# 2018-2019 Summary of Linear LEDs – Longevity and Installs

## Focused on GE/“Current, by GE”, Sylvania/LEDvance, and Philips/Signify

**September 2019**

Joint Project of the Cold Climate Housing Research Center, Alaska Center for Energy and Power of the University of Alaska Fairbanks, and University of Alaska Fairbanks Bristol Bay Campus

Written by:
Dana Truffer-Moudra
Tom Marsik
Conor Sosebee
Robin Garber-Slaght
Riley Bickford

Funded by Alaska Housing Finance Corporation, Office of Naval Research, and the U.S. Department of Education

# Table of Contents



**Disclaimer:** The products were tested using the methodologies described in this report. CCHRC cautions that different results might be obtained using different test methodologies. CCHRC suggests caution in drawing inferences regarding the products beyond the circumstances described in this report.

## Abstract

*Since Light-Emitting-Diode (LED) lights became available on the market more than a decade ago, the number of choices has exploded. This includes an enormous number of linear LED lamps, also called tubular LEDs, or TLEDs, that are used to replace fluorescents. These vary in quality, brightness, and longevity. This report summarizes some of the replacements for fluorescent lamps by the "Big Three" lighting manufacturers of traditional lighting solutions – formerly GE, Sylvania, and Philips. All of them have spun off the manufacturing of LED lamps into businesses with separate names, becoming "Current, by GE", "LEDvance", and "Signify", respectively. Even with these well-established companies, some models have been recalled. The emphasis of this study was on longevity and this report summarizes some known installations of linear LED products from the Big Three companies around Alaska and elsewhere. First, the types of linear LEDs are discussed, as well as some of the possible markings or certifications on the packaging or in brochures. Next, a section for the three manufacturers mentioned above discusses their offerings, some known installations, and failure rate estimates.*


*Keywords:* LED, linear LED, fluorescent, longevity, failure rate, success stories

# 2018-2019 Summary of Linear LEDs – Longevity and Installs

## Focused on GE/"Current, by GE", Sylvania/LEDvance, and Philips/Signify

### Introduction

Light-emitting diode (LED) lamps and luminaires have become widely available in the last decade. They are a type of solid-state lighting (SSL) that also includes organic LED (OLED) and polymer LED (PLED) lighting.

This report discusses linear LED lamp types, major manufacturers of linear LEDs selected for this report, and the outcome of several installations of linear LEDs based on interviews with people familiar with them (approximate number and type of LED lamps installed, approximate age, and number failed, if available). An appendix lists several decision-making resources for building managers.

The largest lighting companies in the world include GE Lighting, Philips, Panasonic and OSRAM Sylvania (technavio, 2017), each of which has been well-established for decades. All but Panasonic manufacture LED tubes that are replacing traditional fluorescent tubes. This study thus focused on GE Lighting, Philips and OSRAM, the "Big Three" traditional lighting companies that make LED tubes. All of them have rebranded the LED businesses: GE is marketing the LED tubes under its "Current, by GE" or "Current, powered by GE" name; OSRAM Sylvania spun off a separate company called LEDvance that is authorized to use OSRAM Sylvania names globally and in the U.S.; and Philips Lighting renamed itself Signify even while continuing to use the Philips brand. Additionally, the brand that a local vendor recommends, and that is thus installed in multiple Alaska entities, Topaz, was included with the Big Three companies in this report.

### Background Information

A lamp can be any light source: an incandescent bulb, an LED replacement for an incandescent bulb, a fluorescent tube, or the LED replacement for a fluorescent tube, etc. A luminaire refers to an object that holds the light source, for example, the ceiling fixture that holds fluorescent tubes.

LED lamps use less energy, and generally last much longer than the incandescent or fluorescent lamps they are replacing. LED lamps slowly lose brightness over time. The time when the LED lamp is down to 70% of its original brightness is called the lamp lifetime, and the lamps are meant to be replaced at that point in order to maintain proper illumination. LED lamps meant to replace fluorescent tubes ubiquitous in office buildings are called either linear LEDs, or tubular LEDs, or TLEDs. This report focuses on LED replacements for four-foot long "T8" (one-inch diameter) fluorescent tubes.

Regardless of size, LED replacements for fluorescent tubes are classified by Underwriter Laboratories (UL) into three major types: UL type A ("replacement lamps", "plug and play"); UL type B ("internal driver", "line voltage", or "ballast bypass"); and UL type C ("external driver"). Some lamps can be a combination, such as type A/B lamps. Note that nearly all manufacturers also sell LED fixtures that can be used to replace fluorescent fixtures, as opposed to only replacing lamps. LED fixtures are not covered in this report.

### Linear LED Type A, B and C Lamps

Type A LED lamps are direct replacements using the existing ballast that the fluorescent tubes used; the LED tube is simply plugged-in in place of the fluorescent one. Not all ballasts are compatible, and the LED manufacturer's ballast compatibility guide must be checked before installation of the LED tubes, in addition to simply testing a few tubes before a major installation. The installed ballasts may fail at some point and

need to be replaced. Ballasts also use some amount of energy, so the overall energy use of each fixture in the LED system is slightly more than simply that of the LED type A tube(s).

One advantage of type A (and most C lamps) is that, due to the use of the ballast (or LED driver), they typically have no or low flicker compared with type B LEDs. The ballast (or LED driver in case of type C LEDs) smoothes out the 60 hertz frequency of the electric current. This is a consideration as some individuals may be sensitive to flicker. Those individuals may develop serious health complications, including epileptic seizures (IEEE, 2015).

Type B linear LEDs are called a variety of names including ballast bypass LEDs, ballast free LEDs, internal driver LEDs (since the LED driver is within the tube itself), or line voltage LEDs; and require a modification of the fluorescent fixture to bypass the ballast and wire the fixture's lamp connectors to line voltage. This requires a qualified electrician, though it is a relatively simple change. The fixture itself must be marked with a sticker that is typically provided with the LED lamp, to note that the fixture may no longer be used for fluorescent tubes. There are two ways of connecting the line voltage to the fixture that manufacturers support: either the voltage is applied to both sides of the lamp ("double-ended"), or only one side of the lamp ("single-ended"). One disadvantage of type B LEDs is that the driver for the LEDs is inside the tube and requires that heat be effectively dissipated, which can be challenging, and ineffective heat dissipation can lead to premature LED failure. Manufacturers appear to have improved this issue since the first generation of these LEDs. Some type B lamps require an in-line fuse. Many, if not most, type B LEDs may flicker.

Type C linear LEDs don't use the fluorescent ballast, and instead have their own driver, separate from the tubes. This means that the heat generated by the driver does not affect the LEDs as much. A qualified electrician must rewire a fluorescent fixture to remove the fluorescent ballast, install the separate LED driver, and mark the fixture as no longer compatible with fluorescent lamps. As with type A LED tubes, the power used by the driver needs to be accounted for when calculating the overall energy consumption of the lighting system. High quality LED drivers will remove the flicker that comes from the 60 Hz oscillation of line power.

## Recalls

Several companies recalled specific LED lamps, including linear LEDs. Sylvania recalled about 55,000 linear LED lamps in 2015 (Sylvania, 2015). According to the website, the problem was that "a manufacturing defect due to a missing component on the electrical connection between two internal printed circuit boards … may cause the lamp to overheat and melt." GE recalled about 90,000 linear LED lamps in 2018 (GE Lighting, n.d.), because "the pins on one end of the lamp can be energized during installation/removal, posing electric shock and electrocution hazards."

## LED Installation Time Estimates

"Current, by GE" provides time (and cost) estimates of how long the installation of each type of product takes, in the brochure "The ABCs of LED Tubes" (Current by GE, 2018). Similar times are expected for other manufacturers. Based on the table within that brochure, it takes approximately 4 minutes of a laborer's time (not necessarily an electrician) to exchange 4 fluorescents in one fixture for type A LED tubes - the same time it takes to replace a failed fluorescent tube with a new one. It takes 12-15 minutes of an electrician's time to either replace a fluorescent ballast if it is old (for either fluorescent lamps or type A LEDs); to wire a fixture for a type B LED by removing the ballast; or to wire a fixture for a type C linear LED by replacing the ballast with an LED driver.

### Other Considerations

The variations between lighting systems are many. Some items that should be taken into consideration include:

- For type A linear LED lamps: is the existing or intended ballast compatible with the linear LED?
- For type B linear LED lamps: are the sockets in which the LED lamps will sit shunted (short-circuited) or not? Some type B lamps require one configuration, others require the other.
- For all (A/B/C) linear LED lamps: Do the sockets have rotating end-caps that require the lamp to be turned 90 degrees in order to lock in? (Since LEDs shine light preferentially in one direction, if they need to be rotated due to the end caps, the light may shine sideways instead of downward.) Does the lamp, once installed, have a noticeable flicker? What is the initial brightness of the selected lamp, and its lifetime? Some LED lamps are dimmable; others are not. The availability of some linear lamps for commercial applications may be limited in the box stores that mainly serve home customers; availability will typically be better in vendors specializing in lighting. In Alaska, many lamps may not be suitable for outside operation in winter, as most lamps have a lower limit on operation of -20F. Manufacturers' reputation and how long they have been in business should also be taken into account, especially if the warranty is longer than the time the company has existed. And even once a lamp is selected, one should do a small test install of a few lamps to ensure everything will work as expected.

## LED Labels and Certifications

### DesignLights Consortium (DLC) Certification

The DesignLights Consortium (DLC), at https://www.designlights.org, is a non-profit organization that promotes widespread adoption of high quality energy efficient commercial lighting solutions. DLC certifies lamps that meet certain criteria and adds them to its Qualified Product List. For all linear LEDs, including the 4-foot linear LED lamps that are replacing T8 (1 inch diameter) fluorescents that this study focuses on, DLC's criteria for certification include a system efficacy of at least 110 lumens being produced per Watt of power consumed, and a minimum of 1,600 lumens produced, among others (Design Lights Consortium, n.d.). The manufacturers submit their products to the DLC, and if they meet the criteria, they are listed in the DLC database. As of April 2019, searching DLC in Solid State Lighting > Search the QPL [Qualified Product List] for Category = "T8 Four-Foot" yielded nearly 17,000 results. Often times, a manufacturer has the same lamp available in multiple color temperatures, as well as drivers for the type C LEDs. For example, in the DLC database, Signify /Philips has nearly 150 offerings, GE nearly 250, and LEDvance nearly 100. These companies offer additional products that may not meet the DLC criteria and may not be in the DLC database. It is recommended that any lamp considered as a replacement for fluorescents in commercial buildings be certified by DLC.

### Other Compliances/Certifications

On LED tube packaging or in online brochures from manufacturers, various other markings or certifications may be mentioned. The LED Lighting Facts labels for products tested according to predetermined standards was initially run by the Department of Energy, later by D+R International, and will not be available after December 2019 (Lighting Facts, n.d.). CE marking indicates the product meets standards for the European Economic Area (European Commission, n.d.). DLC stands for DesignLights Consortium, and the certification is explained above. KEMA-KEUR indicates electrical safety and regular

monitoring of manufacturing facilities. RoHS compliance is a European Union directive on Restriction of Hazardous Substances. TUV is a German inspection service. UL stands for Underwriters Laboratories certification.

## Study Methodology

The Big Three lighting companies, GE/"Current by GE", Philips/Signify, and OSRAM/Sylvania/LEDvance were contacted for examples of where their four-foot-long T8 (one-inch-diameter) linear LEDs have been installed. Some provided responses, some did not. The companies' websites were also reviewed for examples, and if any were identified, an attempt was made to contact the entities. Additionally, archives of LED publications were checked for reports of installations of four-foot T8 linear LEDs by the Big Three lighting manufacturers, and attempts were made to contact any entities identified through that process. Lastly, local vendors were contacted, and any leads followed. Interviews were conducted either in person or via a phone call or email.

Each manufacturer's offerings are outlined below. In the subsequent sections, the data (approximate 4-foot T8 linear LED lamp counts and types installed, age, performance, and failure rate) from the entities identified by the method above are detailed, with the data aggregated, when possible.

## Sylvania/LEDvance Background, Offerings

The lighting company Sylvania/OSRAM markets LED tubes under the label LEDvance. Many are DLC-certified. Sylvania calls type A tubes "SubstiTUBEs" (Sylvania, 2019-1), presumably since they can be simply substituted for fluorescent counterparts, and type B lamps "LEDlescent" (Sylvania, 2019-4). They also offer a universal type A + B lamp called "DUALescent" (Sylvania, 2019-3) that can be used with or without a ballast, as well as retrofit kits that include an LED driver and lamps. Table 1 summarizes the offerings. As with all subsequent tables, within each category, LED lamps are available with color temperatures typically ranging from about 3000K (warm white) to 6000K (cool white).

**Table 1. Sylvania/LEDvance LED T8 Tube Offerings by Type.**

| Type A: Plug and Play | Type B: Line Voltage | Type A/B: Universal | Type C: LED driver |
|---|---|---|---|
| SubstiTUBE | LEDlescent | DUALescent | Offered as retrofit kits of LED driver and lamps |
| SubstiTUBE Value | | | |
| SubstiTUBE Advanced | | | |
| SubstiTUBE Advanced Ultra Output | | | |

One should always check the compatibility of existing or intended ballast with the intended lamp, as well as the configuration of the fixture, to avoid unexpected complications. From the SubstiTUBE brochure (Sylvania 2019-1), these lamps are "engineered to operate on existing instant start and select programmed rapid start electronic T8 ballasts." The application notes include, among others: "5. For instant start ballasts, use lamp holders with an internal shunt or ensure that lamp holders are wired in a shunt configuration. 6. For Programmed Rapid Start ballasts, use rapid-start lamp holders (non-shunted lamp holders)."

On Sylvania/LEDvance's "LED Lamps Product Literature" webpage is the ballast compatibility guide (Sylvania, 2019-2). For example, the ballast manufactured by Philips, Advance IOP-2PSP-32-SC programmed rapid start ballast, is compatible with the 10W (7th generation, G7) and 13W (8th generation, G8) SubstiTUBEs, but not with the 15W (G8 or G7), or 12W (G6) four-foot lamps, according to the compatibility

guide. All of this shows that ballast compatibility is important, and if a ballast works with one product from a manufacturer, it will not necessarily work with another product. On the other hand, it may work with completely different manufacturers' lamps as well.

## Philips/Signify Background, Offerings

Philips, a global company in the luminaire business for more than 100 years, spun off its LED business into the company Signify in 2018 (Signify, 2018). Similar to other LED manufacturers, Philips/Signify offers multiple offerings covering the three UL types of LEDs. Within each type, Philips/Signify offers commercial lines that either meet industry standards (CorePro line), or exceed them (MasterClass line) (Philips Lighting, 2019-4). For type B LEDs, Philips/Signify offers an Ecofit line, not available in the U.S., with a short lifetime. These offerings are shown in Table 2.

**Table 2: Philips/Signify LED T8 Tube Offerings by Type**

| Type A: Plug and Play | Type B: Line Voltage | Type A/B: Universal | Type C: LED driver |
|---|---|---|---|
| "InstantFit" lines | "Mains" lines | "Universal" lines | |
| CorePro LEDtube InstantFit T8<br>MasterClass LEDtube InstantFit T8 | CorePro LEDtube Mains T8<br>MasterClass LEDtube Mains T8<br>Essential LEDtubes T8 Mains<br>Ecofit LEDtubes T8 Mains | CorePro LEDtube Universal T8<br>MasterClass LEDtube Universal T8 | Philips LED drivers available that work with some of their type A lamps |

Philips/Signify's UL type A linear LED lamps are called InstantFit, since they can be simply swapped for fluorescents instantly. Their type B linear LEDs are called Mains, using the UK term for line power, indicating that these lamps require the ballast to be bypassed. The company additionally offers a Universal option, which is its type A + B lamp that works both with and without a ballast. According to the DesignLights Database, Signify/Philips also offers LED drivers that work specifically with some of their type A lamps.

The Essential LEDtubes and EcoFit LEDtubes appear to be low cost and lower quality. They have shorter lifetimes, requiring more frequent replacements, and low power factors, potentially incurring additional electricity costs. They appear to be sold in such countries as Malaysia, Indonesia, Thailand, Vietnam, and Saudi Arabia, and are not available in the U.S.

Philips is the only company of the three in this report that currently makes available its failure rates (Philips Lighting, 2019-1; Philips Lighting, 2019-2, Philips Lighting, 2019-3). Figures 1, 2, and 3 below show the failure rate and luminosity of MasterClass, Ecofit and CorePro lines. Note that the horizontal scale varies between each graph.

For the Ecofit product, the failure rate is 50% at about 17,000 hours. In contrast, the MasterClass product has perhaps 5% failure rate at that same 17,000 hours, and has 50% failure rate at 70,000 hours. CorePro has a similar failure rate to MasterClass.

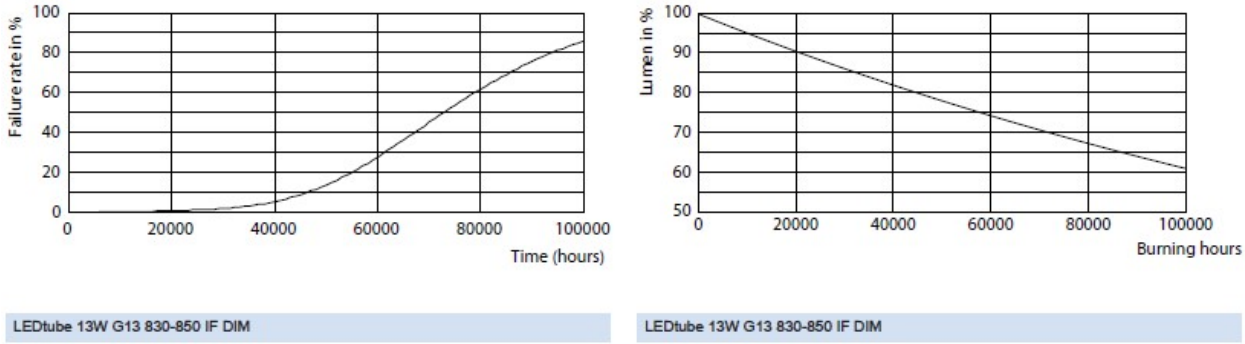


Figure 1: Philips/Signify MasterClass InstantFit T8 Tube LED failure rate and luminous flux. This figure comes from Philips Lighting brochure titled "MasterClass LEDtube InstantFit T8" (Philips Lighting, 2019-1). On the left, the failure rate is shown as a function of time the lamp is on. Failure rate is 50% at approximately 70,000 hours. On the right, the decrease of lumens the lamp is outputting, as a function of the time the lamp is on. This type of lamp reaches 70% of its initial brightness at approximately 70,000 hours.

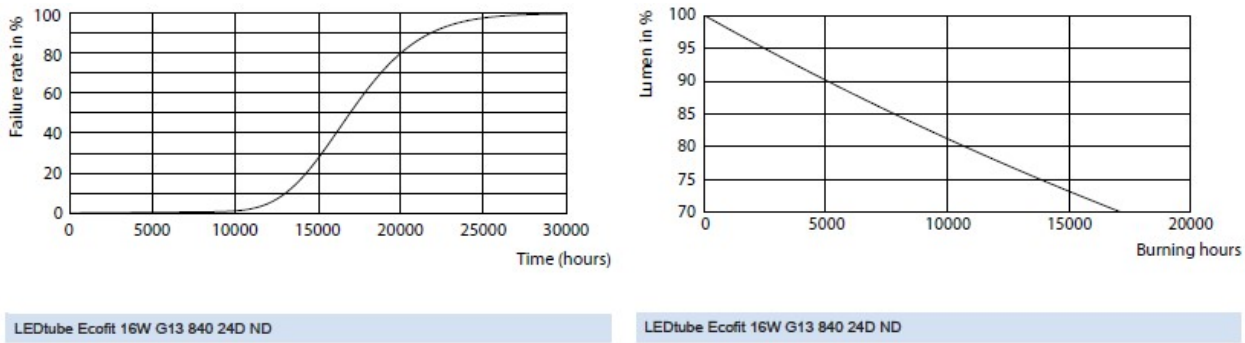


Figure 2: Philips/Signify EcoFit T8 Tube LED failure rate and luminous flux. This figure comes from Philips Lighting brochure titled "Ecofit LED tubes T8 Mains" (Philips Lighting, 2019-3). On the left, the failure rate is shown as a function of time the lamp is on. On the right, the decrease of lumens the lamp is outputting, as a function of the time the lamp is on. Note that the horizontal scale on this figure covers 1/3 to 1/5 that of the previous figure. Failure rate is 50% at approximately 17,000 hours.

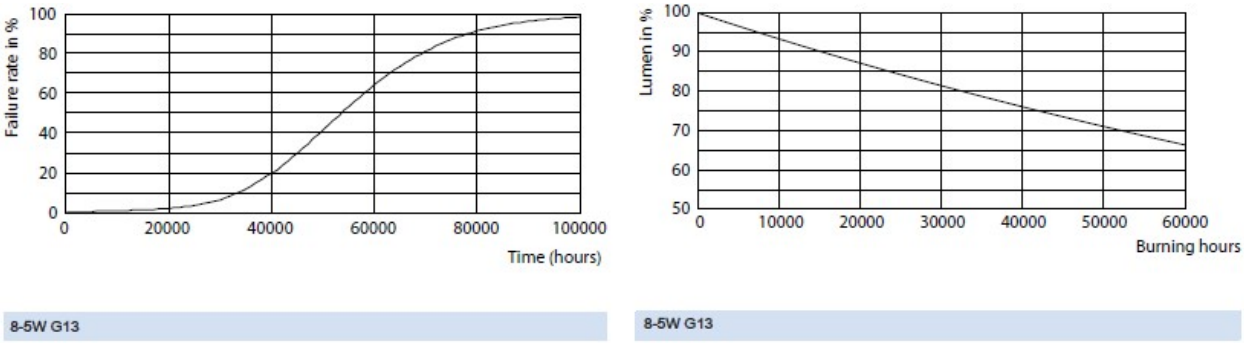


Figure 3: Philips/Signify CorePro T8 Tube LED failure rate and luminous flux. This figure comes from Philips Lighting brochure titled "CorePro LEDtube Mains" (Philips Lighting, 2019-2). On the left, the failure rate is shown as a function of time the lamp is on. On the right, the decrease of lumens the lamp is outputting, as a function of the time the lamp is on. Failure rate is 50% at slightly over 50,000 hours.

## GE/"Current, powered by GE" Background, Offerings

GE spun off its lighting division into "Current, powered by GE" in October 2015. In 2019, there was an announcement that "Current, powered by GE" will be sold to American Industrial Partners (Halper, 2019). The company has testimonials on its success stories website (current by GE, 2019-3).

GE's offerings include 70,000-hour and 50,000-hour LEDs (current by GE, 2019-1). Except for ones in the 6500K color temperature (cool white), most are DLC certified.

Table 3 shows the offerings of LED tubes by GE:

**Table 3: GE/"Current by GE" LED T8 Tube Offerings by Type**

| Type A: Plug and Play | Type B: Line Voltage | Type A/B: Universal | Type C: LED driver |
|---|---|---|---|
| GE's Integrated LED Tube | GE's Ballast Bypass LED Tube | | Remote Driver LED Tube |

GE's type A LED tubes boast a 70,000-hour rated life (current by GE, 2019-4). The ballast compatibility of GE's type A tubes is outlined in a document available on their website (current by GE, 2019-2). GE's type B LED tubes have a 50,000-hour lifetime (current by GE, 2019-5).

## Topaz

A local vendor highly recommends a brand different from the Big Three, Topaz, which has sold many Topaz type B (ballast bypass) LED lamps locally, and provided contacts for several entities that have installed those lamps.

Table 4 shows the offerings of LED tubes by Topaz:

**Table 4: Topaz LED T8 Tube Offerings by Type**

| Type A: Plug and Play | Type B: Line Voltage | Type A/B: Universal | Type C: LED driver |
|---|---|---|---|
| Linear Ballast Compatible | Linear Bypass | Linear Dual Mode | |

## Results

Entities that installed the 4-foot-long T8 LED lamps were identified both in Alaska and elsewhere in North America. Results are broken down by lamp manufacturer, lamp type, and age of installation – more or less than three years. Data is aggregated where possible.

## Sylvania Installations

We have identified one entity that installed Sylvania type A (plug and play) SubstiTUBE lamps more than three years ago and three that installed them fewer than three years ago.

The entity that had the lamps for more than three years installed about 100,000 of type A lamps from all of the Big Three manufacturers (Sylvania, GE and Philips). They were satisfied, but unable to provide a breakdown of the numbers of lamps from individual manufacturers, nor much additional information.

The three entities that installed the lamps more recently did it on average two years ago, and installed on average almost 20,000 lamps. All three entities had specific numbers available and the failure rate ranged from 0% to 0.67% per year, with a weighted average failure rate across the thousands of tubes of 0.13% per year. One entity shared a lesson learned during installation: not all of the ballasts were compatible with the LED lamps.

## GE or "Current, powered by GE", Installations

For older GE installations, we identified one entity that installed "a couple hundred" GE type C – external driver – LED tubes approximately three years ago. They had an estimated 15-20% failure rate, and

did not pursue them further.

For older installations of type A lamps, per the Sylvania section, there was an entity that installed about 100,000 lamps from the Big Three manufacturers (presumably tens of thousands from each), were satisfied, but did not provide much additional information.

One entity interviewed for this study installed 400-500 GE type A–direct replacement–LEDs (LED18ET8/4/840) approximately one year ago, and to date have had "no complaints from users."

### Philips/Signify Installations

Three entities had Philips type A lamps installed more than three years ago. One, as described in the Sylvania section, did not provide any details besides noting they were satisfied. The two entities that had specific numbers available installed on average 20,000 lamps, and reported failure rates of 0.02% and 0.08% per year. The weighted average failure rate was 0.02% per year, which is basically the failure rate of one of the entities, because its installation was much larger than the other. The person familiar with the installation at the larger entity indicated that they went with type A LEDs instead of type C because at the time of installation 1) ballasts were less expensive than LED drivers, and 2) ballasts were typically compatible with more than one LED manufacturer, whereas LED drivers would only be compatible with that manufacturer's LED tubes.

An entity that had the lamps installed for fewer than three years had installed 200 Philips InstantFit (type A) LED tubes, finishing in the summer of 2016. Through winter 2018/2019, they were not aware of any failures.

### Topaz

A local vendor recommends Topaz, and provided the names of several installations. These installations occurred 2-3 years ago, on average approximately 1,000 type B LED tubes were installed, and overall the entities were satisfied. One of these entities said that on install, 1-2% failed during installation, but it was simple to work with the local vendor and get them immediately replaced. One entity also mentioned that one of their employees provided a doctor's note saying that the flicker affected them, and for that employee, they replaced the lamp with a different one that did not flicker.

### Longevity Data Summary

Table 5 summarizes the different entities and their experiences.

**Table 5: User Experience with Linear LED Lamps by Major Manufacturers, indicating type of lamp installed, on average how many, and the experience**

| | GE/Current, powered by GE | Sylvania/LEDvance | Philips/Signify | Topaz |
|---|---|---|---|---|
| **Older Products >= 3 yrs** | Type C:<br>- 15-20% failure out of couple hundred<br>Type A:<br>- 1 entity without specific failure numbers: good experience / tens of thousands | Type A:<br>- 1 entity without specific failure numbers: good experience / tens of thousands | Type A:<br>- 2 entities averaging estimated 20,000 lamps and 0.02% failure rate per year;<br>- 1 entity without specific failure numbers: good experience / tens of thousands | -- |

| | | | | |
|---|---|---|---|---|
| **Newer Products <= 3 yrs** | Type A:<br>- 1 entity without specific failure numbers: good experience / 400-500 | Type A:<br>- 3 entities averaging estimated 17,000 lamps and 0.13% failure rate per year | Type A:<br>- estimated 0% failure rate / 200 | Type B:<br>- 3 entities without specific failure numbers: good experience / ~1000 lamps on average |

## Discussion

We have identified entities that use linear LEDs from the Big Three lighting companies: GE/"Current by GE", Sylvania/LEDvance, and Philips/Signify. All entities in our limited sample size were satisfied with their experience with type A or B linear LEDs from the Big Three.

Philips/Signify is the only manufacturer to provide failure rates in their brochures. It was not possible to judge the longevity of the LED tubes from other manufacturers to that of the published Philips failure rates. For example, if a lamp is on 24 hours a day, 7 days a week, such as in a parking garage, this translates to a lamp being on for 8,760 hours in a year. Office buildings may have lamps on for only half that time, perhaps 4,000 to 5,000 hours a year. Most of the entities contacted had their lamps installed in an office-type setting. After 3 years, the lamps may have been on for 15,000 hours. On the Philips/Signify LED failure rate plots shown in Figure 1 or Figure 3 (for the products available in the US), the failure rate is very near zero at 15,000 hours. To date, our current data matches that provided by Philips/Signify: near zero failure rate at multiple thousand hours of lamp operation. The more interesting part of the curve, at tens of thousands of hours of operation, has not been verified.

Another CCHRC report on T8 linear LED market assessment and testing, "Economic and Performance Analysis of T8 Linear LED Replacement Lamps" (Sosebee et al, 2019) outlines that several of the linear LEDs that were tested performed similarly in illumination as fluorescents. The recommendations from a purely financial standpoint were that if the ballasts were relatively new and compatible with the LEDs, type A LED lamp replacements were the most cost effective, and if the ballasts needed replacement or were not compatible, rewiring the fixture to accept type B LEDs would be the most cost effective.

## Conclusion

Caution should be exercised when selecting LED replacements for fluorescents to ensure appropriate lighting and compatibility with existing system.

The Big Three lighting manufacturers, GE/"Current by GE", Sylvania/LEDvance, and Philips/Signify, all make commercial LED products for 4-foot T8 fluorescent lamp replacement. A number of entities were interviewed regarding their experience in switching from fluorescents to LEDs that were manufactured either by one of the Big Three lighting companies, or by Topaz, an LED company recommended by a local vendor. The vast majority of the entities had a positive experience in switching from fluorescents to LEDs.

Cost savings can be realized by switching to LEDs, and a reliable manufacturer with a solid warranty should be selected. Due to the multitude of details related to ballasts, flicker possibilities that may result in health issues, and other variables, it is a best practice to first replace a smaller subset of fluorescents to ensure the installation will work as intended.

## Appendix A – Using the DesignLights Database

The DesignLights Consortium database is accessible at designlights.org. To view products that qualified

to be in the database due to their high light output, power factor, etc., click on the "Solid State Lighting" name in the search area of the front page. (Alternately, on the main page, click on "Solid State Lighting" along the top bar, and then click on "SSL Qualified Product List.") The next page shows the results, and the options for filtering are along the left side. Multiple filters can be applied at the same time.

For example, one can click on "Manufacturer," put "ge" into the search box, and choose "GE Lighting Solutions" from the list that appears. Similarly, one can find "Philips Lighting", or "LEDVANCE, LLC (formerly OSRAM SYLVANIA, INC)." To proceed with any of the filters, simply close the open filter window, such as the Manufacturer window.

Under "Category", one can select "T8 Four-foot", the first choice in the Linear Replacement Lamp grouping.

Under "Primary Use Designation", one can select the UL type(s).

These results can be displayed as a list, or, if one creates a free login, can be downloaded in a spreadsheet.

## Appendix B - Decision-making Resources

There are several resources that list the questions to ask in order to make the switch to LEDs, and how to decide whether to go with type A, B or C LEDs, as well as what is the most effective way of making the change:

- GE has a short article "8 questions to ask before buying LEDs", which provides some helpful questions to ask before buying: https://www.currentbyge.com/ideas/8-questions-to-ask-before-buying-leds.

- A 2015 presentation posted on the Interior Lighting Campaign webpage has also multiple suggestions in the last page of the presentation: https://interiorlightingcampaign.org/sites/default/files/2015_TU_LED_Lighting_CaseStudy_BBC_24-Sept-2015.pdf.

- The site energy.gov published a brochure titled "LED Retrofit Kits, TLEDs, and Lighting Controls: An Application Guide" in 2017 at https://www.energy.gov/sites/prod/files/2017/03/f34/led_troffer_retrofit_guide.pdf. The brochure calls linear LEDs as tubular LEDs, or TLEDs. It includes discussion of other options, including retrofit kits and new luminaires.

- The website Facility Executive describes four points to consider, from looking up the DLC certification, and UL certification, to asking the manufacturer about testing procedures, and checking the source: https://facilityexecutive.com/2016/04/4-ways-to-avoid-led-lighting-failure/.

## Appendix C - LED News & Periodicals

Some of the LED resources on the web that share the latest and greatest on LEDs:

LED applications: LEDsmagazine: https://www.ledsmagazine.com

LED manufacturing: LEDinside: https://www.ledinside.com/

News blog: LED news: https://leds-news.blogspot.com/

More news: LED Lighting: https://www.electronicsweekly.com/news/products/led/

## References

current by GE (2018, November 14), *The ABCs of LED Tubes (UL Type)*. Retrieved from **https://products.currentbyge.com/sites/products.currentbyge.com/files/documents/document_file/LEDL040-GE-The-ABCs-of-LED-Tubes-UL-Type-White-Paper.pdf**.

current by GE (2019-1, July 18), *GE LED Tubes*. Retrieved from **https://products.currentbyge.com/sites/products.currentbyge.com/files/documents/document_file/LEDL046-GE-LED-Tubes-Brochure.pdf**.

current by GE (2019-2, Aug 1), *GE Commercial T8 LED Tubes – Ballast Compatibility*. Retrieved on Sep 6, 2019 from **https://products.currentbyge.com/sites/products.currentbyge.com/files/documents/document_file/LED-Tubes-Ballast-Compatibility-Sheet_0.pdf**.

current by GE (2019-3), *Customer Success Stories*. Retrieved on Sep 9, 2019 from **https://www.currentbyge.com/ideas/customer-success-stories**.

current by GE (2019-4), *GE's Integrated LED Tube (UL Type A)*. Retrieved on Sep 6, 2019 from **https://products.currentbyge.com/led-tubes/ge-integrated-led-tube-ul-type-a**.

current by GE (2019-5), *GE Double Ended Ballast Bypass LED Tube (UL Type B)*. Retrieved on Sep 6, 2019 from **https://products.currentbyge.com/led-tubes/ge-ballast-bypass-led-tube-ul-type-b**.

Design Lights Consortium (n.d.), *Testing & Reporting Requirements for Linear Replacement Lamps*. Retrieved from **https://www.designlights.org/solid-state-lighting/testing-reporting-requirements/linear-replacement-lamps/**.

European Commission (n.d.), *CE* marking. Retrieved from **https://ec.europa.eu/growth/single-market/ce-marking_en**.

GE Lighting (n.d., no date), *Product Recall*. Retrieved from **https://www.gelighting.com/recall** .

Halper, Mark (2019, Mar 4), *It's not just about services: GE's Current introduces more* lights. Retrieved from **https://www.ledsmagazine.com/architectural-lighting/indoor-lighting/article/16699045/its-not-just-about-services-ges-current-introduces-more-lights-updated.**

IEEE (2015, Jun 5), *IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers*. IEEE Standard 1789-2015, pp.1-80, 5 June 2015 doi: 10.1109/IEEESTD.2015.7118618

Lighting Facts (n.d.), *Just the Facts for LED Lighting*. Retrieved from **https://www.lightingfacts.com/**.

Philips Lighting (2019-1, Jan 18), *MasterClass LEDtube InstantFit T8*. Retrieved on September 6, 2019 from **https://www.assets.lighting.philips.com/is/content/PhilipsLighting/fp929001397934-pss-global**.

Philips Lighting (2019-2, Apr 2), *CorePro LEDtube MainsFit* T8. Retrieved from **https://www.assets.lighting.philips.com/is/content/PhilipsLighting/fp929001363134-pss-global**.

Philips Lighting (2019-3, May 17), *Ecofit Ledtubes T8*. Retrieved on September 6, 2019 from **https://www.assets.lighting.philips.com/is/content/PhilipsLighting/fp929001276302-pss-global**.

Philips Lighting (2019-4), *Professional LED Lamps: Energy savings that inspire*. Retrieved on September 6, 2019 from **https://www.usa.lighting.philips.com/products/ledlamps** .

Signify (2018, May 16), *Philips Lighting is now* Signify. Retrieved on September 6, 2019 from **https://www.signify.com/en-us/our-company/news/press-releases/2018/20180516-philips-lighting-is-now-signify**.

Sosebee, C., Marsik, T., Wiltse, N., Truffer-Moudra, D., & Garber-Slaght, R., (2019) *Economic and Performance Analysis of T8 Linear LED Replacement Lamps*. **www.cchrc.org .**

Sylvania (2015, August 25), *SubstiTUBE IS T8 LED Lamps Recall*. Retrieved on September 6, 2019 from **https://www.sylvania.com/en-us/about/legal/recall/Pages/SubstiTUBE-IS-T8-LED-Recall.aspx**.

Sylvania (2019-1, Jan), *SubstiTUBE IPS LED T8*. Retrieved on September 6, 2019 from **https://assets2.sylvania.com/media/bin/asset-2892497/asset-2892497**.

Sylvania (2019-2, Jun), *SubstiTUBE LED Lamps: Ballast Compatibility List*. Retrieved on September 6, 2019 from **https://assets2.sylvania.com/media/bin/asset-1741001/asset-1741001**.

Sylvania (2019-3, Aug), *SYLVANIA Lamps: DUALescent T8 Universal Lamp*. Retrieved from **https://assets2.sylvania.com/media/bin/asset-7401814/asset-7401814**.

Sylvania (2019-4, Sep), *LEDlescent T8 Ballast-Free Lamps: Internal Driver/Line Voltage Linear LED T8 Lamp*. Retrieved on September 6, 2019 from **https://assets2.sylvania.com/media/bin/asset-1547985/asset-1547985**.

technavio Blog (2017, June 17), *Top 12 Companies in the Global General Lighting Market*. Retrieved on September 6, 2019 from **https://blog.technavio.com/blog/top-12-vendors-global-general-lighting-market**.