



ANSI/ASHRAE/IES Standard 90.1-2016: Power and Lighting

March 2017– PNNL-SA-124553

Prepared by Pacific Northwest
National Laboratory for the
U.S. Department of Energy

PNNL and DOE would like to thank ASHRAE Standing Standard Project Committee 90.1 for their contributions to the development of this presentation and their technical review of the content.

Interior Power Density limits (LPD) were revised for 90.1-2016 primarily because of improved efficacy of LED lighting. All space type models used for LPD development were reviewed and where applicable, LED technology was included as part of the technology mix.

Space-by-Space LPDs – Most were reduced from previous 90.1-2013 levels with an average reduction of 26% but a few went up based on revised design criteria and current practice for that space type

Building area LPDs – Almost all were reduced as much as 34% with an overall average reduction across all building types of 12% from the 90.1-2013 allowances.

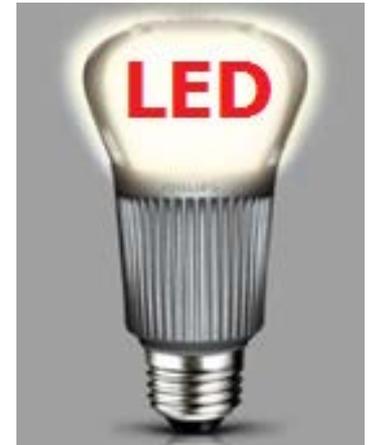
Summary of Changes

Energy Code LPDs and LED Lighting

- Energy codes **do** limit the installed lighting power for interior and exterior (LPD) but.....
- Energy codes (including 90.1) **do not** specify or require the use of specific lighting technologies.

However....

- 90.1-2016 does include partial or complete LED efficacy in many space type models in recognition of:
 - Proven LED efficacy and energy savings capability
 - Continued reduced cost of LEDs
 - Product maturity and reasonable applicability
- It is very likely that the future 90.1-2019 standard will include additional LED technology further reducing some space type and building LPD values.



Exterior Power Density limits (LPD) were reduced for 90.1-2016 based on improved efficacy of LED lighting that is currently effectively applied in exterior environments.

All area, linear, and application limits were reduced an average of **30%** reflecting efficacy data collected on current efficient LED products.



Summary of Changes

Retail Display and Decorative Allowances

Additional allowances for retail display lighting were reduced ~ **25%** to reflect LED technology

Additional Lighting Power Allowance:

1000 watts

+ (Retail Area 1 \times 0.45 W/ft²)

+ (Retail Area 2 \times 0.45 W/ft²)

+ (Retail Area 3 \times 1.05 W/ft²)

+ (Retail Area 4 \times 1.88 W/ft²)



Allowances for decorative lighting were also reduced ~ **25%** from 1.0 W/ft² to 0.75 W/ft² to reflect LED technology

Summary of Changes

Partial Auto-On Restriction

- An exception was added to the requirement for manual on OR partial auto on to accommodate advanced lighting controls for added energy savings
- Lighting in open-plan office spaces will be allowed to turn on automatically to more than 50% (i.e. full auto-on)
- The exception limits control zones to 600 square feet to preserve savings

Summary of Changes

Exterior Lighting Control

- Requirements to reduce lighting power by 30% during periods of non-occupancy or after business hours in exterior applications AND parking garages has been increased to 50%



- Lighting alterations (retrofits) section revised to add interior and exterior controls
 - **Interior** retrofits must now also comply with occupancy and scheduled full and partial shutoff and bi-level switching where specified.
 - **Exterior** retrofits must now also comply with astronomical control and/or scheduled shutoff control where specified for each application.
- Application threshold changed to 20% of lighting load before requirements are applied. This acknowledges the added controls savings and practicality of applying controls in retrofits.
- Lamp plus ballast retrofits and one-for-one fixture replacements need only comply with LPD limits.

Summary of Changes

Other Changes

- New specific parking lighting control
- New requirement for dwelling unit lighting



- Low Voltage Dry Transformer efficiency
 - Values were revised to meet federal efficiency minimums
- Voltage Drop for efficiency
 - Value combined/changed to maximum 5% of design load for combined feeder plus branch circuits

Building System

Compliance Options

Envelope

Prescriptive
Option

HVAC

**Mandatory
Provisions**

Trade Off
Option

SWH

(required for most
compliance options)

Energy Cost
Budget

Power

Lighting

Simplified

Other

Performance
Rating
Method

Energy Code Compliance

- ✓ New Buildings
- ✓ Additions
- ✓ Alterations
- ✓ Mandatory Provisions
 - ✓ Voltage drop
 - ✓ Automatic receptacle control
 - ✓ Electrical Energy Monitoring
 - ✓ Low-Voltage Dry Type Distribution Transformers
- ✓ Submittals

Section 8 – 8.1.2 – 8.1.4

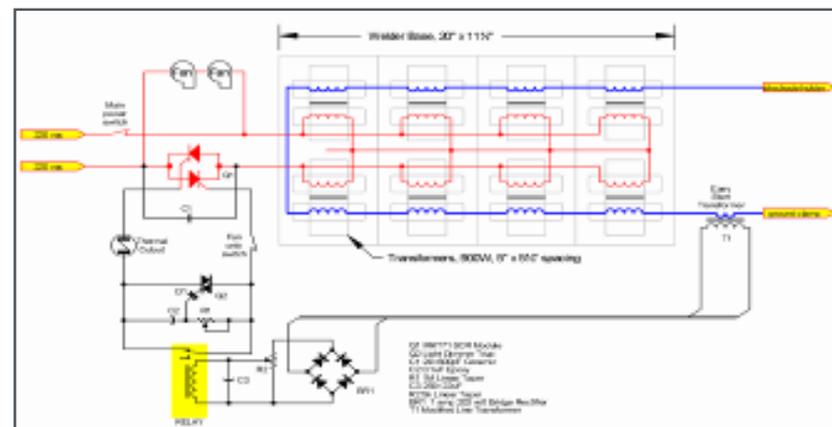
New Buildings, Additions, and Alterations to Existing Buildings

- Equipment installed in **new** buildings or **additions** to existing buildings must comply
- **Alterations** to equipment or systems must comply with requirements applicable to those specific portions of the building and systems being altered
 - New equipment installed as a direct replacement of existing equipment must comply with requirements for that equipment
 - **Exception** - Compliance not required for relocation or reuse of existing equipment at the same site

Two types of conductors

- Feeder conductors
 - Connect service equipment to the branch circuit breaker panels
- Branch circuit conductors
 - Run from the final circuit breaker to the outlet or load

Feeder conductors and branch circuits combined to be sized for a maximum of 5% voltage drop total



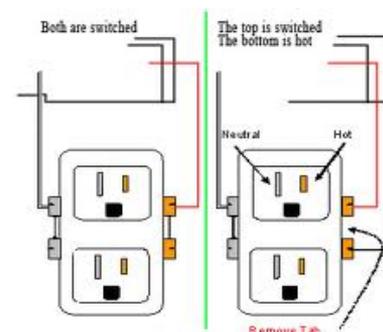
Section 8 – 8.4.2 Automatic Receptacle Control

Automatically controlled

≥ 50% of all 125 volt 15- and 20-amp receptacles in:

- Private offices
- Conference rooms
- Rooms used primarily for printing and/or copying functions
- Break rooms
- Classrooms
- Individual workstations

≥ 25% of branch circuit feeders installed for modular furniture not shown on construction documents



Automatic control devices must function on:

- Time-of-day controller provided to control $\leq 5,000$ ft² and not more than one floor (occupant able to manually override up to 2 hours) OR
- Occupant sensor(s) to turn off receptacles within 20 minutes of occupant leaving the space, OR
- Automated signal from another control or alarm that turns receptacles off within 20 minutes after determining the area is unoccupied

Controlled receptacles must be

- visually marked to differentiate from uncontrolled receptacles
- uniformly distributed throughout the space

Plug-in type devices may not be used to comply with this requirement

Exceptions

- Receptacles designated for equipment requiring 24 hr/day 365 days/yr operation
- Spaces where automatic lighting shutoff would cause security or safety concerns

Measurement devices in new building to monitor electrical energy use for each of these separately:

- Total electrical energy
- HVAC systems
- Interior lighting
- Exterior lighting
- Receptacle circuits

For buildings with multiple tenants, the above must be separately monitored for total building and for each tenant (excluding shared systems)

Exception:

- up to 10% of each separate load (other than total) can be from other electrical loads

Section 8 – 8.4.3

Electrical Energy Monitoring – Recording and Reporting

- Energy use must be automatically recorded a minimum of every 15 minutes
- Use must be reported at least hourly, daily, monthly, and annually
- Data for tenants must be made available to that tenant
- The system must be capable of retaining data for at least 36 months

- Comply with the Energy Policy Act of 2005
 - If not included in scope of EAct 2005, then no requirements

Exceptions

- If meet EAct 2005 exclusions based on 10CFR431
 - Special purpose applications
 - Not likely in general purpose applications
 - Have multiple voltage taps where highest tap is $\geq 20\%$ more than lowest tap
- Some specific products are listed

Owner gets information about the building's electrical system

- ✓ Record drawings of actual installation within 30 days
 - Single-line diagram of electrical distribution system
 - Floor plans showing location and areas served for all distribution
- ✓ Manuals
 - Submittal data stating equipment rating
 - O&M manuals for equipment
 - Qualified service agency contact
 - Complete narrative of system as it's normally intended to operate



Building System

Compliance Options

Envelope

HVAC

SWH

Power

Lighting

Mandatory Provisions
(required for most compliance options)

Prescriptive
Option

Trade Off
Option

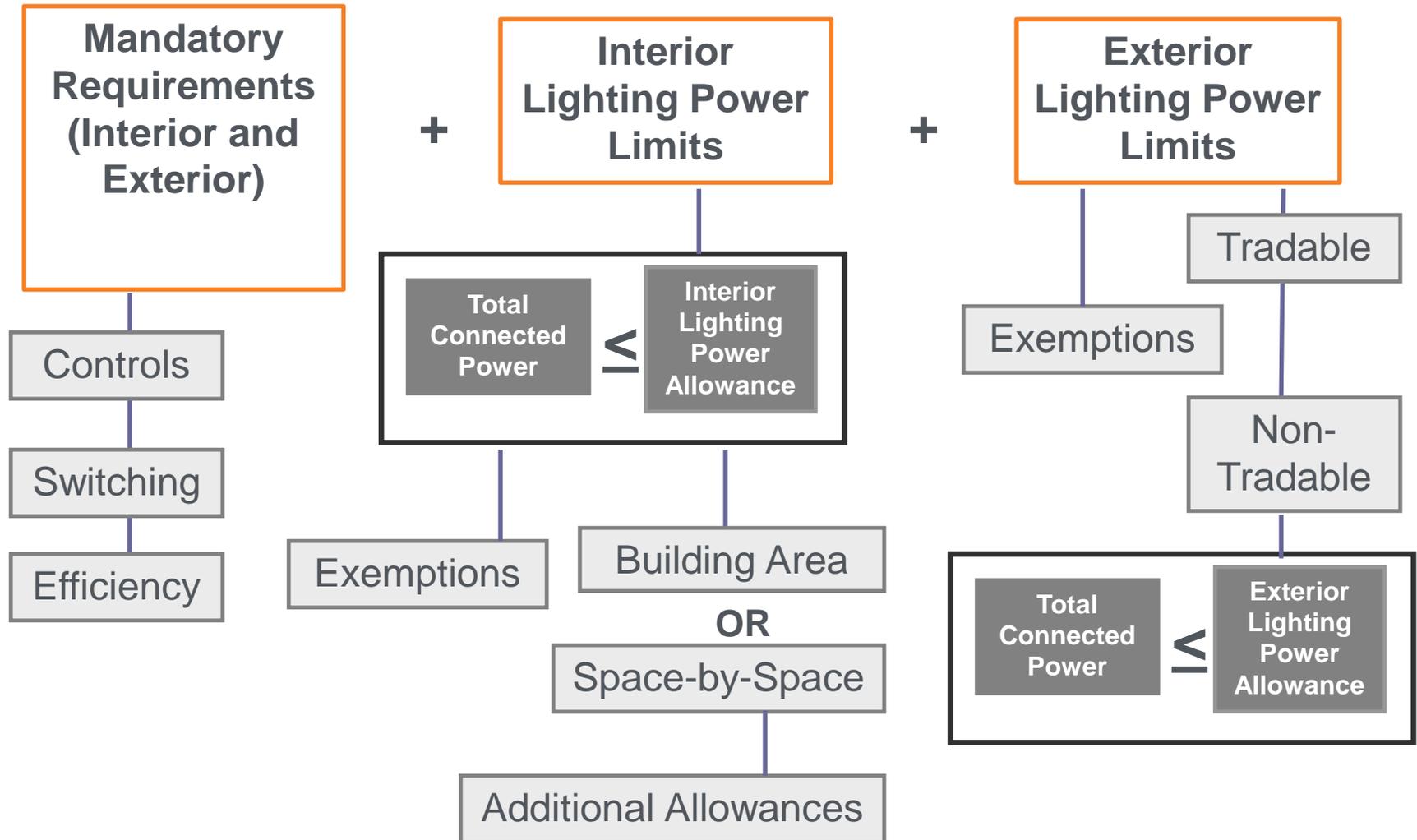
Energy Cost
Budget

Simplified

Performance
Rating
Method

Energy Code Compliance

Basic Lighting Requirements



- ✓ General Application (*Section 9.1*)
 - Scope
 - Lighting Alterations
 - Installed Lighting Power
 - Interior and Exterior Luminaire Wattage
- ✓ Compliance (*Section 9.2*)
- ✓ Mandatory Provisions (*Section 9.4*)
 - Lighting control
 - Exterior lighting power
 - Functional testing
 - Dwelling units
 - Climate zone exception for daylighting control
- ✓ Building Area Method Compliance Path (*Section 9.5*)
- ✓ Alternative Compliance Path: Space-by-Space Method (*Section 9.6*)



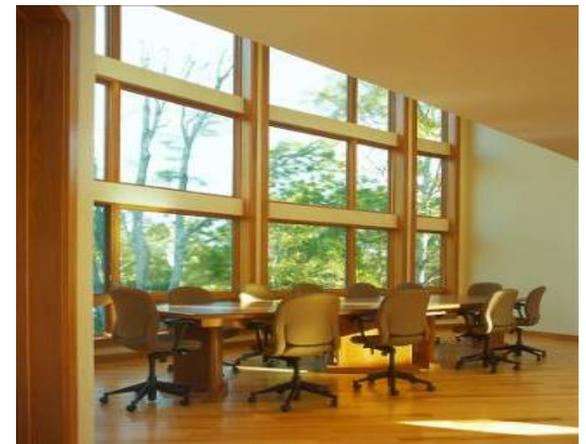
Section 9

Lighting General Scope

- Interior spaces of buildings
- Exterior lighting powered through building

Exceptions

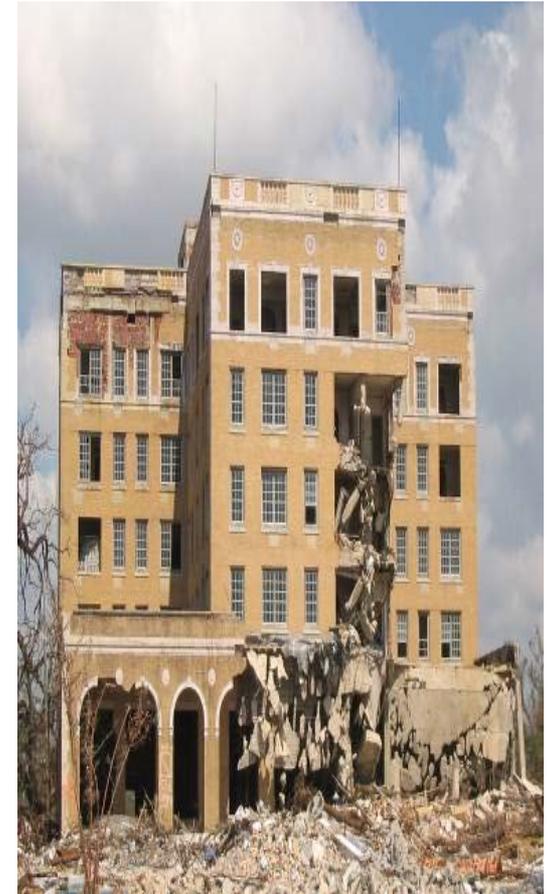
- Emergency lighting
- Lighting required by life safety statute
- Decorative gas lighting



- Applies to these retrofits:
 - where luminaires are added, replaced, or removed
 - Replacement of lamp plus ballast in luminaires
- Requires BOTH interior and exterior alterations to comply with Lighting Power Density (LPD) limits and basic after hours automatic shutoff requirements

Exception

- Spaces where alterations involve < 20% of connected lighting load and the LPD for the space is not increased
- Alterations that only involve replacement of lamps plus ballasts/drivers or only involve one-for-one luminaire replacement to only comply with LPD requirement and Section 9.4.1.1(h) and 9.4.1.1(i)
- Routine maintenance or repair situations



Installed interior lighting power must be \leq lighting power allowance

Installed interior lighting power calculation method

- Calculation requirements
- Lots of exemptions (next page)

Power allowance calculation methods

- Building area compliance path
- Alternative Compliance Path: Space-by-space method

Section 9 – 9.1.3

Installed Lighting Power Calculation Requirements – INTERIOR and EXTERIOR

These requirements apply to both interior and exterior

Installed Lighting Power shall include all power used by the luminaires, including lamps, ballasts/**drivers**, transformers, and controls

- **Exception**: where two independent lighting systems exist in the same space or area and are controlled to prevent simultaneous operation, only the system with the highest total wattage must be included

Luminaire Wattage for various systems shall be determined in accordance with details in Section 9.1.4

These requirements apply to both interior and exterior

- Line voltage luminaires without ballasts or transformers = max. labeled wattage of the luminaire
- Luminaires with ballasts/**drivers** or transformers = wattage of the maximum lamp/auxiliary combination OR max. labeled wattage of the luminaire. For luminaires with factory adjustable ballast factors (not user changeable), apply the ballast factor to be used in the space)
- Line voltage track = actual wattage with a min. 30 W per foot OR wattage limit of system's circuit breaker OR wattage limit of other permanent-current-limiting device(s) on the system
- Low voltage track = transformer wattage
- All others as specified on equipment

Section 9

Installed Interior Lighting Power Calculation Exemptions

Lighting that does not have to be included in the installed lighting power calculation:

- Theatrical, stage, film, and video production
- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Integral to equipment or instrumentation installed by manufacturer
- Integral to both open and glass-enclosed refrigerator and freezer cases
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- Food warming and food preparation equipment
- Interior spaces specifically designated as registered interior historic landmarks
- Integral part of advertising or directional signage
- Exit signs
- Sale or lighting educational demonstration systems
- Lighting for television broadcasting in sporting activity areas
- Casino gaming areas
- Furniture-mounted supplemental task lighting controlled by automatic shutoff and complying with 9.4.1.4(d)
- For use in areas specifically designed for life support of nonhuman life forms
- Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas
- Parking garage transition lighting

Section 9

Building Area Method of Calculating Interior Lighting Power Allowance

Can be used for entire building or separate building type occupancies

Advantages

- ✓ Fewer calculations

Limitations

- ✓ Limited building area type selection - use reasonably equivalent type
- ✓ Insensitive to specific space functions and room configurations
- ✓ Generally more restrictive than space-by-space method

Calculation Process

- 1) Determine gross lighted area for each building type area using:
 - Exterior faces of exterior walls
 - Centerline of interior walls
- 2) Calculate the area power allowance by multiplying the gross lighted area by the applicable building type allowance from Table 9.5.1
- 3) Sum all the allowances (if more than one building type area)

Section 9 – Table 9.5.1

Building Types

Part of Table 9.5.1 shown below.

Complete table in the Standard has 32 different building types

Building Type	Lighting Power Density (W/ft ²)
Automotive Facility	0.71
Convention Center	0.76
Court House	0.90
Dining: Bar Lounge/Leisure	0.90
Dining: Cafeteria/Fast Food	0.79
Dining: Family	0.78
Dormitory	0.61
Exercise Center	0.65

Section 9 – 9.6.1

Space-by-Space Method of Calculating Interior Lighting Power Allowance

Applies to any building configuration by calculating allowances for individual spaces

Advantages

- ✓ More flexible than building area method
- ✓ More accurately accounts for actual room lighting power needs
- ✓ Provides additional allowances for:
 - Difficult room configurations
 - Decorative and retail needs
 - Use of advanced controls not already required in the standard

Limitations

- ✓ More calculations needed (individual spaces)

Calculation Process

- 1) Determine the gross lighted area of each space type
 - include balconies and mezzanines
 - Use centerline of walls between spaces
- 2) Calculate the space power allowance by multiplying the space type area by the applicable allowance from Table 9.6.1
- 3) Sum all the allowances

- If a physical space has multiple functions such that more than one space type from Table 9.6.1 applies
 - Break the space into smaller subspaces
 - Use the centerline of interior walls and dividing line between subspaces to determine subspace areas
 - Calculate the allowance separately for each subspace

Exception

- Subspaces with areas less than 20% of the original space and less than 1000 ft² do not need to be broken out separately

Section 9 – Table 9.6.1 Space-by-Space Allowances

Small part of Table 9.6.1 shown below

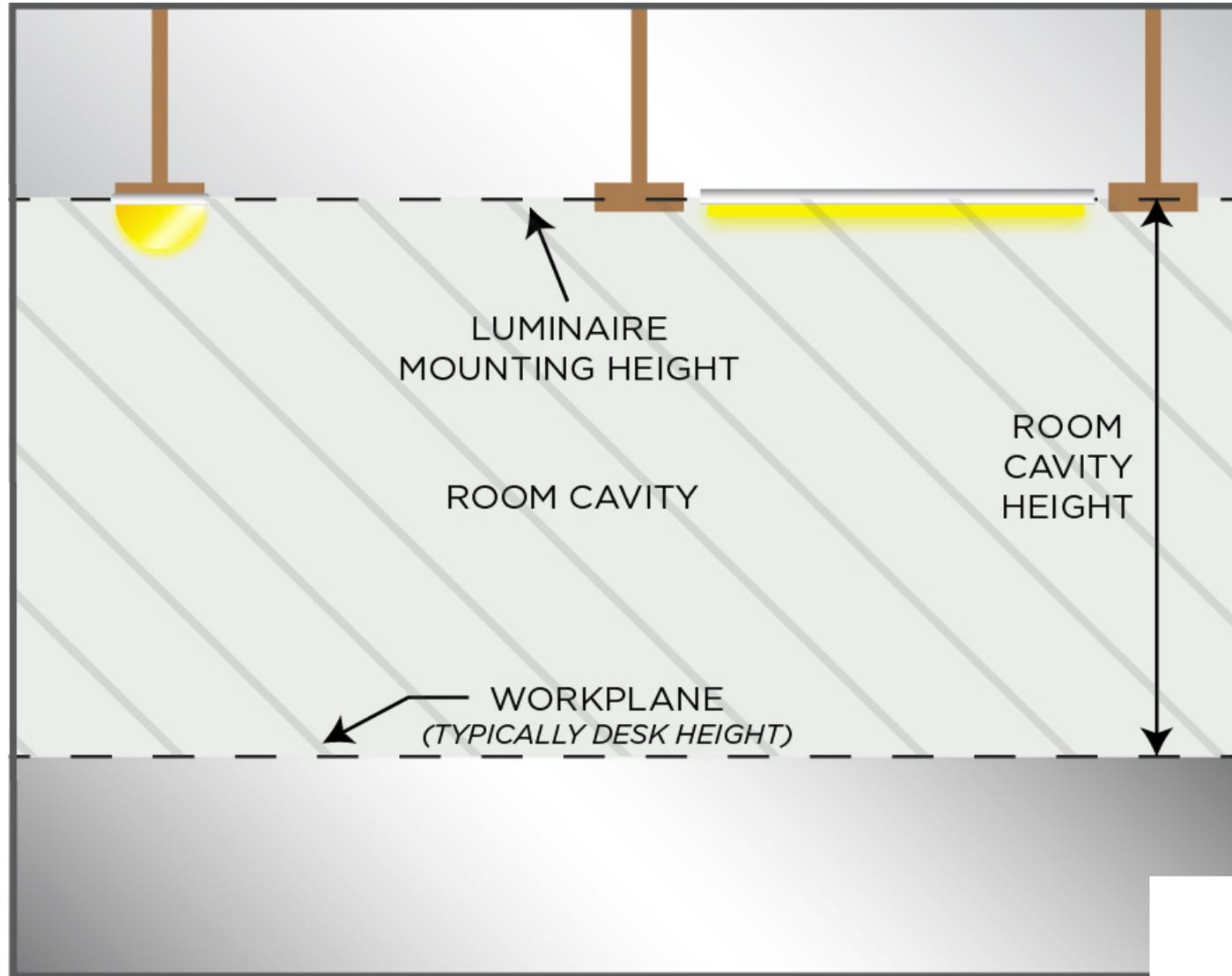
Common Space Types ¹			The control functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each space type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.								
			Local Control (See Section 9.4.1.1[a])	Restricted to Manual ON (See Section 9.4.1.1[b])	Restricted to Partial Automatic ON (See Section 9.4.1.1[c])	Bi-level Lighting Control (See Section 9.4.1.1[d])	Automatic Daylight Responsive Controls for Sidelighting (See Section 9.4.1.1[e])	Automatic Daylight Responsive Controls for Toplighting (See Section 9.4.1.1[f])	Automatic Partial OFF (See Section 9.4.1.1[g]) Full Off compliance	Automatic Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
LPD	RCR	a	b	c	d	e	f	g	h	i	
<i>Informative Note:</i> This table is divided into two sections; this first section covers space types that can be commonly found in multiple building types. The second part of this table covers space types that are typically found in a single building type.											
Atrium											
<20 ft in height	0.03/ft total	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
≥20 ft and ≤40 ft in height	0.03/ft total	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
>40 ft in height	0.40 + 0.02/ft total height	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Audience Seating Area											
Auditorium	0.63	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Convention center	0.82	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Gymnasium	0.65	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Motion picture theater	1.14	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Penitentiary	0.28	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Performing arts theater	2.03	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Religious building	1.53	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports arena	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
All other audience seating areas	0.43	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Banking Activity Area	0.86	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Breakroom (See Lounge/Breakroom)											
Classroom/Lecture Hall/Training Room											

Room Cavity Ratio Adjustment for relief in unusual space configurations

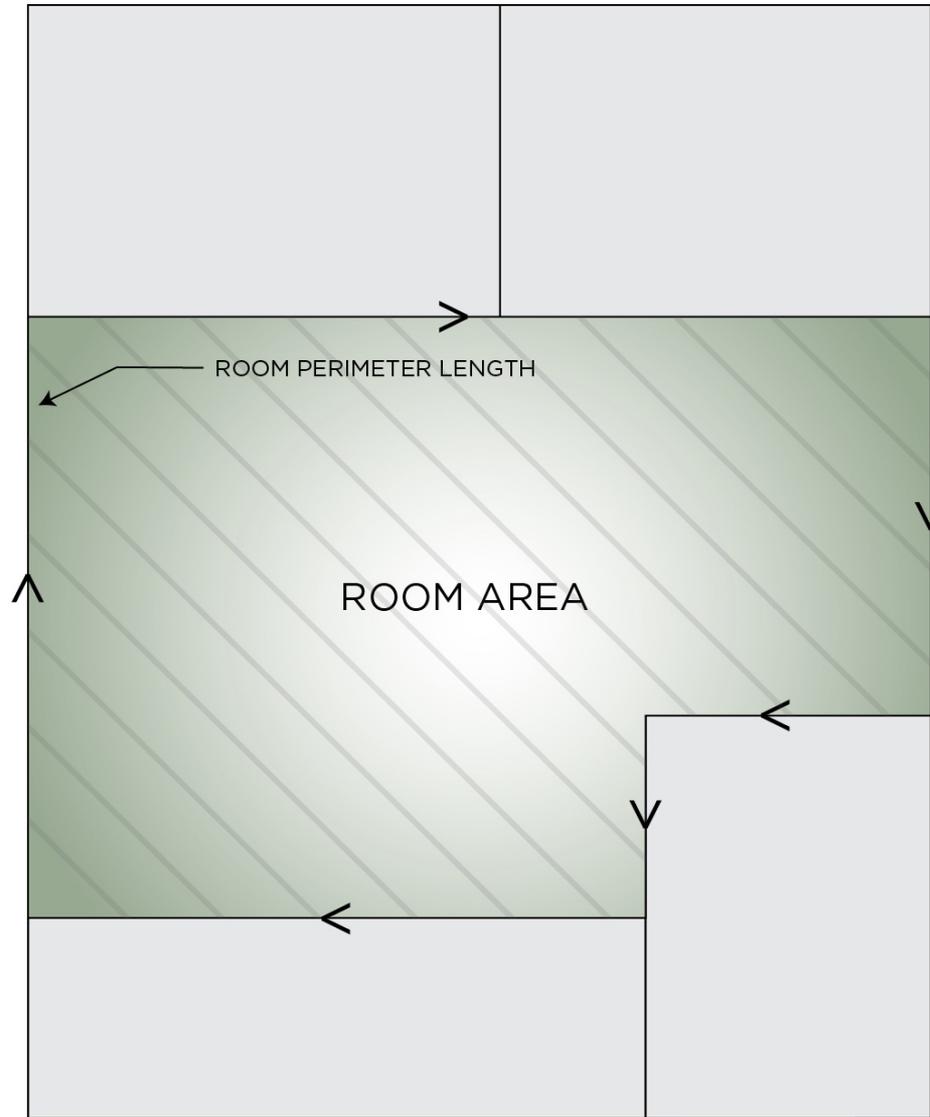
- Used only when applying the space by space method
- Calculate the *Room Cavity Ratio* (RCR) for the empty room:
$$\text{RCR} = \frac{2.5 \times \text{Room Cavity Height} \times \text{room perimeter length}}{\text{room area}}$$

(Room Cavity Height = Luminaire mounting height – Workplane height)
- If RCR is greater than the RCR threshold for that space type from Table 9.6.1, a 20% increase is allowed
- For corridor/transition spaces, a 20% adjustment is allowed when less than 8 feet wide, regardless of the RCR

Room Geometry Adjustment



Room Geometry Adjustment

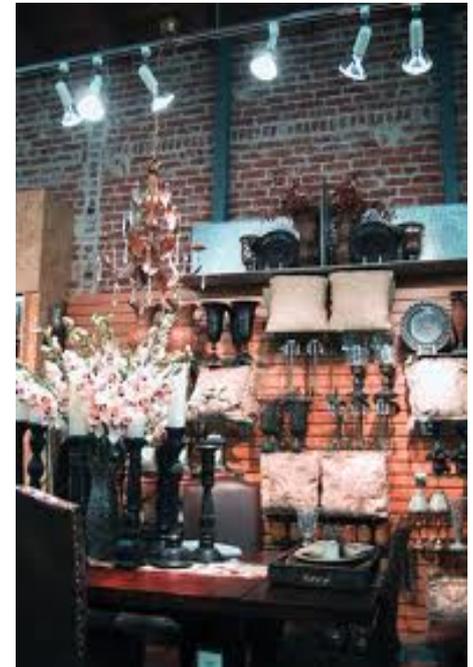


Decorative and Retail display highlighting

An increase in the lighting power allowance is allowed for specific decorative and retail applications when using the space-by-space method.

Applications must be automatically controlled, separately from the general lighting, to be turned off during non-business hours. The additional allowances can only be used for the additional lighting equipment – and not general lighting

- ✓ Decorative luminaires in addition to the general lighting = **0.75** W/ft²
- ✓ Retail display lighting = varies by retail type



Advanced Controls

An increase in the allowance is also allowed for the use of specified advanced controls that are installed in addition to those already required

Section 9 – 9.6.2

Additional Retail Display Lighting Allowance

Additional Interior Lighting Power Allowance = 1000 watts +
(Retail Area 1 x 0.45 W/ft²) +
(Retail Area 2 x 0.45 W/ft²) +
(Retail Area 3 x 1.05 W/ft²) +
(Retail Area 4 x 1.88 W/ft²),

Where:

Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4

Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics

Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork

Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china.

Other merchandise categories not listed may be included in Retail Areas 2 through 4, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

If all mandatory control requirements are met for a space AND advanced controls are installed in that space, THEN additional limited lighting power is allowed:

- Additional power can be used anywhere in the building
- Additional Interior Lighting Power Allowance is calculated as

Lighting Power Under Control x Control Factor

For each space type, apply the lighting control functions listed.

- If using the Space-by-Space method for LPD requirements, use same space type for control requirements. For space types not listed, use a reasonable equivalent
- “REQ” = mandatory
- “ADD1” = at least one of these must be implemented
- “ADD2” = at least one of these must be implemented

- Local control
- Restricted to manual ON
- Restricted to partial automatic ON
- Bilevel lighting control
- Automatic daylight responsive controls for sidelighting
- Automatic daylight responsive controls for toplighting
- Automatic partial OFF (full OFF complies)
- Automatic full OFF
- Scheduled shutoff

At least one control that controls all the lighting in the space

- In spaces $\leq 10,000$ ft², each control serves 2,500 ft² maximum and in spaces $> 10,000$ ft², serves 10,000 ft² maximum

No lighting automatically turned on

Exception

- Where manual ON would endanger safety or security

Typically, users are allowed to choose to implement this control or Partial On

< 50% of general lighting power allowed to be automatically turned on, and none of remaining lighting automatically turned on

Exception

- Lighting in open-plan offices allowed to turn on automatically to > 50% if control zone is $\leq 600 \text{ ft}^2$

Typically, users are allowed to choose to implement this control or Manual On

- General lighting to provide at least one intermediate step in lighting power or continuous dimming in addition to full ON and full OFF
- To have at least one control step between 30% and 70% (inclusive) of full lighting power in addition to all off

Section 9 – 9.4.1.1 (e)

Automatic Daylight Responsive Controls for Sidelighting

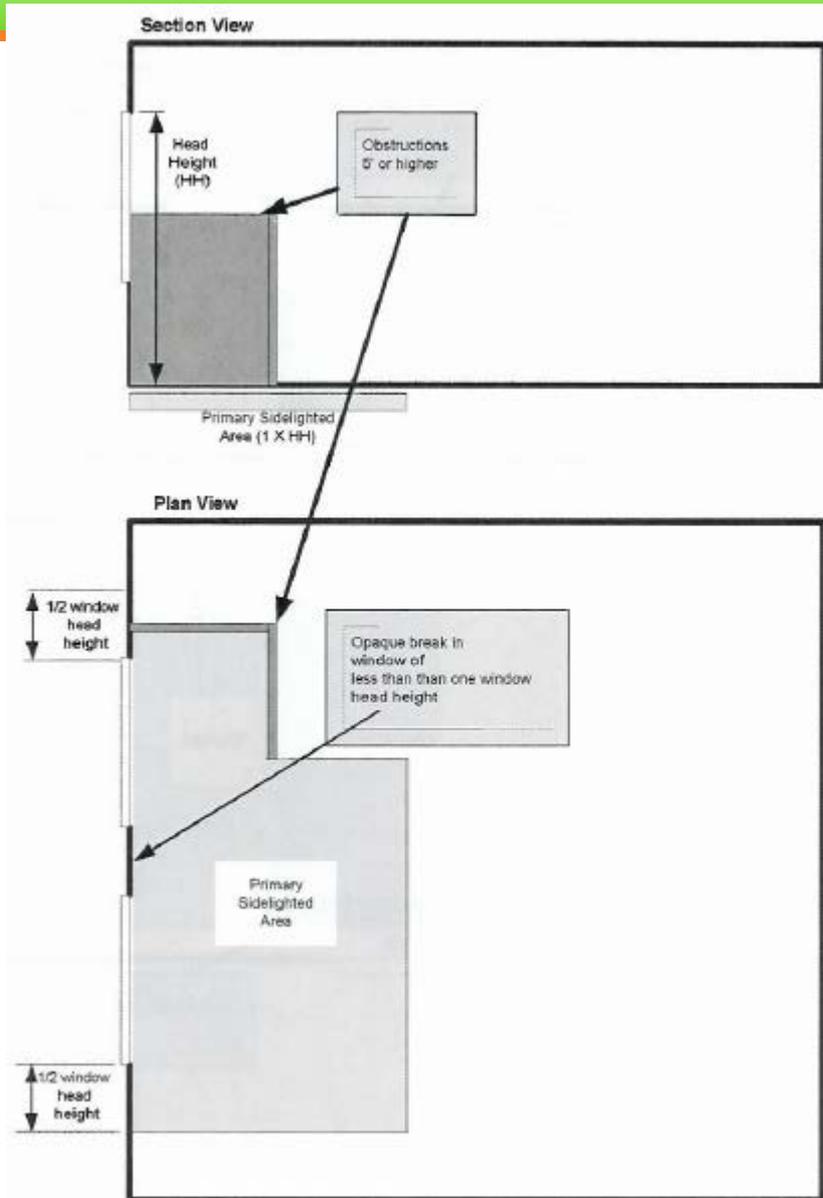
- Apply photocontrols if the combined input power of all general lighting completely or partially within:
 - primary sidelighted areas is ≥ 150 W
 - primary and secondary sidelighted areas is ≥ 300 W
 - general lighting in secondary sidelighted area controlled independently of general lighting in primary sidelighted area
- Control system must have following characteristics
 - Calibration adjustment located ≤ 11 ft above finished floor
 - Photocontrol to reduce electric lighting in response to available daylight using
 - Continuous dimming or
 - At least one control point between 50% and 70% of design light power
 - Second control point between 20% and 40% of design light power or
 - Lowest dimming level technology allows
 - Third control point that turns off all controlled lighting
 - Calibration doesn't require physical presence of a person at sensor while calibration is processing

Exceptions

- Primary sidelighted areas where top of any existing adjacent structure is twice as high above the windows as its distance away from the windows
- Sidelighted areas where total glazing area is $< 20 \text{ ft}^2$
- Retail spaces

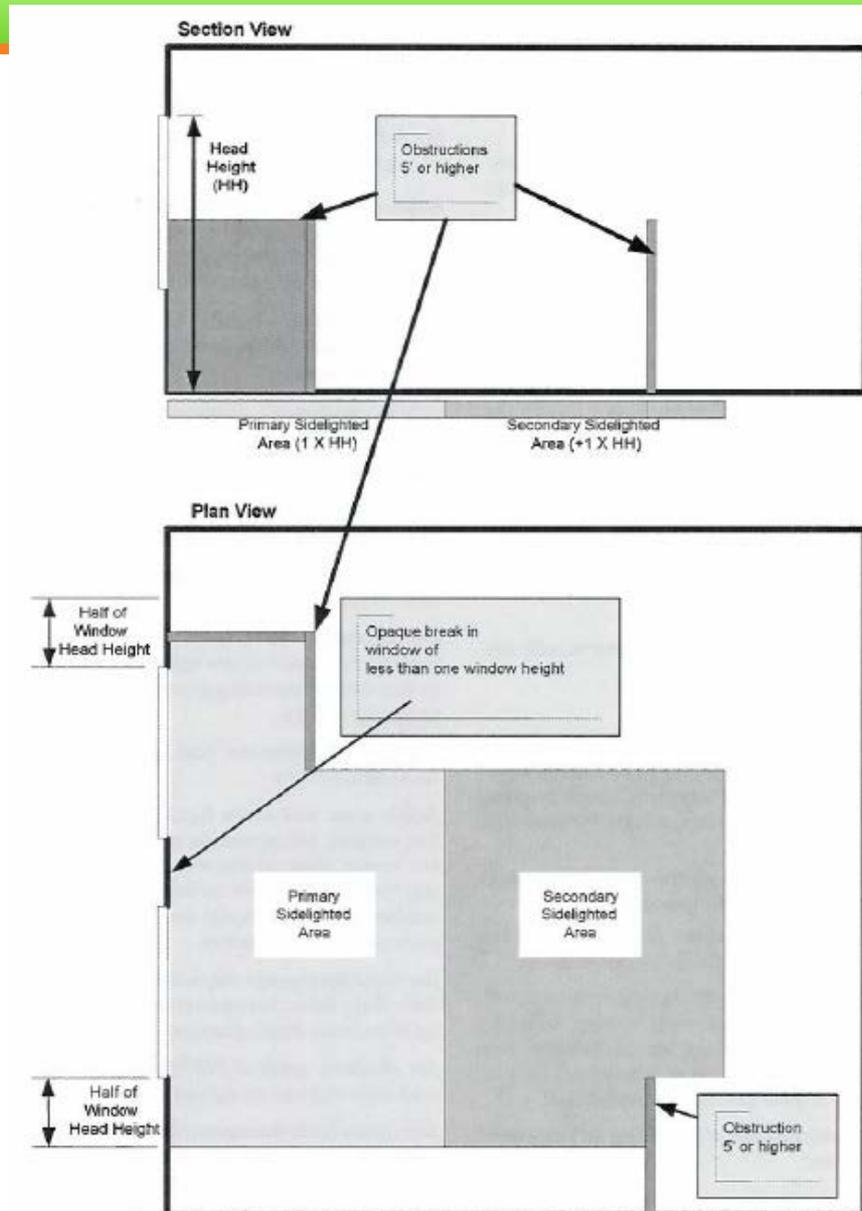
Section 9 – 9.4.1.4

Daylight Zone Definition – Primary Sidelighted Area



Section 9 – 9.4.1.4

Daylight Zone Definition – Secondary Sidelighted Area



Section 9 – 9.4.1.1 (f)

Automatic Daylight Responsive Controls for Toplighting (cont'd)

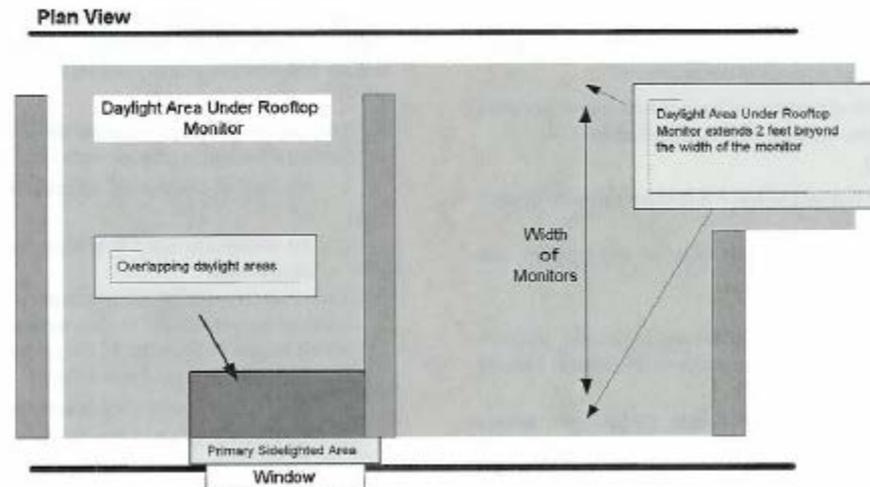
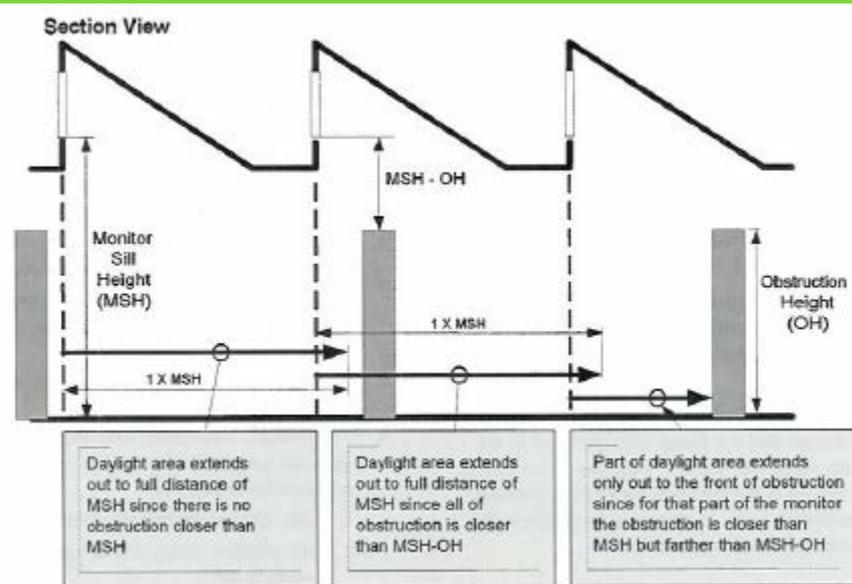
- Apply photocontrols if the combined input power of all general lighting completely or partially under daylight areas under skylights and daylight areas under roof monitors is ≥ 150 W. Photocontrols must:
 - Reduce electric lighting in response to available daylight using
 - Continuous dimming or
 - At least one control point between 50% and 70% of design light power
 - Second control point between 20% and 40% of design light power or
 - Lowest dimming level technology allows
 - Third control point that turns off all controlled lighting
 - Calibration doesn't require physical presence of a person at sensor while calibration is processing
 - Control overlapping toplighted and sidelighted daylight areas together with general lighting in the daylight area under skylights or daylight areas under roof monitors

Exceptions

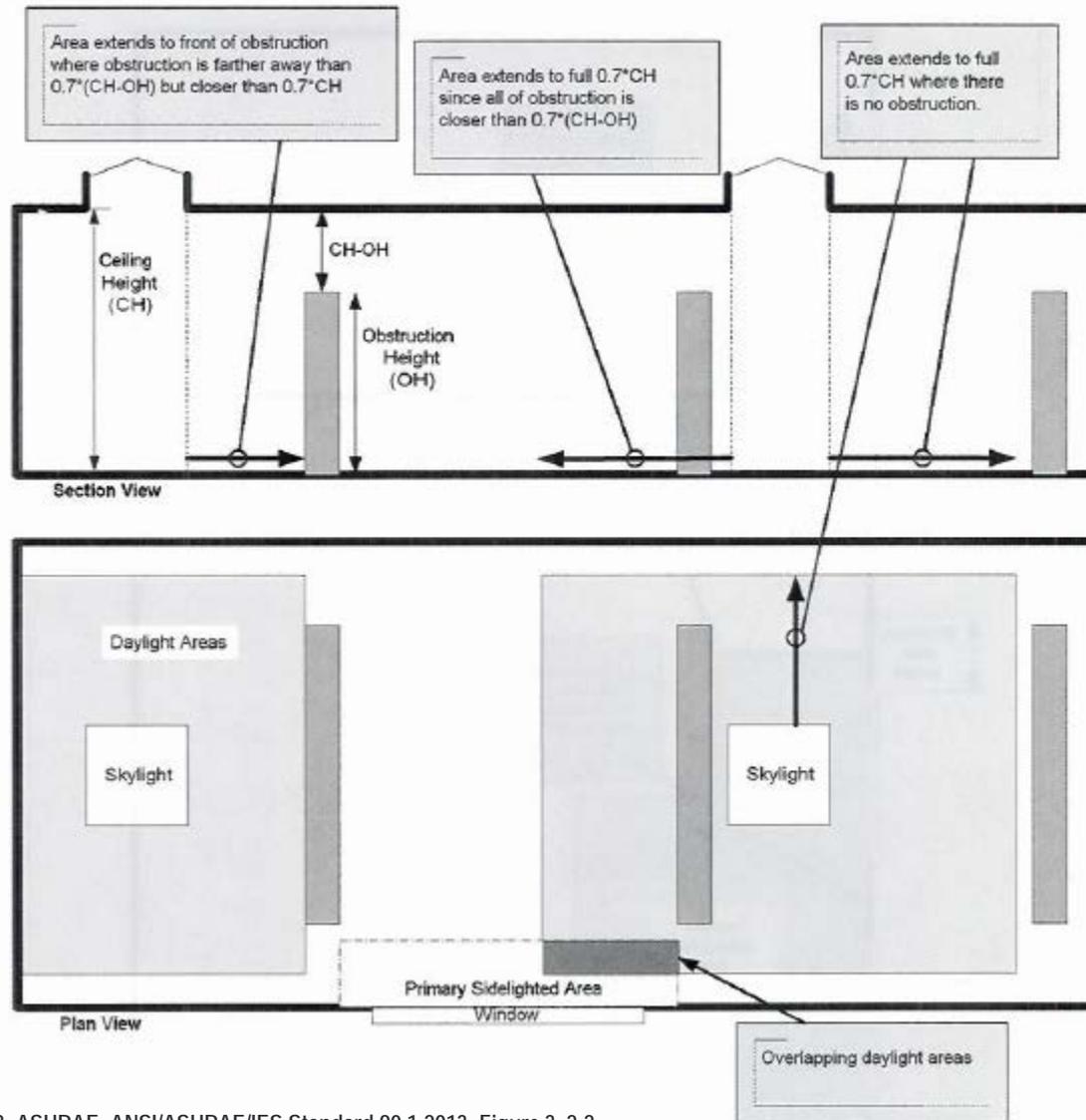
- Daylight area under skylights where documented that existing adjacent structures or natural objects block direct sunlight for > 1500 daytime hours per year between 8am and 4pm
- Daylight area under skylights where overall skylight effective aperture for enclosed space is < 0.006
- In each space within buildings in **Climate Zone 8** where input power of general lighting within daylight areas is < 200 W

Section 9 – 9.4.1.4

Daylight Zone Definition – Under Rooftop Monitors



Section 9 – 9.4.1.4 Daylight Zone Definition – Under Skylights



- Automatically reduce general lighting power by at least 50% within 20 minutes of all occupants leaving the space

Exceptions

- Space has LPD < 0.80 W/ft²
- Space is lighted by High Intensity Discharge technology
- General lighting power in space is automatically reduced by $\geq 30\%$ within 20 minutes of all occupants leaving the space
- Lighting load ≤ 0.02 W/ft² multiplied by gross lighted area of the building

- All lighting automatically shut off within 20 minutes of all occupants leaving the space
- Control device to control < 5,000 ft²

Exceptions

- Shop and lab classrooms
- Areas where auto shutoff causes safety or security concerns
- Lighting for 24/7 operation

Typically, users are allowed to choose to implement this control or Scheduled Shutoff

Control lights on a scheduled basis (automatic time switch)

- Time-of-day controller or
- Signal from another control or alarm

Controller or system provide independent control sequences that

- Controls $\leq 25,000$ ft²
- Not more than one floor
- Accounts for weekend and holidays

Manual override control

- < 2 hours during scheduled off
- Control $\leq 5,000$ ft²

Typically, users are allowed to choose to implement this control or Automatic Full Off

Exceptions

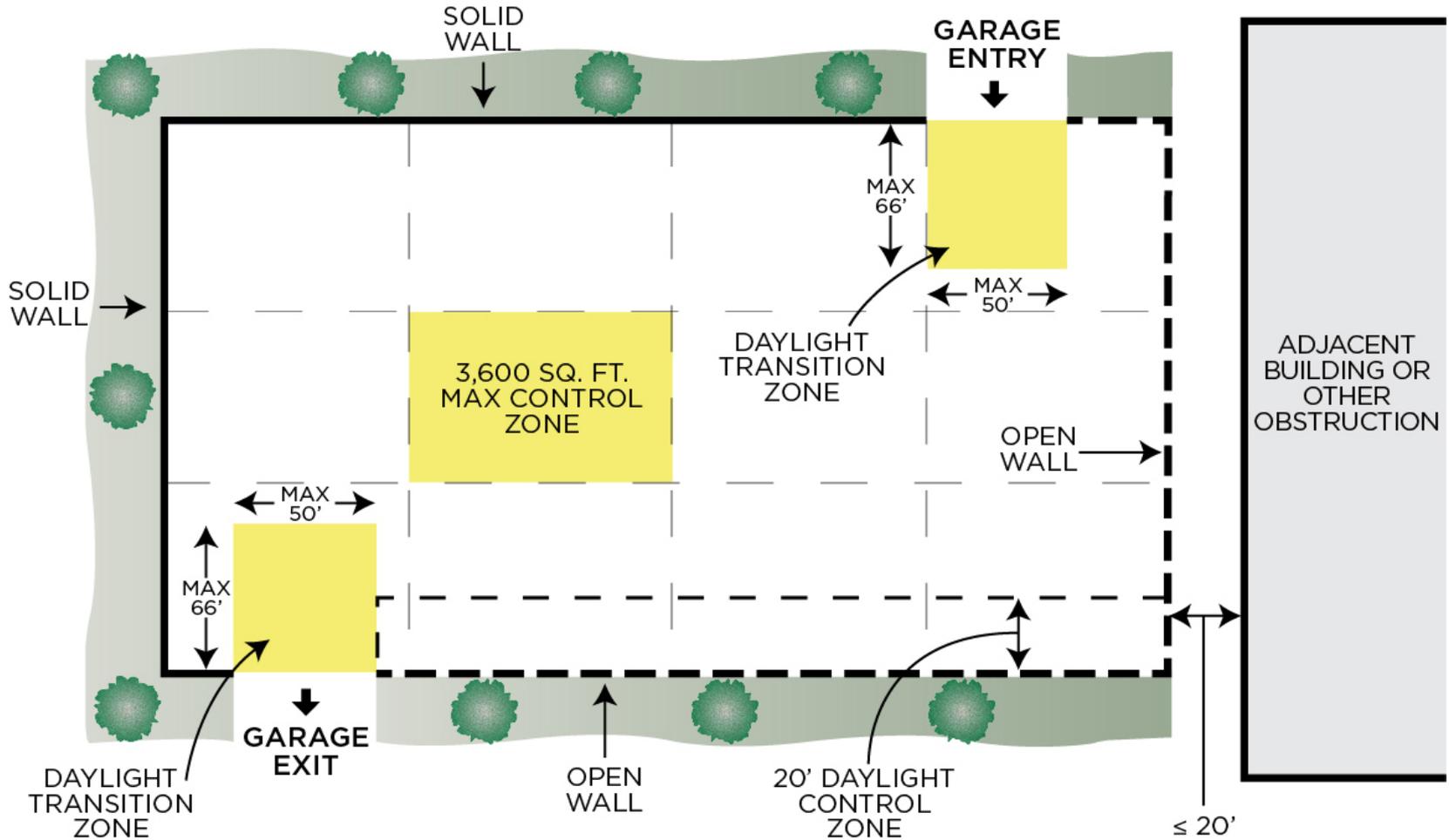
- Lighting for 24/7 operation
- Patient care spaces
- Areas where auto shutoff causes safety or security concerns
- **Lighting load ≤ 0.02 W/ft² multiplied by gross lighted area of the building**

- Automatic lighting shutoff per 9.4.1.1(i)
- Must reduce lighting power by minimum of 30% when no activity is detected for 20 minutes within a lighting zone $\leq 3,600 \text{ ft}^2$
- Automatically reduce power **at least 50%** in response to daylight for luminaires within 20 ft of any perimeter wall that has
 - a net opening to wall ratio of $\geq 40\%$ and
 - no exterior obstructions within 20 ft

Exception

- Daylight transition zones and ramps without parking are exempt from 30% reduction and daylight control

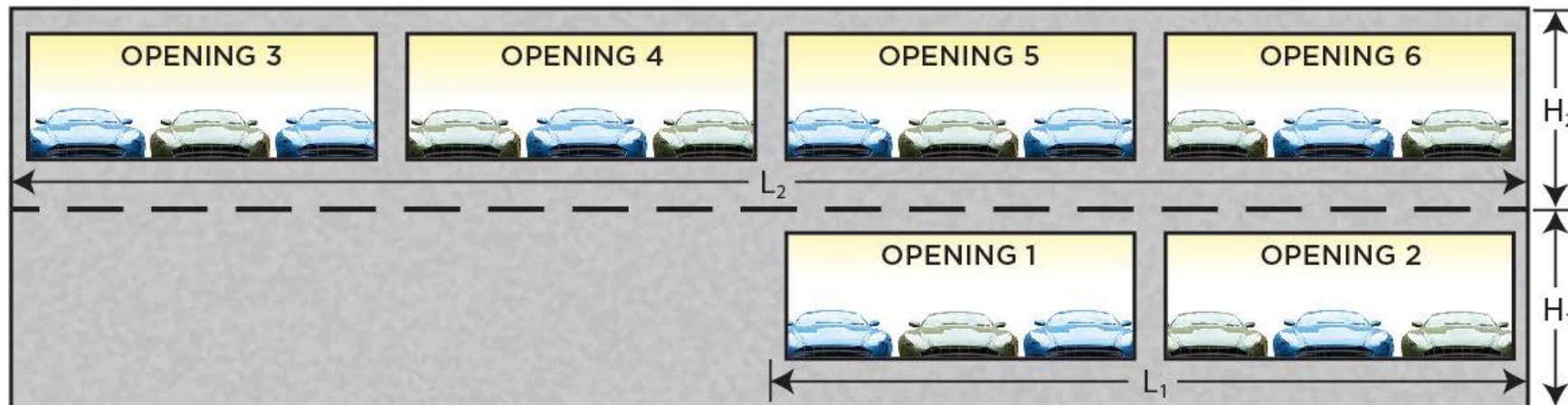
Section 9 – 9.4.1.2 Parking Garage Lighting Control



Section 9 – 9.4.1.2

Parking Garage Lighting Control – Opening to Wall Ratio

PARKING GARAGE SIDE VIEW (ELEVATION)



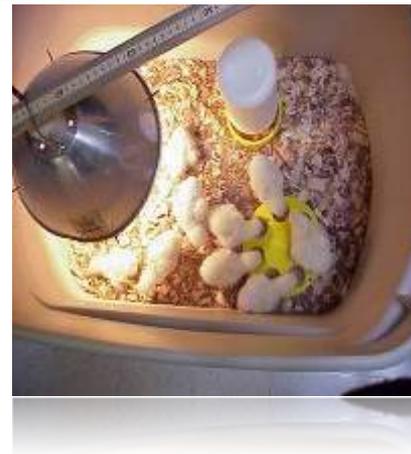
Daylighting control required if the total area of all openings in a wall section (i.e. openings 1-2) are greater than or equal to 40% of the total wall area ($H \times L$).

Example:
$$\frac{\text{Opening 1} + \text{Opening 2}}{H_1 \times L_1}$$

Example:
$$\frac{\text{Opening 3} + \text{Opening 4} + \text{Opening 5} + \text{Opening 6}}{H_2 \times L_2}$$

Special applications separately controlled from general lighting

- Display or accent lighting
- Case lighting
- Nonvisual lighting
- Demonstration lighting



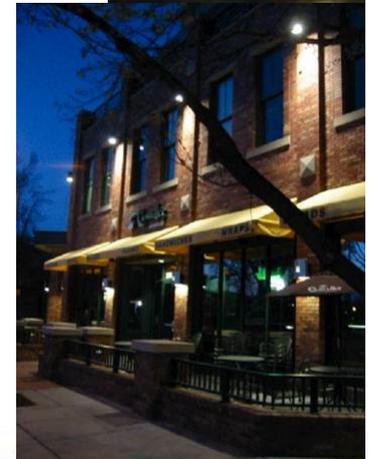
- Guestroom lighting and switched receptacles to be turned off within 20 minutes of occupants leaving the space
 - **Exception:** where captive key systems used
- Bathrooms controlled to automatically turn off lighting within 30 minutes of occupants leaving space
 - **Exception:** night lighting not > 5W
- Supplemental task lighting controlled by
 - Controller integral to the luminaires OR
 - Wall-mounted controller-readily accessible and located so occupant can see controlled lighting



Section 9 – 9.4.1.4

Mandatory Exterior Lighting Control

- Lighting must turn off when there is sufficient daylight
- Building façade and landscape lighting must be shut off between
 - midnight or business closing (whichever is later) and
 - 6am or business opening (whichever comes first) OR
 - times established by AHJ
- Power for other lighting and lighting for signage to be automatically reduced by at least **50%**
 - From midnight or within 1 hour of end of business operations (whichever is later) and until 6am or business opening (whichever is earlier) OR
 - During any period when no activity has been detected for a time no longer than 15 minutes
- **Luminaires serving outdoor parking areas with rated input wattage > 78 W and mounting height of ≤ 24 ft above ground**
 - **Lights must automatically reduce power of each luminaire by > 50% when no activity is detected in the area for 15 minutes or less**
 - **Limited to 1500 W of lighting controlled together**



Exceptions

- Covered vehicle entrances
- Exits from buildings or parking structures
(where required for safety, security, or eye adaptation)
- Lighting integral to signage and installed by manufacturer



Exterior Building Lighting Power must meet prescribed power limits.

- The total exterior lighting power allowance is the sum of the base site allowance plus individual lighting power densities (LPD) for the applicable “lighting power zone”
- Trade-offs are allowed only among “Tradable Surfaces” applications
- Some exemptions apply





- ZONE 1**
Developed areas of parks, forest, and rural areas.
- ZONE 2**
Residential and mixed use, neighborhood business, light industrial with limited night use.
- ZONE 3**
All other.
- ZONE 4**
High activity commercial in major metro as designated by AHJ.

In 2010, Zone 0 was introduced to represent undeveloped areas within national parks, forest land, and rural areas as defined by AHJ.

Section 9

Tradable Exterior LPDs

Exterior applications are divided into 2 categories:

Tradable: allowed wattage may be traded among these applications

Non-Tradable: allowed wattage cannot be traded between surfaces or with other exterior lighting

Table 9.4.2-2 Individual Lighting Power Allowances for *Building* Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Base Site Allowance (Base allowance may be used in tradable or nontradable surfaces.)					
	No allowance	350 W	400 W	500 W	900 W
Tradable Surfaces (LPD allowances for uncovered parking areas, <i>building</i> grounds, <i>building</i> entrances, exits and loading docks, canopies and overhangs, and outdoor sales areas may be traded.)					
Uncovered Parking Areas					
Parking areas and drives	No allowance	0.03 W/ft ²	0.04 W/ft ²	0.06 W/ft ²	0.08 W/ft ²
Building Grounds					
Walkways/ramps less than 10 ft wide	No allowance	0.5 W/linear foot	0.5 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
Walkways/ramps 10 ft wide or greater	No allowance	0.10 W/ft ²	0.10 W/ft ²	0.11 W/ft ²	0.14 W/ft ²
Plaza areas					
Special feature areas					
Dining areas	No allowance	0.65 W/ft ²	0.65 W/ft ²	0.75 W/ft ²	0.95 W/ft ²
Stairways	No allowance	0.6 W/ft ²	0.7 W/ft ²	0.7 W/ft ²	0.7 W/ft ²
Pedestrian tunnels	No allowance	0.12 W/ft ²	0.12 W/ft ²	0.14 W/ft ²	0.21 W/ft ²
Landscaping	No allowance	0.03 W/ft ²	0.04 W/ft ²	0.04 W/ft ²	0.04 W/ft ²
Building Entrances, Exits, and Loading Docks					
Pedestrian and vehicular entrances and exits	No allowance	14 W/lin ft of opening	14 W/lin ft of opening	21 W/lin ft of opening	21 W/lin ft of opening

The following are exempt when equipped with separate controls:

- lighting that is integral to signage and installed by its manufacturer;
- lighting for athletic playing areas;
- lighting for industrial production, material handling, transportation sites, and associated storage areas;
- theme elements in theme/amusement parks;
- lighting used to highlight features of public monuments, **public art displays**, and registered historic landmark structures or buildings;
- lighting for water features;
- specialized signal, directional, and marker lighting associated with transportation;
- lighting that is integral to equipment or instrumentation and is installed by its manufacturer;
- lighting for theatrical purposes, including performance, stage, film, and video production;
- temporary lighting;
- lighting for hazardous locations;
- lighting for swimming pools;
- searchlights.

- Functional testing (calibrated/adjusted/programmed) of lighting control devices and systems required within 90 days of occupancy
 - Must be performed by individuals NOT involved in design, manufacture, or installation
 - For occupant sensors:
 - Certify location and aiming per manufacturer recommendation
 - Test all sensors if project ≤ 7
 - If > 7 sensors, test for each unique combination of sensor type and space geometry and verify
 - Status indicator
 - Lights turn off or down to permitted level within required time
 - Auto-on – lights turn on to permitted level when someone enters the space
 - Manual on – lights turn on only when manually activated
 - Lights aren't incorrectly turned on by movement in nearby areas or by HVAC operation

- For automatic time switches:
 - Confirm programmed schedules
 - Document schedules for owner
 - Verify correct time and date are set
 - Verify any battery backup is installed and energized
 - Verify override time limit set to ≤ 2 hours
 - Simulate occupied condition and verify and document:
 - Lights turn on and off with respective switches
 - Switch only operates lights in enclosed space where switch is located
 - Simulate unoccupied condition and verify and document:
 - All nonexempt lights turn off
 - Manual override only operates lighting where it is located
- For daylighting controls
 - Properly located, field-calibrated, and set to have appropriate setpoints and threshold light levels
 - Daylight controlled lighting loads adjust to correct levels with available daylight
 - Location where calibration adjustments are made is readily accessible only to authorized personnel

- Dwelling units (apartment, condo, living space, etc.) must be built so that at least 75 percent of the permanently installed lighting fixtures utilize lamps with an efficacy of at least 55 lm/W, or have a total luminaire (fixture) efficacy of at least 45 lm/W.
 - **Exception:** Lighting that is controlled with dimmers or automatic control devices.
- Applies to 4 story above grade multi-family (3 story and below not in scope of 90.1)
- Other common spaces in the building must follow standard 90.1 Requirements.



- ✓ Record drawings, to include for each piece of lighting equipment:
 - Location
 - Luminaire identifier
 - Control
 - Circuiting
- ✓ Operation and maintenance manuals
- ✓ Daylighting documentation
 - Identify all general lighting located within daylight areas under skylights, daylight areas under roof monitors as well as primary sidelighted areas and secondary sidelighted areas