Information Bulletin
Environmentally Preferable Purchasing

LOW-WATTAGE T8 FLUORESCENT LAMPS

Lighting accounts for 18% of total electricity consumption in the U.S., presenting a sizable opportunity for energy savings.[1] California is committed to lowering statewide energy use, as demonstrated by the Governor's Executive Order B-18-12, which establishes zero net energy goals for state facilities and state agencies.

Relamping with low-wattage linear T8 fluorescent lamps is a simple, cost-effective way to immediately improve the energy efficiency of a facility's lighting system. By replacing the existing lamps, and often times lamps and ballasts, facility managers can expect energy savings as high as 22% when compared to existing 32W T8 lamps.

Advanced lighting controls, including dimming, occupancy and photocontrols, are another route that facilities managers can take to achieve considerable energy savings. Occupancy sensors are an excellent choice in secondary spaces, such as stairwells, corridors and meeting rooms, which are often vacant. Lighting controls that incorporate photosensors can also reduce electric lighting power in spaces where daylight is often abundant. Automatic dimming controls can facilitate these strategies, while manual dimming can provide occupants with more control over their lighting system, which can further reduce energy use. Unfortunately, facility managers must often choose between the relamping and the use of occupancy and daylighting controls, as dimming controls and low-wattage fluorescent lamps are generally incompatible.

Open offices and other commercial spaces that have supplemental task lighting and high occupancy rates are excellent candidates for low-wattage T8 fluorescent relamping. Relamping is also a good choice in spaces with little potential for daylight harvesting. DGS includes 28W T8 lamps in its Environmentally Preferable Purchasing program. This information bulletin is designed to help personnel understand the benefits and limitations of low-wattage T8 fluorescent lamps.

[1] U.S. Department of Energy. "2010 U.S. Lighting Market Characterization." January 2012.

Dimming and Controls Compatibility

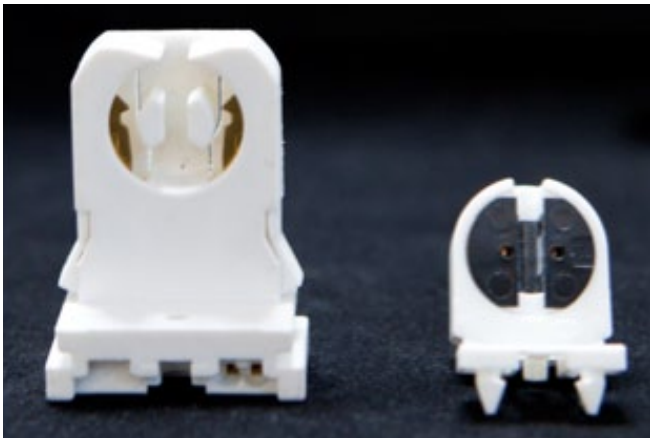
The 32W T8 is a common lamp found in commercial buildings throughout California. These lamps are generally used with standard electronic ballasts.[2] Most 32W T8 lamps are dimmable, so facilities only need to install dimming electronic ballasts, proper sockets (unshunted), and lighting controls to convert a non-dimming T8 lighting system to a dimming system.

Unlike 32W T8 lamps, low-wattage T8 lamps are not compatible with most dimming ballasts. A few dimmable 28W T8 lamps exist, but their availability is extremely limited and their dimming performance has not been proven to the same extent as 32W T8 fluorescent lamps.[3] In addition, low-wattage T8 lamps can only be used in warm environments with little overt air flow. Even dimmable low-wattage solutions will perform poorly if installed in areas where the temperature drops below 60° F or the lamp is exposed to air drafts.

When dimming or other lighting control strategies are not desirable and not required, relamping with low-wattage linear fluorescent lamps can provide energy savings. Relamping with low-wattage T8s may be a good choice for spaces that require continuous lighting or spaces that are over-lit (a common source of energy waste).

Installation and Safety

Low-wattage T8 lamps function similarly to 32W T8 lamps while consuming less energy. They can be installed into luminaires with instant-start fluorescent ballasts and shunted sockets with no wiring or other electrical work required.

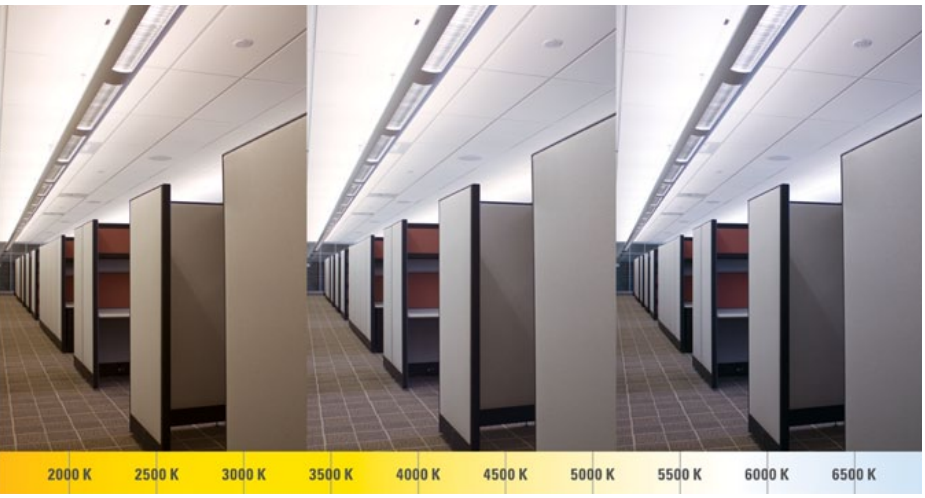


Shunted socket (left) and unshunted socket (right)
Photo: CLTC, UC Davis

TITLE 24, PART 6 REQUIREMENTS FOR CONTROLS

Under California's 2013 Building Energy Efficiency Standards for lighting (Title 24, Part 6), luminaires in corridors and stairwells must be equipped with occupancy sensors and lighting controls that can automatically dim lights to at least 50% of full lighting power when these spaces are vacant. The new standards also require multi-level automatic daylighting controls in sky-lit and side-lit zones where the installed general lighting power is 120 watts or more.

[3]Craig DiLouie, Editor, LightNOW, for Electrical Line. "T5 Lamps." 17 November 2005. www.lightingassociates.org/i/u/2127806/f/tech_sheets/T5_Lamps.pdf



This simulation provides a sense of how the same office space might appear under lighting with three different correlated color temperatures. (Note: The technology shown in the picture is a linear pendant, not a troffer) *Photo: CLTC, UC Davis*

Color Quality

Low-wattage fluorescent lamps are available in a wide variety of color temperatures, allowing facility managers to match the correlated color temperature (CCT) of existing lighting when selecting low-wattage replacements. All types of T8 lamps (25W, 28W and 32W) are available with CCTs between 3000K and 6500K.[4] Linear fluorescent lamps typically measure above 80 on the color rendering index (CRI), the industry standard for measuring how accurately a light source renders colors.

Product Life

Low-wattage and standard T8 lamps have comparable lifetimes. Like 32W T8 lamps, 28W T8 lamps last approximately 18,000–36,000 hours. When comparing the lamp life of different products, be sure to note the switching cycle (time OFF and time ON) used to determine lamp life.[5] Most linear fluorescent lamps are tested with a 3-hour ON period and 20-minute OFF period to determine lamp life . More frequent switching (turning lamps ON and OFF) can reduce fluorescent lamp life; however, dimming does not have the same negative effect on lamp life.

When implementing dimming or switching controls, it is important to select the correct lamp and ballast combination in order to maximize lamp life. Instant-start or rapid-start ballasts are more likely to reduce lamp life in frequently switched applications, while programmed-start ballasts deliver power to lamps in a way that minimizes this damage.

Cost

As with any relighting project, a cost-benefit analysis will help facility managers determine the best course of action for the particular needs of each space. Typically, low-wattage T8 lamps are slightly more expensive than 32W lamps. Low-wattage T8 lamps also produce less light on average than 32W T8 lamps, with lumen output varying by manufacturer, but these differences may have to exceed 20% before occupants would notice a difference. The cost savings associated with low-wattage lamp replacements could be reduced for spaces that require additional lamps or other changes to maintain adequate light levels. But even if light output decreased after relamping with low-wattage T8 lamps, more lamps or higher ballast-factor ballasts may not be needed to maintain recommended light levels. The characteristics of a given

[4]IESNA LM-40-01: IES Approved Method for Life Performance Testing of Fluorescent Lamps. 01 December 2001

[5]IES. Light in Design – An Application Guide. www.iesna.org/PDF/Education/LightInDesign.pdf

space, including ceiling height, space dimensions, daylight contribution, task lighting, and the function of the space, all affect lighting needs.

Efficacy and Brightness

A low-wattage T8 lamp uses 13–22% less energy compared to a standard 32W T8. Changing from 32W T8s to 28W T8s may also result in a decrease in general light levels (up to 17%). This change is likely to go undetected by most occupants. More importantly, it will not necessarily bring illuminance levels in the space below those recommended for visual comfort and may even be beneficial in previously overlit spaces.

The Illuminating Engineering Society of North America (IESNA), an authority on lighting design and ergonomic lighting, publishes recommended light levels for various tasks. For office spaces, 25–50 fc is the recommended lighting level on work surfaces, with very fine, detailed tasks constituting an exception.[6] Table 2 lists the IESNA's recommended light levels, measured in foot-candles (fc), for common visual tasks.[7]

For most spaces, the total light output required can be calculated by multiplying the square footage of the space and the amount of lumens per square foot (foot-candles) required for that space.

Tubular LED lamps made to replace linear fluorescent lamps are an emerging technology with the potential to offer energy savings, but they have yet to prove as safe, consistent, or cost-effective as today's fluorescent lamps.

An information bulletin on tubular LED lamps is available at

Task Type	Illuminance (fc)
Tasks with high contrast and large size *(reading print media)*	30 fc
Tasks with high contrast and small size *(reading blueprints)*	50 fc
Tasks with low contrast and large size *(office work on LCD monitors)*	50 fc
Tasks with low contrast and small size *(inspecting and editing graphics)*	100 fc

Light meters can be used to measure illuminance values on work surfaces before and after relamping. This allows for a detailed comparison of actual light levels in a particular space under different linear fluorescent lamps. Light meters are available through local utilities' tool lending libraries at no cost to borrowers.

[6]CLEAResult. General Lighting Recommendations: Design Guidelines for Energy Efficient Lighting Systems. January 2013. www.eeprograms.net/entergy/documents/CLEAResult_Gen_Lighting_Recs.pdf

[7]Southern California Edison. "Solutions Directory." February 2013. www.sce.com/nrc/ems/download/solutionsdirectory.pdf

1:1 RETROFITS

Because 28W fluorescent lamps can provide less light than 32W fluorescent lamps, one-to-one relamping can result in lower light levels. For example, a 1,000 ft2 office space that had 14 32W T8 fluorescent lamps (3300 lumens each) installed would require 17 28W T8 lamps (2725 lumens each) or 20 25W T8 lamps (2500 lumens each) to provide the same amount of light (45,000 lumens).

High-efficiency Lamp/ Ballast Combinations

The light output of a luminaire is determined by both the type and wattage of the lamp and the ballast that powers it. Ballast factor (BF) is one metric used to compare the performance of different ballasts. Ballast factor is the ratio of light output from a lamp when paired with the ballast being evaluated as compared to the light output from a standard, or reference, ballast. In addition to influencing light output, ballast factors affect the power consumption of the combined lamp and ballast system. Ballast factors below 1.0 reduce the power consumption and light output of the system while ballast factors above 1.0 increase it. For example, a 32W fluorescent lamp will consume less power and produce less light than it is rated for with a 0.78 BF. The same lamp will consume more power and produce more light when paired with a ballast that has a 1.15 BF. The most common ballast factor, and what is classified as "normal," for fluorescent lamps is 0.87. T8 ballast factors range from 0.77 to as high as 1.20. The BF of some types of ballasts may fluctuate depending on the lamp that they are powering. Ballast factor naming methodology (i.e., ultra-low, low, medium, high) is dependent on the fluorescent lamp type specified and the manufacturer of the system components. An ultra-low ballast factor is the most energy efficient, but provides the lowest light output.

Ballast Type	Ballast Factor
Ultra-low	0.60
Low	0.77
Medium	0.87
High	1.20

When installing low-wattage T8 lamps, the best solution is often to replace both lamp and ballast at the same time. Pairing low-wattage T8s with low-bf ballasts provides optimal energy savings, and manufacturers often provide ballasts specifically made to operate with their low-wattage lamps. Existing ballasts typically have a medium, or normal, BF. Pairing a low-wattage lamp with a medium-BF ballast reduces energy savings by as much as 10% compared to a system that uses a low-bf ballast.

One-to-one replacement of 32W T8 lamps with 28W or 25W T8 lamps may result in lower light levels. A relamping simulation using AGi32 lighting design software found this difference to be negligible at just 8% (see table 2).

Table 2: Relamping Simulation Results

T8 Fluorescent Lamp Wattage	Avg.	Min.	Uniformity (Avg./Min.)
32W	52.33 fc	2.9 fc	18.04 fc
28W	48.02 fc	2.6 fc	18.47 fc

Test Relamping

If light levels are a concern when considering relamping, it may be worthwhile to do a mock-up in a test area of the building under consideration. This allows end-users to get a sense of how the lighting may change as a result of relamping, and it will allow time to collect feedback and address any concerns if they arise.

PROCURING LIGHTING SOLUTIONS, INCLUDING LOW-WATTAGE T8S

Facilities interested in saving energy should consider retrofitting existing linear T8 fluorescent luminaires with dimming ballasts and lighting controls. Occupancy sensors, photosensors, and scheduling controls provide effective ways to maintain existing lighting levels when spaces are in use while reducing energy use when they are not.

Replacing 32W T8 lamps with 28W T8 lamps can also reduce lighting energy consumption, particularly when paired with ballasts designed for low-wattage fluorescent lamps. Facility managers must note that these lamps are not typically compatible with dimming controls and may only be used with instant-start or some programmed-start ballasts. At present, there are several utilities across multiple states that advocate the switch from 32W T8 lamps to 28W T8 lamps, including Southern California Edison in California. DGS recommends 28W T8 lamps as an energy-saving replacement for 32W T8 lamps, and has included this product category in the DGS Environmentally Preferable Purchasing program.

ABOUT DGS' ENVIRONMENTALLY PREFERABLE PURCHASING PROGRAM

Environmentally Preferable Purchasing (EPP) is the procurement of goods and services that have a reduced impact on human health and the environment, as compared to other goods and services serving the same purpose (Public Contract Code §12400-12404). In simple terms, EPP means "buying green." The law also states that the Department of General Services (DGS) is to provide state agencies with information and assistance regarding EPP. In response, DGS developed a best practices manual—the Buying Green Guide. This guide provides information, tools and tips for buyers, and it provides insights for suppliers on how the State views "green" products and businesses. View the Guide and learn more at ***www.dgs.ca.gov/buyinggreen/Home.aspx***.

ABOUT CLTC

This fact sheet was prepared by the California Lighting Technology Center (CLTC) for the California Department of General Services. CLTC is a not-for-profit RD&D facility dedicated to advancing energy-efficient lighting and daylighting technologies. Part of the Department of Design at the University of California, Davis, CLTC's facility includes full-scale laboratories for research and development. The center also provides instruction to both undergraduate and graduate students of lighting design.

Working in partnership with designers, manufacturers, end users, utilities, government agencies, and others, CLTC conducts prototype and product testing, technology demonstrations, and case studies. CLTC also provides resources for applying best practices to lighting design and installation. Learn more at ***cltc.ucdavis.edu***.