

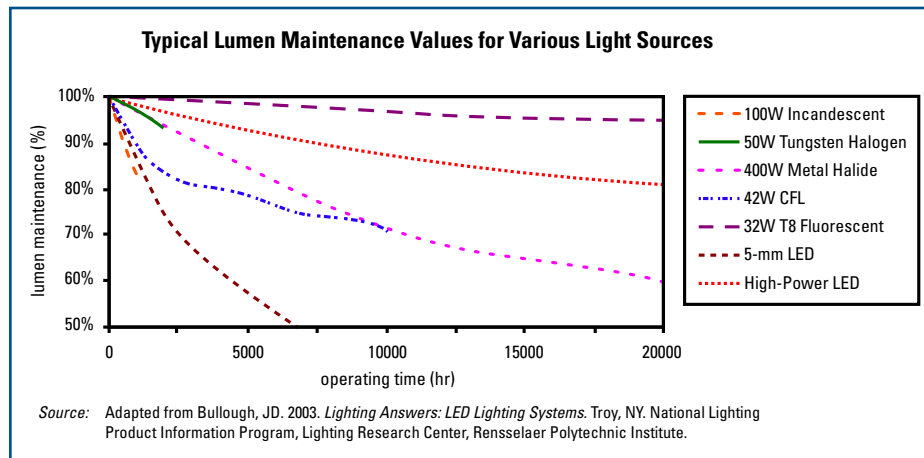
Lifetime of White LEDs

One of the main “selling points” of LEDs is their potentially very long life. Do they really last 50,000 hours or even 100,000 hours? This fact sheet discusses lumen depreciation, measurement of LED useful life, and the features to look for in evaluating LED products.

Lumen Depreciation

All electric light sources experience a decrease in the amount of light they emit over time, a process known as lumen depreciation. Incandescent filaments evaporate over time and the tungsten particles collect on the bulb wall. This typically results in 10-15% depreciation compared to initial lumen output over the 1,000 hour life of an incandescent lamp.

In fluorescent lamps, photochemical degradation of the phosphor coating and accumulation of light-absorbing deposits cause lumen depreciation. Compact fluorescent lamps (CFLs) generally lose no more than 20% of initial lumens over their 10,000 hour life. High-quality linear fluorescent lamps (T8 and T5) using rare earth phosphors will lose only about 5% of initial lumens at 20,000 hours of operation.



The primary cause of LED lumen depreciation is heat generated at the LED junction. LEDs do not emit heat as infrared radiation (IR), so the heat must be removed from the device by conduction or convection. Without adequate heat sinking or ventilation, the device temperature will rise, resulting in lower light output. While the effects of short-term exposure to high temperatures can be reversed, continuous high temperature operation will cause permanent reduction in light output. 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.¹ 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 Alliance for Solid State Illumination Systems and Technologies (ASSIST), a group led by the Lighting Research Center (LRC),

¹Rea MS (ed.). 2000. IESNA Lighting Handbook: Reference and Application, 9th ed. New York: Illuminating Engineering Society of North America.
Knau H. 2000. Thresholds for detecting slowly changing Ganzfeld luminances. *J Opt Soc Am A* 17(8): 1382-1387.



OSRAM Opto Semiconductors Photo credit: OSTAR™ Lighting

Terms

Lumen depreciation - the decrease in lumen output that occurs as a lamp is operated.

Rated lamp life – the life value assigned to a particular type lamp. This is commonly a statistically determined estimate of average or median operational life. For certain lamp types other criteria than failure to light can be used; for example, the life can be based on the average time until the lamp type produces a given fraction of initial luminous flux.

Life performance curve – a curve that presents the variation of a particular characteristic of a light source (such as luminous flux, intensity, etc.) throughout the life of the source. Also called lumen maintenance curve.

Source: Rea 2000.

Checklist

What features should you look for in evaluating the projected lifetime of LED products?

- Does the LED manufacturer publish thermal design guidance?
- Does the lamp design have any special features for heat sinking/thermal management?
- Does the fixture manufacturer have test data supporting life claims?
- What life rating methodology was used?
- What warranty is offered by the manufacturer?



recommends defining useful life as the point at which light output has declined to 70% of initial lumens (abbreviated as L_{70}) for general lighting and 50% (L_{50}) for LEDs used for decorative purposes. For some applications, a level higher than 70% may be required.

Measuring Light Source Life

The lifetimes of traditional light sources are rated through established test procedures. For example, CFLs are tested according to LM-65, published by the Illuminating Engineering Society of North America (IESNA). A statistically valid sample of lamps is tested at an ambient temperature of 25°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.

Full 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.

The IESNA is currently developing a life testing procedure for LED products, based in part on the *ASSIST recommends* approach. The proposed method involves operating the LED component or system at rated current and voltage for 1,000 hours as a “seasoning period.” This is necessary because the light output actually increases during the first 1,000 hours of operation, for most LEDs. Then the LED is operated for another 5,000 hours. The radiant output of the device is measured at 1,000 hours of operation; this is normalized to 100%. Measurements taken between 1,000 and 6,000 hours are compared to the initial (1,000 hour) level. If the L_{70} and L_{50} levels have not been reached during the 6,000 hours, the data are used to extrapolate those points.

LED Lifetime Characteristics

How do the lifetime projections for today’s white LEDs compare to traditional light sources?

Light Source	Range of Typical Rated Life (hours)* (varies by specific lamp type)	Estimated Useful Life (L_{70})
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.

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.

Most manufacturers of high-power white LEDs estimate a lifetime of around 30,000 hours to the 70% lumen maintenance level, assuming operation at 350 milliamps (mA) constant current and maintaining junction temperature at no higher than 90°C. However, LED durability continues to improve, allowing for higher drive currents and higher operating temperatures. Specific manufacturer data should be consulted because some LEDs available today are rated for 50,000 hours at 1000 mA with junction temperature up to 120°C.²

²Philips Lumileds Lighting, LUXEON K2 Emitter Datasheet DS51 (5/06)

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Energy Efficiency and Renewable Energy

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