Technical Bulletin

dmf

LED System Reliability

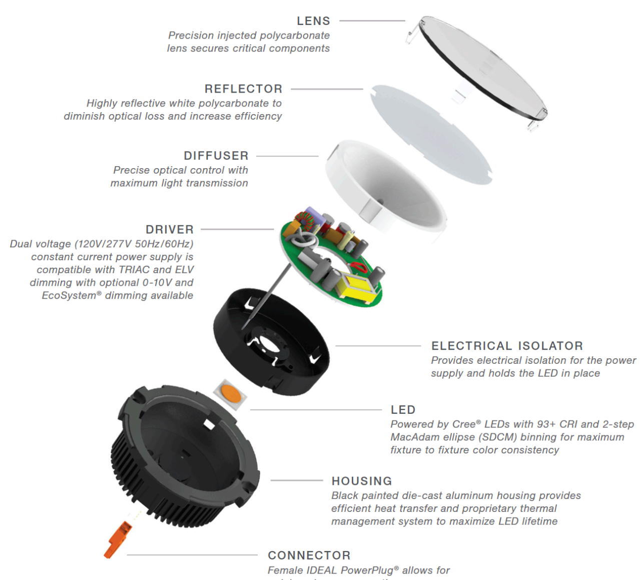
How Reliable is a LED luminaire?

LED based light fixtures have seen a meteoric rise in market acceptance over the last ten years and have demonstrated incredible energy savings[1], but the initial euphoria around life expectancy has been gradually rolled back for LED lamps and has defaulted to the magic 50,000 hours or five-year warranty for LED fixtures. Some manufacturers offer a ten-year warranty, but buyer beware, read the fine print! At the end of the day, what do the numbers really mean, where do they come from, and do they offer a realistic measure of reliability?

To answer the above questions requires knowledge of the components that comprise a LED light fixture, what the weak links really are, how reliability of the system and components are estimated and how the environment where the fixture is used affects the light fixture performance.

LED Module Components

The picture below shows an exploded view of the DRD2M LED module, which illustrates the key components of a LED module: the LED, power supply, reflector, lens and heatsink. Heat is the key factor that affects the long-term reliability of the system. In simple terms, the higher the temperature in the system the more susceptible it is to failure.



[1] See "Our Work Is Done Here," LDA Hot Topic Article by James Benya

Although most LED fixture manufacturers use LM-80[2] data supplied by LED manufactures to justify their TM-21[3] L_{70} extrapolated 50,000-hour longevity claim, it turns out that the LED is not usually the weakest component in the system[4]. The weakest components usually reside in the power supply and are typically electrolytic capacitors and mosfets. The longevity of these components is estimated using factors such as operating temperature and ripple current and operational life data provided by the component manufacturer. In practice a well-designed LED system manages the operating temperature and provides overtemperature control to ensure the electronic components are not overly stressed. For much more information on LED luminaire lifetime testing and reporting please refer to LED Luminaire Lifetime: Recommendations for Testing and Reporting, Third Edition September 2014, published by the Next Generation Lighting Industry Alliance. Needless to say, this is a very complex subject with many design, manufacturing and environmental variables that can significantly change outcomes.

What Environmental Factors Affect Lifetime?

The key environmental factors that affect the real working lifetimes of any LED luminaire are temperature, time and operational abuse. As we have indicated previously, the higher the temperature, the higher the stress placed on the weakest components in the LED luminaire. Environments such as high indoor ceilings, outdoor applications where the ambient temperatures are much higher than 25°C (77°F), along with large swings in ambient temperatures can place significant stress on the LED system. The amount of time the LED fixture is on can vary significantly and LED downlights in a residential bedroom that are used for a short time period each night will stress the light fixture much less than a 24/7 commercial or corridor application. Another reason for LED failure is overvoltage and surge, particularly with 277V systems. Environmental effects can have a significant impact on the long-term performance of any LED luminaire. The luminaire designer can mitigate the effects of many of the environmental variables with appropriate thermal management and sufficient power supply input protection, but the end user must ensure the environmental operating parameter requirements are complied with for successful long-term operation. For example, placing a typical downlight into a sauna may cause a problem if the light fixture cannot handle the humidity or placing a light fixture above a shower if it is not wet location listed.

LM-84 to the rescue!

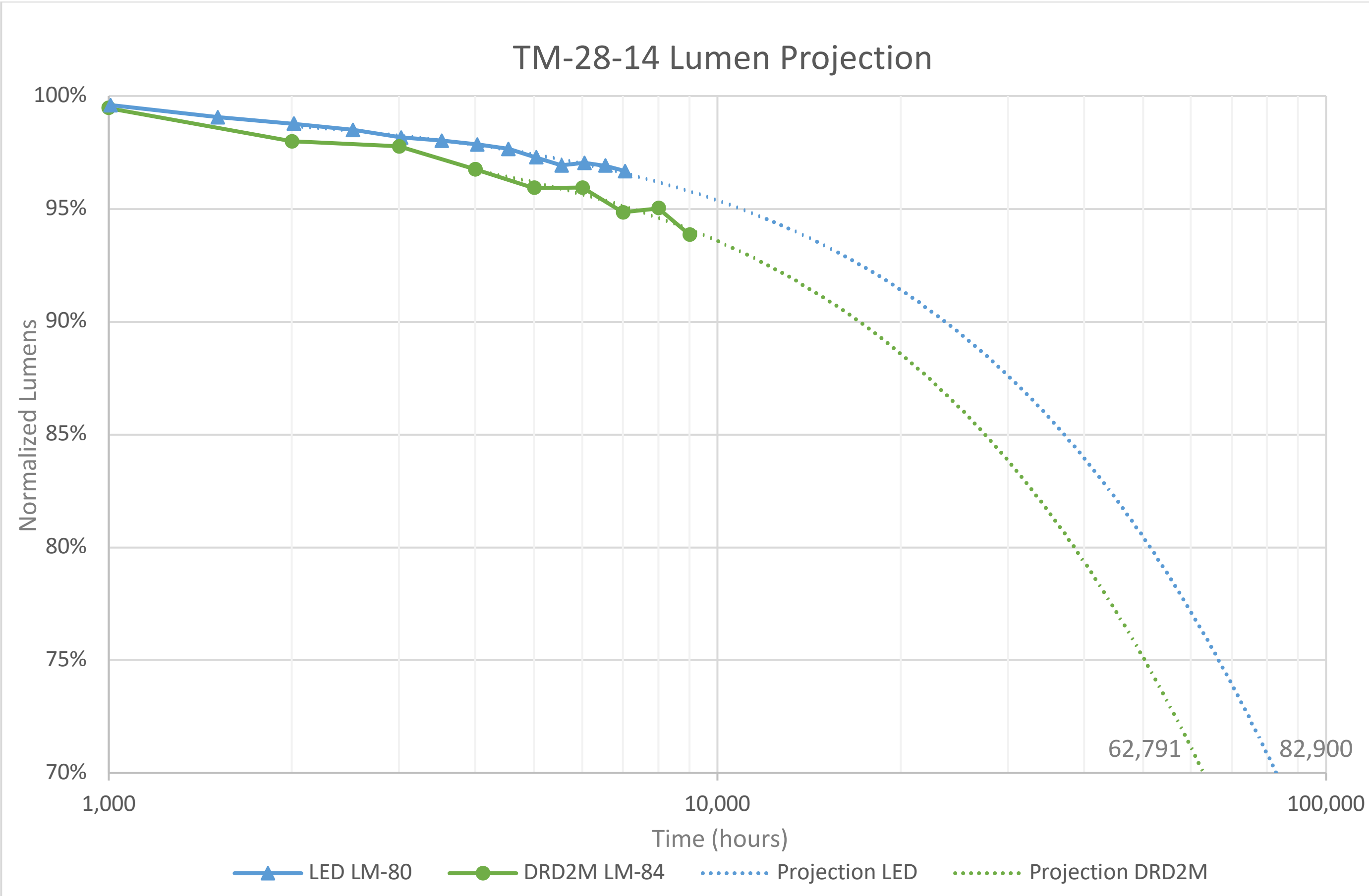
In an attempt to answer the above questions in a meaningful way DMF used the LM-84-14[5] test

[2] IESNA LM-80, Lumen maintenance test method.
[3] IESNA TM-21, Specifies how to extrapolate the LM-80 lumen maintenance data to times beyond the LM-80 test time. L70 (hours) = time to 70% lumen maintenance.
[4] See LEDs Magazine Webcast: "The Realities of LM-80/TM-21 & Setting False Lifetime Expectations" sponsored by Future Lighting Solutions and Nichia.
[5] IESNA LM-84-14 Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires

protocol to generate data to estimate the product lifetime of its DRD2 family of LED modules. To date the test has been running for over nine thousand hours, with modules operating at both 120V and 277V, in a 45°C (113°F) ambient environment for the entire test. Each module is tested every thousand hours for lumen output, chromaticity X/Y color shift and input power. A picture of the temperature-controlled test chamber equipment used is shown below.

Some of the modules under test are shown below.

The graph below shows the normalized lumen output of the test fixtures plotted on a logarithmic time scale, along with the exponentially extrapolated curve to create the projections.



The LED data is also included from the LED manufacturers published LM-80 file[6]. Notice how the LED extrapolation indicates better lumen maintenance over time than the modules, illustrating that using only LED LM-80 based information extrapolations can provide an optimistic prediction of longevity.

Using the 9000-hour test data, the Luminous Flux Maintenance Life L_{70}(9k) based on IES TM-28-14[7] is L_{70}(9k) > 62,791 hours (at Ta = 45°C)[8].

The key result is the L_{70}(9k) calculated lifetime of 62,791 hours. In other words, the extrapolated test results indicate that the DRD2M modules will maintain at least 70% of their initial lumens for over sixty thousand hours. Since DMF initiated these tests the power requirements of the modules have been reduced by over two watts, further mitigating the effects of heat within the

[6] The LED LM-80 data used is based on a higher reported case temperature and drive current. In practice it is expected that the L_{70} calculated lifetime for the LED when used with the DRD2M will be even better.

[7] *IES TM-28-14* Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires. *Specifies how to extrapolate the LM-84 lumen maintenance data to times beyond the LM-84 test time. L70 (hours) = time to 70% lumen maintenance.*

[8] Note based on TM-28-14 only the last six LM-84 data points are used to calculate the projection.

system and improving reliability. DMF anticipates that the power required to achieve a given lumen output will continue to reduce as LED efficiency continues to improve. In addition, DMF expects even better results when the modules operate in situ where the ambient temperature is likely to be less than 45°C (113°F) used during the test.

In conclusion, DMF is leading the way among LED fixture providers using tests such as LM-84 to validate its longevity and reliability claims. DMF has shown with the LM-84 test data and the TM-28 data extrapolation method that the 50,000-hour reported lifetime for the DRD2M LED module family is valid. Unfortunately, to date, few LED fixture manufacturers have published the results of LM-84 tests on their light fixtures, making it impossible for the consumer to objectively assess longevity claims. DMF will continue to use the LM-84 test method to validate new and improved offerings and to explore other test methods to validate its LED light fixture designs and their suitability for long-term trouble-free operation.