CALiPER

Summary Report

September 2008

DOE Solid-State Lighting CALiPER Program

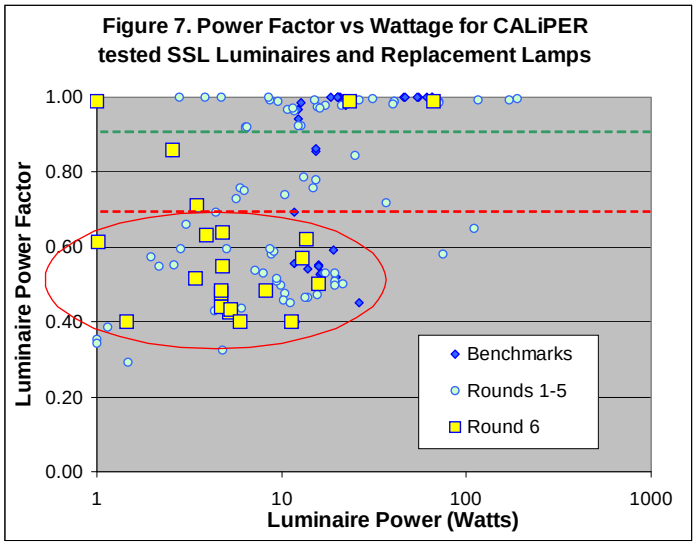
Summary of Results: Round 6 of Product Testing

Prepared for the U.S. Department of Energy by
Pacific Northwest National Laboratory

manufacturers and SSL luminaire and replacement lamp manufacturers need to understand these requirements and understand the nuances of selecting and combining LED color characteristics to make white light products of suitable color quality.

Power Factor

The power factor of Round 6 products was on average worse than in previous rounds of CALiPER testing. Nineteen out of 24 SSL products tested had a power factor under 0.70, the current minimum allowed for residential products by ENERGY STAR for SSL. In fact, over half of the Round 6 products had a power factor under 0.50, as highlighted in Figure 7. Testing laboratories should consider including power factor values with all testing results to help stakeholders better monitor and address this problem.



Performance Reports in Manufacturer Literature

As evidenced in this round of testing, a preponderance of inaccurate and misleading performance claims on SSL product literature persists in the marketplace. This phenomenon is increasingly worrisome with more LED products becoming available through major retail outlets.

Only two of the 24 SSL products tested in this round provided accurate or somewhat accurate performance data in product literature. For some products, little to no performance information is provided. Most products tested have packaging and/or advertisement material and/or data sheets that make highly overstated claims of wattage equivalencies to traditional sources. Such equivalency statements are published for the majority of products tested, e.g., “Replaces 40W”, “Compare to 60-watt light!”, or “50W LED head is = to 100W Metal Halide.” In every case, these comparisons are inaccurate—often overstated by a factor of 2 or 3.

These erroneous and misleading comparisons, like other inaccurate performance claims, may stem from a number of factors:

- Lack of understanding of SSL testing concepts (e.g., that LED device performance does not translate to product performance once the LED device is integrated in a replacement lamp or luminaire);
- Manufacturers’ product literature that does not clearly indicate what specific product configuration was tested to produce the published performance values (e.g., rapidly evolving LED devices and a tendency to publish data for the highest performing version of a product—often that with the highest color temperature);

- Differing interpretations of benchmark values for products using traditional light sources (note that the CALiPER program will soon be issuing benchmark reports for a number of applications to provide a clearer basis for comparison); and
- Inflation of performance claims (e.g., from selection of test conditions not representative of actual use, such as chilled or pulsed device testing or testing without optics, or from testing of prototype units that are not representative of production units).

In addition to false performance claims, SSL replacement lamps purchased from major retail stores may have questionable reliability. For one product, 2 out of 4 units failed before testing could be completed. Another product from the same manufacturer and purchased from the same retail chain had 1 out of 2 samples fail, and yet another type of lamp from the same line had 22 out of 80 LEDs in the lamp fail during testing. For another replacement lamp, purchased from a different retail chain, 1 out of 3 units failed. On visual inspection, the design and construction (as well as quality control) of these products do not appear to be robust—thermal management is not apparent and structural defects are visible. While the CALiPER program recognizes that these are not statistically large samples, these failures can be seen as reasons for caution. Manufacturers and retailers need to be wary.

Reliability: Lumen Depreciation Testing & Variability Testing

Fundamental CALiPER testing as reported above is conducted with new products, at time t=0 in the life of a product. To increase our understanding of the long-term performance of SSL luminaires and replacement lamps, CALiPER is also conducting long-term studies examining lumen depreciation and color shift over the first several thousand hours of operation of a product. The first "batches" of lumen depreciation testing have been completed recently (i.e., from 0 to over 6000 hours of operation), and a report on these results will be issued in Fall 2008.

Similarly, CALiPER performs specific tests and analyses to assess different types of variation surrounding SSL testing. Differences in results are examined between different testing methods (e.g., integrating sphere vs. goniophotometry), among multiple samples of a given product (in many cases two or three samples are tested; for specific studies, up to 10 samples have been tested), among different testing laboratories (in round-robin style testing), and among repeated test runs over different days or months. A report compiling and examining these various perspectives on testing and sampling will be issued in a separate report in Fall 2008.

Appendix A

Testing Methods

The lighting testing laboratories were instructed to follow test procedures specified in the LM-79-08 standard (IESNA Guide for Electrical and Photometric Measurement of Solid-State Lighting Products) which covers "…SSL fixtures as well as SSL sources used in conventional light source fixtures (e.g., replacement of screw base incandescent lamps)."[13] This method tests the luminaire or replacement lamp as a whole — as opposed to traditional testing methods that separate lamp ratings and fixture efficiency or as opposed to testing LED devices or arrays without control electronics and heat sinks. There are two main reasons for this: 1) there is no industry standard test procedure for rating the luminous flux of LED devices or arrays, and 2) because LED performance is particularly temperature sensitive, luminaire design has a material impact on the performance of LEDs used in the luminaire. Similarly, for replacement lamps, the integration of LED devices, heat sinks, drive electronics, and optics within an integral replacement lamp impacts the performance of the LED components within the lamp. For these reasons, luminaire efficacy (efficacy of the whole luminaire or integral replacement lamp) is the measure of interest for assessing energy efficiency of SSL products, as specified in LM-79.

Products sold as luminaires are tested using the entire luminaire. Products sold as replacement lamps are mounted for testing in standard lampholders corresponding to the format of the replacement lamp and the geometry of the measurement instrument used for a given test. Performance results for replacement lamps are thus for the bare lamp, to which appropriate fixture losses should be applied to determine the luminaire output for the replacement lamp installed in a given fixture.[14]

Selection of Products for CALiPER Testing

The general policy of the CALiPER program is to test units of products that are commercially available and have been purchased by the CALiPER program through distributors or other market mechanisms. In some cases, sample products are accepted for testing, either because there is no market for purchasing small quantities of a product or because other DOE SSL programs request CALiPER testing of fixture samples. Detailed CALiPER test reports always indicate whether a product tested was purchased or was a sample product. Detailed CALiPER test reports are issued only for those products that are considered to be commercialized (available or soon to be available for purchase on the open market).

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[13] The testing standard entitled "IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products," designated LM-79-08, is now published. This testing procedure was developed by the Subcommittee on Solid-State Lighting of the IESNA Testing Procedures Committee (http://www.iesna.org/about/committees/) in collaboration with the ANSI Solid State Lighting Committee. This method describes the procedures to be followed and precautions to be observed in performing reproducible measurements of total luminous flux, electrical power, luminous efficacy (lumens per watt), and chromaticity of solid-state lighting (SSL) products under standard conditions. It covers LED-based SSL products with control electronics and heat sinks incorporated, that is, those devices that require only AC mains power or a DC voltage power supply to operate. It does not cover SSL products that require special external operating circuits or external heat sinks.

[14] De-rating factors for specific fixtures or fixture and lamp combinations are not specified, recommended, nor studied by the DOE at this time.