



Lighting control requirements:

What's current and what to expect



This article examines lighting control requirements in various codes and standards, commissioning these controls, and engineers' expectations in the future.

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Learning objectives

- Learn which codes dictate lighting controls and requirements.
- Understand the different lighting controls available for various applications.
- Understand compliance and functional testing requirements.

Energy codes require lighting engineers to design lighting systems that meet prescribed power allowances, use daylighting controls, control spaces through occupancy, and specify and perform functional testing in their lighting designs. ANSI/ASHRAE/IES Standard 90.1 and the International Energy Conservation Code (IECC) are the two most prevalent energy codes governing lighting, with some states having specific energy codes. This article examines lighting control requirements in various codes and standards, commissioning these controls, and what engineers may expect in the future.

ASHRAE 90.1–2010 and IECC-2012 will be the focus.

ASHRAE and IECC both require spaces surrounded by ceiling height partitions (walls) to have an individual manual control (switches/dimmers). The control must be within the space or remote located with an indicator that identifies the space/area it serves. Exemptions to this requirement are for areas that must be continuously illuminated for safety/security and corridors or stairways used for means of egress.

In addition to the above requirement, light reduction is required.

ASHRAE 90.1 Section 9.4.1.2a requires a control step between 30% and 70%, which can be accomplished with a number of variations such as switching alternating lamp, dimming ballast/driver, or stepped ballast/driver. IECC-2012 Section C405.2.1.2 requires a control step of 50% with even illumination in the space and offers specific ways to accomplish this by controlling all lamps or luminaires; dual switching alternate rows of luminaires, alternate luminaires, or alternate lamps; switching the middle lamp luminaires independently of the outer lamps; or switching each luminaire or each lamp.



Figure 1: The boardroom of the Emily Hundley Library at St. Catharine (Ky.) College shows daylighting control for natural side-lighting. Courtesy: CMTA Consulting Engineers

Exceptions to 9.4.1.2a are:

- Lights in corridors, electrical/mechanical rooms, public lobbies, restrooms, stairways, and storage rooms
- Spaces with only one luminaire with rated input power less than 100 W
- Space types with lighting power allowance of less than 0.6 W/sq ft.

Exceptions to C405.2.1.2 are:

- Areas that have only one luminaire, with rated power less than 100 W
- Areas that are controlled by an occupant-sensing device
- Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical rooms, or mechanical rooms
- Sleeping units
- Spaces that use less than 0.6 W/sq ft
- Daylighting spaces complying with C405.2.2.3.2.

Automatic lighting controls

In addition to manual controls, ASHRAE 90.1 and IECC require automatic controls for interior lighting. Automatic time control and occupancy based (occupancy sensors) are methods that can be used to comply. Requirements are defined in IECC Section C405.2.2 and ASHRAE 90.1 Section 9.4.1.

IECC mandates automatic time switch devices in addition to manual controls. This can be accomplished using lighting control systems (LCS), building automation systems (BAS), and/or digital time switches. When an automatic time switch control device is used, an override is to be located in a readily accessible space with a maximum override up to 2 hours. Overrides are to be zoned up to 5,000 sq ft. In malls, arcades, auditoriums, single tenant retail spaces, industrial facilities, and arenas, the override can exceed two hours with a captive key and can be zoned more than 20,000 sq ft.

This IECC mandate may not be the most efficient or practical method for most spaces such as private offices and classrooms. IECC allows engineers to design with occupancy sensors in lieu of time

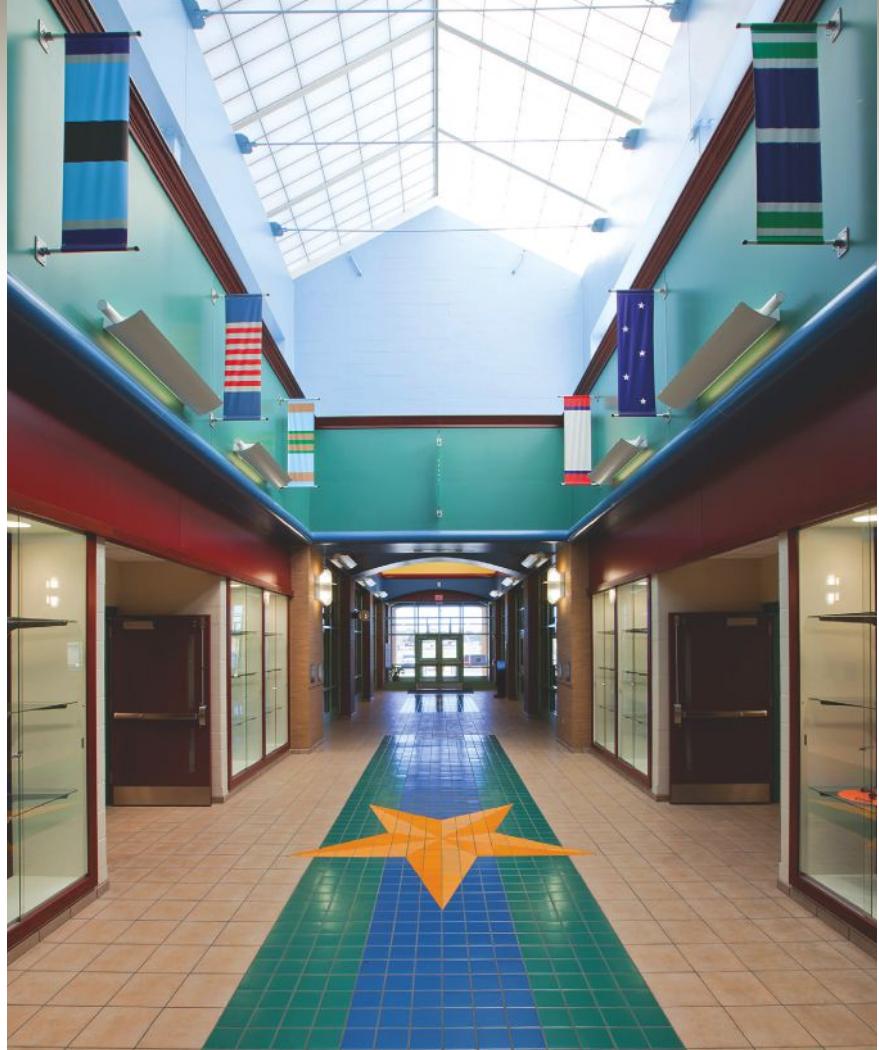


Figure 2: The entrance to Flaherty Primary School shows daylighting controls for top-lighting. Courtesy: Sherman-Carter-Barnhart Architects

Table 1: Automatic lighting shutoff	ASHRAE 90.1-2010	IECC-2012
	Section 9.4.1.1	Section C405.2.2.1
Required in all spaces	X	X
Required in buildings >5,000 sq ft	—	—
Occupancy sensors	X	X (automatic time switch control device)
Signal from another control or alarm system (such as BAS)	X	X
Exceptions		
Lighting used for 24-hr operation	X	X
Automatic shutoff endangers safety/security	X	X
Spaces providing patient care	X	—
Sleeping unit	—	—

Table 1: In addition to manual controls, ASHRAE 90.1 and IECC require automatic controls for interior lighting. Automatic time control and occupancy based (occupancy sensors) are methods that can be used to comply. Requirements are defined in IECC Section C405.2.2 and ASHRAE 90.1 Section 9.4.1. Courtesy: WattStopper

Lighting control requirements

Table 2: Space control	ASHRAE 90.1-2010	IECC-2012
	Section 9.4.1.2	Section C405.2.2.2
Must turn lighting off automatically within 30 minutes after last occupant leaves in the following spaces:	X (time switch or occupancy sensor)	X (occupancy sensor manual-on or auto-on to <50%)
Classrooms	X	X
Lecture halls	X	—
Conference and meeting rooms	X	X
Training rooms	X	—
Employee lunch and break rooms	X	X
Storage and supply rooms	X (50 to 1000 sq ft)	X
Janitorial closet	—	X
All spaces <300 sq ft enclosed by ceiling height partitions	—	X
Rooms used for document copying and printing	X	X
Offices	X (<250 sq ft)	X
Restrooms	X	X (100% auto-on allowed)
Dressing, locker, and fitting rooms	X	—

Table 2: ASHRAE and IECC both require spaces surrounded by ceiling height partitions (walls) to have an individual manual control (switches/dimmers). The control must be within the space or remote located with an indicator that identifies the space/area it serves. Courtesy: WattStopper

switch based devices and systems. Occupancy sensors per C405.2.2.2 are required in all classrooms, conference/meeting rooms, employee lunch and break rooms, private offices, restrooms, storage rooms, janitorial closets, and other spaces 300 sq ft or smaller enclosed by ceiling height partitions. Occupancy sensors for these spaces shall turn the lights off after 30 minutes of being unoccupied. In addition, the occupancy sensor must be manual-on or 50% auto-on/50% manual-on. (Manual-on occupancy sensors are also known as vacancy sensors.) Full automatic-on is acceptable in public corridors, stairways, restrooms, primary building entrance areas, lobbies, and where occupants would be endangered due to safety and security.

Exceptions to C405.2.2.1 and C405.2.2.2 for automatic time switches

and occupancy sensors are in sleeping areas where patient care is directly provided, continuous operation/occupancy, or where automatic shut-off would endanger occupant safety and security (see Table 1).

ASHRAE 90.1 is very similar to the requirements of IECC with the following differences. Automatic schedule based controls shall be zoned up to 25,000 sq ft but for no more than one floor. A signal from an alarm/security system can override the lights to off during unoccupied hours. See Table 2 for the areas that require the lighting to turn off after 30 minutes of all occupants leaving a space.

Exceptions to these are spaces with multi-scene control systems, shop and laboratory classrooms, spaces that would endanger occupants' safety and security, and lighting required for 24-hour operation.

ASHRAE 90.1 mandatory provision 9.4 outlines the requirements for lighting controls. A general statement in the first paragraph requires that any automatic control device for building interiors be either manual-on or controlled to automatically turn on to not more than 50%. Full automatic-on is only allowed public corridors and stairwells, restrooms, primary building entrance areas, and lobbies. In addition, full automatic-on is allowed where manual-on operation would endanger the safety and security of the occupants.

There are several ways to satisfy this mandate, one of which for a small room is to use a stand-alone vacancy sensor in lieu of an occupancy sensor. Vacancy sensors require manual-on by pressing or toggling a switch. If occupancy is not detected after a selected time period, the lights will turn off and must again be manually turned on. Wall-mounted vacancy sensors are almost identical to wall-mounted occupancy sensors. These devices use the same technology, with the exception of how the lights are turned on. Both of these devices can be manually turned off using the pushbutton switch.

For larger and more complex rooms such as school classrooms that also require daylighting zones, a lighting control system or BAS may be necessary. Using a wall-mounted or ceiling-mounted occupancy sensor and momentary switches (as vacancy switches) would be the minimum condition.

Daylight zone control

Per IECC, daylight zones are required and must have individual control (manual or automatic) of the lights independent of general area lighting and controlled per C405.2.2.3.1 (manual daylighting controls) or C405.2.2.3.2 (automatic daylighting controls). Each daylight control zone has to be ≤ 2500 sq ft. Contiguous daylight zones adjacent to vertical fenestrations can be controlled by a single controlling device if the zone doesn't include areas facing more than two adjacent orientations (i.e., north, east, south, and west). Daylight zones under skylights >15 ft from the

perimeter must be controlled separately from daylight zones adjacent to vertical fenestrations.

Exceptions to this rule are daylight spaces either enclosed by walls or ceiling height partitions or containing one or two light fixtures. General lighting would not have to have a separate switch.

Natural top lighting

When natural daylighting is used for top lighting (skylights, tubular daylighting devices, etc.), ASHRAE 90.1-2010 Section 9.4.1.5 and IECC-2012 Section C402.3.2.1 require automatic daylighting controls. Both codes are very similar. The lighting in the daylighted area must be separately controlled by at least one multilevel photocontrol and be remotely controlled and readily accessible. The artificial lighting must be continuously dimmable or step dimmed. Both require a minimum of one step no greater than 35%, and ASHRAE requires a second step between 50% and 70%. There are many fluorescent ballast and LED drivers that can provide either required continuous dimming or stepped dimming. For the daylighting controls, the light fixtures can have integral light sensors or one light sensor for a zone (group) of light fixtures.

ASHRAE exceptions to 9.4.1.5 are:

- Daylighted areas under skylights where it is documented that existing adjacent structures or natural objects block direct beam sunlight for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.
- Daylighted areas where the skylight effective aperture (EA) is less than 0.6%
- Building Climate Zone 8 with daylight areas totaling less than 1,500 sq ft in an enclosed space.

IECC exceptions to C402.3.2.1 are:

- Buildings in Climate Zones 6 through 8
- Spaces where the designated general lighting power densities are less than 0.5 W/sq ft

- Areas where it is documented that existing structures or natural objects block direct beam sunlight on at least half of the roof over the enclosed area for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.
- Spaces where the daylight zone under rooftop monitors is greater than 50% of the enclosed space floor area.

Controls for natural side-lighting

ASHRAE 90.1 requires and IECC has the option of automatic daylighting controls for primary side lighted areas. (IECC has the option for manual controls in lieu of automatic.) When the combined primary side-lighted area in an enclosed space is equal or greater than 250 sq ft, the lamps for general lighting in the primary side-lighted (daylit) area must be separately controlled by at least one multilevel photocontrol and be remotely controlled and readily accessible. The artificial lighting must be continuously dimmable or step dimmed. Both require a minimum of one step no greater than 35%, and ASHRAE requires a second step at between 50% and 70%.

There are many fluorescent ballast and LED drivers that can provide either required continuous dimming or stepped dimming. For the daylighting controls, the light fixtures can have integral light sensors or one light sensor for a zone (group) of light fixtures.

ASHRAE exceptions to 9.4.1.4 are:

- Primary (daylighted) side-lighted areas where the tops of the existing adjacent structures are twice as high above the windows as their distance away from the windows
- Primary side-lighted areas where the side-lighting effective aperture is less than 10% percent
- Retail areas.

Specific application controls

The following areas require special controls above and beyond other requirements in ASHRAE 90.1 and IECC:

1. These types are controlled by dedicated, independent control

- a. Display and accent lighting
 - b. Display case lighting
 - c. Non-visual applications (i.e., plant growth and food warming)
 - d. Lighting equipment for sale or demonstration in lighting education
2. Hotel and motel sleeping units and guest suites
 - a. Master control device at main room entry
 - i. Controls all permanently installed luminaries and switched receptacles
 3. Supplemental task lighting, including permanently installed
 4. Under-shelf or under-cabinet lighting
 - a. Have control device integral to luminaries or
 - b. Be controlled by a readily accessible, wall-mounted control device
 5. Stairwell lighting (ASHRAE 90.1 specific)
 - a. Have one or more control devices to automatically reduce lighting power in any one controlled zone by at least 50% within 30 minutes of all occupants leaving that controlled zone.

Parking garage lighting controls

ASHRAE 90.1 has specific requirements when it comes to parking garage lighting. It is important to note the following requirements:

1. Lighting is to be controlled by one or more devices to reduce the lighting power to each fixture by 30% when no activity is detected within a zone for no more than 30 minutes. This can be accomplished with occupancy sensors. Due to deep structures in garages, the line of sight for occupancy sensors is challenging. A practical way to accomplish this is to provide integral occupancy sensors in the parking garage fixture and link them together in the lighting zone. This will provide good coverage.
2. Daylight transition zone lighting is to be controlled separately by a device that

Lighting control requirements

would automatically turn on the lighting during daylight hours and off at sunset. This helps the eye accommodate from high levels of daylight to lower artificial daylighting levels.

3. For light fixtures within 20 ft of any perimeter wall structure that has a net opening to wall ratio of at least 40% and no exterior obstructions within 20 ft, the power shall be automatically reduced in response to the natural daylighting.

Daylighting transition zones and ramps without parking are exempt from the first two items above. Applications using high-intensity discharge (HID) of 150 W or less or induction lamps are exempt from the first item above.

Exterior lighting controls

IECC requires exterior lighting to be controlled by a photocell and/or astronomical time switch. Lighting control systems and BAS are typically used for astronomical time switches, and photocells can be an input to the system. Dusk to dawn operation can be accomplished

with a photocell controlling all of the fixtures, or lighting fixtures can have integral photocells or a combination of the two approaches. Photocell and astronomical time switches can be used for fixtures that are not dusk to dawn and that can be turned off 2 hours after the last event and then turned on 2 hours before the first event. This reduces total energy consumption and is recommended by Illuminating Engineering Society (IES) as a control strategy for security (dark campus).

ASHRAE is similar to IECC, except the code requires building façade and landscape lighting to shut off between business closing or midnight, and business opening or 6 a.m. In addition, all other exterior lighting, such as area parking lot lighting, wall packs, and canopy fixtures shall reduce 30% for energy savings for at least one of the following conditions:

- From midnight or within 1 hour of the end of business operations, whichever is later, until 6 a.m. or business opening, whichever is earlier

- During any period when no activity has been detected for a time of no longer than 15 minutes. This can be accomplished with an integral occupancy sensor and stepped/continuous dimming ballast/driver.

Exception to ASHRAE 90.1 Section 9.4.1.7: Lighting for covered vehicle entrances or exits from buildings or parking structures where required for safety, security, or eye adaptation.

Functional testing

Functional testing (commissioning) is required for both ASHRAE 90.1 and IECC to verify that all control hardware and software are performing as designed. It assures the controls are located, adjusted, aimed, calibrated, and programmed per construction documents and manufacturer's installation instructions and recommendations. The construction documents must list the person and/or company that will perform the functional testing. The authority having jurisdiction (AHJ) can reserve the right to have an approved party independent of the design or construction perform the functional test. When occupant sensors, time switches, programmable schedule controls, and photosensor daylighting controls are installed, the following procedures shall be performed:

- Placement, sensitivity, and time-out adjustments for occupant sensors yield acceptable performance.

- Time switches and programmable schedule controls are programmed to turn the lights off.

- Placement and sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space as specified.

As-built drawings and operation and maintenance manuals must be turned over to the building owner within 90 days of the date of receipt of the certificate of occupancy. This requirement is for both ASHRAE 90.1 and IECC. Drawings are to include the location and performance data on each piece of equipment.



Figure 3: Functional performance testing ensures that the sensitivity adjustments for photosensor controls reduce electric light based on the amount of usable daylight in the space shown in the art room at Thomas Nelson High School in Bardstown, Ky. Thomas Nelson High School is the most energy-efficient high school in Kentucky with an energy use intensity of 22. Courtesy: Studio Kremer Architects

Compliance submittal

The U.S. Dept. of Energy's (DOE) COMcheck is required in most states and local jurisdictions to show compliance not only for lighting power densities, but also for lighting controls. COMcheck verifies state code compliance for interior lighting, exterior lighting, HVAC, and building envelope. Engineers are required to verify if automatic controls meet or exceed code requirements as discussed above. COMcheck was developed by the DOE to make compliance easier for engineers, architects, and contractors to determine whether applicable projects meet ASHRAE 90.1, IECC, and state-specific codes. Building officials, plan checkers, and inspectors can review a completed COMcheck, allowing them to quickly determine if a building project meets code.

Energy codes are becoming more complex and stringent to meet. Understanding the requirements and what technology

State and local codes and amendments along with local land development codes can be stricter.

is available is imperative for the lighting engineer. Automatic lighting controls are required to provide additional energy savings over the prescribed power densities.

While this is a comprehensive overview of lighting control requirements, it is not an all-encompassing look at lighting control requirements for commercial buildings. State and local codes and amendments along with local land development codes can be stricter than the requirements discussed in this article. Controls are necessary and, with careful selection and thoughtfulness with the owner in mind, can be a successfully engineered system.

Many owners and building managers express frustration when lighting controls

fail, become uncalibrated, or experience other issues. Changes in season affecting the daylighting zone controls or software updates are two of the many issues building owners deal with daily. When designing the lighting control system for a building, consider involving the owner during design to understand complexity and trade-offs that will impact operation. **lcsel**

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