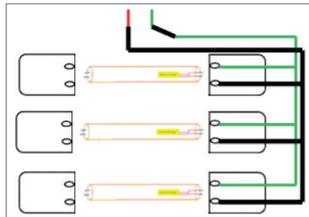


CHALLENGE

When it comes to energy efficient upgrades for retail stores, a T8 fluorescent tube retrofit to LED lighting is considered low hanging fruit. LED tubes consume about half the energy, last five or more years, and contribute to total lower maintenance and labor costs. These savings increase dramatically for facilities with high ceilings.

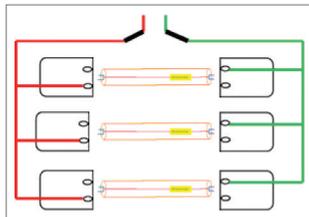
However, not all LED tubes are created equal. Quality issues aside, there are a variety of designs, each with different performance, safety and operational features. Because of this, selecting the right LED tube can be a challenge. There are four different types of internal driver LED tubes in today's market: single-end tube, double-end tube, ballast-compatible tube and dual mode tube.

The single-end LED tube is the most popular model currently available. A retrofit with a single-end LED tube involves the removal of the ballast, wiring hot and neutral to one side, and then replacing the shunted socket with a non-shunted socket, as shown in the figure below.



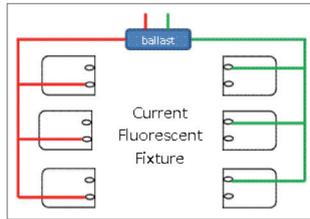
The single-end LED tube is most popular choice because there is no shock hazard with this design. However, there is a serious drawback with this approach. If a maintenance crew accidentally re-inserts a T8 fluorescent tube into a single-end wired fixture, the fluorescent tube may explode -- especially at 277V. One such incident actually occurred to a large United States retail chain with a fluorescent T8 exploding in the face of a maintenance person on a ladder, causing injury and the complete overhaul of the entire facility back to fluorescent T8. It is because of this liability that none of the big three U.S. lighting manufacturers make or sell single-end LED tubes.

Eight years ago, when LED tubes first appeared on the market, every single one of them was a double-ended tube. The retrofit of a double-end LED tube involves the removal of the ballast and direct wire line voltage to each of the sockets as shown below.



Because there is no need to replace the socket, the double-end LED tube retrofit saves 50 to 70 percent on labor alone compared to a single-end model. However, most of the double-ended LED tubes have disappeared from the market because of the new UL 1598C requirement on anti-shock protection. If someone inserts a double-end LED tube into one socket while the power is on, touching the other end of the tube will produce a nasty electric shock.

Ballast-compatible LED tubes appeared on the market recently with the promise of plug-and-play simplicity, as shown below. The reality is more like plug-and-pray: pray that your facility has fixtures with compatible ballasts. If not, the end user has to purchase and install new ballasts.



Additionally, the ballast-compatible LED will not operate without the ballast. This adds cost with both ballast maintenance and higher energy usage. The comparison chart below shows that operating LED tubes on ballast may cause the end user to spend \$18 more per lamp over five years, and \$39 over 10 years. For facilities with 100,000 T8 bulbs, that amounts to spending \$3.9 million on ballast operation and maintenance. It would be wise to avoid this. The extra costs were due to the additional energy consumption at 3W per lamp and the material and the labor costs for replacing the ballast. While using the LED tube with or without a ballast saves more energy as compared to the regular 32W fluorescent T8, one can do much better by taking the ballast out of the lighting system altogether.

Lighting Energy Consumption	DBA Tube on AC-in	DBA Tube on Ballast	Regular T8
days/year	365	365	365
hours/day	24	24	24
hours/year	8760	8760	8760
Energy consumption per lamp (watt)	18	21	32
Energy consumption per year per lamp (watt)	157680	183960	280320
Electrical rate (dollar/kWh)	\$0.10	\$0.10	\$0.10
Annual energy cost per lamp	\$15.77	\$18.40	\$28.03
Ballast maintenance cost over 5 years			
Ballast material cost per fixture	-	\$9.00	\$9.00
Number of lamp per fixture	3	3	3
Ballast material cost per lamp	-	\$3.00	\$3.00
Ballast replacement labor cost per fixture	\$9.00	\$15.00	\$15.00
Ballast replacement labor cost per lamp*	\$3.00	\$5.00	\$5.00
Ballast maintenance cost per lamp over 5 years	\$3.00	\$8.00	\$8.00
Energy and maintenance costs over 5 years			
Energy cost per lamp over 5 years	\$78.84	\$91.98	\$140.16
Ballast maintenance cost per lamp over 5 years	\$3.00	\$8.00	\$8.00
Total energy and maintenance cost over 5 years	\$81.84	\$99.98	\$148.16
Lamp cost over 5 years	\$13.00	\$13.00	\$5.00
Additional cost per lamp over LED tube on AC over 5 years		\$18.14	\$58.32
Energy and maintenance costs over 10 years			
Energy cost per lamp over 10 years	\$157.68	\$183.96	\$280.32
Ballast maintenance cost per lamp over 10 years	\$3.00	\$16.00	\$16.00
Total energy and maintenance cost over 10 years	\$160.68	\$199.96	\$296.32
Lamp cost over 5 years	\$25.00	\$25.00	\$10.00
Additional cost per lamp over LED tube on AC over 10 years		\$39.28	\$120.64
<ol style="list-style-type: none"> 1. When operating on AC, there is one-time labor cost of removing the ballast, which is cheaper than installing a new ballast. 2. The material cost for LED tube are the same for both cases, so they are not shown in the table. 3. Change the yellow fields according to your application. 4. Assuming \$2.50 per regular T8 tube, and needs two T8 tubes over 5 years. 			

Another issue with ballast-compatible tubes is arcing – a flash jumping from the tube bi-pin to the metal in the socket. This is a frequent occurrence with older, linear fixtures with loose sockets. One large lighting manufacturer recently recalled 700,000 of its ballast-compatible LED tubes due to internal arcing.

The root cause of arcing is that a ballast in the system raises voltage to 600V in order to activate the fluorescent tube. Once the ballast is removed, the line voltage alone (even at 277V) is not sufficient to trigger arcing. Now that the LED tube doesn't depend on the ballast, there is no practical reason for keeping the ballast in the system, other than consuming more energy, increasing maintenance costs, and inviting arcing and burn hazards.

BEST PRACTICE IMPLEMENTED

Dual mode LED tubes are one of the latest retrofit options. They can operate on a ballast and on AC line voltage. They allow for a true plug-and-play experience in a facility with compatible ballasts. The facility manager can decide to postpone ballast removal until the ballasts fail, and then the tubes can continue to run on line voltage for years. However, please be aware that many dual mode LED tubes fail UL's anti-shock safety requirement when operating on line voltage. Several manufacturers circumvent the UL requirement by getting an ETL certification for line voltage operation. UL-certified dual mode LED tubes are recommended.

An ideal LED tube should be a dual mode tube with double-end design and address all the drawbacks mentioned above. An example of such a tube should be a double-end tube that comes with two safety switches, one on each endcap. Unless both safety switches are pressed at the same time, i.e., when both endcaps are in the sockets, it will not activate the lamp.

RESULTS OF THE BEST PRACTICE

In addition to solving the shortcomings of other LED tube designs, a dual mode tube also addresses the issue with driver lifetime. The weakest link of any LED system is the driver. The LED chips used in the tube can operate more than 150,000 hours, but the driver might only function for 50,000 to 60,000 hours. This is why every tube is warranted for five years. When the driver fails, the only option until now was to toss it out and get a new one; even though the LED's have plenty of life. This is a waste of money and has a negative environmental impact.

The new design of the LED tube answers this concern by coming up with a field-replaceable driver design. It enables the maintenance crew to replace the driver in the tube in less than two minutes, resulting in another five to six years of tube life at minimal cost.

VERIFICATION OF EFFICIENCY AND/OR SAVINGS CAPTURED

An earlier model of this type of tube (on line-voltage) was used for a T8/T12 retrofit at 38 buildings in the City of Huntsville, AL. The overall energy savings is 60.88 percent, exceeding the original target of 40 percent. These energy savings were made possible by incorporating occupancy sensors as well as performing a 2-to-1 de-lamping.

Aledra LED Lighting is a Seattle-based LED manufacturer well known in the industry for its SureFit DBA LED tube.