Tubular LED Guide

Powering forward.
Together.

SMUD®

Commitment to our Customers

As a community-owned, not-for-profit electric service, SMUD exists only to serve you, our customer. This means we're able to make decisions that focus on the best interests of our community. We make every effort to provide you with affordable, reliable electricity and offer services that can increase energy efficiency, lower your energy costs and protect our environment. We're always on the lookout for the latest innovations in electricity that can help our customers. We've done this for more than 70 years, and will continue to do so moving forward.

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Introduction

There is a lot of confusion in the industry regarding tubular LED replacement lamps (TLEDs) and retrofit kits in general. Since there are so many options to choose from, it can be difficult to decide which one is best to use. Some of the options include LED replacement lamps, LED retrofit kits with internal drivers, LED retrofit kits with external drivers, and LED light bars. These are important decisions because these technologies will remain in your buildings for a very long time.

This guide is written for Energy Managers, Facility Managers, Building Operators, Electrical Contractors and anyone else considering using tubular LED replacement lamps or retrofit kits. Our goal is to help you make the best decision for your space.

Don't forget to check out SMUD incentives at smud.org.

On behalf of SMUD, we hope this guide will help you with your lighting decisions!

Try before you buy!

There are many TLED options when selecting the right product for your space. Every product varies in its light distribution, physical size, thermal management, control compatibility, as well as other features. We recommend you try a couple first before purchasing for your entire space to be sure you selected the right TLED.

Dimming LEDs may be a challenge. Not all LED drivers are compatible with all dimming systems. Some LEDs may flicker or color shift.

Additional Resources

Department of Energy Caliper testing of TLEDs and troffers. *https://energy.gov/eere/ssl/caliper-testing*

LED Retrofit Options for Linear Fluorescent Luminaires, California Lighting Technology Center: http://*cltc.ucdavis.edu/sites/default/files/files/publication/LED_Retrofit_Options_Linear_Fluorescent_FINAL.pdf*

LED T8 Replacement Lamps

UL classifies tubular LEDs into 3 types:

Type A: tubular LEDs that work with many (but not all) fluorescent ballasts without *any* form of mechanical modifications or electrical rewiring.

Type B: tubular LEDs that require bypassing the fluorescent ballast (rewiring the fixture).

Type C: tubular LEDs that replace existing ballasts with LED drivers.

Type A benefits:

- Possible energy savings (depends on the product chosen)
- Simple drop-in lamp replacements (no rewiring required)
- May be more cost effective than other LED retrofit options (if the TLEDs are compatible with the existing fluorescent ballasts)

Things to consider:

- Manufacturer cut sheets may be vague, LED lamp and ballast must be compatible

- Since lamps may need to be dimmable to comply with Federal and State Energy Standards (e.g. California Title 24), instant start ballasts may pose a problem
- Verify condition of lens or louvers of existing light fixtures
- Light distribution, light output, and quality of light should be verified prior to purchasing in volume

Design Tips:

- These are typically used in recessed or surface mounted direct fixtures
- Verify distribution angle for use in direct/indirect fixtures
- Compare the cost and life of the TLED to the cost and life of a new LED fixture. Prices continue to drop as the market increases.

Recommendations:

- Products should be on the DLC Qualified Product List www.designlights.org/QPL
- Products should be UL Listed
- The installed system (lamps/driver/dimmer control) should be continuously dimmable down to 10%
- The project should meet applicable State and Federal Energy Standards (e.g. California Title 24)

Lamp Style LED Retrofit Kits

Type B: tubular LEDs that require bypassing the fluorescent ballast (rewiring the fixture).

LED lamps with **internal LED drivers** obtain power from either a single end or both ends of the lamp.

Single-ended power TLEDs use one lamp socket for power and the other merely to support the lamp. Lamps with double-

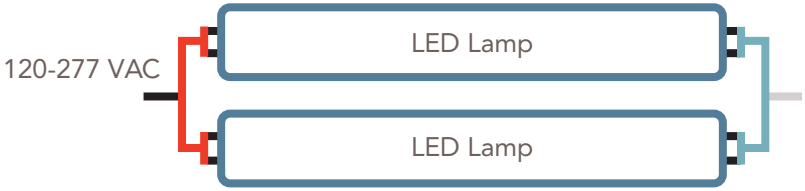
ended power inputs use both lamp sockets for power and mechanical support. The power is typically 110-277VAC for both formats and requires bypassing the fluorescent ballast and re-wiring the lamp sockets. Regardless of the lamp type, SMUD recommends replacing the lamps sockets during installation.

Single-ended power input TLED

110-277 VAC

No electrical connections on this end

Double-ended power input TLED with internal driver

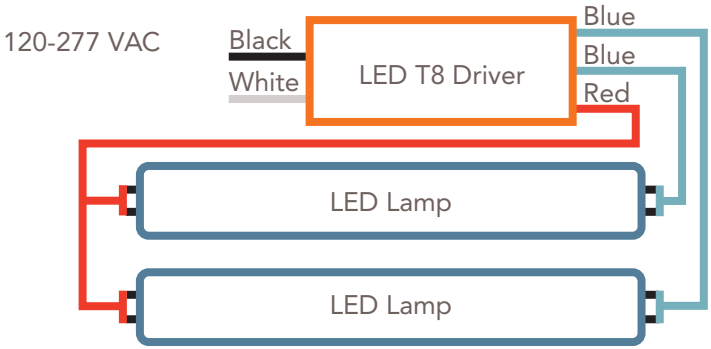


Note: Sample wiring diagrams. Consult with TLED manufacturer for specific wiring instructions.

Type C: tubular LEDs that replace existing ballasts with LED drivers.

Some LED lamps with **external LED drivers** usually don't use the lamp sockets for power, but still rely on the sockets for mechanical support. Products that use the lamp sockets are often wired similarly to fluorescent lamps with instant start ballasts, except they use low voltage wiring.

TLED with external driver and powered sockets

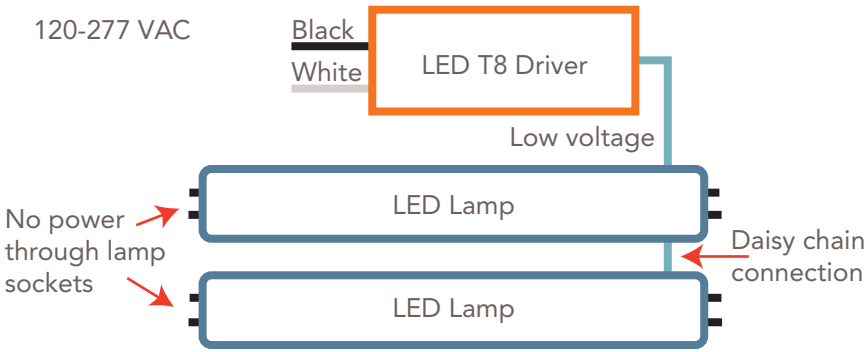


Note: Sample wiring diagram. Consult with TLED manufacturer for specific wiring instructions..

With some products, the LED driver is connected to the LED lamps via low-voltage cables with plug-in connectors. Lamps also may be daisy chained together with these cables.

The power is typically 110-277VAC to the LED driver for both formats.

TLED with external driver and non-powered sockets



Note: Sample wiring diagram. Consult with TLED manufacturer for specific wiring instructions.

Benefits:

- Possible energy savings (depends on product chosen)
- Potential maintenance savings (compared to standard fluorescent T8 lamps)
- Less expensive than LED luminaires and troffer retrofits
- Retain appearance of original light fixtures

Things to consider:

- Should be installed only by qualified electricians
- Verify that dimmability complies with local energy standards
- Verify condition of lens or louvers of existing luminaire (aka light fixture)
- Look for higher efficacy products (70+ LPW)
- Verify light distribution, light output, and quality of light before purchasing in volume

Design Tips:

- These are good to use in direct fixtures when you want to keep the luminaire housing. If the fixtures are in poor condition, don't expect the TLED to perform miracles
- Systems that use external drivers may be easier to dim since they are available with common control communications formats such as 0-10V and DALI

Recommendations:

- Products should be on the DLC Qualified Product List www.designlights.org/QPL
- The installer should replace existing fluorescent lamp sockets with sockets recommended by the LED retrofit kit manufacturer. Push-in type lamp sockets should also be replaced
- Existing fluorescent ballasts should be removed
- Products should be UL Classified
- An electrical disconnect should be installed {similar to fluorescent fixtures as required by NEC Section 410.73(G)} on the incoming power leads
- The installed system (lamps/driver/dimmer control) should be continuously dimmable down to 10%.
- Fixtures should be properly labeled with manufacturer-provided labels to inform future maintenance workers about conversion to LED
- The project should meet applicable State and Federal Energy Standards (e.g. California Title 24)

LED Light Bar Retrofit Kits

SMUD definition: LED light bar retrofit kits are designed to fit into existing fluorescent troffers and require some form of electrical rewiring (e.g. bypass or replace the fluorescent ballasts). The LED light bars are mounted to the luminaire and don't use the lamp sockets. They may use either internal or external LED drivers.

Benefits:

- Possible energy savings (depends on product chosen)
- Potential maintenance savings (compared to standard fluorescent T8 lamps)
- Less expensive than LED luminaires and troffer retrofits
- Does not use lamp sockets for support
- Retain appearance of original light fixtures

Things to consider:

- Many attach directly to the luminaire housing with screws, tape, etc.
- Should be installed only by qualified electricians
- Verify that dimmability complies with local energy standards
- Verify light distribution, light output, and quality of light before purchasing in volume
- Look for higher efficacy products (70+ LPW)
- Light bars vary greatly in quality – verify the thermal management of the kit

Design Tips:

- Great option for lensed or volumetric fixtures
- Light bar kits with external drivers are often easier to integrate into lighting control systems
- Some of these products may provide additional up lighting due to their configuration and flexibility within the fixture

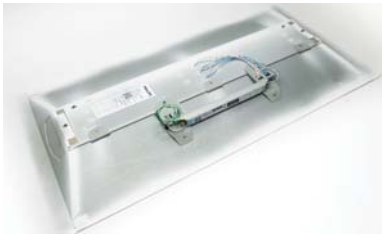
Recommendations:

- Products should be on the DLC Qualified Product List www.designlights.org/QPL
- The installer should remove existing fluorescent ballasts and lamp sockets
- Products should be UL Classified
- An electrical disconnect should be installed {similar to fluorescent fixtures as required by NEC Section 410.73(G)} on the incoming power leads

- The installed system (lamps/driver/dimmer control) should be continuously dimmable down to 10%
- The project should meet applicable State and Federal Energy Standards (e.g. California Title 24)

LED Troffer Retrofit Kits

SMUD definition: LED troffer retrofit kits are designed to replace existing fluorescent lamps, sockets and ballasts within existing fluorescent troffers. Kits must include new optical assembly specifically designed for LEDs.



Benefits:

- Energy savings: Many kits are now available with integral occupancy and daylight harvesting sensors.
- May be easier and more cost effective than a complete LED luminaire (aka light fixture) replacement
- Kits include optical assembly specifically designed for LEDs
- Great option for ceilings with asbestos or insulation directly above the luminaire

Things to consider:

- Should be installed only by qualified electricians
- Verify that dimmability complies with local energy standards
- Check seismic code requirements
- Verify condition of lens or louvers of existing luminaire
- Look for higher efficacy products (90+ LPW)
- Ensure kits work for your luminaires: test for physical fit, light distribution and lighting quality before committing to any major purchases

Recommendations:

- Products should be on the DLC Qualified Product List www.designlights.org/QPL
- Products should be UL Classified
- LED troffer kits should be continuously dimmable down to 10%
- Project should meet applicable State and Federal Energy Standards (e.g. California Title 24)

LED Troffers

Complete LED luminaires are designed specifically to replace fluorescent troffers.

Benefits:

- Energy savings: Many products are now available with integral occupancy and daylight harvesting controls.
- Potential maintenance savings
- Full warranty (up to 10 years for some products)
- May dramatically improve lighting quality
- Luminaires are specifically designed for LEDs
- Provides great option for relocating or redesigning overlit or improperly lit spaces

Things to consider:

- Consider relocating fixtures where best needed
- May be the best or most expensive option (labor and materials) depending on the site conditions
- Some LED troffers may produce uncomfortable glare. Dimming these down 10-20% will help reduce glare and save energy
- Should be installed only by qualified electricians
- Verify that dimmability complies with local energy standards
- Look for higher efficacy products (90+ LPW)
- Check seismic code requirements
- Check serviceability which can vary considerably between products
    - Are the replacement parts modular?
    - What is the availability of replacement parts?

Recommendations:

- Products should be on the DLC Qualified Product List www.designlights.org/QPL
- Products should be UL Listed
- LED troffers should be continuously dimmable down to 10%
- Project should meet or exceed applicable State and Federal Energy Standards (e.g. California Title 24)

Fluorescent as an Option

Benefits of linear T8 fluorescent lamps

Newer generation fluorescent T8 lamps have advanced greatly in the past few years. Some benefits include:

- Efficacy of over 100 lumens per Watt
- Rated life up to 84,000 hours (based on a 12 hour start)
- Color rendering in the 90's (CRI)
- Wattages range from 25 to 32 Watts
- Low cost
- Mature technology
- Dimmable (pay close attention to dimming ballast performance curves - see next page)

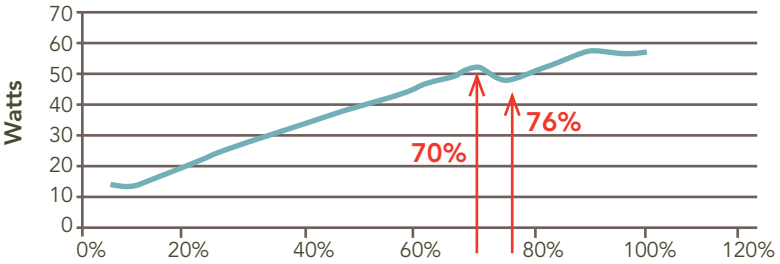
Things to consider:

- All fluorescent T8 lamps contain mercury and must be disposed of properly. They are considered Universal waste which is a category of hazardous waste
- All new installations in California most likely will have to be dimmable under the 2016 Energy Standards

Pay Close Attention to Ballast Curves

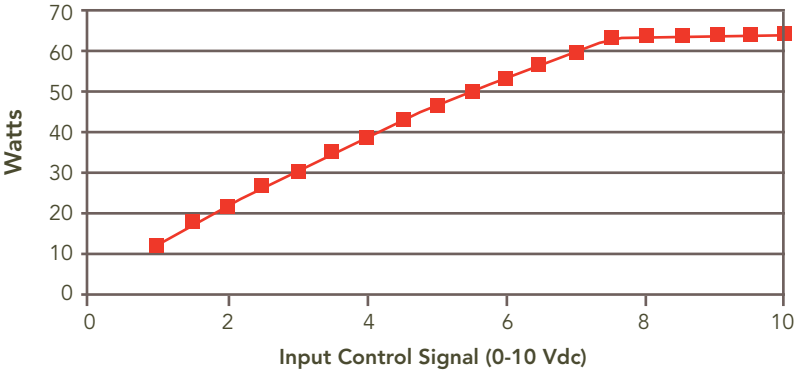
When selecting dimming fluorescent ballasts, it is important to consider the performance curves. Recent studies by SMUD and NEEA revealed that some popular dimming ballasts that use 0-10V control inputs, have some unexpected performance characteristics. Below are two specific examples from the study.

Power vs. Dim Level



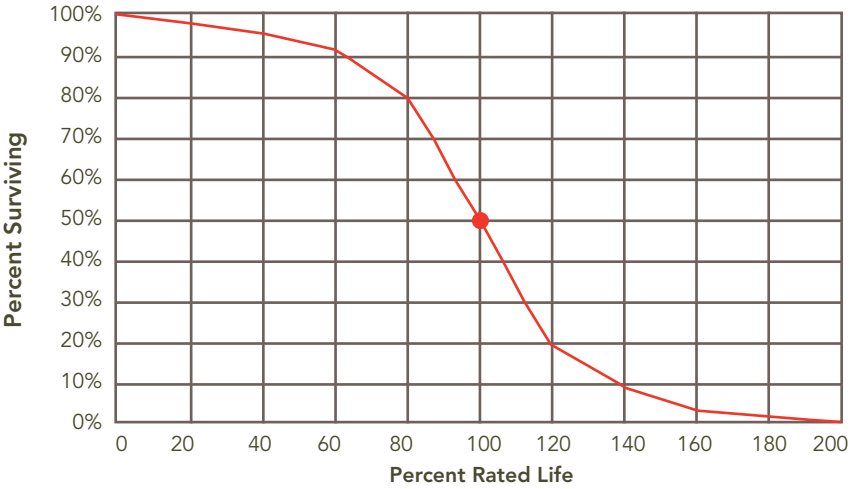
This popular dimming ballast consumes more power when dimmed to 70% than it does at 76% (due to cathode heating).

Power vs. Control Signal

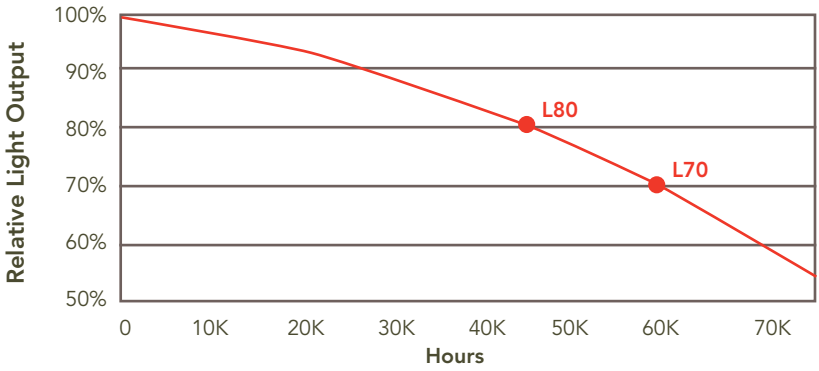


This commonly used ballast has a deadband from 7.5V – 10V (lights won't provide energy savings until dimmed approximately 25%).

Lamp Life



Typical life of a lamp (non-LED): half of the lamps fail at the published rated life. i.e. 36,000 hours (lamp life varies with 3 hour or 12 hour starts)



Typical life of a LED: L70 = when the LED loses 30% of its lumen output. L80 = when the LED loses 20% of its lumen output.

UL Requirements

Underwriter's Laboratory (UL) performs numerous tests for TLEDs for safety. However the Marks may be confusing. It is important to understand the different markings because some products claim to meet UL Standards but don't.

UL Listed, the most common UL Mark.

- "The UL Listed" Mark indicates that the laboratory found that a representative group of product samples met UL's safety requirements, usually based on published standards
- The typical listed product is a complete system meant to be "plug and play," meaning nothing else needs to be done to the product other than connecting power, either with a cord-and-plug or by hard-wiring
- Tubular LED lamps fall into this category if they are designed as a fluorescent lamp replacement with no ballast change or disconnection

UL Classified

- A Classified Mark indicates the product has been evaluated by a qualified laboratory, but only with respect to specific properties, a limited range of hazards, or suitability for use under limited or special conditions
- LED retrofit kits and LED replacement lamps that require disconnection of the original ballast and re-wiring are products that fall into the "Classified" category

- For LED replacement kits or lamps that are UL-1598C classified and properly installed in a UL certified luminaire will retain the original UL certification

UL Recognized

- The UL Recognized Component Mark is used with components that are intended to be installed as part of a specific larger end product or system
- Consumers rarely see this Mark because these products are installed at the factory, not the field
- A luminaire can be rated to use a variety of Recognized components without requiring re-testing for relisting
- This Mark is found on critical components such as lamp holders, drivers, wiring, and connectors

Other Markings

Canadian Standards Association Mark (CSA)

C US

- This Mark means the product has been found to comply with CSA's listing requirements as well as U.S. requirements, likely found in a UL Standard
- This Mark is similar to the UL Listing Mark, however issued by CSA
- There are many 'deviations' to the parallel standards in the U.S. and Canadian requirements, largely driven by differences in our National Electric Codes

Environmental Testing Labs (ETL)

- Intertek is Nationally Recognized Testing Laboratory (NRTL)
- Manufacturers may request NRTLs to test

their products to one or more of the following standards: UL, ANSI, CSA, ASTM, NFPA, NOM, etc. Because of this, it is important to know which standards were used during testing

Conformité Européenne (CE)

- The CE marking is the manufacturer's declaration that the product meets the requirements of the applicable EC (European Economic Area) directives and so enables the free movement of products within the European market
- CE marking is a self-certification
- The manufacturer declares, at its sole responsibility, conformity with all the legal requirements to achieve the CE marking
- The CE marking in itself does not certify conformity with relevant technical standards. Because of this, SMUD doesn't accept the CE marking alone for the TLED program

Reference: www.UL.com/marks/

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