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LED MR16 Lamps: Despite Progress, Room to Improve

According to the recent DOE report *Adoption of Light-Emitting Diodes in Common Lighting Applications*, the installed penetration of LED MR16s and other small directional lamps more than doubled over the past two years, increasing from 10% in 2012 to 22% in 2014 — the highest of any LED lighting product. But DOE's CALiPER program has identified a number of issues in this popular and fast-growing category. CALiPER *Application Summary Report 22*, which was published last year and investigated the photometric performance of 27 LED MR16 lamps compared to benchmark halogens, found that while all of the LED MR16s offered some efficacy advantage over the halogens, the range in efficacy among the LED MR16s was substantial (38 lm/W to 90 lm/W), many equivalency claims were inaccurate, and a majority of the products had CRIs in the low 80s.

A follow-up CALiPER study, which was just released, examined the photoelectric performance of that same set of lamps, using commercially available transformers and dimmers, as well as laboratory power supplies providing either AC or DC. Compared to line-voltage products such as A lamps and PAR lamps, the MR16's form factor and system requirements pose challenges for LEDs. Besides the small size, which creates unique driver design challenges and tradeoffs, one of the most important considerations for performance — both in testing and when installed — is the fact that pin-based MR16 lamps operate at 12V, which requires that a transformer be included in the system. Add in a dimmer, and there are three electronic devices that must all work together, which can lead to unwieldy compatibility tables and often results in complications before, during, or after installation.

One goal of the new study was to examine whether characterization using laboratory power supplies instead of commercial transformers can result in misleading flicker and power quality performance characterization. More generally, the goal was to examine the range of performance that's possible for a given lamp model, based on the system to which it is connected; while system-level effects are a known phenomenon, to date there has been limited characterization of the impact of real-world system variations on energy performance. As usual with CALiPER, the intention was not to determine the best-performing products, but rather to compare the test results against established thresholds and benchmark conventional lamps, with additional analysis focused on identifying variation and trends in performance. The results can be found in *CALiPER Report 22.1: Photoelectric Performance of LED MR16 Lamps*.

Five different test scenarios were used in the new study:

1. *Electronic/ELV* — Operation of each lamp model with an electronic transformer selected from the lamp's compatibility list (if available), and an electronic low-voltage (ELV) dimmer. The goal was to specify a system where the lamp, transformer, and dimmer were all listed as compatible, but limited available information often made this difficult.
2. *Electronic/INC* — Operation of each lamp model with an electronic transformer and a typical incandescent dimmer. The transformer was listed as compatible with the dimmer.
3. *Magnetic/MLV* — Operation of each lamp model with a typical magnetic transformer and a magnetic low-voltage (MLV) dimmer. The transformer and dimmer were considered compatible.
4. *AC Supply* — Operation of each lamp model using a laboratory power supply delivering RMS (root-mean-square) 12V AC.
5. *DC Supply* — Operation of each lamp model using a laboratory power supply delivering 12V DC.

As with previous CALiPER photoelectric testing, the results demonstrated substantial variation in the performance of commercially available LED MR16 lamps, both within a given test scenario and across multiple test scenarios. Scenario one demonstrated the value of manufacturer-provided compatibility recommendations; lamps that provided them performed best when operated with compatible transformers and/or dimmers. In addition, the products that were tested with the same transformer but a different dimmer demonstrated that, while transformer compatibility is paramount, the choice of dimmer could still have an effect on the performance of low-voltage products. One important difference from previous CALiPER photoelectric testing — regardless of the scenario — was that none of the LED MR16 lamps exhibited dimming curves similar to those of the benchmark halogen lamps.

Scenario two demonstrated the potential problem of installing LED MR16 lamps with a typical incandescent dimmer, which is commonly found in existing halogen MR16 installations together with a potentially unknown transformer. Few of the lamps in this scenario performed adequately, and many exhibited highly erratic dimming behavior. In contrast, test scenario three demonstrated the relative stability of magnetic transformer-based systems, which eliminate the compatibility concerns of one electronic component from the system, but which draw higher system power. The greater compatibility may also come with additional tradeoffs, such as more dead travel and higher minimum dimming levels.

Scenarios four and five were included in the investigation to help understand the relevance of basic photometric testing (following LM-79) of low-voltage products.

Although only a limited set of metrics could be compared due to equipment limitations and normalization procedures, the results show that while lamp power-quality measurements are unlikely to represent the installed performance of the lighting system, flicker measurements with an AC power supply may be informative. Testing with a DC power supply does not allow for evaluation of either of these important metrics.

For full details on this informative study, see the report.

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