California's 2008 Building Energy Efficiency Standards for Residential and Nonresidential Buildings

A Title 24 Code Review
for Electrical Professionals

By: Brian Friedel LEED AP

brian.friedel@wattstopper.com
District Sales Manager
Watt Stopper / Legrand

WattStopper

legrand

Learning Objectives

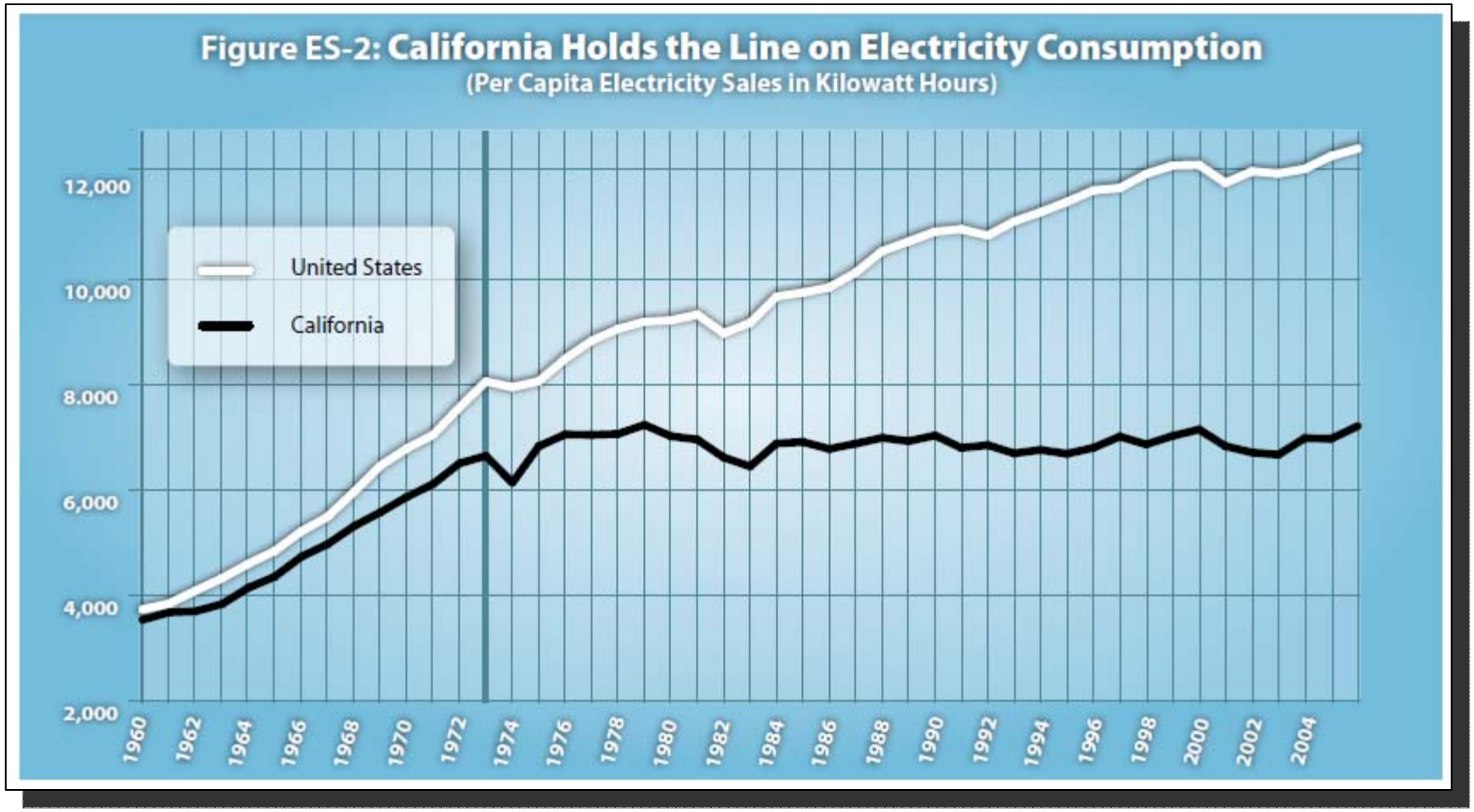
1. In depth review of the new California Energy Code requirements for lighting controls, and touch on lighting changes
2. Identify how specific new requirements impact current building designs
3. Apply lighting and lighting controls knowledge to create code-compliant project designs

Why Bother?

- Future Energy Questions
  - Uncertain supply
    - Bulk of CA's energy comes from petroleum-based products
  - Capacity constraints
    - Cost and Environmental impact to build new power new generation plants
- Environmental Concerns
  - Green Building Designs
  - LEED
  - Darksky

WattStopper
legrand

Has it worked?



CEC Integrated Energy Policy Report 2007
(CEC-100-2007-008-CMF)

WattStopper
legrand

Code Goals

- Energy Savings
- Electricity Reliability and Demand
- Comfort Economics
- Environment
  - Green House Gas Emissions
  - Impact on Climate Change

WattStopper
legrand

3 Key Ideas behind Title 24

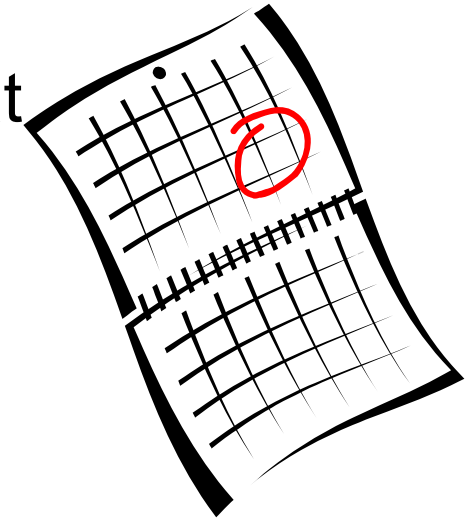
- Mandate minimum automation
  - Eliminate “wasted” electrical consumption
- Mandate maximum allowed watt/ft²
  - Ensure lower electrical envelope for new buildings
- Provide incentives for exceeding current mandatory measures
  - Allow engineers to offer creative solutions

Major Changes from 2005 Version

- Major Changes to Daylighting Requirements
- Occupancy sensors required in certain areas
- Lighting power limits for indoor lighting have been reduced
- Demand Response controls
- Outdoor Lighting Changes
- Sign Lighting Changes

When?

- 2008 Building Energy Standards take effect August 1, 2009
  - for any site pulling a permit after that date.



From 2005

Buildings Covered

- Buildings that are "**unconditioned**, indirectly or directly conditioned by mechanical heating or mechanical cooling" [§100(a)]
- Outdoor lighting systems, indoor & outdoor signs included [§100(b) and (d)]
- Exceptions: Some temporary & qualified historic buildings

Review the definitions…

- "Shall" is mandatory, "May" is permissive
- Highlight these definitions:
  - "**Nonresidential Function Area or Type of Use**"
    - Was "Occupancy Types"
    - Atria, Classroom, Mall, Office, Stair, Waiting area…
  - "**Outdoor Lighting**" defines many exterior areas
    - Canopy, Hardscape, Lantern, Pendant, Principal viewing location, Vehicle service station…
  - "**Residential Space Type**"
    - Bathroom, Closet, Garage, Kitchen…
  - "**Sign**" lists many different sign types
    - Cabinet, externally illuminated, traffic…

Definitions

- **Occupant Sensors** turn off lights in an indoor lighting system after an area is empty of people.
  - When used to control outdoor lighting systems, it is termed a motion sensor.

- **Vacancy Sensors** are units where the lights must manually be turned on, but the sensor automatically turns the lights off soon after an area is vacated.
  - Also may be called a manual-on occupant sensor.

- **Daylight Area** is the floor area under skylights or next to windows.The daylight area includes:
  - Primary Sidelit Daylight Area,
  - Secondary Sidelit Daylight Area, and
  - Skylit Daylight Area

WattStopper

legrand

Lighting Control Products

- Performance criteria & physical product constraints requirements
- Changes for Sensors & Daylighting
- Adds §'s for Dimmers, Ballasts, Current Limiters, and LED
- Certification requirements for manufactured devices [§100(h)]
  - http://www.energy.ca.gov/appliances/appliance/

Lighting Control Devices

- NEW Indicator lights
  - Indicator lights integral to lighting control devices can not consume more than 1 watt of power per indicator light

- Automatic Time Switch Devices
  - If power is lost the switch must save schedules for at least 7 days and the time and date setting for 72 hours (was 10 hrs for both)

Occupancy Sensors

- Occupancy and Vacancy Sensors

NEW – Must have a visible status signal to indicate the device is operating properly

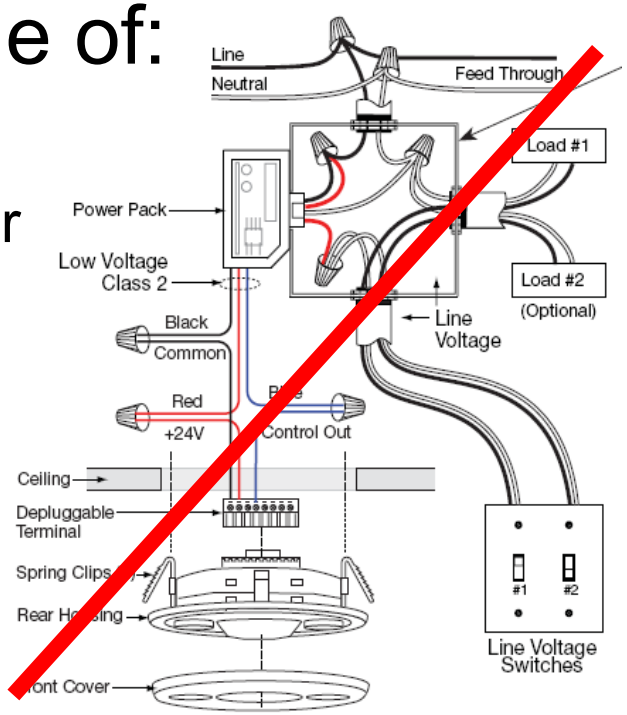
NEW – Status signal can have an override switch to turn off the signal

New Device!

Multi-level Occupancy Sensors

- Will automatically turn off all lights
- Manually or Automatically turn on 30-70% of the lighting power in a room,
- Then must be manually capable of:
  - Activating the alternate set of lights
  - Activating 100% of the lighting power
  - Deactivating all lights

OK!

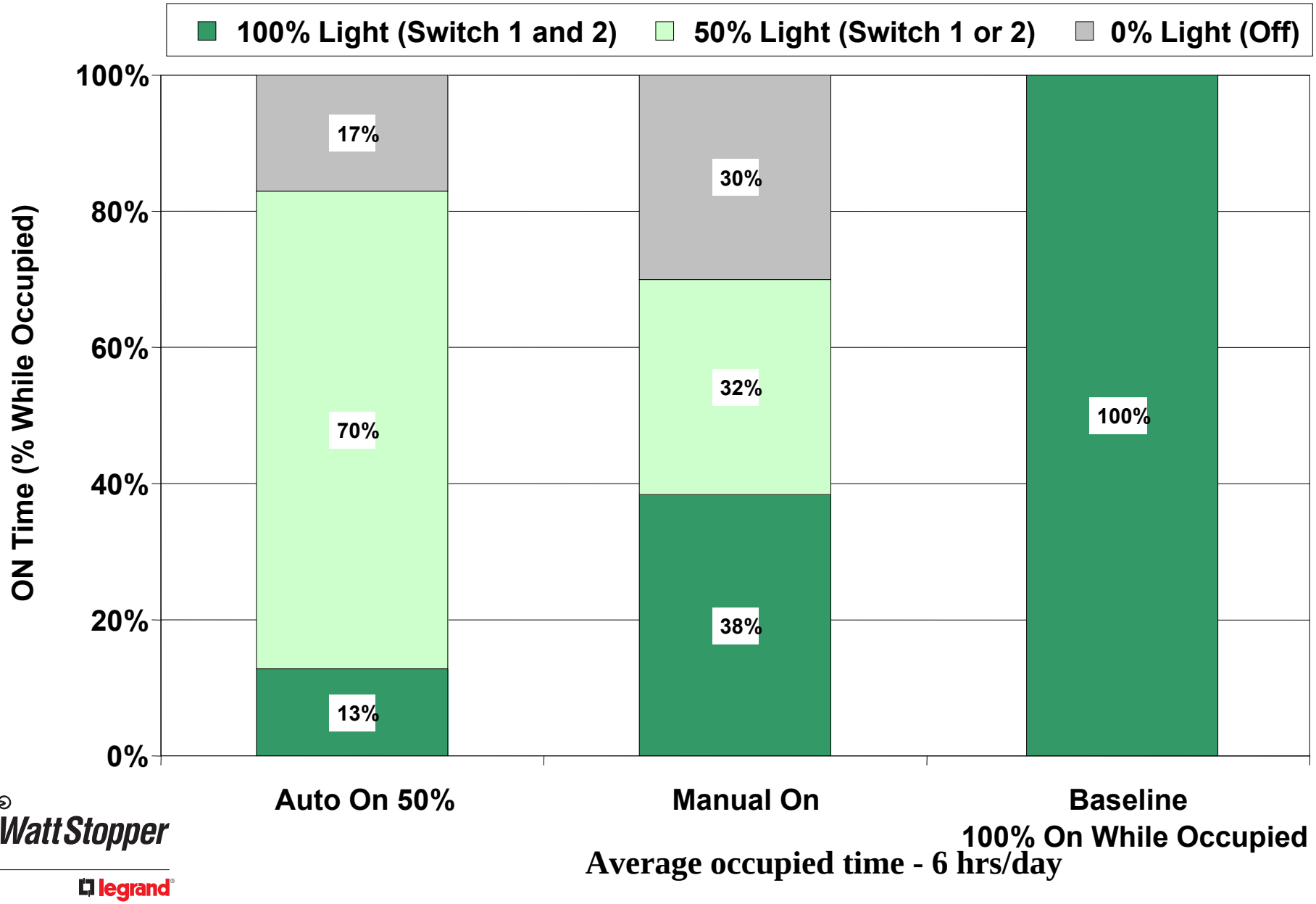


WattStopper

legrand

Comparison to Occupancy Sensor

Bi-Level Switch Study - Comparison

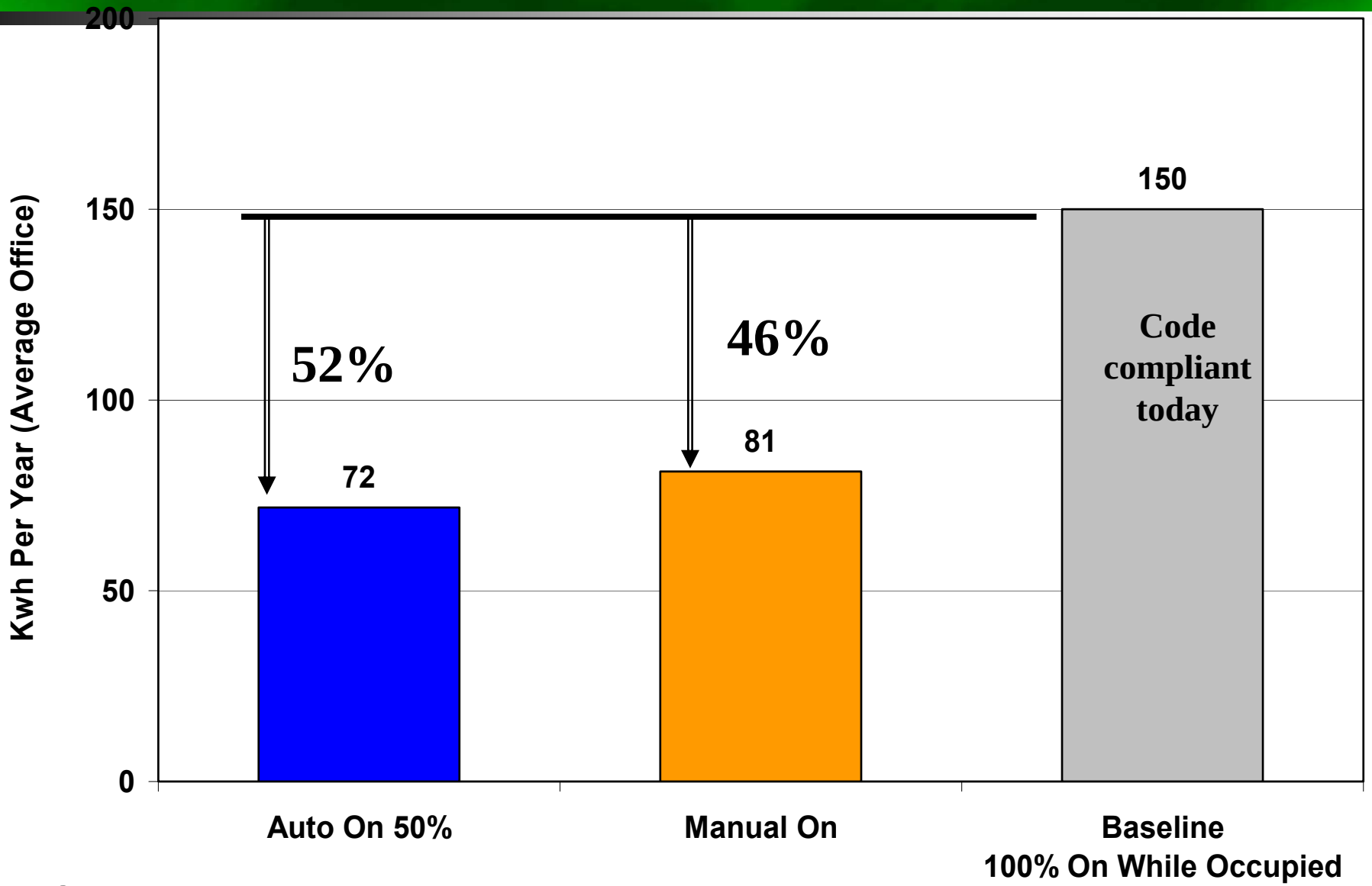


Average occupied time - 6 hrs/day

WattStopper

legrand

Annual Lighting Energy Use



WattStopper

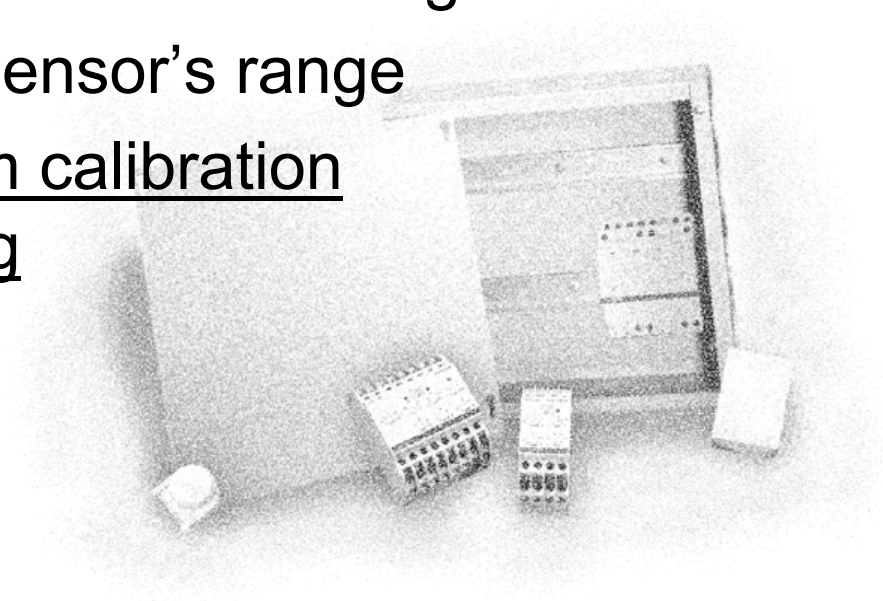
legrand

Daylighting Controllers

Revised!

Requirements include:

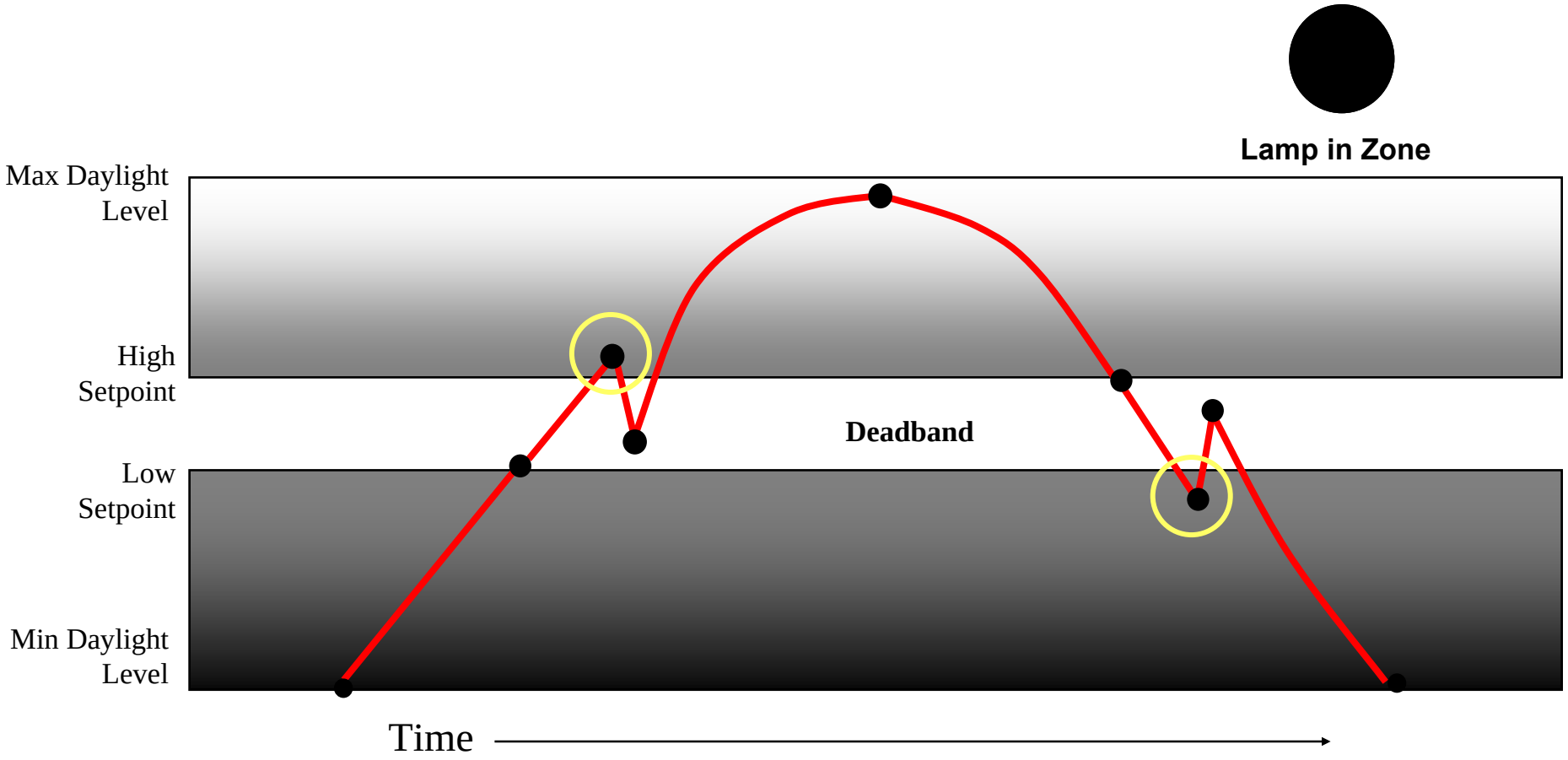
- Reduce general lighting uniformly by ≥ 66% (was 50%)
- Stepped systems need dead band & time delay
- Temporary override for calibration for devices with time delays (< 60 minutes)
- Setpoint scale resolution ≤10% of full range
- Linear 5% accuracy over sensor's range
- Light Sensor separate from calibration device or unaffected during startup



WattStopper

legrand

Deadband Definition



Note: Changes of state happen when <u>leaving</u> the deadband, not when entering

Did you know?

- Interior photosensor can't have a mechanical slide cover that permits easy unauthorized disabling of the control, and
- Cannot be incorporated into a wall-mounted occupant sensor?

Astro-based Daylighting Device

- Multi-level astronomical time switch device used for daylit zones
  - 2 separately programmable steps (relays) per zone
  - Offset control for each step from 1-240 minutes
  - Sunrise/set accurate to within +/- 15 minutes; clock accurate to within 5 minutes per year; performs daylight savings changes automatically
  - NEW Must now be capable of storing astronomic time parameters (used to develop longitude, latitude, time zone) for at least 7 days in case of power outage
  - Display date/time; sunrise/set; switching times

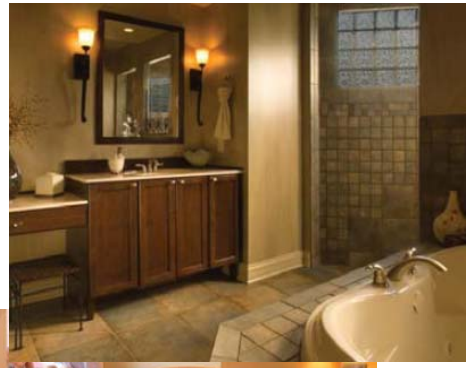
Outdoor Astro Time Switch

- New exterior lighting controller
  - Similar to device in §119(h)
  - Applies to outdoor lighting in §132(c)
  - 2 separately programmable channels, individually offset 1-99 minutes
  - Store astro time parameters for at least 7 days if power is interrupted

New Device!

Vacancy Sensor

- Vacancy Sensor (Manual-On Occupancy Sensor)
  - Used to meet §150(k)
  - Turns off lighting within 30 minutes after a room is vacated
  - Visible status signal §119(d)
  - Not turn lighting off automatically except for a 15 – 30 sec grace period
  - No override switch to disable the sensor
  - No override switch to convert the sensor from manual-on to auto-on



What buildings do codes apply to?

- Nonresidential, high-rise residential, motel/hotel, & outdoor lighting (§130 - §139)
- High rise residential dwelling units & Hotel/Motel guest rooms follow §150(k)
  - ~~Exception for 10% guest rooms~~

Overview

- §131(a) Area controls
- **§131(b) Multi-level lighting controls**
- **§131(c) Daylit areas**
- **§131(d) Shut-off controls**
- **§131(e) Display lighting**
- ~~**§131(f) Lighting control accep**~~ **Moved §134**

*** Bold items = biggest changes**

Area Controls – Minimal Changes

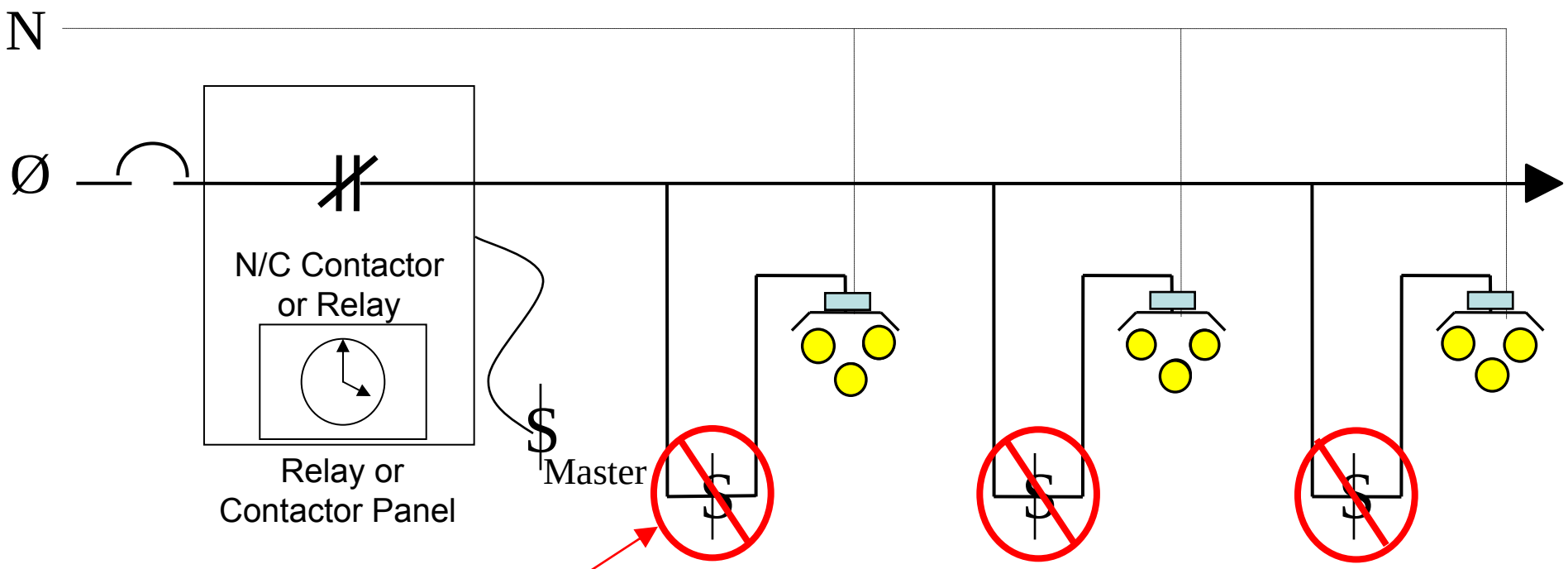
- Each area enclosed by ceiling height partition shall have a device:
  - Readily accessible
  - Pilot lit, or can view controlled lights
  - Manually operated or occupancy sensor
- Other devices may be installed with the switching or control device if:
  - They permit the switching or control device to manually turn off the lights in each area enclosed by ceiling height partition.
  - They reset any automatic system to normal
- Exception for 0.3 Watts of security lighting, or in public areas with switches accessible to Authorized Personnel.

"Other Devices" Requirement

From the 2005 Title 24 Compliance Manual:

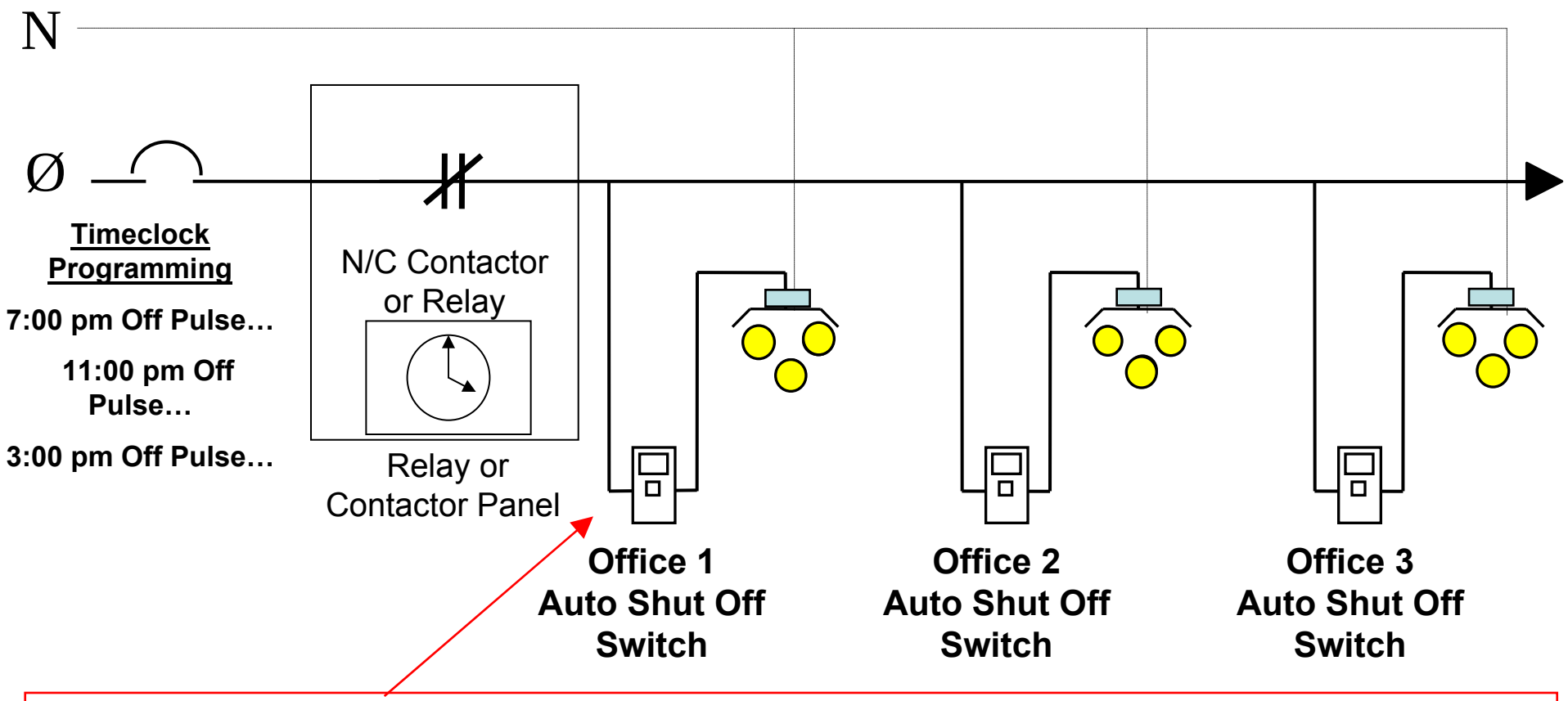
"If the room switching operates in conjunction with any other kind of lighting control device, there are two other requirements: 1) the other control device must allow the room switching to override its action, and 2) if the other control device is automatic, it must automatically reset to its normal operation mode without any further action.

Switches Must Override Schedules



Since SPST Line Voltage Switches do not override the time clock, they can't be used.

“Auto Shut Off Switches”



Control devices are available that can be signaled to go Off by a timeclock “pulse”. Since the occupant can manually turn these On & Off, they meet Title 24 requirements.

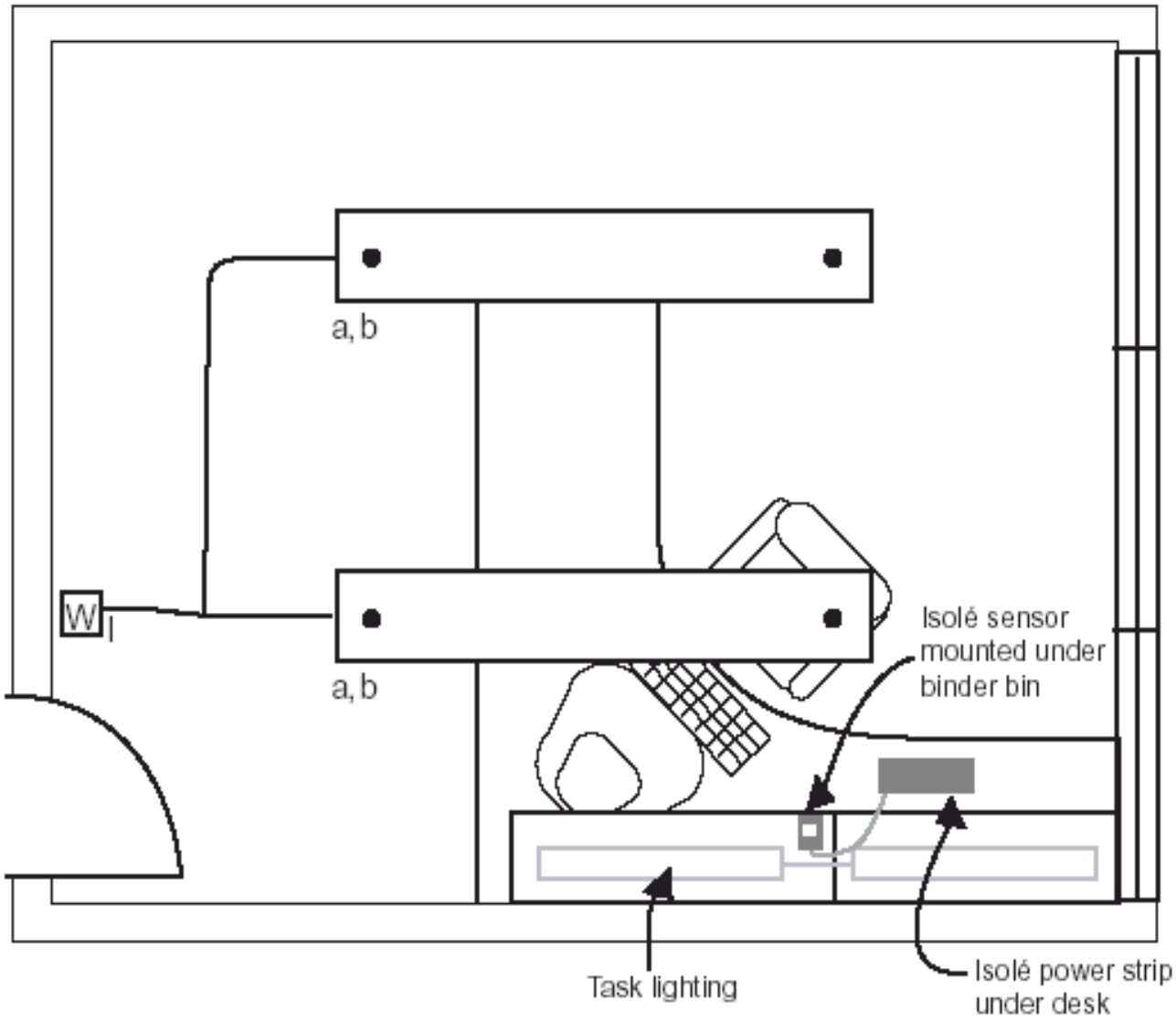
WattStopper
legrand

Multi-Level Lighting Controls

- Required for spaces:
  - ≥ 100 ft², and
  - Lighting power density > .8 W/ft², and
- Minimum of two levels of control:
  - Between 30% & 70% of full power
  - Full Off
- Can dim all lamps or luminaires, or step switch alternate lamps, luminaires, or rows
- Exception for
  - Corridor Lights, or
  - Spaces with a single 1 or 2 lamp luminaire

Application – Small Private Office

Bi-level Occupancy Sensor Switching, Plug load control

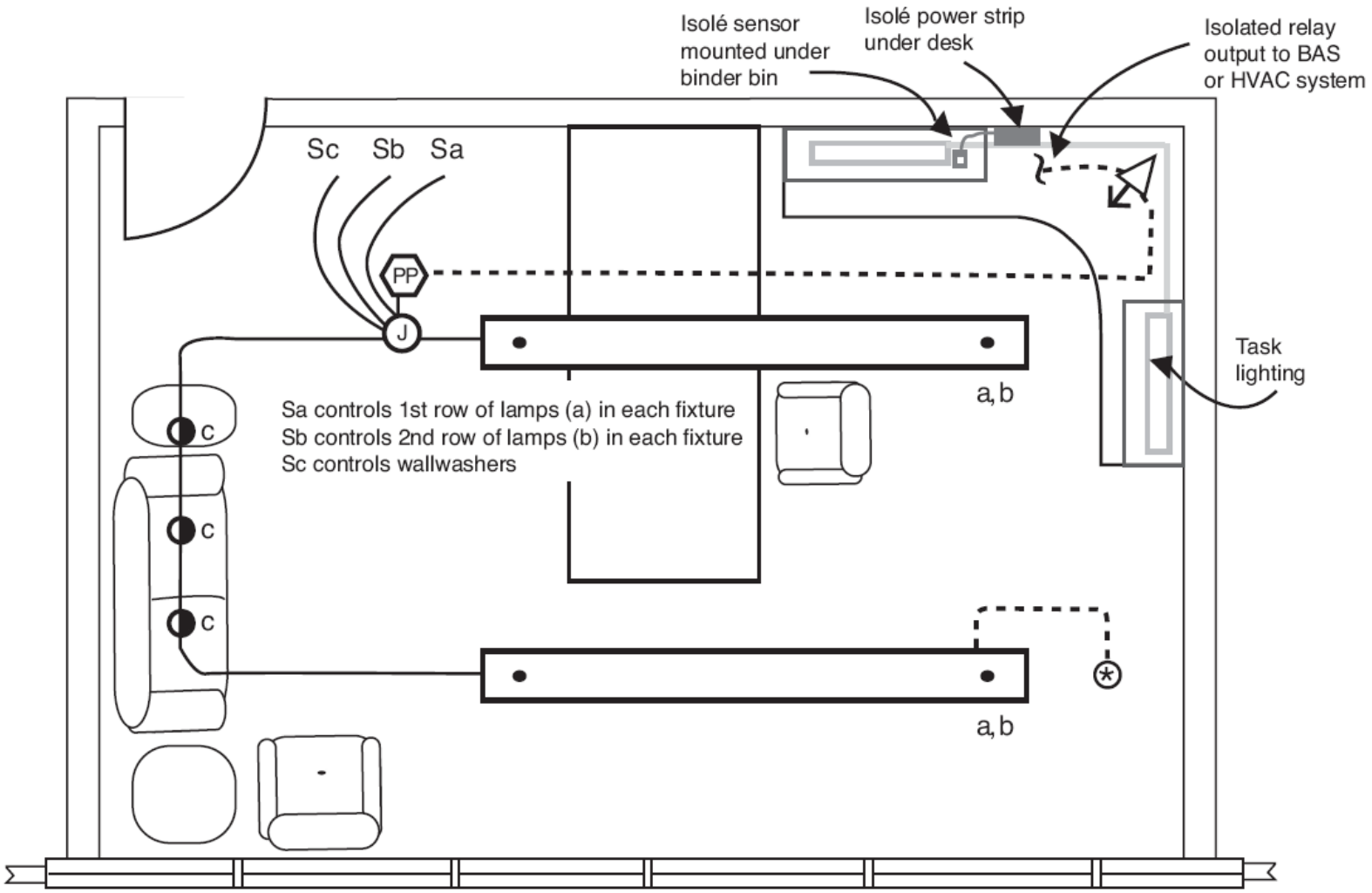


WattStopper

legrand

Application – Large Private Office

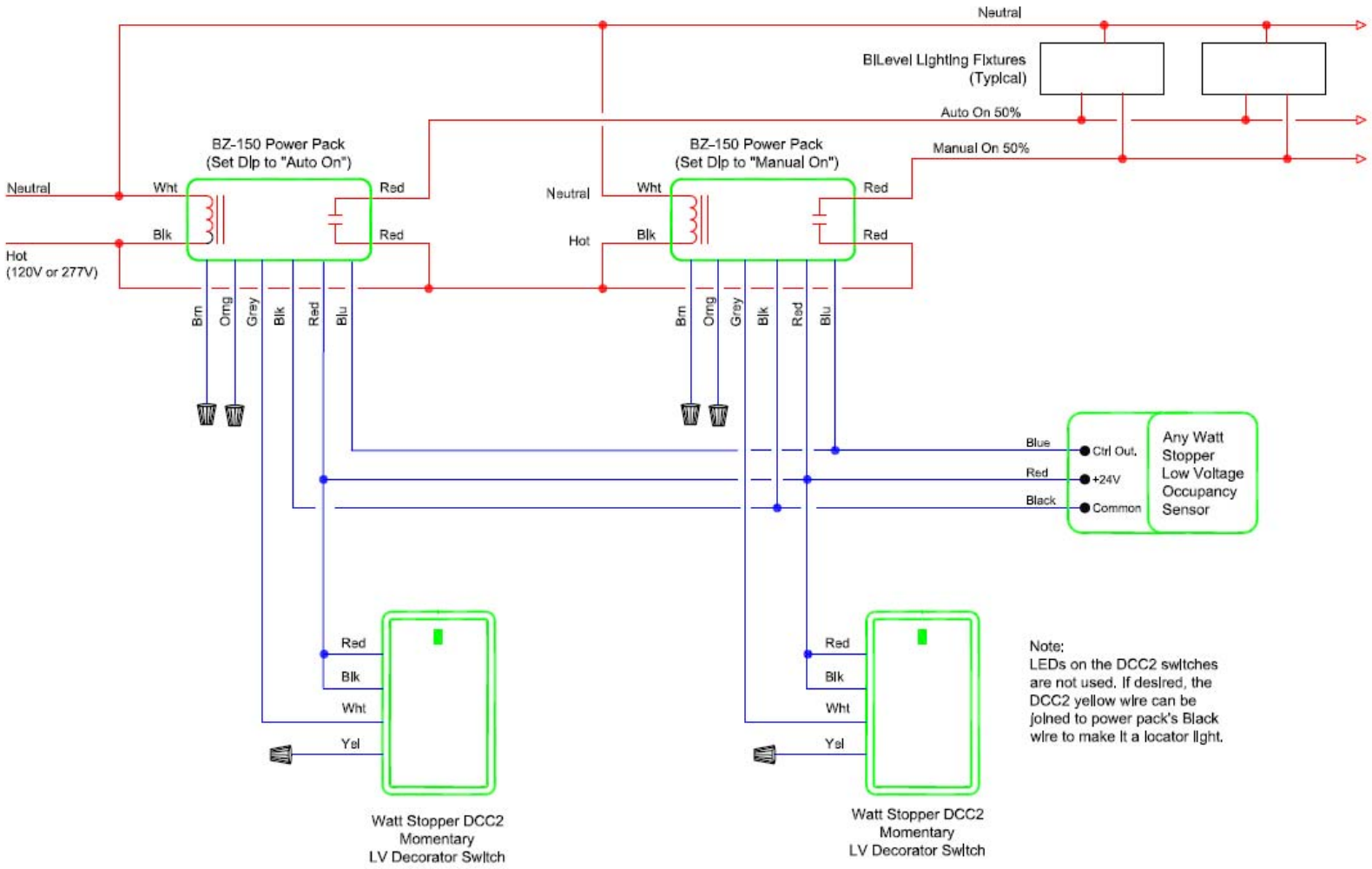
Occupancy Sensor, Bi-level Switching, Daylight, Plug Load , HVAC



WattStopper

legrand

Application – Large Private Office
Ceiling Occupancy Sensor, Power Pack, Bi-level Switching



WattStopper

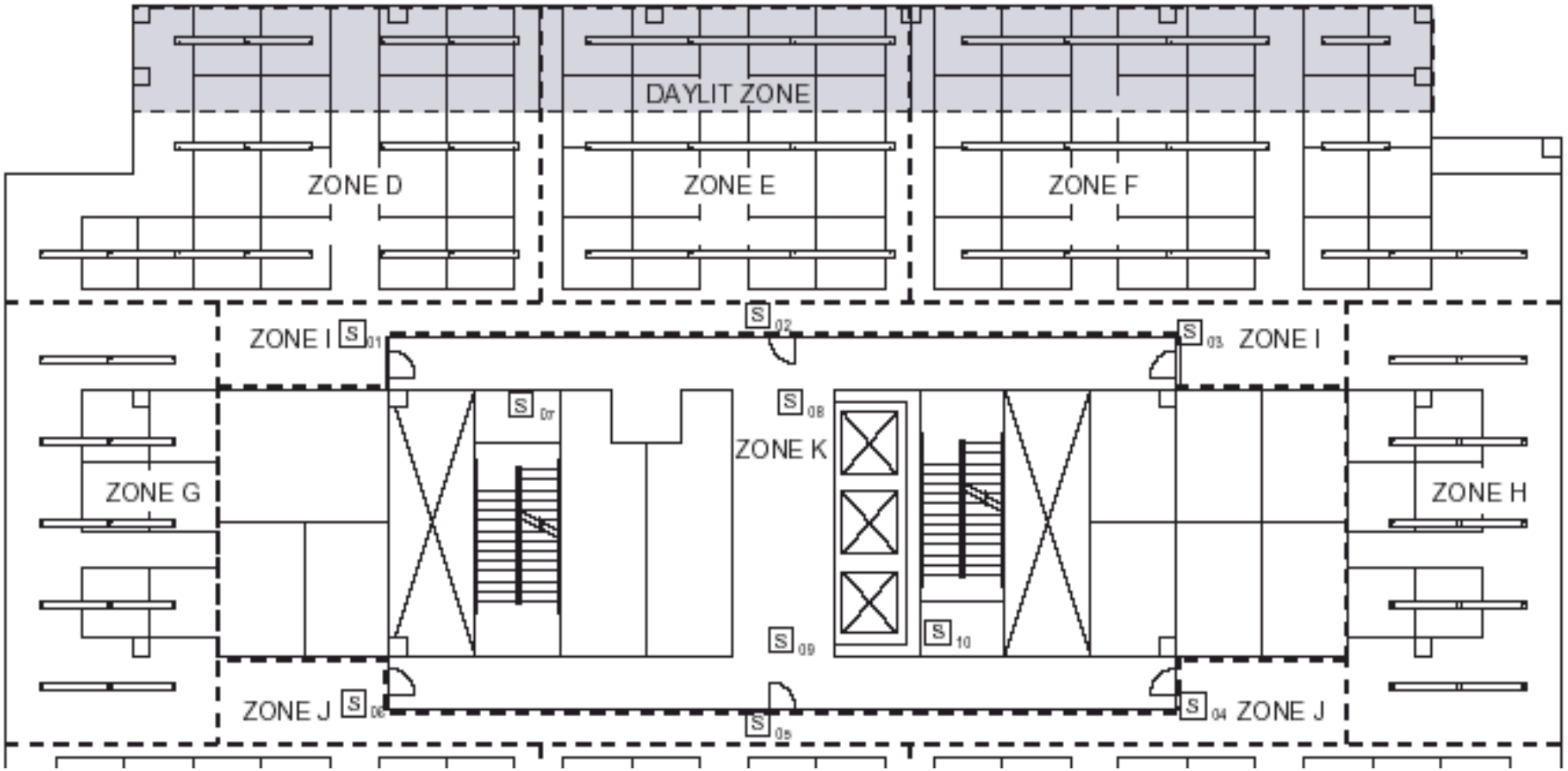
legrand

Daylighting – 2005 T24

The Old Way

- Daylight areas > 250 ft² must:
  - Control 50% of the power in the daylit area lighting separately from other lighting in enclosed space
  - Control sidelighting & toplighting separately
  - Provide even illumination level [similar to §131(b)]

Application Example – Open Office w/ Daylight Zone



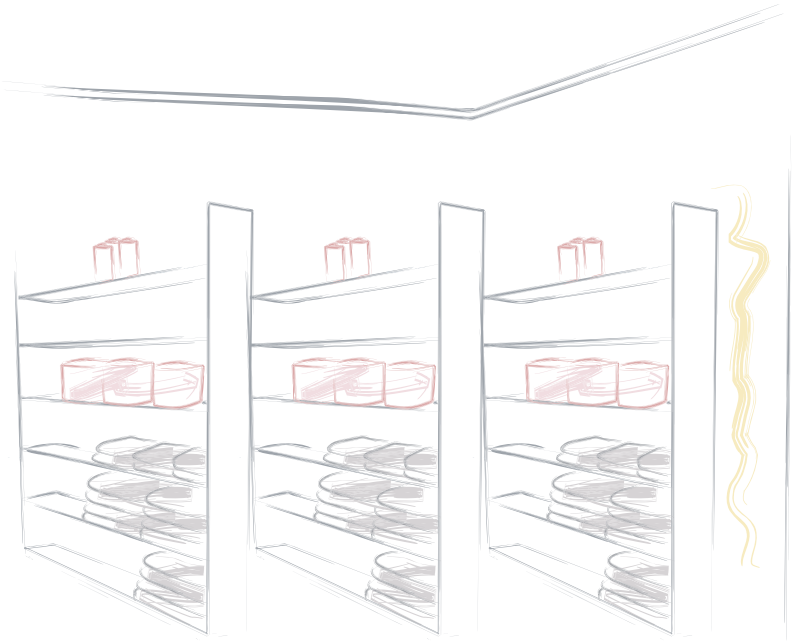
WattStopper

legrand

The Old Way

Daylighting – 2005 T24

- Skylight daylit areas > 2,500 ft² (in any room) require:
  - Automatic multi-level daylighting controller with 2-level reduction [§119(i)], or
  - Multi-level time switch [§119(h)], and Override switches [§131(d)2]
- Exceptions for obstructing structures and where effective skylight aperture is too low.



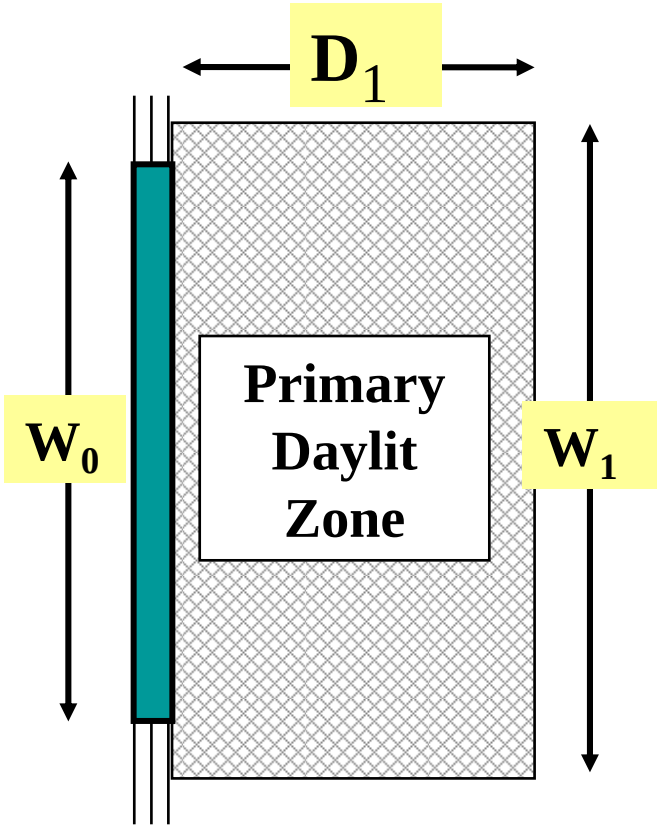
Director's Cut
Completely Rewritten

Daylighting Definitions

- Three different Daylight Zones
- DO NOT double count overlapping areas
  - Primary Sidelit
  - Secondary Sidelit
  - Daylight Area Skylit

Primary Sidelit Area

Control luminaires in the Primary Sidelit area



D_1 = **Window Head Height**, or

- Distance to closest 60” high permanent obstruction*

W_1 = Window Width (W_0) + (on each side)

- 2’, or
- Distance to closest 60” high permanent obstruction

Primary Sidelit area = (D_1) x (W_0 + 4’)

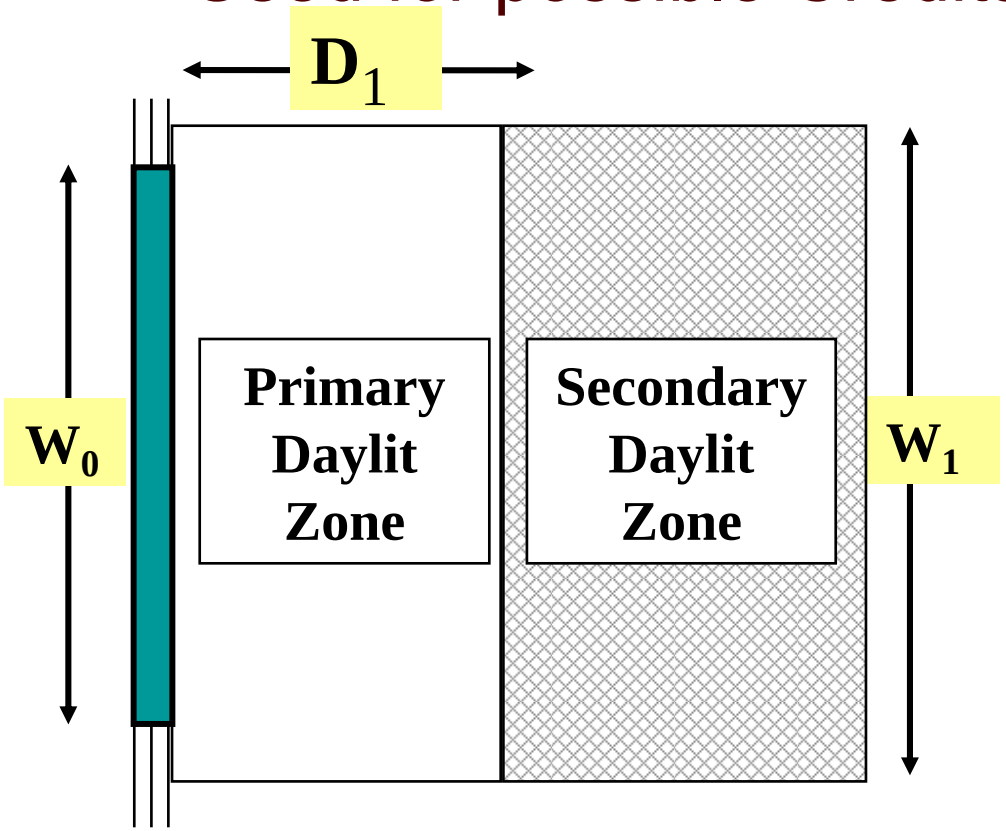
WattStopper

legrand

* Per Compliance Manual, Cubical Walls ARE NOT Permanent

Secondary Sidelit Area

Used for possible Credits in 146(c)



D_1 = **Window Head Height**, or

- Distance to closest 60” high permanent obstruction*, or
- Distance to skylit Daylit area

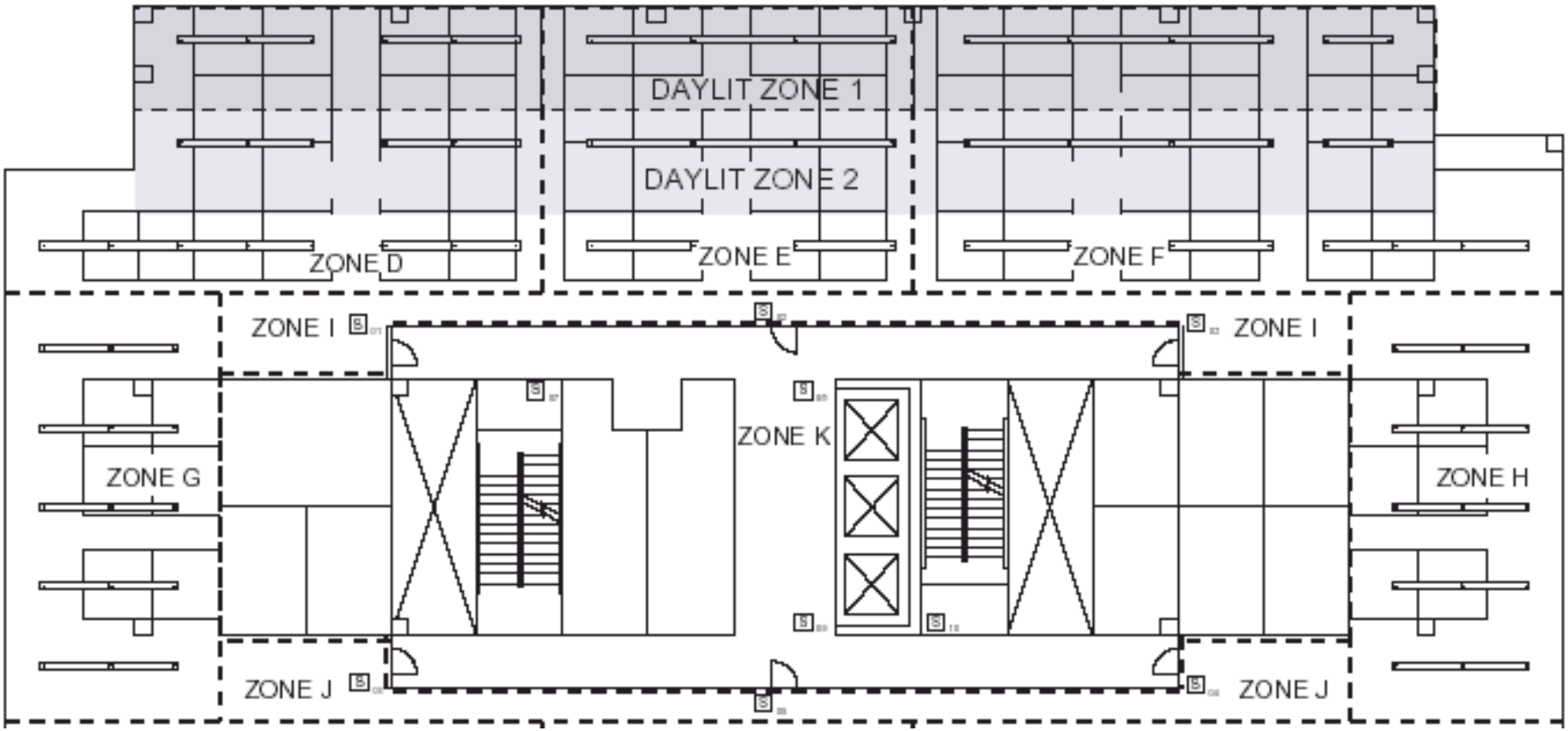
W_1= Window Width (W_0) + (on each side)

- 2’, or
- Distance to closest 60” high permanent obstruction, or
- Distance to skylit Daylit area

Secondary Sidelit area = (D_1) x (W_0 + 4’)

* Per Compliance Manual, Cubical Walls ARE NOT Permanent

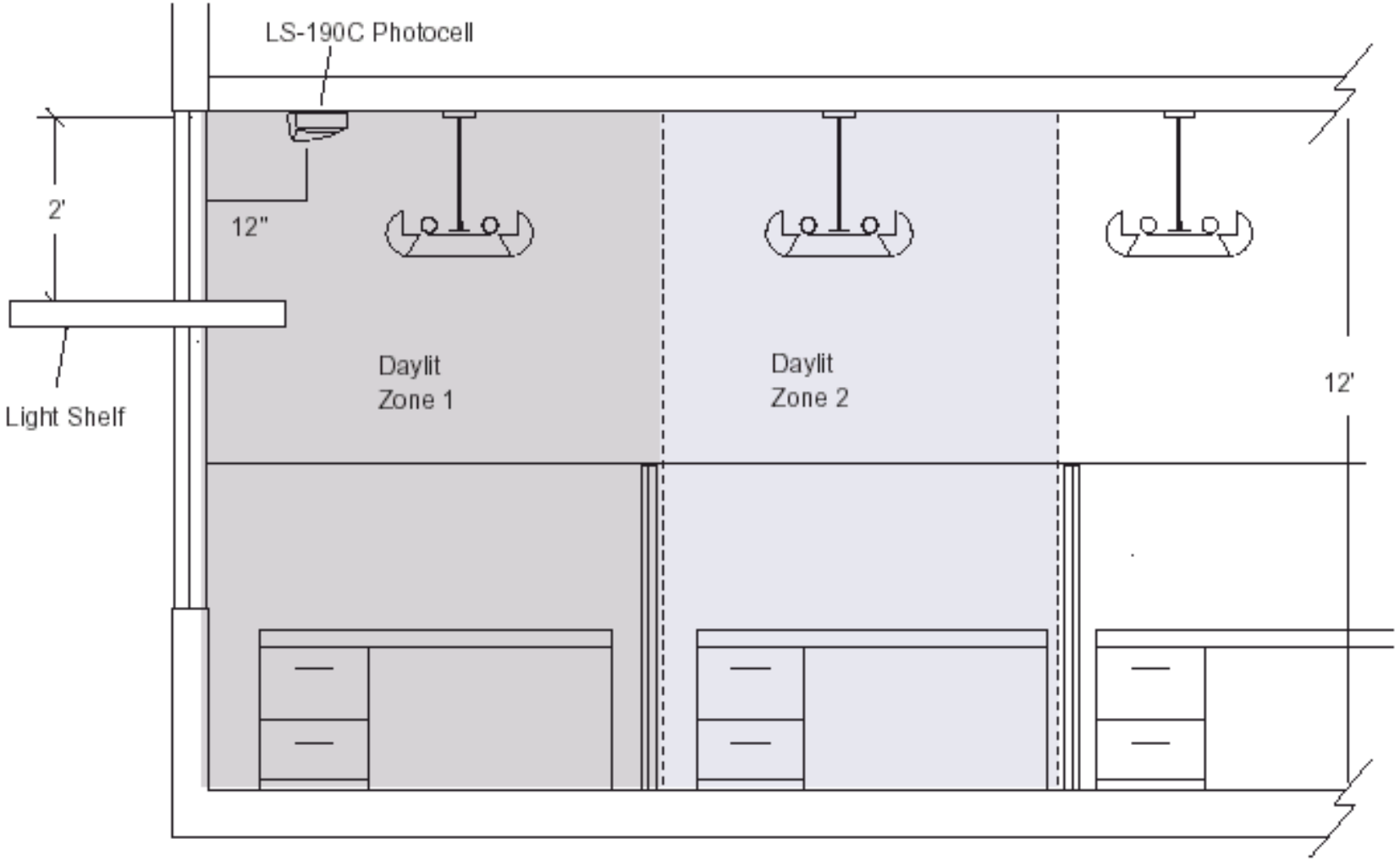
Application Example – Open Office w/ Two Daylight Zones



WattStopper

legrand

Application Example – Two Daylight Zones

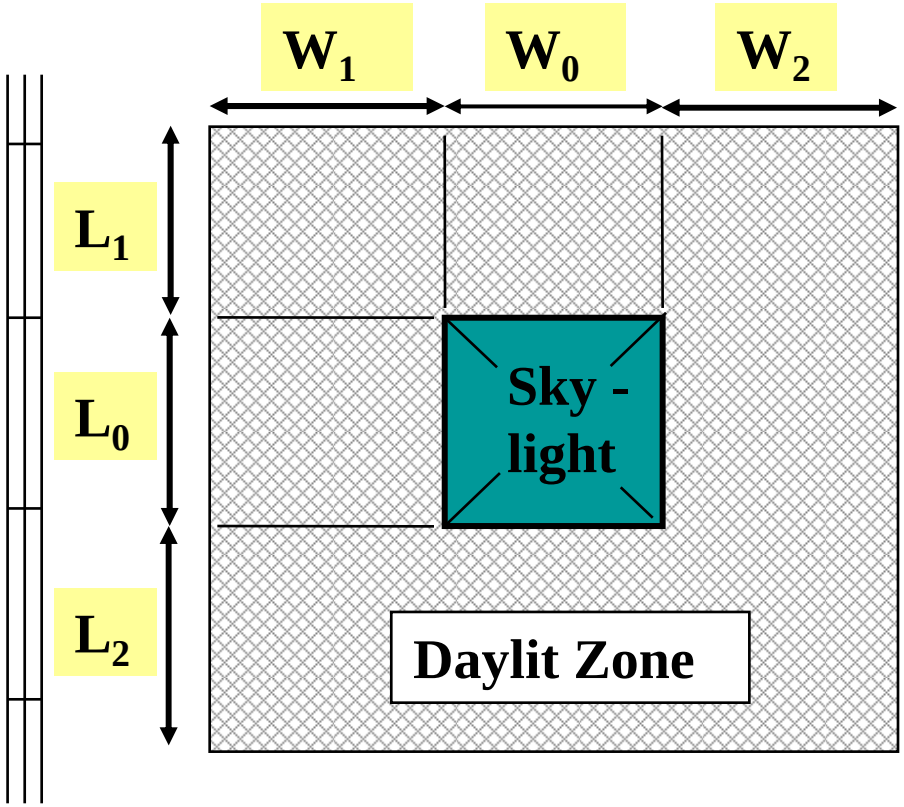


WattStopper

legrand

Toplighting Area Determination

- Control luminaires in or partially in the daylit area



L_1, L_2, W_1,W_2 = smallest of the following values:

- 70% of ceiling height, or
- Distance to any Primary Sidelit edge (includes Rooftop Monitor Daylit, or
- Distance to permanent partition or rack that's further away than 70% distance between partition/rack top and ceiling.

Daylit area= L x W = $(L_1+L_o+L_2)$ x $(W_1+W_0+W_2)$

WattStopper
legrand

Sample Skylight Calculations

Skylight Length	Skylight Width	Height	Zone Ft^2
4	4	10	324
4	4	15	625
4	4	20	1024
4	4	30	2116
4	8	10	396
4	8	15	725
4	8	20	1152
4	8	30	2300
8	8	10	484
8	8	15	841
8	8	20	1296
8	8	30	2500

Daylight Areas

- If General Lighting Luminaires are totally or partially in the Skylit daylight area and/or the Primary Sidelit daylight area:
  - Control at least 50 percent of the general lighting power in the primary sidelit and skylit daylight areas separately from other lighting in the enclosed space.
  - Control luminaires in primary sidelit areas separately from skylit areas.
- Exception
  - When Primary Sidelit and Skylit Daylight areas total ≤ 250 square feet within any enclosed space.

Skylit Daylight Areas

- Skylit Daylight Areas:
  - **Show areas on the plans**.
  - Control general lighting in the area with an **automatic daylighting controller for areas >2,500 sq ft** per §131(c)2D.
- Exceptions
  - Areas in any enclosed space is **≤ 2,500 sq ft**
  - Where sunlight is blocked at least 6 hours during the equinox
  - When skylight effective aperture is > 4.0%, and all general lighting in the area is controlled by a multi-level astronomical time switch with an override switch.
  - Skylit daylight areas have too small an effective aperture (<0.006) per §146(a)2E.

Primary Sidelit Daylight Areas

- Primary Sidelit Areas
  - **Show on the plans**,
  - Control general lighting with an **automatic daylighting controller for areas >2,500 sq ft** per §131(c) 2D.
- Exceptions:
  - Total Primary Sidelit area in enclosed space is **≤ 2,500 sq ft**
  - Primary sidelit daylight areas where the effective aperture is < 0.1 (per §146(a)2E)
  - Where existing structures are twice as tall as their distance from the windows.
  - Parking garages

Automatic Daylighting Control Device

- Automatic daylighting control devices shall be installed per following:
  - Photosensors are located so that they are not readily accessible per designer's or manufacturer's instructions.
  - Calibration should be adjusted in a place readily accessible to authorized personnel, near a ceiling access panel that is ≤11 feet above floor.
  - Shall be multi-level, including continuous dimming, with one step between 50-70% percent lighting power.

Automatic Daylighting Control Device

- **Exceptions**
  - Controlled lighting has lighting power density **< 0.3 W/ft^2**.
  - When replacing skylights in a building with an existing general lighting system.
  - When doing so would provide less light than the controlled electric lights themselves.

Revised Rule!

Skylights - Large Spaces, Bldgs ≤ 3 Stories

- Conditioned or Unconditioned spaces > 8,000 ft^2 (was 25,000) under roof, with ceilings > 15 ft and LPD ≥ 0.5 W/ft^2 must:
  - Have ≥ 50% floor area in between Primary Sidelit and Skylit Daylit areas.
  - Meet minimum Skylit and Sidelit Daylit ratios
- Lighting in daylit area controlled per §131(c) 2 (= 250 ft^2 and 2,500 ft^2 zone rules)
- Exceptions:
  - Climate zones 1 & 16, theatres, churches, museums, and refrigerated warehouses.
  - Some buildings with future built out spaces
  - Enclosed spaces with LPD < .5W / sqft

Applications: Warehouses & Big-box Retail

Daylighting Suggestions

- **Think:**
  - Skylights = Big, additive zones. Code may require controls.
  - Windows = Small, individual zones. Controls may be a good idea, but not required.
- **When creating Daylight Zones:**
  - Consistent daylight contribution
  - Minimize shadowing in a zone
  - Create zones with consistent use / appearance
  - Visual and logical connection

Shut-off Requirements

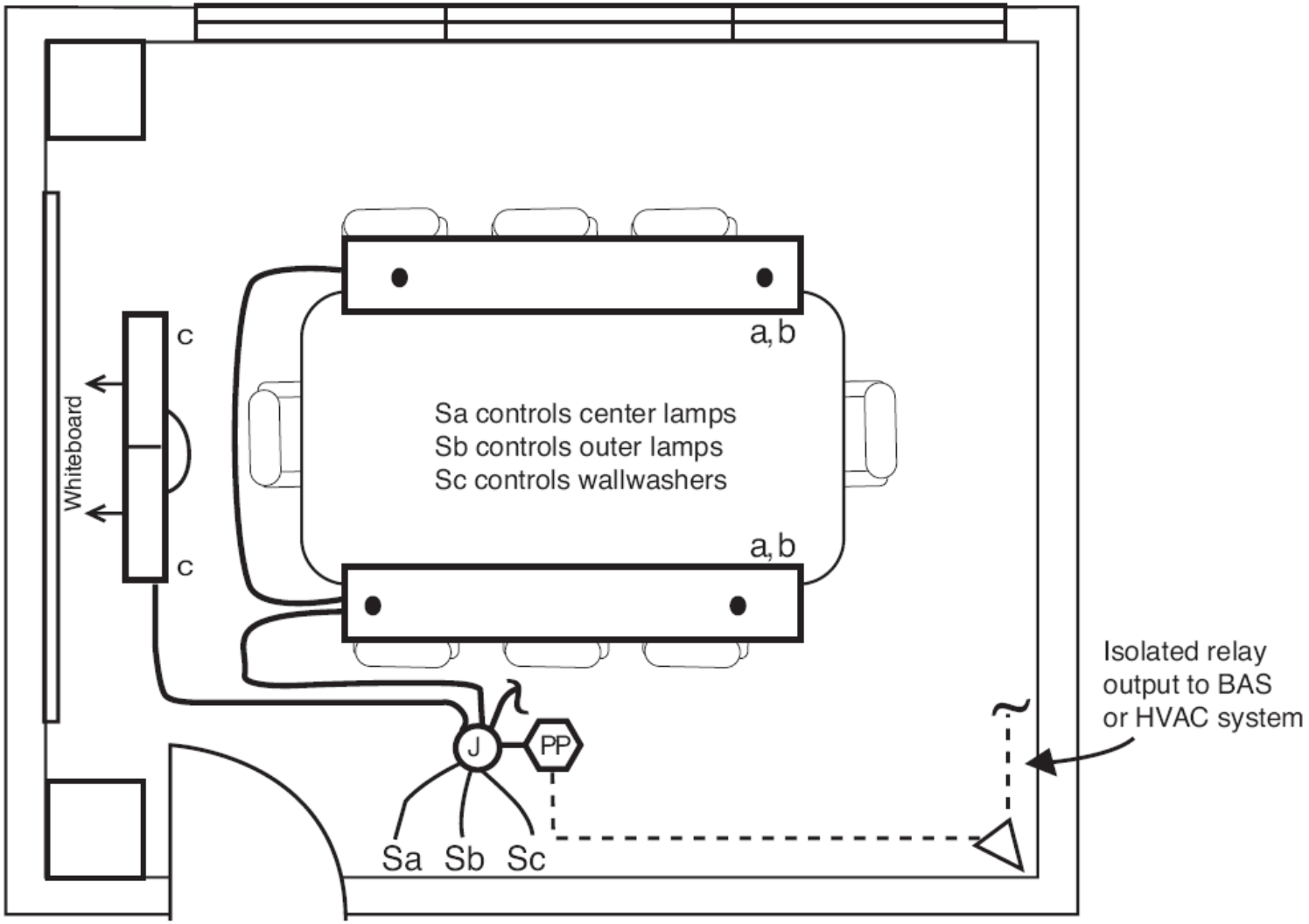
- Every floor must have method of turning off all interior lighting systems, either:
  - Occupancy sensor
  - Automatic time switch
  - Other device
- Exceptions:
  - 24/365 operational areas
  - Corridor, guest-rooms & dwelling units, parking garages
  - .3W/ft² (was .5) security/emergency egress

New Requirement

Mandatory use of Sensors

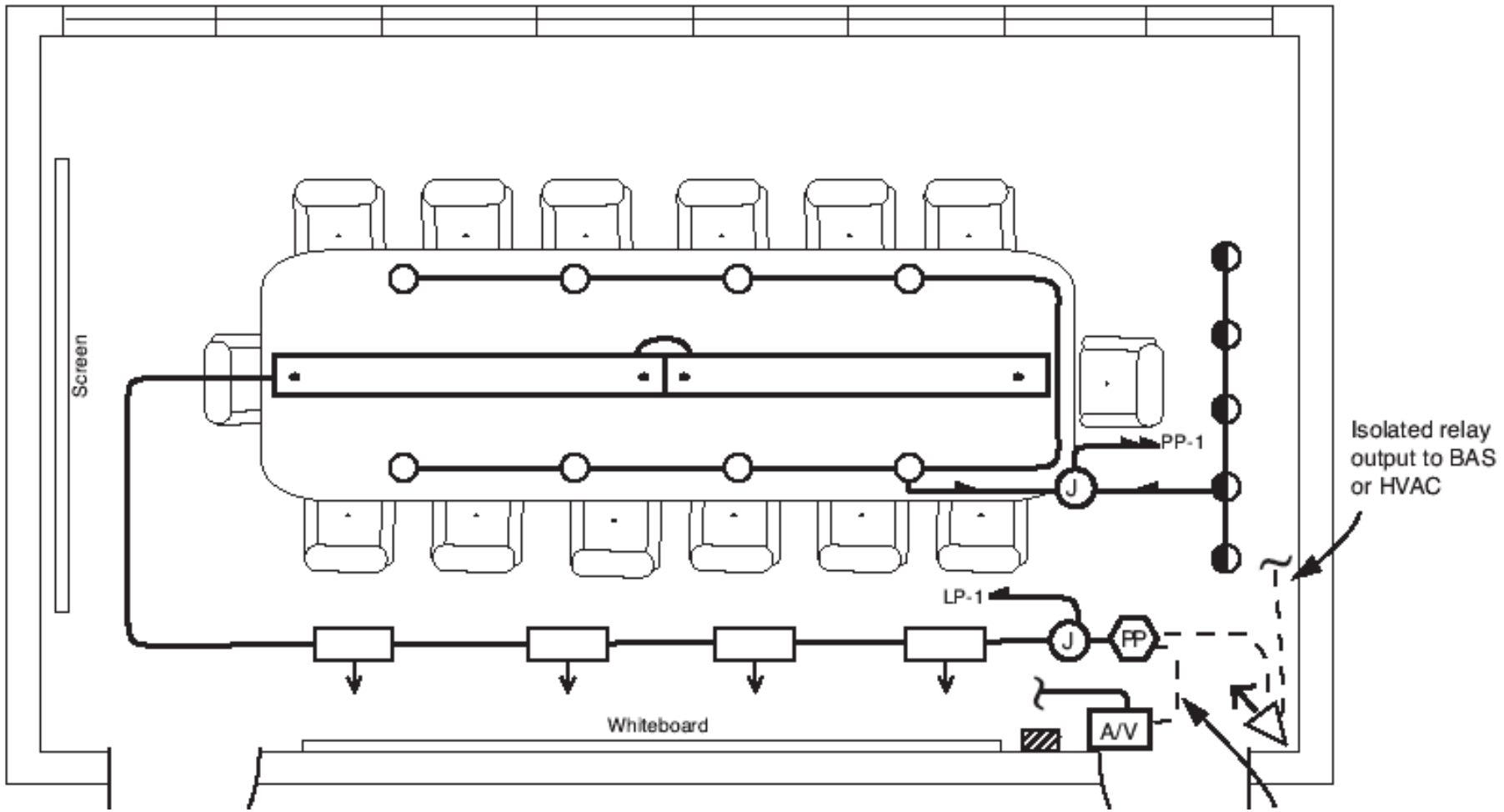
- Occupancy sensors must be installed in the following areas to shut off the lighting:
  - Offices 250 sq ft or smaller
  - Multipurpose rooms of less than 1000 sq ft
  - Classrooms of any size
  - Conference rooms of any size
- Controls must allow the lights to be manually shut off in compliance with §131(a) regardless of the sensor's status

Application – Conference Room
Occupancy sensor, Bi-level Switching, HVAC Interface



WattStopper
legrand

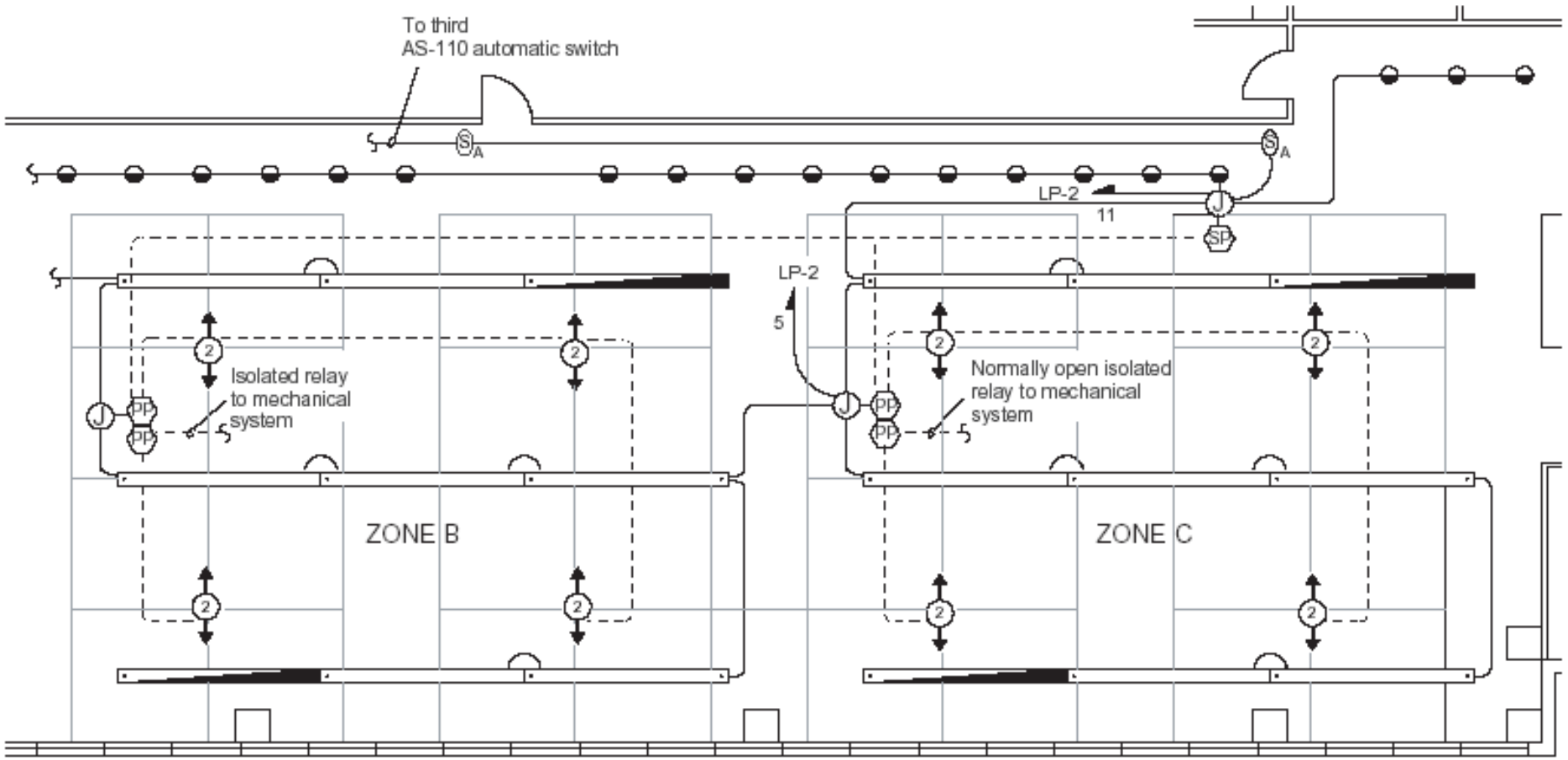
Application – Conference Room
Occupancy Sensor, Dimming Controls, HVAC Interface



WattStopper

legrand

Application Example – Open Office Occupancy Sensor, HVAC Interface



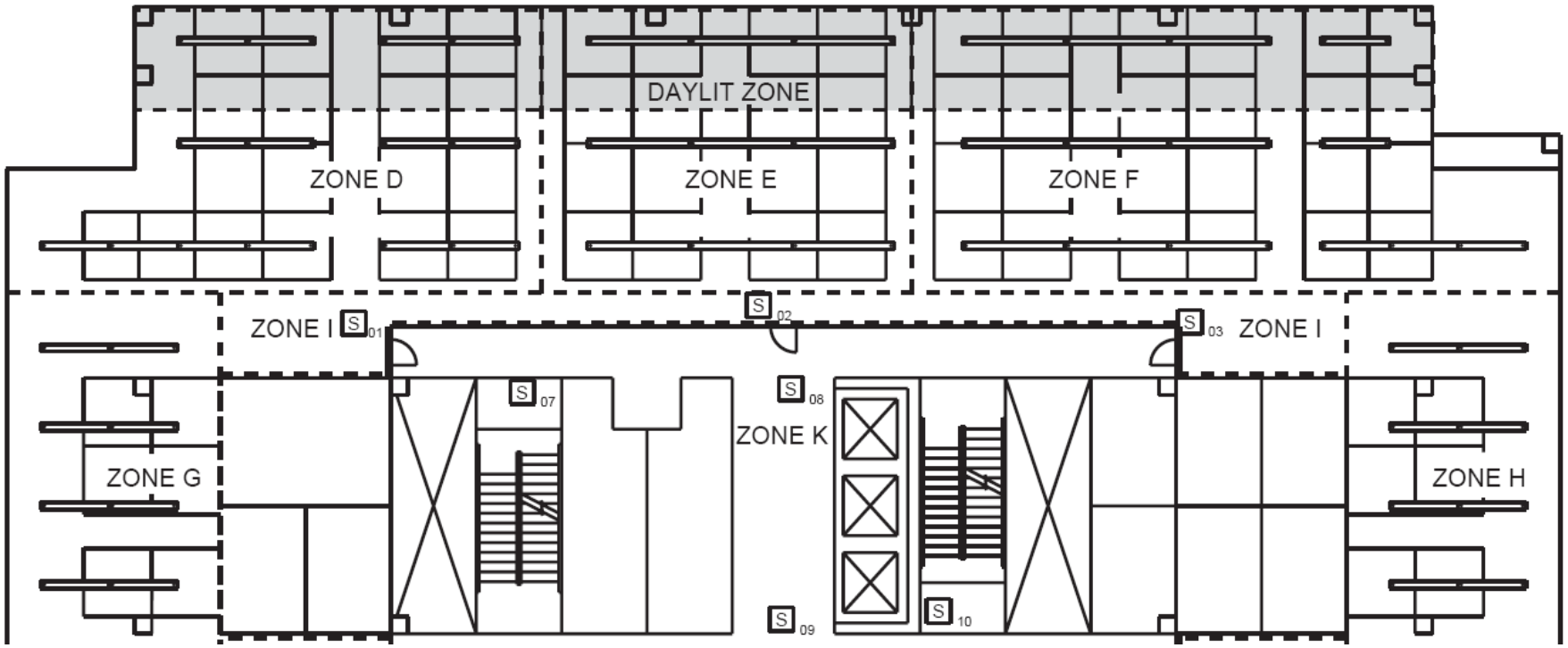
WattStopper

legrand

Auto Time Switch Shut-off Requirements

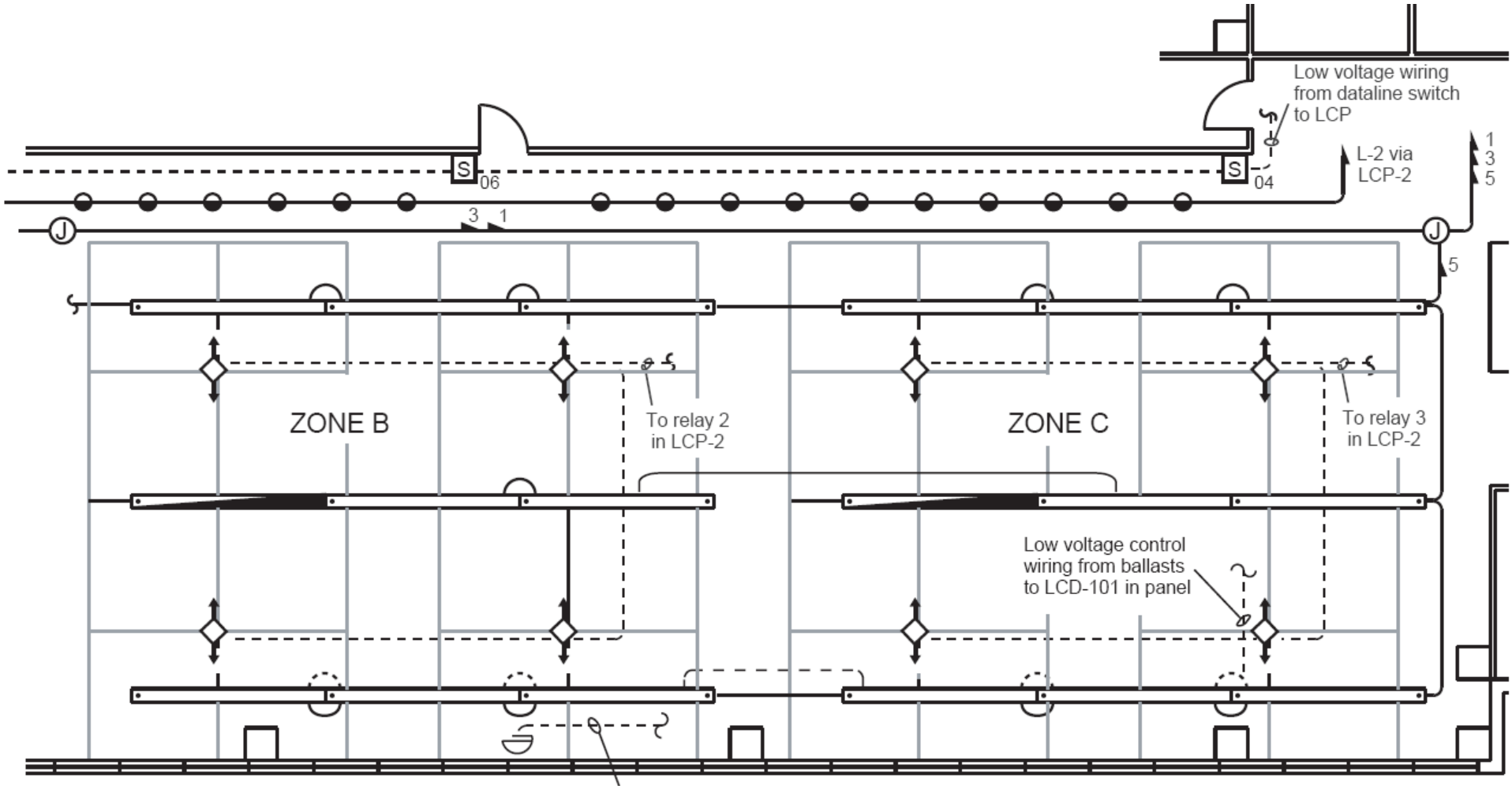
- Override switching device
  - Readily accessible, pilot or within eyesight of lamps controlled, manually operated
  - Allow override ≤ 2 hours
    - Malls, Single Tenant Retail, Auditoriums, Industrials, and Arenas allowed longer via captive key switches
  - Controls area enclosed by ceiling height partition ≤ 5,000 ft^2
    - Above Spaces and Convention Centers ≤ 20,000 ft^2
- Most sites require automatic holiday shutoff

Application Example – Open Office
Time Schedule, Daylighting



WattStopper
legrand

Application Example – Open Office
Time Schedule, Occupancy Sensor, Daylighting



WattStopper

legrand

Display Lighting

- Floor, wall, window, and case display lighting shall each be separately switched on circuits that are 20 amps or less

NEW

Demand Responsive Lighting Controls

- Demand responsive automatic lighting controls must be installed in Retail buildings with sales floor areas > 50,000 sq ft
- Controls must uniformly reduce lighting power consumption by 15%
- **Exception:**
  - Buildings where more than 50% of the lighting power is controlled by daylighting controls

Reduction of Wattage through Controls

- Controlled watts of lighting may be reduced by watts times the PAF Table 146C

NEW

- In the following areas multi-level occupant sensors used to qualify for the Power Adjustment Factor must comply with Section 119
  - Any space 250 ft or smaller enclosed by floor-to-ceiling partitions
  - Classroom of any size
  - Corridors of any size
  - Conference room of any size
  - Waiting room of any size

WattStopper

legrand

NEW

Lighting Power Adjustment Factors

Type of Control	Type of Space	Factor
Multi-level occupant sensor combined with multi-level circuitry and switching	Any space <250 sq ft enclosed by floor-to-ceiling partition; any size classroom, corridor, conference room or waiting room	0.2
Multi-level occupant sensor that reduces lighting power at least 50% when no persons are present. May be switching or dimming	Hallways of hotels/motels, multi-family, dormitory, and senior housing.	0.25
	Commercial & Industrial storage stack areas (max 2 aisles/sensor)	0.15
	Library Stacks	0.15
Manual Dimming System	Hotels/motels, restaurants, auditoriums, theaters	0.1
Multiscene programmable dimming system	Hotels/motels, restaurants, auditoriums, theaters	0.2
Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal	All building types	0.05
Manual dimming of dimmable electronic ballasts	All building types	0.15
Demand responsive lighting control that reduces lighting power consumption in response to a demand response signal when used in combination with manual dimming of dimmable electronic ballasts	All building types	0.15
Combined controls – multi-level occupant sensor combined with multi-level circuitry and switching combined with automatic multi-level daylighting controls	Any space ≤ 250 sq ft within a daylit area and enclosed by floor-to-ceiling partitions, any size classroom, corridor, conference room or waiting room. PAF may be added to daylighting control credit	0.10
Combined controls – manual dimming of dimmable electronic ballasts when used in combination with multi-level circuitry and switching	Any space ≤ 250 sq ft enclosed by floor-to-ceiling partitions; any size classroom, corridor, conference or waiting room	0.25

NEW

Lighting Power Adjustment Factors

Automatic multi-level daylighting controls (See Note 1)	Total primary sidelit daylight areas less than 2,500 ft² in an enclosed space and all secondary sidelit areas. (see Note ~~3~~4)		Effective Aperture			
		General Lighting Power Density (W/ft²)	>10% and <20%	>20% and <35%	>35% and <65%	> 65%
		All	0.12	0.20	0.25	0.30
	Total skylit daylight areas in an enclosed space less than 2,500 square feet, and where glazing material or diffuser has ASTM D1003 haze measurement greater than 90%		Effective Aperture			
		General Lighting Power Density (W/ft²)	0.6% < EA < 1%	1% < EA < 1.4%	1.4% ≤ EA < 1.8%	1.8% < EA
		LPD < 0.7	0.24	0.30	0.32	0.34
		0.7 < LPD< 1.0	0.18	0.26	0.30	0.32
		1.0 < LPD < 1.4	0.12	0.22	0.26	0.28
		1.4 < LPD	0.08	0.20	0.24	0.28

NOTES FOR TABLE 146-C:

1. PAFs shall not be available for lighting controls required by Title 24, Part 6.
2. To qualify for the PAF the multi-level occupant sensor shall comply with the applicable requirements of Section 119.
3. To qualify for the PAF all dimming ballasts for T5 and T8 linear fluorescent lamps shall be electronic and shall be certified to the ~~Energy~~ Commission with a minimum RSE in accordance with Table 146-D.
4. If the primary sidelit daylight area and the secondary sidelit daylight area are controlled together, the PAF is determined based on the secondary sidelit effective aperture for both the primary sidelit daylight area and the secondary sidelit daylight area.

WattStopper

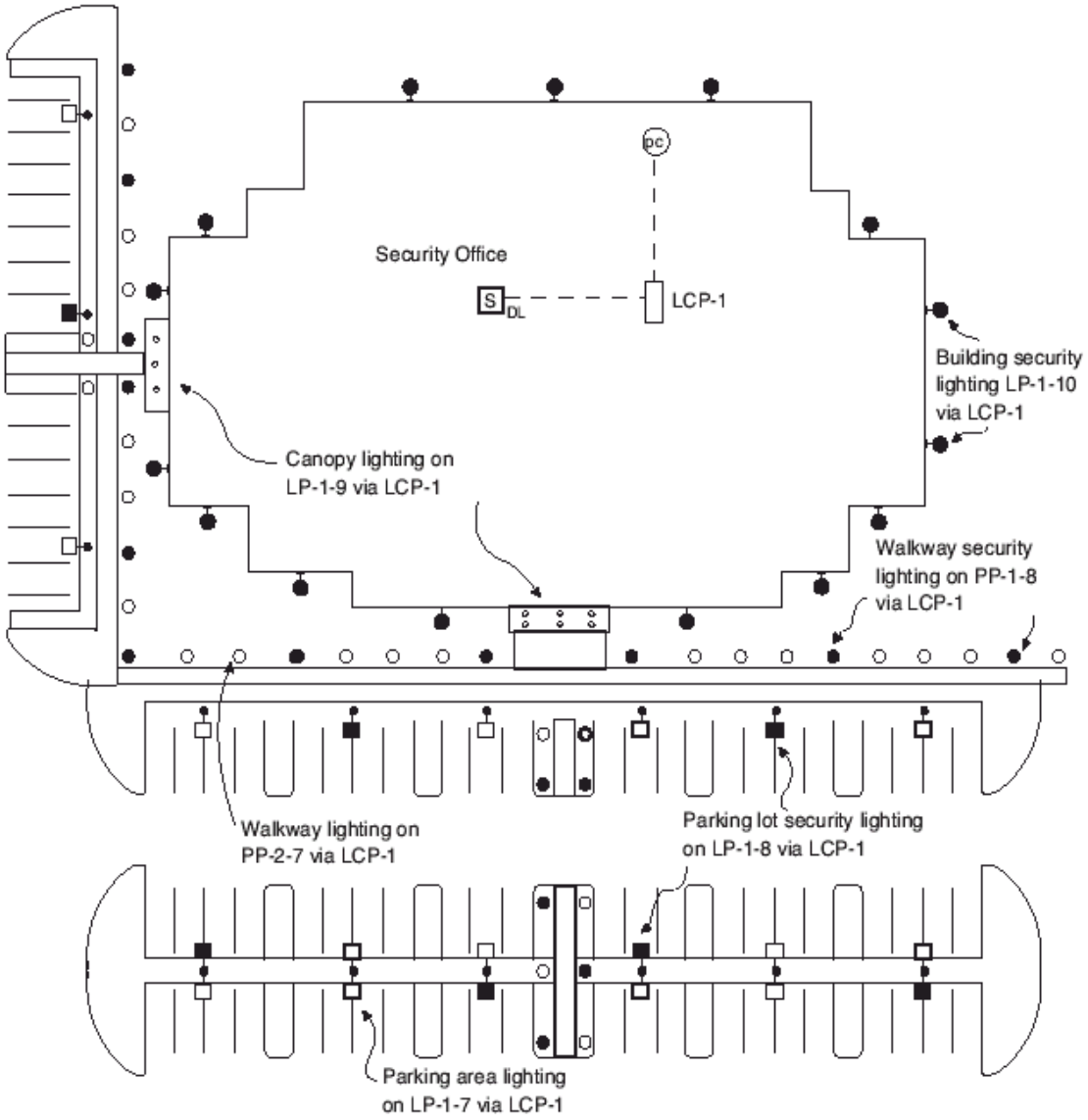
legrand

Exterior Lighting Controls

- Permanent outdoor lighting shall be controlled by photocell or astro time clock
  - Exceptions: Garages, tunnels, large covered areas.

- Building facades, parking lots, garages, sales & non-sales canopies, & outdoor sales areas with 2+ luminaires need automatic time switch
  - Turns Lights Off when not needed
  - Reduces power by 50-80%
  - Exceptions: Motion and photocell controlled lights, some stairs, health or life safety, temporary lighting, signs, or 24/7

Application Example – Exterior Lighting



WattStopper

legrand

New Section

Controls for all Signs

- Signs with permanently connected lighting
  1. Must have an Automatic Time Switch
  2. If an Outdoor sign, shall have a photocontrol or outdoor astronomical time switch controller
     - Exception for Outdoor signs in tunnels and large covered area the require illumination during daylight hours

WattStopper
legrand

New Section

Controls for all Signs (cont.)

3. All outdoor signs must have **dimmer** to automatically reduce sign power by a minimum of 65% during nighttime hours.
   - Exceptions
     - Signs illuminated for less than 1 hour per day during daylight hours
     - Outdoor signs in tunnels and large covered areas that require illumination during daylight hours
     - Metal halide, high pressure sodium, cold cathode, and neon lamps used to illuminate signs or parts of signs
     - Demand Responsive Electronic Message Center Control
     - EMC required by a health or life safety statue, ordinance, or regulation

Lighting Control Acceptance

- Mandates certification of lighting controls before occupancy permit granted
- Compliance with Part 6 requirements for plans, specifications, installation certificates, operating and maintenance info
- Acceptance testing performed on:
  - Automatic daylighting controls: §119, §131(c)2D,
  - Multi-level Astro: §119 and §131(d)2
  - Lighting Controls: §131(a)-(c), (e), (f) and §146(a)2D
  - Automatic Lighting Controls: §119 and §131(d)
  - Occupancy Sensors: §119 and §131(d)
  - Outdoor Lighting Controls: §119 and §132

Title 24 Resources

- http://www.energy.ca.gov/title24
  - Energy Efficiency Standards
  - Compliance Manual
- Hotline: 800-772-3300

California Energy Commission
Energy Standards Hotline

(916) 654-5106
or toll free in California
(800) 772-3300

HOURS:
Monday through Friday
8 a.m. to 12 p.m. and 1 p.m. to 4:30 p.m.

E-mail: title24@energy.state.ca.us

Questions???

Thank You