

Industry alliance proposes standard definition for LED life

The Alliance for Solid-State Illumination Systems and Technologies has developed guidelines for defining LED life as a step towards establishing product standards, writes **Jennifer Taylor**.

Despite continual improvements in LED brightness, color and efficacy, one problem remains that could hamper the LED's success in the lighting community: the absence of a consistent definition of life. At the moment there is no standard for defining or measuring LED lifetime. Much of the confusion within the lighting community is related to the fact that LEDs do not fail in the same manner as other types of light sources. Rather than experiencing a complete operational failure, LED light output slowly decreases with time. Long-life claims without concrete data also have led to skepticism among lighting professionals and would-be purchasers of LED systems. Manufacturers do not present measured life data primarily because no standard testing procedure exists and life tests are generally too time consuming and costly.

The Alliance for Solid-State Illumination Systems and Technologies (ASSIST)—a collaborative group of LED and fixture manufacturers, systems end-users, and government agencies organized by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute—recently set forth recommendations that define LED life and life measurement methods for general lighting. These recommendations were developed from studies of LED life and light level acceptance conducted at the LRC and by other researchers, as well as from input provided by major LED and traditional lighting manufacturers.

Nadarajah Narendran, PhD, director of research at the LRC and head of its Solid-State Lighting Program, says a definition for life and a standard method for testing are necessary in order to advance LED technology for general illumination applications. “Ultimately the success of LEDs and their adoption by the lighting community will depend upon a consistent and accurate presentation of life data,” he says.

Definition of LED life

The guidelines, published in *ASSIST recommends: LED Life for General Lighting*, revolve around the concept of “useful life” that was first proposed by Narendran *et al.* in 2001. The term describes the period in which a light source provides an acceptable light level for a given application, and in addition does not have a noticeable color shift.

In defining this period of useful life, *ASSIST recommends* uses lumen maintenance values, or how a lamp maintains its light output over its lifetime. The guidelines specify two levels of lumen maintenance for different types of LED lighting applications. The group has proposed a lumen maintenance of 70%, corresponding to a 30% reduction in initial light output, as the end of useful life for general lighting. For decorative lighting applications where light level is not critical, the group recommends a drop of 50% as the end of life.

The 70% cut-off was based on research showing that most people will accept up to a 30% reduction in light level (see *ASSIST recommends: LED Life for General Lighting* for references on light level

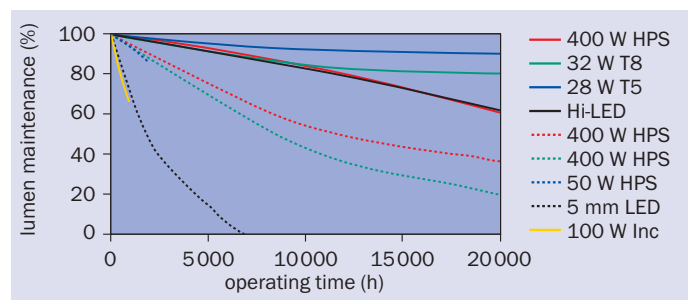


Fig. 1. Lumen maintenance curves for various light sources out to 20 000 hours (Rea 2000; Bullough 2003). High-power LEDs (Hi-LEDs) show much better lumen maintenance than 5 mm LEDs.

acceptance). Narendran says, “by setting a lumen maintenance level based upon human factors studies, the guidelines will not become dated as the technology advances”.

In certain applications where light sources are placed side by side, however, light output differences of more than 20% may reduce the visual aesthetics of the space (for example, wall washing in a corridor). In these situations, the lighting specifier may choose an 80% lumen maintenance value for relamping.

Most successful light sources sustain lumen maintenance values greater than 70% before failure (figure 1). Therefore, lamp life based on lumen maintenance criteria is relatively uncommon, says Narendran. However, relamping at the end of useful life rather than rated life is not uncommon. For example, certain types of metal halide lamp can exhibit a light output depreciation of as much as 50% at only 40% of rated lamp life (Figueiro 2003). As a result, some manufacturers recommend group relamping of metal halide lamps long before operational failure.

ASSIST also recommends that within the useful life period, LEDs should not exhibit color shifts greater than a four-step MacAdam ellipse. “Excessive color shift results in reduced visual aesthetics of the lighted space, and this would not be accepted by occupants,” says Narendran.

Manufacturers who follow the ASSIST recommendations will publish the number of hours a product will operate before reaching 70% and 50% of initial light levels. Providing the operating time will assist specifiers and designers in selecting the right LED product for the job, says Narendran.

Measuring lumen maintenance

Along with the lumen maintenance recommendations come methods for measuring and extrapolating data to estimate life, in hours, for both LEDs and integrated systems using LEDs. ASSIST has outlined

different methods for components (the individual LEDs) and systems (the integrated packaging of LEDs).

For measuring both components and systems, ASSIST recommends a minimum operating period of 6000 hours (250 days) at rated current and voltage. The first 1000 hours is an initial seasoning period for the LEDs, and the next 5000 hours is for actual light output measurement. Light output data collected between 1000 and 6000 hours is used to measure or estimate the time needed to reach 70% and 50% lumen maintenance. ASSIST recommends an initial seasoning period because studies at the LRC have shown LED light output to increase during this time (Gu *et al.* 2004). The LRC's comparisons of extrapolated and measured life show that inclusion of the first 1000 hours of data can lead to false life estimates.

LED life is related to junction temperature (T_j) (Fukuda 1991), but T_j can be difficult to measure, especially once LED dies are packaged into their housing. A reasonable estimate of T_j can be made by measuring the temperature of the closest measurable location to the LED junction (T_s). This is usually where the LED is soldered to the circuit board (figure 2). Because T_s can be measured more conveniently and has a similar relationship to life as T_j , ASSIST recommends using T_s for component life measurements.

The ASSIST guidelines propose component life measurements to be taken at three different T_s temperatures. For high-power components (those operating above 100 mA), the recommended T_s temperatures are 45 °C, 65 °C and 85 °C. For low-power components (those operating below 100 mA), the recommended T_s temperatures are 35 °C, 45 °C and 55 °C.

Different T_s temperatures can be achieved either by changing the current or by changing the ambient temperature of the testing space. In this case, because the document guidelines say to run the component at rated current, the manufacturer would have to vary the ambient temperature to achieve the desired T_s testing value.

For LED systems, ASSIST recommends measuring life inside a temperature-controlled space at an ambient temperature of 25 °C.

Because the goal of *ASSIST recommends* is to encourage manufacturers, small and large, to provide life data, the document calls for inexpensive test equipment. Since relative light output is the only measurement needed, a broadband detector that can measure radiant energy is an acceptable alternative to expensive light measurement equipment with $V(\lambda)$ correction, says Narendran.

If 70% and 50% lumen maintenance values are not reached within 6000 hours, ASSIST recommends applying a mathematical fit to the light output data collected between 1000 and 6000 hours and extrapolating to estimate when the light level will reach these values. Figure 3 shows a sample life graph that an LED component manufacturer may provide.

ASSIST cautions that as LEDs improve in the future, it may be necessary to increase both the initial seasoning period and the measurement period to longer than 6000 hours in order to develop reasonable predictions of light output.

Consistency in life estimation and data reporting methods

The new recommendations will help on two fronts, says Narendran. First of all, they will establish a realistic life expectancy for LED lighting products, which will help consumers to conduct lifecycle estimates and comparisons among lighting products. Second, the measurement and extrapolation guidelines will ensure that all LED

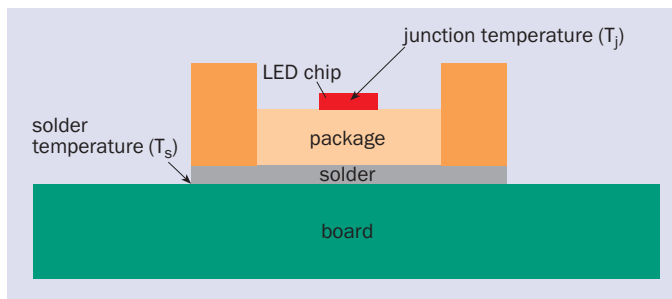


Fig. 2. LED package showing the position of the T_s measurement.

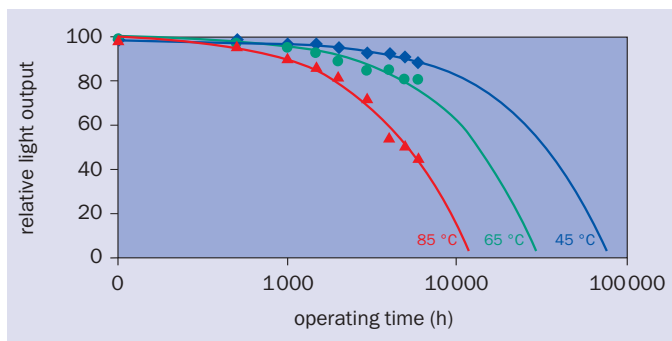


Fig. 3. Sample high-power LED component life graph for one product at each recommended T_s temperature (not actual data). Solid lines represent the mathematical fit for the extrapolation of life data to 70% and 50% lumen maintenance.

lighting manufacturers test their products in a similar manner.

In addition to the recommendations, ASSIST has provided sample data-recording sheets for high- and low-power components and for LED systems. For component manufacturers, these sheets list other details that should be recorded beyond life data, including sample size, thermal resistance coefficients, and junction temperatures. As for system manufacturers, ASSIST is calling on them to provide life data beyond that which is provided by component manufacturers, primarily because LED system life can vary depending on the packaging.

Next step: industry standards

Narendran says these recommendations are the first step towards the creation of standards for LED lighting products, such as those in place for traditional light sources. Going forward, he says the group plans to contact LED component and system manufacturers and encourage them to review *ASSIST recommends* and to provide life data using the guidelines.

“This is really just a starting point for the industry to begin collecting sufficient data and evaluating these recommended methods. Hopefully, these can lead to the establishment of good standards down the road,” says Narendran.

Feedback welcome

The Lighting Research Center welcomes all comments on these proposals from LED component and system manufacturers and other interested parties. Send your comments via *LEDs Magazine* to editor@leds.iop.org, or contact the LRC directly at lrc@rpi.edu.

Companies participating in the development of *ASSIST recommends* include Boeing, GELcore, New York State Energy Research and Development Authority, Nichia America Corporation, Philips Lighting, OSRAM SYLVANIA/OSRAM Opto Semiconductors, and the United States Environmental Protection Agency. ●

Further reading

J D Bullough 2003 *Lighting Answers: LED Lighting Systems* (Troy, New York: National Lighting Product Information Program, Lighting Research Center, Rensselaer Polytechnic Institute.

See www.lrc.rpi.edu/programs/NLPIP/publications.asp).

M G Figueiro 2003 *Lighting Answers: Mid-wattage Metal Halide Lamps* (Troy, New York: National Lighting Product Information Program, Lighting Research Center, Rensselaer Polytechnic Institute. See www.lrc.rpi.edu/programs/NLPIP/publications.asp).

M Fukuda 1991 *Reliability and Degradation of Semiconductor Lasers and LEDs* (Artech House, Boston).

Y Gu, N Narendran and J P Freyssinier 2004 White LED Performance *Fourth International Conference on Solid State Lighting, Proceedings of SPIE 5530*, eds I T Ferguson *et al.* 119–124.

N Narendran, J Bullough, N Maliyagoda and A Bierman 2001 What is useful life for white light LEDs? *Journal of the Illuminating Engineering Society* **30(1)** 57–67.

M S Rea ed. 2000 *IESNA Lighting Handbook: Reference and*

Links

ASSIST: www.lrc.rpi.edu/programs/solidstate/assist/index.asp

LRC Solid-State Lighting program: www.lrc.rpi.edu/programs/solidstate/index.asp

A free download of *ASSIST recommends: LED Life for General Lighting* can be found at: www.lrc.rpi.edu/programs/solidstate/assist/recommends.asp

On our website

“Moving LEDs into the mainstream: ASSIST develops research, education, and industry ties”

See www.ledsmagazine.com/articles/features/1/2/4/1.

“Lighting Research Center applies research, demonstrations, and education to advance LED technology”

See www.ledsmagazine.com/articles/features/1/2/5/1.

Application 9th edn (Illuminating Engineering Society of North America, New York).

About the author

Jennifer Taylor is a communications specialist with the Lighting Research Center at Rensselaer Polytechnic Institute.