

# LED FACT SHEETS

## LED LIFE

### Lifetime of White LEDs

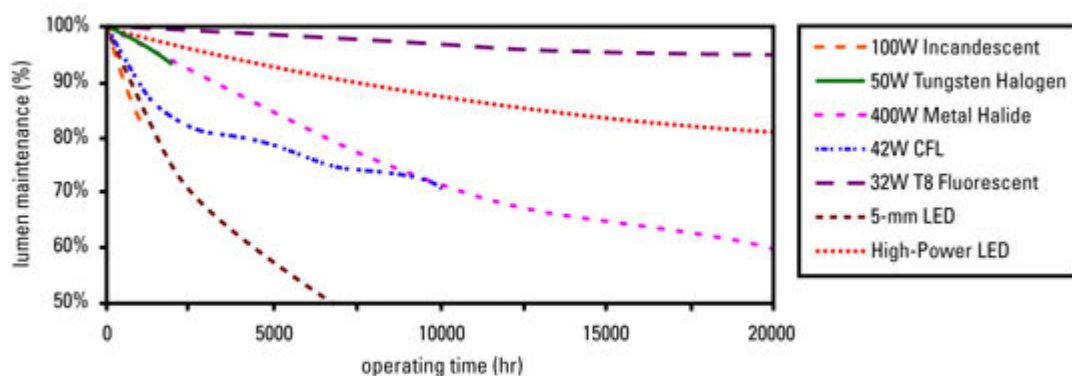
One of the main advantages of LEDs is their potentially very long life. Do they really last 50,000 hours or even 100,000 hours? It depends on LED quality, system design, operating environment and other factors. This Fact Sheet provides information on lumen depreciation and life measurement for LEDs compared to other light sources.

### Lumen Depreciation

All types of electric light sources experience lumen depreciation, defined as the decrease in lumen output that occurs as a lamp is operated. The causes of lumen depreciation in incandescent lamps are depletion of the filament over time and the accumulation of evaporated tungsten particles on the bulb wall. This typically results in 10% to 15% depreciation compared to initial lumen output over the 1,000 hour life of an incandescent lamp.

In fluorescent lamps, the causes of lumen depreciation are photochemical degradation of the phosphor coating and the glass tube, and the accumulation of light-absorbing deposits within the lamp over time. Specific lamp lumen depreciation curves are provided by the lamp manufacturers. Current high quality fluorescent lamps using rare earth phosphors will lose only 5-10% of initial lumens at 20,000 hours of operation. Compact fluorescent lamps (CFLs) experience higher lumen depreciation compared to linear sources, but higher quality models generally lose no more than 20% of initial lumens over their 10,000 hour life.

**Typical Lumen Maintenance Values for Various Light Sources**



Source: Adapted from Bullough, JD. 2003. *Lighting Answers: LED Lighting Systems*. Troy, NY. National Lighting Product Information Program, Lighting Research Center, Rensselaer Polytechnic Institute.

Lumen depreciation in LEDs varies depending on package and system design. The primary cause of lumen depreciation is heat generated at the LED junction. LEDs do not emit heat as infrared radiation (IR) like other light sources, so the heat must be removed from the device by conduction or convection. If the LED system design has inadequate heat sinking or other means of removing the heat, the device temperature will rise, resulting in lower light output. Clouding of the epoxy encapsulant used to cover some LED chips also results in decreased lumens making it out of the device. Newer high-power LED devices use silicone as an encapsulant, which prevents this problem. LEDs continue to operate even after their light output has decreased to very low levels. This becomes the important factor in determining the effective useful life of the LED.

### **Defining LED Useful Life**

To provide an appropriate measure of useful life of an LED, a level of acceptable lumen depreciation must be chosen. At what point is the light level no longer meeting the needs of the application? The answer may differ depending on the application of the product. For a common application such as general lighting in an office environment, research has shown that the majority of occupants in a space will accept light level reductions of up to 30% with little notice, particularly if the reduction is gradual. Therefore a level of 70% of initial light level could be considered an appropriate threshold of useful life for general lighting. Based on this research, the US Alliance for Solid State Illumination Systems and Technologies (ASSIST), a group led by the Lighting Research Center (LRC), recommends defining useful life as the point at which light output has declined to 70% of initial lumens (abbreviated as L70) for general lighting and 50% (L50) for LEDs used for decorative purposes. For some applications, a level higher than 70% may be required.

### **Measuring Light Source Life**

We've all heard the small "pop" as an incandescent lamp fails. It's the sound of the tungsten filament finally breaking as the electric current hits it. This makes it easy to recognize the end of life for an incandescent light source. With fluorescent lamps, end of life may involve flickering or the lamp may simply not activate when the switch is turned on. With LEDs, outright failure of the device is less likely, although it can happen due to component failure. Instead, the LED's light output slowly declines over time.

The lifetimes of traditional light sources are rated through established test procedures. The life testing procedure for compact fluorescent lamps, for example, is published by the Illuminating Engineering Society of North America as LM-65. It calls for a statistically valid sample of lamps to be tested at an ambient temperature of 25 degrees Celsius using an operating cycle of 3 hours ON and 20 minutes OFF. The point at which half the lamps in the sample have failed is the rated average life for that lamp. For 10,000 hour lamps, this process takes about 15 months.

How are LED lifetimes rated? Life testing for LEDs is impractical due to the long expected lifetimes. Switching is not a determining factor in LED life, so there is no need for the on-off cycling used with other light sources. But even with 24/7 operation, testing an LED for 50,000 hours would take 5.7 years. Because the technology continues to develop and evolve so quickly, products would be obsolete by the time they finished life testing.

A life testing procedure for LEDs is currently under development by the Illuminating Engineering Society of North America. The proposed method is based on the idea of "useful life," i.e., the operating time in hours at which the device's light output has declined to a level deemed to no longer meet the needs of the application. For example, for general ambient lighting, the level might be set at 70% of initial lumens. Useful life would be stated as the average number of hours that the LED would operate before depreciating to 70% of initial lumens.

The leading LED manufacturers have begun using the L<sub>70</sub> language, stating that their white LEDs "are projected" to have lumen maintenance of greater than 70% on average after 50,000 hours when used in accordance with published guidelines.

Electrical and thermal design of the LED system or fixture determine how long LEDs will last and how much light they will provide. Driving the LED at higher than rated current will increase relative light output but decrease useful life. Operating the LED at higher than design temperature will also decrease useful life significantly.

How do the lifetime projections for LEDs compare to traditional light sources?

Light Source	Range of Typical Rated Life (hours)* (varies by specific lamp type)	Estimated Useful Life (L <sub>70</sub> )
Incandescent	750-2,000	
Halogen incandescent	3,000-4,000	
Compact fluorescent (CFL)	8,000-10,000	
Metal halide	7,500-20,000	
Linear fluorescent	20,000-30,000	
High-Power White LED		35,000-50,000

\*Source: lamp manufacturer data.

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Source: US Department of Energy. Reproduced with permission.