MANDATORY MEASURES
INDOOR LIGHTING CONTROLS

(Reference: Sub-Chapter 4, Section 130.1)
MANDATORY LIGHTING CONTROLS

1. 130.1 (a) Area Controls: Manual controls that control lighting in each area separately

2. 130.1 (b) Multi-level Controls: “Dimmability.” Allow occupants to choose the appropriate light level for each area

3. 130.1 (c) Shut-off Controls: Automatically shut off lighting or reduce light levels when illumination is not needed

4. 130.1 (d) Automatic Daylighting Controls: Adjust electric lighting in response to the presence of daylight

5. 130.1 (e) Automated Demand Response: Receive and automatically respond to demand response (DR) signals
MANUAL ON/OFF CONTROLS

An “area” is a space enclosed by ceiling-height partitions.

All lighting in each area must be controlled separately from luminaires in other areas by manual on/off lighting controls that are:

1. Readily accessible
2. Located in the same room or area as the lighting they control and with the lighting in view
3. Able to provide any required dimming or multi-level controls steps in addition to on/off
PUBLIC RESTROOMS

Any public restroom with two or more stalls may use a manual switch that is not accessible to unauthorized personnel. All other lighting controls are still required.
EGRESS LIGHTING

Reduced exception for egress lighting

**2008:** 0.3 W/ft$^2$ anywhere

**2013:** Maximum security and egress lighting allowance of **0.2 W/ft$^2$** when a building is occupied

- **General and egress lighting must be shut off** during unoccupied times
- **Exception:** Offices are allowed up to **0.05 W / ft$^2$** for lighting during unoccupied periods, but only along emergency egress areas designated on the building plans
MULTI-LEVEL LIGHTING CONTROLS

Title 24 sets a minimum number of control steps and illuminance uniformity requirements for most major luminaire types (see TABLE 130.1-A). These requirements are required *in addition to* any mandatory manual, daylight, shut-off, or demand response controls.

The criteria in 130.1 (b) applies to **general lighting** for enclosed areas that:

- Are at least 100 ft² in size
- Have a connected lighting load over 0.5 W/ft²
- Have more than one luminaire or more than two lamps
- Controlled lighting in daylit zones over 0.3 W/ft²
MULTI-LEVEL LIGHTING CONTROLS

Each luminaire must meet the multi-level control requirements. Controlling alternating luminaires or rows of luminaires does not meet the requirements.
# TABLE 130.1-A

<table>
<thead>
<tr>
<th>LUMINAIRE TYPE</th>
<th>MINIMUM REQUIRED CONTROL STEPS (%) of full rated power</th>
<th>UNIFORM LEVEL OF ILLUMINANCE ACHIEVED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-voltage sockets except GU-24</td>
<td>Continuous dimming 10–100%</td>
<td></td>
</tr>
<tr>
<td>Low-voltage incandescent systems</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>LED luminaires &amp; LED source systems</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>GU-24 rated for LED</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>GU-24 sockets rated for fluorescent &gt; 20W</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>Pin-based compact fluorescent &gt; 20W^2</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>GU-24 sockets rated for fluorescent ≤ 20W</td>
<td>Continuous dimming 20–100%</td>
<td></td>
</tr>
<tr>
<td>Pin-based compact fluorescent ≤ 20W^2</td>
<td>Minimum one step between 30–70%</td>
<td>Stepped dimming; or continuous dimming; or switching alternate lamps in a luminaire.</td>
</tr>
<tr>
<td>Linear &amp; U-bent fluorescent ≤ 13W</td>
<td>Minimum one step in each range:</td>
<td>Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of four lamps per luminaire, illuminating the same area and in the same manner.</td>
</tr>
<tr>
<td>Linear &amp; U-bent fluorescent &gt; 13W</td>
<td>Minimum one step in each range:</td>
<td>Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.</td>
</tr>
<tr>
<td>Track Lighting</td>
<td>Minimum one step between 30–70%</td>
<td>Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.</td>
</tr>
<tr>
<td>HID&gt;20W</td>
<td>Minimum one step between 50–70%</td>
<td>Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.</td>
</tr>
<tr>
<td>Induction &gt; 25W</td>
<td>Minimum one step between 50–70%</td>
<td>Stepped dimming; or continuous dimming; or separately switching circuits in a multi-circuit track with a minimum of two circuits.</td>
</tr>
<tr>
<td>Other light sources</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Full rated input power of ballast and lamp, corresponding to maximum ballast factor.
2. Includes only pin based lamps: twin tube, multiple twin tube, and spiral lamps.

*NOTE: Multi-level controls must not override the functionality of other controls required for compliance*
MULTI-LEVEL LIGHTING CONTROLS

In addition to meeting the dimmability requirements, each luminaire must also be controlled with one of the following strategies:

- Manual dimming
- Lumen maintenance
- Tuning
- Automatic daylighting
- Demand response
AUTOMATIC SHUT-OFF CONTROLS

Automatic shut-off controls turn lights off when a space is unoccupied. All lighting must be controlled by one or more of the following:

1. Occupant sensing control
2. Automatic time-switch
3. Building Energy Management System
4. Other control mechanism capable of automatically shutting off all lights for vacant periods

A single control may not monitor more than 5,000 ft$^2$
AUTOMATIC SHUT-OFF CONTROLS

In the following spaces, shut-off controls MUST be occupancy sensing:

1. Offices 250 ft\(^2\) or smaller
2. Multipurpose rooms smaller than 1,000 ft\(^2\)
3. Conference rooms of any size
4. Classrooms of any size
AUTOMATIC SHUT-OFF CONTROLS

Countdown timer switches may only be used in:
1. Single-stall bathrooms smaller than 70 ft\(^2\)
2. Closets smaller than 70 ft\(^2\)
3. Server rooms smaller than 500 ft\(^2\)

If time-based controls are used, occupants there after hours must be able to activate lighting as needed:
- Manual switch
- Temporary override
- Occupancy-based control
AUTOMATIC SHUT-OFF CONTROLS

Adaptive controls in secondary spaces

Controls for lighting in corridors and stairwells must be capable of:

- Partially reducing lighting power during hours of operation *in addition to*
- Providing full shut-off functionality when the building is vacant.
AUTOMATIC SHUT-OFF CONTROLS

Corridors and stairwells

- Sensors/controls should be activated from all potential entrances
- Minimum automatic 50% reduction in lighting power when vacant
- Exceptions for hospitality and residential applications
MIXED-USE BUILDINGS

For mixed-use buildings (e.g. high-rise residential, hotels, and motels) with a total interior common area that is greater than 20 percent of the floor area of that building, the common areas must comply with the Nonresidential Lighting Standards, while dwelling units must comply with the Residential Lighting Standards.
CASE STUDY: ADAPTIVE CORRIDOR LIGHTING

Bainer Hall, UC Davis (Davis, CA)

- Research conducted in spring 2011
- CLTC replaced or retrofit 4-lamp T8 fluorescent luminaires with three adaptive corridor lighting solutions from different manufacturers
- **Average energy savings: 73%**
  (based on an average occupancy rate of 18%)
CASE STUDY: ADAPTIVE CORRIDOR LIGHTING

Latham Square (Oakland, CA)

- In January 2012, CLTC installed adaptive (bi-level) lighting controls on 12 floors of the Latham Square office building
- 174 Luminaires retrofitted with 64W T8 fluorescents
- Average energy savings: 86%
- Cost savings over five-years: $23,803
AUTOMATIC SHUT-OFF CONTROLS

Spaces that are exempt from automatic shut-off controls requirements:

1. Buildings with lighting in continuous use 24 hours/day, 365 days/year
2. Areas where partial on/off controls are required instead of shut-off controls (such as stairwells and corridors)
3. Electrical equipment rooms
4. Emergency egress lighting
Automatic daylight controls adjust electric lighting power when ample daylight is available. “Ample daylight” is defined by the standards as 150% of the designed light level for electric lighting.

**Automatic daylighting controls are required for luminaires that:**

1. Provide general lighting
2. Are at least half in a skylit or sidelit area
3. Are in an area where the total installed general lighting power is at least 120 watts
4. Are located in an area which has at least 24 ft² of glazing
AUTOMATIC DAYLIGHTING CONTROLS

Automatic daylighting controls requirements:

1. Controlled lighting with an LPD greater than 0.3 W/ft$^2$ must have multi-level lighting in accordance with Table 130.1-A.

2. Controlled lighting + daylight must equal or exceed the controlled electric lighting level without daylight.

3. When there is ample daylight detected, the general lighting power in that space must be reduced by at least 65%.
CASE STUDY: DAYLIGHTING / INTEGRATED OFFICE LIGHTING

California National Guard Joint Force Headquarters (Sacramento, California)

- In the open office area, recessed T8 fluorescents were replaced with indirect/direct pendant luminaires
- **Integrated photosensors in luminaires along west and north perimeters**
- Ceiling-mounted zonal occupancy sensors
- LED undercabinet and desktop task lighting (6W or 9W)
- **Annual energy savings:** 50% or 16,400 kWh
- **Annual cost savings:** $2,100

Integrated Office Lighting System (IOLS) with luminaire-integrated photosensors along perimeters and occupancy sensors for ambient and task lighting
DEMAND RESPONSE

When the demand for electricity threatens to exceed supply, the power grid becomes less stable and the risk of outages increases.

Demand response (DR) programs allow end users to temporarily reduce their electricity use in response to a notice or automated signal sent from a utility, independent system operator (ISO) or other power provider.

This flexibility helps reduce peak demand and maintain grid stability. Currently, participating customers also receive financial incentives.
DEMAND RESPONSE

How DR Works
In traditional, non-automated DR programs, a local service provider sends notification of a pending DR event to facility managers, via e-mail, phone call or text message, requesting a reduction in electricity consumption for a limited period of time.

Auto DR
Automated demand response (ADR) programs make use of energy management technologies and controls to respond to DR events more quickly and reliably. The provider issues an automated DR signal to energy management control systems enrolled in ADR programs. The systems then automatically respond by reducing electricity use according to pre-programmed load shed strategies.
DEMAND RESPONSE

Lighting is extremely well-suited to DR
1. Peak demand periods typically overlap daylight hours
2. Research indicates illuminance levels can be reduced by as much as 20% without occupants detecting the change
3. Light levels can be immediately restored when DR events end

Buildings larger than 10,000 ft\(^2\) must be capable of responding to a DR signal by automatically reducing lighting power at least 15% below the total installed lighting power while maintaining the uniformity requirements listed in Table 130.1-A.

Spaces that use less than 0.5 W/ft\(^2\) and non-habitable spaces, such as storage closets, are exempt and cannot be counted toward ADR compliance.
What is a DR-capable system?
A DR system reduces electricity demand in response to a notice or automated signal from utilities, independent system operators or other power providers.

Manual DR
- Requires occupant to manually adjust lighting systems in response to a phone call, e-mail, system notification, etc.

Automatic DR
- The removal of human interaction from the process allows faster reaction to DR events.
- An electronic DR message will be broadcasted to energy management control systems when an electricity grid experiences high period of high demand or limited supply.
DEMAND RESPONSE DEVICES

Network adapter for zone based system

Ethernet cable
OR
Built-in

Control Panel

OR

Input 1
Input 2
Input 3
CHECK YOUR UNDERSTANDING: DEMAND RESPONSE

An 80,000 ft² building is being constructed. It will contain 10 tenant spaces, each 8,000 ft² in size. Do these tenant spaces need to comply with the requirements for automatic demand response?
CASE STUDY: ADAPTIVE CORRIDOR

UCSF Mount Zion Medical Center

- In 2013 SPEED installed three different lighting control systems in 3 separate corridors of the UCSF Medical Center
- Total: 50 two-lamp T8 fluorescent fixtures
- Bi-Level occupancy based dimming between 20% (Low Mode) and 70% (High Mode) on 50 2-Lamp T8 fixtures
- **Energy and CO₂E Savings: 53-68%**
CASE STUDY: LIGHTING TECHNOLOGY SHOWCASE

UCSB LED Retrofit

- Student Information Systems and Technology office
- Three open office spaces with cubicles
- 58 2'x2' 56W recessed fluorescent replaced by 58 dimmable LED
- Monitored from May to October 2013
- Occupancy rate: 28%
- Reduced energy use by 89%
- Annual energy savings estimate: 11,500 kWh
- Lifetime energy cost savings: $315 per fixture based on UCSB rate of $0.11/kWh
SUMMARY OF MANDATORY LIGHTING CONTROLS

DISCUSSION: What types of controls will office spaces typically require?

1. **Manual controls**
   What needs to be switched separately?

2. **Automatic shut-off controls**
   Where are they required?

3. **Automatic daylighting controls**
   Which lighting systems must comply?

4. **ADR**
   When a signal is received, what should occur?
PARKING GARAGES

Parking garages are considered **interior** nonresidential spaces, except for the top level of each multi-tier garage.

- General lighting must have occupant sensing controls with at least one control step between 20% and 50% of design lighting power
- No more than 500 watts of rated lighting power may be controlled together
- Parking garage areas with at least 36 ft$^2$ of glazing or opening must have automatic daylighting controls
DAYLIGHT CONTROLS EXEMPTIONS IN PARKING GARAGES

Luminaires in the following areas do not need to use photocontrols:

**Daylight transition zone:** The pathway vehicles use to enter a parking garage.

**Dedicated ramps:** Driveways specifically meant to move vehicles between the floors of a parking garage and which have no adjacent parking.

**Some sidelit zones:** If the primary sidelit zone uses less than 60W of lighting power, the combined primary and secondary sidelit zones do not require daylight controls.
## CASE STUDY: SAN MARCOS CIVIC CENTER PARKING GARAGE

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>SYSTEM SIZE (W)</th>
<th>ANNUAL ENERGY CONSUMPTION (kWh)</th>
<th>ANNUAL ENERGY COST</th>
<th>ANNUAL MAINTENANCE COST</th>
<th>TOTAL ANNUAL COST</th>
<th>LIFE-CYCLE ENERGY COST</th>
<th>LIFE-CYCLE MAINTENANCE COST</th>
<th>TOTAL LIFE-CYCLE COST \ TOTAL LIFE-CYCLE COST FOR ALL FIXTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPS</td>
<td>210</td>
<td>1,840</td>
<td>$235</td>
<td>$25</td>
<td>$260</td>
<td>$2,688</td>
<td>$280</td>
<td>$2,968</td>
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<tr>
<td>HPS PERIMETER</td>
<td>210</td>
<td>920</td>
<td>$118</td>
<td>$25</td>
<td>$142</td>
<td>$1,344</td>
<td>$280</td>
<td>$1,624</td>
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<tr>
<td>LED CANOPY 7 (Low)</td>
<td>70 (High)</td>
<td>354</td>
<td>$45</td>
<td>$0</td>
<td>$45</td>
<td>$517</td>
<td>$0</td>
<td>$517</td>
</tr>
<tr>
<td>LED CANOPY PERIMETER 7 (Low) 70 (High)</td>
<td>177</td>
<td>$23</td>
<td>$0</td>
<td>$23</td>
<td>$258</td>
<td>$0</td>
<td>$259</td>
<td>$1,809</td>
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<td>HPS TOTAL</td>
<td>2,760</td>
<td>$353</td>
<td>$50</td>
<td>$402</td>
<td>$4,032</td>
<td>$560</td>
<td>$4,592</td>
<td>$58,856</td>
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<tr>
<td>LED TOTAL</td>
<td>531</td>
<td>$68</td>
<td>$0</td>
<td>$68</td>
<td>$775</td>
<td>$0</td>
<td>$776</td>
<td>$10,081</td>
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<tr>
<td>SAVINGS</td>
<td>2,229</td>
<td>$285</td>
<td>$50</td>
<td>$334</td>
<td>$3,257</td>
<td>$560</td>
<td>$3,816</td>
<td>$48,775</td>
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