



White Paper: Life and Depreciation

How is service life measured for LED systems?

- *Life and Lamp Lumen Depreciation*
- *IES Standard LM80*

While there has been great excitement about the potential for digital lighting to save energy, certainly at least as much anticipation has surrounded the promise of LEDs to deliver extremely long life. **The practical service life of LEDs for commercial lighting applications is a complex issue and it is VERY important that facts are separated from hype.** As digital lighting technology evolves, what is seemingly solid knowledge today will change as R&D efforts (and associated rigorous testing programs) combine with field experience to frame up a more complete picture of the capabilities of this source.

With today's conventional light sources (HID, fluorescent, incandescent), the industry-set definition of service life is the point at which 50% of lamps have failed. Each of these source types has a distinct failure mode (e.g. electrode wear, cathode burnout, burned filaments, among others) that is known and anticipated before a new lamp is even launched. The rich history of these lamp development efforts over the past decades has enabled manufacturers to build a comprehensive data set to use in creating statistical projections of lamp life. All this has defined the current industry-accepted normal life functions and have shaped customers' expectations of source mortality.

All of this changes with the digital light source.

To date, no consistent failure modes across the array of currently available LEDs have been uncovered. So, in the absence of catastrophic (i.e. non-operational) failures at the LED-package level, **manufacturers have agreed to define life for an LED as the time at which it degrades in light output to a given percent of its initial value. The nomenclature is given as L50 (50% of initial), L70 (70% of initial), and so on.** It is important to realize however, the rate of this depreciation is highly dependent on the operating conditions of the LED—namely junction temperature, operating current, and in some cases local ambient temperature (defined as the temperature immediately surrounding the LED). Since life is integrally tied to the LED's operating conditions, one can no longer separate the life of the LED from the characteristics of the luminaire. So, given the same LED, a luminaire with a poorly designed thermal system (leading to higher junction temperature) will have a far shorter life than one with a solid thermal management approach.

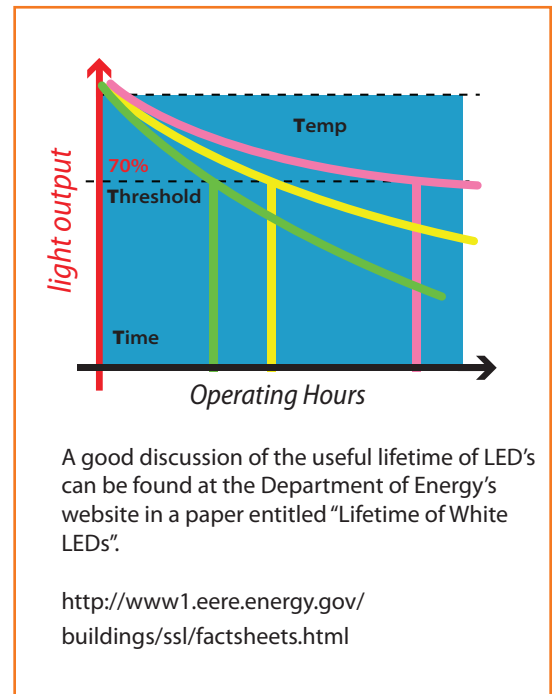
Bottom line: LED service life and lumen depreciation metrics are fundamentally interconnected and must be provided in the context of a specific luminaire design and intended application.

For example, the figure at rights shows three curves for luminaires with varying degrees of thermal management.

As can be seen, life (defined by the time at which light degrades to 70% of initial lumens) is significantly shorter for the luminaires with poor thermal management. In order to ensure that LED suppliers measure and report the lumen maintenance characteristics of their LEDs in a consistent way, the Department of Energy (DOE) engaged the support of IES to establish Standard LM80. This test method requires LED suppliers to test and report the LED's lumen depreciation values at three operating conditions (two set within the document, and the third at the manufacturer's discretion) over a period of 6,000 hours.

This establishes a standard test methodology that (along with the LED spec sheets) allows luminaire companies to compare performance across LED suppliers.

NOTE: Standard LM80 does not prescribe how to extrapolate this 6khr data to the life predictions of the LED.



This task has been left to another standard, titled IES TM21, which will take this LM80 data and use some form of curve fit to project the point at which lumens depreciate to 50%, 70% or any other desired point. This is a critical task, as there is still debate within the lighting community over the completeness of the LM80 test method, the mathematical form of the extrapolation, and the time period over which the extrapolation is valid. These developments are very critical, as they are fueled by the fast pace of discovery in the field of LEDs.

Hence, it is very important for the luminaire manufacturer to understand the specific extrapolation methods used by their chosen supplier and how the luminaire design impacts these critical parameters. In turn, manufacturers must process and supply the relevant results of this analysis (life of the luminaire, temperature limitations, etc) to customers for their consideration in selecting a digital lighting system.

For more information about standards LM80 and IES TM21, you may refer to:
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/comparing_white_leds.pdf