SSL Postings
U.S. DEPARTMENT OF ENERGY

October 9, 2014

Major Report on Longer-Term Performance of LED Lighting in the Field

The LED lighting system on the I-35W Bridge in Minneapolis is one of the country's oldest exterior LED installations in continuous operation. It was implemented in September 2008 in place of a conventional high-pressure sodium (HPS) system, and a GATEWAY report comparing energy use and illuminance levels with a simulated HPS baseline condition was issued in August 2009. Additional testing has been performed since then, and the results are published in a new report.

The first detailed account of longer-term performance of LED lighting in the field, the new report examined three distinct sets of testing:

- Prior to installation, two of the LED luminaires were tested, along with a third luminaire that was not installed on the bridge but was tested for 6,000 hours in a laboratory for comparison purposes. Follow-up testing on the two luminaires was conducted by GATEWAY and the Minnesota Department of Transportation (MnDOT) in May 2013—with those luminaires tested first in their as-is condition and then again after cleaning.
- During the first three years of operation, illuminance levels on the bridge were monitored and recorded using a mobile monitoring system (MMS) designed by the Virginia Tech Transportation Institute (VTTI), with seven sets of measurements collected by MnDOT at various times between April 2009 and October 2011.
- Two luminaires (different from the pretested units) were removed from the installation in November 2009 because of a marked reduction in illuminance in the corresponding roadway area. These removed luminaires were tested in their as-is condition and then retested after cleaning.

Although the bridge's LED luminaires represent a very early state of the art for the technology, they were found to still be effective in May 2013, exhibiting comparatively reliable performance compared with a conventional HPS baseline

and, even today, still providing value for a generally pleased MnDOT. At the time the new report was being prepared (i.e., following approximately 25,000 hours of cumulative operation), the bridge would have required at least one complete re-lamping if HPS had been installed instead of LEDs in 2008. What's more, there would likely have been an additional number of premature failures that are typical with any traditional lamp-based technology.

While the I-35W Bridge's LED installation has not been problem-free, the few issues that have been encountered have not been entirely unexpected, given the early stage of SSL development at the time of purchase. After roughly 20,300 hours of operation, the two installed luminaires that had been pretested in 2008 were found to average an 18% decline in light output that was independent of dirt accumulation. Overall luminaire efficacy fell by a corresponding 15%. A slight and unexplained reduction in input power was partly responsible for the decline in light output, but two other factors also contributed: normal LED lumen depreciation, which by itself was estimated to be responsible for a 10% decline; and a bubble issue in the optical gel that was estimated to be responsible for a 5–7% decline but which the manufacturer subsequently resolved.

Dirt depreciation was measured at an average of 4% after 5,000 hours and 12% after 20,300 hours. A 30% decline from initial output is commonly used to define luminaire design lifetime for LED systems; thus, more than one-third of that lifetime reduction had already been reached by the effects of dirt alone within the first 20,300 hours. While it wasn't possible to determine whether this depreciation occurred steadily over that period or varied widely on a seasonal or other basis—nor what the maximum level of dirt accumulation might be—the data suggest that periodic cleaning of the luminaires may be important in applications where maintaining road illuminance is critical.

Some change in color properties was noted after 6,000 hours of use in the luminaire that remained in the testing lab—namely, a decrease in CCT of roughly 800K, an increase in D_{uv} of roughly 0.01 toward the yellow-green region, and a decrease in R9. The factors causing this color shift couldn't be precisely determined within the scope of the project, but the nature of the shift appears to be consistent with a possible change in the phosphor used in the LED packages—although other factors may have also contributed.

Over the period that VTTI's MMS was used (covering roughly 10,000 hours of operation), the measured average ground illuminance decreased by about 10%. Illuminances measured on the ground reflect the cumulative impact of many factors (e.g., lumen depreciation, dirt, ambient temperature and other weather conditions at the time of measurement, measurement uncertainty), and the relative contribution of individual factors cannot be determined from the illuminance data alone.

The entire lighting community continues to learn from the I-35W Bridge's LED

system, as well as from other early installations. But it’s also important to recognize the limitations in applying longer-term performance of early LED luminaires to their modern counterparts, because of the continuous and ongoing advancements in the technology.

The report and a brief are available on the DOE website. DOE will host a 60-minute webinar on the report on Tuesday, October 21, at 1:00 p.m. Eastern Time; register online.

As always, if you have questions or comments, you can reach us at postings@akoyaonline.com.