



**METROPOLITAN**  
Community College

# Commercial Energy Code – IECC Session

*Lighting Systems and Controls*

Instructors: Matt Belcher and Thomas Yarbrough  
Tuesday, February 14, 6:00pm -8:00pm

# Housekeeping

- ▶ Attendees are muted upon entry
- ▶ Questions? Enter them in the chat box
- ▶ Webinar is being recorded – slides and recording will be sent to attendees
- ▶ CEUs from ICC and AIA are available
- ▶ Email [canderson@mwalliance.org](mailto:canderson@mwalliance.org) with questions

# Today's Agenda

- ▶ 2018 IECC Compliance and Applicability
- ▶ System Terminology
- ▶ Lighting Systems Overview
- ▶ Selected Mandatory Requirements
- ▶ Selected Prescriptive Requirements
- ▶ Commercial Example (Building Area)
- ▶ Commercial Example (Space-by-Space)
- ▶ Photometrics and Luminaire info



# The Instructors



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# The Instructors



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MISSOURI  
S&T



# **2018 IECC COMPLIANCE AND APPLICABILITY**



# Commercial Compliance Options

## 2018 IECC - Prescriptive

1

● ASHRAE  
90.1-2016

OR

2

- C402 - Envelope
- C403 - Mechanical
- C404 - SWH
- C405 - Lighting
- **C406** - Pick At Least One C406:

C406.2 – Eff. HVAC Performance

C406.3 – Reduced Lighting Power

C406.4 – Enhanced Lighting Controls

C406.5 – On-site Supply of Renewable energy

C406.6 – Dedicated Outdoor Air System

C406.7 – High Eff. Service Water Heating

C406.8 – Enhanced Envelope Performance

C406.9 – Reduced Air Infiltration

*Choose one path  
and stick to it – **no**  
mixing and  
matching!*

OR

3

## 2018 IECC - Performance

- C407 – Total Building Performance
- C402.5 – Air Leakage
- C403.2 – Provisions applicable to all mechanical systems
- C404 - SWH
- **C405** - Lighting Mandatory Sections
  - C405.2
  - C405.3
  - C405.4
  - C405.6
- Building energy cost to be  $\leq 85\%$  of standard reference design building

# Additional Efficiency Package Options

## Section C406

One or more additional efficiency features must be selected to comply with the IECC

- More efficient HVAC performance
- **Reduced lighting power system**
- **Enhanced lighting controls**
- On-site supply of renewable energy
- Dedicated outdoor air system
- More efficient SWH
- Enhanced envelope performance
- Reduced air infiltration



More Efficient Lighting System



Enhanced Lighting Controls



# When do the Lighting and Power Requirements Apply?

- ✓ Original Installed Lighting System in a New Building, Addition, or Tenant Build-out
- ✓ Existing Lighting System that is Altered
- ✓ Change in Occupancy that Increases Energy
- ✓ Change in Occupancy that requires less LPD as shown in the LPD tables



Image: saveelectronics.com

# When do the Lighting and Power Requirements Apply?

## Exceptions:

- Historic buildings
  - State or National listing
  - Eligible to be listed
- Alterations where less than 10% of the luminaires in a space are replaced and installed interior power lighting is not increased
- Lighting within dwelling units
  - Where  $\geq 75\%$  of permanently installed fixtures (except low-voltage) are fitted for and include high-efficacy lamps
- Walk-in coolers, walk-in freezers, refrigerated warehouse coolers, and refrigerated warehouse freezers comply with C403.2.15 or C403.2.16

# Lighting and Power Terminology

- LED – Light Emitting Diode
- LPD – Lighting Power Density ( $\text{W}/\text{ft}^2$ )
- LPA – Lighting Power Allowance
- Lumen – Unit of illumination
- Luminaire – Lighting Assembly
- Efficacy – Efficiency of lighting source ( $\text{Lumen}/\text{W}$ )
- CRI – Color Rendering Index
- CCT – Correlated Color Temperature



# What's Covered Under Electrical Power and Lighting Systems Requirements?

- Mandatory Interior Lighting requirements
  - Required Controls
  - Wattage/Efficiency Limits
- Interior Lighting Power Allowances (watts/ft<sup>2</sup>)
- Exterior Lighting Controls
  - Required Controls
  - Lamp Efficiency
- Exterior Lighting Power Allowances (watts/ft<sup>2</sup>)
- Dwelling Electric Meters
- Electrical Transformers and Motors
- Vertical and Horizontal Transportation Systems and Equipment





# **MANDATORY INTERIOR LIGHTING REQUIREMENTS**



# Very Brief History of Indoor Lighting



Wicked Candle  
3,000 BCE  
? lumens/watt



Gas Lamp  
1820  
1.5 lumens/watt

Images: [pinterest.com](#); [wikipedia.com](#);  
[scarce.com](#); [earth911.com](#)



Incandescent Bulb  
1880  
14 lumens/watt



Fluorescent Bulb  
1940  
65 lumens/watt



Light Emitting Diode (LED)  
2010  
100+ lumens/watt

# Lighting Controls

## *Section C405.2 - Mandatory*

Lighting systems have requirements for:

- ▶ Occupant sensor controls
- ▶ Time-switch controls
- ▶ Daylight-responsive controls
- ▶ Specific application controls
- ▶ Manual controls
- ▶ Exterior lighting controls

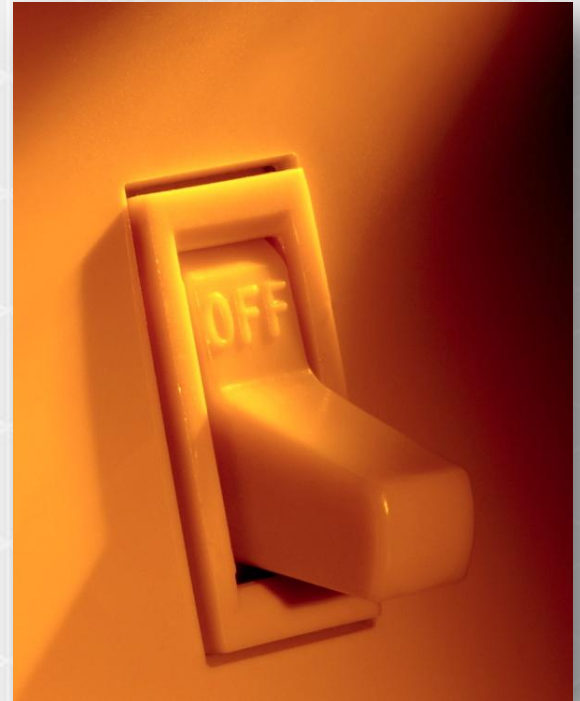


Image: DOE

# Light-reduction Controls

## Section C405.2.2.2



Image: modernplace

Light Reduction Controls must allow the occupant to reduce connected lighting load

- ✓ By at least 50%
- ✓ In a reasonably uniform illumination pattern



# Occupant Sensor Controls

## Sections C405.2.1, C405.2.1.1

Occupancy sensors are ***required*** in:

- ✓ Classrooms/lecture/training rooms
- ✓ Conference/meeting/multipurpose rooms
- ✓ Copy/print rooms
- ✓ Lounges/breakrooms
- ✓ Enclosed offices
- ✓ Open plan office areas
- ✓ Restrooms
- ✓ Storage rooms
- ✓ Locker rooms
- ✓ Other spaces < 300 ft<sup>2</sup> enclosed by floor-to-ceiling height partitions
- ✓ Warehouse storage areas




# Mandatory Interior Lighting Requirements

- Section C405.1 – C405.2.6.4
  - Required Controls
    - Occupancy
    - Daylight Response
    - Zoned Strategies and Specific Applications

## C405.2 Lighting controls (Mandatory).

Lighting systems shall be provided with controls that comply with one of the following.

- 
1. Lighting controls as specified in Sections C405.2.1 through C405.2.6.
  2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.4 and C405.2.5. The LLLC luminaire shall be independently capable of:
    - 2.1. Monitoring occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
    - 2.2. Monitoring ambient light, both electric light and daylight, and brighten or dim artificial light to maintain desired light level.
    - 2.3. For each control strategy, configuration and reconfiguration of performance parameters including; bright and dim setpoints, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configurations.

# Occupant Sensor Controls

## Sections C405.2.1, C405.2.1.1

Occupancy sensor function (other than open office/ warehouses):

- ✓ **Automatically turn lights off** within 20 minutes after occupants have left space
- ✓ Either manual-on or controlled to automatically turn on lighting to not more than 50% power
- ✓ Incorporate a manual control to allow occupants to turn off lights

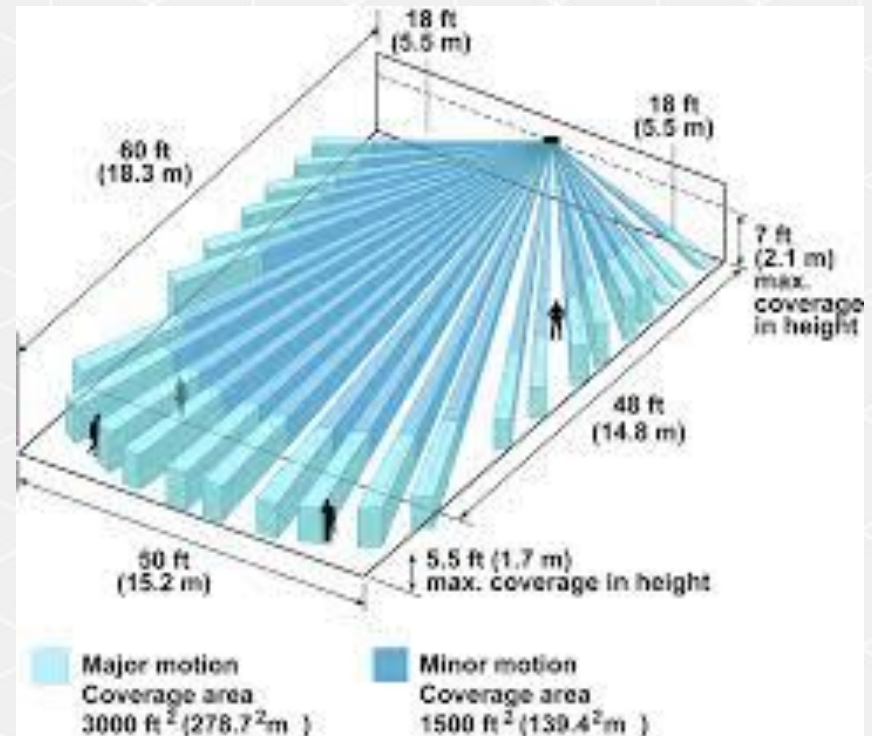


Image: energy.gov



# Occupancy Sensors (Open Office Areas)

- Applicable to areas over 300 sq ft
- Controlled zones shall not exceed 600 sq ft
- 20 minutes after last occupancy
- Lighting reduced by “not less than 80%”

## **C405.2.1.3 Occupant sensor control function in open plan office areas.**

Occupant sensor controls in open plan office spaces less than 300 square feet (28 m<sup>2</sup>) in area shall comply with Section C405.2.1.1. Occupant sensor controls in all other open plan office spaces shall comply with all of the following:

1. The controls shall be configured so that general lighting can be controlled separately in control zones with floor areas not greater than 600 square feet (55 m<sup>2</sup>) within the open plan office space.
2. The controls shall automatically turn off general lighting in all control zones within 20 minutes after all occupants have left the open plan office space.
3. The controls shall be configured so that general lighting power in each control zone is reduced by not less than 80 percent of the full zone general lighting power in a reasonably uniform illumination pattern within 20 minutes of all occupants leaving that control zone. Control functions that switch control zone lights completely off when the zone is vacant meet this requirement.
4. The controls shall be configured such that any daylight responsive control will activate open plan office space general lighting or control zone general lighting only when occupancy for the same area is detected.



# Occupancy Sensors (Warehouse)

- Occupancy sensor in open areas
- Reduce lighting by “not less than 50%”
- Aisles separate controls

## **C405.2.1.2 Occupant sensor control function in warehouses. P**

In warehouses, the lighting in aisleways and open areas shall be controlled with occupant sensors that automatically reduce lighting power by not less than 50 percent when the areas are unoccupied. The occupant sensors shall control lighting in each aisleway independently and shall not control lighting beyond the aisleway being controlled by the sensor.

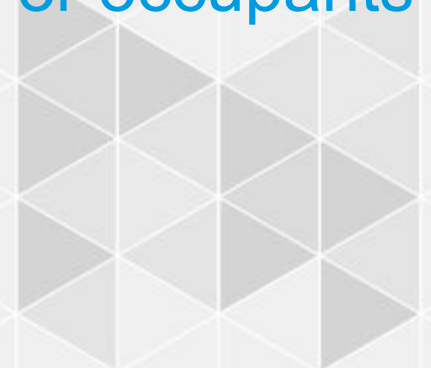
# Occupant Sensor Controls

## *C405.2.1.1 Exemptions*

### Exemptions:

Full auto-on controls allowed in

- ✓ Public corridors
- ✓ Stairways
- ✓ Restrooms
- ✓ Primary building entrance areas and lobbies
- ✓ Areas where manual-on operation would endanger safety / security of room or occupants



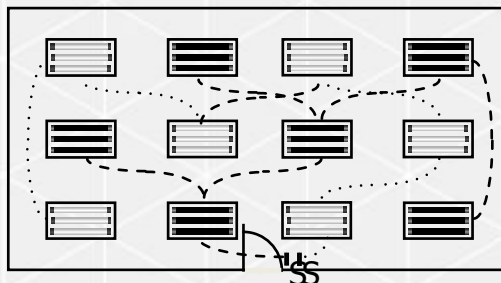
# Light-reduction Control Options

Light Reduction Controls must allow the occupant to reduce connected lighting load

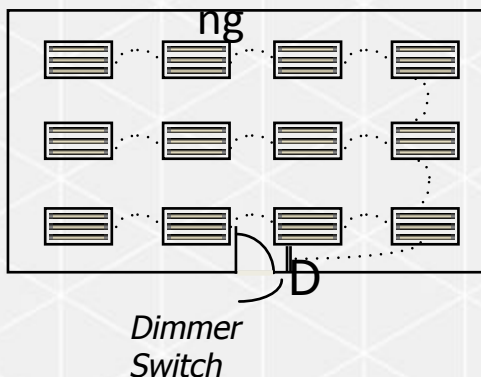
- ✓ By not less than 50%
- ✓ In a reasonably uniform illumination pattern
- ✓ Not required in daylight responsive control zones

- ✓ Controlling / dimming all lamps or luminaires
- ✓ Dual switching of alternate rows of luminaires, alternate luminaires or lamps
- ✓ Switching middle lamp luminaires independently from the outer lamps

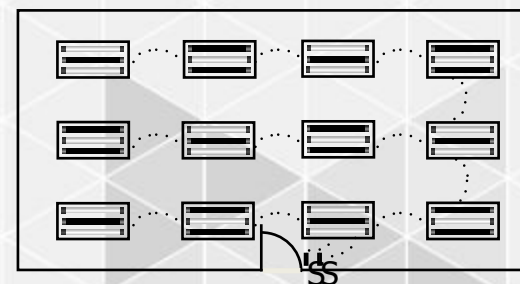
Alternating Luminaires



Dimming



Alternating Lamps



# Daylight-responsive Controls

## Section C405.2.3

- ▶ Definition: A device or system that provides automatic control of electric light levels based on the amount of daylight in a space
- ▶ Required to control lighting in spaces with  $\leq 150$  watts of general lighting:
  - Sidelit zones
  - Toplit zones
- ▶ Exceptions:
  - Health care facilities where patient care is directly provided
  - Lighting required for specific application control per C405.2.4
  - Sidelight daylight zones on 1<sup>st</sup> floor above grade in Group A-2 and Group M occupancies



# Daylight-responsive Control Functions

## *Section C405.2.3.1*

- ▶ Toplit zones shall be controlled independently of lights in sidelit zones
- ▶ Controls shall be configured so that they can be calibrated from within the space by authorized personnel
- ▶ Calibration mechanisms shall be in a location with ready access
- ▶ In offices, classrooms, laboratories, and library reading rooms, controls shall dim lights continuously from full light output to  $\leq 15\%$

# Toplit Daylight Zone

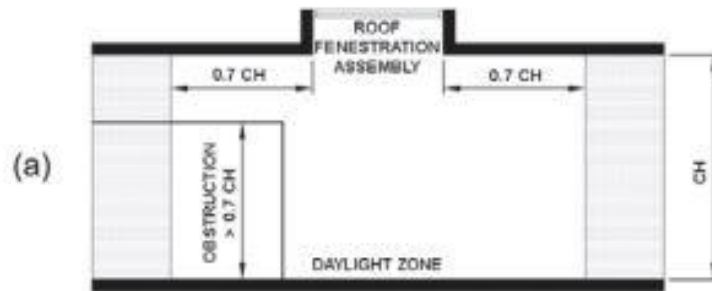
## Section C405.2.3.3

Definition: the floor area underneath a roof fenestration assembly that complies with all of the following:

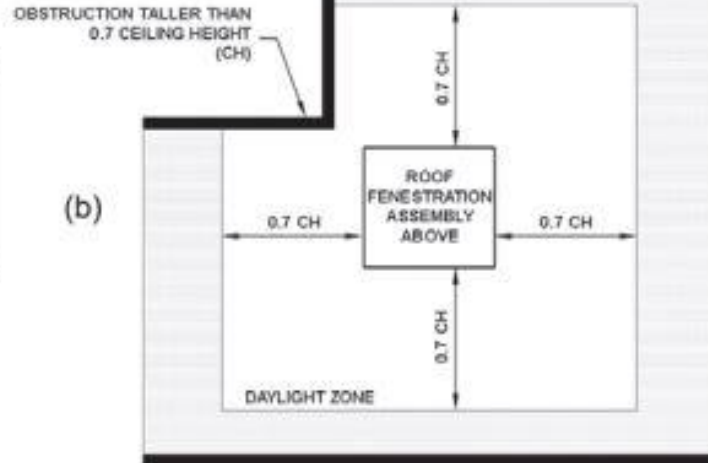
- ▶ Zone shall extend laterally and longitudinally beyond the edge of the roof fenestration assembly to the nearest obstruction that is (taller)  $> 0.7 \times$  the ceiling height,  $> 0.7 \times$  the ceiling height, whichever is less
- ▶ Where located in rooftop monitor, toplit zone to extend laterally to nearest obstruction taller than  $0.7 \times$  the ceiling height, or up to 1.0 times the height from floor to bottom of fenestration, whichever is less, and longitudinally from the edge of the fenestration to the nearest obstruction taller than  $0.7 \times$  ceiling height, or up to 0.25 times the height from the floor to bottom of fenestration, whichever is less
- ▶ No building or geological formation blocks direct sunlight from hitting the roof fenestration assembly at the peak solar angle on the summer solstice
- ▶ Where located in existing buildings, visible transmittance of the roof fenestration assembly times the area of the rough opening of the roof fenestration assembly divided by area of daylight zone  $\geq 0.008$

# Toplit Daylight Zone

## Section C405.2.3.3

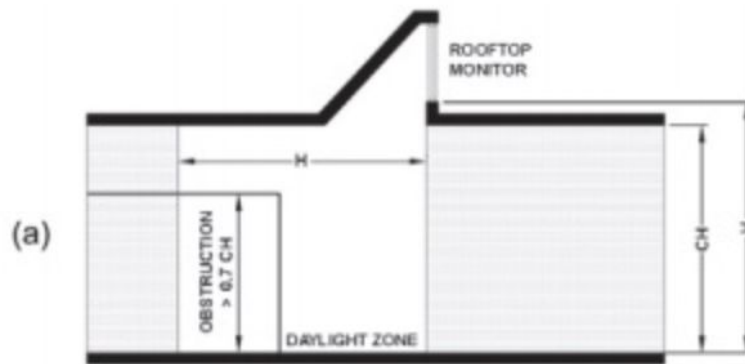


(a) Section view  
(b) Plan view of daylight zone under a roof fenestration assembly



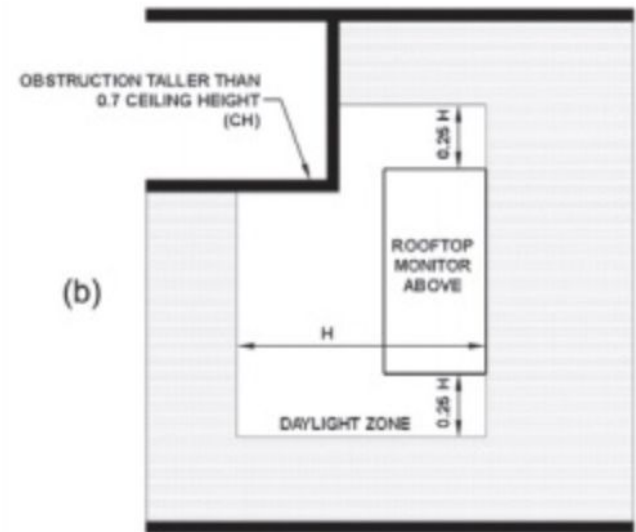
# Toplit Daylight Zone

## Section C405.2.3.3



(a) Section view

(b) Plan view of daylight zone under a rooftop monitor



**FIGURE C405.2.3.3(3) DAYLIGHT ZONE UNDER A SLOPED ROOFTOP MONITOR**



# Daylight-responsive Controls

## *Section C405.2.3 – Cont'd.*

- ▶ Configured to completely shut off all controlled lights
- ▶ Sidelit zones facing different cardinal orientations (within 45 degrees of due north, east, south, west) controlled independently of each other

### Exception:

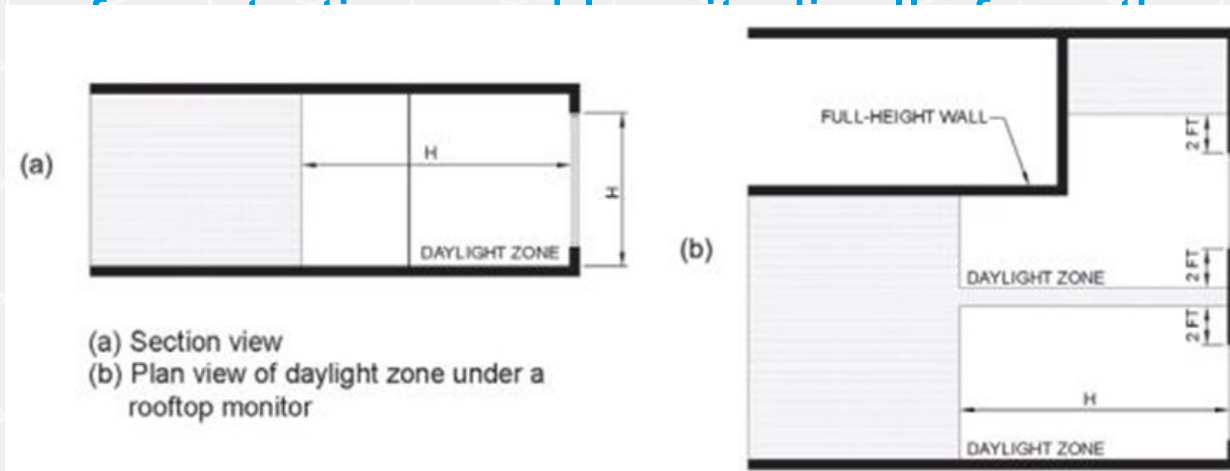
- ▶ < 150 watts in each space is permitted to be controlled together with lighting in a daylight zone facing a different cardinal orientation

# Sidelit Zone

## Section C405.2.3.2

Definition: floor area adjacent to vertical fenestration that complies with the following:

- Fenestration located in a wall:
  - Sidelit zone shall extend laterally to the nearest full-height wall OR
  - $< 1.0 \times$  height from the floor to the top of the fenestration, or up to 2



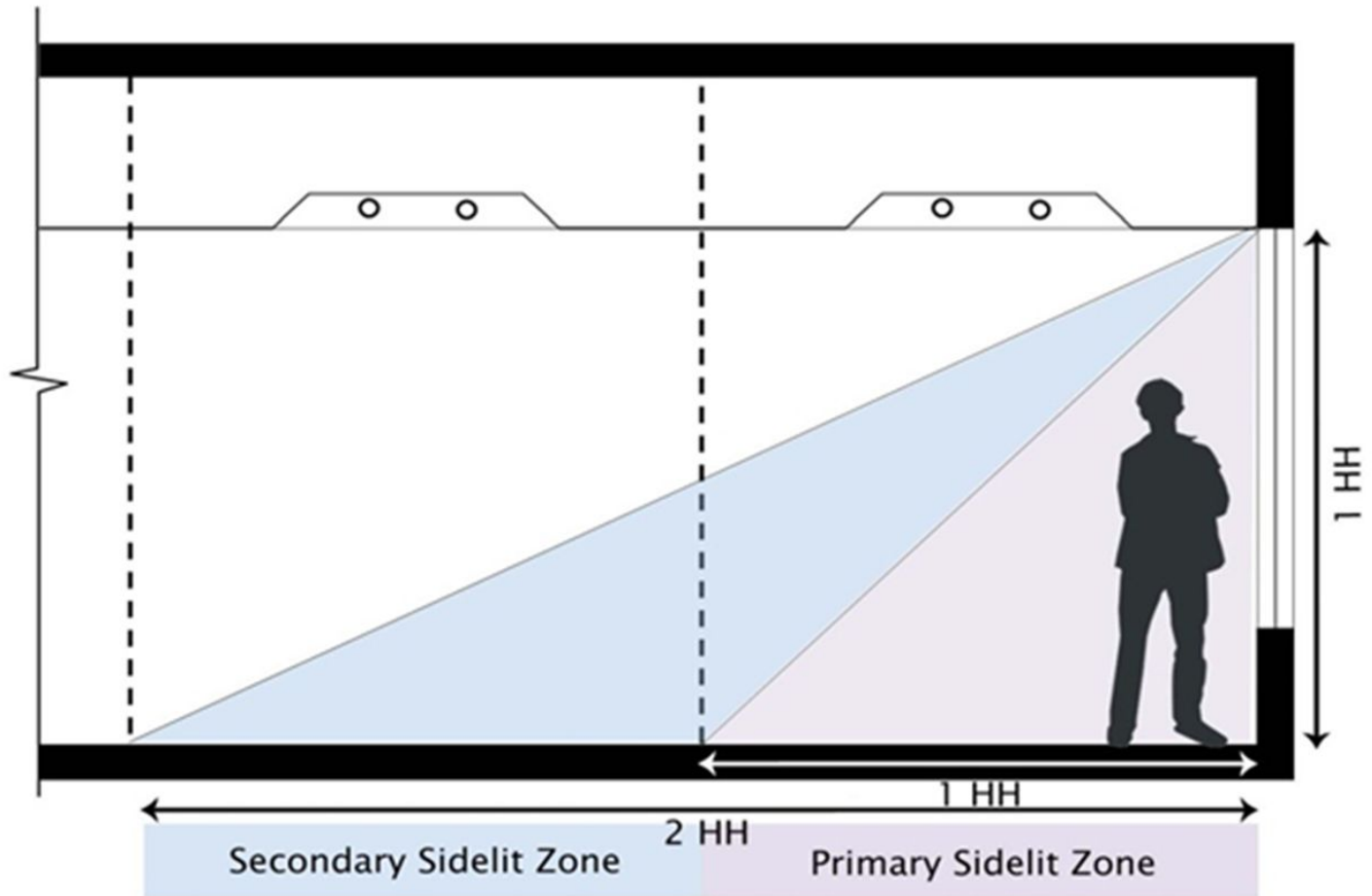
# Sidelit Daylight Zone

## *Section C405.2.3.2 – Cont'd.*

- ▶ Area of fenestration  $\geq 24 \text{ ft}^2$
- ▶ Distance from fenestration to any building or geological information that would block access to daylight is  $>$  than the height from bottom of fenestration to top of building or geologic information
- ▶ The visible transmittance of fenestration  $\geq 0.20$

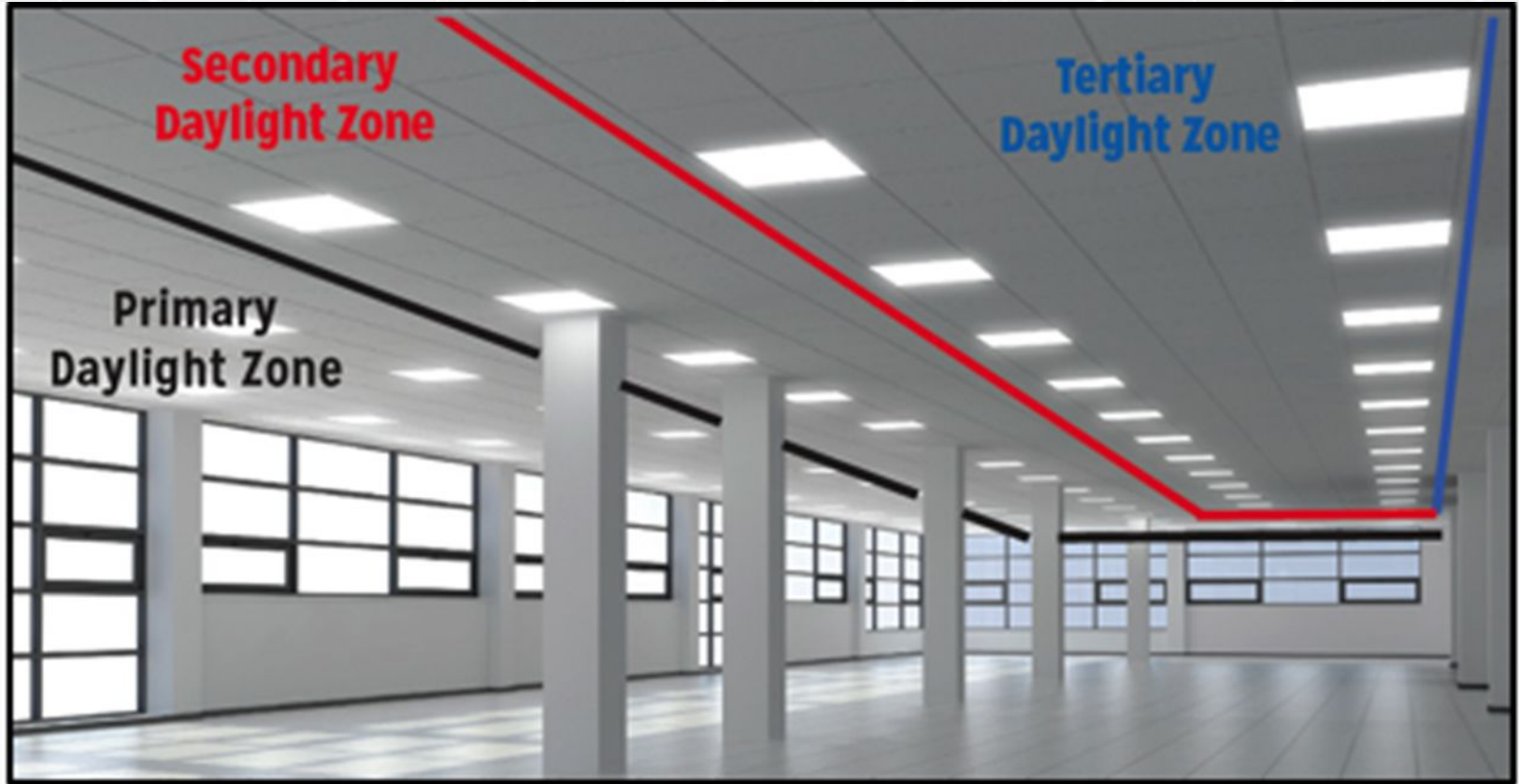


# Daylighting Zones

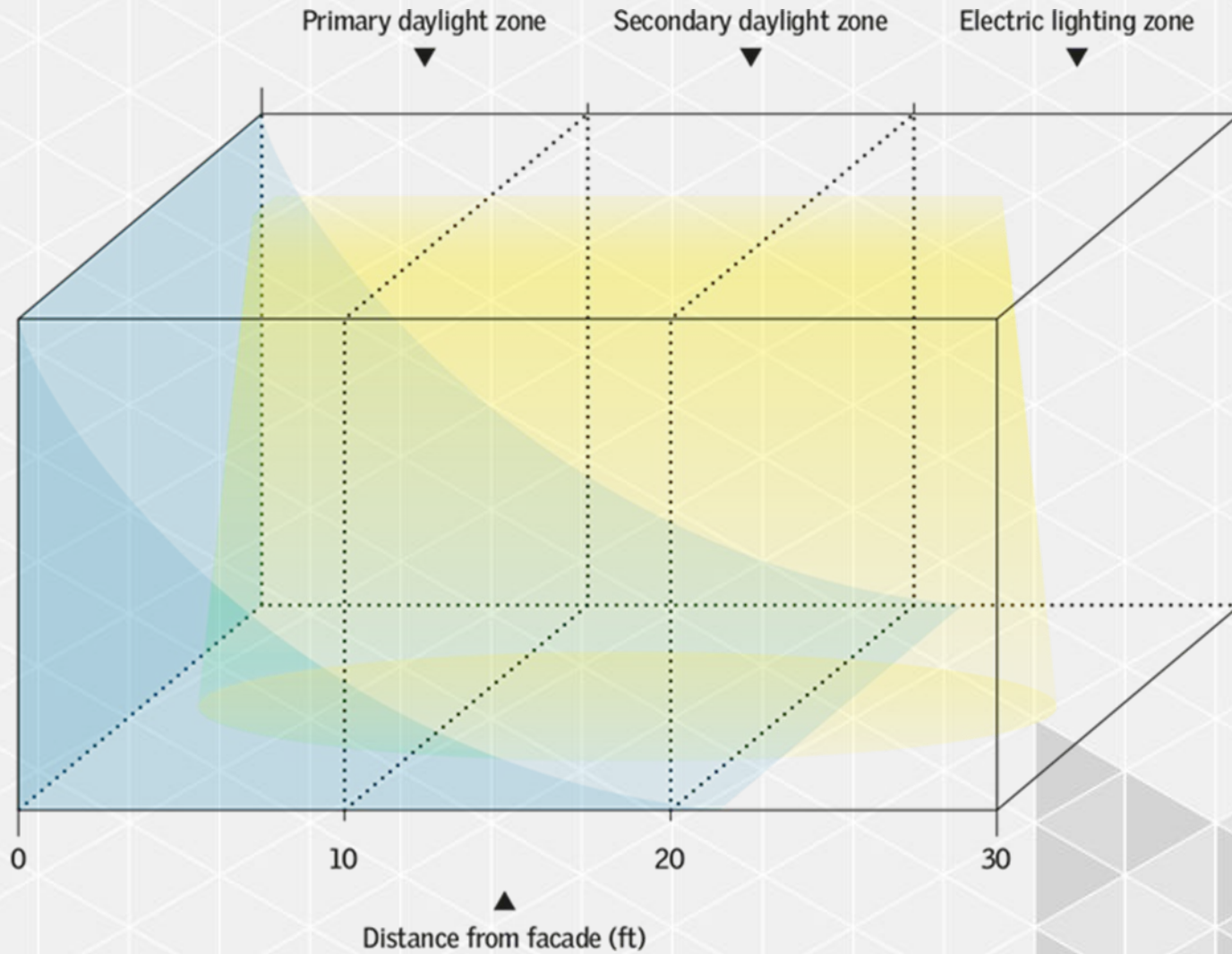




# Daylighting Zones



# Daylighting Zones



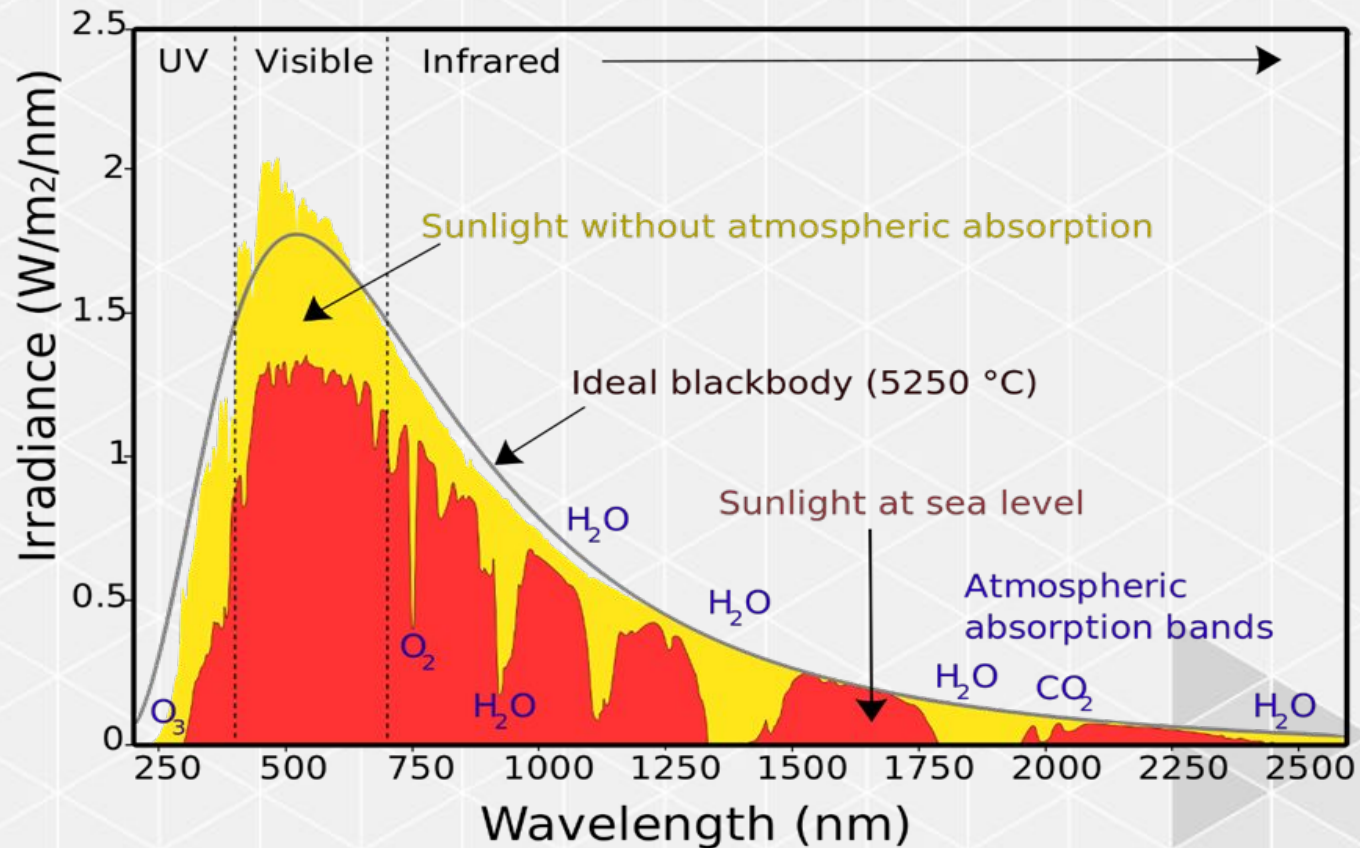
# Daylighting Zones

- ▶ Illumination levels need to be consistent
- ▶ Multi-zone controls based on distance from fenestration
- ▶ Distance can be based on head height
- ▶ CCT should try to be relative
- ▶ Occupant based controls for glare reduction
- ▶ Orient workspaces to avoid veiling glare



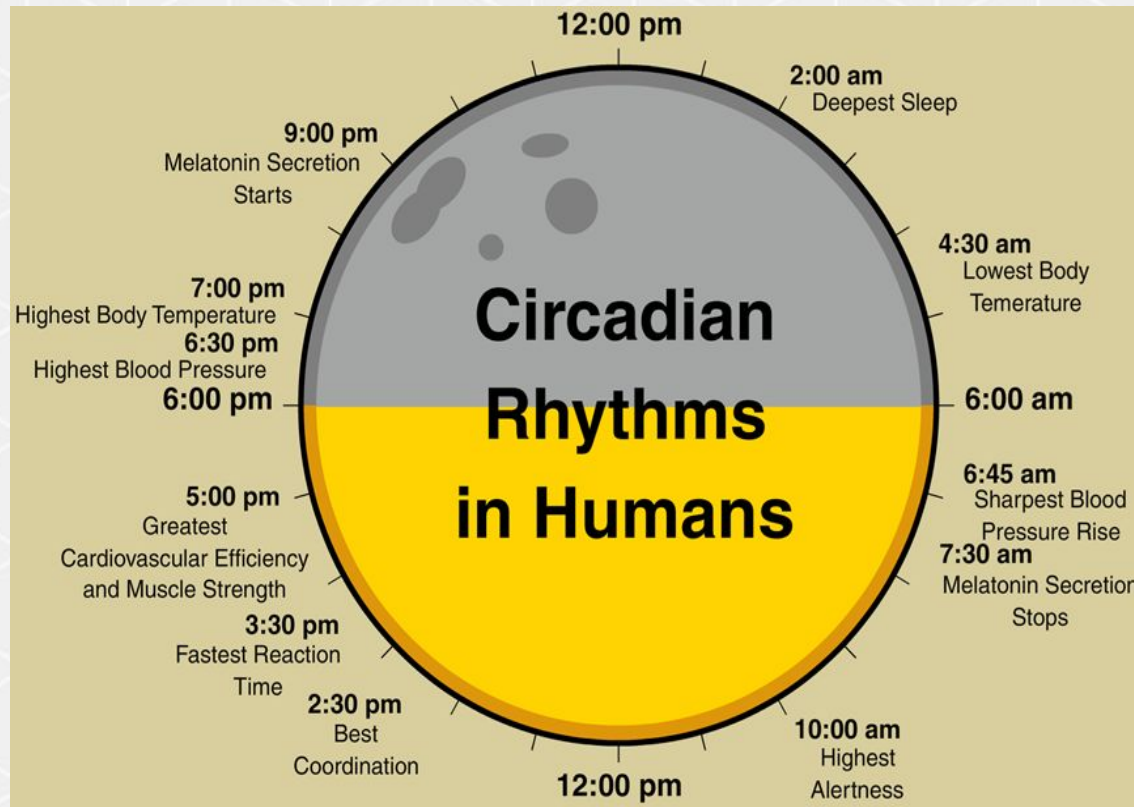
# Daylighting Benefits

## Spectrum of Solar Radiation (Earth)



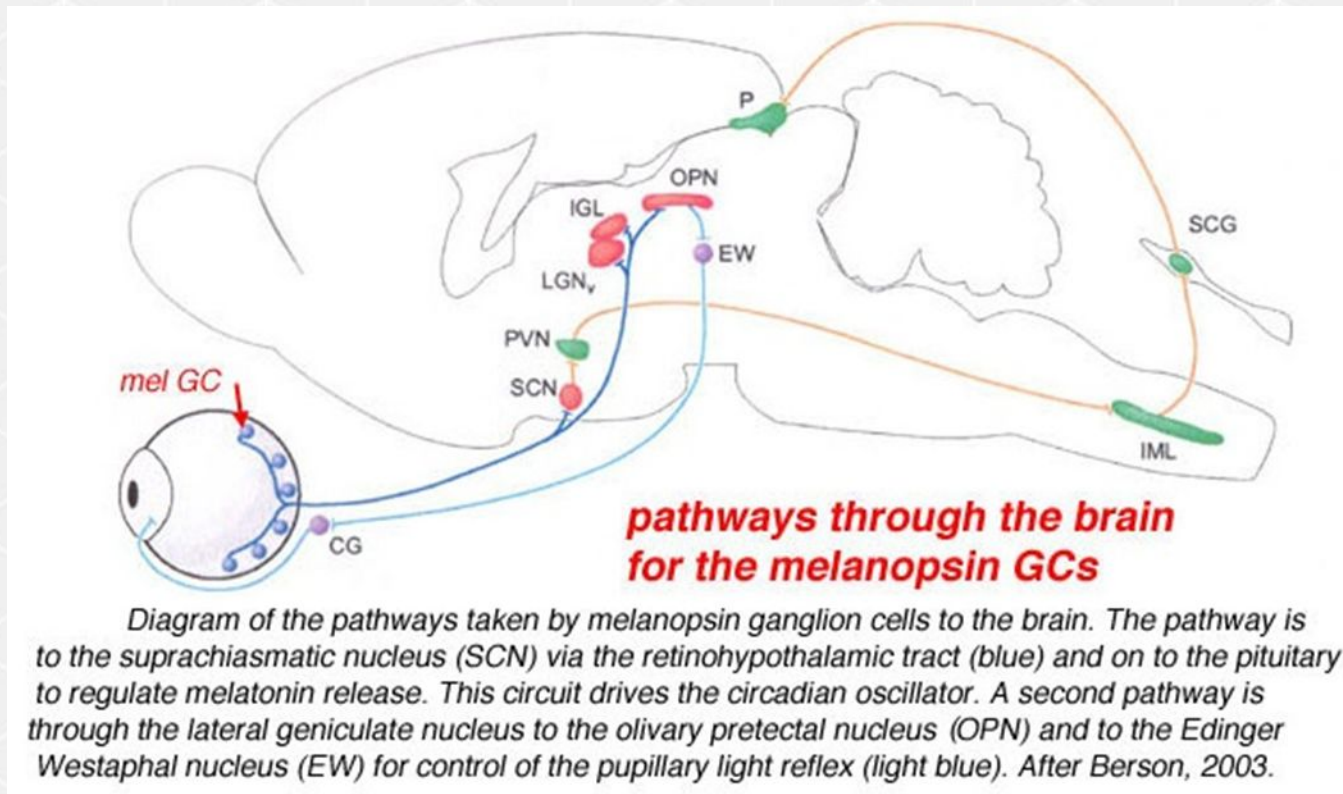


# Daylighting Benefits



- Our internal clock
- Suprachiasmatic Nucleus
- Behavioral and Psychological Effects

# Supra...chi...a...thingy



**Very Important for chemical production**



# Seasonal Effect Disorder (SAD)



# Seasonal Effect Disorder (SAD)

- **In 2007, the World Health Organization declared that “shift work that involves circadian disruption is probably carcinogenic to humans”.**
- **Design goals for housing, offices, and schools are to create lighting conditions that synchronize**





# Seasonal Effect Disorder (SAD)



# Daylighting Zones Skylights



- Creates diffuse lighting conditions
- Reduces glare conditions
- With correct coatings, can greatly reduce solar heating loads
- Larger cavity infiltration



# Daylighting Zones Skylights



# Daylighting Zones Skylights



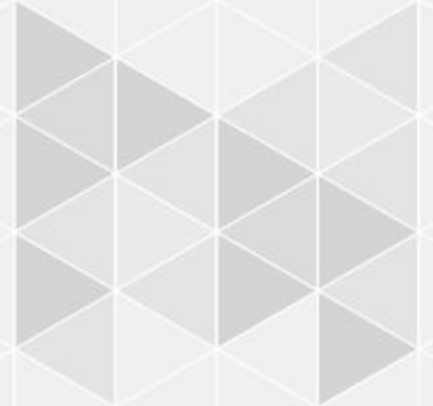


# Daylighting Zones Skylights



## Daylighting Zones Skylights

They are all fake!!



# Specific Application Controls

## Section C405.2.4

- ✓ These types to be controlled by occupant sensor or time-switch control, and a manual control provided to control separately from general lighting
  - Display and accent lighting
  - Display case lighting
  - Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting
  - Equipment for sale or educational demonstrations
- ✓ Hotel and motel sleeping units
  - Master control device capable of automatically switching off all installed luminaires and switched receptacles within 20 minutes of occupants leaving the room
  - Exceptions: lighting and switch receptacles controlled by captive key systems and spaces where patient care is provided
- ✓ Permanently installed luminaires within dwelling units to have controls complying with C405.2.1.1 or C405.2.2.2
- ✓ Nonvisual applications, plant growth and food warming shall be controlled via time-switch control



# Time-switch Controls

## Section C405.2.2

Each area of the building that is ***not*** provided with occupant sensor control must have a time-switch control to turn lights off automatically.

### Exceptions:

- Spaces where patient care is directly provided
- Spaces where an automatic shutoff would endanger occupant safety or security
- Lighting intended for continuous operation
- Shop and laboratory classrooms



# Time-switch Controls

## Section C408.3.1.2

- 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  $\leq 2$  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
- Additional testing as specified by the *registered design professional*

**DO WE NEED A BREAK?**



# **COMMERCIAL LIGHTING SYSTEMS POWER ALLOWANCE**



## High-Efficacy Lamps - Definition

- ✓ Compact fluorescent lamps, LED lamps, T8 or smaller diameter linear fluorescent lamps, or other lamps with an efficacy based on lamp wattage

Lamp Wattage	Minimum Efficacy
> 40 watts	60 lumens/watt
15-40 watts	50 lumens/watt
< 15 watts	40 lumens/watt



# Existing Buildings

## Section C502.2.6 *Lighting Power and Systems*

New lighting systems installed as part of an addition to comply with C405

- ▶ Total interior lighting power to comply either as
  - Stand alone addition OR
  - Addition + existing building as a single building
- ▶ Total exterior lighting power to comply either as:
  - Stand alone addition
  - Addition + existing building as a single building
- ▶ Repairs are exempt where
  - Only the bulb / ballast are replaced within the existing luminaires
  - Do not increase the installed interior lighting power



# Interior Lighting Power Allowance

## Section C405.3.2

Two methods to determine allowance:

### ✓ Building Area Method

- Floor area for each building area type x value for the area
- “area” defined as all contiguous spaces that accommodate or are associated with a single building area type as per the table
- When used for an entire building, each building area type to be treated as a separate area

### ✓ Space-by-Space Method

- Floor area of each space x value for the area
- Then sum the allowances for all the spaces
- Tradeoffs among spaces are allowed

# Building Area Method

## Table C405.3.2(1)

Building Area Type	LPD (w/ft <sup>2</sup> )
Automotive facility	0.71
Convention center	0.76
Courthouse	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
Fire station	0.53
Retail	1.06

(partial table)

BUILDING AREA TYPE	LPD (w/ft <sup>2</sup> )	LPD (w/ft <sup>2</sup> )
Automotive facility	0.71	0.75
Convention center	0.76	0.64
Courthouse	0.90	0.79
Dining: bar lounge/leisure	0.90	0.80
Dining: cafeteria/fast food	0.79	0.76
Dining: family	0.78	0.71
Dormitory <sup>a, b</sup>	0.61	0.53
Exercise center	0.65	0.72
Fire station <sup>a</sup>	0.53	0.56
Gymnasium	0.68	0.76
Health care clinic	0.82	0.81
Hospital <sup>a</sup>	1.05	0.96
Hotel/Motel <sup>a, b</sup>	0.75	0.56
Library	0.78	0.83
Manufacturing facility	0.90	0.82
Motion picture theater	0.83	0.44
Multifamily <sup>c</sup>	0.68	0.45
Museum	1.06	0.55
Office	0.79	0.64
Parking garage	0.15	0.18
Penitentiary	0.75	0.69
Performing arts theater	1.18	0.84
Police station	0.80	0.66
Post office	0.67	0.65
Religious building	0.94	0.67
Retail	1.06	0.84
School/university	0.81	0.72
Sports arena	0.87	0.76
Town hall	0.80	0.69
Transportation	0.61	0.50
Warehouse	0.48	0.45
Workshop	0.90	0.91



# Space-By-Space Method

## Table C405.3.2(2)

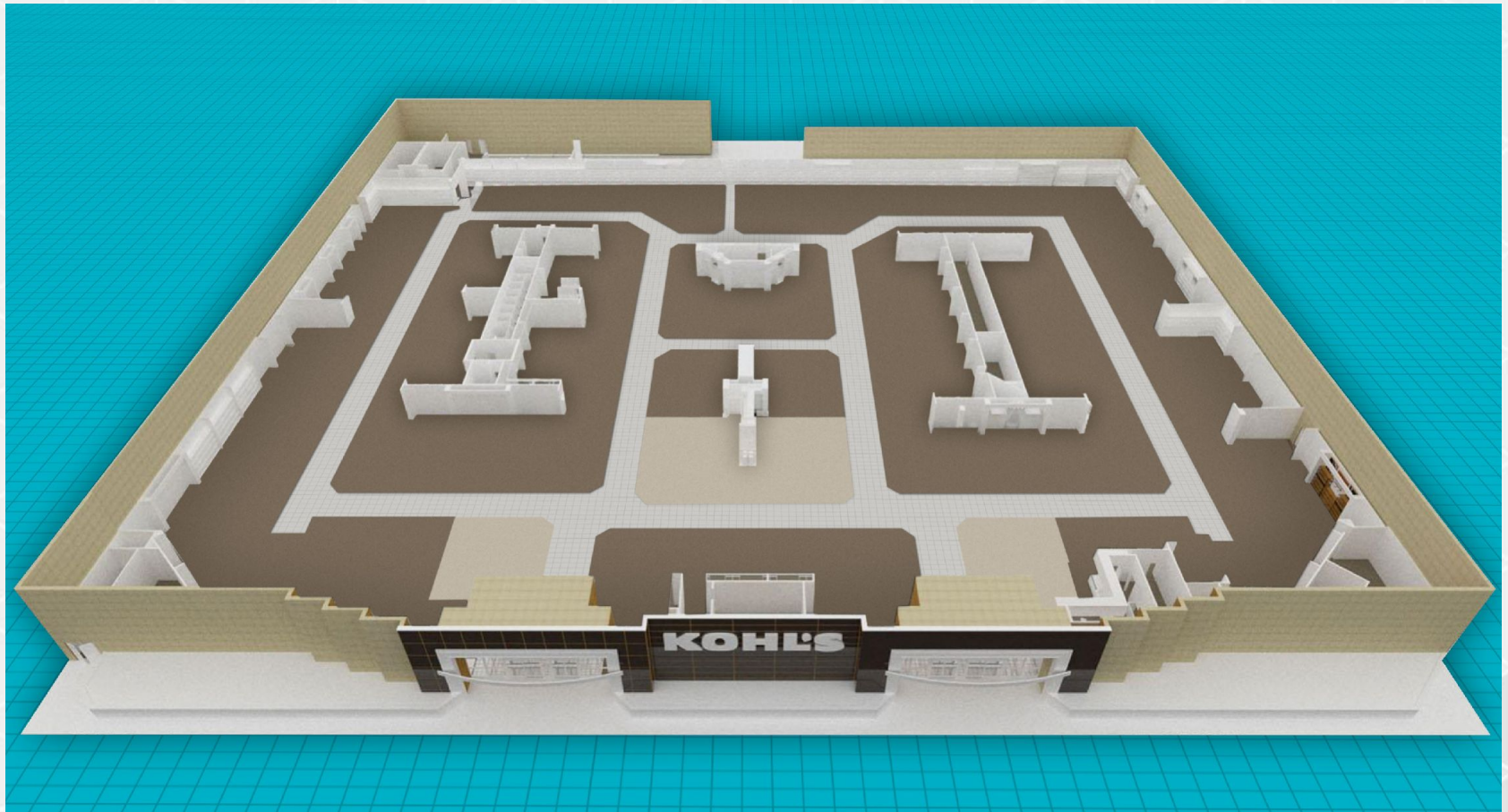
Common Space Types	LPD (w/ft <sup>2</sup> )
Locker room	0.48
Lounge/breakroom	
In a healthcare facility	0.78
Otherwise	0.62
Office	
Enclosed	0.93
Open plan	0.81
Parking area, interior	0.14
Pharmacy area	1.34

(partial table)

# Building Lighting Allowance



# Building Lighting Allowance



# Building Lighting Allowance

Kohl's Store Space Types	Usage Area (ft <sup>2</sup> )
Lobby/ Foyer	420
Lounge/breakroom	180
Sales Area	18,600 (Total)
Retail Area 3	15,200
Retail Area 4	3,400
Office (Enclosed)	200
Storage Room	4,800
Dressing Rooms	800
<b>Total Area</b>	<b>25,000</b>



# Building Lighting Allowance (Building Area)

*Building Area Type*  $\times$  *Lighting Power Density (LPD)*

**Units:**  $(ft^2) \times (W/ft^2) = W$

**Building Area Method**

$$(25,000 ft^2) \times (1.06/ft^2) = 26,500W$$

# Additional Interior Lighting Power

## Section C405.3.2.2.1



Image: DOE

**Additional Interior Lighting Power Allowance =**  
**1000 watts +**

**(Retail Area 1 x 0.45 W/ft<sup>2</sup>) +**  
**(Retail Area 2 x 0.45 W/ft<sup>2</sup>) +**  
**(Retail Area 3 x 1.05 W/ft<sup>2</sup>) +**  
**(Retail Area 4 x 1.87 W/ft<sup>2</sup>),**

**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.**

# Building Lighting Allowance

Kohl's Store Space Types	Usage Area (ft <sup>2</sup> )	Space Allowance (W/ft <sup>2</sup> )
Lobby/ Foyer	420	0.43
Lounge/breakroom	180	0.62
Sales Area	18,600 (Total)	
Retail Area 3	15,200	1.05
Retail Area 4	3,400	1.87
Office (Enclosed)	200	0.93
Storage Room	4,800	0.46
Dressing Rooms	800	0.50
<b>Total Area</b>	<b>25,000</b>	

# Building Lighting Allowance (Space by Space)

*Building Area Type*  $\times$  *Lighting Power Density (LPD)*

**Sum the Areas:  $\Sigma (ft^2) \times (W/ft^2) = W$**

**Space-by-Space Method**

***(Use Areas  $ft^2$ )  $\times$  ( $W/ft^2$ ) = 26,404W***



# Lighting Power Compliance Calculation

- Sum the wattage of all proposed connected lighting power
- This must include all lighting that is part of the design for the space including:
  - ✓ Overhead lighting
  - ✓ Task lighting
  - ✓ Decorative lighting
- Compare values; proposed wattage must be less than or equal to allowed wattage



# Lighting Power Compliance

- C405.9

The total voltage drop across the combination of feeders and branch circuits shall not exceed 5 percent

- ▶ C406.3

The total connected interior lighting shall be less than 90% of the total lighting power allowance calculated in accordance with Section



# Building Lighting Illumination Level

## Illuminating Engineer's Society of North America (IESNA)

IESNA Lighting Design Guide

Interior-15

I. INTERIOR LOCATIONS AND TASKS		Very Important		Important		Somewhat important		Blank = Not important or not applicable																	
	Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformity)	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Specific visual tasks																									
Dining																				B					
Grooming																									
Makeup and shaving																				D		B			
Dressing evaluation (mirror)																				D		B			
Handcrafts and hobbies																									
Ordinary tasks (e.g., crafts)																				D		B			
Difficult tasks (e.g., sewing)																				E		C			
Critical tasks (e.g., workbench)																				F		D			
Easel hobbies																						D			
Ironing																				D					
Kitchen counter																									
Critical seeing (e.g., cutting)																				E		C			
General																				D		B			
Kitchen range																									
Difficult seeing (e.g., cooking)																				E		C			
Kitchen sink																									
Difficult seeing																				E		C			
Noncritical (clean up)																				D		B			
Laundry																				D		A			
Music study (piano, organ)																				D		B			
Reading																									
In a chair (casual)																				D		B			
In a chair (serious)																				E		C			
In bed (casual)																				D		B			

# Building Lighting Illumination Level

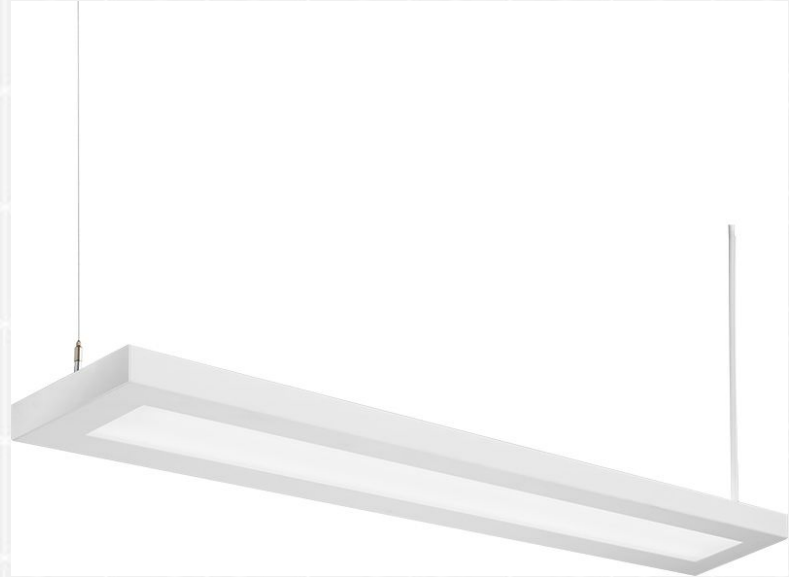
## Illuminating Engineer's Society of North America (IESNA)

Application and Task	Maintained Horizontal		Maintained Vertical		Comments
	Average (fc) <sup>1</sup>	Range (fc) <sup>2</sup>	Average (fc) <sup>1</sup>	Range (fc) <sup>2</sup>	
EXTERIOR					
Parking (Covered)	5	-	-	-	1 Min; 10:1 Max-Min Uniformity
Parking (Uncovered) Zone 3 (Urban)	1.5	0.75 - 3	0.8	0.4 - 1.6	
Parking (Uncovered) Zone 2 (Suburban)	1	0.5 - 2	0.6	0.3 - 1.2	
Gas Station Canopy	12.5	10 - 15	-	-	
Safety (Building Exterior)	1	0.5 - 2	-	-	For security issues, raise Avg to 3
INDUSTRIAL/MANUFACTURING					
Assembly & Inspection (Simple) Component Manufacture (Large Part)	30	15 - 60	30	15 - 60	
Component Manufacture (Med. Part)	50	25 - 100	50	25 - 100	
Assembly & Inspection (Difficult) Component Manufacture (Fine Part)	100	50 - 200	100	50 - 200	
Assembly & Inspection (Exacting)	300	150 – 600	-	-	
RETAIL					
Discount/Warehouse/Drug/ Convenience (Ambient)	50	25 - 100	20	10 - 40	
Discount/Warehouse/Drug/ Convenience (Perimeter)	-	-	50	25 - 100	
Department Store (Ambient)	40	20 - 80	15	7.5 - 30	
Department Store (Perimeter)	-	-	75	25 - 150	
Accent Lighting (Displays)	-	-	-	-	3-10 times more than ambient



# Luminaire Selection

## Lithonia Lighting Grad Linear



Images: [acuitybrands.com](https://www.acuitybrands.com)

# Luminaire Selection

## GRAD LINEAR I/D or Direct | Suspended

### ORDERING INFORMATION

Lead times will vary depending on options selected.  
Consult with your sales representative.

**Example:** GRD LLP 16FT MSL4 80CRI 30K ID1000LMF 80/20 MIN1 ZT 120 SCT F1/24A C110

Luminaire	Linear length plan	Total run length	Maximum section length	LED color rendering	LED color temperature	Indirect/direct LED output
GRD	LLP Linear longest possible LSL Linear same length	___FT Indicate luminaire row length in 4' increments. Ex: 12FT	MSL4 4' section(s) MSL8 8' section(s)	80CRI 80+ CRI	27K 2700K 30K 3000K 35K 3500K 40K 4000K 50K 5000K	ID800LMF 800 nominal lumens per foot ID1000LMF 1000 nominal lumens per foot ID1300LMF 1300 nominal lumens per foot ID1500LMF 1500 nominal lumens per foot

Indirect/direct intensity ratio	Minimum dimming level	Control input	Voltage	Wiring option	Emergency options <sup>8</sup>
80/20 Std. 80% up/ 20% down 20/80 20% up/ 80% down *Nominal Distribution. Refer to photometric tests for exact distribution	MIN1 Constant current, dimming to 1% MIN10 <sup>1</sup> Constant current, dimming to 10%	ZT 0-10V <sup>2</sup> NLIGHT nLight enabled <sup>3</sup> ECO Lutron Ecosystem Interface <sup>4</sup>	120 120V 277 277V	SCT Single circuit	(blank) None 1EC (1) Emergency circuit module 2EC (2) Emergency circuit modules ___EC ___ Emergency circuit modules ___E10WLCP ___10 Watt battery pack, constant power with self diagnostics. CEC Certified

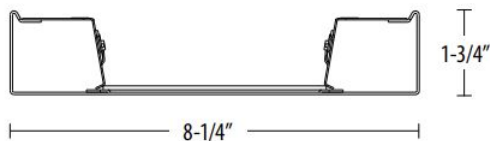
Mounting type <sup>9</sup> /	Overall suspension	Color	Fusing	Territory compliance	Cover
F1/ T-bar ceiling (universal mounting bracket)	12F 12" fixed 18F 18" fixed	72A 72" adjustable 96A 96" adjustable	C110 Painted aluminum (low gloss) GLR Fast blow	(blank) None CSA <sup>7</sup> Manufactured to Canadian standards	(blank) None DU Dust cover
F1A/ T-bar ceiling (UMB with integrated J-box)	24F 24" fixed 24A 24" adjustable	144A 144" adjustable 192A 192" adjustable	C210 White white (fine textured) C202 <sup>6</sup> Black (fine textured)		
F2/ Hard ceiling (horizontal J-box)	36A 36" adjustable 48A 48" adjustable	240A 240" adjustable	C099 <sup>13</sup> Custom color		

Canopy	Junction box	Slope	Primary Sensor <sup>5</sup>	Secondary Sensor <sup>5</sup>	Option
(blank) None MCS <sup>11</sup> Matching canopy at support for aesthetics MCSJ <sup>14</sup> Matching canopy for J-box mounting at non-power feed support locations BLK <sup>6</sup> Black cord, cord manager and canopy	(blank) None OJB <sup>11</sup> Offset J-box at feed	(blank) None SLP <sup>12</sup> Sloped ceiling	(blank) No factory-installed, integrated sensor PDT_ Dual technology occupancy sensor. PIR & microphonics sensor ADC_ Daylight Dimming Sensor APDT_ Dual technology occupancy sensor and daylight dimming sensor	(blank) No factory-installed, integrated sensor SPDT_ Dual technology occupancy sensor. PIR & microphonics sensor SADC_ Daylight Dimming Sensor SAPDT_ Dual technology occupancy sensor and daylight dimming sensor	IND <sup>10</sup> Individual luminaire (factory installed end caps and power cord; hanging hardware in box)

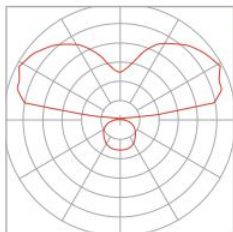
# Luminaire Selection

## DIMENSIONS

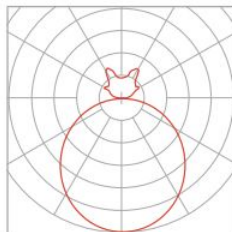
All dimensions are inches (centimeters) unless otherwise specified.



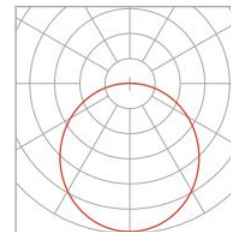
## PHOTOMETRICS



**ID800LMF 80/20 80CRI 35K**  
137 lm/W  
3401 delivered lumens per 4' section



**ID800LMF 20/80 80CRI 35K**  
105 lm/W  
2621 delivered lumens per 4' section



**ID800LMF 0/100 80CRI 35K**  
94 lm/W  
2335 delivered lumens per 4' section

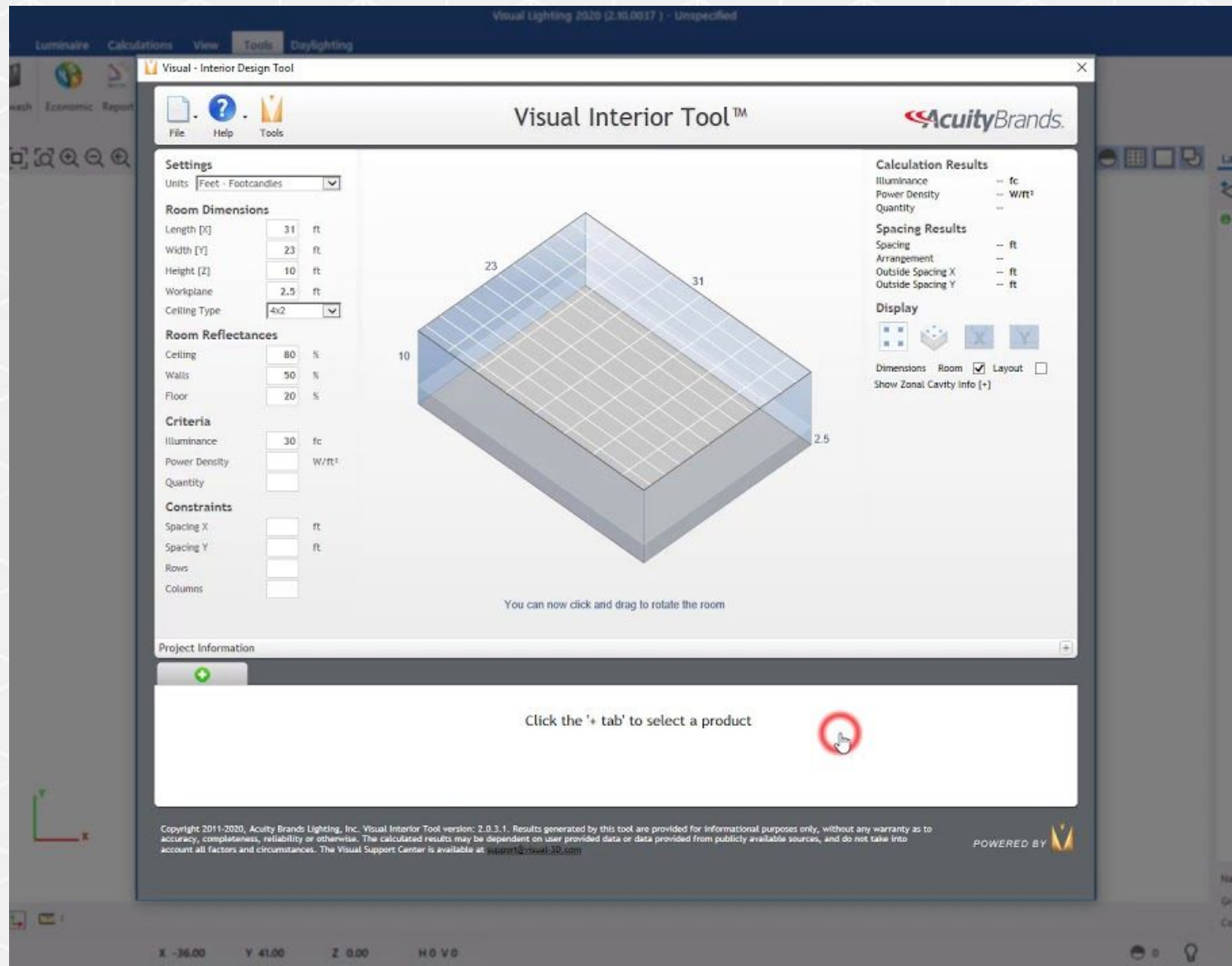
## Fixture Performance

	3000K				3500K				4000K			
	800LMF	1000LMF	1300LMF	1500LMF	800LMF	1000LMF	1300LMF	1500LMF	800LMF	1000LMF	1300LMF	1500LMF
<b>Lumen Output</b>	3303	4033	4843	5841	3401	4153	4987	6015	3456	4220	5067	6111
<b>Input Watts</b>	25	32	40	51	25	32	40	51	25	32	40	51
<b>Lumens/Watt</b>	133	125	121	115	137	129	124	119	139	131	126	121

\*AT 80/20 Indirect/Direct Intensity Ratio

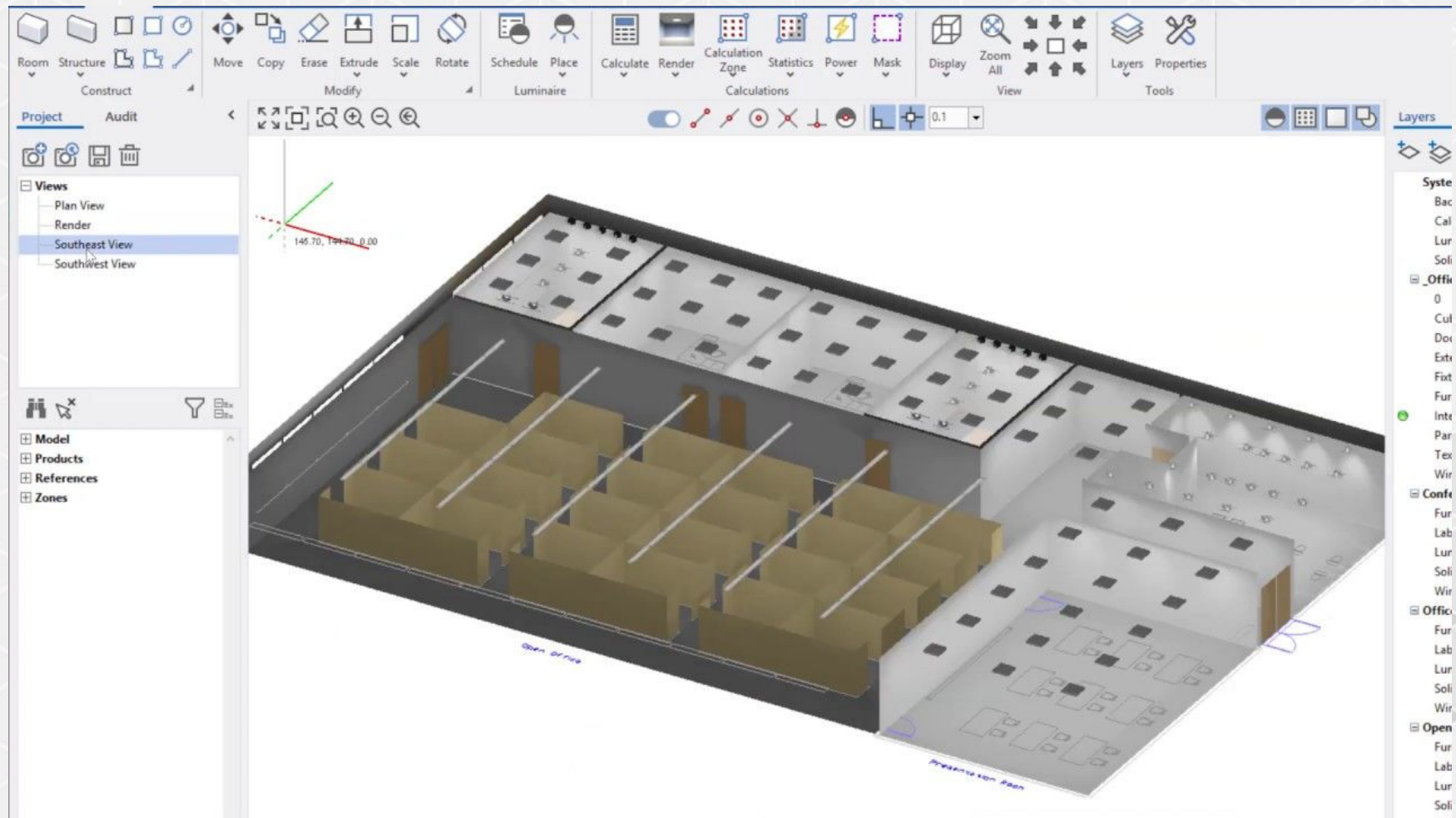


# Luminaire Selection (Visual Software)

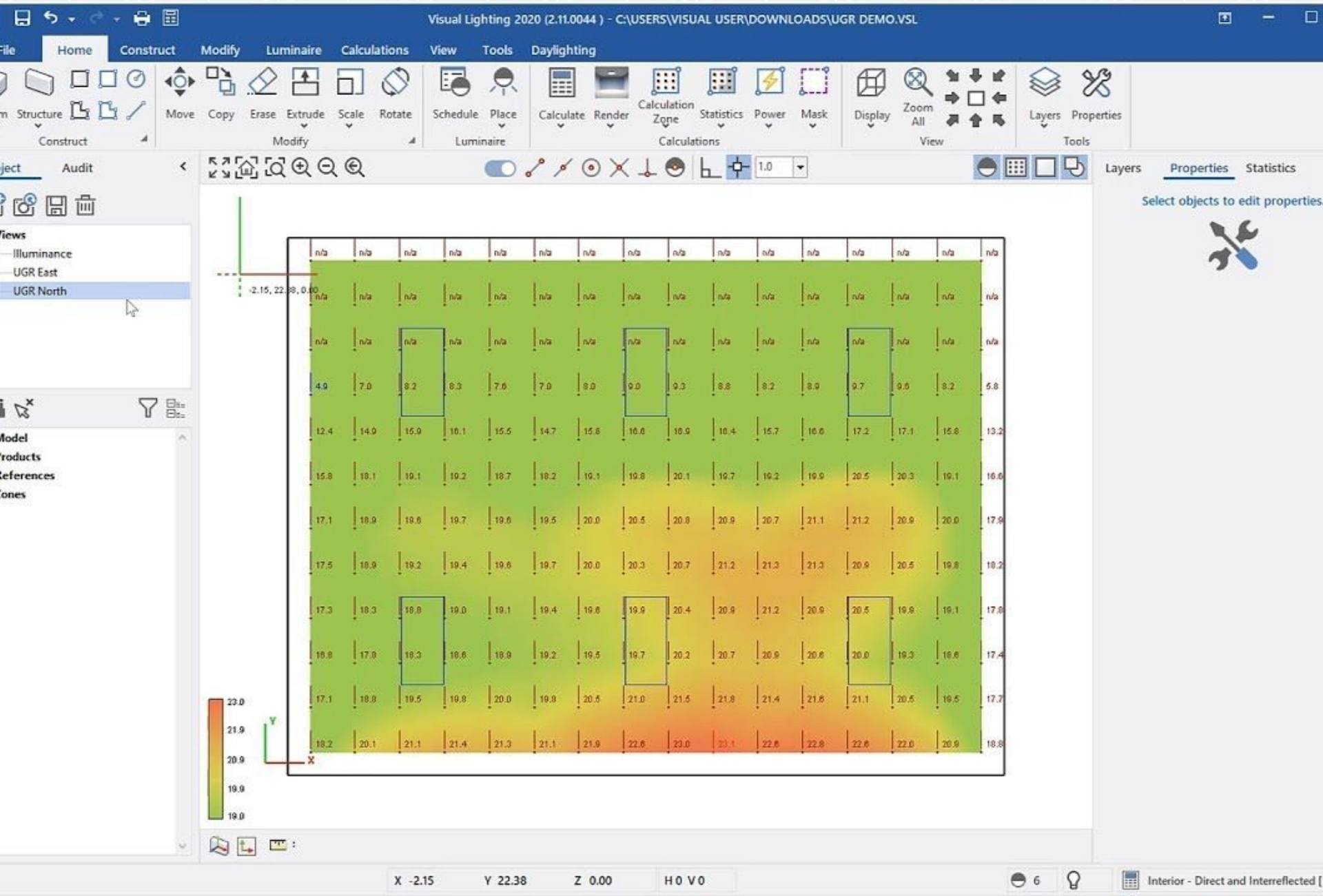




# Luminaire Selection (Visual Software)



# Luminaire Selection (Visual Software)



## **Building Lighting Allowance ( Both Methods)**

**Building Area Method = 26,500W**

**Space-by-Space Method = 26,404W**

**Using Lithonia LED to achieve needed illumination = 22,800W**



# **COMMERCIAL EXTERIOR LIGHTING SYSTEMS LIGHTING CONTROLS**



# Exterior Lighting and Building

## Lighting Power

### *Sections C405.4 – Mandatory, C405.4.1*

Total exterior connected lighting power to be the maximum rated wattage of all lighting powered through the energy service to the building

**Exception:** approved because of safety considerations

Connected Exterior Lighting Power must not exceed Exterior Lighting Power Allowance except where approved because of historical, safety, signage or emergency considerations:

1. Calculate exterior lighting power allowance
  - Lighting power densities by exterior function and by applicable lighting zone
2. Calculate proposed connected lighting power
  - Wattage calculation “rules”
  - Exempted lighting
3. Compare values: proposed wattage must be less than or equal to allowed wattage

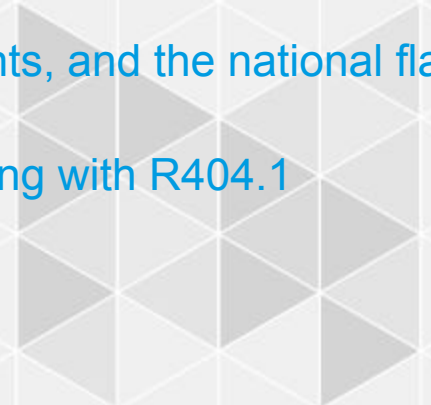


# Exemptions from Exterior Calculation

## Section C405.4.1

The following lighting does not need to be included in the proposed lighting calculation:

- ▶ Emergency lighting automatically off during normal business operation
- ▶ Exit signs
- ▶ Specialized signal, directional, and marker lighting associated with transportation
- ▶ Advertising signage or directional signage
- ▶ Lighting integral to *equipment* or instrumentation and installed by its *manufacturer*
- ▶ Lighting for theatrical purposes, including performance, stage, film production, and video production
- ▶ Lighting for athletic playing areas
- ▶ Temporary lighting
- ▶ Lighting for industrial production, material handling, transportation sites, and associated storage areas
- ▶ Theme elements in theme/amusement parks
- ▶ Lighting used to highlight features of art, public monuments, and the national flag
- ▶ Lighting used for water features and swimming pools
- ▶ Lighting controlled from within dwelling units and complying with R404.1



# Exterior Lighting Zones

## Table C405.4.2(1)

Power allowances are listed by lighting zone

Lighting Zone	Description
1	Developed areas of national parks, state parks, forest land, and rural areas
2	Areas predominantly consisting of residential zoning, neighborhood business districts, light industrial with limited nighttime use and residential mixed use areas
3	All other areas not classified as lighting zone 1, 2 or 4
4	High-activity commercial districts in major metropolitan areas as designated by the local land use planning authority



# Exterior Lighting Zones

*Table C405.4.2(1)*





# Exterior Lighting Zones

## Table C405.4.2(2)

Allowances include a base allowance plus tradeable allowance

		<u><b>Zone 1</b></u>	<u><b>Zone 2</b></u>	<u><b>Zone 3</b></u>	<u><b>Zone 4</b></u>
<b>Base Site Allowance</b>		350 W	400 W	500 W	900 W
	<b>Uncovered Parking Areas</b>				
	Parking areas and drives	0.03 W/ft <sup>2</sup>	0.04 W/ft <sup>2</sup>	0.06 W/ft <sup>2</sup>	0.08 W/ft <sup>2</sup>
	<b>Building Grounds</b>				
	Walkways and ramps less than 10 feet wide	0.5 W/linear foot	0.5 W/linear foot	0.6 W/linear foot	0.7 W/linear foot
	Walkways and ramps 10 feet wide or greater Plaza areas Special Feature Areas	0.10 W/ft <sup>2</sup>	0.10 W/ft <sup>2</sup>	0.11 W/ft <sup>2</sup>	0.14 W/ft <sup>2</sup>

Partial Table

# Exterior Lighting Control Requirements

## Section C405.2.6

- ✓ Exterior lighting systems provided with controls complying with C405.2.6.1 through C405.2.6.4
- ✓ Decorative lighting systems comply with Sections C405.2.6.1, C405.2.6.2, and C405.2.6.4

**Exceptions:** Covered vehicle entrances or exits from buildings and parking structures where required for safety, security or eye adaptation; and lighting controlled from within dwelling units



Image: DOE

# Daylight Shutoff

## Section C405.2.6.1

- ✓ Lighting to be automatically off if sufficient daylight is present satisfying needs in the space



# Decorative Lighting Shutoff

## Section C405.2.6.2

- ✓ Lighting for building façade and landscape automatically off from not later than 1 hour after business closing to not earlier than 1 hour before opening





# Lighting Setback

## Section C405.2.6.3

- ✓ Building façade or landscape NOT covered in Section C405.2.6.2 shall have controls configured to automatically reduce connected lighting power  $\geq 30\%$
- ✓ no later than midnight to not earlier than 6 am
- ✓ from not later than 1 hour after business closing to not earlier than 1 hour before opening
- ✓ any period where activity has not been detected for at least 15 minutes

# Exterior Time-Switch Control Function

## Section C405.2.6.4

- ✓ All time switch controls
  - ✓ have a clock capable of being programmed for not fewer than 7 days
  - ✓ capable of being set for 7 different day types per week
  - ✓ incorporate automatic holiday setback feature
  - ✓ be able to retain programming and the time setting during loss of power for a period of  $\geq 10$  hours

# Functional Testing of Lighting Controls

## Section C408.3.1

Prior to passing final inspection, *registered design professional* to provide evidence that lighting control systems have been tested to ensure that control hardware and software are calibrated, adjusted, programmed and in proper working order per construction documents and manufacturer's installation instructions

# Occupant Sensor Controls

## Section C408.3.1.1

- Certify location and aiming per manufacturer recommendation
- Test all sensors if project  $\leq 7$
- If  $> 7$  sensors, test for each unique combination of sensor type and space geometry
- Where multiples of each unique combination of sensor type and space geometry are provided  $\geq 10\%$ , but in no case  $< 1$  of each combination shall be tested unless the code official or design professional requires a higher percentage to be tested
- Where  $\geq 30\%$  of tested controls fail, all remaining identical combinations must be tested

### Verify the following:

- Status indicator, verify correct operation
- 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



# Documentation Requirements

## Section C408.3.2

- ▶ Construction documents specify that documents in this section be provided to building owner or owner's authorized agent within 90 days of date of receipt of *certificate of occupancy*



# Existing Buildings

## Section C502.2.6 *Lighting Power and Systems*

New lighting systems installed as part of an addition to comply with C405

- ▶ Total interior lighting power to comply C405.3.2
  - Stand alone addition
  - Addition + existing building as a single building
- ▶ Total exterior lighting power to comply C405.4.2
  - Stand alone addition
  - Addition + existing building as a single building
- ▶ Repairs – C504.2
  - Repairs exempt where only the bulb, ballast or both within the existing luminaires in a space are replaced, provided that the replacement does not increase the installed interior lighting power



**SEE YOU NEXT SESSION!**

