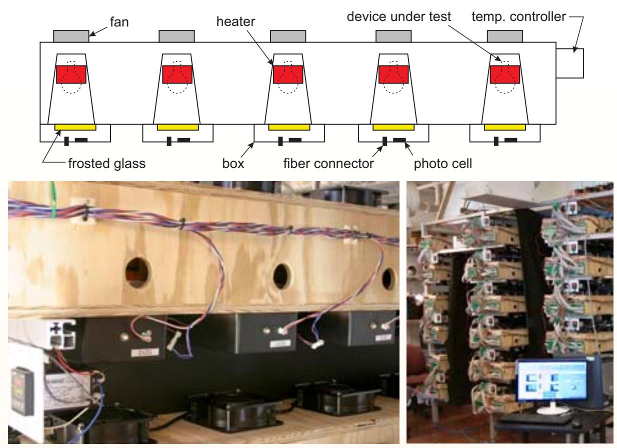
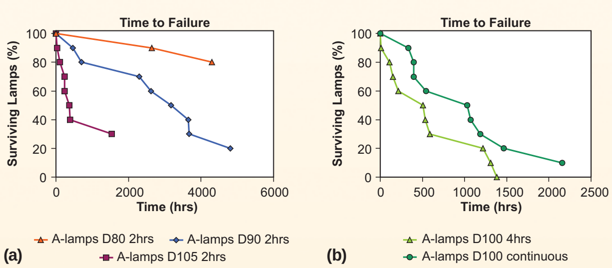
Developing a Predictive Life Test for LED Systems

An LED lighting product's rated life sets users' expectations for how long that product will serve in an application and allows for estimating maintenance schedules. Today, life is rated based upon the lumen maintenance (L_{70}) value of the LEDs used in the system. Manufacturers test LEDs according to IES standard LM-80 and use TM-21 to project data to determine the time in hours for the light output to reach 70 percent of its initial value. An LED lighting system has many components, however, and failure of any one can cause system failure. As such, current industry practice does not yield accurate system life information. IESNA LM-84 is a system life test method that stresses all the components in the system, but this method may not provide a good life estimate because it is based on continuous operation rather than more realistic on-off cycling. The failure modes are different when a lighting system is tested continuously on compared to switching on and off. Products also need to experience temperature changes similar to their intended applications during the on-off cycle.

Since 2010, with ASSIST funding, the LRC has been investigating accelerated test methods to develop a predictive life-test procedure that accounts for both lumen depreciation and catastrophic failure of an LED system at any given environment temperature and use pattern. Through these studies, LRC researchers found that delta temperature (the temperature change during the on-off cycle, ΔT) and dwell time (the duration the system is operating at its maximum steady-state temperature) affect time to failure.



Individual test chamber design with five product samples in each box. The setup controls the lighting system temperature and on-off cycles accurately while continuously monitoring the light output, LED system temperature, and power input of each product. Furthermore, the spectral power distribution of each product is measured at regular intervals. Racks house the 270 LED product samples and the computer controlled data acquisition system.



Preliminary results for A-lamps: (a) Time to failure at 2-hour dwell time at 80°C, 90°C, and 105°C ΔT; b) Time to failure at 100°C ΔT at 4 hours dwell time and at continuous operation. These sample results show that the time to failure decreases with increasing ΔT for a fixed dwell time. The time to failure increases when the dwell time increases at a fixed ΔT.

Current Study

In 2014, the Bonneville Power Administration and the New York State Energy Research and Development Authority provided co-funding to expand on the earlier studies. The current study includes a 16W integral A-lamp (75W equivalent), an 8W MR16 lamp (50W equivalent), and a 14W downlight fixture (75W equivalent). Objectives for the two-year project that started in October 2014 include:

- To further validate the test method proposed in the previous LRC studies
- To develop a cost-effective, accelerated test method for predicting accurate system life in any application
- To estimate color shift at projected end of life
- To move the testing method forward toward industry adoption

Sponsors

Bonneville Power Administration (TIP 322: Predictive Life Test Method for LED Luminaires)

New York State Energy Research and Development Authority (Agreement no. 46905)

Alliance for Solid-State Illumination Systems and Technologies (ASSIST)

Rensselaer

Lighting Research Center

Lighting Research Center, Rensselaer Polytechnic Institute • 21 Union Street • Troy, NY 12180 • (518) 687-7100 • www.lrc.rpi.edu