used in new construction projects, rather than lighting retrofits.

System Trade-offs Allowed

In addition to meeting the mandatory requirements, actual lighting power may not exceed LPD limits set forth by the standards, unless traded with other energy features of the building using the Performance Approach. The Performance Approach to complying with these limits is recommended for professionals with experience using software modeling to manage energy budgets.

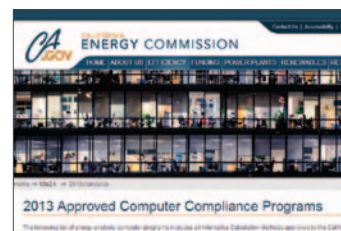
Under the Performance Approach, trade-offs may be made between different systems within a building. For example, energy-efficient lighting can allow more installed power for heating and cooling. There is no trade-off benefit to using this method on projects that only affect the lighting system.

Approved Software Required

Those choosing the Performance Approach to compliance must use software to model building energy use, and that software must be approved by the Energy Commission. At the time this guide was created, two programs were approved for use with nonresidential building projects:

- **CBECC-Com V2b:** CBECC-Com uses EnergyPlus v8.0 to perform simulations and Sketchup (v8.0/Pro) with OpenStudio SketchUp Plugin for geometry input. Software can be downloaded at: bees.archenergy.com/software.html
- **IES Virtual Environment 2013 Title-24 Feature Pack 1 (VE2013 Title-24 FP1:** Integrated Environmental Solutions' VE Feature Pack works with SketchUp, Revit, DXF, gbXML, and IFC to import model geometry; data can be shared across all VE modules including the VE-Navigator for ASHRAE 90.1 (LEED Energy), Daylighting and Solar analysis modules. Software can be downloaded at: www.iesve.com/software/title24
- **EnergyPro Nonresidential:** This software was conditionally approved for demonstrating compliance with the nonresidential provisions of the standards until 03/31/2015. Software can be downloaded at: energysoft.com/download/energypro-6

Professional energy consultants to assist with the Performance Approach and Title 24, Part 6 compliance can be located through the California Association of Building Energy Consultants.



Approved Computer Compliance Programs

energy.ca.gov/title24/2013standards/2013_computer_prog_list.html

More information on "Approved Computer Compliance Programs" is available through the Energy Commission's website.



PHOTO: SORAA

+ PRESCRIPTIVE APPROACH

Retailers opting to use the Prescriptive Approach to lighting power density compliance should select one of the following methods to calculate the allowed indoor lighting power for each room or area of a building:

- 1. Area Category Method**
- 2. Tailored Method**

Both methods involve multiplying the area of a space (ft²) by the allowed LPD (W/ft²) for that space and adding special allowances for display lighting and decorative or ornamental lighting. Actual lighting power may not exceed this allotment.

With the Prescriptive Approach, trade-offs are limited to general lighting power and restricted to certain space types.

Under the Prescriptive Approach, the actual lighting power is compared to an allowed lighting power total. If the actual is less than or equal to the allowed, the project complies with the lighting power budget requirements.

Prescriptive Approach in Practice

Exercises for lighting power adjustments, Area Category Method, and Tailored Method can be found at the end of this section.



ACTUAL LIGHTING POWER

Section 140.6(a)

The actual indoor lighting power of the proposed building area is the total sum of all planned permanent and portable lighting systems, after any lighting power adjustments.

Lighting Power Adjustments

Exceeding the mandatory requirements for lighting controls (for example, by installing a control where it is not required) makes an installation eligible for a Power Adjustment Factor (PAF). This lowers the calculated lighting power use for the installed system.

Lighting Power Reduction = Controlled lighting power x PAF from Table 140.6-A

Lighting Power Density Adjustment Factors (PAF)

Type of Control		Type of Area	Factor
a. To qualify for any of the Power Adjustment Factors in this table, the installation will comply with the applicable requirements in Section 140.6(a)2 b. Only one PAF may be used for each qualifying luminaire unless combined below c. Lighting controls that are required for compliance with Part 6 shall not be eligible for a PAF			
Partial-ON Occupant Sensing Control		Any area $\leq 250 \text{ ft}^2$ enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room	0.20
Occupant Sensing Controls in Large Open Plan Offices		In open plan offices $> 250 \text{ ft}^2$: One sensor controlling an area that is:	No larger than 125 ft^2
			From 126 to 250 ft^2
			From 251 to 500 ft^2
Dimming System	Manual Dimming	Hotels/motels, restaurants, auditoriums, theaters	0.10
	Multiscene Programmable		0.20
Demand Responsive Control		All building types less than $10,000 \text{ ft}^2$ Luminaires that qualify for other PAFs in this table may also qualify for this demand responsive control PAF	0.05
Combined Manual Dimming plus Partial-ON Occupant Sensing Control		Any area $\leq 250 \text{ ft}^2$ enclosed by floor-to-ceiling partitions; any size classroom, conference or waiting room	0.25

Table 140.6-A in the standards

Lighting Power Exclusions

The power used by certain lighting applications may be excluded from actual lighting power calculations. Selections from the list of exclusions include but are not limited to:

- Equipment that is for sale and for demonstration
- Manufacturer-installed lighting in vending machines, refrigerated cases, walk-in freezers, and food preparation equipment

DETERMINING ALLOWED POWER UNDER THE AREA CATEGORY METHOD

Section 140.6(c)2

The Area Category Method provides a single lighting power allowance for each primary function area listed in **Table 140.6-C**. This exact value is calculated by multiplying the entire area (ft²) of each function area (including floor space used by partitions) by the Allowed Lighting Power (W/ft²) for that function area.

Allowed Lighting Power = W / ft² from Table 140.6-C x entire floor area

The total allowed lighting power is the sum of the lighting power allotments for all the areas covered by the permit application.

Additional Lighting Power Allotments

Additional lighting energy use is allowed under the Area Category Method for areas including but not limited to:

- Adjustable or directional accent, display and feature lighting
- Decorative lighting
- Ornamental lighting

Retail-specific selections from the Allowed Lighting Power table

Primary Function Area	Allowed General Lighting Power	Additional Power Allowances (As listed in footnotes for Table 140.6-C)
Retail Merchandise Sales Areas and Wholesale Showroom Areas	1.2 W/ft ²	+ 0.3 W/ft ² Accent, Display and Feature Lighting using adjustable luminaires
		+ 0.2 W/ft ² Decorative Lighting
Malls and Atria	1.2 W/ft ²	+ 0.5 W/ft ² Ornamental Lighting
Waiting Area	1.1 W/ft ²	+ 0.5 W/ft ² Ornamental Lighting
Commercial and Industrial Storage Areas (conditioned and unconditioned)	0.6 W/ft ²	
Corridors, Restrooms, Stairs, and Support Areas	0.6 W/ft ²	
Locker / Dressing Room	0.8 W/ft ²	

Based on Table 140.6-C: Area Category Method—Lighting Power Density Values in the standards

DETERMINING ALLOWED POWER UNDER THE TAILORED METHOD

Section 140.6(c)3

The Tailored Method is typically used for projects that include space types listed in **Table 140.6-D** of the standards. Within the retail sector, these space types include:

- Merchandise sales areas
- Dining areas (i.e. a coffee shop or snack bar)
- Showroom areas
- Financial transaction areas
- Malls and atria
- Grocery store areas

Retail space types, or “primary function areas,” not listed in **Table 140.6-D** can refer to the Tenth Edition IES Handbook to apply the tailored method in other areas by obtaining an illuminance value appropriate for the tasks occurring in that area. See **Section 140.6(c) 3 H (i) (e)** for details.

General Lighting Power Allotments

Under the Tailored Method, general lighting power allotments are tailored to each space or area based on the dimensions of the space, including ceiling height and IES-recommended illumination levels. The process includes the following steps:

1. Determine the primary function area, and the illuminance value (listed in lux) per **Table 140.6-D**
2. Determine the room cavity ratio (RCR) according to **Table 140.6-F**
3. Use the illuminance value and the RCR to find the allowed LPD according to **Table 140.6-G**

Areas with high ceilings have a high RCR, making them more difficult to light. The Tailored Method allows greater LPD allowances as the RCR increases. The RCR trigger points for increased LPD allowances start 2.0, then increase at 3.5 and 7.0.

GENERAL LIGHTING TRADE-OFFS

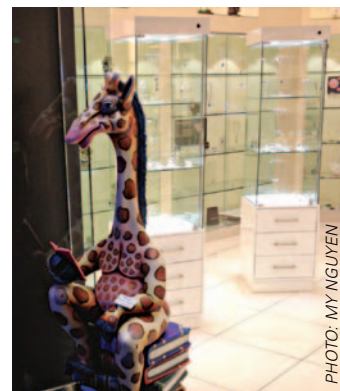
The Tailored Method allows for certain LPD trade-offs for general lighting only. Trade-offs must be documented using compliance forms and must be kept within conditioned areas or within unconditioned areas. Trade-offs are allowed:

- From one conditioned area using the Tailored Method to another conditioned area using either the Tailored or Area Category Method
- From one unconditioned area using the Tailored Method to another unconditioned area using either the Tailored or Area Category Method



"Area" Defined for the Tailored Method

*The standards define an "area" as all the contiguous areas associated with a single primary function area listed in **Table 140.6-D**.*



Use It or Lose It

Additional lighting power allowances, such as those for display lighting, cannot be used in other areas or applications. Such trade-offs are only allowed for general lighting.

Additional Lighting Power Allotments

In addition to general lighting power allotments, the Tailored Method provides lighting energy use allotments for special tasks that use lighting as a way to draw attention to an area of the retail application, by providing visual contrast to what is contributed from the general lighting:

- **Wall display lighting:** Supplementary lighting required to highlight features such as merchandise on a shelf, which is displayed on perimeter walls. It provides a higher level of illuminance to a specific area than the level of surrounding ambient illuminance.
- **Floor display lighting and task lighting (combined):** Supplementary lighting required to highlight features, such as merchandise on a clothing rack, which is not displayed against a wall. It provides a higher level of illuminance to specific areas of the sales floor than the level of surrounding ambient illuminance. Task lighting specifically illuminates a location where a task is performed, such as a examining fine details on jewelry.
- **Ornamental/special effects lighting:** Decorative indoor luminaires are typically chandeliers, sconces, theatrical projectors, dynamic or moving lighting or illuminated colored panels that are not providing general illumination. Neon and cold cathode lighting devices are often associated with this category.
- **Very valuable display case lighting (internal display case lighting or external lighting employing highly directional luminaires):** This includes lighting for locked cases that contain rare or precious objects such as jewelry, coins, small art objects, crystal, ceramics, or silver. The objects involve customer inspection of very fine details from outside the case.

Lighting Power Allowances

Primary Function Area	General Illumination Level	ALLOWED POWER			
		Wall Display	Floor Displays, Internal Display Case and Task	Ornamental and Special Effects	Very Valuable Display Case*
Retail Merchandise Sales Areas and Wholesale Showroom Areas	400lx	14 W/ft ²	1 W/ft ²	0.5 W/ft ²	THE LEAST OF: <ul style="list-style-type: none"> ▪ Primary Function area x 0.8 W/ft² ▪ Display case area x 12 W/ft² OR Total lighting power for the case
Malls and Atria	300lx	3.5 W/ft ²	0.5 W/ft ²	0.5 W/ft ²	
Grocery Store Area	500lx	8 W/ft ²	0.9 W/ft ²	0.5 W/ft ²	
Dining Area	200lx	1.5 W/ft ²	0.6 W/ft ²	0.5 W/ft ²	
Financial Transaction Area	300lx	3.15 W/ft ²	0.2 W/ft ²	0.5 W/ft ²	
Waiting Area	300lx	3.15 W/ft ²	0.2 W/ft ²	0.5 W/ft ²	

Based on Table 140.6-D in the standards

* The maximum lighting power allotment for very valuable display case lighting is the lowest product of the three calculations listed in the table above. Note that cases qualifying as very valuable display cases are different from display cases grouped with floor displays (see **Sections 140.6(c)3Liii** and **140.6(c)3Liv**). Additional lighting power allotments for valuable display case lighting must be documented on compliance forms.

Room Cavity Ratio

The room cavity ratio describes the configuration of a room. Rooms with high ceilings are typically more difficult to illuminate and have a high RCR. Because luminaires are not as effective in areas with a high RCR, the standards allow a higher lighting power density.

The RCR must be calculated for any function area using the Tailored Method. **Section 140.6-F** of the standards provides the equations for the calculations.

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

✓ **EXCEPTION:**
Room Cavity Ratio

*RCR allows for imaginary or virtual walls when the boundaries are established by "high stack" elements (close to the ceiling structure and high storage (shelves) or high partial walls defined as "perimeter full height partitions" described in **Section 140.6(c) 3liv**.*

Room Cavity Ratio (RCR) Equations

Determine the Room Cavity Ratio using one of the following equations

Room cavity ratio for rectangular rooms

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

Room cavity ratio for irregularly shaped rooms

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

H = Vertical distance from the work plane to the center line of the lighting fixture
L = Room Length W = Room Width P = Room Perimeter Length A = Room Area

Table 140.6-F in the standards



PRESCRIPTIVE APPROACH IN PRACTICE

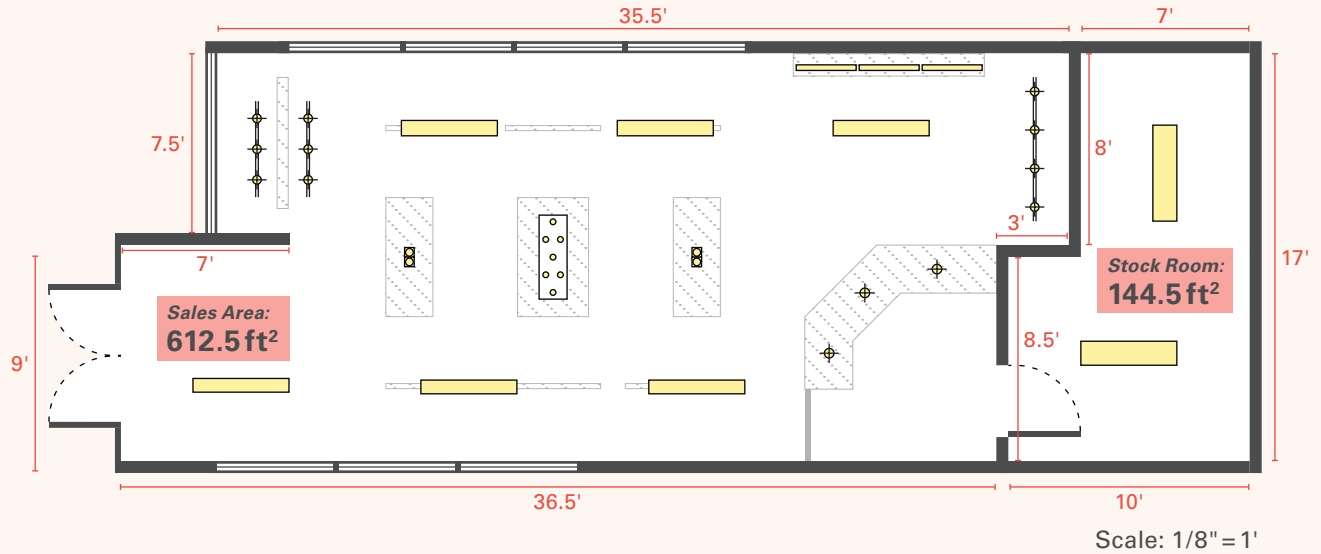
The floor plan on the next page features a 767 ft² clothing and accessory retail store. The store has 11.5-ft ceilings. Six 4-ft suspended linear pendants are used for general lighting. There are 19-ft of track lighting in the window display area and on the back wall. The shelves have three LED under-shelf luminaires. The store has ornamental pendants on the center table display, adjustable downlights for floor display lighting, and pendants for task lighting. It has a total of 41.5 ft of floor-to-ceiling windows. The store also has a 144.5 ft² stock room with 1x4 troffers with partial-ON occupancy controls.

The following exercises are designed to follow the forms and Certificates of Compliance for Nonresidential Indoor Lighting. They are on the Energy Commission's website at energy.ca.gov/title24/2013standards/nonresidential_manual.html.

- NRCC-LTI-01-E** Indoor Lighting
- NRCC-LTI-02-E** Indoor Lighting Controls
- NRCC-LTI-03-E** Indoor Lighting Power Allowance
- NRCC-LTI-04-E** Tailored Method Worksheets
- NRCC-LTI-05-E** Line-Voltage Track Lighting Worksheet

JONNY'S BOUTIQUE

767 ft² retail store



Indoor Lighting Schedule

Symbol	Luminaire	Qty.	Watts	Total Watts	Efficacy* (Lumens / Watt)
	4' SUSPENDED LINEAR PENDANT Lunera L7-G3	6	44	264	69
	RECTANGLE CANOPY WITH PENDANTS Tech Lighting Freejack Rectangle Canopy 7 Port Tibor Pendant	1-7-port mount 7 pendant	6	42	60
	4" ADJUSTABLE RECESSED DOWNLIGHT Juno IC LED Retrofit Eyeball Trim	4	11	44	54.5
	TRACK SYSTEM WITH LED HEADS* Tech Lighting Envision 18W LED Head Nora Lighting Two-Circuit Track with NT-2358/IA Current Limiter	2-4' tracks 3 heads each 1-6' track 4 heads	60 75	195	47
	UNDER-SHELF LIGHTING Tech Lighting 30" Unilume Slimline	3	18	54	61
	PENDANT WAC Lighting Rocket	3	12	36	35
	1x4 RECESSED TROFFER Cree CR14	2	33	66	115

Use to fill in NRCC-LTI-01-E
"C. Indoor Lighting Schedule and Field Inspection Energy Checklist"

Total Watts:
701 W

* There are no efficacy requirements for commercial applications in Title 24, Part 6.

** Track system wattage calculated using Method 3 on
"Form NRCC-LTI-05-E: Line Voltage Track Lighting Worksheet."

ACTUAL LIGHTING POWER

Lighting Control Credits

This lighting plan exceeds the mandatory requirements for lighting controls by including the two 1x4 recessed troffers connected to partial-ON occupant sensing controls in the stock room. These controls comply with [§ 130.1\(a\)](#), [§ 130.1\(c\)](#), and [§ 130.1\(a\)2](#) and is exempt from [§ 130.1\(b\)](#). Additionally, this is an enclosed area that is smaller than 250 ft².

This design is eligible for a PAF, which lowers the calculated lighting power use for the installed system.

1. Determine the PAF using [Table 140.6-A](#).

The PAF is 0.20.

2. Calculate the watts of controlled lighting. There are two 33 W troffers so there are **66 W of controlled lighting.**

3. Multiply the watts of controlled lighting by the PAF to determine the control credit.
66 W x 0.20 = 13.2 W

There are 13.2 W of lighting control credits.

Adjusted Lighting Power

Using [Form NRCC-LTI-01-E](#), calculate the adjusted installed lighting power by subtracting the lighting control credits from the total installed lighting.

701 W – 13.2 W = 687.8 W

The adjusted lighting power is 687.8 W.

**Form NRCC-LTI-02-E:
Indoor Lighting —
Lighting Controls**

**Mandatory and
Prescriptive Indoor
Lighting Control Schedule,
PAF Calculation, and Field
Inspection Checklist**

**Form: NRCC-LTI-01-E:
Indoor Lighting**

**Summary of Allowed
Lighting Power**

AREA CATEGORY

Lighting Power Allowance

There are two function areas in this space. The main sales floor is classified as "Retail Merchandise Sales, Wholesale Showroom Areas." The stock room is classified as "Commercial and Industrial Storage Areas (conditioned and unconditioned)."

1. Determine the watts per square foot according to [Table 140.6-C](#).
Retail Merchandise Sales, Wholesale Showroom Areas: **1.2 ft²**
Commercial and Industrial Storage Areas
(conditioned and unconditioned): **0.6 ft²**
2. Multiply the watts per square foot by the area of the spaces.
1.2 W/ft² x 612.5 ft² = 735 W
0.6 W/ft² x 144.5 ft² = 86.7 W
3. Total the allowed watts.
735 W + 86.7 W = 821.7 W

The allowed watts for this space is 821.7 W.

Additional Lighting Wattage Allowance

The pendant canopy in this space is classified as "Decorative Lighting," while the adjustable recessed downlights, track lighting, and shelf lighting is classified as "Display Lighting," according to the footnotes in [Table 140.6-C](#).

1. Determine the additional watts allowed according to the footnotes in [Table 140.6-C](#).
Decorative Lighting: **0.2 W**
Display Lighting: **0.3 W**
2. Determine the square feet of the sales area.
612.5 ft²
3. Calculate the wattage allowance by multiplying the square feet of the sales area by the additional watts allowed.
Decorative Lighting: **612.5 ft² x 0.2 W = 122.5 W**
Display Lighting: **612.5 ft² x 0.3 W = 183.75 W**
4. Choose the smaller of either the newly calculated allowed watts or the total design watts of the luminaire.

There are 42 W for decorative lighting and 183.75 W for display lighting, totaling 225.75 W of additional allowed lighting wattage.

Total Lighting Power Allowances

Using [Form NRCC-LTI-03-E](#), calculate the adjusted installed lighting power by adding the additional lighting wattage allowance to the general lighting power allowance.

$$821.7W + 225.75W = 1,047.45W$$

The adjusted lighting power is 1,047.45 W.

**Form NRCC-LTI-03-E:
Indoor Lighting
Power Allowance**

**C-2 Area Category
Method General Lighting
Power Allowance**

**C-3 Area Category
Method Additional
Lighting Wattage
Allowance**

**C-1 Area Category
Method Total Lighting
Power Allowances**

TAILORED METHOD

Room Cavity Ratio

This floor plan is a non-rectangular shape so the RCR can be determined by the calculation for irregular-shaped rooms in [Table 140.6-E](#).

The stock room is not listed as a primary function area so it is not included in the total room area.

1. Determine the room area (A) of the sales area. **612.5ft²**
2. Determine the room perimeter (P). **108.5ft**
3. Determine the room cavity height (H). **11.5ft**
4. Calculate the RCR by using the room cavity ratio equation for irregular shaped rooms.

$$2.5 \times 11.5\text{ft} \times 108.5\text{ft} / 612.5\text{ft}^2 = 5.1$$

The RCR for this store is 5.1.

Allowed General Lighting Power

According to [Table 140.6-D](#), this retail store can be classified as "Retail Merchandise Sales, and Showroom Areas." The stock room is not listed as a primary function area. It must follow the Area Category Method of compliance and is not included in the total room area.

1. Determine the illuminance value using [Table 140.6-D](#). **400lx**
2. Use the RCR to determine the allowed LPD using [Table 140.6-G](#).
The RCR is 5.1. The RCR is > 3.5 and ≤ 7.0 and the illuminance level is 400 so **the allowed LPD is 1.5.**
3. Multiply the allowed LPD by the floor area.

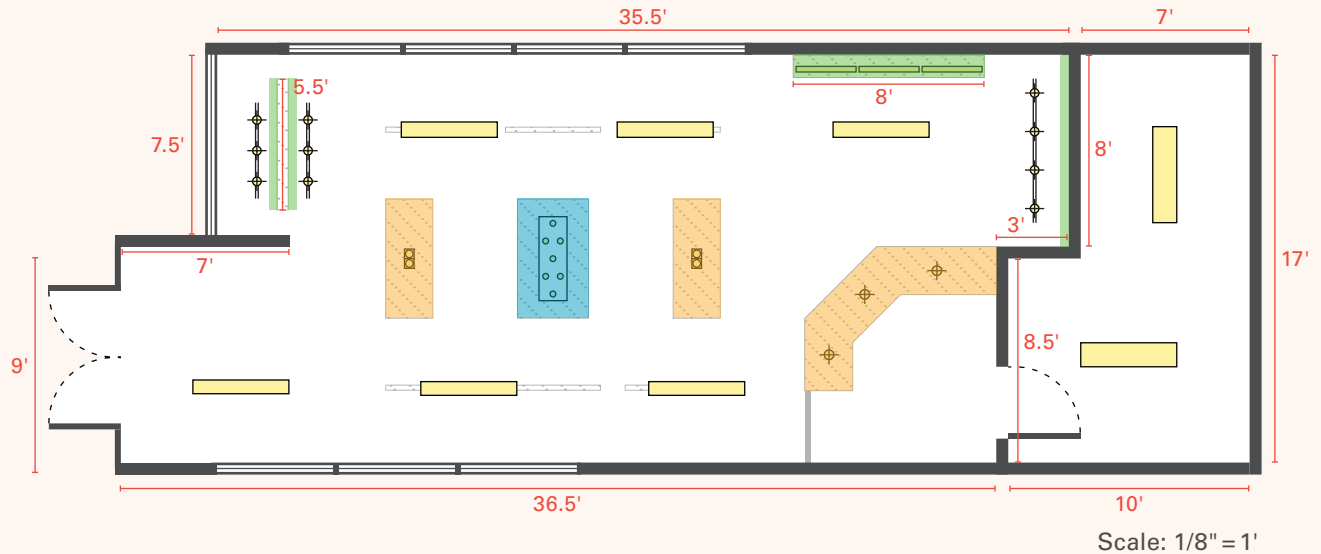
$$1.5 \times 612.5\text{ft}^2 = 918.75\text{W}.$$

There are 918.75 W allowed watts for general lighting.

**Form NRCC-LTI-04-E:
Tailored Method**

**Room Cavity
Ratio (RCR) Worksheet**

**Tailored Method Allowed
General Lighting Power
from Table 140.6-D**



Additional Lighting Power Allowances

Additional lighting power allowances include lighting that is not general lighting. For this store, the track lighting, adjustable recessed downlights, pendants, and ornamental pendant canopy qualify for additional lighting power allowances.

Calculations for these allowances depend on the areas they are illuminating, including wall displays and table surfaces. Refer to **Table 140.6-D** for lighting power allowances and **Table 140.6-F** for adjustments for mounting height above floor.

WALL DISPLAY LIGHTING

The track lighting in the front window display on either side of the dividing wall and the display in the back of the store qualifies as wall display lighting. Wall display lighting also includes lighting for shelves, according to the standards.

Each LED track head is 18W. The mounting height for all luminaires is < 12 ft and the mounting height factor is 1.00. The wall display power according to **Table 140.6-D** is 14 W/ft².

- Determine the wall display length in linear feet.
 Window Display (front): **5.5 ft** Window Display (back): **5.5 ft**
 Back Wall Display: **8 ft** Shelf: **8 ft**
- Multiply the wall display length by the wall display power to determine the allotted watts.
 Window Display (front): **5.5 ft x 14 W / ft² = 77 W**
 Window Display (back): **5.5 ft x 14 W / ft² = 77 W**
 Back Wall Display: **8 ft x 14 W / ft² = 112 W**
 Shelf: **8 ft x 14 W / ft² = 112 W**
TOTAL ALLOTTED WATTS: 378 W
- Calculate the design watts by multiplying the mounting height factor, watts per luminaire, and the number of luminaires.
 Window Display (front): **1.00 x 18 W x 3 = 54 W**
 Window Display (back): **1.00 x 18 W x 3 = 54 W**
 Back Wall Display: **1.00 x 18 W x 4 = 72 W**
 Shelf: **1.00 x 18 W x 3 = 54 W**
TOTAL DESIGN WATTS: 234 W
- Choose the smaller total of either the allotted watts or the design watts.

There are 234 W allowed watts for wall display lighting.

Refer to Section 140.6(c)3I to determine what qualifies for Wall Display Lighting

D-1 Additional allowed lighting power for wall display lighting

FLOOR DISPLAY AND TASK LIGHTING

The four adjustable recessed downlights above the two side tables in the center of the room qualify as floor display lighting. The three pendants above the cashier are considered task lighting.

The mounting height is < 12 ft and the mounting height factor is 1.00.

The allowed combined floor display power and task lighting power is 1 W/ft², according to **Table 140.6-D**.

1. Multiply the area of the primary function area by the lighting power to determine the allotted watts.

Floor Display & Task Lighting Combined:

$$612.5 \text{ ft}^2 \times 1.0 \text{ W / ft}^2 = 612.5 \text{ W}$$

TOTAL ALLOTTED WATTS: 612.5 W

2. Calculate the design watts by multiplying the mounting height factor, watts per luminaire, and the number of luminaires.

$$4" \text{ adjustable recessed downlights: } 1.00 \times 11 \text{ W} \times 4 = 44 \text{ W}$$

$$\text{Pendants: } 1.00 \times 12 \text{ W} \times 3 = 36 \text{ W}$$

TOTAL DESIGN WATTS: 80 W

3. Choose the smaller of either the allotted watts or the design watts.

There are 80 W allowed watts for floor display and task lighting.

ORNAMENTAL AND SPECIAL EFFECTS

The pendant canopy in this space is classified as ornamental lighting.

It is used in a decorative manner and does not serve as display lighting or general lighting.

The allowed ornamental/special effect lighting power according to

Table 140.6-D is 0.5 W/ft².

1. Multiply the area of the primary function area by the lighting power to determine the allotted watts.

$$612.5 \text{ ft}^2 \times 0.5 \text{ W / ft}^2 = 306.25 \text{ W}$$

TOTAL ALLOTTED WATTS: 306.25 W

2. Calculate the design watts by multiplying the watts per luminaire and the number of luminaires.

$$42 \text{ W} \times 1 = 42 \text{ W}$$

TOTAL DESIGN WATTS: 42 W

3. Choose the smaller of either the allotted watts or the design watts.

There are 42 W allowed watts for ornamental lighting.

Lighting Power Allowance Summary

Using **Form NRCC-LTI-04-E**, calculate the total allowed watts using the Tailored Method.

Add the general lighting power to the additional allowed lighting power for wall display, floor display, task, and ornamental lighting.

$$918.75 \text{ W} + 234 \text{ W} + 80 \text{ W} + 42 \text{ W} = 1,274.75 \text{ W}$$

The total allowed watts using the Tailored Method is 1,274.75 W.

Refer to Section 140.6(c)3J to determine what qualifies for Floor Display and Task Lighting

D-2 Additional allowed lighting power for combined floor display and task lighting

Refer to Section 140.6(c)3K to determine what qualifies for Ornamental and Special Effects Lighting

D-3 Additional allowed lighting power for combined ornamental and special effects

Tailored Method Lighting Power Allowance Summary

LINE-VOLTAGE TRACK LIGHTING

There are four different options for determining how many watts of line-voltage track or line-voltage busway has been installed. One or more methods may be used to determine how many watts of line-voltage track or line-voltage busway has been installed. Use this worksheet to separately calculate the input wattage for each system.

- Method 1: Volt-ampere (VA) rating of the branch circuit(s)
- Method 2: Use the higher of 45 watts per linear foot of track or total rated wattage of all luminaires
- Method 3: Use the higher of: 12.5 watts/linear ft of track — or VA rating of a certified integral current limiter
- Method 4: Dedicated track lighting supplementary overcurrent protection panel

Line-Voltage Track Lighting Wattage

The track lighting in this schedule includes an integral current limiter that is certified to the Energy Commission so Method 3 will be used to calculate the line-voltage track lighting wattage. This method will not be recognized if **Installation Certificate NRCI-LTI-03-E** is not submitted.

The VA rating of the integral current limiter is 60W.

1. Determine the amount of linear feet of track in the lighting plan.
Track 1: **4ft** Track 2: **4ft** Track 3: **6ft**
2. Multiply the linear feet of track by 12.5W/LF.
Track 1: **4ft x 12.5W/LF = 50W**
Track 2: **4ft x 12.5W/LF = 50W**
Track 3: **6ft x 12.5W/LF = 75W**
3. Choose the larger of either the linear feet of track multiplied by 12.5W or the VA rating of the integral current limiter.

There are 60W each for the 4ft tracks and 75W for the 6ft track, totaling 195W of installed watts from track lighting.

**Form NRCC-LTI-05-E:
Line-Voltage Track
Lighting Worksheet**

**Method 3 — Use
the Higher of: 12.5
Watts / Linear Foot of
Track — Or VA Rating of
Integral Current Limiter**

**Separately enter each
row of this worksheet
into the luminaire
schedule in Section C
of NRCC-LTI-01-E.**



Dimmable LED Downlights—Just Say When *The Abbey Espresso Bar & Cafe, Belleville, IL*

The Abbey Espresso Bar & Café is more than a coffee shop. It also serves as a live music venue, restaurant, gelato bar, and retail store. The space needed a flexible lighting design that served all these purposes efficiently, effectively and attractively. The dimmable Halo ML56 13.5W LED recessed downlight from Eaton's Cooper Lighting business provides a warm color temperature and 900 lumens. The project saved more than \$2,000 in yearly electricity costs over more traditional 75W PAR30 lamps.

This case study is at cooperindustries.com/content/public/en/lighting/resources/LightingStories/The-Abbey-Espresso-Bar-and-Cafe.html.

REQUIREMENTS & RECOMMENDATIONS

BY SPACE TYPE

DESIGNING TO CODE

Good retail lighting can enhance the shopping experience. In most retail applications, this involves maximizing illumination while minimizing the visibility of light sources, allowing customers to focus on the merchandise. Title 24, Part 6 allows designers to create an appropriate retail lighting layout utilizing luminaires and design conventions of their choosing. The standards provide energy use constraints, but do not restrict design choices. In lighting any retail space, it is important to consider:

Architecture

Lighting can emphasize, soften or balance certain architectural features, from making a small boutique feel more spacious to playing up (or playing down) the texture of a wall or accenting coves and valances. It is also helpful to consider the materials used in the space. Dark, polished granite will reflect light differently than wood or brick.

Atmosphere

Consider what activities or tasks will take place in different areas. High-contrast lighting is often used in more upscale boutiques while higher, more uniform light levels are commonly found in big box retail stores and similar outlets to support high-volume sales tasks.

Aesthetics

The style of the lighting design should complement the store's style. It should suit its demographic, whether it is classic or contemporary aesthetic, youthful or sophisticated, cutting-edge or family-oriented.

Light source choices should include the careful consideration of an appropriate correlated color temperature (CCT) and color rendering ability to showcase products. Recently, the ability to adjust the CCT in-situ as seasonal displays change has become an option for retailers to consider. This category of products shows promise to adjust intensity and color, and offers a way to change the visual appearance of the space and product from a mobile device at any time.

PHOTO: EATON'S COOPER LIGHTING BUSINESS



LARGE RETAIL & OUTLET STORES

Compliance in Practice

Switch Placement

Section 130.1(a)

In most areas, luminaires and manual controls are required to be located in close proximity. This may work well in office applications, but in retail settings unauthorized persons should not have access to the lighting controls. In malls, and retail and wholesale sales floors, the lighting control is required to be located so that a person using the lighting control can see the lights or area controlled by that lighting control. The switch does not have to be in that immediate vicinity and accessible to the public. Alternatively, it is permitted to use a lighting controls system where that area of the store is annunciated through the control interface, and the person controlling the lighting can see the effect of their actions remotely.

Floor, Wall and Window Displays

Section 130.1(a)

Floor, wall, and window displays are required to be switched separately. In the example on the next page, a separate switch in view of the window display lighting controls the window displays at the front of the store. Case display, ornamental and special effects lighting are also required to be switched separately. Controlled layers of lighting should be on circuits of 20 amps or less.

Track Lighting

Section 130.0(c)

Line-voltage track lighting is popular in retail because it can be adjusted to suit changing displays and focus attention on a small area. Line-voltage track heads compatible with screw-base lamps may not be counted at the wattage actually used by the lamp, even if highly efficacious LED lamps are used. Instead, use [Section 130.0\(c\)7](#) to determine how much to count towards the actual lighting power budget.

Additional Lighting Power Allowances

In areas approved to use the Tailored Method of the Prescriptive Approach, displays with very valuable merchandise may be eligible for additional lighting power.

★ Recommendations

Flattering Fitting Rooms

High-CRI luminaires enhance the colors and textures of merchandise. Choose luminaires that provide soft, even distribution and consider lighting mirrors along either vertical edge to prevent unflattering shadows. In small fitting rooms, cove lighting located behind mirrors can help make these spaces feel larger.

Large Retail Store Lighting Schedule

Symbol	Luminaire Type	Lamp	Qty.	Watts	Total Watts	Efficacy (lm / W)
	Pendant	Induction	5	55	275	65
	Decorative pendant	Dedicated LED	6	10	60	60
	6" recessed downlight	Dedicated LED	10	12	120	67
	1x4 ceiling-mounted troffer	Dedicated LED	4	38	152	105
TRACK LIGHTING: The track lighting wattage claimed for compliance purposes used the method described in Section 130.0(c) 7 B iii, or 12.5 watts per linear foot of track lighting. All tracks have an integral current limiter that is certified to the Energy Commission.						
	8' track with 5 heads	LED track heads	8	100	800	47
	4' track with 3 heads	LED track heads	1	60	60	47

CONTROLS

Switch

INSTALLED WATTS TOTAL 1,467 W

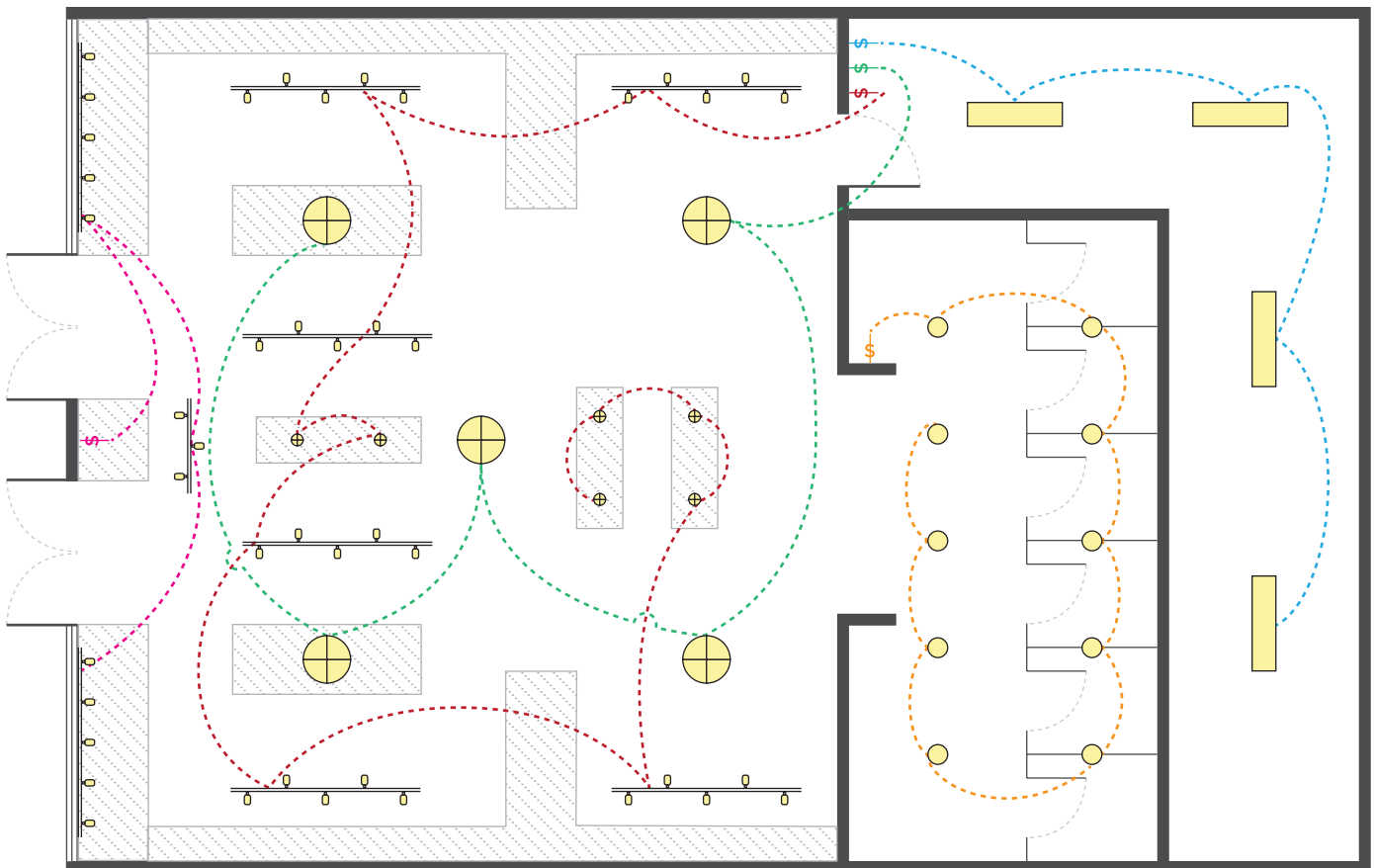




PHOTO: ACUTY BRANDS

BOUTIQUES & SMALLER STORES

Compliance in Practice

Occupancy Controls Section 130.1(c)

Placing occupancy sensors in stock rooms complies with the standards for lighting controls in secondary spaces. Occupancy sensors will also turn lights ON and OFF automatically for employees. The use of partial-ON occupant sensors can earn a lighting power density adjustment factor in spaces less than or equal to 250 square feet or any size waiting room, conference room or classroom.

★ Recommendations

Accent Lighting

Use accent lighting strategically to draw customers' attention to certain displays and enhance merchandise details.

Ambient / Display Lighting Contrast

Keeping lower ambient light levels heightens the impact of display lighting and accent lighting in boutiques. This high-contrast lighting design strategy conveys a more upscale atmosphere to customers and saves energy.







Color Shifting Display Lighting

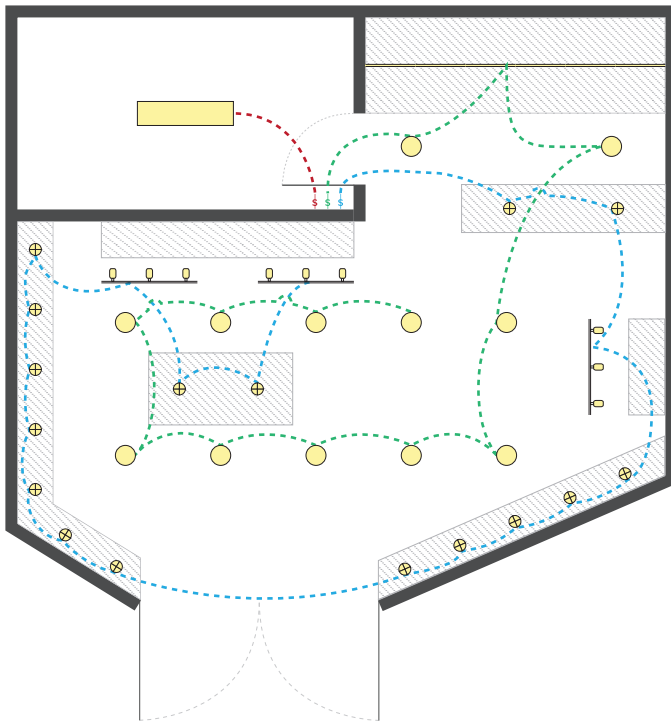
Consider tunable lighting to enhance displays and command customers' attention. Color-tunable LED lighting is one effective option.

Window Displays

Window displays are critical for attracting customers. Position lights to avoid glare in spaces with large front-facing windows.

Boutique Lighting Schedule

Symbol	Luminaire Type	Lamp	Qty.	Watts	Total Watts	Efficacy (lm / W)
	6" recessed downlight	Dedicated LED	12	9.5	114	67
	4" adjustable recessed downlight	Dedicated LED	16	11	176	54.5
	48" cove lighting	Dedicated LED	3	14	42	98
	1 x 4 ceiling-mounted troffer	Dedicated LED	1	38	38	105
TRACK LIGHTING: The track lighting wattage claimed for compliance purposes used the method described in Section 130.0(c) 7 B iii, or 12.5 watts per linear foot of track lighting. All tracks have an integral current limiter that is certified to the Energy Commission.						
	4' track with 3 heads	LED track heads	3	60	180	47
CONTROLS		 Switch				
				INSTALLED WATTS TOTAL 550 W		



Luminaires with Integrated Controls

Occupancy-based lighting controls can save significant amounts of energy in areas, such as stock rooms, which are often characterized by highly intermittent occupancy patterns. Integrated, occupancy-based lighting controls offer the largest opportunity for energy and cost savings. Integrate dimming or multi-level stepped lighting controls that include a lower light setting for periods of inactivity (to support safety) and additional settings to provide light levels for different activities.



PHOTO: CREE, INC.

CONVENIENCE STORES

Compliance in Practice

Daylight Controls

Section 130.1(d)

Front windows provide a large amount of daylight in convenience stores. Luminaires providing general illumination in the **primary sidelit zone** will require daylighting controls to reduce lighting power when daylight is present.

★ Recommendations

Reflective Surfaces

Adjust spotlights and general light sources near refrigerated cases and windows to minimize glare.



Refrigerated Cases

Illuminated appliances such as open cooler cases and freezer cases offer an excellent opportunity to elevate a project from standard practice to best practice for maximum long-term benefit. LEDs perform well in cool temperature applications such as refrigerated cases. They use less energy for lighting than traditional fluorescent systems. They also produce less heat, reducing cooling demand and energy use.

Consider adding occupancy controls to further reduce the lighting energy use when the area is vacant. LED cases with integrated controls brighten when occupants are detected. The energy reduction opportunity from this feature is significant, in addition to the reduced energy use and maintenance costs from switching to LED.

The standards include lighting control requirements for refrigerated display cases in **Section 120.6(b) 3**, but occupancy controls are not mandatory for every application. In this section, retail food stores that must comply can use automatic time switch controls or occupancy controls. Stores open for more than 140 hours per week have an exception from this section, even though they may have hours where significant energy use reductions could be achieved by lowering lighting power. Include this strategy in the design plan, regardless of requirement, for maximum savings and to communicate to customers that the retailer values energy efficiency.

Convenience Lighting Schedule

Symbol	Luminaire Type	Lamp	Qty.	Watts	Total Watts	Efficacy (lm / W)
	2x4 recessed troffer	Dedicated LED	12	38	456	125
TRACK LIGHTING: The track lighting wattage claimed for compliance purposes used the method described in Section 130.0(c) 7 B iii, or 12.5 watts per linear foot of track lighting. All tracks have an integral current limiter that is certified to the Energy Commission.						
	8' track with 5 heads	LED track heads	2	100	200	47
CONTROLS \$ Switch (P) Photosensor INSTALLED WATTS TOTAL 656W						

Applying Sidelit Zone Calculations

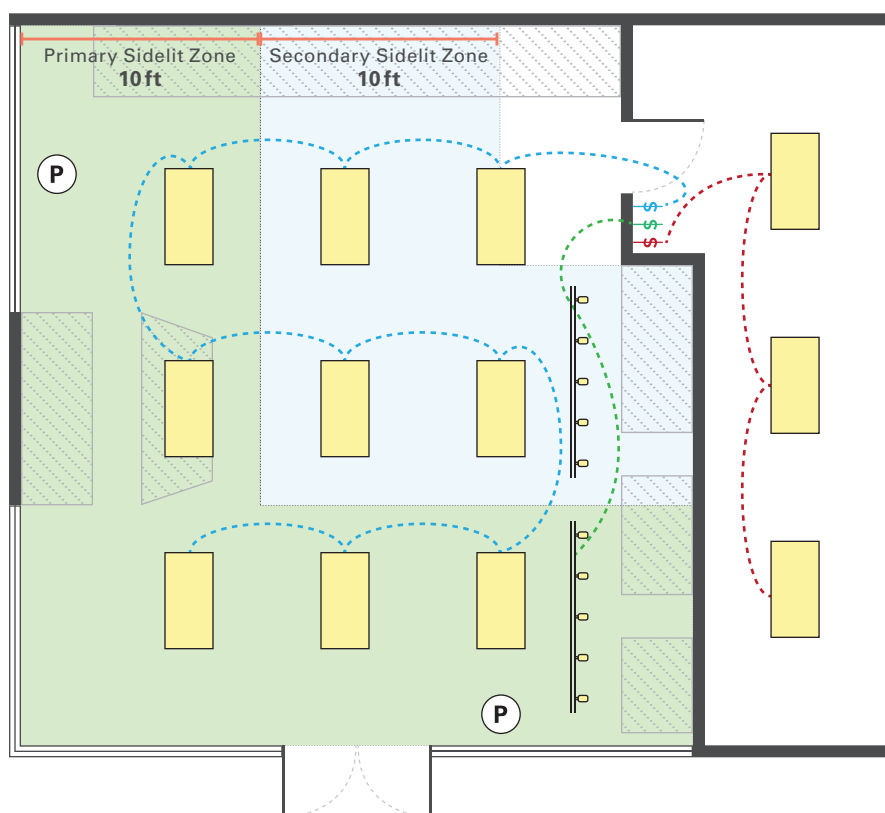
Use the floor plan below to calculate sidelit zones.

PRIMARY SIDELIT ZONE

1. Determine the window head height for each window. **The window head height is 10ft.**
2. Determine the depth of the zone. **The depth of the zone is 10ft, the window head height, into the area adjacent to the window.**
3. Determine the width of the zone. **The width of the zone is the window plus 5ft on each side of the window.**

SECONDARY SIDELIT ZONE

1. Add one additional window head height to the same dimensions determined for the primary sidelit zone. **The secondary sidelit zone extends an additional 10ft beyond the primary sidelit zone adjacent to it.**





COMMERCIAL RESTROOMS

Compliance in Practice

Manual Controls

Section 130.1(a)2

In public restrooms with two or more stalls, a manual switch may be used that is only accessible to authorized personnel. All other applicable lighting controls for the space are still required.

★ Recommendations



Occupancy Sensors

Ultrasonic occupancy sensors can detect occupants through stall doors. This prevents lights from turning OFF while the space is in use. Ceiling-mounted dual-technology sensors that include both ultrasonic and passive infrared (PIR) technologies are available to assure the lighting stays on when customers need it.

Vanity Lighting

Flattering lighting around mirrors contributes to customers' overall retail experience. Vertical bath bars placed parallel to mirrors minimize unflattering shadows.

Commercial Restroom Lighting Schedule

Symbol	Luminaire Type	Lamp	Qty.	Watts	Total Watts	Efficacy (lm / W)
	2x4 recessed troffer	Dedicated LED	4	22	88	100
	3' vertical bath bar	Dedicated LED	8	15	120	60

CONTROLS

\$ Switch

(VC) Vacancy Control

INSTALLED WATTS TOTAL 208 W

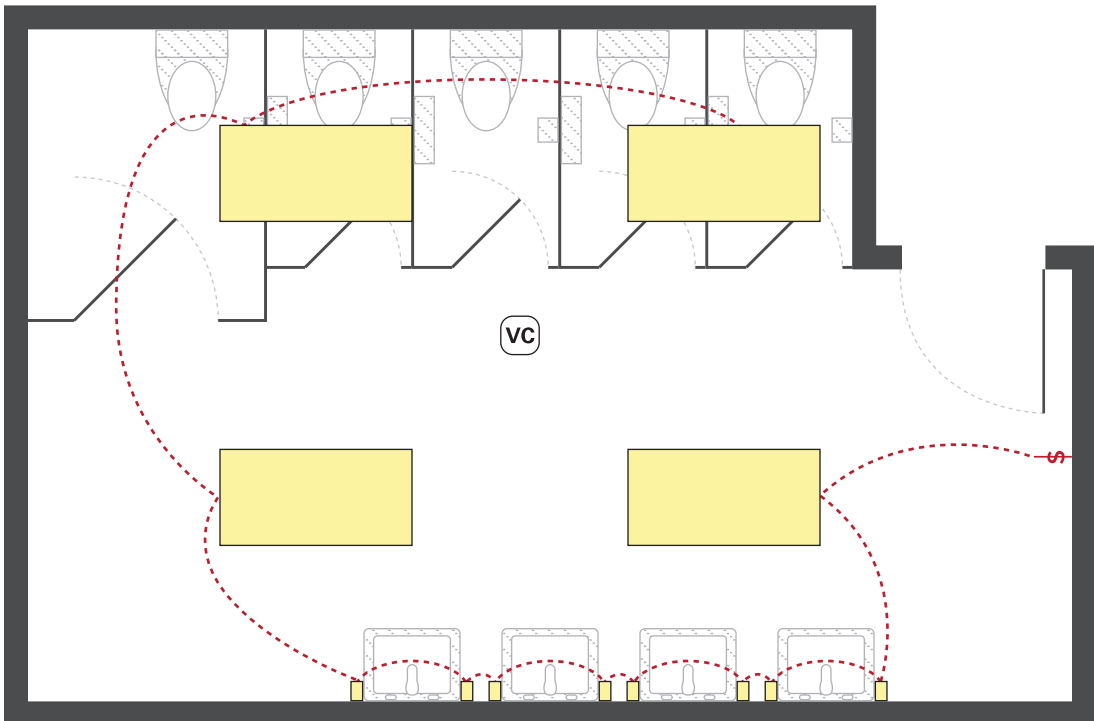




PHOTO: CLTC, UC DAVIS

MASS MERCHANDISING

✓ Compliance in Practice

Demand Response

Section 130.1(e)

Controls that automatically respond to a demand response signal are required in buildings larger than 10,000 ft², including retail applications. The required minimum response is only a 15% reduction below the total installed lighting power. This can be accomplished with minimal visible impact on sales areas.

Minimum Daylight requirements

Section 140.3(c) and 130.1(d)

Large retail buildings must have a minimum amount of daylight available from skylights. Daylighting controls are required in all skylit zones that reduce lighting energy use when daylight is present.

★ Recommendations

Energy Savings

In large, open warehouse-style sales floors, occupancy controls can provide significant energy savings. For most lighting systems, tuning to reduce lighting energy use by 10–20% may be undetectable to shoppers or employees.



PHOTO: WATTSTOPPER


PHOTO: CLTC, UC DAVIS

📄 Unbeatable Savings On Energy and Maintenance Walmart, West Sacramento, CA

CLTC partnered with Walmart on a 12-month demonstration of an advanced photosensor control system for daylight harvesting. The dual-loop technology combines open-loop and closed-loop photosensors for more accurate light level readings. The device also automatically recalibrates itself on a continuous basis to optimize performance. The system increased energy savings more than 50% over the previous open-loop system while maintaining designed light levels far better. It is commercially available as part of WattStopper's Digital Lighting Management system.

A case study of the project is available at: cltc.ucdavis.edu.

Mass Merchandising Lighting Schedule

Symbol	Luminaire Type	Lamp	Qty.	Watts	Total Watts	Efficacy (lm / W)
	Linear pendant	Dedicated LED	18	38	684	100

CONTROLS

 Switch

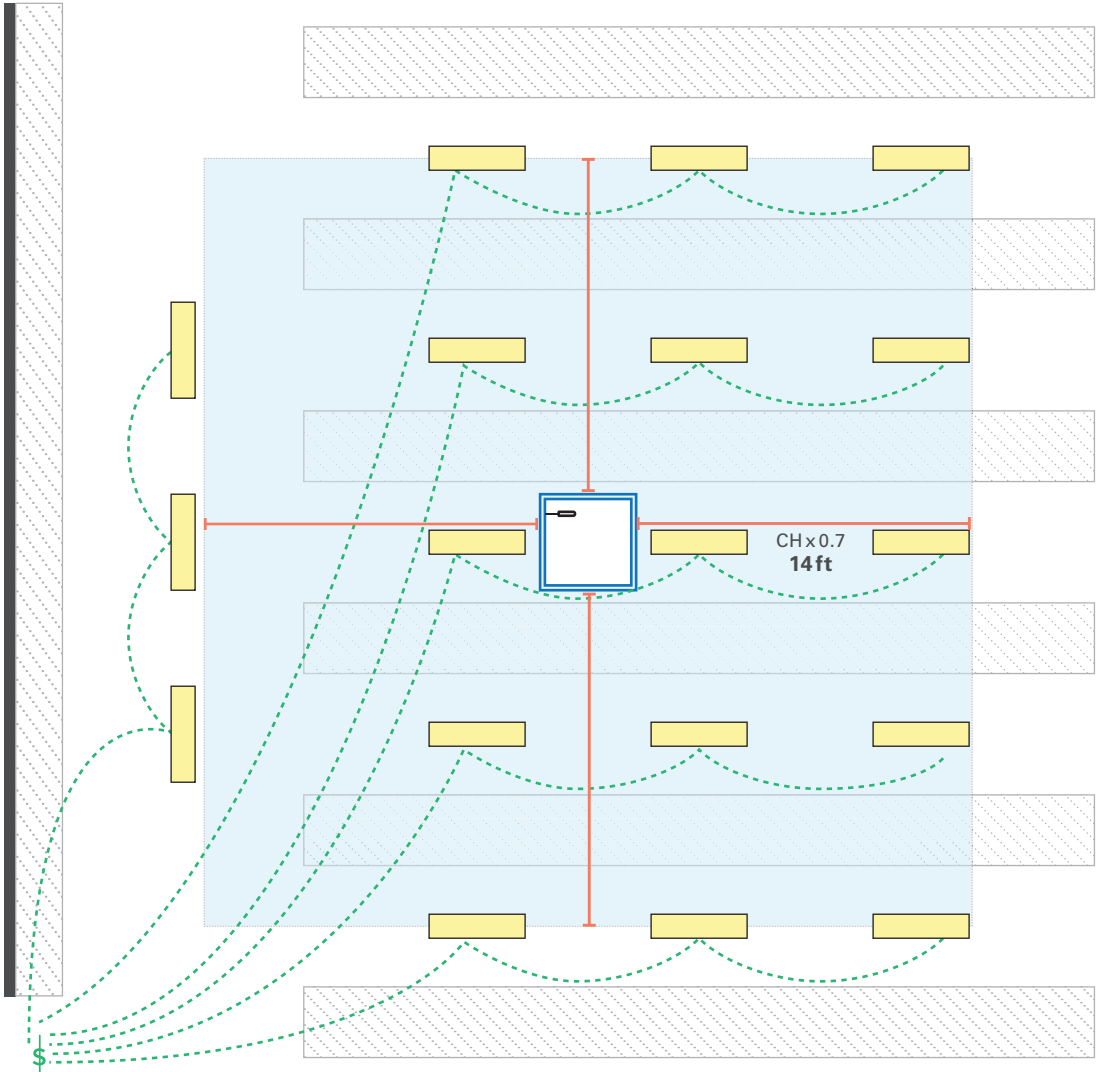
 Dual-loop photosensor

Applying Skylit Zone Calculations

The floor plan below has a square skylight 4' x 4', an average ceiling height of 20', and the aisle shelves are 6' tall.

SKYLIT ZONE

1. Define the shape of the skylight. **The square skylight will produce a square daylight zone.**
2. Determine the average ceiling height. **The average ceiling height is 20ft.**
3. Multiply the CH by 0.7 and add the value in all directions around the skylight.
The skylit zone is 14ft in all directions. The skylit zone is 1,296ft, centered on the skylight.







GLOSSARY

A

Accent lighting: Also called **display lighting**, this is adjustable directional lighting designed to provide additional lighting on display merchandise, in contrast with lower ambient, or general, light levels. It can be recessed, surface mounted or mounted to a pendant, stem or track.

Ambient lighting: Also known as **general lighting**, this lighting is designed to provide fairly uniform illumination throughout a space. Ambient lighting is generally supplemented by task lighting and accent lighting.

Astronomical time-switch control: An automatic lighting control device that switches lights ON or OFF at specified times of the day, or during astronomical events such as sunset and sunrise, to prevent energy waste during periods when daylight is available. These devices can account for geographic location and calendar date. **Multi-level astronomical time switch controls** reduce lighting power in multiple steps between full light output and their OFF setting.

B

Beam angle: Also known as **beam spread**, the width of the cone of light emitted from a light source, defined from the center of the beam to the angle where the intensity of light is half of its maximum. Narrow beam angles create a spotlight effect while broader beam angles spread light more evenly across a larger area.

C

Candela (cd): Unit of measurement for luminous intensity. One candela (cd) is equal to one lumen per steradian (lm/sr). A candle flame emits light with a luminous intensity of approximately one candela.

Case lighting Lighting designed for enclosed cases, such as glass display cases, that display jewelry, electronics or other valuable items.

Center beam candlepower (CBCP): Luminous intensity at the center of the beam from a reflector lamp, such as a parabolic aluminized reflector (PAR) lamp. CBCP is measured in candelas (cd).

Ceramic metal halide (CMH): A type of high-intensity discharge (HID) lamp commonly used in retail lighting, particularly high- and low-bay applications. Like **metal halide** lamps, CMH lamps generate light using a mixture of argon, mercury and metal halide vapors. CMH lamps are a newer variation of MH capable of producing white light with a CRI as high as 96. Full light output takes about 2–10 minutes, making them less compatible with adaptive lighting controls. They can produce energy savings of up to 90% when replacing incandescent sources.

Chandelier: A ceiling-mounted or suspended decorative luminaire that typically uses many small lamps and incorporates glass, crystal, ornamental metals, or other reflective decorative materials.

Correlated Color Temperature (CCT): Measured in Kelvins (K), CCT indicates the warmth or coolness of light emitted from a lamp. Low CCT indicates a warmer (more red) hue while high CCT denotes a cooler (more blue) appearance. CCT helps set the general atmosphere of a retail space. Sources with a CCT of 2700–3000 K emit incandescent-like light, while lamps with cooler color temperatures, such as 5000–6500 K, are often chosen to approximate bright daylight on a clear afternoon.

Color Rendering Index (CRI): The current industry-standard scale used to measure how truly light sources can render the colors of the objects they illuminate. The maximum CRI value is 100. Lamps with a high CRI (at least 80) render colors more accurately. It is important to select lamps and luminaires with high CRI values for retail applications so that

customers can easily evaluate merchandise.

Compact fluorescent lamp (CFL): A type of fluorescent lamp shorter than 9 inches in overall length with a T5 glass tube (or smaller diameter) folded, bent or bridged to create a compact shape.

Countdown timer switch: A device featuring one or more preset countdown time periods that turns lighting (or other loads) ON when activated and automatically turns lighting (or other loads) OFF when the selected time period had elapsed.

D

Daylight control: An automatic lighting control device that uses one or more photosensors to detect changes in daylight contribution and automatically adjust electric lighting levels accordingly. A **multi-level daylight control** adjusts the luminous flux of the electric lighting system in either a series of steps or by continuous dimming in response to available daylight.

Daylit Zone: The floor area under skylights or next to windows. Title 24 includes building and lighting control requirements for specific types of daylit zones, including Primary Sidelit, Secondary Sidelit, and Skylit zones.

Decorative Lighting: Luminaires installed only for aesthetic purposes that do not serve as general, display or task lighting.

Dimmer: A lighting control device that adjusts the light output (or luminous flux) of an electric lighting system by decreasing or increasing the power delivered to that system. **Step Dimmers**

provide end-users with one or more distinct light level settings (or steps) between maximum light output and OFF. **Continuous Dimmers** offer finer, more subtle control over a continuous range between maximum light output and the OFF setting.

E

Efficacy: The amount of light produced by a lamp or luminaire relative to the amount of electrical power it consumes (lm/W). To calculate lamp efficacy, divide the lamp's rated initial lumens (lm) by the rated lamp power (watts) without including auxiliaries such as ballasts, transformers and power supplies.

Energy Management Control System (EMCS): A computerized control system designed to regulate energy consumption by controlling the operation of one or more building systems, such as lighting and HVAC. An EMCS can also monitor environmental and system loads, adjust system operations, optimize energy usage, and respond to demand response signals.

F

Fluorescent: A low-pressure mercury electric-discharge lamp in which a phosphor coating transforms some of the UV energy generated into visible light.

G

General lighting See **Ambient lighting**.

GU24: A bi-pin (versus screw-base) lamp holder and socket configuration based on a coding system by the International Energy Consortium, where “G” stands for the broad type of two or more projecting contacts, “U” distinguishes between lamp and holder designs of similar but not interchangeable types, and “24” indicates 24 millimeters center-to-center spacing between the electrical contact posts or pins.

H

HID lamps: High-intensity discharge (HID) lamps, such as metal halide or high-pressure sodium, lamps.

I

Illuminance: A measure of the intensity of incident light illuminating a surface; measured in lux (lx) or lumens (lm) per unit of surface area (lm/ft² or lm/m², for example).

Illumination: Density of light incident at a point on a surface, measured in footcandles (fc), perpendicular to the surface.

Incandescent: A type of lamp with a filament that gives off light when heated by an electric current.

L

Lamp: An electric light source, such as a light bulb or fluorescent tube. This is the term used in the lighting industry to describe replacement bulbs or tubes consisting of an electric light source, a holder and a cover.

Lighting control system: Technology consisting of two or more components and capable of providing full functionality for lighting control compliance.

Light-emitting diode (LED): A solid-state diode that is constructed to emit colored or white light. It is often used to describe a component, device or package that incorporates an array of light emitting diodes.

LED lamp: An LED component, device, or package, and other optical, thermal, mechanical, and electrical (control circuitry) components with an integrated LED driver (power source) and a standardized base that is designed to connect to the branch circuit via a standardized base, lamp holder or socket.

LED luminaire: A complete LED lighting unit consisting of a light source, driver and other parts designed to distribute light, to position and protect the light source, and to connect the light source to a branch circuit. The light source itself may be an LED component, package, device, array, module, source system, or lamp. The LED luminaire is intended to be connected directly to a branch circuit.

Low-efficacy luminaire: Any luminaire that does not meet the qualifications for high efficacy set forth by Title 24 standards or contains any type of line-voltage socket or lamp holder capable of

accepting a low-efficacy lamp. Low-efficacy luminaires include track lighting, incandescent lighting, conversions between screw-base and pin-base sockets, electrical boxes used for a luminaire or ceiling fan, and uncertified LED lighting or GU-24 base lamps or luminaires.

Lumen: The unit of measurement that describes the amount of light emitted from a light source. Higher lumen output indicates a brighter light source.

Luminaire: Also commonly referred to as a **light fixture**, this is the lighting industry term for a complete lighting unit. It consists of a housing, socket, one or more lamps, a base that connects the fixture to a power source, and any integrated lighting control elements.

Luminance (L): The intensity of light reflected from a surface in a given direction. Measured in candelas per area unit (generally, cd/ft² or cd/m²).

Luminous flux: The rate at which a light source emits visible light. This “flow rate” of light is measured as lumens over time and defines “light,” generally, for purposes of lighting design and illuminating engineering.

M

Mandatory measures checklist:

A form used by the building plan checker and field inspector to verify a building's compliance with the prescribed list of mandatory features, equipment efficiencies and product certification requirements. The documentation author indicates compliance by initialing, checking or marking N/A (for not applicable) in the boxes or spaces provided for the designer.

Metal halide (MH): A high-intensity discharge (HID) light source commonly used in retail, industrial and outdoor applications. MH lamps use a mixture of argon, mercury and metal halide. A hard outer glass covering absorbs much of the UV radiation emitted by MH lamps, thereby reducing their efficacy. MH lamps have CRI ratings of 60. Full light output takes about 2–10 minutes, making them less compatible with adaptive lighting controls. MH lamps produce more light than mercury vapor lamps and provide better color rendering, with CRI ratings of 60–96.

Motion sensor: A device that automatically turns lights OFF soon after an area is vacated. Motion sensor applies to outdoor lighting controls. When the device is used to control indoor lighting systems, it is called an occupant sensor, occupancy sensor, occupant-sensing device, or vacancy sensor.

Multi-level lighting control: A lighting control device that reduces power going to a lighting system, and the consequent light output of the system, in multiple discrete steps.

Multi-scene lighting control:

In addition to all-OFF, this feature allows end-users to program or select pre-defined lighting settings for two or more groups of luminaires in order to suit multiple activities or displays within a space.

O

Occupant sensor: A device that automatically turns lights OFF soon after an area is vacated. The term occupant sensor applies to a device that controls indoor lighting systems. It is called a motion detector when used to control outdoor lighting systems.

P

Pendant: A type of ceiling-mounted luminaire that is suspended from the ceiling, often above task surfaces.

Permanently installed lighting: All luminaires attached to the inside or outside of a building site, including track and flexible lighting systems; lighting attached to walls, ceilings, or columns; inside or outside of permanently installed cabinets; internally illuminated case work; lighting mounted on poles, in trees, or in the ground; and lighting attached to ceiling fans and integral to exhaust fans other than exhaust hoods for cooking equipment. Portable lighting and lighting installed in appliances by the manufacturer is not considered permanently installed lighting.

Photocontrol: A device that detects changes in illumination levels and controls lighting load at predetermined illumination levels. Automatically turns ON luminaires at dusk and turns them OFF at dawn).

Pin-base luminaire: A luminaire, or fixture, that accepts lamps with a pin base, as opposed to a screw base. GU-24 pin-base luminaires prevent the use of low-efficacy lamps in high-efficacy luminaires.

Portable lighting: Lighting with plug-in connections for electric power, including: table lamps and freestanding floor lamps, lighting attached to modular furniture, workstation task lights, lights attached to workstation panels, movable displays, and other equipment that is not

Permanently installed lighting.

R

Readily accessible: Capable of being reached quickly for operation, repair or inspection. Readily accessible items must be accessible without the use of special equipment, removal of obstacles or need for climbing.

S

Screw-base luminaire: A luminaire, or fixture, with a socket that accepts screw-base lamps (e.g., incandescent, CFL or LED replacement lamps). Screw-base luminaires are considered low-efficacy under Title 24, Part 6 because they are compatible with low-efficacy lamps.



Lux

RETAIL LIGHTING SHOWCASE

The California Lighting Technology Center at UC Davis collaborated with PG&E and the Energy Commission to develop Lux, the LED lighting showcase and learning center. This demonstration space was created to help retailers navigate new choices available in LED lighting technologies. This training space complements the Title 24, Part 6 Retail Lighting courses offered through PG&E.

For more information:
cltc.ucdavis.edu/led-retail-showcase-market-survey.

PHOTO: CLTC, UC DAVIS

Skylight: A window (fenestration surface) installed in a roof and having a slope of less than 60 degrees from the horizontal plane.

T

Task lighting: Lighting that is designed to meet the specific illumination needs of an area designated for specific tasks.

Time switch: Also called a **timer switch** or **timer**, this device automatically controls lighting based on time of day.

Track lighting: A system that utilizes luminaires mounted to a track, rails or cables.

U

Utility room: A non-habitable room or building (not a bathroom, closet, garage, or laundry room) that contains only HVAC, plumbing or electrical controls, or equipment.

V

Vacancy sensor: An occupant sensor that requires occupants turn lights ON manually but automatically switches lights OFF soon after an area is vacated. Also called a **manual-ON occupant sensor** or **manual-ON / automatic-OFF sensor**.

W

Watt: The unit of measure for the electric power used by a lamp or luminaire.

TABLES

The original versions of the tables in this section can be found in the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. These tables are used for determining compliance what is required for compliance with Title 24, Part 6 and in the process of calculating lighting energy budgets.

Table: 141.0-E: Requirements for Luminaire Alterations

Quantity of existing affected luminaires per Enclosed Space ¹	Resulting lighting power for each enclosed space	Applicable mandatory control provisions for each enclosed space	Multi-level lighting control requirements for each altered luminaire
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Alterations that do not change the area of the enclosed space or the space type (lighting alterations where enclosed space area or type has not changed and lighting wattage not increased)

Sum total < 10% of existing luminaires	Existing lighting power is permitted	Existing provisions are permitted	Existing controls are permitted
Sum total ≥ 10% of existing luminaires	≤ 85% of allowed lighting power per § 140.6 Area Category Method	§ 130.1(a), (c)	Two level lighting control ² OR § 130.1(b)
	> 85% of allowed lighting power per § 140.6 Area Category Method	§ 130.1(a), (c), (d) ³	§ 130.1(b)

Alterations that change the area of the enclosed space or the space type or increase the lighting power in the enclosed space (lighting alterations accompanying changes to the enclosed space area or space type or accompanying an increased in lighting power)

Any number	Comply with § 140.6	§ 130.0 (d) ³ § 130.1(a), (c), (d) ³ , (e)	§ 130.1(b)
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¹ Affected luminaires include any luminaire that is changed, replaced, removed, relocated; or, connected to, altered or revised wiring, except as permitted by EXCEPTIONS 1 and 2 to § 141.0(b)2iii:

² Two level lighting control shall have at least one control step between 30 and 70% of design lighting power in a manner providing reasonably uniform illuminations

³ Daylight controls in accordance with § 130.0(d) are required only for luminaires that are altered.

Table 141.0-F: Requirements for Luminaire Modifications-in-Place

For compliance with this table, building space is defined as any of the following:

1. A complete single story building
2. A complete floor of a multi-floor building
3. The entire space in a building of a single tenant under a single lease
4. All of the common, not leasable space in single building

Quantity of affected luminaires per building space per annum	Resulting lighting power per each enclosed space where $\geq 10\%$ of existing luminaires are luminaire modifications-in-place	Applicable mandatory control provisions for each enclosed space ¹	Applicable multi-level lighting control requirements for each modified luminaire ²
Sum total < 40 luminaire modifications-in-place	Existing lighting power is permitted	Existing provisions are permitted	Existing controls are permitted
Sum total ≥ 40 luminaire modifications-in-place	$\leq 85\%$ of allowed lighting power per § 140.6 Area Category Method	§ 130.1(a), (c)	Two level lighting control ³ OR § 130.1(b)
	$> 85\%$ of allowed lighting power per § 140.6 Area Category Method	§ 130.0(d) ⁴ , § 130.1(a), (c), (d) ⁴	§ 130.1(b)

¹ Control requirements only apply to enclosed spaces for which there are luminaire modifications-in-place

² Multi-level controls are required only for luminaires for which there are luminaire modifications-in-place

³ Two level lighting control shall have at least one control step between 30% and 70% of design lighting power in a manner providing reasonably uniform illuminations

⁴ Daylight controls in accordance with § 130.0(d) are required only for luminaires that are modified-in-place

Table 140.6-C: Area Category Method Lighting Power Density Values (W/ft²)

Primary Function Area			Allowed Lighting Power (W / ft²)	Primary Function Area	Allowed Lighting Power (W / ft²)	
Auditorium Area			1.5 ³	Library Area	Reading Areas	1.2 ³
Auto Repair Area			0.9 ²		Stack Areas	1.5 ³
Beauty Salon Area			1.7	Lobby Area	Hotel lobby	1.1 ³
Civic Meeting Place Area			1.3 ³		Main entry lobby	1.5 ³
Classroom, Lecture, Training, Vocational Areas			1.2 ⁵	Locker/ Dressing Room		0.8
Commercial and Industrial Storage Areas (conditioned and unconditioned)			0.6	Lounge Area		1.1 ³
Commercial and Industrial Storage Areas (refrigerated)			0.7	Malls and Atria		1.2 ³
Convention, Conference, Multipurpose and Meeting Center Areas			1.4 ³	Medical and Clinical Care Area		1.2
Corridor, Restroom, Stair, and Support Areas			0.6	Office Area	>250 square feet	0.75
Dining Area			1.1 ³		≤ 250 square feet	1.0
Electrical, Mechanical, Telephone Rooms			0.7 ²	Parking Garage Area	Parking Area	0.14
Exercise-Center, Gymnasium Areas			1.0		Dedicated Ramps	0.3
Exhibit, Museum Areas			2.0		Daylight Adaptation Zones ⁹	0.6
Financial Transaction Area			1.2 ³	Religious Worship Area		1.5 ³
General Commercial and Industrial Areas	Low bay	0.9 ²	Retail Merchandise Sales, Wholesale Showroom Areas		1.2 ^{6 and 7}	
	High bay	1.0 ²	Theatre Area	Motion Picture	0.9 ³	
	Precision	1.2 ⁴		Performance	1.4 ³	
Grocery Sales Area			1.2 ^{6 and 7}	Transportation Function Area		1.2
Hotel Function Area			1.5 ³	Video Conferencing Studio		1.2 ⁸
Kitchen, Food Preparation Areas			1.6	Waiting Area		1.1 ³
Laboratory Area, Scientific			1.4 ¹	All Other Area		0.6
Laundry Area			0.9			

Footnotes for Table 140.6-C:

See Section 140.6(c)2 for an explanation of additional lighting power available for specialized task work, ornamental, precision, accent, display, decorative, and white boards and chalk boards, in accordance with the footnotes in this table. The smallest of the added lighting power listed in each footnote below, or the actual design wattage, may be added to the allowed lighting power only when using the Area Category Method of compliance.

Footnote number	Type of lighting system allowed	Maximum allowed added lighting power (W/ft ² of task area unless otherwise noted)
1	Specialized task work	0.2 W/ft ²
2	Specialized task work	0.5 W/ft ²
3	Ornamental lighting as defined in Section 100.1 and in accordance with Section 140.6(c)2	0.5 W/ft ²
4	Precision commercial and industrial work	1.0 W/ft ²
5	Per linear foot of white board or chalk board	5.5 W per linear foot
6	Accent, display and feature lighting—luminaires shall be adjustable or directional	0.3 W/ft ²
7	Decorative lighting—primary function shall be decorative and shall be in addition to general illumination	0.2 W/ft ²
8	Additional Videoconferencing Studio lighting complying with all of the requirements in Section 140.6(c)2Gvii.	1.5 W/ft ²
9	Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage	

Table 140.6-D: Tailored Method Lighting Power Allowances

Primary Function Area	General Illumination Level (Lux)	Wall Display Power (W/ft)	Allowed Combined Floor Display Power and Task Lighting Power (W / ft ²)	Allowed Ornamental/ Special Effect Lighting
Auditorium Area	300	2.25	0.3	0.5
Civic Meeting Place	300	3.15	0.2	0.5
Convention, Conference, Multipurpose, and Meeting Center Areas	300	2.50	0.4	0.5
Dining Areas	200	1.50	0.6	0.5
Exhibit, Museum Areas	150	15.0	1.2	0.5
Financial Transaction Area	300	3.15	0.2	0.5
Grocery Store Area	500	8.00	0.9	0.5
Hotel Function Area	400	2.25	0.2	0.5
Lobby Area				
Hotel Lobby	200	3.15	0.2	0.5
Main Entry Lobby	200	0	0.2	0
Lounge Area	200	7.00	0	0.5
Malls and Atria	300	3.50	0.5	0.5
Religious Worship Area	300	1.50	0.5	0.5
Retail Merchandise Sales, and Showroom Area	400	14.00	1.0	0.5
Theater Area				
Motion Picture	200	3.00	0	0.5
Performance	200	6.00	0	0.5
Transportation Function Area	300	3.15	0.3	0.5
Waiting Area	300	3.15	0.2	0.5

Table 140.6-E: Adjustments for Mounting Height Above Floor

Height in feet above finished floor and bottom of luminaire(s)	Floor Display or Wall Display — Multiply by
< 12'	1.00
12' to 16'	1.15
> 16'	1.30

Table 140.6-F: Room Cavity Ratio (RCR) Equations

Determine the Room Cavity Ratio using one of the following equations

Room cavity ratio for rectangular rooms

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

Room cavity ratio for irregularly shaped rooms

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

H = Vertical distance from the work plane to the center line of the lighting fixture
 L = Length W = Width P = Perimeter A = Area of the room

Table 140.6-G: Illuminance Level (Lux) Power Density Values (W/ft²)

Illuminance Level (lux)	RCR ≤ 2.0	RCR > 2.0 and ≤ 3.5	RCR > 3.5 and ≤ 7.0	RCR > 7.0
50	0.2	0.3	0.4	0.6
100	0.4	0.6	0.8	1.2
200	0.6	0.8	1.3	1.9
300	0.8	1.0	1.4	2.0
400	0.9	1.1	1.5	2.2
500	1.0	1.2	1.6	2.4
600	1.2	1.4	2.0	2.9
700	1.4	1.7	2.3	3.3
800	1.6	1.9	2.6	3.8
900	1.8	2.2	3.0	4.3
1,000	1.9	2.4	3.3	4.8

RESOURCES



COMPLIANCE RESOURCES

2013 Title 24 Building Energy Efficiency Standards and Related Documents

energy.ca.gov/title24/2013standards

Visit the Energy Commission website to download the 2013 Building Energy Efficiency Standards for Residential and Nonresidential Buildings. The nonresidential standards cover retail lighting and should be the first resource for any contractor, builder or designer with questions about Title 24 regulations. Supporting documents and information on how to obtain public domain software for complying with the 2013 commercial standards (CBECC-Com) are also available. The Nonresidential Compliance Manual and 2013 Nonresidential Alternative Calculation Method Reference Manual are among the related documents available.

Energy Standards Hotline

Toll-free in California: (800) 772-3300

Title24@energy.ca.gov

The Energy Standards Hotline is a resource for any questions regarding the 2013 Title 24, Part 6 standards. The hotline is available Monday through Friday, 8 a.m.–12 p.m. and 1–4:30 p.m.

California Energy Commission Appliance Efficiency Database

appliances.energy.ca.gov

This online database features Quick Search and Advanced Search options that allow users to easily verify if lighting products have been certified to the Energy Commission as meeting applicable efficiency standards.

Title 20 Appliance Efficiency Regulations

energy.ca.gov/appliances

Energy efficiency and performance standards for appliances, including ballasts, lamps, luminaires, and lighting controls, are detailed in the 2012 Appliance Efficiency Regulations, which took effect February 1, 2013. This and other resources are available through the Energy Commission's website.

Energy Code Ace

energycodeace.com

This new site developed by the California Statewide Codes & Standards Program provides free tools, trainings and resources to help users meet the latest Title 24, Part 6 requirements. Visitors can download fact sheets, trigger sheets, checklists, and information on classes (online or in person) and workshops.

California Advanced Lighting Controls Training Program (CALCTP)

calctp.org

CALCTP educates, trains, and certifies licensed electrical contractors and state certified general electricians in the proper installation, programming, testing, commissioning, and maintenance of advanced lighting control systems.

California Lighting Technology Center

cltc.ucdavis.edu/title24

The Title 24 Retail Lighting Design Guide was developed by the California Lighting Technology Center. CLTC was established through joint efforts by the Energy Commission and the University of California, Davis. CLTC develops and tests state-of-the-art, energy-saving lighting and daylighting innovations. CLTC also offers training and educational programs on energy-efficient lighting.

DesignLights Consortium Qualified Products List

designlights.org/qpl

This online database of quality, high-efficiency LED products for the commercial sector is maintained by the DesignLights Consortium, a project of the regional non-profit, Northeast Energy Efficiency Partnerships. It allows users to search for LED products by criteria (such as CRI and light output), categories (including display case lighting and track lighting), manufacturer, or keyword. Products listed may or may not qualify for certification to the Energy Commission.

RILA's Retail Sustainability Resources

rila.org/sustainability

The Retail Industry Leaders Association (RILA) supports the sustainability efforts of its members through the Retail Sustainability Initiative (RSI), Retail Sustainability Reports (2012 and 2013), and RILA's Retail Sustainability Conference. These resources educate retailers and share best practices within the industry.

CLASSES

California Association of Building Energy Consultants' Title 24 Resources

[cabec.org / title24info.php](http://cabec.org/title24info.php)

California Training Schedule for Building Operator Certification

theboc.info/ca/ca-schedule.html

Education Schedule for the Building Owners and Managers Association

boma.org/education/Pages/default.aspx

Workshop & Event Calendar for the Center for Sustainable Energy, California

energycenter.org/events

UTILITY EDUCATION & DEMONSTRATION CENTERS

All or most of these California utility centers host Title 24 lighting classes. They also house lighting technology demonstration spaces and tool lending libraries that can provide visitors with energy and light meters, data loggers, lighting design software, lighting design manuals, and other resources.

Online calendars list training events and workshops. Some websites offer virtual video tours of the demonstration centers and information on resources and services. Visitors and class participants can also learn about the utilities' rebate and incentive programs.

Pacific Gas and Electric Company (PG&E)

pge.com

Pacific Energy Center (PEC), San Francisco

Energy Training Center, Stockton

Sacramento Municipal Utility District

smud.org

Energy & Technology Center, Sacramento

San Diego Gas & Electric

sdge.com

Energy Innovation Center, San Diego

Southern California Edison (SCE)

sce.com

Energy Education Centers

Irwindale, Tulare and on-location in other cities

MANUFACTURER TRAINING CENTERS

Acuity Brands Center for Light&Space

Berkeley, CA

acuitybrands.com

Eaton's Cooper Lighting Business

Online Design Center

cooperindustries.com

Lutron

California Experience and Training Center

Irvine, CA

lutron.com

*For more information and resources about Title 24, Part 6,
visit the CLTC website at cltc.ucdavis.edu/title24.*

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