

CALiPER

Report 21.4:

Summary of Linear (T8) LED Lamp Testing

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CALIPER

SERIES 21: LINEAR LED LAMPS



Application Summary Report 21: Linear (T8) LED Lamps

This report focused on the bare-lamp performance of 31 linear LED lamps intended as alternatives to T8 fluorescent lamps. Data obtained in accordance with IES LM-79-08 indicated that the mean efficacy of the group was slightly higher than that of fluorescent lamps (with ballast), but that lumen output was often lower. Along with a range of color quality attributes, the luminous intensity distributions of the linear LED lamps varied substantially, with none truly comparable to a linear fluorescent lamp. (March 2014)

Report 21.1: Linear (T8) LED Lamps in a 2x4 K12-Lensed Troffer

This report focused on the performance of the 31 linear LED lamps operated in a typical troffer with a K12 prismatic lens. In general, luminaire efficacy was strongly dictated by lamp efficacy, but the optical system of the luminaire substantially reduced the differences among the luminous intensity distributions of the LED lamps and fluorescent benchmark. Workplane illuminance uniformity may be reduced, although luminaire efficiency may be higher compared to fluorescent, especially for LED lamps with a narrow distribution. (April 2014)

Report 21.2: Linear (T8) LED Lamp Performance in Five Types of Recessed Troffers

This report examined the performance of three linear LED lamps, spanning the range of luminous intensity distributions found for the Series 21 lamps, and a typical linear fluorescent lamp, in five different troffer types. Both photometric and subjective evaluations demonstrated that certain types of troffers are more suitable for using linear LED lamps instead of fluorescent lamps, and that the distribution of the LED lamps can affect performance and appearance. (May 2014)

Report 21.3: Cost-Effectiveness of Linear (T8) LED Lamps

Using average input power data from the Series 21 LED lamps, the cost-effectiveness of using linear LED lamps versus relamping with new fluorescent lamps was evaluated over a 10-year study period. Life-cycle cost analyses were completed while varying equipment cost, installation time, hours of use, and electricity rate. The results can be used to estimate cost-effectiveness over a range of applications. (May 2014)

LINEAR LAMPS

Fluorescent versus LED



Troffer luminaires typically use either T12 (1.5" diameter) or T8 (1" diameter) linear fluorescent lamps. All fluorescent lamps require a ballast, which can be magnetic or electronic.

Typical 4' T8 fluorescent lamps are nominally rated at 25 to 32 W, although the actual power draw will depend on the electronic ballast driving it, which draws a few additional watts. T12 lamps can consume up to 40 W, plus a few ballast watts.

Typically, 28 W T8 fluorescent lamps are rated to emit about 2,700 lumens, with the final output multiplied by the ballast factor (BF), a characteristic of the ballast that can range from about 0.70 to 1.2. 32 W T8 lamps are nominally rated at around 3,000 lumens.

Including ballast losses, T8 fluorescent lamps typically deliver between 80 and 100 lm/W, with T12 lamps slightly lower. Total luminaire efficacy is typically between 50% and 90% of lamp efficacy.

One of the key characteristics of fluorescent lamps is that they emit light equally in all directions around the major axis of the lamp; that is, they are omnidirectional. Luminaires are designed to redirect the omnidirectional emission, but they do so at different efficiency levels.

For new projects, most high-efficiency linear fluorescent lamps will have a CRI in the 80s and a nominal CCT of 3000 K, 3500 K, 4000 K, or 5000 K, although products are available with a range of attributes.

Fluorescent lamps can be operated in instant-start sockets (shunted), or rapid-start sockets (unshunted), depending on the design of the installed ballast. Unshunted sockets can be wired to be shunted or unshunted.

Traditionally, linear fluorescent lamps have rated lifetimes of around 20,000 to 40,000 hours. However, some new lamps have rated lifetimes in excess of 80,000 hours. Typically, ballasts have an expected lifetime of around 50,000 to 60,000 hours.

General

Linear LED lamps often have a similar form factor to T8 fluorescent lamps, but usually about half of the volume is dedicated to thermal management and/or an integral driver (others have an external drive). Some lamps can operate on an existing ballast, but others require rewiring.

Power

The input power for linear LED lamps can vary substantially. The Series 21 lamps ranged from 11.5 to 28.6 W, including the driver. In some cases, linear LED lamps may draw more power than the fluorescent lamp they are intended to replace.

Output

The Series 21 linear LED lamps emitted between 1,300 and 3,200 lumens, with all but one lamp emitting less than 2,400 lumens. The mean was 1,790 lumens, which is slightly below what is typically necessary to deliver illumination equivalent to 28 W fluorescent (0.87 BF).

Efficacy

Most of the tested LED lamps were between 80 and 115 lm/W, with one product at 143 lm/W. Thus, few offered substantial energy-efficiency advantages. However, in some luminaires the LED lamps produced higher luminaire efficiencies than the fluorescent benchmark.

Distribution

None of the CALiPER-tested LED lamps were omnidirectional, or even close, with beam angles between 105° and 120° for lamps with a clear lens and between 126° and 160° degrees for lamps with a diffuse lens. Directional emission may increase the efficiency of some luminaires.

Color

The Series 21 LED lamps had CRIs between 68 and 90, and CCTs between 3000 K and 6000 K. Given the variety, it is important to understand what is necessary or desired for a given space.

Electrical

There are at least seven electrical configurations for linear LED lamps, based on the need for shunted sockets, unshunted sockets, or no sockets at all, and the need for an internal or remote driver. This necessitates careful specification, and may limit future interchangeability.

Life

Most of the Series 21 linear LED lamps had a rated lifetime of 50,000 hours, with some as low as 35,000 hours and others as high as 72,000 hours. Few manufacturers noted how this value was derived.

SPECIFYING LINEAR LED LAMPS

A Rule-of-Thumb Guide*

More-Favorable Troffer Type for Linear LED Lamps

Recessed Indirect

Do not consider unless lamp efficacy and lumen output of the linear LED lamps are at least 20% higher than fluorescent.

Parabolic Louver

Use linear LEDs with a diffuse lens (wide distribution), and be aware of potentially increased glare, dark-appearing upper walls, and/or less workplane uniformity.

K12 Lens

Be aware that the lens may appear stripey and/or more glaring, and light distribution may be narrowed compared to fluorescent.

High Performance

Consider wide-distribution (diffuse) lamps, but avoid narrow-distribution (clear) linear LED lamps because they affect light distribution and appearance.

Volumetric

Luminaire efficiency, distribution, appearance, and glare perception were affected very little by the LED lamps.

More-Favorable Existing Lamp/Ballast System for LED Retrofit

Premium (25 or 28 W) T8 Fluorescent High-Efficiency Electronic Ballast

Linear LED lamps may not be cost-effective solution unless utility rates are very high and LED lamp costs very low.

Standard (32 W) T8 Fluorescent Magnetic or Electronic Ballast

Consider linear LED lamps, but also compare against a troffer retrofit with a combination of premium-quality, high-efficiency, long-life fluorescent lamps (36,000 to 80,000 hours life) and high-efficiency electronic ballast.

T12 Fluorescent Magnetic or Electronic Ballast

Consider linear LED lamps, but also compare against a troffer retrofit with a combination of premium-quality, high-efficiency, long-life fluorescent lamps (36,000 to 80,000 hours life) and high-efficiency electronic ballast.

2,000 lumens

If seeking a one-for-one replacement for fluorescent lamps, the linear LED lamps should generally produce a minimum of 70% of the rated T8 fluorescent lamp lumens, assuming a normal ballast factor of 0.87 for the fluorescent lamps. Slightly lower lamp output may result in equal delivered illuminance in some luminaires, because of the greater directionality of the LED lamps. This rule-of-thumb multiplier does not apply to recessed indirect luminaires and could vary upward or downward, depending on the specific combination of troffer and lamp.

> 100 lm/W

Assuming equal delivered illuminance, LED lamps generally need to be at least 100 lm/W to save energy compared to a typical fluorescent lamp.

> 80 CRI

Color temperature can vary based on preference, but in most applications a CRI of 80 should be considered the minimum.

< \$40

Cost-effectiveness varies based on many factors, such as electricity rate, hours of use, input power, and installation and maintenance costs. Assuming equal delivered illuminance, with average milled electricity rates (\$0.12/kWh) and longer annual hours of use (4,000), a typical linear LED lamp from the Series 21 sample (19 W) would be cost-effective over a 10-year period if the initial price was less than \$40 per lamp (including electronics). With other parameters, lower or higher prices may allow for economic viability.

*Every installation is unique, there is great variety in LED product offerings, and product change is constant. The included recommendations are based on CALiPER's evaluation of linear LED lamps between 2012 and 2014. Beyond these basic performance parameters, there are many other considerations when specifying a linear LED lamp, including the wiring configuration, warranty, lifetime, and luminous intensity distribution. In retrofit applications, other alternatives, such as LED retrofit kits or dedicated LED troffers, should also be considered.

THE RETROFIT PROCESS

1 Existing System Evaluation

Examine the condition of all existing lighting equipment to determine which parts are reusable. If a lamp retrofit is an option, determine the type and number of installed lamps (i.e., T12 or T8), type of installed ballast(s) (i.e., electronic or magnetic), and wiring configuration for the sockets (i.e., instant-start or rapid-start). Also record the specific model number of the luminaire, as well as the type of optical system.

Determine if a reduction in light output is acceptable, or if equivalent lighting performance is an important design criterion. If reducing light levels is an option, delamping or a simple change to a low-wattage fluorescent lamp type may be cost-effective options.

2 Specification

Based on the results of the existing system evaluation, determine the necessary system performance (e.g., luminaire lumen output and distribution) and desired appearance (e.g., color temperature). Search for products that can provide the necessary performance.

Important criteria to compare include input power, color quality, safety certifications, warranty, and cost. A life-cycle cost analysis can help determine if a retrofit using linear LED lamps is a cost-effective solution. An electrical contractor can be consulted to determine the time and cost associated with the installation.

3 Pre-Installation

Conduct a mockup with four to eight troffers. Bring in an electrician to rewire the troffer for the LED lamps (if needed), and get feedback on the ease and time needed for the retrofit. Also get feedback from the occupants on the appearance/glare/color quality of the modified luminaires. Is the change acceptable?

Consider modifying every troffer in the building with the same linear LED lamp and wiring type. Keep 5% spares on hand, so that if one or more lamps fail, a lamp with the identical wiring will be on hand as a replacement. Avoiding mixes of multiple source types, wiring types, or product types, in order to reduce the chances of an unsafe replacement in the future.

A practical, step-by-step guide to upgrading troffers to LED can be found at:
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led_troffer-upgrades_fs.pdf

FOR MANUFACTURERS

- ◆ Providing wiring diagrams on a specification sheet can aid users in selecting an appropriate product. Including clear instructions with the products can help installers avoid unsafe conditions.
- ◆ Use different product codes for different wiring configurations to help ensure that the right products are used during the initial installation, and whether replacement products are needed in the future.
- ◆ Lamps should be shipped with clear instructions and stickers for modifying troffers, with accurate company name, catalog number, contact information, and wiring information on them. Manufacturer names and catalog numbers on lamps and installation instructions must match.
- ◆ Providing appropriate new sockets with the lamp can make installation easier for the electrical contractor.
- ◆ It is important to have NRTL certification for specific existing troffers.
- ◆ There is a substantial difference between beam angle and aperture angle. Using terms properly can ensure that the best product is chosen for a given application.
- ◆ Beam angle and aperture angle simplify luminous intensity distribution data; provide complete data on specification sheets (measured according to LM-79) to help specifiers choose an appropriate product.
- ◆ Design Lights Consortium (DLC)-qualified products must be listed under a manufacturer's specific name and product number. A DLC-listed product that is private-labeled cannot automatically claim DLC listing under the original manufacturer's name. Guidelines for private labeling can be found at <https://www.designlights.org/content/QPL/ProductSubmit/PrivateLabeling>

