Title 24:
A Practical Point of View

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Title 24 for Retailers: A Practical Point of View

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Title 24

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What is "Title 24"?

Background

The state of California's administrative laws, the California Code of Regulations (CCR's), consists of 28 sections called "titles". Title 24 is the state's Building Standards Code and it includes the following parts:

- Part 1: California Building Standards Administrative Code
- Part 2: California Building Code (based on the International Building Code)
- Part 2.5: California Residential Building Code (based on the International Residential Code)
- Part 3: California Electrical Code (based on the National Electrical Code)
- Part 4: California Mechanical Code (based on the Uniform Mechanical Code)
- Part 5: California Plumbing Code (based on the Uniform Plumbing Code)
- **Part 6: California Energy Code**
- Part 8: California Historical Building Code
- Part 9: California Fire Code (based on the International Fire Code)
- Part 10: California Existing Building Code
- **Part 11: California Green Building Standards Code (CALGreen Code)**
- Part 12: California Reference Standards Code

California mostly uses national model codes like the National Electrical Code, with minor administrative changes. But Part 6, the California Energy Code, is unique. The primary rationale for having its own energy code is due to California's wide range of climate zones, 16 in all, ranging from desert to shoreline to high mountains. In addition, Title 24 Part 6 is a fundamental part of the state's energy and environmental policy. For many years the Building Energy Efficiency Standards were more aggressive than any other energy code in the world. Only in the last 5 years has ANSI/ASHRAE/IES 90.1, the national energy code standard, become equally stringent.

- The California Building Code (Part 2) includes path of egress lighting requirements (Section 1006). This is critical in designing lighting systems for egress and emergency conditions.
- The California Electrical Code (Part 3) is essentially the same as the National Electrical Code.
- The CALGreen (Part11) is the state's green building code. At present, its impact on lighting is to require outdoor lighting to be shielded, preventing sky glow and light trespass.

In addition, Title 20, which regulates appliances, places requirements on light sources and controls that can affect a lighting design.

Summary of Documents

The State of California makes the Building Energy Efficiency Standards and its related documents available on-line at no charge. Consider downloading the following:

- Part 1: California Building Standards Administrative Code
- Building Energy Efficiency Standards, Title 24 Part 6 ("the Standards"). This is the code to be followed.
- Non-Residential Compliance Manual ("the Manual"). This explains the code

and contains the forms that must be submitted.

- Residential Compliance Manual (the "Manual"). Same but for homes.
- Reference Appendices (the "Appendices"). These contain certain key technical requirements and procedures that are necessary to meet the Standards.

Title 24 Part 6 in Practice

Compliance with the Building Energy Efficiency Standards is mandatory and enforced. In order to help ensure compliance, there are four key sets of documents that must be completed and submitted for approval by the authority having jurisdiction (AHJ):

- Compliance documents submitted with a building permit application
- Certificates of installation, submitted with application for a certificate of occupancy
- Certificates of acceptance testing, submitted with application for a certificate of occupancy
- Final plans and specifications including all of the above forms, provided to the Owner within 90 days of the issuance of the Certificate of Occupancy

Compliance documents include a number of forms such as a standardized lighting fixture schedule, checklists of required documents, calculations showing compliance, and certification of the documents. Compliance forms require certain information to be placed on plans and specifications, and most architects and engineers include compliance forms on drawings. Forms must be signed by the primary lighting designer and countersigned by the licensed electrical contractor who will perform the installation, or any licensed architect or licensed engineer.

Certificates of Installation are also signed by the primary lighting designer and countersigned by the licensed electrical contractor who performed the installation, or any licensed architect or licensed engineer. These certificates are required when certain types of lighting or controls are installed, including an Energy Management Control System, track lighting integral current limiter(s), track lighting supplementary overcurrent protection panel(s), interlocked lighting system(s), lighting Power Adjustment Factor(s), or additional wattage claimed for a video conference studio.

Acceptance testing certificates can only be signed by the Certified Lighting Controls Acceptance Test Technician (CLCATT or "cool cat") who performed acceptance testing. Acceptance testing assures that automatic lighting controls were installed and commissioned and are performing correctly and include:

- Automatic daylighting controls
- Manual daylighting controls
- Occupancy sensing devices
- Automatic shut-off controls

Final plans and specifications ("record drawings") must be provided to the building owner within 90 days of the final occupancy permit and must also include:

- Requirement for the issuance of installation certificates for daylighting controls, occupant sensing devices and automatic shut-off controls.
- Completed acceptance testing forms for automatic daylighting controls, manual daylight switching, occupant sensing devices and automatic shut-off controls.
- Other operating and maintenance information.

Energy Code Development and Evolution

In America, energy codes for buildings are required on a state-by-state basis by Federal Law. Most states comply but a few still do not. The current Federal energy code standard is ANSI/ASHRAE/IES 90.1-2010. Most states employ the International Energy Conservation Code (IECC) that is essentially a simplified version of 90.1. The US Department of Energy has certified that California's Title 24 Part 6 is essentially as stringent as 90.1.

Presently, all three codes (Title 24, 90.1 and IECC) are revised approximately every three years. The next Title 24 revision is scheduled for 2016, which means that it will probably be effective January 1, 2017.

Historically, Title 24 changes were the most stringent, but were often then picked up in the next edition of 90.1 and then finally, IECC. This relationship has changed recently, with all three standards becoming increasingly similar in most ways.

Parts of the Title 24 Energy Code and What They Mean

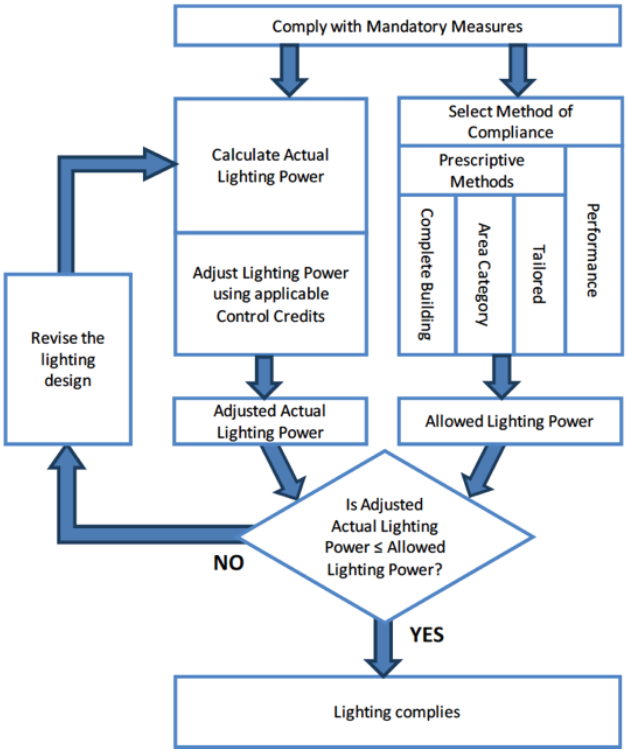
The Standards consist of a number of several major parts, each having a significant group of requirements.

Prescriptive versus Performance

In Title 24 as well as other energy codes, the Standards may be met using one of two very different methods. The method must be chosen at the beginning of demonstrating compliance:

- In the **Prescriptive Method**, the designer follows specific rules affecting lighting but not other trades or disciplines. Primarily, connected lighting watts are restricted to an amount based on the project area and the type of occupancy. The Prescriptive Method is typically used for smaller projects and especially for additions, alterations and tenant improvements, and is almost always used for specialty retail stores and for hospitality projects like hotels.
- In the **Performance Method**, the entire building is modeled using energy analysis software. This allows savings in one trade or discipline, such as lighting, to be traded off to an inefficient aspect of the project, such as a building with too much glass or a poor solar orientation. The maximum total allowed energy consumption measured in British Thermal Units (BTU's) per year includes all energy uses. The Performance Method is typically used for larger projects, especially schools, offices, big box retail stores, and government projects like airports, administrative buildings like police stations and city halls, and light industrial buildings.

When the **prescriptive method** is used, the lighting designer can demonstrate compliance without concern over other aspects of building energy. However, when the **performance method** is used, the entire design team of architects and engineers provide data to skilled analysts, who periodically check to make sure that the building design meets code. For new projects such as schools for which a LEED or CHPS certification is important, or when certain utility incentives are involved, the performance method is often necessary to prove compliance with the additional requirements of these certifications. Performance method calculations are also required for federal tax deductions and energy tax credits.



The Title 24 Lighting Flowchart ***(From the Non-residential Manual)***
Shown in the flowchart above, the Standards require the designer to:

- Comply with all mandatory measures
- Decide whether to use the prescriptive or performance method
- Calculate how many watts are being proposed by the design
- Determine what controls are being proposed by the design
- Redesign if more watts are being used than allowed

Designing lighting systems to meet Title 24 is a little bit science, a little bit engineering, and a whole lot knowing the Standards and how to use them. The **prescriptive method** is actually a **power (watts) code** for practical reasons. But knowledgeable designers realize that watts do not measure energy. Energy is measured in **kilowatt-hours** (watts multiplied by hours/1000). In the **performance method**, energy use is calculated and converted to British Thermal Units (BTU's) for compliance calculations. The energy analysis software takes into the account the design watts and determines the hours based on building occupancy, lighting controls and other factors.

Overall Structure
There are nine sections that directly regulate lighting for most projects.

1. Administrative Rules Sections 10-103, 10-103a and 10-114. The primary impact to lighting affects the training and certification of CLCATTs, and in determining the lighting zone for outdoor lighting power allowances.

2. Scope and Definitions Section Sections 100.0-100.1. Be certain to frequently refer to the definitions. Often, rules are embedded in the definitions that affect calculations and outcomes.

The following are described in more detail below.

3. Mandatory for Lighting Control Devices and Systems, Ballasts and Luminaires Section 110.9.
4. Mandatory Requirements for Lighting Systems and Equipment, Sections 130.1-130.4.
5. Prescriptive Requirements for Building Envelopes, Section 140.3.
6. Prescriptive Requirements for Indoor Lighting, Section 140.6.
7. Prescriptive Requirements for Outdoor Lighting, Section 140.7.
8. Prescriptive Requirements for Signs, Section 140.8.
9. Alterations, additions and repairs, Section 141.0.

Requirements for Specific Systems and Products (§110.9, JA7 and 8)
The requirements in this section are mandatory for all projects, including both **prescriptive** and **performance** methods. It is largely concerned with lighting controls devices and systems. Self contained lighting controls devices are regulated by Title 20, which essentially means that devices like time switches and daylighting controls are regulated like appliances in California.

For retail and museum projects, this section regulates track current limiters and track lighting supplementary overcurrent protection panels.

Mandatory Requirements (§130)
The requirements in this section are mandatory for all projects, including both **prescriptive** and **performance** methods. This section has five critical subsections.

1. The primary purpose of **Section 130.0** is to allow determination of the wattage of a specific luminaire or lighting system. There are rules for different light sources, and key requirements if using certain types of luminaires or lighting systems. This is particularly important in luminaires having medium base (Edison or E26/E27) sockets, ballasts and drivers capable of powering different lamps, GU-24 bases, and LED light sources.
2. The primary purpose of **Section 130.1** is to require that all indoor spaces have both manual and automatic lighting controls. In general, light sources must be dimmable, and automatic controls must be provided to automatically shut off lights and to reduce light levels whenever possible. If interior spaces are daylighted, this section requires automatic dimming in daylighted areas. It also requires demand response capability for indoor lighting systems in buildings or spaces over 10,000 square feet.
3. The primary purpose of Section 130.2 is to require that outdoor light sources be controlled, with reduced power and light levels after hours.
4. The primary purpose of Section 130.3 is to require that sign lighting has appropriate controls, with dimmed levels at night and with demand response reductions for digital message signs.
5. The primary purpose of Section 130.4 is to require specific installation and acceptance testing and certification.

Daylighting Requirements (§140.3)
Section 140.3 contains regulations for the building envelope, including roof, walls and windows. It requires skylights for interior spaces 5,000 square feet or larger that are directly under a roof with a ceiling at least 15 feet hight. These spaces are required to employ automatic daylight dimming in the primary daylight zone.

The primary impact will be on big box retail stores, gymnasiums, and industrial spaces. Retailer like grocery stores and department stores can choose to have ceilings shorter than 15' to avoid the daylighting requirement.

Indoor Prescriptive Lighting Power Limits (§140.6)
This section only applies when using the **prescriptive** method.

For lighting, Section 140.6 is the biggest and most important section. In this section, the designer determines how much power is allowed for his/her design. There are three alternative methods:

- The Whole Building Method is the easiest, but it may allow for the fewest watts. This method may not be used for stores.
- The Area Category Method is the most commonly used for most commercial and industrial building types, a good combination of relative calculation ease and reasonable power allowances.
- The Tailored Method is a lot more work that the others, but it allows the designer the most watts for demanding space types, especially retail sales.

All three methods determine ***allowed lighting power*** by multiplying the area of the space (square feet) by the ***allowed lighting power*** density (watts per square foot). Note that **total** actual lighting watts must be less than **total** allowed lighting watts. Individual spaces or space types do not have to comply, so that some spaces can be "over" and some "under". These are called "tradeoffs". The only exception to this rule is that additional lighting power for tasks in the area category and tailored methods are "use it or lose it" – they must be used in the space for which they are allowed and only for lighting that uses it for the intended purpose.

It is possible to demonstrate compliance for part of the building using one method, and part of the building using another, but only under limited conditions. The primary application is where a portion of a building is best demonstrated by the Tailored Method, such as retail sales area, and the balance of the building is best demonstrated by the Area Category Method, such as storage, shipping/receiving areas, restrooms and work spaces. You can also use separate Methods if one part of the building is conditioned space and another part is unconditioned, such as a parking garage. Then each must comply separately and on separate sheets.

Additionally, there are some special parts of Section 140.6:

- In subsection A.(2), the actual power (watts) of the lighting system can be lowered by the use of controls that exceed the mandatory requirements under §130.1.
- In subsection A.(3), there are 22 lighting applications that are exempt from the energy code, such as dance floor lighting, historic lighting in historic facilities, and theme lighting for theme parks.

Outdoor Lighting Power Limits (§140.7)
This section applies to all outdoor lighting because the prescriptive/performance choice is only intended for buildings.

Outdoor lighting power is regulated by lighting zone, with the lowest power allowance for lighting zone 1 and the most for lighting zone 4. The lighting zone is determined by the authority having jurisdiction, but in general most cities are lighting zone 3 and most suburbs and rural areas are lighting zone 2.

There is only one method. First, determine the lighting zone for the project. Then, determine the general hardscape lighting power allowance by:

- Begin with the initial lighting wattage allowance
- Add to it the product of the area of hardscape (in square feet) by the allowed lighting power density in watts per square foot.
- Add to it the product of the perimeter of the hardscape (in lineal feet) by the allowed linear power allowance in watts per lineal foot.

This method equalizes the allowance among parking lots and other hardscapes of differing shapes and sizes. Trade-offs among hardscape lighting areas is permitted, as long as areas are lighted. You cannot claim allowed watts for areas that are not lighted at all.

To this, additional lighting power can be added for a number of specific tasks such as building facades, outdoor dining, outdoor sales, vehicle service, and drive up windows. Additional lighting power is also allowed for entries to buildings, drop off zones, guard stations, and special security lighting. However, these additional allowances are "use it or lose it" and can not be traded off for other spaces.

Sign Lighting (§140.8)
This section applies to all signs because the prescriptive/performance choice is only intended for buildings. If using LED, fluorescent or HID light sources, signs comply. Otherwise, there is a watts per square foot limit that differs between internally and externally illuminated signs.

Renovations and Additions (§141.0)
This section guides the application of the Standards to renovations and additions. As a general rule, an addition must meet the current Standards using either the performance or prescriptive approach. As long as a renovation does not add or alter existing lighting, there are no requirements to improve the lighting.

However, if a lighting system is altered in any way, regulations apply as follows:

- Any change that increases the lighting load from existing conditions requires bringing the entire lighting system into compliance with the current Standards.
- **Lighting System Alterations** include alterations where an existing lighting system is modified, luminaires are replaced, or luminaires are disconnected from the circuit, removed and reinstalled, whether in the same location or installed elsewhere. In general, a lighting system alteration involving more than 10% of the luminaires in a space requires that the entire installation must include automatic shut off and manual override requirements of the current code. If the resulting lighting power is 85% or more of the current Standards, fully controllable (dimmable) lighting must also be added.
- **A Luminaire Modification in Place** is limited to retrofits that change the light source, optical system or other listed alteration that is not part of any alteration to the space and does not remove or relocate the luminaire – in other words, a retrofit. In general, as long as less than 40 luminaires are altered in a building space, no other requirements apply. However, if more than 40 luminaires are modified, the entire installation must include automatic shut off and manual override requirements of the current code. If the resulting lighting power is 85% or more of the current Standards, fully controllable (dimmable) lighting must also be added.
- **Lighting Wiring Alterations** include adding a circuit feeding luminaires, modifying or relocating wiring to provide power to new or relocated luminaires, replacing wiring between a switch or panelboard and luminaire(s), or replacing or installing a new panelboard feeding lighting systems. Any of these

will require all lighting controls under Section 130.1 to be provided.

- There are special exceptions for lighting maintenance and for facilities in which the presence of asbestos has dictated the need for building changes.

This section is new material in the 2013 Standard and was written to not unnecessarily burden lighting retrofits while preventing lighting retrofits from used to avoid compliance with the Standards for tenant improvements and new tenant renovations.

Changes from 2008 Standard to 2013 Standard

Those familiar with the Standards will be interested in the following summary of important changes from the 2008 Standards that went into effect in 2010. Note: there are many changes throughout the Standards. These are some of the more important ones. Careful reading of every section is strongly recommended even for Title 24 experts.

General

The standards were re-numbered to allow for new requirements. Most section numbers changed by adding a zero. For example, Section 146 became section 140.6. Some definitions (Section 100) were changed.

Acceptance testing requirements were expanded, and installation certificates were added.

Certified Lighting Controls Acceptance Test Technician (CLCATT or "cool cat") requirements were added.

Mandatory requirements

1. Unitary lighting controls devices (not systems) are now regulated by Title 20 and require certification by the California Energy Commission. See Title 20 Section 1605.2.
2. Lighting controls systems (not devices) remain regulated by the Standards in Section 100.9.
3. Changes to luminaire classifications and calculations of "actual lighting power" This is relatively straightforward, with its primary intent to address LED lighting and to close loopholes.
4. Mandatory multi-level control which essentially makes all lighting systems dimmable, or in the case of light sources that don't dim well, like HID, step dimming.
5. Requires partial on/off occupancy sensors in corridors, stairwells, library stacks and warehouse aisles. Partial on or partial off sensors reduce light levels but do not turn them totally on or totally off, depending on the circumstances.
6. Security and egress lighting must be switched off automatically. There are essentially no "night lights" any more, except for a small allowance in office buildings. Motion sensors must be used for security lighting purposes.
7. Photocontrols are required in much smaller spaces with adequate daylighting (250 sf minimum).
8. Mandatory demand response is now required in all buildings >10,000 sf .
9. Mandatory voltage drop limits are now in place.
10. Mandatory power system disaggregation is now required. This means that for buildings with a service size over 50 KVA, all lighting must be on a separate feeder, all receptacles must be on a separate feeder, etc. This will allow easy measurement of how energy is being used, although at this time, separate energy metering is not required.
11. Mandatory switching of receptacles in offices and schools is now required in order to reduce

energy waste due to vampire loads at night.

Daylighting
In the prescriptive method, skylights are required for spaces 5000 square feet and larger directly under a roof and having ceilings at least 15 feet above the floor. Exceptions to this rule include auditoriums, churches, movie theaters, museums, and refrigerated warehouses, and spaces with electric lighting power density of less than 0.5 watts per square foot. This requirement now applies to smaller spaces and requires a larger percentage of the floor area to be daylighted.

Lighting Power Allowances

1. Additional power allowances have been added to the area category method.
2. The tailored method has been changed from IES Illumination Categories to lux levels.
3. There are reductions in office lighting power allowances
4. There are significant reductions in retail lighting power allowances. The 2008 Standards were based on halogen retail display lighting; the 2013 Standards are based on LED or CMH display lighting.
5. Additional office Power Adjustment Factors have been added for controls over and above minimum mandatory controls.

Outdoor Lighting

1. Reduced outdoor lighting power allowances in all zones.
2. Mandatory UG (not BUG) for outdoor luminaires.
3. Mandatory photocontrol and time scheduling for outdoor luminaires
4. Mandatory partial on/off occ sensing for outdoor luminaires mounted at 24' or less.

Additions and Alterations

1. New language addressing lighting system alterations and luminaire modifications in place.
2. Requirements to update lighting systems with new controls when a threshold of alterations or modifications has been passed.

Special Note About LED Color
In Joint Appendices JA8, a new LED color quality initiative was introduced for residential lighting, requiring a minimum 90 CRI for indoor LED light sources being used to meet the high efficacy lighting requirement.

The California Public Service Commission has adopted this lamp quality initiative. We expect that for non-residential lighting, a minimum of 90 CRI may be required for LED indoor lighting systems in order that a rebate or incentive be paid by a utility.

Incentives

California utilities provide rebates for energy efficient lighting, especially for replacing conventional legacy lighting with LED's and modern controls. Projects can qualify in a number of ways, depending on the particular utility company. It often pays to investigate the opportunity early in the process.

Savings By Design
This program is sponsored by all California's major utilities. For new designs, it pays incentives to the building owner and to the design team for bettering Title 24 by at least 10%. Incentives can be whole building (all systems)

or system-by-system. Design teams must inquire about project candidacy, the availability of funds and program support prior to starting design.

Direct Incentives and Rebates
This program is offered for improvements to existing facilities. Sometimes called "express" incentives, these generally provide a specific incentive for a specific lighting product, such as an LED lamp, LED replacement luminaire, or a specific control device such as a motion sensor. Incentive amounts are determined on a utility-by-utility basis.

Custom Incentives and Rebates
This program is also for improvements to existing facilities. They involve the applications of controls systems and other more complex energy efficiency solutions. The incentive amount is based on predicted energy savings in the first year. Incentive amounts are determined on a utility-by-utility basis.

Demand Response Incentives
A demand response system sheds loads when there is a peak power emergency upon receiving a command from the utility company. Most California utilities offer incentives to customers who install either voluntary (customer chooses to respond) or involuntary (customer must respond) demand response systems. Involuntary systems currently have some of the largest incentives. The response must turn off or dim lighting as well as other building systems and appliances. The incentive is based on the kilowatts of demand that are shed when the installed system is tested.

Compliance Strategy

Throughout its history, Title 24 has gained the reputation of being very strict, and causing stores to redesign lighting systems that are legal in other states. This is no longer as true as it once was; nonetheless, the designer often completes the lighting design and compliance documentation, only to realize it does not comply.

In retail, there are two strategies of design to comply:

- Small projects with relatively simple lighting designs generally use the Area Category Method. A simple design means general lighting with some display lighting. When using track, this means roughly 25 lineal feet of track for every 1000 square feet of sales area. When using recessed accent lighting, this means about 10-20 lamps per 1000 sf. As long as the design meets these limitations, the area category method might be best. Sales areas can have up to 1.7 w/sf of connected lighting load.
- On the other hand, the Tailored Method is first and foremost designed to allow specialty retail stores to have more watts to achieve the appearance of "high end" stores or to properly illuminate jewelry and other very valuable merchandise. Whereas it is not possible to design a complying all-incandescent store, the Tailored Method will allow an extremely complex and sophisticated lighting design as long as energy efficient light sources and controls are employed. For a jewelry or fine art store with many display cabinets, up to 4.5 w/sf can be made to comply; for a high end fine merchandise with only some very valuable display cabinets, a more practical limit is about 4 w/sf. To get the greatest allowance, be sure to use up all additional power allowances before designing general or ambient lighting.

Especially with the Tailored Method, it is hard to judge whether the design complies until after the design and the calculations are complete. However, an experienced designer knows that there are many honest trade-offs in the course of lighting design and compliance documentation. For example, separate use-it-or-lose-it allowances are provided for wall display and floor display lighting. As long as luminaires or track are mounted between 2' and 10' laterally from a ceiling-high wall, they can be counted as either (but not both). The best strategy is to make sure

that all use-it-or-lose it allowances are used up. Note: if the authority having jurisdiction were to object and insist on separate switching for luminaires aimed at the wall and luminaires aimed towards the floor, the designer could circuit individual luminaires accordingly and employ two circuit track with separate controls.

Other strategies for making a challenging design comply include:

- Reducing track rating using either current limiters or a secondary overcurrent protection panel. With the most powerful LED luminaires now operating at 40 watts, a luminaire every 3 feet is 13.3 watts per foot; two 20-watt track luminaires would also work. Be careful, however, as this will limit flexibility with future store designs and layouts.
- For stores under 10,000 sf, using a lighting power adjustment factor for providing demand responsive lighting controls as part of the control panel. This would allow 5% of the total connected lighting load to be deducted.
- Reducing the connected lighting load system-by-system. For instance, ambient lighting could be reduced 10-20% in many cases.
- Using a mounting height adjustment factor to account for the inefficiency of display lighting at tall mounting heights. Raising the ceiling to 12 feet permits an additional 13 percent watts for display lighting.

For the retail designer, lighting control systems with programmable time of day, astronomic time, and calendar time will almost always be needed, especially those that allow different programmed light levels as well as fixed tuning of light level maximums. Separate control zones for general lighting, wall display, floor display, display cases, window displays, exterior lighting, and sign lighting will be needed. Occupancy sensors can be used in smaller spaces such as toilet rooms and stock rooms. Note that in stores, manual override switches are required but they may be hidden from public access.

Renovations and Retrofits

While it is theoretically possible to renovate a store without requiring compliance with the lighting standards, it is unlikely. Almost any renovation to a space that relocates walls and ceilings will invoke all of the Standards unless all lighting is left untouched.

However, in order to get an incentive and save energy, it is often very desireable to retrofit lighting systems. Note that Section 141.0 delineates specific requirements including “luminaire system alterations”, “luminaire modifications in place”, and “lighting wiring alterations”. Each has certain criteria that invoke requirements for power density, controls improvements, etc. Be sure to consult with these requirements before proceeding with any alterations or retrofits of lighting.

Daylighting

Title 24 requires skylights for all spaces 5000 square feet or larger that are directly under a roof and have a ceiling at least 15 feet high. If there is no ceiling, the exposed deck height is the ceiling height. There will be many stores at least 5,000 square feet; whether to have a 14’-11” or lower ceiling or whether to have skylights will be a design challenge but also, an opportunity to save energy and create a dramatic and dynamic space.

Whether to employ daylighting is an interesting question. Daylighting can include skylights, windows and clerestory (high wall) windows. Aside from impacting the architecture, ceiling and lighting plan, daylighting would dramatically affect the energy use and energy code compliance documentation.
There are two primary daylighting approaches:

1. Save as much energy as possible by turning lights off. This method works well for big-box stores and grocery stores. However, it is hard to make daylighting “dramatic”, and it may appear less

appealing in an upscale specialty retail store.

2. Use "half daylighting", which means daylighting mixes with an electric lighting design to create a brighter store by day, and a dimmer store by night. This is especially good for stores with an outdoor entrance, as it helps the shopper better adjust to the transition from outdoors to indoors.

Automatic daylighting controls will be required and additional documentation and forms submitted. Also, automatic daylighting controls have the most extensive installation certification and acceptance testing requirements.

Outdoor Lighting

For stores with outdoor lighting, the 2013 Title 24 reduces allowed lighting watts quite a bit. Conventional designs will still work, but designers will need to rely almost completely on LED lighting for area lighting, building floodlighting and signs. The outdoor standards in §140.7 are very much like the Tailored Method, so be certain to use the additional power allowances for entrances, facades, outdoor dining, decorative lighting, etc. to justify special lighting for better store exteriors.

Final Comments

The Standards have been developed to allow "just enough" lighting power to meet contemporary design demands while remaining responsible to California's Warren Alquist Act, the state law mandating energy efficiency lighting. Over the years, Title 24 has set the pace for efficiency, but now ANSI/ASHRAE/IES 90.1 is essentially as stringent. Designers whose projects meet Title 24 most likely will meet energy codes elsewhere in North America and most of the world.

Title 24:
Example Projects & Forms

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Retail Lighting Under Title 24-2013: Example Projects and Forms

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Attachments: Completed Forms for Neighborhood Grocery and Specialty Retail Store

Designing for Compliance

Basic Considerations

Title 24 Part 6 is California's Building Energy Efficiency Standards, part of California's state building codes. Designing for and demonstrating compliance is mandatory to obtain a building permit, and verification of construction and proper commissioning is mandatory to obtain an occupancy permit.

There are two primary ways to demonstrate compliance: performance, which means a computer simulation of building energy use, and prescriptive, which means following specific rules for lighting, building envelope (glazing, insulation, etc.), and HVAC systems. For retail lighting, most projects are major interior renovations, which generally do not permit performance compliance because the building shell is not altered and HVAC seldom changed. They must use prescriptive performance, on which this white paper focuses.

Lighting Design Approach

The Title 24 standards are based on three primary approaches to retail lighting:

1. General lighting consisting of a relatively uniform grid of high efficiency luminaires.
2. General lighting with occasional highlights from accent lighting equipment and/or occasional use of decorative lighting.
3. Layered lighting design consisting of:
    a. General or "ambient" illumination from high efficiency sources
    b. Wall display lighting mounted within 10 feet of the wall and being of a type suitable for wall display such as track, recessed or monopoint accent lights, wall washers, valance lighting, shelf display lighting, etc.
    c. Floor display and task lighting mounted more than 2 feet away from any wall and being of a type suitable for display such as track, recessed or monopoint accent lights.
    d. Very valuable merchandise lighting for display cases, which can consist of internal or external luminaires. External luminaires must be of a special display type suited for illuminating display cases.
    e. Decorative and special effects lighting, which must not be used for general or display lighting.

The "area category" compliance method matches best the first two designs, and the "tailored method" matches the third approach. These principles have served for almost three decades of Title 24 enforcement. They differ from standard 90.1 and IECC in that, with the exception of very valuable merchandise allowances, any store with any type or quality level of product can use any design approach and any compliance method. For regional and national store chains, it is strongly recommended that prototype designs be evaluated for all three energy codes (title 24, standard 90.1 and IECC) to ensure compliance on all markets.

Compliance Documentation Strategy

Regardless of whether the project is a new building or tenant improvement, most retail projects will have to comply with some or all Title 24's lighting requirements. You can avoid this only if existing lighting is not altered in any way.

When you start a retail project, you generally must choose between the simpler Area Category Method and the more complex Tailored Method to demonstrate compliance. The Area Category Method is relatively fast and inexpensive (in terms of professional time), but will generally limit lighting power to less than 2 w/sf. The Tailored Method is slow and expensive, but allows much more lighting power when it is needed. However, in either case, to meet IES recommendations and Title 24, energy efficient lighting equipment and controls will always be necessary.

Title 24

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Choosing the compliance method is a crucial strategy at the beginning of a project. Don't waste a lot of time (and money) trying to decide. Use this simple guide:

Method	Area Category Method	Tailored Method
Best for	Retail stores using general lighting practices such as convenience stores, general merchandise stores and consumer goods stores. Stores with a little bit of display lighting such as track or built-in case displays, but not a lot. Stores with some decorative or special effects lighting but not a lot.	Department stores, specialty retail stores and fine merchandise such as jewelry, fine art, and collectibles stores. Stores with extensive track and display lighting (except refrigerated goods). Stores with a lot of wall displays with accent or wall wash lighting. Stores with a lot of decorative or special effects lighting. Stores with very high mounting heights for wall and floor display lighting (>12')
Required Indoor Calculations	Allowed general lighting power. Use it or lose it additional display lighting power. Use it or lose it additional decorative lighting power. --- Actual lighting power.	Allowed general lighting power (cannot be used for display lighting equipment). Use it or lose it wall display lighting power, including mounting height multiplier. Use it or lose it floor display/task lighting power, including mounting height multiplier. Use it or lose it decorative lighting power. Use it or lose it very valuable merchandise lighting power. --- Actual lighting power.
Likely Range of Total Indoor Lighting Power Allowance	From 1.2 w/sf for a simple grocery store to 1.7 w/sf for a specialty retail store.	Up to 4.5 w/sf for a specialty retail store selling jewelry, fine art or other merchandise requiring display in cabinets

Special Notes About Track

Recognizing that track lighting can be used to circumvent the code, Title 24 is especially concerned with track. For this reason, track must be counted as 45 watts per foot regardless of how few lighting devices or power or watts are connected unless some additional components are provided. Ordinarily this would make track essentially useless because title 24's display lighting allowance is relatively low. However, track lighting can be made useful without severely limiting lighting options if:

- Do not use track for general lighting under the tailored method. Have separate track and general lighting systems.
- Use track current limiters (in line circuit breakers) to carefully allow just enough power for each track length. This will reduce track to as low as 12.5 watts per foot; or,
- Use track supplementary overcurrent protection panel(s) to carefully allow just enough power for each track length. This will reduce track power to the rating of the breaker, so in theory, track power for code purposes can become very low; or,
- Use low voltage track. This will reduce track wattage to the capacity of the transformer or power supply; or,
- Use branch circuit design such that a lot of track is on one branch circuit. For instance, a single 20 amp branch circuit is rated at 2400 volt amps (for these purposes, watts = volt amps). If you had 240 feet of track on one circuit, it would be 2400/240 = 10 watts per foot. If using track rated more than 20 amps, this is the only method to prevent track watts from making energy code compliance difficult or impossible.

If track lighting is used, additional compliance forms are required, and installation certification forms must be submitted for the track lighting.

As a general rule, designs relying solely on track lighting, especially designs that employ all adjustable accent luminaires, should not be used in California. This type of design will make compliance difficult or impossible due to the restriction against using accent luminaires for general lighting.

Forms

Forms demonstrating compliance can be filled in by hand or by using one of several computer programs that partially automate the process. The forms can be found at the back of the Manual. For the purposes of this study, hand-written forms are used.

Daylighting

Starting with the 2013 Standards, all spaces If a sales area is greater than 5000 square feet and the ceiling is 15' high or higher and directly under a roof, skylights are required that illuminate 75% or more of the floor area. There can be many benefits to daylighting, but there can be drawbacks, too. For projects in which daylighting is not preferred, you may wish to subdivide departments of the store to limit each space to less than 5000 square feet, or alternatively, reduce ceiling height to less than 15 feet.

Case Study: Small Neighborhood Grocery Store

This small grocery store has a sales area of 4,000 square feet and a total footprint of less than 5,000 square feet. Let's assume this is a complete renovation or new building. The design employs energy efficient, standard general lighting systems. Overhead lighting consists of (72) 2x4 LED troffers. In addition to overhead general lighting, there is lighting in refrigerated cases and freezer cases, and there are conventional beer signs in the store window. The front exterior of the building and entry is washed with arm mounted wall wash luminaires. Lighting at the back door consists of (2) 26 watt LED wallpacks. The rest is simple lighting for the restroom and stocking areas.

Interior Lighting

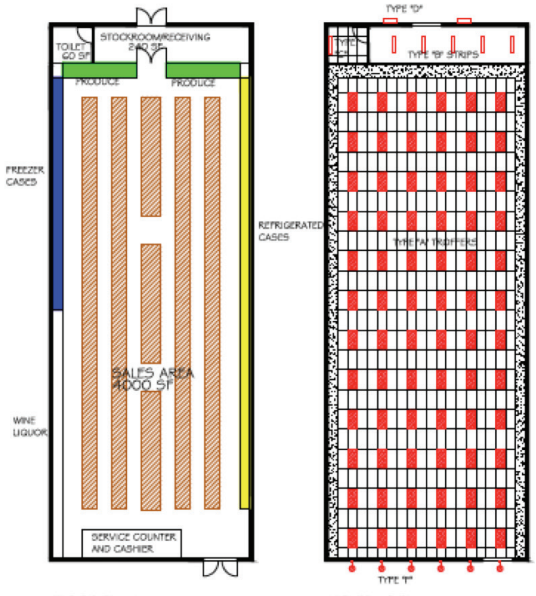
Allowed Lighting Power

Small projects with relatively simple lighting designs generally use the Area Category Method. From Table 140.6-C, look up the allowed lighting power density for a grocery sales area:

Primary Function Area	Allowed Lighting Power
Grocery Sales Area	1.2 [6 and 7]

Footnotes 6 and 7 of the table point to additional lighting power allowances for grocery stores. These are use-it-or-lose it allowances. Our design does not employ directional lighting or decorative lighting, so we cannot use these allowances.

6	Accent, display and feature lighting - luminaures shall be adjustable or directional	0.3 w/ft
7	Decorative lighting - primary function shall be decorative and shall be in addition to general illumination	0.2 w/ft



NEIGHBORHOOD GROCERY STORE

Note the maximum lighting power density that can be permitted under the area category method is 1.7 watts per square foot for all interior lighting using all allowances. If you wish to maximize lighting and lighting power, it is advisable to use up the display and decorative allowances first, because with this method the general lighting power allowance can include display and decorative lighting, but not the other way around.

(If you wish, once comfortable with this design and its compliance, add some decorative and accent lighting and see how quickly you might "use up" these additional allowances.)
There are also support spaces. From Table 140.6-C, look up their allowed lighting power density values, too. These values will be used to calculate the indoor lighting power for the back of house spaces.

Primary Function Area	Allowed Lighting Power
Corridor, Restroom, Stairs & Support Areas	0.6
Commercial & Industrial Storage	0.6

Using form page NRCC-LTI-03-E, Indoor Lighting Power Allowance, Section C-2, fill in Columns A, and B, and perform the calculations filling in columns D and G. There are 4000 sf of grocery sales area (including the footprint of floor displays and refrigerated cases), 240 square feet of storage, and 60 square feet of restrooms. Total the columns. **The project is allowed 4,980 watts.**

Actual Lighting Power
The next step is to determine the actual lighting power being used. First, check for lighting that is exempt. We have refrigerated and freezer cases around the back and sides of the space. Look up "refrigerated cases" under the definitions:

> REFRIGERATED CASE is manufactured commercial refrigerator or freezer, including but not limited to display cases, reach-in cabinets, meat cases, and frozen food and soda fountain units.

Under §140.6 (a) 3., refrigerated cases are exempt, as are exit signs. If normally off emergency lighting is used, it too is exempt.

The balance of the lighting is entered onto sheet NRCC-LTI-01-E, Table C as follows:

- There are (72) 2x4 Type "A" troffers using LED light sources. Each is rated 38 watts, for a total of 2,736 watts.
- There are (5) Type "B" strip lights using 2-F32T8/28 lamps and a low ballast factor high efficiency ballast, each rated 45 watts for a total of 225 watts.
- There is (1) Type "C" vanity light using 2-F32T8/28 lamps and a low ballast factor high efficiency ballast rated 45 watts.

The indoor lighting total watts is 3,006, and the interior lighting design complies.

The total actual interior lighting power is 3,006 watts. The interior lighting complies it is well within the allowance of 4,980 watts. The interior lighting power density is about 0.70 w/sf. (This will make multi-level lighting controls necessary – see below).

Exterior Lighting

Allowed Lighting Power

Because the store project has no parking lot or hardscape that is part of the project, the exterior lighting allowance is a little tricky. The exterior lighting for the front of the store is intended to light the sidewalk and because street lighting does not meet IES recommended light levels for this situation, it is reasonable to claim the sidewalk area to be lighted, which is the width of the store (40') by the width of the sidewalk (6' to the curb), for a hardscape area of 240 square feet and a perimeter of 92 linear feet. Assuming a city location, the default lighting zone is LZ3. Find the allowed lighting power from Table 140.7-A. Fill in Form NRCC-LTO-03-E (1 of 6), Table B, columns A, B, D, E, and G, and calculate columns C, F, and H. Sum the values at the bottom; enter the sum to the top of the form under A. (1.) and enter on form NRCC-LTO-01-E (2 of 3) Line 1.

Type of Power Allowance	Lighting Zone 3
Area Wattage Allowance (AWA)	0.090 w/ft^2
Linear Wattage Allowance (LWA)	0.60 w/ft^2
Initial Wattage Allowance (IWA)	770w

The project is allowed 770 watts (IWA) plus 55 watts (LWA) plus 22 watts (AWA) for a total of 847 watts of hardscape lighting.

Additional "use it or lose it" lighting allowances are allowed for the building entrances (front and rear).

Lighting Application	Lighting Zone 3
WATTAGE ALLOWANCE PER APPLICATION. Use all that apply as appropriate	
Building Entrance or Exits. Allowance per door. Luminaires qualifying for this allowance shall be within 20 feet of the door	90 watts

The rear entrance is lighted by (2) type "D" wallpacks, 26 watts each. The front entrance is illuminated by two type "F" wall mounted lights at 45 watts each. Fill in form NRCC-LTO-03-E (2 of 6), Table C-1, all columns. Calculate and fill in the sum for Table C-1. All 142 watts are allowed. Enter this value on NRCC-LTO-03-E (1 of 6), under Table A. (2) under "per application from C-1" and add lines (2) and (1) and place the result under (3). Also, enter the value on NRCC-LTO-01-E Line 2, and sum lines 1 through 4 and place the result in line 5.

This is the total outdoor lighting power allowance, 989 watts.

Actual Lighting Power

The remaining four (4) Type "F" luminaires provide hardscape lighting. Fill in form NRCC-LTO-01-E (Page 3 of 3) columns A through G for all outdoor lighting types D and F. Note that the watts are determined from the luminaire rating per Section 130.0(c), so check this box.

None of the luminaires is equal to 150 lamp watts, therefore by §130.2 (b) the outdoor luminaires are exempt from BUG (Backlight and Up-Light Glare) requirements. Write "Exempt" in column H of form NRCC-LTO-01-E (Page 3 of 3) and fill in the appropriate lines of form NRCC-LTO-01-E (Page 2 of 3).

Total the installed watts at the bottom of the table. Enter this value on NRCC-LTO-01-E (Page 2 of 3), line 6 at the top. The design watts are 322, and the design complies.

Lighting Controls and Other Requirements
Use form NRCC-LTI-02-E (Interior) and NRCC-LTO-02-E (Outdoor) to review choices for lighting controls. Because this project does not have store window displays, track lighting, or decorative lighting, the controls can be simple, but they must provide:

Interior Lighting (§130.1)

- Manual on/off override (can be located in a concealed location per Exception 1 §130.1 (a.) 2.)
- Automatic shut off by calendar and clock time, with motion sensor override should the space become occupied.
- In the restroom only: an on/off motion sensor or count-down timer can be used.
- Separate controls for display lighting (refrigerated displays), and general lighting.
- Multi-level control (dimming) for the retail sales area and the storage/shipping/receiving area is required because the spaces exceed 100 square feet, and because the lighting power density is over 0.5 w/sf.
- A choice of manual dimming, tuning, or demand response controls (except for the restroom).

  Small lighting control systems having a programmable calendar and time of day switching are often used for this type of project. They will need to meet the requirements of §110.9.

Exterior Lighting (§130.2)
The requirements of Section 130.2(c) present a quandary. Since all of the luminaires on the front of the building are greater than 30 watts and mounted lower than 24 feet, the Standards call for these luminaires to be constantly motion controlled based on occupancy. For sidewalk and façade lighting, this is probably undesirable during business hours. There are several possible solutions:

- Re-work the forms with the type "F" lights put forth as façade lighting or as sign lighting. With a façade that is nominally 18' x 40', the Standards permit façade lighting, without motion dimming requirements with almost enough watts to preserve the original design. Only one luminaire would have to be controlled by a sensor, or lower wattage luminaires could be used. In the restroom only: an on/off motion sensor or count-down timer can be used.
- Claim exception 3 from Section 140.7(a) by claiming that the lighting illuminates the public sidewalk, public curb and public street.
- Paint a large sign on the façade that is illuminated by the Type "F" lights. With an allowance of 2.3 w/sf, the approximate sign area would have to be about 60 sf, comprised of letters and graphics roughly 30 feet wide and 2 feet tall. Signs must have astronomic or photo-responsive lighting controls, but are not required to be dimmed by motion.

The watts of the luminaires at the back door are low enough to not require a motion sensor.

The lighting control system proposed for the interior is also suitable for the exterior. If desired, outdoor motion sensors can be connected to this type of system, and these systems generally offer astronomic time, calendar and clock time functions. Separate controls can be provided for back door and front door lighting.

Complete the balance of the interior and exterior forms. Note that, depending on the choice of controls, it is necessary to indicate the need for certificates of installation and for acceptance testing of both the indoor and exterior lighting controls.

Case Study: Specialty Retail Store

This store has a sales area of 3,200 square feet, changing and fitting rooms, and a restroom and work area with a total footprint of about 4,300 square feet. This is an interior-only renovation. Exterior lighting is not included.

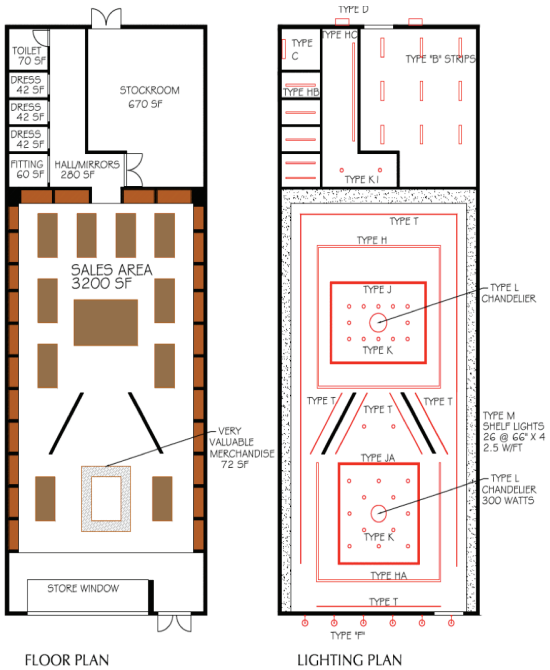
The project has a sophisticated interior with niche displays all around, angled display walls, a central cash/wrap and glass covered counter, and a common sales/window area. Architectural features include a flat wallboard ceiling at 11'6" with two large coffers up to 13'6". There is a soffit around the sales area creating a series of wall niches, 26 in all, with (4) shelves 5'6" and a base cabinet for storage. The main sales area is subdivided by the 2 angled walls for additional vertical display. There is a sales counter with very valuable merchandise (e.g. watches, jewelry) all around with a cash wrap counter in the middle (not shown). In the rear of the store, there are three dressing rooms, a fitting room, an open area with mirrored walls, a workroom, and a unisex toilet.

The lighting design employs a current contemporary approach. It includes chandeliers, cove lighted coffers, track lighting, and continuous linear LED lens lighting. Linear LED lens lighting is also used in the dressing and fitting areas. There is simple lighting for the restroom and stocking areas.

Strategy

For lighting design compliance, the Tailored Method is first and foremost designed to allow specialty retail stores to have more watts to achieve the appearance of "high end" stores or to properly illuminate jewelry and other very valuable merchandise. Whereas it is not possible to design a complying all-incandescent store, the Tailored Method will allow an extremely complex and sophisticated lighting design as long as energy efficient light sources and controls are employed.

Display lighting for this project includes track, adjustable recessed accent lights, LED lighting built into shelves, accent lighting for the store window area, and accent lighting inside of valuable merchandise cabinets. It is widely agreed that the only way to demonstrate compliance for a project that has a lot of display lighting is to employ the Tailored Method.



SPECIALTY RETAIL STORE

Organize the Forms

In order, the forms for a indoor tailored method compliance documentation are

- Forms Group 1: NRCC-LTI-01-E (Certificate of Compliance) 5 sheets
- Forms Group 2: NRCC-LTI-02-E (Lighting Controls, Certificate of Compliance and PAF Calculation) 4 sheets
- Forms Group 3: NRCC-LTI-03-E (Interior Lighting Power Allowance) 5 sheets
- Forms Group 4: NRCC-LTI-04-E (Tailored Method) 7 sheets
- Forms Group 5: NRCC-LTI-05-E (Track Lighting Worksheet) 2 sheets

Not all projects will require all sheets in all groups, but in some cases you may have to use the same sheet several times to capture all of the information. Simple projects may only need the first three groups. The last two groups are for the tailored method and for line voltage track lighting, both of which will be needed for this project.

Every group ends with a signature sheet. At some point in the process, these sheets must be filled in and signed by the responsible parties, but only for the groups being completed.

The forms are designed like income tax forms, in that you fill in basic information on the first form, then complete the later forms in the order, and bring the data forward to the first form before finishing. If doing the forms by hand, print out blank forms and fill in dates, project names, and other required information. Like tax forms it can be confusing, but carefully read the forms and keep them organized and it will work out fairly well.

Start with Sheet NRCC-LTI-01-E (1 of 5). Proceed to the checklist of Lighting Compliance Documents. In this case, we will check most of the documents, because our strategy includes all five groups of documents.

Also on NRCC-LTI-01-E (page 2 of 5) under Declaration of Required Installation Certificate, check the first three boxes “yes”. Check the last three boxes “no”.

For lighting controls, stores typically use programmable time controls and/or motion sensors. At the bottom of NRCC-LTI-01-E (2 of 5), check “yes” under the Declaration of Required Certificates of Acceptance for the form NRCA-LTI-02-E and no for the other types of controls.

In Box A. at the top of NRCC-LTI-01-E (3 of 5) check the conditioned space box and the boxes in “A” except complete building method, which will not be used and is therefore not checked.

Wattage Calculations

Title 24 permits using both the Tailored Method and the Area Category Method to demonstrate compliance for the same project. In simple terms, use the Tailored Method for retail spaces, especially when using accent lighting, wall lighting, etc. and use the Area Category Method for simple spaces without accent lighting. This saves time and work. For this project, we will use the Tailored Method for the Retail Sales Area and the dressing and fitting rooms. We will use the Area Category Method for the stockroom/workroom and restroom.

Start with the Tailored Method, forms NRCC-ETI-04-E.

Allowed Lighting Power

The allowed lighting power under the Tailored Method consists of a base power allowance, to which is added additional lighting power allowances for wall display, floor display and task lighting, ornamental/special effects, and very valuable display cases. The allowances are listed in Table 140.6-D.

Table 140.6-D TAILORED METHOD LIGHTING POWER ALLOWANCES				
1	2	3	4	5
Primary Function Area	General Illumination Level (Lux)	Wall Display Power (w/ft)	Allowed Combined Floor Display Power & Task Lighting Power (w/ft²)	Allowed Ornamental/ Special Effect Lighting
Retail Merchandise Sales & Showroom Areas	400	14.00	1.0	0.5

First, determine the approximate Room Cavity Ratio (RCR) of the sales area. The formula for RCR is:

Table 140.6-F ROOM CAVITY RATIO (RCR) EQUATIONS
Determine the Room Cavity Ratio for TABLE 140.6-G 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 irregular-shaped rooms $RCR = \frac{2.5 \times H \times P}{A}$ Where L = length of room; W = width of room; H = vertical distance from the work plane to the centerline of the lighting fixture; P = perimeter of room; A = area of room

The main sales area is 40' x 80' and the finished ceiling height is 11'6" above finished floor. (The two coffers are 2' deep, with a finished ceiling height of 14', but this value should not be used to determine RCR.) The height of the working plane is 2.5' making H = 9.0'. The room is 40' wide and 80' long. The RCR is:

Enter the RCR calculations on Page NRCC-LTI-04-E Page 6 of 7.The base lighting allowance is then determined from Table 140.6-G.

$$\frac{5 \times 9 \times (40 + 80)}{40 \times 80}$$

Table 140.6-G ILLUMINANCE LEVEL (LUX) DENSITY VALUES (W/FT²)				
Illuminance Level (LUX)	RCR ≤ 2.0	RCR > 2.0 & ≤ 3.5	RCR > 3.5 & ≤ 7.0	RCR > 7.0
400	0.9	1.1	1.5	2.2

This sales area is allowed 0.9 watts per square foot for general lighting. The general lighting allowance is 3200 sf x **0.9 w/sf** = 2880 watts. Enter the room data on form NRCC-LTI-04-E, Page 1 of 7, Table B, on the first line. For room number, enter "main sales".

Repeat this process for the dressing and fitting area. Ceilings are 9' high and H is 6.5. Because these areas need fairly high light levels for the tasks, they are considered part of the sales area. The rooms are:

- Dressing rooms 1, 2 and 3 each 42.5 sf (5' x 8.5'), RCR = 10.32, general lighting allowance **2.2 w/sf** = 93.5 watts per roomSeparate controls for display lighting (refrigerated displays), and general lighting.
- Fitting room 60 sf (8.5' x 7') RCR = 8.39, general lighting allowance **2.2 w/sf** = 132 watts
- Fitting/mirror hallway 285 sf, P=91.1', RCR =5.20, general lighting allowance **1.5 w/sf** = 427.5 watts

Add the RCR data on sheet NRCC-LTI-04-E (6 of 7) and to sheet NRCC-LTI-04-E, (1 of 7) Table B. It is OK to use room names instead of numbers for a small project. Room numbers are preferred for larger projects. To simplify the dressing rooms are combined.

Finally, address the stockroom. This is not a sales area, but it is a commercial "work area" in which some precise work might occur. For this we use the Area Category Method, Table 140.6-C. RCR does not matter for Area Category. The space does not have a ceiling, so the deck height is assumed to be 14' above finished floor. We are allowed:

General Commercial & Industrial Work Areas	Low bay	0.9 [2]
	High bay	1.0 [2]
	Precision	1.2 [4]

At this time we don't know of any specific special task work areas (footnote 2), and because this is a low bay space we choose 0.9 w/sf x 678 watts = 610 watts. This data gets entered onto NRCC-LTI-03 (2 of 4) under Table C-2.

Corridor, Restroom, Stair, & Support Areas	0.6

The restroom data is entered as 0.6 w/sf x 70 sf = 42 watts. Also enter this data onto NRCC-LTI-03-E (2 of 4) under Table C-2. Total the allowed watts (610+42) = 652 for the area category method under table C-2 at the top of page NRCC-LTI-03-E (3 of 4) and carry this value to line 2, Table A on NRCC-LTI-03-E (1 of 4).

Because we're using the tailored method for the sales area, the allowed power includes use-it-or-lose it amounts that still need to be determined.

Actual Lighting Power and Allowed Use-It-Or-Lose-It Power

Check for lighting that is exempt. Exit signs are exempt. If normally off emergency lighting is used, it too is exempt. The balance of the lighting is entered as follows:

General Lighting – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C only. *(If you need more room, add continuation sheets to NRCC-LTI-01-E (4 of 5))*. Indicate quantities and calculate total watts for each luminaire type.

- Type "H" is a continuous LED 4" wide lens fixture that is 100 feet long and operates at 7.5 watts per foot.
- Type "HA" is a continuous LED 4" wide lens fixture that is 68 feet long and operates at 7.5 watts per foot.
- Type "J" and "JA" are LED cove lighting each 70' long and operate at 7.5 watts per foot.
- There are 5 "HB" recessed linear LED luminaires operating at 50 watts.
- There is one "HC" recessed linear LED luminaire operating at 135 watts.
- There is one "C" toilet vanity light using (2) F32T8/28 fluorescent lamps and low ballast factor high efficiency ballasts, operating at 45 watts.
- There are nine "B" striplights using (2) F32T8/28 fluorescent lamps and low ballast factor high efficiency ballasts, operating at 45 watts each.

Track Lighting – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C and NRCC-LTI-05-E (1 of 2)

- Type "T" track is line voltage and there is 239 linear feet.
- You must decide on whether you will limit track watts. There are four choices: (1) the VA rating of branch circuits feeding the track; (2) the higher of 45 watts per foot or the rating of the luminaires; (3) the higher of 12.5 watts per foot or the total VA rating of all track current limiters; (4) the total VA rating of all circuit breakers in a secondary overcurrent protection panel feeding the track.
- For the purposes of this exercise, we plan to install a 45-watt maximum LED track luminaire every 3 feet, equaling 15 watts per foot. This equates to (15 x 239) = 3,585 watts. We have the option of using 2 circuits for all of the track (2400 x 2 = 4,800 watts) or current limiters or breakers in a track lighting panel equaling 30 amps (3,600 watts). We choose 4,800 watts and check method 1 on page NRCC-LTI-05 E (1 of 2), filling in the circuit numbers and 4,800 watts. Use 4800 watts on sheet NRCC-LTI-01 (4 of 5).
- We will choose to assign some of the track to wall display, and some to floor display, below.

Wall Display – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C and NRCC-LTI-04-E (2 of 7) Table D-1, Wall Display.
There are 26 "niches" used for shelves, hanging clothes or wall displays. Each will have (4) shelves 66" long equipped with an LED strip light Type M operating at 2.5 watts per foot, for a total of 1,430 watts.

Floor Display – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C and on NRCC-LTI-04-E (2 of 7) Table D-2, Wall Display and on Sheet NRCC-LTI-01 (4 of 5).
There are 28 type "K" recessed adjustable accent LED at 42 watts each used for floor display.

Decorative Lighting – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C and on NRCC-LTI-04-E (4 of 7) Table D-3, Ornamental and Special Effects Lighting, and on Sheet NRCC-LTI-01 (4 of 5).
There are two type "L" chandeliers operating at 300 watts each as decorative lighting.

Very Valuable Display – Enter luminaire information on Sheet NRCC-LTI-01-E (4 of 5) Table C and on NRCC-LTI-04-E (5 of 7) Table D-4, Very Valuable Display Case Lighting, and on Sheet NRCC-LTI-01 (4 of 5).
Inside the display case, there is a continuous LED highlighting system Type "N", operating at 4.5 watts per linear foot. The case is 72 sf and the length of the lighting system is 42 feet. The lighting is 189 watts.

Total the installed interior lighting power on Page NRCC-LTI-01-E (4 of 5). It is 11,340 watts. Carry this value to NRCC-LTI-01-E (1 of 5), Line 1 on the left.

Turn to sheets NRCC-LTI-04-E (1 through 5 of 7) and complete them as follows:

- Sheet (5) – The actual lighting is 189 watts; the allowed watts for the case is (72*12) = 864 watts. Enter 189 watts in column J. Carry this to Page 1, line 3, cell "D-4".

Table 140.6-D TAILORED METHOD LIGHTING POWER ALLOWANCES				
1	2	3	4	5
Primary Function Area	General Illumination Level (Lux)	Wall Display Power (w/ft)	Allowed Combined Floor Display Power & Task Lighting Power (w/ft^2)	Allowed Ornamental/ Special Effect Lighting
Retail Merchandise Sales & Showroom Areas	400	14.00	1.0	0.5

- Sheet (4) – The Primary Function area is general sales 3,200 sf. The allowed ornamental/special effects lighting is (3200*.5) = 1,600 watts. The actual power is 2 – type "L" luminaires at 300 watts = 600 watts total. Enter 600 watts in column J as it is smaller than 1,600 watts. Carry this to Page 1, line 3, cell "D-3".
- Sheet (3) – The Primary function area is general sales 3200 sf. The allowed combined task/floor display is 1 w/sf = 3200 watts. The actual power is 28 type K luminaires at 42 watts = 1176 watts for the first luminaire type. But this project has two lighting types. We change the form by scratching out mounting height and mounting heigh factors. Use (1) circuit of track at 2400 watts for the second luminaire type. Add (2400 + 1176) = 3,576 watts. Use 3200 watts in Column J because it is smaller. Carry this to Page 1, line 3, cell "D-2".
- Page (2) – The Primary function area is general sales 3,200 sf. The total of all ceiling-height walls is 254 ft. The maximum allowed wall lighting is (254 x 14) = 3,556 watts. Use type M as the first luminaire type at 1,430 watts. As above scratch out mounting height to make room for a second luminaire type. Use the second track circuit at 2400 watts as the second wall lighting type. Add (1,430 + 2,400) = 3,830 watts. Enter 3556 watts in column J because it is smaller. Carry this to Page 1, line 3, cell "D-1".
- Page 1 – Line 3. Add and fill the total of 7,545 watts for the block A.(3.) subtotal.
- Page 1 – sum up the general lighting allowances from Table B. column (G.), including:
  - **a.** 2,880 watts for the main sales area
  - **b.** 93.5 watts each for dressing rooms 1, 2 and 3
  - **c.** 132 watts for fitting room
  - **d.** 427.5 watts for the mirror/fitting area

e. Total allowed general lighting watts for Tailored Method is 3,720 watts. Enter this in Line 1 at the top of page NRCC-LTI-04-E.
f. Lines 1, 2 and 3 in line 4. The total allowed watts using the tailored method is 11,265 watts. Enter this on Line 3, Box A. of NRCC-LTI-03-E (1 of 4).

Finally, on page NRCC-LTI-03-E (1 of 4), box A, total lines 2 and 3. The total allowed interior lighting power is (11,265 + 652) = 11,917 watts. Carry this value to NRCC-LTI-01 (Page 2 of 5) Line 6 at the top left. Good news – the allowed power is greater than the actual power, and the design passes.

Lighting Controls and Other Requirements
Use form NRCC-LTI- 02-E (Interior) and NRCC-LTO-02-E (Outdoor) to review choices for lighting controls. Because this project does not have store window displays, track lighting, or decorative lighting, the controls can be simple, but per §130.1 they must provide:

- Manual on/off override (can be located in a concealed location per Exception 1 §130.1 (a.) 2.)
- Automatic shut off by calendar and clock time, with motion sensor override should the space become occupied.
- In the restroom only: an on/off motion sensor or count-down timer can be used.
- Separate controls for display lighting (refrigerated displays), and general lighting.
- Multi level control (dimming) for the retail sales area and the storage/shipping/receiving area is required because the spaces exceed 100 square feet, and because the lighting power density is over 0.5 w/sf.
- A choice of manual dimming, tuning, or demand response controls (except for the restroom).

Small lighting control systems having a programmable calendar and time of day switching are often used for this type of project. They will need to meet the requirements of §110.9.

Review Required Controls
Use form NRCC-LTI-02-E (Interior) to review choices for lighting controls. Because this project has store window displays, track lighting, or decorative lighting, the controls must allow switching of each, and they must provide:

- Manual on/off override (can be located in a concealed location per Exception 1 §130.1 (a.) 2.)
- Automatic shut off by calendar and clock time, with motion sensor override should the space become occupied.
- In the restroom only: an on/off motion sensor or count-down timer can be used.
- Separate controls for display lighting (wall display, floor display, window area display, very valuable case display), signs, and general lighting.
- Multi-level control (dimming) for the retail sales area and the storage/shipping/receiving area is required because the spaces exceed 100 square feet, and because the lighting power density is over 0.5 w/sf.
- A choice of manual dimming, tuning, or demand response controls (except for the restroom).

Small, stand alone programmable dimming panels are great solutions for the specialty retail store. A panel with up to 8 zones is a good choice because we have general lighting, track lighting for wall displays, track lighting for floor displays, track lighting for the window area, shelf lighting, case lighting, and decorative lighting. The system must have a programmable calendar and time of day switching, and the light levels need to be adjustable using dimming. The dimming technique will probably be "tuning" but demand response may also be possible. Make sure that the system meets the requirements of §110.9 as well as §130.1. Complete the balance of the interior and exterior forms. Note that, depending on the choice of controls, it is necessary to indicate the need for certificates of installation and for acceptance testing of both the indoor and exterior lighting controls.

Closing Comments and Fine Points

Throughout its history, Title 24 has gained the reputation of being very strict, and causing stores to redesign lighting systems that are legal in other states. This is no longer as true as it once was; nonetheless, the designer often completes the lighting design and compliance documentation, only to realize it does not comply. Especially with the Tailored Method, it is hard to judge whether the design complies until after the design and the calculations are complete. In this case, the design complied with 577 watts to spare.

This was not by accident. An experienced designer knows that there are many honest trade-offs in the course of lighting design and compliance documentation. In this case, we legitimately divided the track lighting between wall display and floor display, assigning ½ of the track power (2400 watts) to wall and ½ of the track power to floor display. Had we assigned all of the track power to wall display, we would only have been allowed 1176 watts for floor display instead of 3200, but the wall display would not have increased. Instead of complying, the design would have failed by 1447 watts.

(Note: if the authority having jurisdiction were to object and insist on separate switching for luminaires aimed at the wall and luminaires aimed towards the floor, the designer could employ two circuit track with separate controls.)

Other strategies for making a challenging design comply include:

- Using a lighting power adjustment factor by providing demand responsive lighting controls as part of the control panel. This would allow 5% of the total connected lighting load to be deducted, or 567 fewer actual watts.
- Reducing the linear lighting load system-by-system. Reducing these systems to 5.5 w/ft would reduce lighting power by 616 watts. However, this would result in a 25% drop in ambient light levels.
- Reducing track rating using either current limiters or a secondary overcurrent protection panel. Instead of 4800 watts for track, the total could have been reduced to 239 ft x 12.5 w/ft = 2987.5 w However, this would limit flexibility with future store designs and layouts.
- Using a mounting height adjustment factor to account for the inefficiency of display lighting at tall mounting heights. Raising the ceiling 6 inches would permit additional 13 percent watts for display lighting of the track and recessed accent lighting, or about 624 more track lighting watts, and 153 more recessed type K lighting watts.