Lifetime Concerns

BY JAMES BRODRICK

When it comes to LED lighting products, you've heard it all before: "lasts forever," "same as a 60-W incandescent lamp," "produces no heat" and so on. Usually it's easy for lighting professionals to spot gross exaggerations, but not when it comes to lifetime. That's because these products haven't been around for that long, and thus there's no long-term experience to go by. So the questions linger: Do LED lighting products really last 60,000 hours, as some manufacturers claim? If so, does the color remain constant over that time? And since they don't burn out like ordinary lamps, how does one know when their lifetime has expired?

When the U.S. Department of Energy (DOE) launched the SSL Quality Advocates program a year ago, we knew it was just a beginning. Our first step was to create a guide, *Reporting LED Luminaire Product Performance,* and a Lighting Facts label, both of which focused on five key parameters: lumens, efficacy, watts, correlated color temperature (CCT) and color rendering index (CRI). We viewed the label as a work in progress, with other parameters possibly added in the future as the technology and our understanding evolved. And we knew that one of the next steps was to focus on the thorny issue of reliability and lifetime, but that we first needed to find a common language and definition.

That's why we created, under the Quality Advocates umbrella, a special working group on solid-state lighting (SSL) reliability and lifetime. Composed of a wide range of experts in reliability, lighting and LED technology, this dedicated group is hard at work developing a set of guidelines, which DOE expects to publish in early 2010. We intend to add the parameter of lifetime to the Lighting Facts label, as many people have requested, but we can't do so without these guidelines, which will provide a common understanding of how to define and report it.

DEFINING LONGEVITY

So what are the questions being considered in developing these new guidelines on SSL lifetime and reliability? Probably the most basic one is how best to define the longevity of LED luminaires. That's not a simple matter, because it doesn't just involve the LEDs themselves, but rather encompasses the entire system—including the power supply or driver, the electrical connections, various optical components and the fixture housing. LED luminaires are more complex than conventional lighting fixtures and sometimes have no replacement parts. When one component fails, it may mean a whole new luminaire must be reinstalled, or it may be repairable in the field; either way, though, the customer would likely view it as a failure. That means a luminaire whose LEDs last for 60,000 hours will fall way short of that mark if one of its other key components fails after only 30,000 hours. And at present, it's hard to know with certainty just how long these other components will last.

For example, fluorescent ballasts are manufactured to outlast their lamps many times over, because those lamps are easily replaced. But at this relatively early stage in the development of SSL technology, there's very little data available to confirm that LED drivers will last as long as the expected life of LEDs. And there's a similar lack of data on how well these drivers and other components will hold up when they're part of a heat-producing LED luminaire, or how these other components may affect the life of the LEDs. Yet another complexity is that we need to consider a population of luminaires, not just one, and in doing so need to consider "early" catastrophic failures that may result from defects in materials or manufacturing.

Even defining the lifetime of the LEDs themselves, which is just one component of lifetime, is no easy matter. That's because unlike conventional lamps, LEDs have no filaments or electrodes to burn out and thus generally keep on producing light, although at declining levels. The most commonly accepted way of defining the end of an LED module's lifetime is to equate it with the point where lumen output has declined by 30 percent from initial output. This point is often expressed as "L_{70}"—meaning that the lumen output has fallen to 70 percent of initial output—and is used because the average human

Fast Facts

Jointly developed by DOE and the Next Generation Lighting Industry Alliance (NGLIA), SSL Quality Advocates is a voluntary pledge program to ensure the accurate representation of LED lighting on the market. Quality Advocates is built around the Lighting Facts℠ label, and although it's been less than a year since the initiative was launched, there's already widespread support for this "truth in advertising" effort. To date:

180 manufacturers have pledged to use the Lighting Facts label on their SSL products.

170 products have been approved to use the label.

90 retailers and distributors, lighting designers, specifiers, utilities, and efficiency programs have agreed to ask vendors for products bearing this label.

To take the Lighting Facts pledge, or for more information, go to www.lightingfacts.com.

eye can't detect decreases in light levels of less than 30 percent.

MAKING PREDICTIONS

The problem is that we don't yet have a standard method for predicting when a luminaire has reached the L_{70} point. A test method published last year by the IES (IES-LM-80-08) prescribes how to measure the lumen depreciation of an LED module through at least 6,000 hours of testing at various temperatures. But we don't have a way to accurately predict L_{70} lifetime from the data collected during this relatively short period of measurement. An IES technical committee is currently working on developing such a method (labeled TM-21), but while it's making good progress, the committee is not quite there yet. And the long time frame involved makes it impractical to measure the lifetime of an LED luminaire by continuous testing. Plus, the technology is evolving so rapidly that by the time any lifetime test could be completed, the product would most certainly have been superseded by a more advanced version.

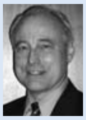
So meanwhile, for lack of a better option, many luminaire manufacturers are simply relying on LM-80 data and have worked out their own methods of using it to project product lifetime, which they label "expected lifetime" and include in the product literature. One obvious problem with this is that, even if the projection happens to be accurate, it only applies to the LEDs and assumes that there are no other potential failure mechanisms involved. Yet as stated above, before the LEDs reach L_{70}, many other components—such as the power supply, optics and reflectors—can go wrong and shorten the lifetime of the luminaire.

That's why all of these factors have to be taken into consideration. The most common way to do this is to define the expected lifetime of a population of LED luminaires as the median time to failure—that is, the point in time (represented as B_{50}) when half of the product has failed outright or fallen to L_{70} or less, whether from LED degradation, or component failure, or any other reason. While that's a step in the right direction, we have to think carefully about whether basing lifetime calculations on a failure rate of 50 percent is likely to lead to consumer satisfaction or disappointment. On the other hand, given that the lifetimes of conventional light sources are based upon a 50 percent failure rate, lowering the lifetime requirement threshold below a 50 percent failure threshold may put LEDs at a competitive disadvantage relative to other light source technologies.

THE COLOR QUESTION

Another important factor in defining the lifetime of LED luminaires is color consistency. The human eye can detect even small differences in color, and DOE's CALiPER testing program has found a significant correlated color temperature shift in some products over the first 6,000 hours of operation. While this may not be important in some applications, in others it can mean the end of the luminaire's useful life. And, like lumen depreciation, we have no way right now to predict color shift based on data over a limited test time. Rather than making color shift part of the lifetime definition, which would further complicate things, the two will work hand-in-hand. That is, both parameters will be listed on the Lighting Facts label: the expected luminaire lifetime defined as lumen output, along with the expected color shift over that stated lifetime. That way, buyers, lighting designers and other specifiers will be able to decide for themselves whether a luminaire's color consistency meets the particular requirements of a given application.

The question of LED luminaire lifetime and reliability is a complex one, fraught with nuance and ramification. In the process of answering the initial questions, new questions arise that we hadn't thought of. Having only recently taken the plunge into this particular pool, we're still gaining an appreciation for how deep and murky it is. Our ultimate goal, as a continuation of the Quality Advocates program, is to come up with an accurate and useful way to represent LED luminaire lifetime on the Lighting Facts label. Thanks to the efforts of the Quality Advocates working group and a steady input of feedback from a wide range of stakeholders, we're getting closer to achieving it.



James Brodrick is the lighting program manager for the U.S. Department of Energy, Building Technologies Program. The Department's national strategy to guide high-efficiency, high-performance solid-state lighting products from laboratory to market draws on key partnerships with the lighting industry, research community, standards organizations, energy-efficiency programs, utilities and many other voices for efficiency.

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