




Lighting Design Lab








Code Compliant Lighting Controls

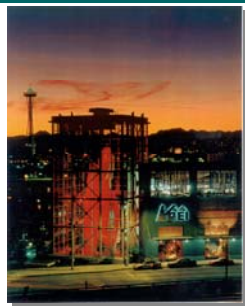
COOPER Controls Jeff Robbins, LC
 TRIDONIC.ATCO jeff@lightingdesignlab.com
 SQUARE D LEVITON Universal
 by Schneider Electric sensor switch WattStopper
 logand

lightingdesignlab.com

Today's Agenda



- Energy Savings**
 - Lights turned down or off when not required saves electricity, reduces greenhouse gas emissions, and saves money.
- Maintenance Savings**
 - Turning of lighting when not required can extend lamp life and lower maintenance costs.
- Productivity Gains**
 - Tuning lighting to appropriate levels can increase visibility and enhance worker productivity.
- Employee Satisfaction**
 - Accessible lighting controls allow employees more control over their working environment.
- Energy Code Compliance**
 - Energy codes now **REQUIRE** the use of lighting controls.



REI Flagship - Seattle 4

But First ...




Did you fill out Andrew's Evaluation Form?

lightingdesignlab.com 2

Typical Savings





Table 8-4 – Lighting Control Energy Savings Examples by Application and Control Type


Space Type	Controls Type	Maximum Expected Yearly Energy Savings
Private Office	Occupancy sensor	45%
	Sidelighting w/photosensor	35%
	Manual dimming or multilevel switching	30%
Open Office	Sidelighting w/photosensor	40%
	Occupancy sensor	35%
Classroom	Multilevel switching	15%
	Sidelighting w/photosensor	40%
	Occupancy sensor	25%
Grocery Store	Adaptive compensation	15%
	Toplighting w/photosensor	40%
Big Box Retail	Toplighting w/photosensor	60%
	Bilevel switching	10%

Advanced Lighting Guidelines 5

What's to be Gained?




- Energy Savings**
 - Lights turned down or off when not required saves electricity, reduces greenhouse gas emissions, and saves money.
- Maintenance Savings**
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- Productivity Gains**
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 - Accessible lighting controls allow employees more control over their working environment.
- Energy Code Compliance**
 - Energy codes now **REQUIRE** the use of lighting controls.



Edison Middle School – Branford, CT
Courtesy: Sensor Switch

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Today's Energy Codes



ALL Energy Codes now include lighting control requirements, but may vary by jurisdiction.

Typical Requirements:

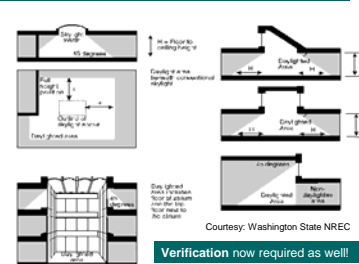
- User accessible controls
- Automatic shutoff controls**
- Occupancy Sensing**
- Time of Day Scheduling
- Maximum Zone control areas

Daylight Zone Control:

- Separate Control Zoning
- Bi-Level Switching/Dimming**
- Automatic Dimming**

Exterior Lighting:

- Photocell Control
- Time Clock Shutoff



Verification now required as well!
Courtesy: Washington State NREC

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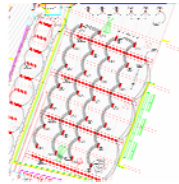


Energy Code Compliance

A 2007 study by Zing Inc. surveyed 11,000 architects, EE's, designers and contractors. The results suggest:

- 80% compliance rate across all respondents!
- Jurisdictions likely to require code compliance documentation prior to permit.
- Local building dept./individual, likely to interpret code, approve its application, and verify compliance.

- 10% of the time, inspections do not occur.
- VE, initial costs, and lack of enforcement are most significant barriers to compliance.



Courtesy: Lighting Controls Association

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Montana State Energy Code

Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Automatic Shutoff Controls:

- * Buildings greater than 5000 ft.²
- * Offices greater than 2000 ft. contiguous
- * Offices less than 300 ft.² **MUST** have Occupancy Sensors
- * Controls may be any automatic device



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ASHRAE 90.1 / IECC



Latest version is 2007
Next version due this year!

Current version is 2009
Next version 2012



Code Changes under Consideration

- * Occupancy Sensors must be programmed in **MANUAL ON** mode, or if (2) circuit, second circuit must reduce light output by 50%.
- * Occupancy Sensors in Parking Garages must reduce light output in unoccupied spaces by 30%, though 50% is also being proposed, as is the case in enclosed Staircases.
- * **Daylight Zones** will be redefined as being one window height into the space. Other definitions for spaces being top-lighted will likewise be more stringent.

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Montana State Energy Code

Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Local Shutoff Controls:

- * At least 1 Local Shutoff per 2000 ft.² of lit area
- * 1 Local Shutoff for walled spaces, or full height partitioned spaces



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Montana State Energy Code

As of 4-8-10: Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Highlights pertaining to controls:

- * Automatic Shutoff Controls
- * Local Shutoff Control
- * Occupancy Sensors
- * Time Switches
- * Daylighting Controls
- * Exterior Lighting



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Montana State Energy Code

Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Occupancy Sensors:

- * Must turn lights off **no more than 30 minutes** after vacancy
- * Must include wall mounted manual override switch



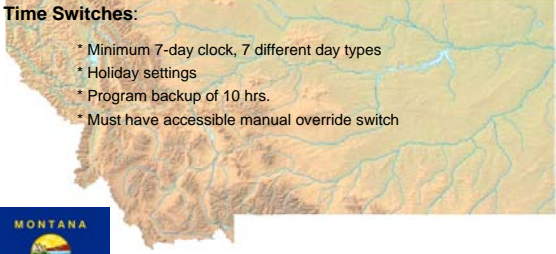
12

Montana State Energy Code

Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Time Switches:

- Minimum 7-day clock, 7 different day types
- Holiday settings
- Program backup of 10 hrs.
- Must have accessible manual override switch




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Lighting Controls

THE BASICS

- Typical Controls Strategies
 - Scheduling
 - Daylight Dimming
 - Task Tuning
 - Adaptive Compensation
 - Lumen Maintenance
 - Occupancy Sensing
- Controls Equipment
 - Occupancy Sensors
 - Sensors / Timers
 - Photo-Cells
 - Dimmers
 - Whole Building Systems
- Typical Examples
 - Offices
 - Classrooms / Library
 - Big Box Retail



Montana State University
Billings, MT

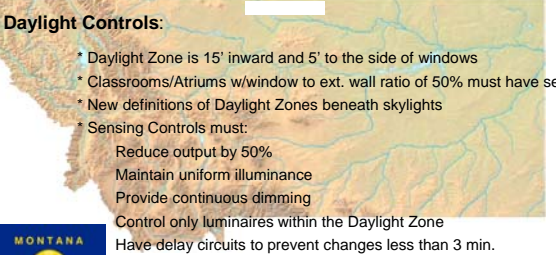
16

Montana State Energy Code

Based on IECC 2009 w/ Ref. to ASHRAE 90.1-2007

Daylight Controls:

- Daylight Zone is 15' inward and 5' to the side of windows
- Classrooms/Atriums w/window to ext. wall ratio of 50% must have sensors
- New definitions of Daylight Zones beneath skylights
- Sensing Controls must:
 - Reduce output by 50%
 - Maintain uniform illuminance
 - Provide continuous dimming
 - Control only luminaires within the Daylight Zone
 - Have delay circuits to prevent changes less than 3 min.



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Occupancy Sensing

Automatically turn lights on, or **OFF** when spaces are unoccupied.

Most appropriate for:

- Classrooms
- Offices
- Restrooms
- Storage spaces
- Almost any spaces in which occupancy is *infrequent* or *irregular*.

Results:

- Energy Savings
- Convenience
- Energy Code compliance!



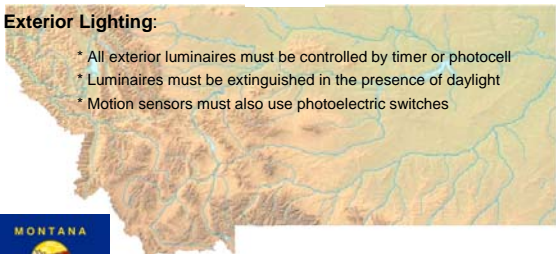
17

Montana State Energy Code

Based on IECC 2009 w/Ref. to ASHRAE 90.1-2007

Exterior Lighting:

- All exterior luminaires must be controlled by timer or photocell
- Luminaires must be extinguished in the presence of daylight
- Motion sensors must also use photoelectric switches



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Occupancy Sensors

Characteristics:

- Generally ceiling mounted, or as replacement for wall switches.
- Many versions, including dual circuit, and **wireless!!!**
- Intelligence, (traffic pattern memory!)

Considerations:

- Required in ALL code jurisdictions
- Many configurations possible
- Types of areas to be controlled will dictate sensor selection
- Must be commissioned and calibrated



Courtesy: Sensorswitch, Unico

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Occupancy Sensors

The Basic Technologies:

Passive Infrared


- Passively scans the field of view for moving heat sources.
- Must have line of sight to function
- Generally used in smaller, open areas
- Great for offices and classrooms

Ultrasonic

- Emits high frequency sound waves and measures return waves for Doppler shift.
- Does not need line of sight to function
- Generally used in larger or obstructed areas
- Great for restrooms
- May have problems in areas with heavy airflow
- Micro-phonics option

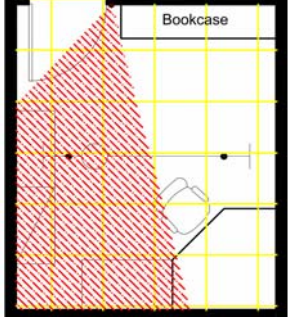
Dual Technology

- Uses two technologies to maximize sensing capabilities.



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Wall Mounted Occupancy Sensors



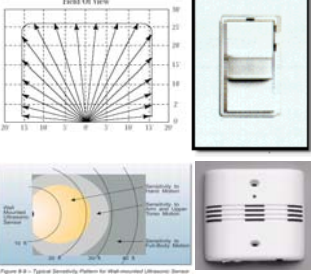
This PIR wall switch has been positioned to look into the room rather than out the door, minimizing the possibility of false triggers. Nothing is obstructing the sensor's view and it faces the front of the worker.

Courtesy: Wattstopper

Wall Mounted Occupancy Sensors

Characteristics

- Replaces the standard wall switch.
- May be *automatic* or *manual* on. **Manual on will result in the greatest savings!**
- Consult product spec sheets for effective *coverage area* and *field of view*.
- May control the circuit(s), or use low voltage data wire to provide input to a larger system.
- Some sensors also incorporate an integral fluorescent dimmer.



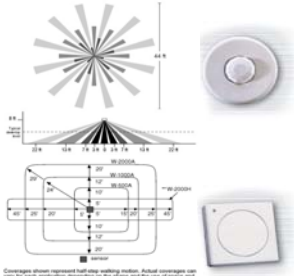
20

Courtesy: Lightolier, Mytech

Ceiling Mounted Occupancy Sensors

Characteristics:

- May directly control lighting circuits or use low voltage data wire to provide input to a larger system.
- May require a remote relay pack to control lighting directly.
- Consult product spec sheets for effective coverage area and field of view.
- Larger coverage areas.
- Can be *wireless!*



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Courtesy: Wattstopper, Advance Lighting Guidelines

Wall Mounted Occupancy Sensors

Fresnel lens sees all!
(Or does it?)

Operational Modes:


For, 'VACANCY' sensing*, preferred mode is –

Auto ON / Auto OFF

Operational Modes:

For max. energy savings and user acceptance, preferred mode is –

Manual ON / Auto OFF



N.B. these can be dual circuit, and wireless!

Time-out delay, and sensitivity range adjustment are located behind face plate

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*Code in some jurisdictions

Daylighting

Use daylight to reduce reliance on electric sources.


More than 90% of commercial space is single story, directly under a roof, or within **15' of a window wall**.

Now by code, most of this commercial space must be equipped with automatic daylight balancing controls.

Daylighting requires careful integration of light and architecture.

Effective Strategies:

- Automatic dimming controls
- User managed shading devices
- Automatic Bi-level switching controls
- Astronomic Time Scheduling



The 'Old' Daylight Zone

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Step Switching

Configures luminaires with 2 or more switched circuits.

- Characteristics:**
 - Simple
 - Easy to Understand
 - May be used with an Occupancy Sensor
- Considerations:**
 - All lamps frequently left on
 - Installed cost may be equivalent to dimming!**
 - May alter light distribution

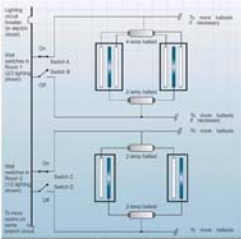
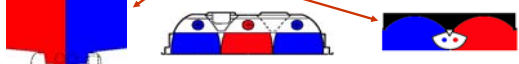


Figure B-3 - Bi-level Switching in Typical Office Application



25

Courtesy: Advanced Lighting Guidelines, Lithonia, Focal Point

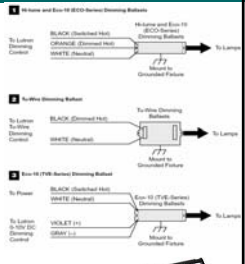
Fluorescent Dimming

Considerations:

- Specific Dimming Ballasts are required for continuous dimming control
- Energy Saving ballasts typically dim to 5-10%
- Architectural ballasts typically dim to 1%
- Control interface types vary - the ballast and control device must be coordinated to ensure proper function.
- Most dimming ballasts will be controlled by a 0-10v low voltage control signal, or by a three wire system using a dimmed leg, a switched leg, and a neutral.
- DALI (More on this later!)**

Note:

Dimming costs have dropped significantly in recent years. In many applications, the installed cost of dimming vs. bi-level switching are **equivalent!**





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Courtesy: Lutron Electronics


Bi-Level Switching

Configures luminaires normally, using bi-level ballasts.

- Characteristics:**
 - Reasonably simple to operate
 - Reasonably easy to understand
 - May be used with an Occupancy Sensor
 - *1 or 2 circuit**
- Considerations:**
 - Wall switch configured for 2 levels
 - Installed cost may be equivalent to dimming!**
 - Light distribution unaltered

100% light level



50% light level

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H. I. D. Lamps





Characteristics:

- Easiest to use with scheduled control strategies.
- May be dimmed* or bi-level switched.

Considerations:

- Lamps require warm up and re-strike time, so do not respond well to standard Occupancy Sensors
- Lamps may be used with relays or occupancy sensors and ballasts designed for bi-level switching.

**HID dimming is possible because of new electronic ballasts, is getting easier, but is currently very expensive, requires dimming ballasts, and may affect the perceived color temperature of the lamp.*

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Courtesy: Philips, Widelite


Fluorescent Lamps

Characteristics:

- May be used with all controls strategies.
- All lamps require a ballast for use.

Considerations:

- Switching Control**
 - Ballasts are generally rapid start, instant start, or programmed start types.
 - Programmed start ballasts seem to perform best when used with occupancy sensors.
- (Instant Start lamps now good with sensors)*
- Bi-level switching control within a luminaire requires either separate ballasts for separate control circuits, or step switching.





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Courtesy: Philips

Let's Take a Break!

And now would be a good time to make sure, (if you haven't already) you've signed in!

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Daylight Controls


Automatic photo-sensing control devices raise or lower lighting levels according to daylight contribution.

Characteristics:

- Full range dimming or multi-level switching
- May be a discrete system, or tie into a comprehensive control system
- Energy savings and light balancing
- **Now available in wireless!**

Considerations:


- Lighting must be properly zoned to maximize benefits
- Dimming is generally preferable to switching for user satisfaction



University of Montana Rec Center
DT Architects 31

Open Loop

So where are the sensors?



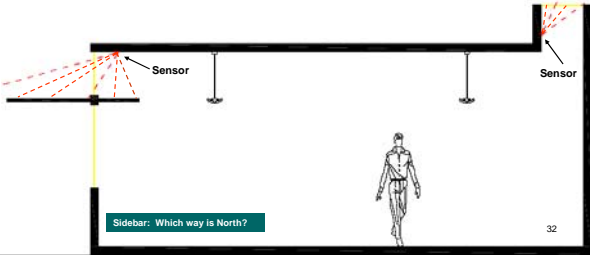
Toplighted gymnasiumToplight is easier to controlToplighted grocery store

34

Open Loop

Open Loop sensors register **available daylight only**.

- Easier to Commission
- Less precise than Closed Loop
- Better performance with top light than side light



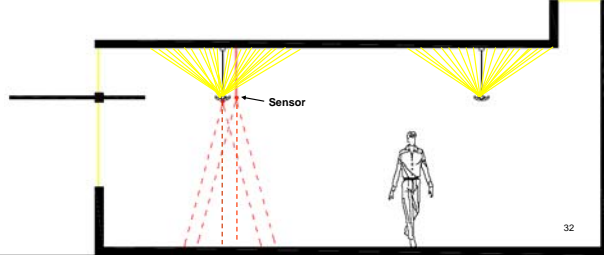
32

Sidebar: Which way is North?

Closed Loop


Closed Loop sensors look for **available daylight and electric light** on a workplane.

- More difficult to Commission
- More precise though **NOT** full proof.



32

Open Loop



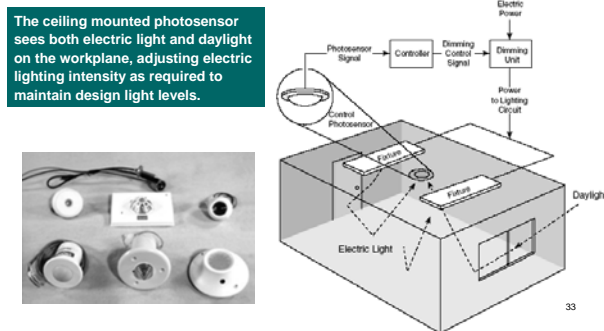
Lane County Mental Health
Eugene, OR
Balhizer Hubbard Engineers

Effective where daylight contribution is liable to be modified

33



Closed Loop

The ceiling mounted photosensor sees both electric light and daylight on the workplane, adjusting electric lighting intensity as required to maintain design light levels.



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Example - Closed Loop

Ash Creek Middle School
Independence, OR
Boora Architects

Where's the sensor?

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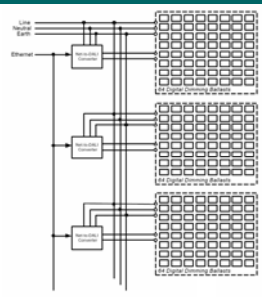
D. A. L. I.

Digitally Addressable Lighting Interface:

- Open Source Standard (IEC 62386)
- Each device has a unique address
- Photocells / occupancy sensors, etc.
- Provides maximum flexibility
- Demands maximum commissioning
- Dimming
- Desk top control

Energy management software allows:

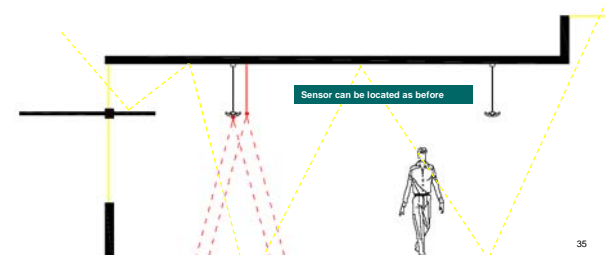
- Lumen Maintenance
- Scheduling
- Data Logging
- Load Shedding



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Dual Loop

Uses a Closed loop sensor that *references* an Open Loop sensor to determine if changes to the Closed Loop sensor are from daylight, or from changes in the space.



Sensor can be located as before

35

D. A. L. I.

Typical Wiring Diagram:

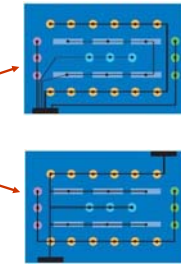
Control of Lighting 'Zones' limited by line-voltage wiring patterns

This space limited to 5 control 'Zones'

This space now has the potential for 27 Control 'Zones'

D.A.L.I. Wiring Diagram:




Each device addressed uniquely
No limit to Lighting 'Zone' definitions
Each luminaire can be controlled separately



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Examples - Dual Loop

Sensors are self-commissioning. Object is to solve the short comings of Closed and Open Loop technologies by combining them.

CLTC test site simulating an infinite space

Big Box retail, ideal application for Dual Loop

Dual Loop system installed at Wal-Mart

Courtesy: CLTC

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D. A. L. I.

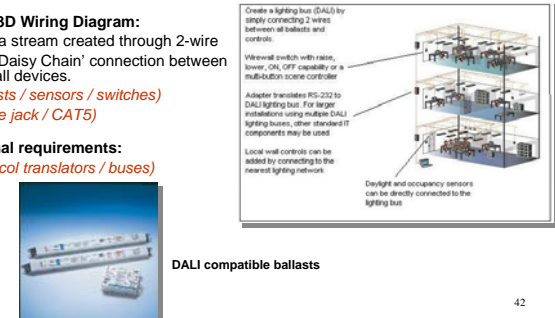
Typical 3D Wiring Diagram:

Data stream created through 2-wire 'Daisy Chain' connection between all devices.

(Ballasts / sensors / switches)
(Phone jack / CAT5)

Additional requirements:

(Protocol translators / buses)



DALY compatible ballasts

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Building Management Systems

Comprehensive Building Controls

Characteristics:

- Can be stand alone or fully integrated.
- Can be a scaleable digital system.
- Can incorporate scheduling capability
- Can accept input from occupancy sensors, photo-controllers, and other systems
- Can include Astronomic Time Clock

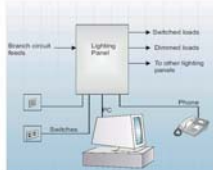


Figure 9-29 - Circuit Diagram for EMS-Based Scheduling, Large Building

Considerations:

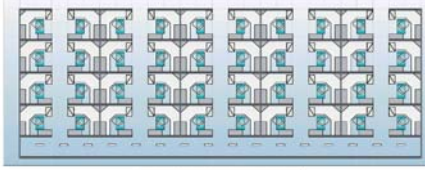

- Can require considerable commissioning
- Coordinate digital protocol - LON, BacNet
- Home run circuiting may be required for each control zone

Courtesy: Advanced Lighting Guidelines 43

Application Example - Open Plan Office

Typical Controls:

- Daylight Dimming
- Occupancy Sensors
- Sweep Control





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System Commissioning

Lighting Systems *must* be Commissioned

Commissioning is defined as "a systematic process of ensuring that all building systems perform interactively according to documented design intent and the owner's operational needs"




Advanced Lighting Guidelines

Montana State University
Billings, MT 44

Application Example - Classroom

Typical Controls:

- Daylight Dimming
- Occupancy Sensors
- Manual Dimming




Strawberry Vale School
Patkau Architects 47

System Commissioning

Typical Commissioning Items:

- Calibrate Occupancy / Daylight Sensors
- Calibrate Lumen Maintenance Levels
- Program Time of Day Scheduling
- Program Preset Dimming Scenes
- Interface with BMS / Fire / Security
- Interface with AV systems
- Program User PC Controls

Explain and Demonstrate System Functions and Programming to Owners and occupants!!


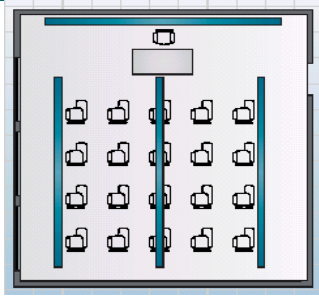


45

Application Example - Classroom

Typical Controls:

- Daylight Dimming
- Occupancy Sensors
- Manual Dimming

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Application Example - Library

Poor Daylight Control:

•Luminaires are turned off rather than dimmed resulting in excessive contrast between dark ceiling plane and bright glazing

•24 Hour "emergency" circuit produces an unfortunate patchwork of lit versus unlit surfaces



Spokane Public Library

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Low Bay Luminaires

Typical Controls:

- Occupancy Sensors
- Sweep Control
- Daylight Multi-level switching

•Note: Multiple lamp compact fluorescent sources were used to simplify multi-level lighting approach while maintaining "low bay" lighting approach.

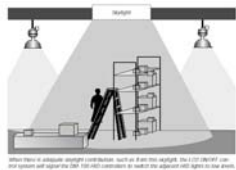
•Linear fluorescent luminaires may have been a better choice for lowered cost and maintenance.



52



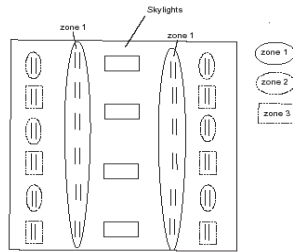
Application Example - Warehouse



Typical Controls:

- Occupancy Sensors
- Daylight Multi-level switching

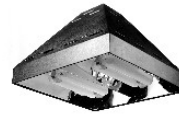
•Note: Using fluorescent sources will simplify controls and lead to improved lighting quality while decreasing energy consumption in most industrial applications.



50



Low Bay Luminaires



Inductive fluorescent lamps may be used to provide low bay lighting that is "instant on/off" simplifying use of occupancy sensors.



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Application Example - Factory



Which way is north?

Typical Controls:

- Occupancy Sensors
- Sweep Control
- Daylight Multi-level switching

•Note: Here too, using fluorescent sources will simplify controls and lead to improved lighting quality, while decreasing energy consumption in most industrial applications.



Jorgenson Forge
Seattle, WA

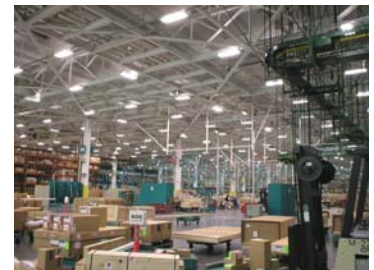
51



High Bay Luminaires



T5 HO and 'High Performance' T8 fluorescent lamps may also be used to provide high bay lighting that is "instant on/off" simplifying use of occupancy sensors.



Boeing - Seattle

54

Application Example - Alaska Distributors

CK-100-3
Two sided ambirelay

55

Vertically Integrated Luminaire Systems

Courtesy: Ledalite, B.C. Hydro

Scenario	Energy Consumed (%)
Typical recessed layout - no controls	100%
Direct-indirect layout - no controls	60%
Ergolite - full controls	22%

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Application Example - Alaska Distributors

Inductive fluorescent luminaires may be used to provide low bay lighting in cold storage areas that is "instant on/off" simplifying use of occupancy sensors.

Courtesy: 1st Source

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Lighting Controls Resources

Institutions:

- Illuminating Engineering Society: ies.org
- Lighting Controls Association: aboutlightingcontrols.org
- Lighting Research Center: irc.rpi.edu/
- Energy Design Resources: energydesignresources.com
- Lawrence Berkeley Labs: eetd.lbl.gov/http/lslr/index.html
- Digital Addressable Lighting Interface: dali-ag.org/

Some Equipment Manufacturers:

- Colortran: colortran.com
- Douglas: douglaslightingcontrol.com
- ETC: etcconnect.com
- L&L: lightingcontrols.com
- Leviton: leviton.com
- Lightolier Controls: lolcontrols.com
- Lithonia: lithonia.com
- Lutron Electronics: lutron.com
- Novitas: novitas.com
- Sensorswitch: sensorswitch.com
- Payne Sparkman: paynesparkman.com
- Unenco: unenco.com
- Wattstopper: wattstopper.com

Some Dimming Ballast Manufacturers:

- Advance: advancetransformer.com
- ESI: esavings.com
- Holophane: holophane.com
- Lutron: lutron.com
- Osram: sylvania.sylvania.com
- Payne Sparkman: paynesparkman.com
- Widelite: widelite.com

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Application Example - Big Box Retail

Wal-Mart, Lawrence Kansas, reported "significantly higher" sales in the skylit part of the store.
The Wall Street Journal, Nov. 20, 1995

- Most retail ambient lighting systems are linear fluorescent.
- Daylighting controls including stepped switching and dimming can significantly decrease energy usage.
- Electricity saved is during peak demand times when kWh charges can be many times higher than off peak.

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Additional Resources

Northwest Energy Efficiency Alliance: www.nwalliance.org

Northwest Energy Education Institute: www.nweei.org

Energy Ideas Clearinghouse: www.energyideas.org

US Green Buildings Council: www.usgbc.org

Institute for Research in Construction: www.nrc.ca

Lighting Research Center: www.lrc.rpi.edu

Electric Power Research Institute: www.epri.com

US EPA Energy Star: www.energystar.gov

Whole Building Design Guide: www.wbdg.org

Light Forum: www.lightforum.com

Text Material:

Lighting Controls Handbook
Craig DiLouie
Fairmont Press 2008

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