BUILDING ENERGY CODES PROGRAM

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ANSI/ASHRAE/IES Standard 90.1-2019: Power and Lighting

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

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Acknowledgements

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OVERVIEW OF CHANGES TO 90.1-2019

Summary of Changes

Updated:

- Lighting model for LPD calculations
- LPD allowances (9.5.1, 9.6.1)
- Interior and exterior lighting wattage (9.1.4)
- Parking garage lighting control requirements (9.4.1.2)
- Special applications lighting and controls (9.4.1.2)
- Daylighting control requirements (9.4.1.1)
- Daylighting zones [3.2, 9.4.1.1(e)]
- LPDs for non-typical exterior areas (9.4.2)

New:

- Simplified lighting method for select buildings up to 25,000 ft^2 (9.3)

Summary of Changes

Lighting Model

- 90.1 lighting methodology used to develop LPAs was evaluated and model reconstructed
- Now more representative of real-world conditions
- Updated IES recommendations, room cavity ratios, light loss factors, and efficacy values
- Additional surface reflectance categories added
- Features a 100% LED baseline

Simplified Building Method Compliance Path

- Intended for contractors who design or renovate office, school, and retail buildings up to 25,000 ft^2
- Single interior and exterior LPD targets cover the entire building; LPAs are lower than other methods
- Requirements occupancy sensor lighting control in most spaces, with some exemptions where life safety concerns apply
- All power from all lights must be counted towards the Interior Lighting Power Allowance – NO EXEMPTIONS

Interior Lighting Power Allowances Space-by-Space Method

- Average LPD reduction from 2016: **5%**
- Space-by-space values are primary
- Building area method LPDs values flow from the space-by-space

Space-by-Space Method – Lighting Power Densities (w/sq. ft.)

Space Type	90.1 2016	90.1 2019
Office, open plan	0.81	0.61
Guest room	0.77	0.41
Lobby, hotel	1.06	0.51
Parking area, interior	0.14	0.15
Retail sales Area	1.22	1.05
Classroom/lecture/training	0.92	0.71
Warehouse, med. To bulky items	0.35	0.33

LOOK HERE

Addendum BB

Interior Lighting Power Allowances
Building Area Method

- Average LPD reduction from 2016: 5%
- BAM values flow from the space-by-space values

Building Area Method – Lighting Power Densities (w/sq. ft.)

Building Type	90.1 2016	90.1 2019
Office	0.79	0.64
Hotel/Motel	0.75	0.56
Manufacturing Facility	0.90	0.82
Parking Garage	0.15	0.18
Retail	1.06	0.84
School/University	0.81	0.72
Warehouse	0.48	0.45

Addendum CG

New Compliance Method for Lighting in Simple Buildings

- Intended for contractors who design or renovate office, school, and retail buildings up to 25,000 sq. ft.
- Single interior and exterior LPD targets that cover the entire building, LPAs are lower than other methods
- Requires occupancy sensor lighting control in most spaces with some exemption where life safety concerns apply
- All power from all lights must be counted towards the Interior Lighting Power Allowance ILPA **No Exemptions** ⇦

Addendum BG

New Compliance Method for Lighting in Simple Buildings

Table 9.3.1-3 Simplified Building Method for School *Buildings*

Interior *Space* Type	Interior Lighting Power Allowance	*Controls* [a]
All *spaces* in school *buildings* other than parking garages, stairwells, and corridors	0.70 W/ft^2	All lighting shall be *automatically* controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied. (**Exception:** Lighting load not exceeding 0.02 W/ft^2 multiplied by the gross lighted area of the *building* shall be permitted to operate at all times.) Each *space* shall have a *manual control* device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.
Classrooms, offices *spaces*, conference rooms, meeting rooms, library, storage rooms, and break rooms	0.70 W/ft^2	These *spaces* shall also be controlled by *manual-ON occupant sensors*.
Gymnasiums and cafeterias	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors*.
Restrooms	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors*.
Stairwells and corridors in school *buildings* and parking garages	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors* that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes and be controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied.
Parking garages	0.13 W/ft^2	All lighting shall be *automatically* controlled to turn off during garage nonoperating hours. Lighting shall also be controlled by *occupant sensors*. *Controls* shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft^2.

a. All lights in the space shall be controlled.

Addendum BG

New Compliance Method for Lighting in Simple Buildings

Table 9.3.2 Simplified Building Method for *Building* Exteriors

Exterior Area Type	*Exterior Lighting Power Allowance*[a,b]	*Controls*[c]
Base allowance	200 W	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Façade lighting and special feature areas, walkways, plazas	0.10 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Landscape	0.04 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Entry doors	14 W/linear foot	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.
Stairs and ramps	0.7 W/ft^2	No additional *controls* required.
Parking lots and drives	0.05 W/ft^2	*Luminaires* mounted 25 ft or less above grade shall be controlled to reduce the power by at least 50% when no activity is detected for not longer than 15 minutes.
All other areas not listed	0.20 W/ft^2	*Luminaires* shall be turned off or the power reduced by a minimum of 75% during nonoperating hours.

a. To calculate the exterior allowance, multiply the *space* or area square footage by the allowed W/ft^2 and sum the exterior allowances and the base allowance. Façade lighting shall be calculated separately by multiplying the façade area by the allowed W/ft^2. Façade allowance shall not be traded with other exterior areas or between separate *façade areas*.
b. For *buildings* in Lighting Zone 2, as defined in Table 9.4.2-1, decrease exterior allowances by 20%. For *buildings* in Lighting Zone 4, as defined in Table 9.4.2-1, increase exterior allowances by 25%.
c. All exterior lighting shall be automatically controlled by either a photocell or an astronomical time switch to shut off the lighting when daylight is available.

Addendum BG

Interior and Exterior Lighting Wattage

- Replaced *luminaire* with *lighting equipment*
- Changed the term *ballast* to be *ballast/driver*
- Section now clearly split into 5 categories:
  1. Line voltage lighting equipment
  2. Line voltage lighting equipment with remote ballast/driver
  3. Track/plug-in busway
  4. Low-voltage track
  5. DC low voltage lighting systems with flexible cabling for plug-in connection of lighting equipment and remote power supply (e.g., PoE lighting)

- Wattage of a DC low voltage lighting system that employs flexible cabling for plug-in connection of the lighting equipment and a remote power supply shall be the labeled maximum wattage of the system power supply
- For systems that also provide power to equipment other than lighting, the wattage shall be the labeled maximum wattage of the system power supply reduced by the wattage of the non-lighting equipment connected to the system

Addendum AH

Parking Garage Lighting Control Requirements

- Increased the stringency of setback in parking garages – % reduction & time period
- Updated control requirements for transition lighting
- Continuous daylight dimming down to 50% required for luminaires within 20 ft. of wall openings

NEW

- **NEW** exemptions for permanent architectural screens or architectural elements that obstruct more than 50% of the opening and where the top of and existing adjacent structures or natural objects is at least twice as high above the openings as its horizontal distance from the opening.

Parking Garages

	90.1 2016	90.1 2019
Time	20	10
Reduction	30%	50%

Addendum CV

Special Applications Lighting and Controls

- Clarified the lighting control requirements for lighting applications not specifically covered in Table 9.6.1 and aligned them to the mandatory control provisions in 9.4.1

Item #	Equipment/Application	In Addition to and controlled Separately from *General Lighting*	Required Controls
1	Lighting that is integral to *equipment*, medical *equipment* or instrumentation and is installed by its *manufacturer.*	YES	No control requirements
2	Lighting specifically designed for use only during medical or dental procedures	YES	9.4.1.1(a) - Local control
8	Lighting integral to both open and glass-enclosed refrigerator and freezer cases.	YES	9.4.1.1(h) - Automatic full OFF or 9.4.1.1(i) - Scheduled shutoff
9	Casino gaming areas.	NO	
10	Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.	YES	9.4.1.1(a) - Local control and 9.4.1.1(i) - Scheduled shutoff

Addendum AQ

Daylighting Control Requirements

- **NEW:** Continuous daylight dimming required for all spaces
  - –Step dimming (control points) eliminated from requirements

- Calibration for automatic daylight responsive controls for sidelighting no longer requires the physical presence of a person at the sensor while processing
- Low setting for the photocontrol to reduce electric lighting power in response to available daylight using continuous dimming set to '20% or less or off'
- When an *automatic* partial OFF control has reduced the lighting power to the unoccupied setpoint, the daylight responsive control shall adjust the electric light in response to available daylight, but it shall not allow the lighting power to be above the unoccupied setpoint

continuous dimming: a lighting control strategy that varies the light output of a *lighting system* over a continuous range from full light output to a minimum light output in imperceptible steps without flickering.

Addendum CW

Daylighting Zones

- **NEW:** Added definition for daylight area under skylights in multi-story space
- Added two figures for clarity
- Added an exemption for primary sidelighted areas adjacent to vertical fenestration that have external projections and no *vertical fenestration* above the external projection and *projection factor* >1.0 for *north-oriented* projections or where the external projection has a *projection factor* > 1.5 for all other orientations

NEW

daylight area under skylights in multistory spaces: the *daylight area under skylights in multi-story spaces* shall include *floor* areas directly beneath the skylight and portions of the uppermost *floor* adjacent to the multistory space that meet the criteria for a *daylight area under skylights*, where CH is the ceiling height of the uppermost *floor*

Addendum CH

Daylighting for Sidelighting Requirements

- Modified the sidelighting requirements to clarify that the setback distance is a horizontal measurement
- Added natural objects as obstructions in addition to existing adjacent structures
- Removed an error that inadvertently set an exact measurement for an obstruction (instead of saying at least twice as high above the windows as its horizontal distance away from the windows)

Addendum CY

Selecting LPDs for Non-Typical Exterior Areas

- Clarified how to select an LPD for an exterior area not *already* listed in Table 9.4.2-2 by moving the language from 9.4.2 to a new explanatory row at the end of Table 9.4.2-2
- Interior LPDs from Table 9.6.1 are referenced and an appropriate reduction is applied to recognize the reduced power and illumination needs in exterior applications

For areas that are not listed in this Table or are not comparable to areas listed in this Table, use the comparable interior *space* type from Table 9.6.1 as modified by the factors in this row	No allowance	65% of the *interior lighting power allowance* value	65% of the *interior lighting power allowance* value	80% of the *interior lighting power allowance* value	100% of the *interior lighting power allowance* value

Addendum T

DETAILED INFORMATION

CHANGES TO 90.1-2019 SHOWN IN RED

Compliance Paths
Power

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Building System

- Envelope
- HVAC
- SWH
- **Power**
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- Prescriptive Path
- Simplified
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

- Submittal Requirements
- Information and Installation Requirements
- Verification, Testing, Inspection & Commissioning

Energy Code Compliance

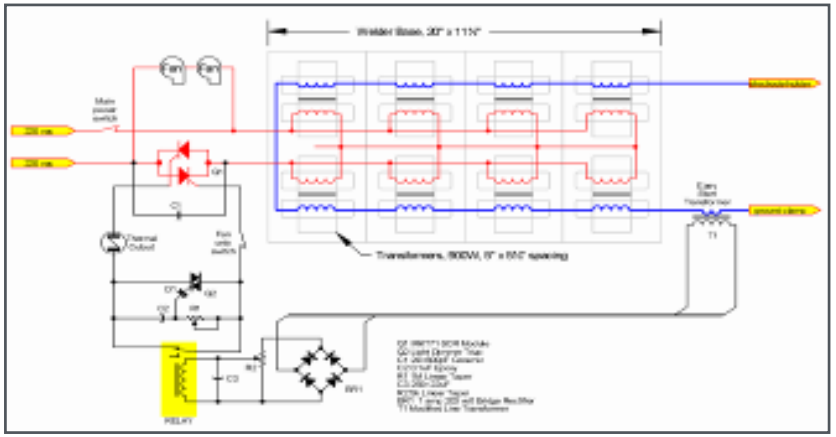
- New Buildings
- Additions
- Alterations
- Mandatory Provisions
  - Voltage drop
  - Automatic receptacle control
  - Electrical Energy Monitoring
  - Low-Voltage Dry Type Distribution Transformers
- Submittals

- 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

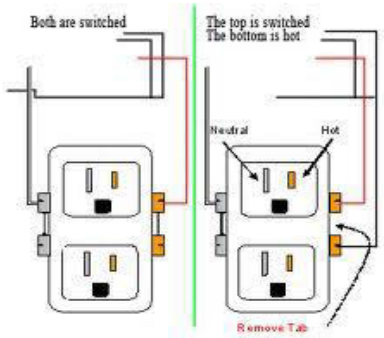
Feeder conductors and branch circuits combined to be sized for a maximum of 5% voltage drop total



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 ≤ 5,000 ft^2 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

- 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 EPAct 2005, then no requirements

Exceptions

- If meet EPAct 2005 exclusions based on 10 CFR 431
  - Special purpose applications
  - Not likely in general purpose applications
  - Have multiple voltage taps where highest tap is ≥ 20% more than lowest tap
- Some specific products are listed

- Power distribution systems and equipment only serving a computer room with IT equipment load > 10 kW to comply with Standard 90.4 (Energy Standard for Data Centers)

Compliance Paths
Power

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
- HVAC
- SWH
- **Power**
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- Prescriptive Path
- Simplified
- Trade Off Option
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- Information and Installation Requirements
- Verification, Testing, Inspection & Commissioning

Energy Code Compliance

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

Compliance Paths
Power

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
- HVAC
- SWH
- **Power**
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- Prescriptive Path
- Simplified
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

- Submittal Requirements
- Information and Installation Requirements
- Verification, Testing, Inspection & Commissioning

Energy Code Compliance

Verification and Testing

- Verify and test per 4.2.5.1 that control elements are configured and operating per 8.4.2 and 8.4.3
  - automatic receptacles controls
  - energy monitoring
- Verification and Functional Performance Testing (FPT) documentation per 4.2.5.1
- Commissioning
  - energy performance of the power systems per 4.2.5.2
  - Reporting per 4.2.5.2.2

Compliance Paths
Lighting

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
- HVAC
- SWH
- Power
- **Lighting**
- Other

Compliance Requirements

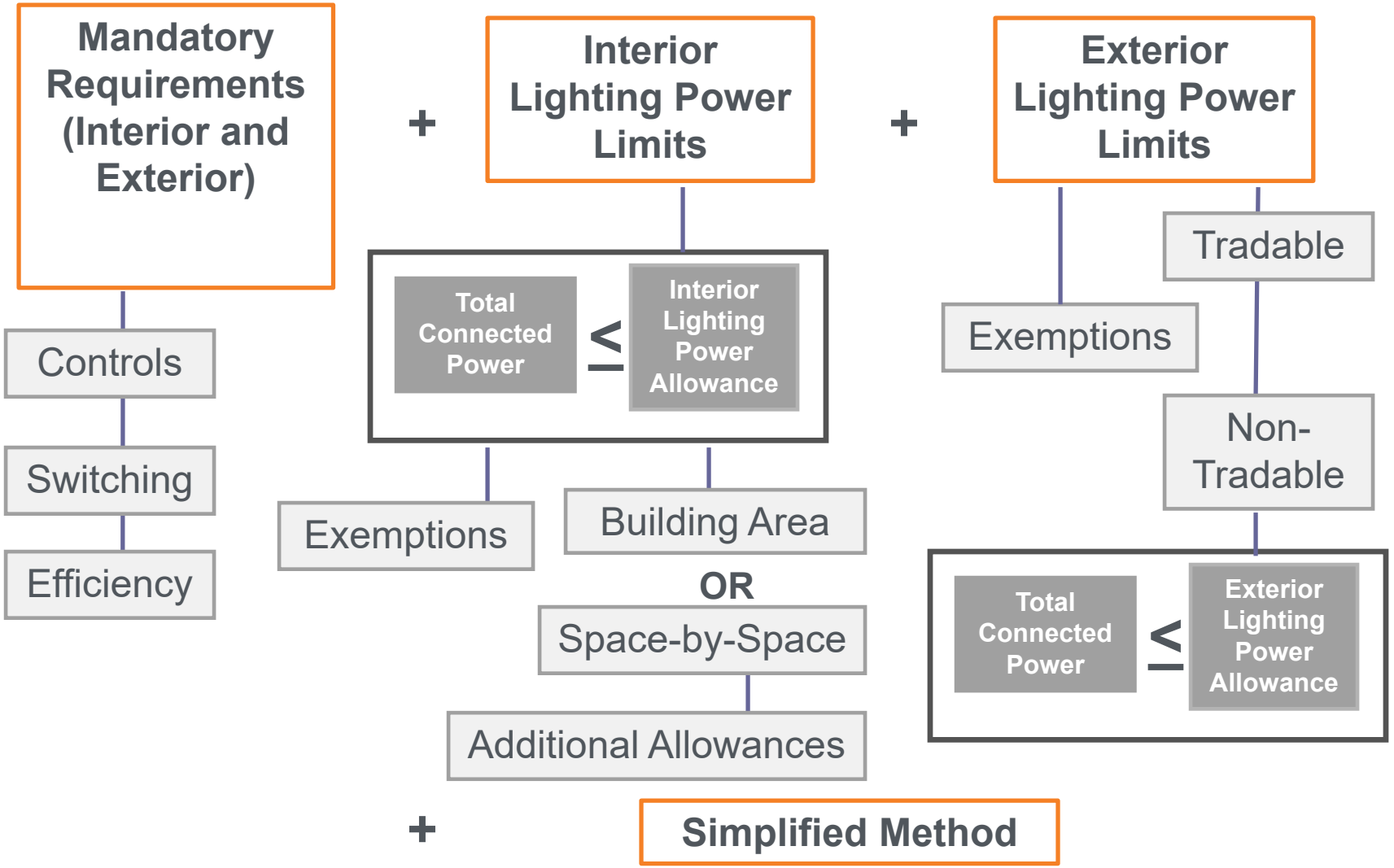
Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

Basic Lighting Requirements



- ✓ General Application *(Section 9.1)*
  - Scope
  - Lighting Alterations
  - Installed Lighting Power
  - Interior and Exterior Luminaire Wattage
- ✓ Compliance Paths *(Section 9.2)*
- ✓ Mandatory Provisions *(Section 9.4)*
  - Lighting control
  - Exterior lighting power
  - Dwelling units

- ✓ Building Area Method Compliance Path *(Section 9.5)*
- ✓ Alternative Compliance Path: Space-by-Space Method *(Section 9.6)*

- 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 ≤ lighting power allowance

Installed interior lighting power calculation method

- Calculation requirements
- Lots of exemptions

Power allowance calculation methods

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

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

- Wattage of lighting equipment connected to line voltage = manufacturers' labeled max. wattage
- Luminaires with ballasts/drivers or transformers = total input wattage of all components. 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
- DC low-voltage with flexible cabling for plug-in connection and remote power supply = labeled maximum wattage of power supply minus wattage of connected non-lighting equipment
- All others as specified on equipment

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

- Theatrical, stage, broadcast studio, film, and video production
- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Integral to equipment, medical 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 in sporting activity areas for television broadcasting
- Casino gaming areas
- Furniture-mounted supplemental task lighting
- For use in areas specifically designed for life support of nonhuman life forms
- Mirror lighting in dressing rooms
- Accent lighting in religious pulpit and choir areas
- Parking garage transition lighting
- Photographic processes

Includes requirements for:

- interior lighting (Section 9.3.1)
- exterior lighting (Section 9.3.2)

(wattage allowances calculated and complied with separately)

- Allowed if at least 80% of floor area is office, retail, or school

- Can be used for new buildings or tenant improvements < 25,000 ft^2

Table 9.3.1-3 Simplified Building Method for School *Buildings*

Interior *Space* Type	Interior Lighting Power Allowance	*Controls* [a]
All *spaces* in school *buildings* other than parking garages, stairwells, and corridors	0.70 W/ft^2	All lighting shall be *automatically* controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied. (**Exception:** Lighting load not exceeding 0.02 W/ft^2 multiplied by the gross lighted area of the *building* shall be permitted to operate at all times.) Each *space* shall have a *manual control* device that allows the occupant to reduce lighting power by a minimum of 50% and to turn the lighting off.
Classrooms, offices *spaces*, conference rooms, meeting rooms, library, storage rooms, and break rooms	0.70 W/ft^2	These *spaces* shall also be controlled by *manual-ON occupant sensors*.
Gymnasiums and cafeterias	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors*.
Restrooms	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors*.
Stairwells and corridors in school *buildings* and parking garages	0.70 W/ft^2	These *spaces* shall also be controlled by *occupant sensors* that reduce the lighting power by a minimum of 50% when no activity is detected for not longer than 20 minutes and be controlled to turn off when the *building* is either unoccupied or scheduled to be unoccupied.
Parking garages	0.13 W/ft^2	All lighting shall be *automatically* controlled to turn off during garage nonoperating hours. Lighting shall also be controlled by *occupant sensors*. *Controls* shall reduce the power by a minimum of 50% when no activity is detected for not longer than 20 minutes. No device shall control more than 3600 ft^2.

a. All lights in the space shall be controlled.

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 that 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)

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	0.75
Convention Center	0.64
Court House	0.79
Dining: Bar Lounge/Leisure	0.80
Dining: Cafeteria/Fast Food	0.76
Dining: Family	0.71
Dormitory	0.53
Exercise Center	0.72

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 ft^2 do not need to be broken out separately

Small part of Table 9.6.1 shown below

Table 9.6.1 ***Lighting Power Density*** **Allowances Using the Space-by-Space Method and Minimum** ***Control*** **Requirements Using Either Method**

Informative Note: 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.			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])	Bilevel Lighting *Control* (See Section 9.4.1.1[d])	*Automatic* Daylight Responsive *Controls* for Sidelighting (See Section 9.4.1.1[e][6])	*Automatic* Daylight Responsive *Controls* for *Toplighting* (See Section 9.4.1.1[f][6])	*Automatic* Partial OFF (See Section 9.4.1.1[g] [Full Off complies])	*Automatic* Full OFF (See Section 9.4.1.1[h])	Scheduled Shutoff (See Section 9.4.1.1[i])
Common *Space* Types[1]	*LPD* Allowances, W/ft^2	*RCR* Threshold	a	b	c	d	e	f	g	h	i
Atrium											
<20 ft in height	0.39	NA	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
≥20 ft and ≤40 ft in height	0.48	NA	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
>40 ft in height	0.60	11	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Audience Seating Area											
Auditorium	0.61	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Gymnasium	0.23	6	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Motion picture theater	0.27	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Penitentiary	0.67	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
Performing arts theater	1.16	8	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Religious facility	0.72	4	REQ	ADD1	ADD1	REQ	REQ	REQ		ADD2	ADD2
Sports arena	0.33	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2
All other audience seating areas	0.23	4	REQ	ADD1	ADD1		REQ	REQ		ADD2	ADD2

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/ft^2
- ✓ 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

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

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

Room Geometry Adjustment – 9.6.4

Room Cavity Ratio Adjustment for relief in unusual space configurations

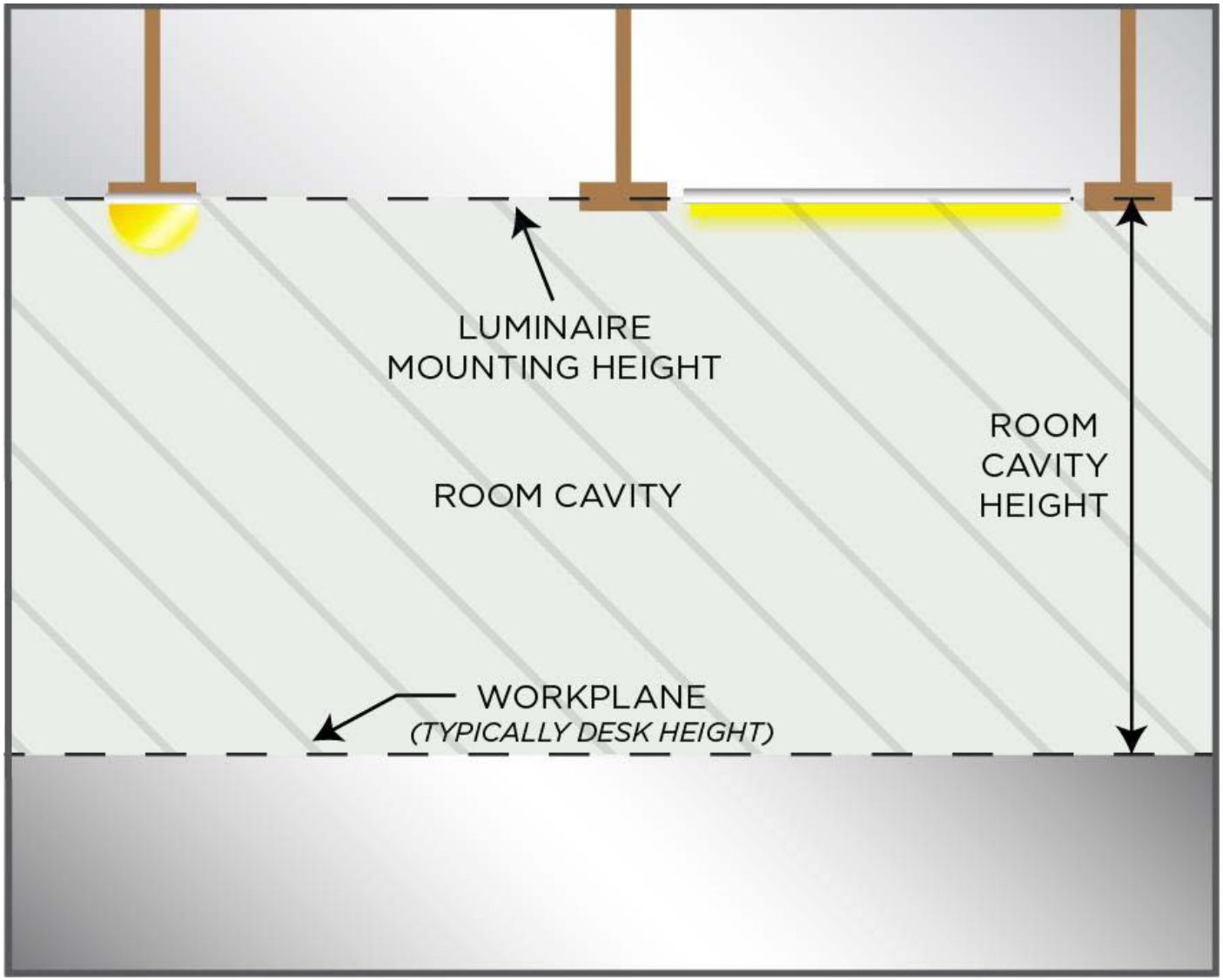
- Used only when applying the space by space method
- Calculate the *Room Cavity Ratio* (RCR) for the empty room:

  $$RCR = \frac{2.5 \times \text{Room Cavity Height} \times \text{room perimeter length}}{\text{room area}}$$

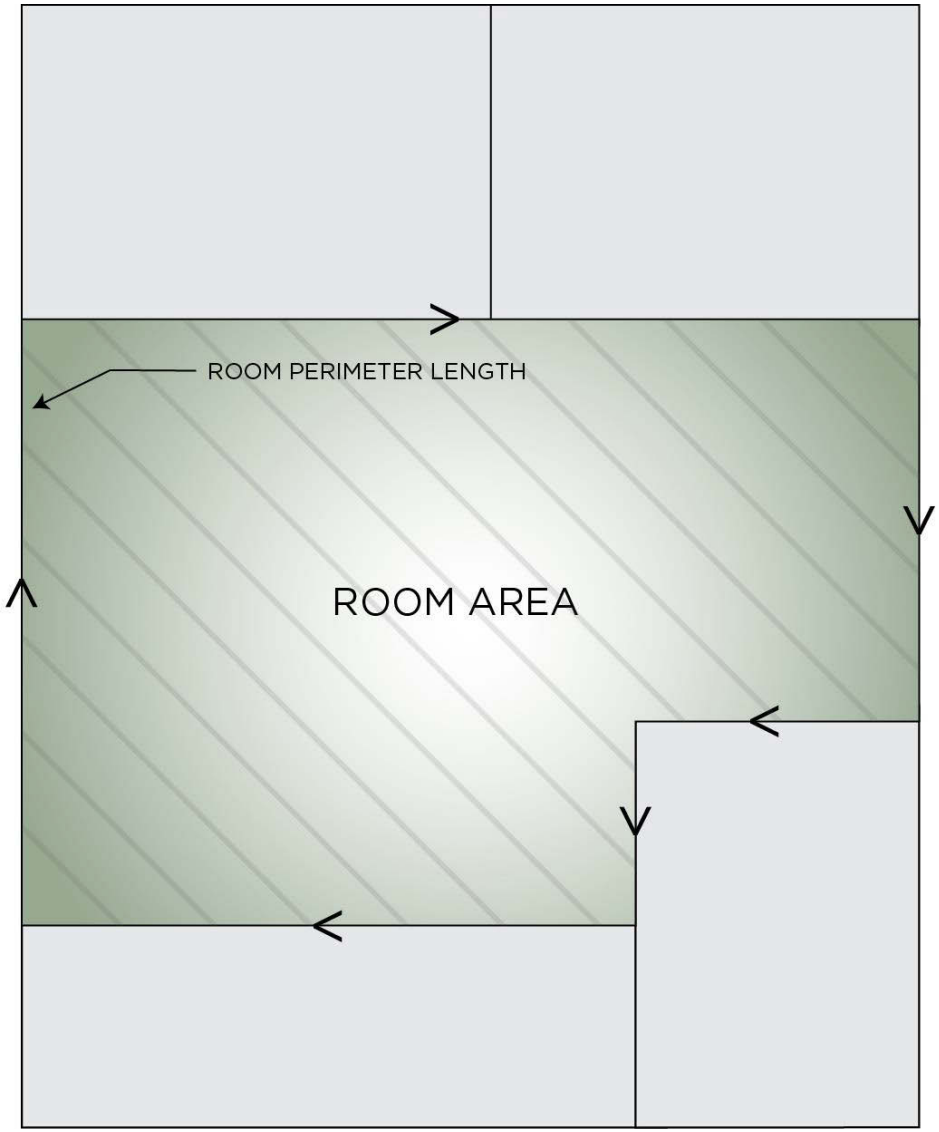
  (Room Cavity Height = Luminaire mounting height – Workplane height)

- 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



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
- Scheduled OFF during nonbusiness hours

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

- In spaces ≤ 10,000 ft^2, each control serves 2,500 ft^2 maximum and in spaces > 10,000 ft^2, serves 10,000 ft^2 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 ≤ 600 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

- 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 ≤ 11ft above finished floor (no person needed at sensor while processing)
  - Reduce electric lighting in response to available daylight using continuous dimming to ≤ 20% and off
  - When automatic partial OFF control has reduced to unoccupied set point, daylight responsive control to adjust electric light in response to available daylight (but not above unoccupied set point)

Exceptions

- Primary sidelighted areas where top of any existing adjacent structure is at least twice as high above the windows as its horizontal distance away from the windows
- Sidelighted areas where total glazing area is < 20 ft^2
- Retail spaces
- Primary sidelighted areas adjacent to vertical fenestration with external projections and no vertical fenestration above projections, where projection has projection factor (PF)
  - > 1.0 if north oriented or
  - > 1.5 for all other orientations

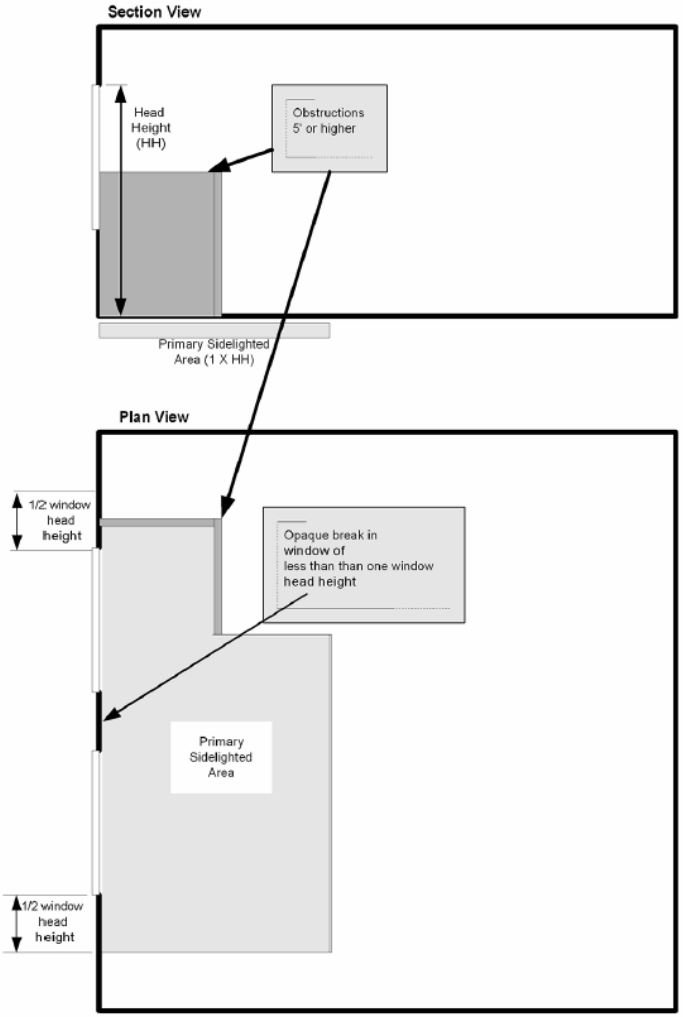


Figure 3.2-4 Computing the *primary sidelighted area.*

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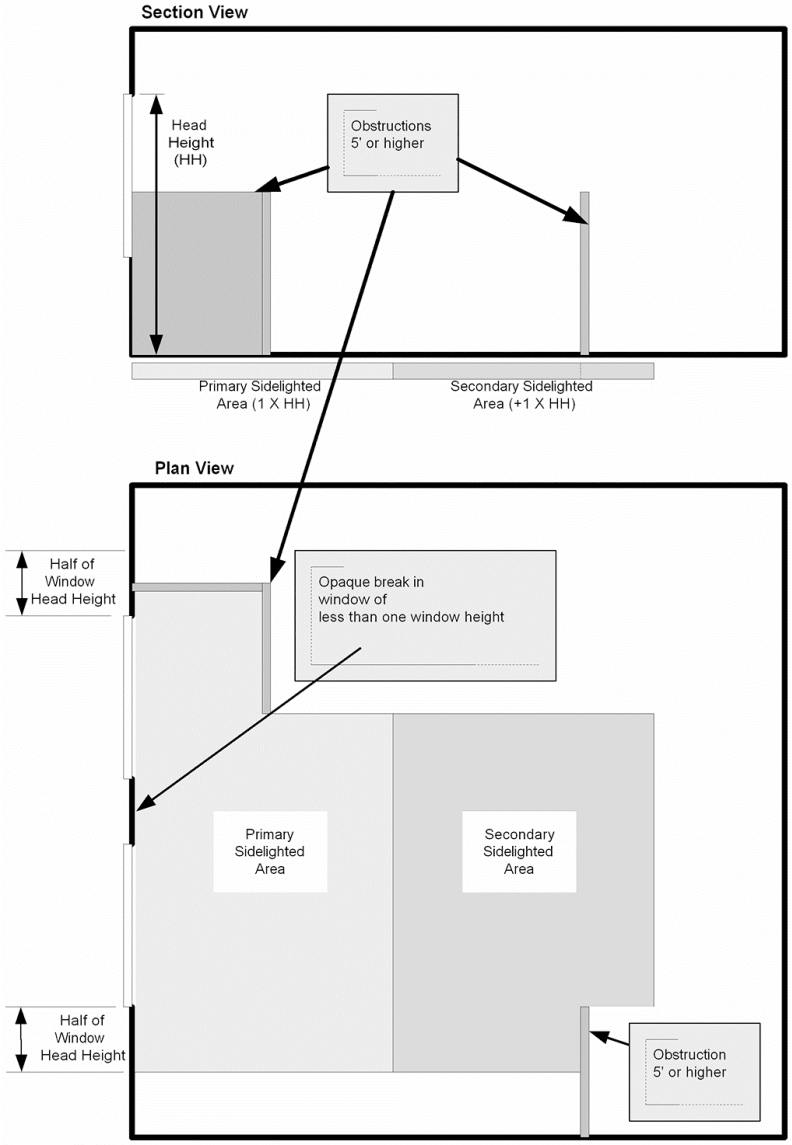
Section 9 – 9.4.1.4
Daylight Zone Definition – Secondary Sidelighted Area



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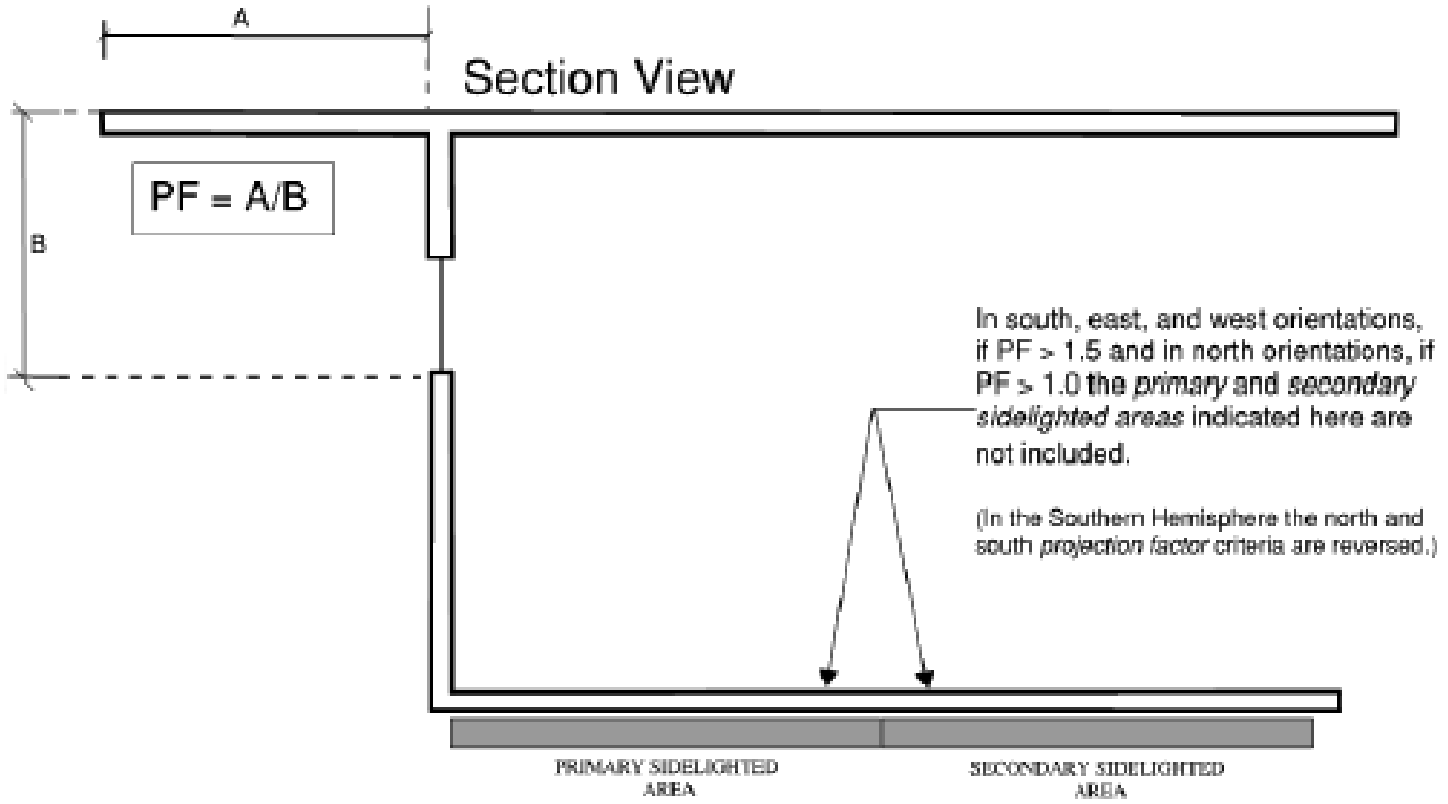

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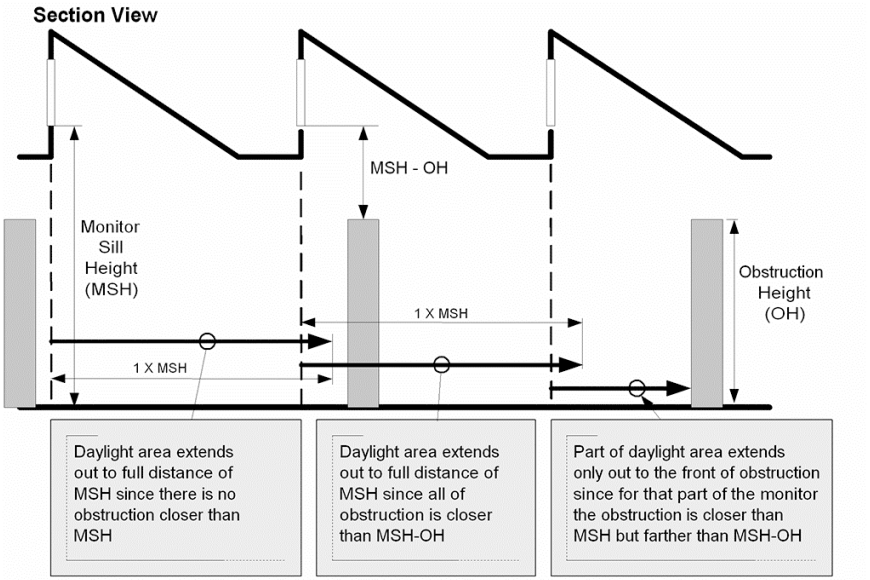
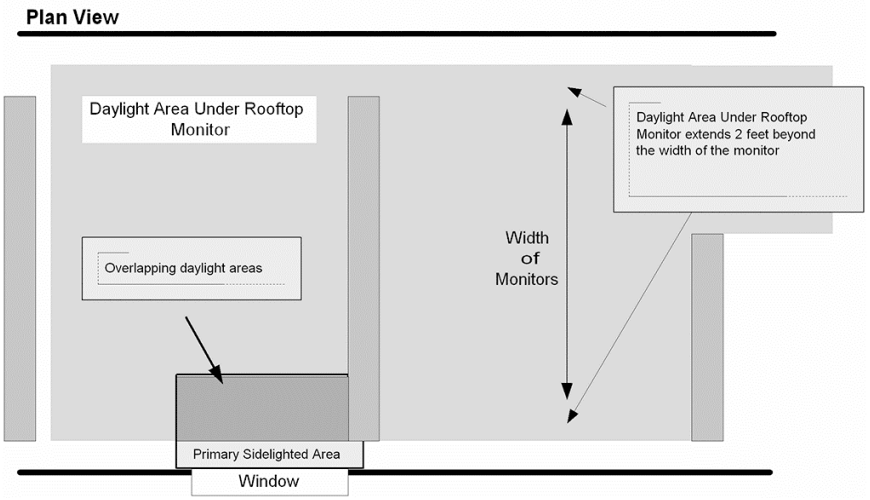
- Apply photocontrols if the combined input power of all general lighting completely or partially under daylight areas under skylights and daylight areas under roof monitors is ≥ 150 W. Photocontrols must:
  - Calibration adjustment located ≤ 11ft above finished floor (no person needed at sensor while processing)
  - Reduce electric lighting in response to available daylight using continuous dimming to ≤ 20% and off
  - When automatic partial OFF control has reduced to unoccupied set point, daylight responsive control to adjust electric light in response to available daylight (but not above unoccupied set point)
  - 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 fore > 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 – 9.4.1.1 (f)
Daylight Zone Definition: Under Rooftop Monitors





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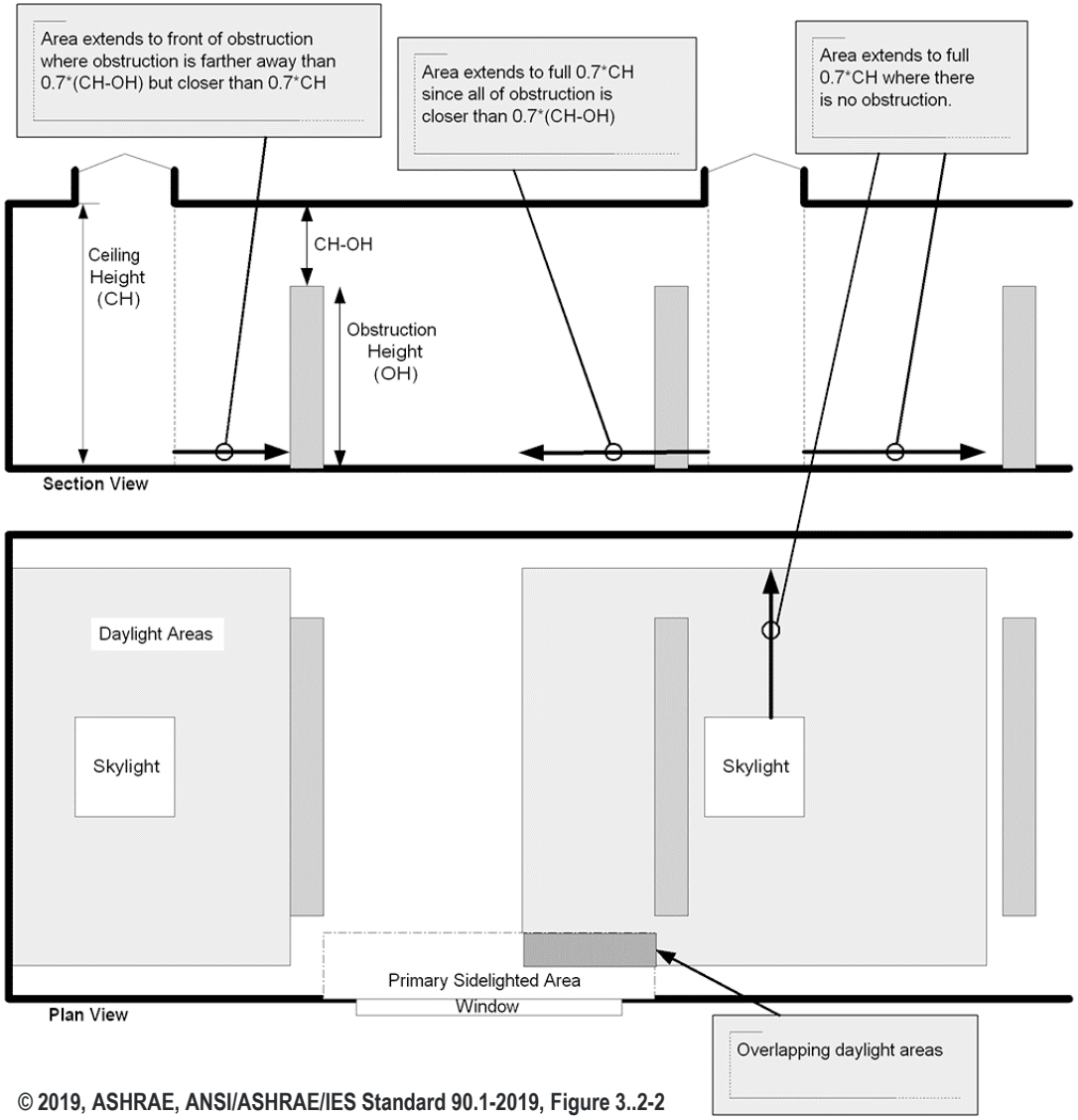

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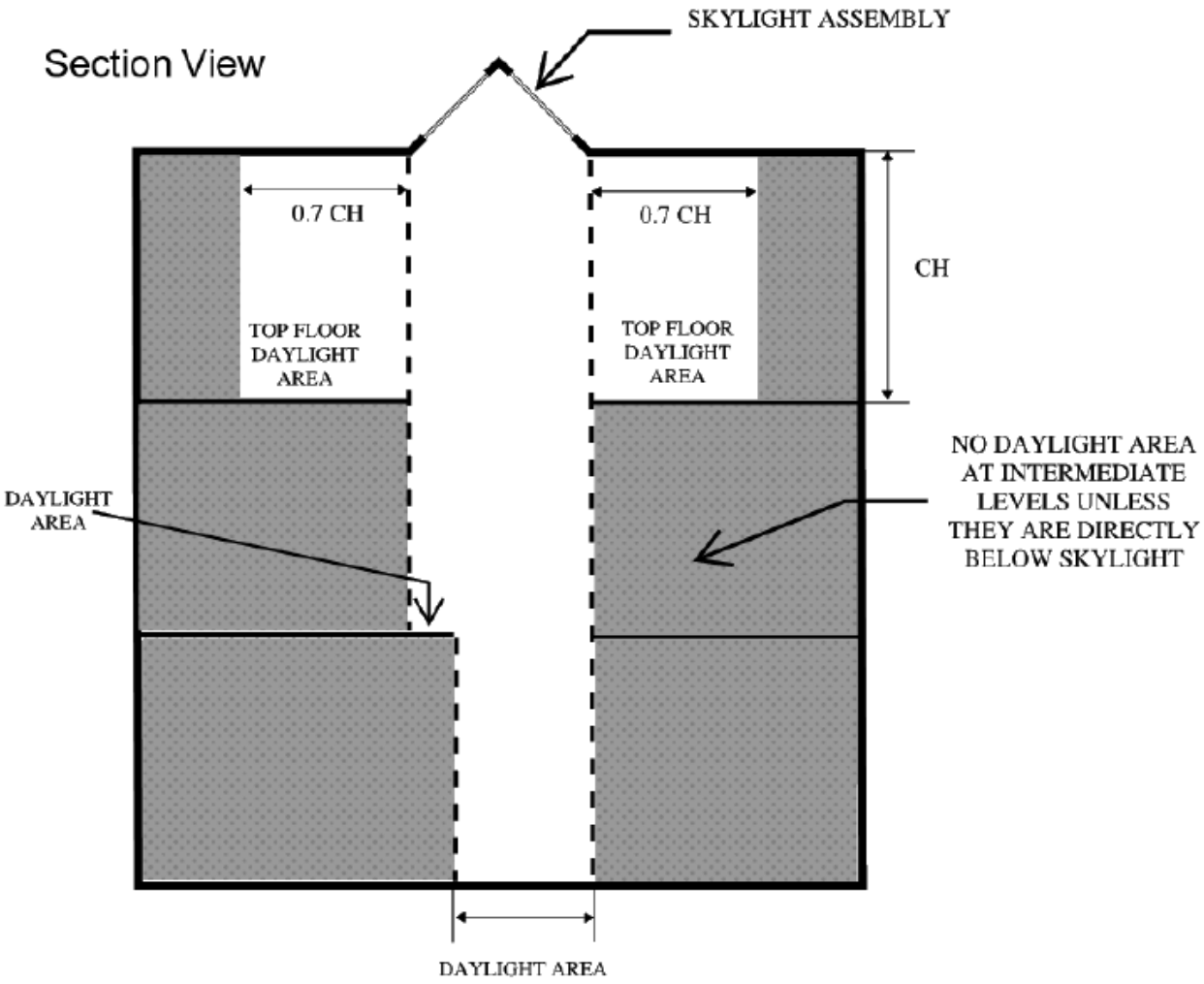
Section 9 – 9.4.1.1 (f)
Daylight Zone Definition: Under Skylights



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- 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/ft^2
- Space is lighted by High-Intensity Discharge technology
- General lighting power in space is automatically reduced by ≥ 30% within 20 minutes of all occupants leaving the space
- Lighting load ≤ 0.02 W/ft^2 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 ft^2

Exceptions

- Shop and lab classrooms
- Areas where auto shutoff causes safety or security concerns
- Lighting for 24/7 operation
- Lighting load < 0.02 W/ft^2 multiplied by the gross lighted floor area

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 ≤ 25,000 ft^2
- Not more than one floor
- Accounts for weekend and holidays

Manual override control

- < 2 hours during scheduled off
- Control ≤ 5,000 ft^2

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/ft^2 multiplied by gross lighted area of the building

Lights scheduled off at end of business hours using either

- Time-of-day control automatically turns lighting off as programmed OR
- Signal from another automatic control or alarm/security system

Any manual, override control to not turn lighting on > 2 hours during scheduled off

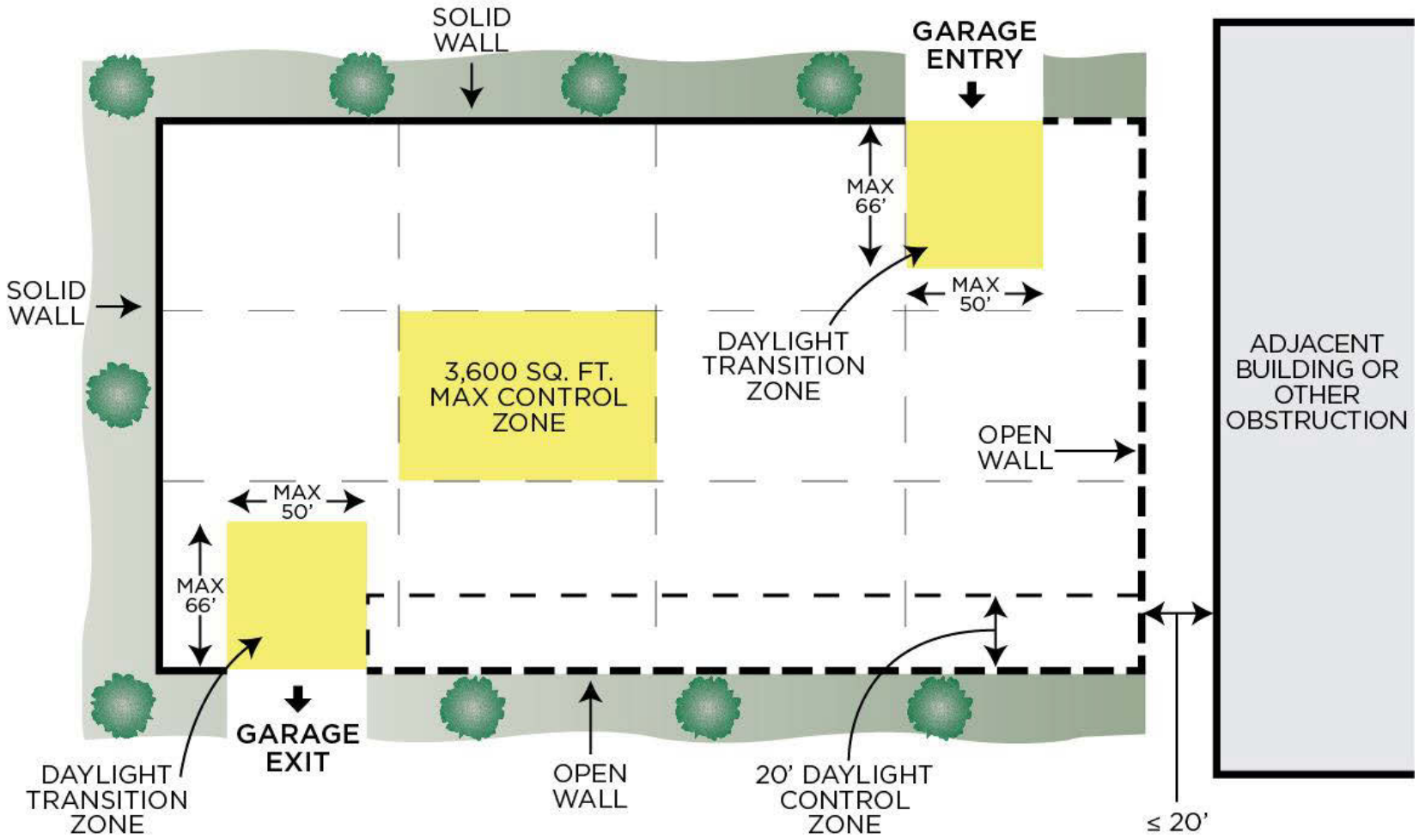
- Automatic lighting shutoff per 9.4.1.1(i)
- Must reduce lighting power by minimum of 50% when no activity is detected for 10 minutes within a lighting zone ≤ 3,600 ft^2
- Parking garage daylight transition lighting exempt per Section 9.2.3.1 to be separately controlled to automatically reduce lighting to no more than general light level from sunset to sunrise

- Automatically reduce power through continuous dimming in response to daylight for luminaires within 20 ft of any perimeter wall openings totaling at least 24 ft^2

Exceptions

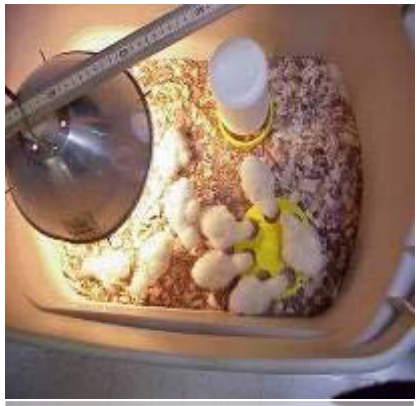
- Parking garage daylight transition lighting exempt per 9.2.3.1
- Where permanent screens or architectural elements obstruct > 50% of opening
- Where top of any existing adjacent structure or natural object is at least twice as high above the openings as its horizontal distance from opening

Section 9 – 9.4.1.2
Parking Garage Lighting Control



Special applications separately controlled from general lighting

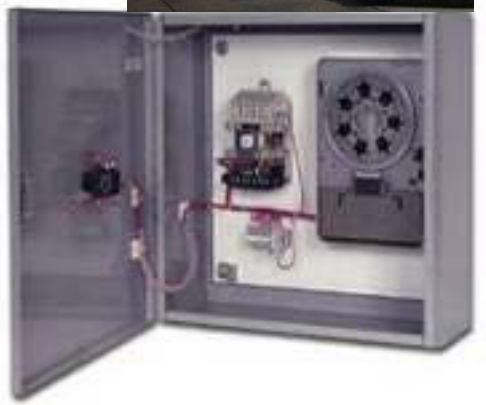
- Display or accent lighting
- Case lighting
- Demonstration lighting



- 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
  - Local control independent of general lighting control (and per 9.4.1.1(h) and (i)

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

Exterior Lighting Power Zones

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.

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, *building* grounds, *building 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 Plaza areas Special feature areas	No allowance	0.10 W/ft^2	0.10 W/ft^2	0.11 W/ft^2	0.14 W/ft^2
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.

- 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
  - **Exceptions:**
    - Lighting that is controlled with dimmers or automatic control devices
    - Hotel/motel guest rooms [those requirements covered in Table 9.6.1 and Section 9.4.1.3(b)]
- 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.

Compliance Paths
Lighting

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
- HVAC
- SWH
- Power
- **Lighting**
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- Prescriptive Path
- Simplified
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

- **Submittal Requirements**
- Information and Installation Requirements
- Verification, Testing, Inspection & Commissioning

Energy Code Compliance

- 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

Compliance Paths
Lighting

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
- HVAC
- SWH
- Power
- **Lighting**
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- Prescriptive Path
- Simplified
- Trade Off Option
- Energy Cost Budget
- Performance Rating Method

- Submittal Requirements
- Information and Installation Requirements
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

- 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 occupancy 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

Referenced 9.9 testing and commissioning refers to 4.2.5
New in 2019: Central FPT & Commissioning requirements

4.2.5.2 Commissioning & 90.1 compliance verification	• 4.2.5.2.1 Cx Plan • 4.2.5.2.2 Cx Reporting • Any added Cx: 5.9.2 thru 10.9.2
4.2.5.1 Verification & Testing (FPT)	• 4.2.5.1.1 V&T providers • FPT provision in Const. Docs • 4.2.5.1.2 V&T Documentation
Verification & Functional Performance Testing Details	• Specific for each discipline/path • 5.9.1, 6.9.1, 7.9.1, 8.9.1, • 9.9.1, 10.9.1, 11.2(d), G1.21(c)

Referenced 9.9 testing and commissioning refers to 4.2.5

4.2.5 Verification, Testing, and Commissioning

4.2.5.1 Verification and Testing (V&T)

- V&T provider qualifications
- V&T requirements in construction documents
- Functional Performance Testing (FPT) & Verification Documentation

4.2.5.2 Commissioning (Cx) (unless Excepted)

- Cx provider qualifications
- Cx plan, design review, requirements in construction documents
- Preliminary and Final Cx report includes FPT & verification

Where to FPT & Cx requirements apply

	Simple buildings (<10k conditioned ft², warehouse, or Simple HVAC path < 25k ft²)	Complex Buildings < 25,000 ft²	All Buildings ≥ 50,000 ft² Except Warehouse
Verification, FPT	Required	Required	Required
Pre- & Design phase Cx	NR	Required	Required
Construction Phase Cx	NR	Required	Required

- 80% of US buildings are exempt from commissioning requirements
- Verification and functional performance testing (FPT) required throughout
- Pre- & design-phase Cx saves energy and cost by catching issues early
- 90.1 Cx requirements only apply to 90.1 standard requirements
- Verification that the design substantially meets 90.1 included