

T8 LEDs for Troffers: A Slam-Dunk?



LightFair

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LED T8s in Troffers: A Slam-dunk??

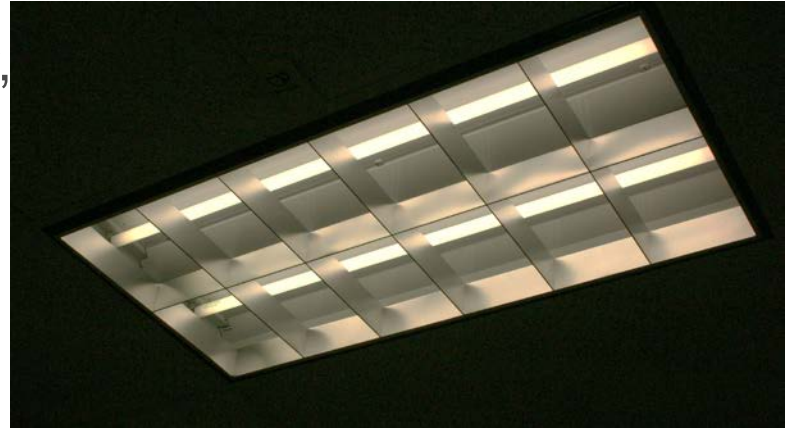
CALiPER tests performance claims with sphere and gonio photometry

- Lumens, Watts, LPW, Distribution, Color, Power Quality, etc.
- Bare lamp AND inside luminaires

We ALSO want to know...

Does the LED lamp and its distribution affect

- Appearance?
- Glare?
- Light distribution on work plane?
- Light pattern on adjacent walls?
- Luminaire efficiency?



LED T8s in Troffers: A Slam-dunk??

CALiPER exploration

- Reviewed and catalogued the available market of T8 LED lamps
- Purchased 31 LED T8 lamp types
- Baseline was premium 28 W T8 (GE 28T8/XL/SPX41/ECO) and Instant Start electronic ballast (51W for 2 lamps at .87 BF)



A subset of the Series 21 linear LED lamp (and fluorescent benchmark, top), illustrating the diversity of product designs.

LED T8s in Troffers: A Slam-dunk??

Options in LED T8 lamps:

- Aperture finish (clear/diffuse/other)
- Beam angle
 - Clear: 105° to approx. 125°
 - Diffuse: approx. 125° to 160°
- Color variations (CCT, CRI, R9)
- Dimmability (~20% showed option)
- Rotatable ends

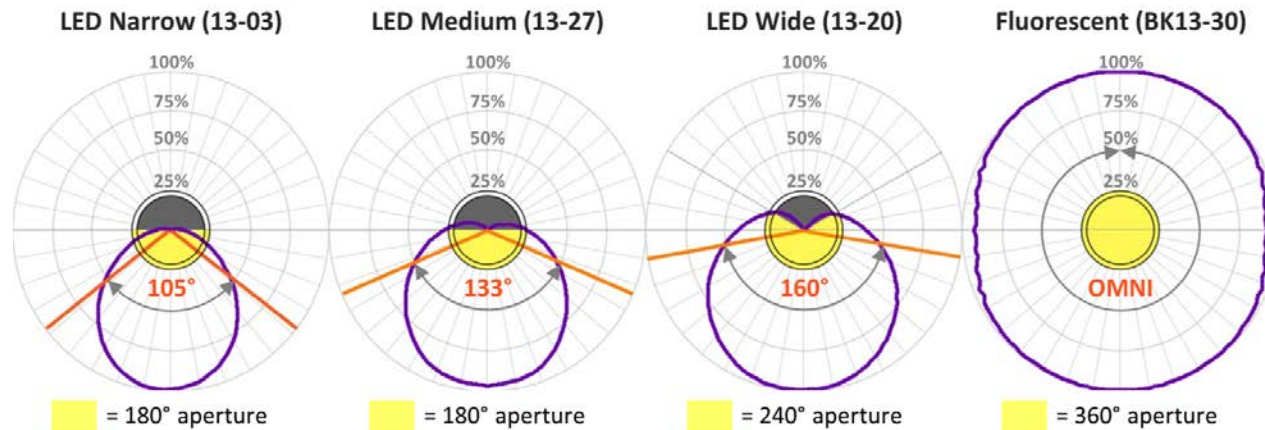


Figure 3. Aperture angle and beam angle of Report 21.2 LED and fluorescent lamp products. The aperture angle for the wide distribution LED lamp (13-20) is approximate, because the diffuser wraps around the edge of the opaque interior surface. The yellow indicates the front of the lamp and thus the direction of emitted light, whereas the gray indicates the back of the lamp.

- Wiring/electrical characteristics

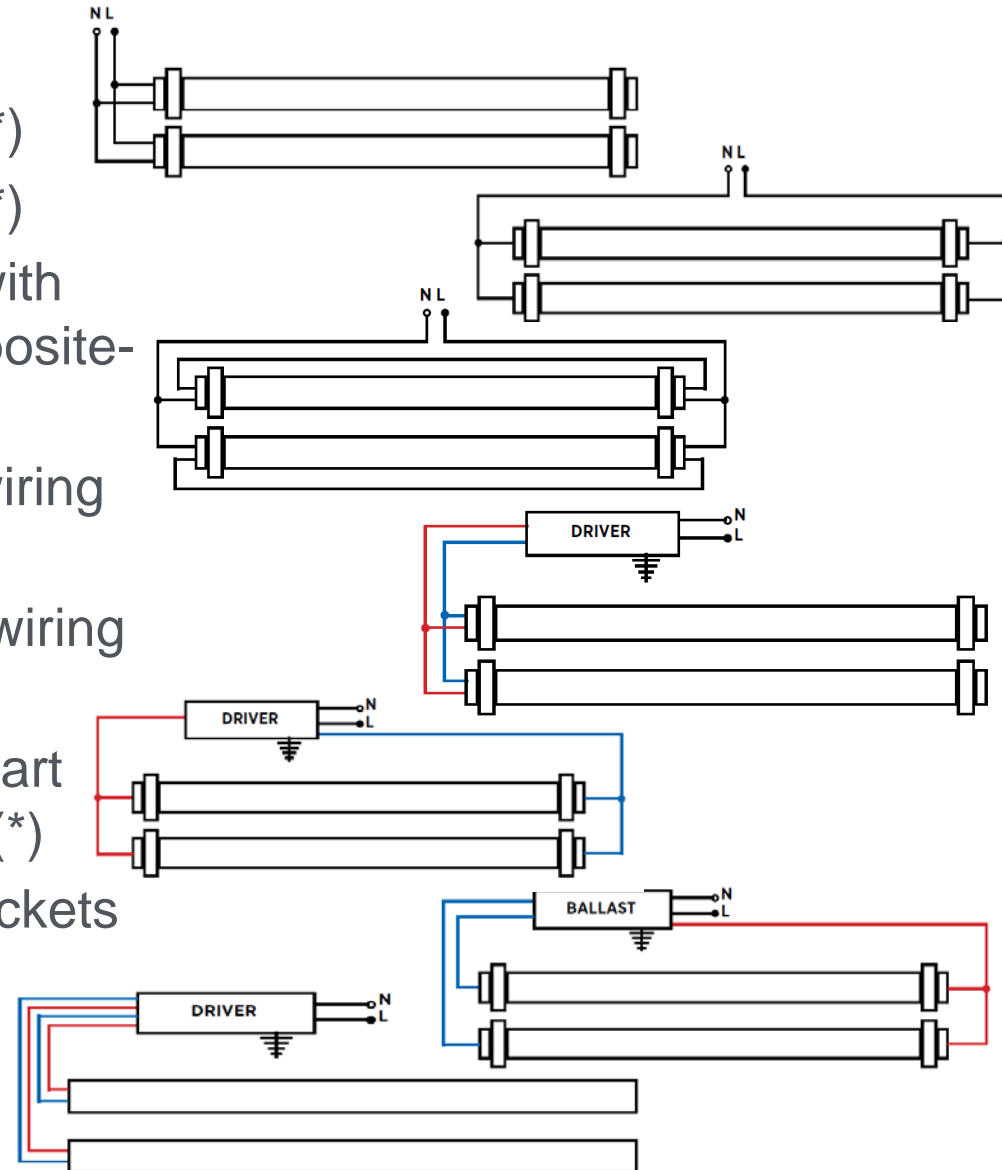
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Wiring/electrical characteristics

1. Line voltage single end wired (**)
2. Line voltage double end wired (*)
3. Line voltage double end wired with additional wire between two opposite-end pins (**)
4. Remote driver with single-end wiring (**)
5. Remote driver with double-end wiring (*)
6. Operates with existing instant-start fluorescent ballast and sockets (*)
7. Operates without fluorescent sockets

* Instant-start or *shunted* sockets req'd

** Rapid-start or *unshunted* sockets req'd

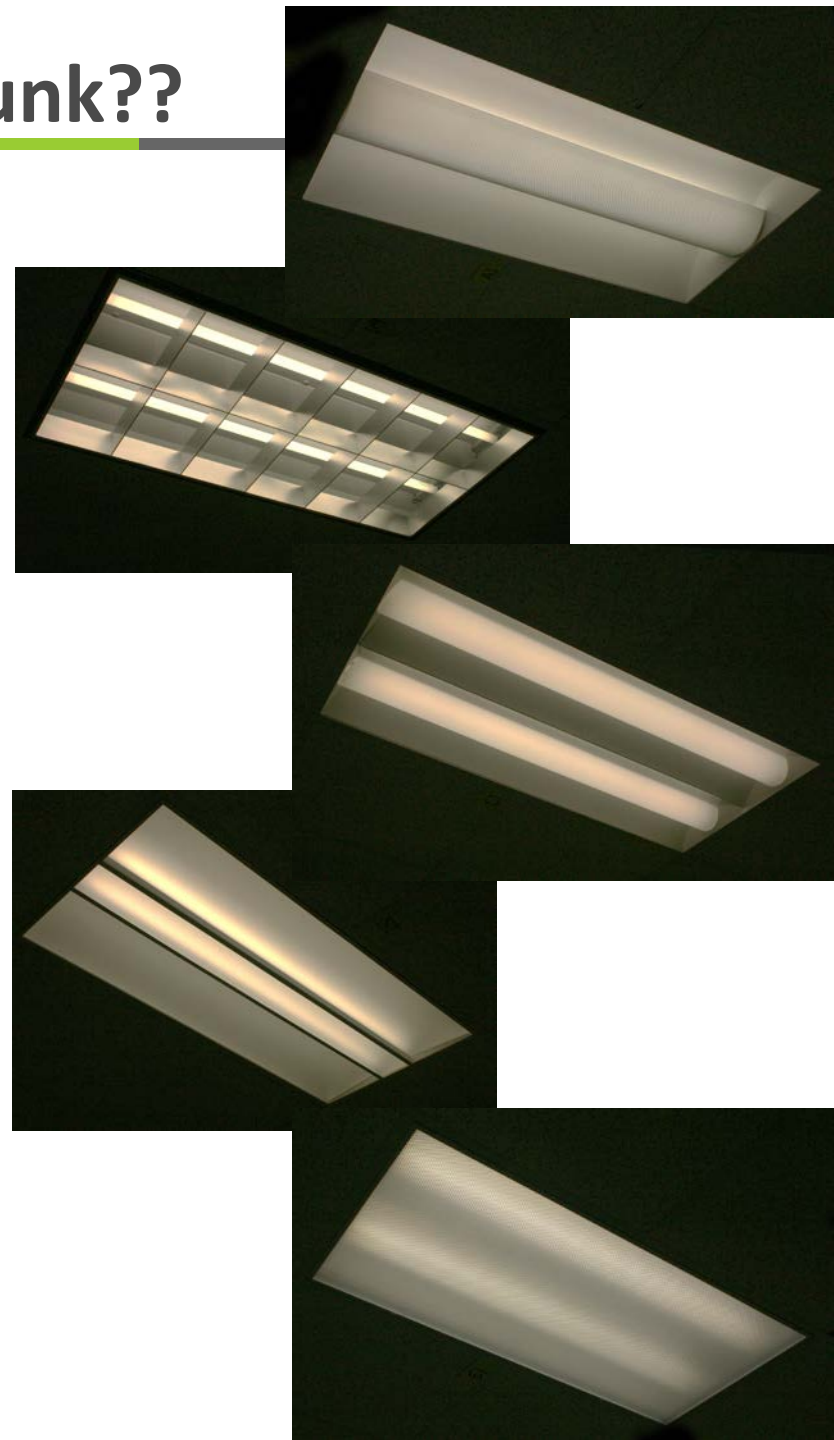


LED T8s in Troffers: A Slam-dunk??

What happens when you put narrow-medium-wide beam angle lamps inside 5 standard troffer types?

- Recessed indirect troffer (perforated metal basket luminaires)
- Troffer with 3" deep 12-cell parabolic louver
- "Volumetric" high-performance troffer with two linear rounded diffusers
- High performance troffer with diffuser and linear details
- Troffer with K12 acrylic prismatic lens

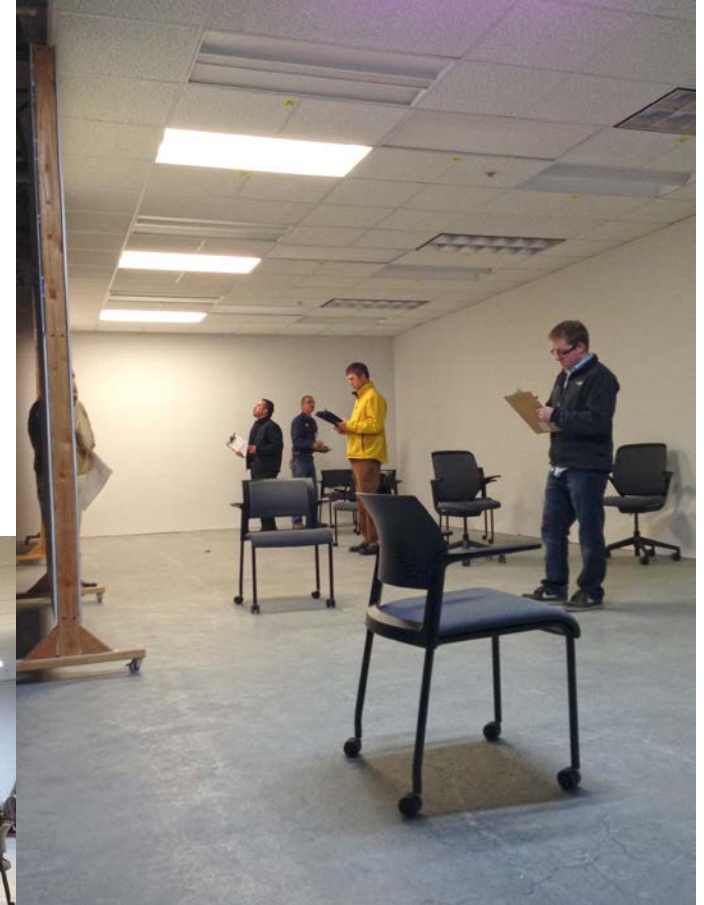
Compare to fluorescent with IS ballast at 26W, 2675 lumens, 103 LPW, 84 CRI, 3893K.



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Input from REAL PEOPLE

- PNNL invited 24 facility managers, energy engineers, and lighting industry people to observe installed luminaires and complete questionnaires about glare and appearance.



LED T8s in Troffers: A Slam-dunk??

Bare lamp

LED T8 lamp performance compared to fluorescent baseline

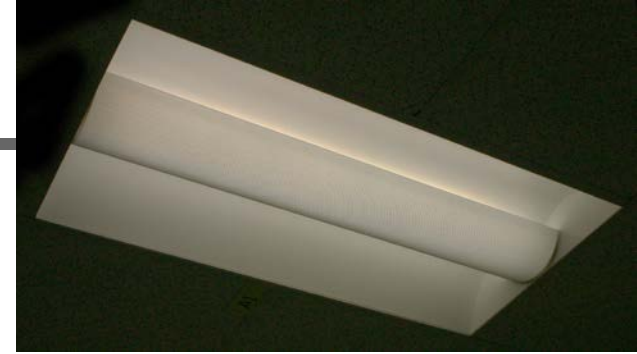
	Distribution	Efficacy (LPW)	Luminaire Light output
T8 LED lamps (31 in total)	Not omni-directional, 105 - 160° beam angle	66-143 lm/W; lamp efficacy is higher or lower (91 lm/W for fluorescent benchmark)	1,357 - 3,126 lm; compare to 2193 lm avg for fluorescent benchmark
T8 LED lamps used in mockup (3 types total)	Not omni-directional, 105-160° beam angle	82-101 lm/W; lamp efficacy is higher or lower (90 lm/W for fluorescent benchmark)	1,607-1,973 lm; lamp output is lower than for fluorescent benchmark (2193 lm avg)

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Recessed indirect troffer

(perforated metal basket luminaires)

LED T8 lamp performance compared to FL baseline



	Distribution	Visual appearance	Efficacy (LPW)	Luminaire Efficiency	Luminaire Light output
[A] Perforated metal basket (aka “recessed indirect”)	Insensitive to lamp beam angle for diffuse lamps. Narrow LEDs widened distribution.	Pattern of light on upper reflector changed with beam angle	Depends on lamp efficacy; LEDs lower than expected due to reduction in luminaire efficiency	3% to 18% lower (relative) for linear LED lamps, depending on the type; worse for narrow (clear) lamps.	Depends on lamp lumens; linear LED lamps proportionally lower due to lower luminaire efficiency.

Observers: Preferred fluorescent for glare and appearance

Recommendation: Little point in changing to LED. LED Performance is worse than fluorescent unless LED efficacy and lumens are 20% higher than fluorescent. Use fluorescent lamp or ballast improvement instead, luminaire retrofit kit, or replace luminaire altogether.



Fluorescent



133 degree beam angle LED



105 degree beam angle
LED



160 degree beam angle
LED

LED T8s in Troffers: A Slam-dunk??



Troffer with 3” deep 12-cell parabolic louver
LED T8 lamp performance compared to FL baseline

	Distribution	Visual appearance	Efficacy (LPW)	Luminaire Efficiency	Luminaire Light output
[B] Semi-specular 12-cell parabolic	“Spikier”, more light straight downward, sharper edge of batwing	Affected – upper reflector becomes dark; lamp face perceived as brighter by contrast	Increased or decreased, depending on lamp efficacy	8-15% higher	Depends on LED lamp lumens. Generally lower unless lamp lumens are within 15% of fluorescent lamp output

Observers: Appearance and glare are worse than fluorescent when lamped with T8 LEDs. Narrow beam angle/clear LED lamps are worst. Wide beam angle/diffuse is better.

Recommendation: Consider, but cautiously. Choose wide beam angle LED lamp and diffuse lamp finish. Light distribution on workplane may be more uneven. Room walls may appear darker. Expect increased glare. Output varies with T8 LED lamp lumens.



Fluorescent



133 degree beam angle LED



105 degree beam angle LED



160 degree beam angle LED

LED T8s in Troffers: A Slam-dunk??

**“Volumetric” high-performance troffer
with two linear rounded diffusers**

LED T8 lamp performance compared to FL baseline

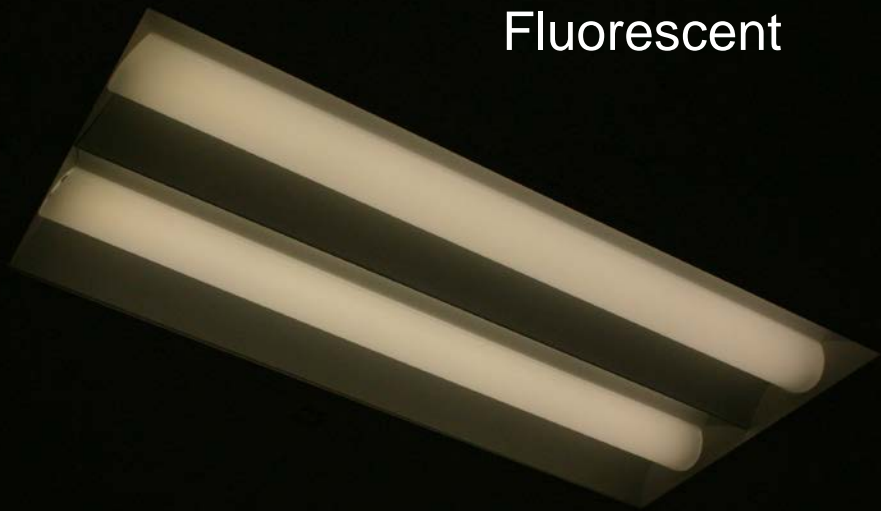


	Distribution	Visual appearance	Efficacy (LPW)	Luminaire Efficiency	Luminaire Light output
[C] “Volumetric” troffer (two linear rounded diffusers)	Does not change appreciably	Does not change appreciably	Proportional to lamp efficacy	About the same	Proportional to LED lamp lumens

Observers: Little appearance or glare difference between fluorescent and LED T8 lamps

Recommendation: Definitely consider. Choose diffuse T8 LED lamps and lamps with high lumen output (usually >1900 lm) and high efficacy (>100 LPW) for comparable performance.

Fluorescent



133 degree beam angle
LED



105 degree beam angle
LED



160 degree beam angle
LED



LED T8s in Troffers: A Slam-dunk??



High performance troffer with diffuser and linear details

LED T8 lamp performance compared to FL baseline

	Distribution	Visual appearance	Efficacy (LPW)	Luminaire Efficiency	Luminaire Light output
[D] High performance diffuser troffer with linear details	Clear/narrow LED beam angles change light distribution. Diffuse/wider is similar to FL	Moderately affected – clear/narrow lamps produce a stripey appearance on diffuser	Increased or decreased, depending on LED lamp efficacy	Lower (2% to 8%)	Reduced, slightly lower than proportional to LED lamp lumens

Observers: Preferred fluorescent for glare and appearance, but T8 LED lamps were acceptable. Widest beam angle was preferred among LEDs.

Recommendation: Consider. Choose diffuse/wide beam angle lamps and lamps with high lumen output ($>\sim 1900$ lm) and high efficacy (>100 LPW).

Fluorescent



133 degree beam angle
LED



105 degree beam angle
LED



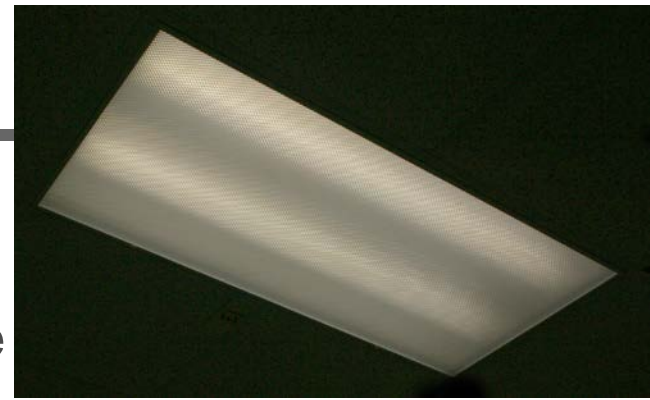
160 degree beam angle LED



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Troffer with K12 acrylic prismatic lens

LED T8 lamp performance compared to FL baseline

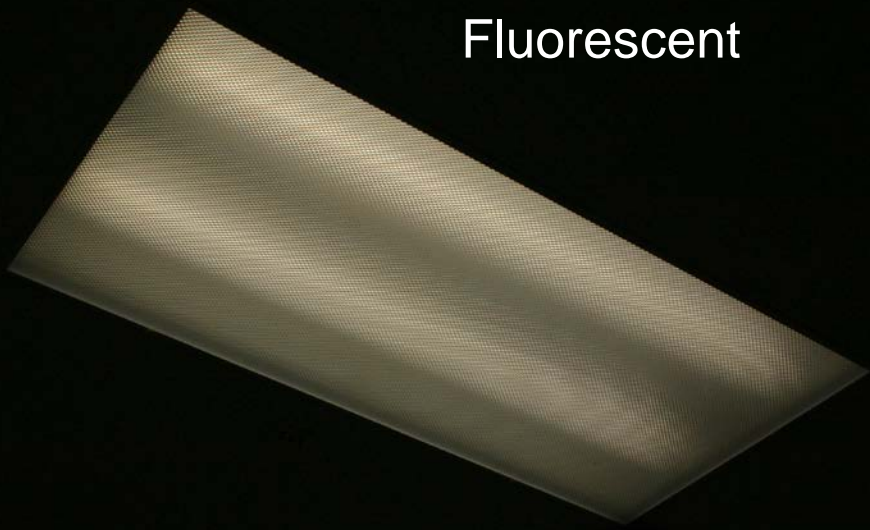


	Distribution	Visual appearance	Efficacy (LPW)	Luminaire Efficiency	Luminaire Light output
[E] K12 lensed troffer	All LED beam angles narrowed light distribution by 4 to 15 degrees	Affected by beam angle – looks more striped, especially with clear/narrow lamp	Increased due to increase in luminaire efficiency from LED lamps	Higher by 5% to 12%, for all LED lamp beam angles	Depends on lamp lumens. Proportionally higher than LED lamp lumens

Observers: Preferred fluorescent for glare and appearance. Lens may look stripey with LED lamps. Widest beam angle provided best appearance and glare.

Recommendation: Definitely consider. Choose diffuse/wide lamp beam angle, high lumen output (>1900 lm), and high efficacy (>100 LPW) in T8 LED lamp. Workplane illuminances may be less uniform.

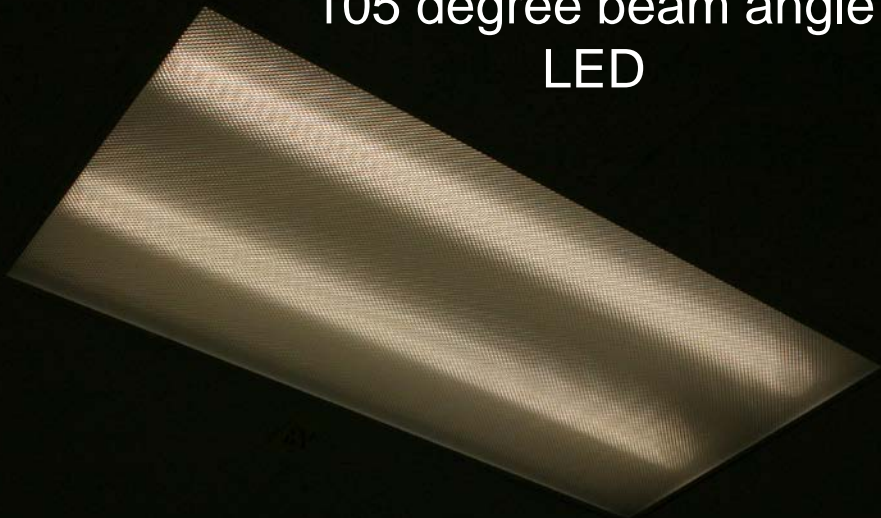
Fluorescent



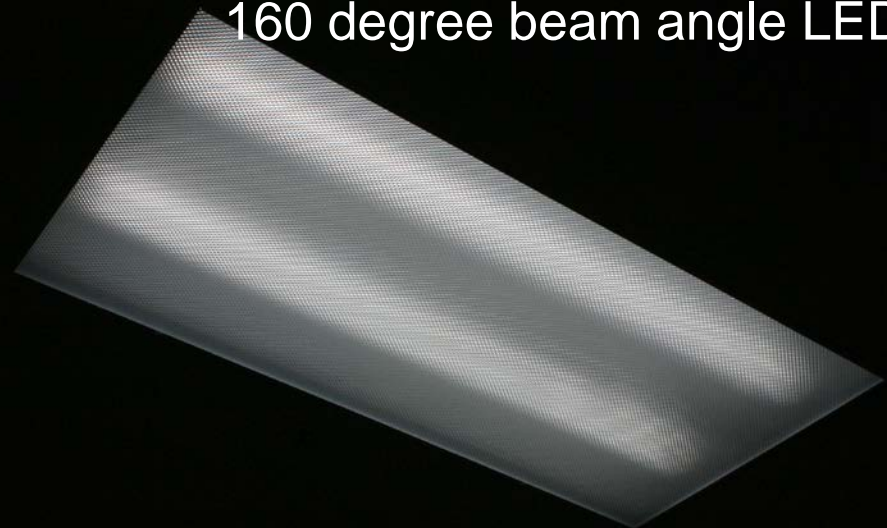
133 degree beam angle LED



105 degree beam angle
LED



160 degree beam angle LED



LED T8s in Troffers: A Slam-dunk??

Should you use them?



LED T8s in Troffers: A Slam-dunk??

If you do you should...

- Find out exactly what troffer is installed in your building.
- T12 or T8 lamps?
- Magnetic or electronic ballast?
- Rapid-start or Instant-start or programmed rapid start ballast?
- What are the input watts and light output?



LED T8s in Troffers: A Slam-dunk??

If you do, you should ask...

- Is this a troffer type where T8 LED lamps make sense?
- What is the condition of the luminaire and its sockets? If it is in very poor shape, consider a new troffer or a full kit retrofit instead of lamp retrofits.
- Do you want a reduction in light output? If so, can this be more easily and inexpensively accomplished with a low-output fluorescent lamp change, a low-output ballast change or delamping?
- Consider options like troffer retrofit kits as well.



LED T8s in Troffers: A Slam-dunk??

If you do you should...

- Study the product literature of the T8 LED lamps. Look for wiring diagrams (for compatibility with existing troffers), lumen output, input watts, color rendering index, CCT, light distribution from the lamp, NRTL Listings, and warranties.
- Get enough lamps for 4-8 troffers and bring in electrician to rewire the luminaire (if needed). Get electrician feedback on the ease of the retrofit and the modification time/cost.
- Get feedback from staff on the appearance/glare/color quality of the modified luminaires. Is it an acceptable change?

LED T8s in Troffers: A Slam-dunk??

If you do you should...

- Modify every troffer/luminaire in the building with the same lamp and wiring type. Keep 5% spares on hand, so that if one or more lamps fail, you will have the identical wiring lamp on hand. **You do not want maintenance staff mixing up fluorescent and T8 LED lamps, or single-end-wired with double-end-wired LED lamps.**

LED T8s in Troffers: A Slam-dunk??

Are there bad products? **YES.**

- Lamps that underperform claims by 32% on lumens
 - Some with CRIs as low as 68
 - Some with lumen output as low as 1357 lm, and efficacy as low as 65.9 LPW
 - Some that failed in PNNL mockup space with no more than 50 hours of use.
 - Some that had electrical design flaws that PNNL considered a safety concern.
-
- CAVEAT EMPTOR!

LED T8s in Troffers: A Slam-dunk??

Are there good products, too? **YES.**

- Some with very high lumens, comparable to fluorescent (as high as 3126 lm)
- Some with high efficacies, as high as 116 LPW or 143 LPW (but with poor CRI or high CCT)
- Some with high CRIs, better than fluorescent
- Some with beam angles as wide as 160 degrees
- Some that operate on existing electronic fluorescent ballasts and are easy to retrofit in the right troffer
- Some that eliminate the socket altogether

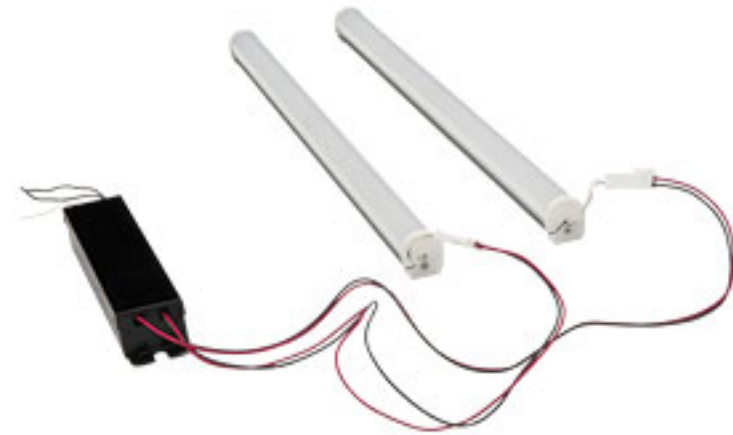
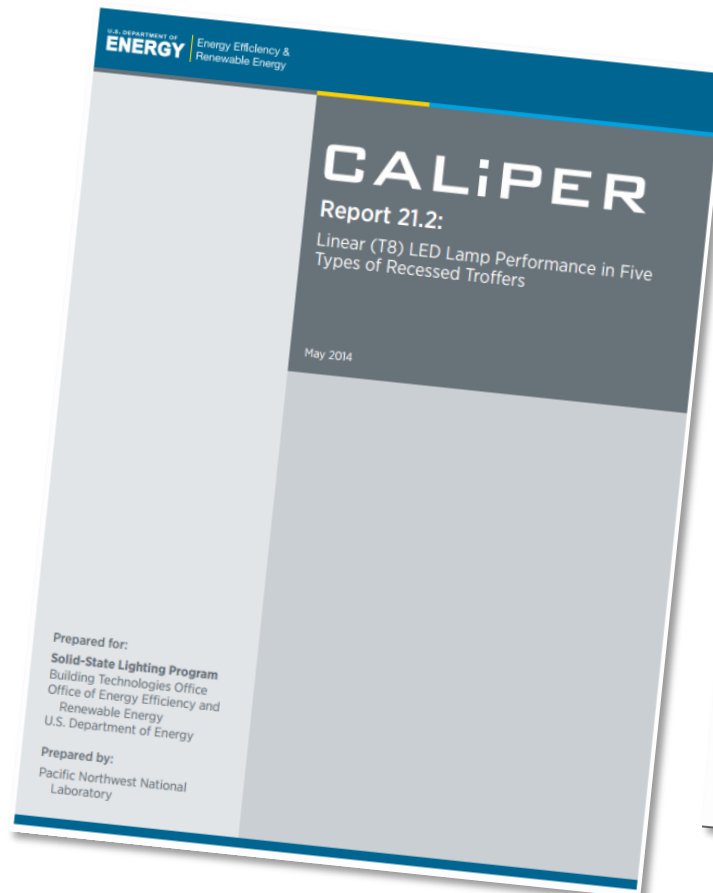


Photo courtesy of Cree Lighting

LED T8s in Troffers: A Slam-dunk?

Find the CALiPER reports on Linear T8 LEDs [here](#).

Here's a handy guide: [Upgrading Troffer Luminaires to LED](#)



LED T8s in Troffers: A Slam-dunk??

Conclusions:

- NO.
- It's not a slam dunk.
- There are some excellent T8 LED tubes.
- But there are bad ones, too.
- Ya gotta choose carefully. Look for T8 LED tube tech sheets with *complete information* backed up by good warranties from people you know and trust.
- Consider alternatives like LED troffer retrofit kits and even premium fluorescent
- Do a small-scale mockup before buying.
- Get feedback from users.
- **DON'T** mix different wiring types on a single project.



Questions for LED T8s in Troffers: A slam-dunk?



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