

OFFICE LIGHTING

The Value of Lighting Quality
 Lighting Fixture Specifications
 Lighting Controls for Offices

Private Office Layouts
 Open-plan Office Layouts
 Office Corridor Layouts



OFFICE LIGHTING

knowhow

This guide gives you the KnowHow to provide "energy effective" lighting for offices –

lighting systems that save energy while creating a comfortable and productive work environment.

Energy conserving lighting products are common, but not all products are appropriate for all applications. Lighting fixtures and controls must be carefully selected and

adequate quantity of light (measured in footcandles) is not enough. Lighting quality means comfort, good color, uniformity and balanced brightness relationships – factors that contribute to long term work performance. Shadows, glare, flicker or chaotic patterns of light or fixtures are distracting to employees and should be avoided.

PENNY WISE AND POUND FOOLISH

Employees' salaries are the costliest part of running a business. If poorly designed lighting distracts the average occupant for only 1% of the time, this is equivalent to a \$5 per square foot annual loss. Good quality lighting is an essential part of occupant comfort



Photo courtesy of Linear Lighting Corporation

In open-plan offices, lighting the walls and ceiling provides a major improvement in lighting quality.

and satisfaction, providing productivity benefits in the short run and potential employee retention in the long run. The design strategies and technologies

herein can provide office occupants with a safe, comfortable and cost-effective lighting system, and reduce energy and maintenance costs.



"Lighting systems for offices must be cost effective and provide a comfortable, productive and energy efficient workplace."

Building Owner, Cummings Properties

located to provide the proper balance of energy savings and lighting quality. Providing an

QUALITY ISSUES FOR OFFICE LIGHTING

	Private Offices	Open-plan Offices	Office Corridor
Control of direct and reflected glare	●	●	○
Light on walls and ceilings	●	●	⬇
Physical relation of fixtures to users	●	●	○
Uniformity / Reduce shadows and flicker	⬇	⬇	○
Room surface characteristics	⬇	⬇	⬇
Color rendering and color temperature	⬇	⬇	○
Daylighting	⬇	⬇	○
Lighting controls	⬇	⬇	○
Quantity of light on task (footcandles)	40-50 fc	40-50 fc	5-10 fc

● Very Important ⬇ Important ○ Somewhat Important

* Adapted from the Lighting Design Guide. IESNA Lighting Handbook, 9th Edition

ACHIEVING BETTER & BETTER YET RESULTS

This *knowhow* guide shows you basic lighting solutions that will deliver Better quality and more energy-efficient lighting systems for offices than traditional approaches. The Better Yet solutions identify further improvements and efficiencies. To realize even greater energy conservation and higher lighting quality than can be covered in this short guide, see page 8 for advanced lighting references.

the value of quality lighting

OFFICE QUALITY ISSUES: GLARE

Glare occurs when bright light sources interfere with the viewing of objects or surfaces that are less bright. The contrast between very bright and less bright may be uncomfortable or disabling, both of which are undesirable in an office environment. Fixtures located to the front or side of the employee cause direct glare. Overhead glare is caused by excessive brightness directly above. Reflected glare occurs on computer screens from images of fixtures located behind the employee. Reflected glare can also occur on glossy paper from lights directly in front. Most

glare can be controlled either by increasing the brightness of the surroundings or decreasing the brightness of the sources, or both.

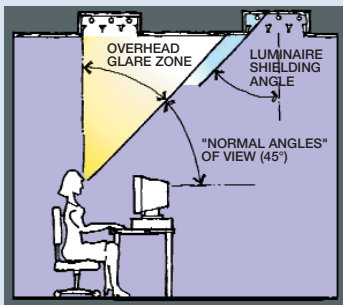
Some contrast-reducing suggestions:

- Increase room surface brightness by illuminating walls and ceilings, and using lighter colored materials.
- Increase the brightness around the glare source by using semi-specular or white louvers, or by

indirectly illuminating the ceiling. (See fixture type 'E').

- Shield the lamps from view with baffles, louvers, lenses or overlays.
- Reduce the brightness of the lamps by using more lamps of lower brightness. Use more fixtures if necessary.

PREVENTING OVERHEAD GLARE



While many lighting fixtures are designed to shield the view of lamps from "normal" viewing angles (eyes straight ahead), fixtures with exposed lamps (downlights, fluorescent parabolic troffers) can still produce glare which impedes office work.

TO AVOID OVERHEAD GLARE

1. No more than three T-8 lamps in a 2'x4' fixture.
2. No specular (shiny) reflectors visible from any angles.
3. No specular louvers or baffles (semi-specular or white only).
4. No T-5 lamps visible from any angle.



better yet

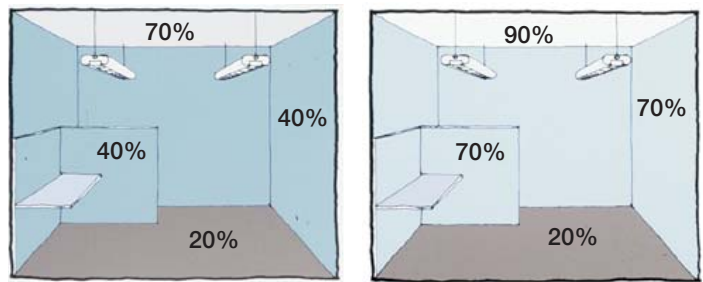
Medium-Sized Private Office

LIGHTING WALLS AND CEILINGS

To provide a productive working environment, lighting must be designed for long term comfort. Lighting the wall and ceiling reduces contrast, shadows, glare and distractions — all of which are directly related to a worker's performance. While the desktop and the worker's task should be the brightest surface in the room, the walls, ceiling and partitions should be about 1/3 as bright. Rooms with darker colored walls or partitions, which absorb light, may never achieve a good balance of brightness.

REFLECTANCES

Light is absorbed every time it is reflected off a room surface. Light colors reflect more light than dark colors. Select ceilings that are white and reflect at least 80% of the light. Select light colored vertical room surfaces in work areas (walls, panels, overhead bins) which reflect 65% or more. All major surfaces should be matte, not shiny, to improve uniformity and avoid reflected glare.



A small increase in room reflectances produces a big improvement in efficiency. The lighter room provides 55% more light on the work surface for the same energy or uses 70% less energy to provide equivalent brightness. The lighter room also provides better brightness ratios, comfort and daylight distribution.



"Even if it costs me \$1.00/sf more to light the walls and ceiling, better quality lighting only has to achieve a 1 percent improvement in my employee's performance to provide a 3-month simple payback. Now that's an investment that makes sense."

Owner and Employer, J.R. Gainfort

UNIFORMITY

Light should be distributed relatively uniformly in a work environment, avoiding "hot spots," shadows or sharp patterns of light and dark. In larger offices or open-plan spaces, use more than one type of light fixture, each with specific distribution characteristics, to light the task and room surfaces most effectively. Select fixtures specifically designed for wall washing, to light walls from top to bottom. Avoid locating fixtures closer than 3' from walls. If they are too close, they create harsh patterns and dark upper walls, resulting in a cave-like appearance.

TASK LIGHTING

Compact fluorescent desk lights allow workers to control their own lighting to accommodate their individual visual needs. "Articulated" task lights,

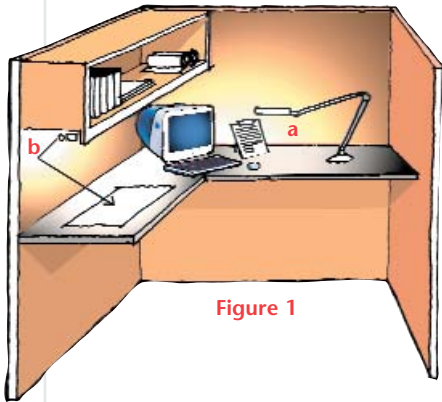


Figure 1

which allow adjustment in all three planes, are extremely effective without being expensive and are preferable to undercabinet lights for illuminating the task. In particular, they offer flexibility for different workers and different task requirements, and allow for lower levels of ambient light from the ceiling-mounted light fixtures.

See Figure 1(a)

UNDERCABINET LIGHTS

Wall cabinets and cabinets attached to furniture partitions create disturbing shadows on the vertical surfaces they overhang. A low quantity of lighting should be provided to remove this shadow and maintain a balance of brightness. Undercabinet lights with opaque fronts are available commercially or sold as part of the furniture system. Standard side-socket fluorescent channels may be used, if shielded by the cabinet edge. In either case, a single T-8 lamp generally provides too much light, so it should be coupled with a 50% output ballast which reduces the amount of light, reduces energy consumption and balances the brightness. Since undercabinet lights provide light from directly in front of the worker, creating reflected glare, they tend to perform poorly as "task" lights but are useful for removing shadows. See Figure 1(b)

POWER LIMITS FOR OFFICE SPACES*

	Watts / SF
Private Offices	1.5
Open Plan Offices	1.3
Office Corridor	0.7
Reception/Lobby	1.8
Conference/Meeting	1.5
Active Stairs	0.9
Active Storage	1.1

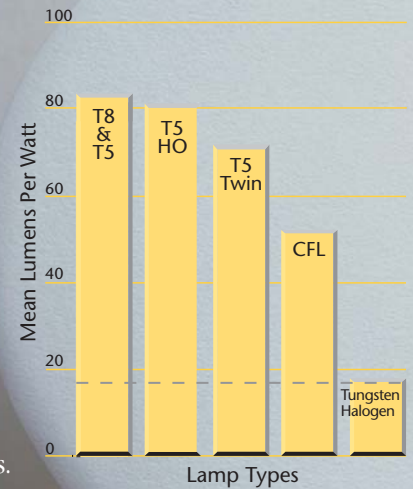
Note: Local task lighting must be accommodated within these power limits.
* From ANSI/ASHRAE/IESNA Standard 90.1-1999

Lamp / Ballast Efficacies

USE ENERGY EFFICIENT SOURCES

Fluorescent lighting today is not only more energy efficient, but rivals incandescent in quality, comfort and aesthetics.

Lamps are available in a variety of superior colors providing a natural appearance for people and room colors. Electronic high frequency ballasts eliminate the flicker and noise of older model ballasts. The graph compares efficacies (mean lumens per watt) of common fluorescent lamp/ ballast combinations with the efficacy of a tungsten halogen (incandescent) lamp.



"Pendant fixtures save installation time and cost, since they only require one power feed at the end of each row."

Electrical Contractor, Rise Engineering



What's wrong with this picture?

Avoid staggered layouts and locating fixtures too close to walls.

Photo by J. Lindley

private office layouts

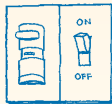
Making an informed choice

Designs using pendant direct-indirect fixtures (layouts 3 & 6) are the most efficient of all three systems, and provide significantly better comfort and visibility for task performance by reducing shadows and lighting the ceilings and upper walls. 2' x 4' fixtures (layouts 2 & 5) offer the lowest first cost, but provide lower comfort and quality. Although 2' x 2' fixtures (layouts 1 & 4) are often preferred for their shape, they are less efficient and more costly than 2' x 4' fixtures, with no increase in lighting quality.

CONTROLS

Use wall-mounted occupancy sensors (WOS) with "manual-on" for private offices. Slave-wire a standard switch (\$), for second zone, to provide two levels of light.

WOS

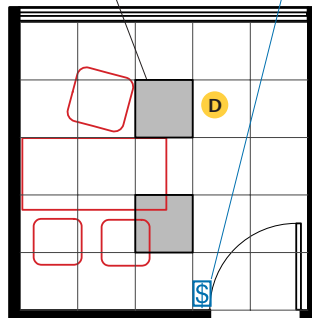
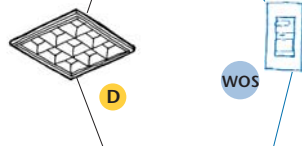
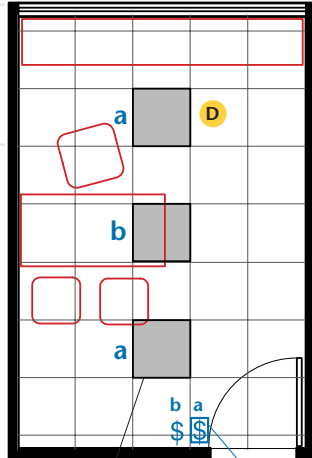


See page 7 for complete fixture specifications and page 8 for lighting controls.



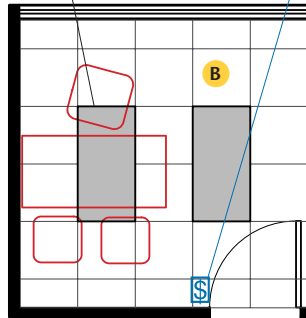
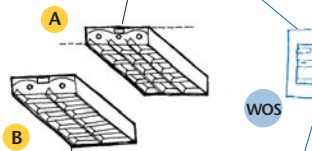
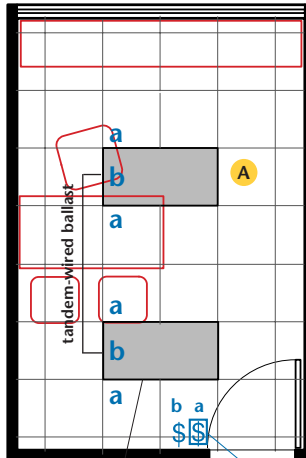
medium private offices (150 square feet shown) 2'x2' ceiling grid

LAYOUT 1
ACCEPTABLE



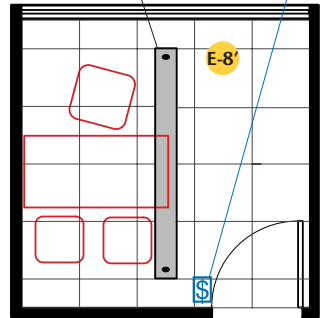
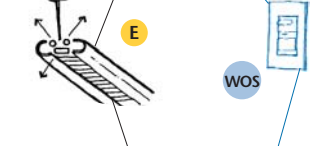
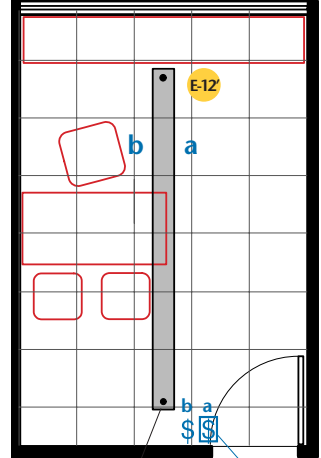
LAYOUT 4
ACCEPTABLE

LAYOUT 2
BETTER



LAYOUT 5
BETTER

LAYOUT 3
BETTER YET



LAYOUT 6
BETTER YET

small private offices (100 square feet shown) 2'x2' ceiling grid

COMPARISON CHART FOR PRIVATE OFFICES

	Layout 1	Base Case Layout 2	Layout 3	Layout 4	Base Case Layout 5	Layout 6
Uniformity	★★	★★	★★★	★★	★★	★★★
Comfort & Quality	★★	★★	★★★★	★★	★★	★★★★
Maintained Footcandles on Desk (fc)	35-45	45-58	45-50	35-40	40-58	40-55
Ambient Connected Load (W/sf)	1.2	1.2	1.1	1.2	1.2	1.1
Potential Energy Savings ¹ (%)	0-20%	0-20%	10-25%	0-20%	0-20%	10-25%
First Cost Increase ² (material & labor)	+55-65%	Base case	20-30%	+5-15%	Base case	+0-5%
Applicable Square Foot Range ³ (sf)	125-150	135-185	115-180	80-100	90-110	85-140
OVERALL VALUE	ACCEPTABLE	BETTER	BETTER YET	ACCEPTABLE	BETTER	BETTER YET

1 - Savings estimates are based on research of current lighting practices in the New England region. 2 - First cost compared to layouts 2 and 5 respectively. 3 - Layout applies to any office within this size range while meeting light level recommendations and without exceeding energy codes, with 8'-0" to 8'-6" ceiling heights.

What's wrong with this picture?

- Specular louvers
- Cave effect
- Dark colored finishes
- No light on ceiling
- Shadows

See page 2 for quality pointers

COMPARISON CHART FOR OPEN-PLAN OFFICES

	Layout 7	Layout 8	Layout 9
Uniformity	★★	★★	★★★
Comfort & Quality	★★	★★★	★★★★
Maintained Footcandles on Desk ¹ (fc)	40-45	50-60	50-80
Ambient Connected Load (W/sf)	1.2	1.1	1.0
Potential Energy Savings ² (%)	20-35%	25-40%	30-45%
First Cost Increase ³ (material & labor)	+20-30%	+0-5%	+35-45%
Applicable Square Foot Range ⁴ (sf)	1700-2200	1600-2600	1400-2800
OVERALL VALUE	ACCEPTABLE	BETTER	BETTER YET

- 1 - Footcandles do not account for partial height partitions, which will reduce actual footcandles.
 2 - Savings estimates are based on research of current lighting practices in the New England region.
 3 - Cost increase over one 3-lamp 2'x4' fluorescent parabolic every 64 s.f.
 4 - Layout applies to any office within this size range while meeting light level recommendations and without exceeding energy codes, with 8'-0" to 8'-6" ceiling heights. Add rows of fixtures for larger rooms.

open-plan office layouts

Making an informed choice

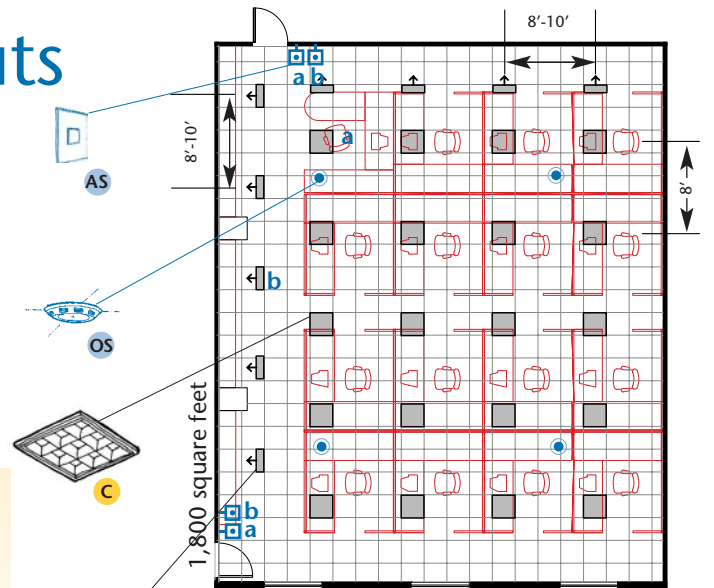
The design using pendant direct-indirect fixtures (layout 9) is the most efficient of all three systems, and provides significantly better comfort and visibility for task performance by reducing shadows and lighting the ceilings and upper walls. In addition, these fixtures need not relate directly to the workstations, due to the indirect lighting component. 2' x 4' fixtures (layout 8) offer the lowest first cost, but provide lower comfort and quality. Although 2' x 2' fixtures (layout 7) are often preferred for their shape, they are less efficient and more costly than 2' x 4' fixtures, with no increase in lighting quality.

CONTROLS

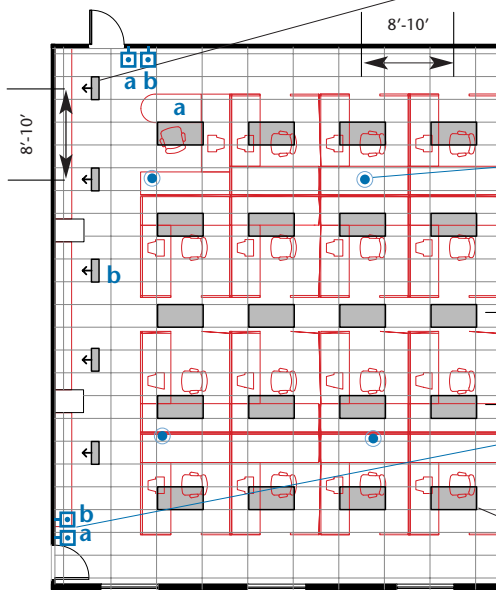
Control different fixture types separately, in 'zones'. For open-plan offices, use ultrasonic ceiling-mounted occupancy sensors (OS), with manual-on automatic switches (AS) for each control zone. The four occupancy sensors shown are wired in series, to sense motion in the room as a whole. When the entire room is unoccupied, all lighting zones will be turned off.

See page 7 for fixture specifications. See page 8 for lighting controls. Go to www.designlights.org/officewiring/ for schematic control wiring diagram.

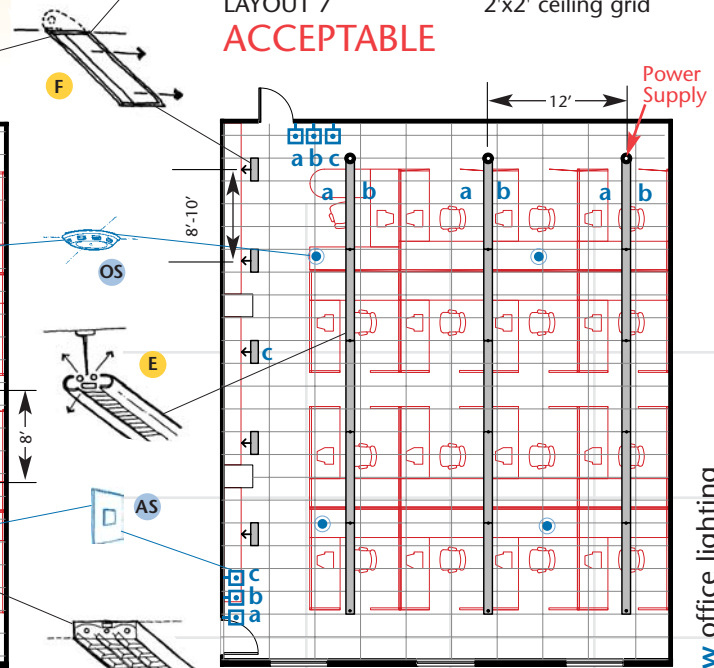
QUICK TIP: Actual footcandles at the desk will be 15 to 20% lower if furniture partitions taller than 54" are used. Furniture-mounted overhead storage bins further reduce light levels. If bins are used, consider providing fewer footcandles from the ceiling and providing local task lighting (see page 3). Remember to reduce the number of lamps, not the number of fixtures.



LAYOUT 7
ACCEPTABLE
2'x2' ceiling grid

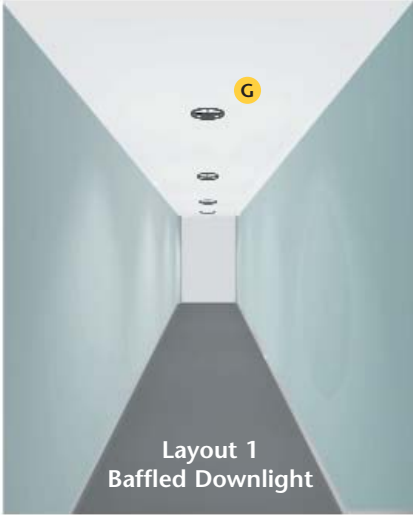


LAYOUT 8
BETTER
2'x4' ceiling grid



LAYOUT 9
BETTER YET
2'x4' ceiling grid

office corridor layouts



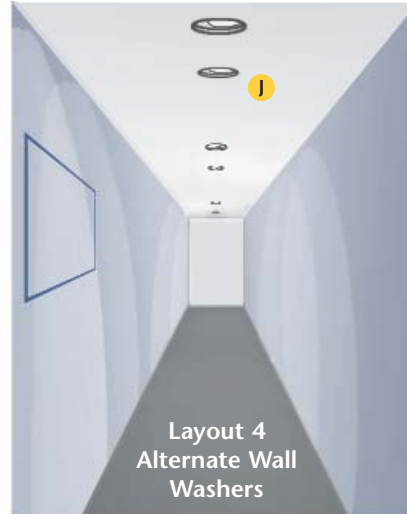
Type "G" located 10' on center



Type "H" located 10' on center



Type "I" located 10' on center



Type "J" 3' on center, 15' between pairs

CONTROLS

Use ceiling-mounted occupancy sensors designed for corridors. See page 8 for Lighting Controls.



SUMMARY CHART FOR OFFICE CORRIDORS

	All Layouts
Maintained Footcandles (fc)	5-10
Potential Energy Savings ¹ (%)	35-45%
First Cost Increase ² (material & labor)	+0-40%
Connected Load ³ (W/sf)	0.7

1- Savings and cost estimates are based on research of current lighting practices in the New England region. 2-Costs compared to one 2-lamp, 2'x2' fixture every 45 sf.

SPACING

Layouts shown are based on 30 Watts maximum every 10 feet of corridor with 8'-0" to 8'-6" ceiling heights, for corridors between 4'-3" and 5'-3" wide. For corridors 5'-4" to 6'-4" wide: locate fixtures 8 feet on center, or select higher wattage compact fluorescent lamps; do not exceed 12' on center spacing between individual fixtures; for Type J, reduce spacing between pairs to 12' on center.

OFFICE CORRIDOR FIXTURE SCHEDULE

- G: Cross-Baffle Downlight 26W
- H: Glowing Disk 26W
- I: Wall Sconce 26W
- J: Wall-Wash Downlight 26W

All fixtures use compact fluorescent lamps. See page 7 for complete fixture specifications.

lamp and ballast specifications

The following specifications apply to all of the fixture types shown on page 7.

Lamp Criteria:

- Minimum Color Rendering Index (CRI) of 80.
- Color temperature of 3500 Kelvin.
Note: Generic color code "835" means CRI of 80+ and color temperature of 3500.
- Mean lamp lumens (at 40% of rated life) at least 94% of initial lumens.

Ballast and Lamp-Ballast System Criteria:

- High-frequency electronic, using instant start or program rapid start circuitry.
- Harmonic distortion shall not exceed 20%.
- Ballast factor minimum 0.88 for T8.
- Mean system efficacy (mean lamp lumens times # of lamps divided by ballast input power): Minimum 83 lumens/watt for 4' long T8.



"Corridors should offer a break from the office environment. Apply color and variety and make sure the walls are lighted. Using standard office fixtures in corridors not only won't meet the energy code, it misses a great opportunity to refresh the office worker with a change, and to reduce eye fatigue."

Director of Lighting Design, The RETEC Group



current practice

Using building-standard office fixtures in corridors wastes energy.

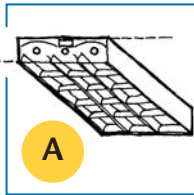
lighting fixture schedule

These fixture specifications include fixtures that ensure a balance of performance, energy savings, comfort, lighting quality, quantity and maintenance, at a cost-effective price. Many standard products meet these generic specifications. Even small variations from these specifications may result in undesirable effects. For example, specular louvers or reflectors may increase light levels and reduce reflected glare, but will also increase overhead glare and decrease desirable room surface brightness.

A. 2' x 4' THREE-LAMP PARABOLIC TROFFER

LAMPS: (3) 32W T8, 835 color

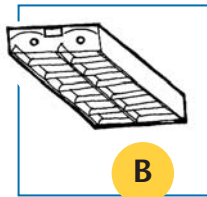
DESCRIPTION: Recessed fluorescent troffer 2' by 4' with white baked enamel interior, semi-specular low-iridescent parabolic louvers with 18 cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Three-lamp electronic instant-start ballast, nominal 91 input watts. 71% minimum fixture efficiency. Note: 3-lamp or 2-lamp ballasts with inboard-outboard switching and tandem wiring.



B. 2' x 4' TWO-LAMP PARABOLIC TROFFER

LAMPS: (2) 32W T8, 835 color

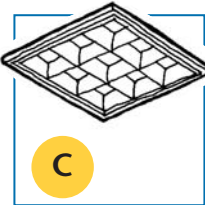
DESCRIPTION: Recessed fluorescent troffer 2' by 4' with white baked enamel interior, semi-specular low-iridescent parabolic louvers with 12 cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Two-lamp electronic instant-start ballast, nominal 61 input watts. 73% minimum fixture efficiency.



C. 2' x 2' THREE-LAMP PARABOLIC TROFFER

LAMPS: (3) 31W T8 U-Tube 1-5/8" leg spacing, 835 color

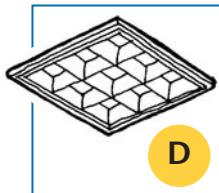
DESCRIPTION: Recessed fluorescent housing with white baked enamel interior, semi-specular low-iridescent parabolic louvers with nine cells, minimum 2-3/4" deep. Three-lamp electronic instant-start ballast, nominal 91 input watts. 64% minimum fixture efficiency.



D. 2' x 2' TWO-LAMP PARABOLIC TROFFER

LAMPS: (2) 31W T8 U-Tube 6" leg spacing, 835 color

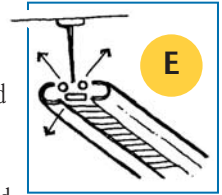
DESCRIPTION: Recessed fluorescent housing with white baked enamel interior, semi-specular low-iridescent parabolic louvers with nine cells, minimum 2-3/4" deep. Use white painted louvers in private offices. Two-lamp electronic instant-start ballast, nominal 61 input watts. 61% minimum fixture efficiency.



E. 2-LAMP PENDANT DIRECT / INDIRECT

LAMPS: (2) 32W T8, 835 color

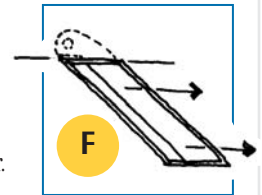
DESCRIPTION: Stem mounted fluorescent luminaire in lengths of 8'-0" or 12'-0". White baked enamel finish. Minimum 30% uplight. Minimum 40% downlight. Cross baffles 1-3/4" deep x 2" on center. Semi-specular low-iridescent or white painted cross baffles. Total 4-lamps per 8' long fixture. Four-lamp electronic instant-start ballast, nominal 110 input watts. Minimum fixture efficiency 80%. Also available in 12' lengths and continuous rows. Mount a minimum of 6'-8" above finished floor. Minimum 12" stem, 18" preferred.



F. 1' x 2' LINEAR WALL WASH

LAMP: (1) 40W TT, 835 color

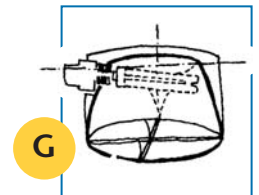
DESCRIPTION: Nominal 1' x 2' recessed fluorescent wall wash located 2'-3' away from wall or furniture being washed. Semi-specular or white painted louver. Spaced 8' to 10' on center. Electronic instant-start ballast.



G. COMPACT FLUORESCENT CROSS-BAFFLE DOWNLIGHT

LAMPS: (2) 13W TT, 830 color

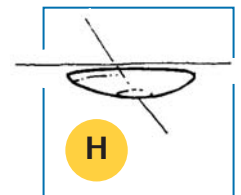
DESCRIPTION: Nominal 8" diameter recessed downlight with white painted parabolic shaped cross baffles, minimum 2-1/2" deep. Two-lamp electronic ballast.



H. COMPACT FLUORESCENT GLOWING DISK

LAMPS: (2) 13W TT, 830 color

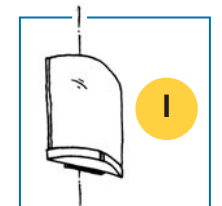
DESCRIPTION: Surface-Mounted bowl with white opal glass or acrylic diffuser. Two-lamp electronic ballast.



I. COMPACT FLUORESCENT WALL SCENCE

LAMPS: (2) 13W TT, 830 color

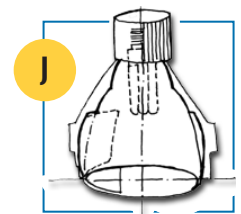
DESCRIPTION: Decorative wall sconce with glowing front face. Extension from wall must be less than 4" or the bottom must be mounted at least 6'-8" above the floor for ADA compliance. Two-lamp electronic ballast.



J. COMPACT FLUORESCENT WALL WASH DOWNLIGHT

LAMPS: (2) 13W TT, 830 color

DESCRIPTION: Nominal 7" or 8" diameter recessed fixture with asymmetrical wall-wash distribution by means of kicker reflector or lens. Semi-specular low-iridescent reflector cone. Two-lamp electronic ballast.



lighting controls

Energy savings are achieved by control strategies which reduce both the connected load and the hours of operation especially during the mid-day “peak demand” hours. Automatic controls may be required by your state code.

Occupancy Sensors

Private Offices

Install ultrasonic manual-on wall mounted occupancy sensors (WOS), set for maximum sensitivity and a 10 minute delay in private offices.

Ultrasonic sensors are more sensitive to subtle motion like typing and less likely to turn lights off in an occupied room.

WOS



Use wall-mounted sensors in a small office with a direct line of sight between sensor and occupant. Specify sensors to be factory-set for manual-on operation. *This prevents lights from turning on unnecessarily during corridor activity, ample daylight, brief occupancy or when a task light is sufficient.*

Alternative approach: Install a manual-on, two-level wall mounted sensor or a single pole switch wired in series with an occupancy sensor. *Two-level switching allows people to have greater flexibility and control, and still automatically turns lights off when the space is unoccupied.*

Open Offices

Install ultrasonic ceiling mounted occupancy sensors (OS), set to maximum sensitivity with a 15 minute time delay. Connect sensors to an automatic wall switch (AS), wired so that lights must be manually turned on

at the switch, but are turned off by the sensor when the space is unoccupied. In spaces with vertical partitions, files or any other objects that create “walls” higher than four feet, reduce the sensor “coverage area” given in manufacturer’s literature. Verify sensor spacing and location directly with sensor manufacturer.



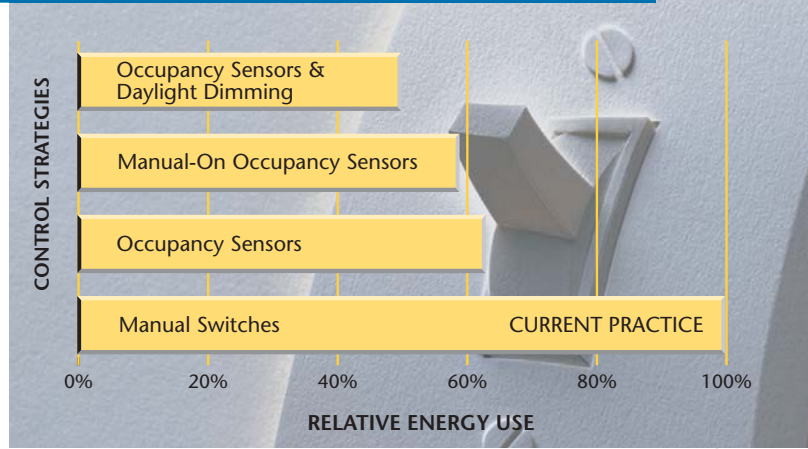
AS



Corridors

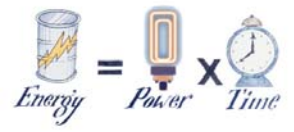
Install ceiling mounted ultrasonic sensors, specifically designed for linear corridor distribution. Set to maximum sensitivity and 15 minute time delay. *The narrow linear distribution patterns increase sensitivity at a distance, activating lights long before a person reaches an unlighted area.*

Comparison of Lighting Controls



Daylight-related Controls

Install switching or automatic dimming for those fixtures in the “daylight zone,” usually within 12’ from a window wall in daylighted offices. Alternatively, in rooms smaller than 400 square feet, provide separate switches for the light fixtures in the daylighted zone and connect them to a separate occupancy sensor. In daylighted zones greater than 400 square feet, consider electronic fluorescent dimming ballasts, for continuous dimming down to 20% or less, automatically controlled via photosensors. Only smooth, continuous dimming should be used for office spaces to prevent distraction to the employees. Avoid “stepped dimming.” The smoothness of the dimming depends on the quality of the dimming ballast more than the controls.



Lighting controls are essential for limiting the quantity and duration of power consumed.

Going a Step Beyond

Careful design and the use of strategies such as daylighting, task-ambient lighting, and advanced technologies can achieve even greater energy efficiency and higher quality lighting than the basic solutions covered in this guide. More information is available from the Advanced Lighting Guidelines, at www.newbuildings.org, and from Tips For Daylighting With Windows at <http://windows.lbl.gov/daylighting/designguide/designguide.html>.

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