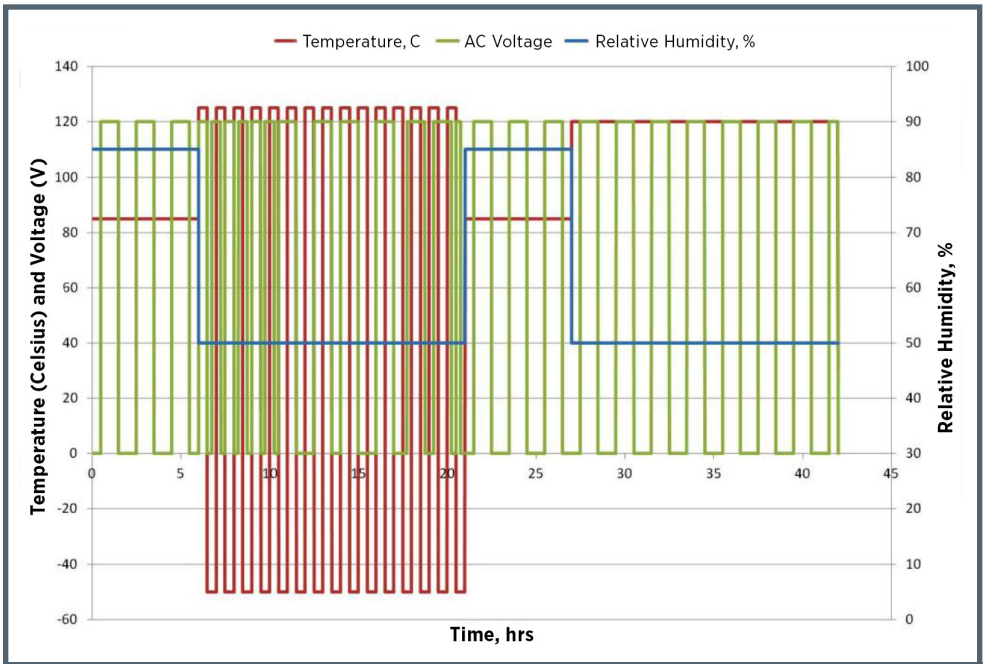
REPORT SUMMARY:

Hammer Testing Findings for Solid-State Lighting Luminaires

Next to energy efficiency, long life is probably the most publicized of solid-state lighting's (SSL) potential advantages, and plays a key role in any cost-benefit analysis. To accommodate the rapid evolution of SSL technologies and fully realize their energy-savings potential, there is a widespread need in the lighting industry to understand potential failure modes of luminaires. LED luminaires are composed of many working parts, each of which could impact product reliability, so a systems approach is needed to understand failure rates, and merely relying on LED lumen maintenance as a proxy for luminaire lifetime is inaccurate. Long LED lifetimes may not be realized at the luminaire level if, for example, the drivers fail prematurely or the lenses become cloudy. Clearly, developing a library of potential failure modes for LED luminaires, and not just the LEDs, is necessary to estimate the lifetime of these devices.

The U.S. Department of Energy (DOE) has published the findings of a new study utilizing a highly accelerated life-test method—called the "hammer test"—intended to produce failures in LED luminaires. The goal is to provide insight into potential failure modes for normal operation, recognizing that overstressing can in some cases result in new failure modes. Entitled *Hammer Testing Findings for Solid-State Lighting Luminaires*, the report was prepared by RTI International for DOE's LED Systems Reliability Consortium.

In the testing described in the report, seven different kinds of commercial indoor LED luminaires were subjected to extreme environmental stressors, including temperature cycling, temperature and humidity soak, and high-temperature bake, with power cycled to provide electrical stress as well.



Hammer test protocol, showing the changes in temperature, humidity, and electrical voltage during the 42-hour testing loop

Findings

- All of the luminaires survived more than 100 cycles of temperature shock (-50º C to 125º C).
- Nearly half survived more than 300 42-hour test loops.
- The failures that were observed typically occurred in the driver circuit, with board-level failures being most common.
- The 611 LEDs in these luminaires endured nearly 1 million LED-hours of cumulative exposure to the hammer test, with only four failures—two of which were attributed to solder-joint fatigue, and the other two to board-level corrosion.

The findings reinforce the belief that LEDs in lighting systems are highly robust, even under extreme conditions, and indicate that other luminaire components may be more likely to fail first, depending on the details of luminaire design. While the results suggest that LED luminaires will have a low probability of random failure in the field during normal use, additional work is needed to determine actual wear-out mechanisms, quantify failure modes, and determine acceleration factors, in order to provide estimates of lifetime and reliability.

The report is available at www.ssl.energy.gov/tech_reports.html.

For More Information

To learn more about DOE Solid-State Lighting program activities, visit www.ssl.energy.gov.

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