Benefits of Retrofitting T8 Luminaires

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Howard Wolfman, PE
Lumispec Consulting

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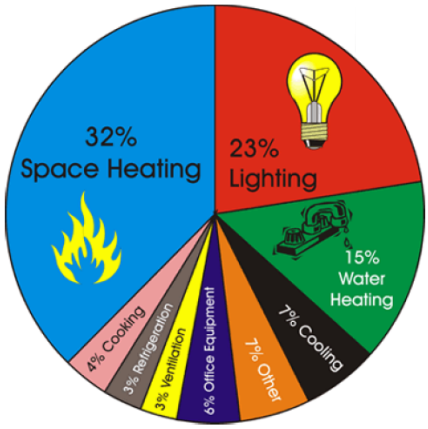
Lighting Consumes How Much Energy in a Building???



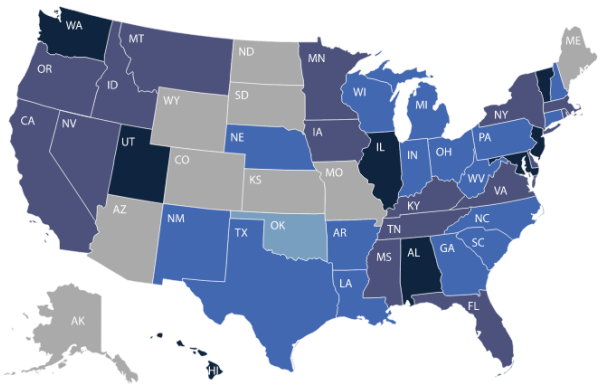
Source: consulting-specifying engineer

Interior Lighting by the Numbers - Commercial Buildings

- Commercial lighting is ≈ 2.6% of **ALL** primary energy consumption in the U.S.
- Troffers ≈ 1% of **ALL** energy use
- ≈ 20% of building energy is lighting and troffers are ≈ 50% of that energy

Source: US DOE presentation at 2016 Lightfair

ASHRAE 90.1 Commercial Code Status Map



Meets or exceeds **ASHRAE 90.1-2013** or equivalent (8)
Meets or exceeds **ASHRAE 90.1-2010** or equivalent (17)
Meets or exceeds **ASHRAE 90.1-2007** or equivalent (19)
Meets or exceeds **ASHRAE 90.1-2004** or equivalent (1)
No statewide code or predates ASHRAE 90.1-2004 (11)

This map reflects only mandatory statewide commercial energy codes currently in effect.

In instances where a state has developed its own code, the maps approximate its energy efficiency in terms of the national model codes. Every effort is made to ensure that they are accurate and up-to-date. If you have any questions or comments about the maps, please contact us.

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Why Convert from Fluorescent to LED Tubes

- In North America, there are hundreds of millions of installed T8 fluorescent lamp systems that are “wasting energy”
  - Use more energy than alternatives
- There are several cost effective, alternative LED T8 Tube retrofit solutions that are offered in today’s market.
  - Alternatives do not require replacing a luminaire
  - Alternatives do not require opening the ceiling – Asbestos concerns
- All of these alternative solutions reduce maintenance, material, and labor costs, but each solution has its benefits and drawbacks relative to installation and energy savings.

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Top 10 reasons why everyone is interested in TLEDs

1. They last longer (forever maybe) than fluorescent lamps
2. A TLED is perceived to be the lowest cost option to get the benefits of LED
3. Efficacy has been steadily increasing
4. Prices have been steadily decreasing
5. I get to keep my existing fixture that's been in my ceiling for 20 years
6. They don't have any of that bad 'ol mercury
7. Many continue to cling to the old paradigm that "a-lamp-is-a-lamp" and all lamps interchange "one-for-one"
8. I can potentially do away with my ballasts and get into the "lamps only" business
9. Installation is just a "point" and "click" away
10. They truly are shiniest damn thing in my ceiling!

Source: US DOE presentation at 2016 Lightfair

Power draw of 32W T8 lamp or LED Tube

- How much power does a 32W T8 lamp draw?
  - Well, its rated at **32 Watts**
  - But when used with a normal ballast factor, Instant Start or Programmed Start ballast (BF= 0.88), the arc power is about **29 Watts**. Arc power is the power used during operation, after starting the lamp.
  - The T8 Fluorescent lamp and ballast system power draw is the sum of the lamp power and ballast consumed power

    29W + ≈2W or ≈ 31Watts
- How much power does an LED Tube draw?
  - 15 to19 Watts
- Power savings of using a LED Tube vs. 32W T8 Lamp

  31W – 19W = 12 Watts or 39% savings

  31W – 15W = 16 Watts or 52% savings

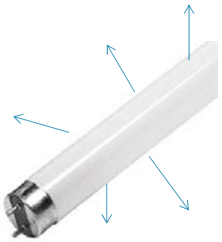
Light Distribution

- A fluorescent lamp is an omni-directional light source,
  - It shoots light in every direction
  - Only 1/3 to 1/2 of that light directly illuminates it's intended surface.
  - If the tube is mounted in a troffer an even larger portion is reflected within the fixture and really never leaves it.
- A LED lamp is a directional light source.
  - It's lumen output is measured outside the fixture or once the light actually exits the fixture.
  - It's usable light that is directed towards it's intended surface vs. light that is scattered and lost from a fluorescent source.

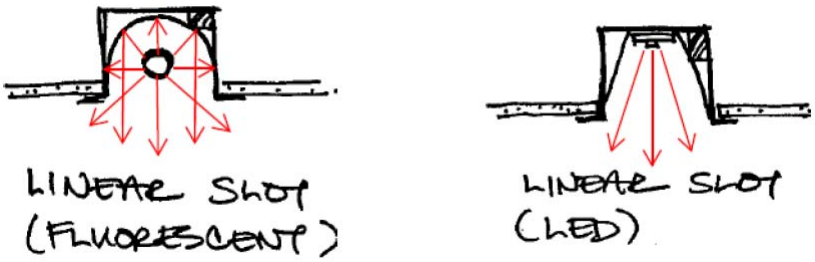
Light Distribution

T8 Fluorescent Lamp

T8 LED Tube

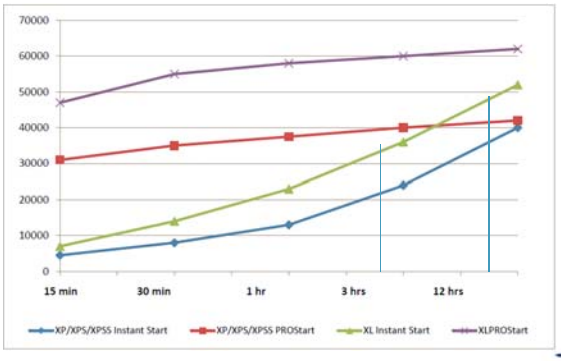


Directionality



Lamp Life T8 Fluorescent vs. T8 LED Tube

- **Definition**: Fluorescent lamp life is the number of hours at which half of a large sample of lamps has failed
- **Standard T8 32 Watt Fluorescent Lamp on Instant Start Ballast**
  - **3 hr. per start = 18K hrs. or at 12 hr. per start = 30K hrs**
- **Long life T8 32 W**
  - **3 hr. 29K hrs.**
  - **12 hr. 40K hrs.**

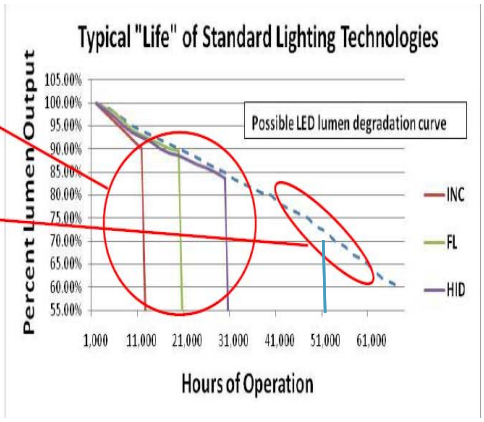


LED Tube Life

- **Definition**: LED lamp life is defined as 70 % lumen maintenance e.g. when the lumen depreciation of a large sample of lamps has reached 30%, the LED lamp is considered to be at end of life
- However, unlike Fluorescent lamps, the LED lamp will continue to operate and emit light
- T8 LED tube life for the better designed tubes is defined as 50,000 hours

Everlasting LEDs do not last Forever

- **ALL** light sources degrade - most fail before critical light output level is reached
- LED diodes can survive but also degrade well beyond useful light level
- Industry considers lumen output as one measure of the **useful life** of an LED diode. Commonly, 70% of initial output is used.



Types of T8 LED Tubes

Source: DOE CALiPER Report 21

UL Definitions for T8 LED Tubes

Copy of part of UL 1598C SA13 Devices Substituting for Linear Fluorescent Lamps

- SA13.1 The requirements in this section apply to LED devices that have the general appearance, length, and lamp base types of a conventional fluorescent lamp. These devices have the physical dimensions of a lamp as specified in the Standard for Electric Lamps – Double-Capped Fluorescent Lamps – Dimensional and Electrical Characteristics, NEMA ANSLG C78.81. The types specified below are to be used for purposes of this supplement:
- a) **Type A** – A device for general-use is intended for direct substitution of a fluorescent lamp and operating from the ballast that would be provided for the fluorescent lamp without additional modifications of the fluorescent lamp circuit.
- b) **Type B** – A device for special-use intended for operation in luminaires that are either factory wired especially for the device or as a component for retrofit luminaire conversions involving modification of an existing luminaire, and, where the LED driver components are an integral part of the device.
- c) **Type C** – A device for special-use intended for operation in luminaires that are either factory wired especially for the device or as a component for retrofit luminaire conversions involving modification of an existing luminaire, and, where the LED driver components are remote from(or not an integral part of) the device.

Design Lights Consortium Description of LED Tubes

Replacement Lamps (UL Type A):

Four-foot or two-foot LED "tubes" designed to replace four-foot or two-foot fluorescent lamps, respectively. Products in this category employ lamp holders to connect to the fixture being retrofitted and are designed to be "plug and play" replacements for fluorescent lamps. That is, products in this category **can operate off an existing fluorescent ballast,** and **do not require mechanical or electrical changes to the fixture.** Note that due to testing considerations, at this time **only products that can operate off electronic instant start ballasts are eligible.** Replacement lamps designed to operate off existing magnetic ballasts, or off other types of electronic ballasts, are not eligible.

Internal Driver/Line Voltage Lamp-Style Retrofit Kits (UL Type B):

Four-foot or two-foot LED "tubes" designed to replace four-foot or two-foot fluorescent lamps, respectively. Products in this category employ lamp holders to connect to the fixture being retrofitted, **but do not operate off the existing fluorescent ballast**. These products **require rewiring of the existing fixture to bypass the ballast and send line voltage directly to the lamp holders.**

Design Lights Consortium Description of LED Tubes

- **External Driver Lamp-Style Retrofit Kits (UL Type C):**
  - Four-foot or two-foot LED "tubes" designed to replace four-foot or two-foot fluorescent lamps, respectively. Products in this category employ lamp holders to connect to the fixture being retrofitted**, do not operate off the existing fluorescent ballast,** and **require rewiring of the existing fixture to replace the ballast with an external driver. The lamp holders are then wired to receive only the low-voltage electricity that is supplied by that external diver.**
- **Dual Mode Internal Driver (UL Type A and Type B):**
  - Four-foot or two-foot LED “tubes” designed to replace four-foot or two-foot fluorescent lamps, respectively. Products in this category have the ability to **operate off the existing fluorescent ballast and also have the ability to operate off of line voltage if the troffer is rewired to bypass the ballast. These products connect to the troffer using standard pin-base connections to the lamp holders.** Note that at this time **only products that can operate off electronic instant start ballasts are eligible.** Products that are designed to operate off magnetic or non-instant start electronic ballasts are not eligible.

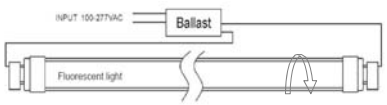
Types of T8 LED Tubes

- **UL Type A**
  - direct substitution of a fluorescent lamp operating from the ballast in the luminaire
  - without additional modifications of the circuit.
- **UL Type B**
  - direct wire from the AC mains
  - LED Driver contained in the tube
- **UL Type C**
  - LED Driver remote from the tube
- **UL Type A and B**
  - Can be operated as either a type A or B

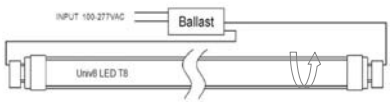
Type A of T8 LED Tubes

Lamp replacement

- Type A is a replacement for the fluorescent tube and is powered by the fluorescent ballast.
- With a UL Type A T8 LED Tube, when the fluorescent ballast fails, it normally needs to be replaced or the lighting system will not work.
- If the fluorescent ballast is a dimming ballast, the T8 LED Tube can be dimmed
- Since the fluorescent ballast is still operating, the total energy consumed is the sum of that consumed by the fluorescent ballast and that consumed by the LED tube.



T8 Fluorescent Lamp



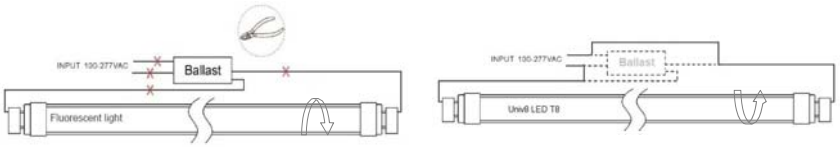
T8 LED Tube

 UniV8 is a Forest trademark

Type B of T8 LED Tubes

Direct Wire

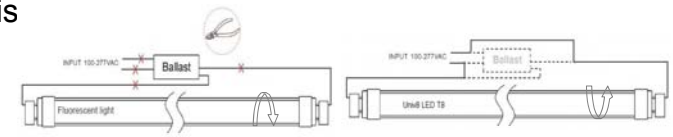
- UL type B T8 LED tube bypasses the existing fluorescent ballast and rewires mains voltage to the lamp holder.
- Contained in a simple retrofit kit that includes the tube, installation instructions, and labels.
- Since the fluorescent ballast is bypassed, the total energy consumed is only that of the LED tube.



Type A/B of T8 LED Tubes

Combination of Direct Wire and Lamp Replacement

- This



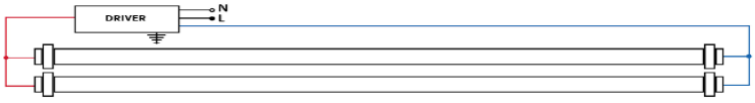
- And/or this

- **BIG Advantage – reduce SKUs by 50%**
- Also, when the fluorescent ballast fails, the tube can be rewired as a direct wire tube

Type C of T8 LED Tubes

External Driver Lamp-Style Retrofit Kits

- Use lamp holders to connect to the fixture being retrofitted
- Do not operate off the existing fluorescent ballast
- Require rewiring of the existing fixture to replace the ballast with an external driver
- Wired to receive only the low-voltage power supplied by the external driver
- May be dimmable, normally with 0-10V DC control signal
- The total energy consumed is the sum of that consumed by the Driver and that consumed by the LED tube



UL Safety Standards, Electromagnetic Interference (EMI) Standards

How to maintain UL listing of the Luminaire

Direct Wire - Doesn't rewiring void the UL listing of the luminaire?

- **No**, rewiring the luminaire does not void the UL listing of the luminaire per UL 1598C
- UL 1598C Section 15.1 states "Installation of the retrofit kit on the intended luminaire when conducted in accordance with the installation instructions provided with the retrofit kit and using components and materials provided with the kit shall facilitate continued compliance of the retrofitted luminaire with the requirements in the Standard for Luminaires, UL 1598."
- **This means that as long the installation instructions for the retrofit kit are followed, the retrofitted luminaire shall comply with the requirements in the UL Standard**
- UL urges those installing a lighting retrofit to use only third-party certified retrofit kits and follow the accompanying installation instructions. UL Certified lighting retrofit kits can be verified in UL's Certification database found on ul.com at http://iq.ul.com/ssl/ and selecting LED Retrofit Kits from the product category pull-down

Lamp Replacement –

- **No issue** – a T8 LED Tube must meet the requirements of UL 1993

UL Comparison of Direct Wire (Ballast By-pass) External Driver, and Direct Replacement (Plug and Play) LED T8 tubes

- **Commonality**
  - All require some type of UL Standards Compliance
- **Difference**
  - Direct Replacement tubes (Type A) shall comply with UL 1993 *Standard for Safety Self - Ballasted Lamps and Lamp Adapters*
  - Direct Wire and External Driver tubes (types B & C) shall comply with UL 1598C *Standard for Safety Light - Emitting Diode (LED) Retrofit Luminaire Conversion Kits*
- **Combination** T8 LED Lamp
  - Dual UL rated for compliance with both 1598C and 1993..

UL 1598 – Standard for Safety – Luminaires

- **"Voluntary"** Standard for Safety for Luminaires – 304 pages
- This Standard applies to luminaires for use in non-hazardous locations and that are intended for installation on branch circuits of 600 V nominal or less between conductors
- Covers Incandescent, HID, Fluorescent, and SSL luminaires
- Supplements
  - 1598A Luminaires for Installation on Marine Vessels
  - 1598B Luminaire Reflector Kits for Installation on Previously Installed Fluorescent Luminaires
  - 1598C Light-emitting diode (LED) retrofit luminaire conversion kits (TLEDS)

UL 8750 Light Emitting Diode (LED) Equipment for Use in Lighting Products

- **"Voluntary"** Safety requirements for LED equipment that is an integral part of a luminaire or other lighting equipment and which operates in the visible light spectrum between 400 – 700 nm
- Requirements **also cover the component parts** of light emitting diode (LED) equipment, including LED drivers, controllers, arrays, modules, and packages as defined within this standard
- Requirements in this standard are intended to supplement those in 12 other UL end-product standards including UL1598

FCC Part 15

- **Mandatory** per US government
- Covers conducted and radiated EMI and EMC
- Somewhat similar to CISPR 15 (IEC and Europe)
- FCC practice faster and less costly than IEC
- Review being conducted by FCC and Industry Canada regarding expanding the radiated frequency range..

Characteristics of LED Tubes

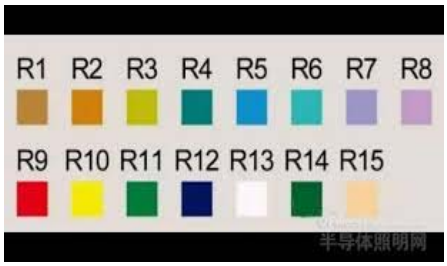
Dimming

- Type A – can only be dimmed if the fluorescent ballast is a dimming ballast (an expensive ballast)
- Type B – cannot be dimmed
- Type C – if the remote driver is dimmable, the LED Tube can be dimmed
- Type A and B – see A and B above

Glare

- LED tubes normally are offered in two basic lens
- Clear
  - Highest efficacy
  - Greatest glare
  - Individual LEDs visible
- Frosted
  - Slightly lower efficacy
  - Minimal glare
  - Individual LEDs not visible

CRI – Color Rendering Index



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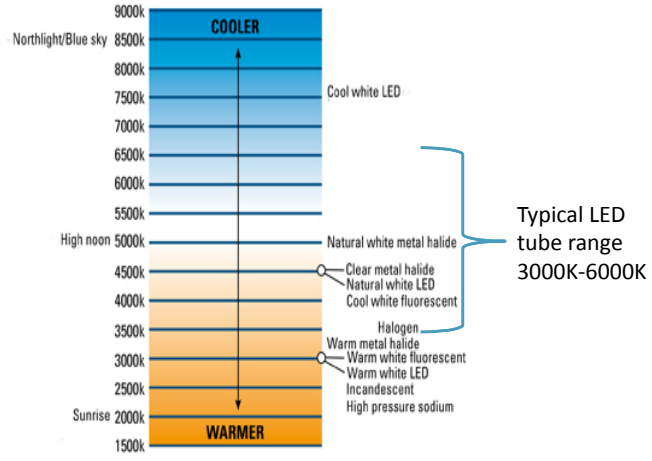
CCT – Correlated Color Temperature



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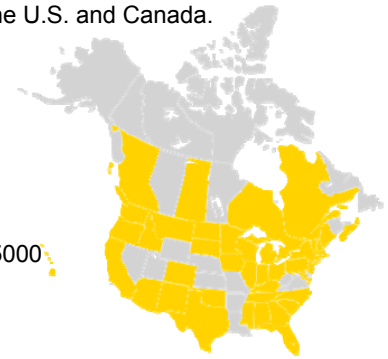
Rebate Programs

- The most common rebate program is the Design Lights Consortium (DLC) program
- DLC is supported by its 78 members who are regional, state, utility, and energy efficiency programs throughout the U.S. and Canada.
- 210,000 Products listed
- 14,500 T8 LED tubes listed
  - 3760 Lamp Replacement A
  - 4900 Direct Wire B
  - 1340 Combination A & B
  - 1640 Remote Driver C
  - Includes 4 ft, 2ft, CCT from 3000 to 5000
  - Includes requirements for
    - CCT. CRI, Power Factor, etc.



Comparison of T8 LED Tube Types

	T8 LED Tube Type			
	Type B Direct Wire	Type A Lamp Replacement	Type A/B Combination	Type C External Driver
Pros	Eliminates the ballast	Does not Require rewiring	Use with ballast or rewire	Eliminates the Ballast
	Lowest total power consumption		Can be lowest power consumption or does not require rewiring	
	Does not require opening ceiling	Does not require opening ceiling	Does not require opening ceiling	Does not require opening ceiling
	Separate set of SKUs	Separate set of SKUs	50% fewer SKUs	Separate set of SKUs
	Lamp life = 50,000 hrs.	Lamp life = 50,000 hrs.	Lamp life = 50,000 hrs.	Lamp life = 50,000 hrs.
Cons	Requires rewiring	Power=∑ ballast +lamp	None	Required rewiring

"How to sell more Luminaires"

"Remodeling with Existing Luminaire"

“Outside Work”

Questions?

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