



LED LAMP TESTING AT UC DAVIS

Contributing to the implementation of the Voluntary California Quality LED Lamp Specification

Since its establishment in 2003, the California Lighting Technology Center (CLTC) at UC Davis has conducted extended photometric and electrical testing of light sources. During the last 10 years, CLTC has been successful in establishing an array of testing facilities, some with unique capabilities, including complete photometric and electrical testing laboratories, and chambers for lifecycle testing under customized operational conditions.

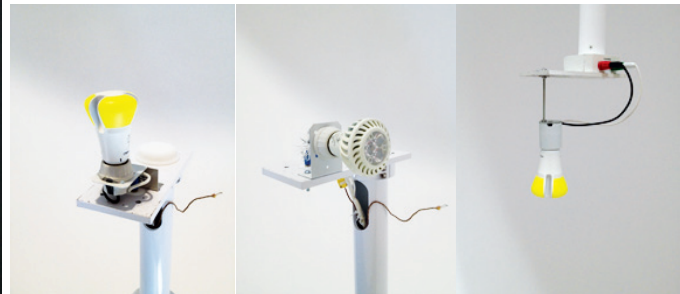
CLTC's testing capabilities have been instrumental in developing multiple new technologies with industry partners. They are now instrumental in contributing to the development and implementation of the Voluntary California Quality LED Lamp Specification (or "California Quality" specification for LED replacement lamps), which is aimed at balancing energy and lighting quality performance for successful market transformation to meet California's residential lighting efficiency goals.¹

CLTC researchers are developing and using advanced testing protocols that address a variety of different thermal, dimming and operating characteristics, factors that affect the actual in-situ performance of lamps installed in buildings. The data produced by these tests, based on long-term life testing under realistic conditions, are most useful in understanding long-term performance, which is crucial for true market transformation.

CLTC's life testing facilities include large banks of lamps operating under standard environmental conditions as well as within thermally insulated fixtures designed to accurately simulate ambient conditions encountered in real buildings. These capabilities constitute a unique experimental resource for the state of California, as they support a variety of ongoing public programs, including new standards as well as evolving industry-based testing efforts and methodologies.

To support the California Quality specification for LED lamps, CLTC has developed a comprehensive database for storing and analyzing all LED replacement lamp test results. This LED Lamp Database includes all measured and computed data. It supports comprehensive filtering and presents data in tabular and graphic formats with real-time interactive capabilities. The database will be instrumental in understanding performance potential and market trends for the development of utility rebate and consumer education programs in California.

¹ These goals include a 50 percent reduction in residential interior lighting energy use and a 25 percent reduction in commercial lighting energy use between 2007 and 2018, per the California Lighting Efficiency and Toxics Reduction Act of 2007 (AB 1109).

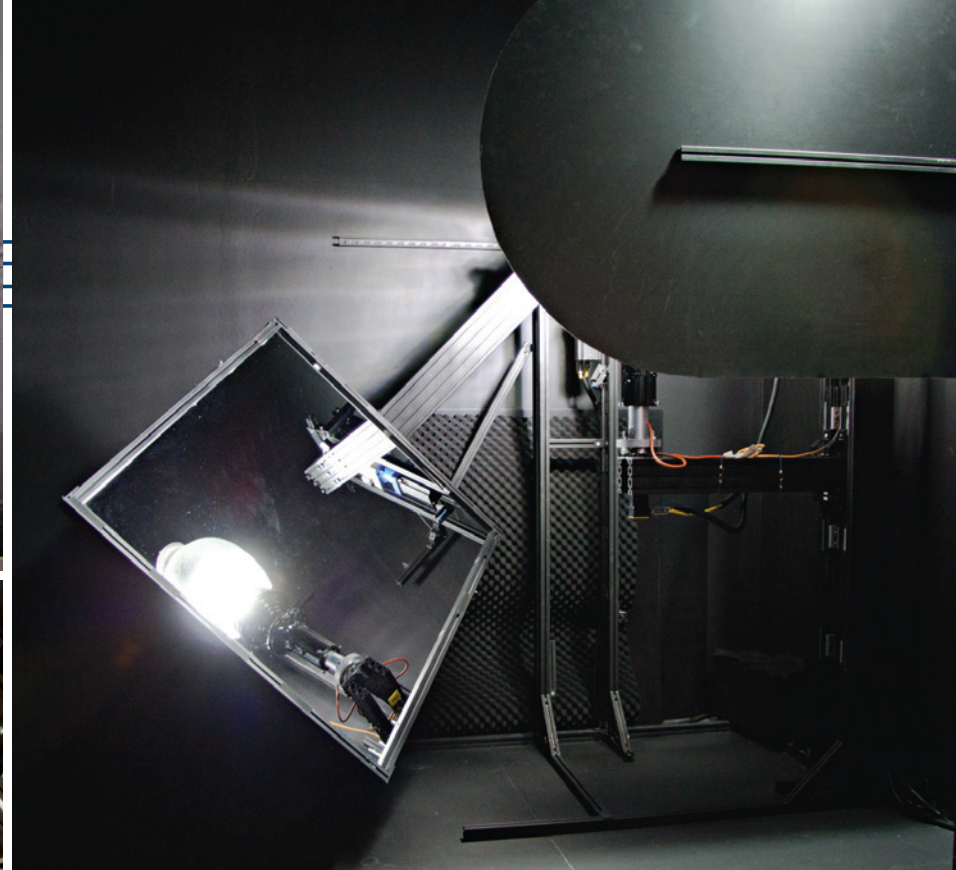


PHOTOMETRIC TESTING: INTEGRATING SPHERES

CLTC has four integrating spheres of different diameters: one small sphere, 20 inches in diameter, a medium 1-meter integrating sphere, and two 2-meter integrating spheres. These specialized devices support measurement of the spectral power distribution (SPD) of light sources. SPD represents the raw data used for the determination of key photometric characteristics, including total light output, chromaticity, correlated color temperature (CCT), and color rendering index (CRI). One of the two large integrating spheres is custom-made and features a controlled environment. This jacketed integrating sphere consists of three separate hemispheres, two of which can be altered to suit testing needs. It is designed to support multiple measurement protocols that address lamp orientation and thermal conditions.

An integrating sphere captures all light emitted from a light source and uses a spectrometer to measure the amount of light emitted at each discrete wavelength, following the IES LM-79 testing protocol for LED light source. The photometric measurements at CLTC also extend beyond SPD to include flicker. Measuring flicker depends heavily on the quality of raw photometric measurements.

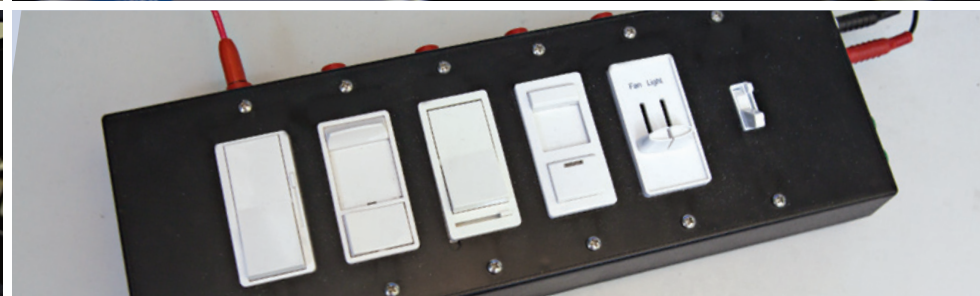
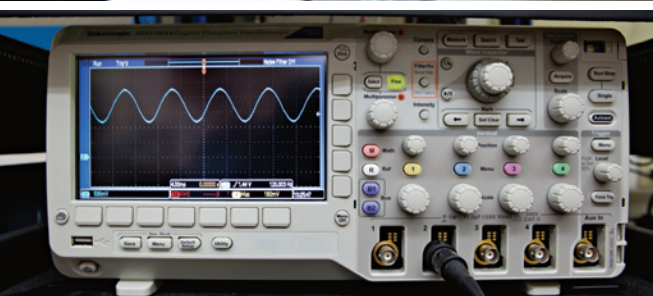
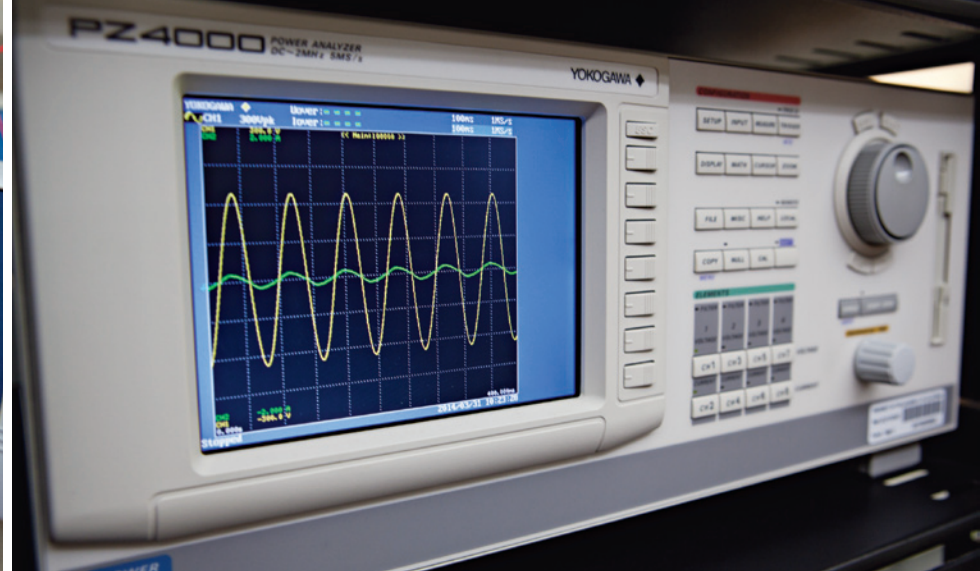
CLTC researchers assess flicker using photosensors, transimpedance amplifiers and oscilloscopes, along with the LabVIEW software for instrument simulation. Laboratory-grade power supplies are used to generate repeatable electrical waveforms that simulate triac dimming, allowing for the assessment of lamp flicker with different dimmers and under different dimming scenarios. Data acquisition hardware is NIST-certified with traceable calibration.



CLTC has two goniophotometers, one small and one large. Goniophotometers are devices that allow measurements of the candle-power distribution (CPD) of light sources. CPD is the directional intensity of the light output towards all outgoing directions. Both goniophotometers were designed and constructed by CLTC engineers, each with unique capabilities.

The small goniophotometer was designed for CPD measurements of small light sources, as well as measurements of the directional sensitivity of photosensors. The large goniophotometer supports conventional CPD measurements in terms of lumens per solid angle. Moreover, it supports SPD measurements for each outgoing direction, which is a unique capability. This is especially useful for characterizing the output of systems that use more than one light source, a relatively common approach with LED light sources.

Both goniophotometers are operated by custom LabVIEW software developed at CLTC. The small goniophotometer takes measurements using moving photosensors in a large, dark environment. The large goniophotometer uses fixed photosensors and spectral sensors with a moving mirror.



ELECTRICAL TESTING

Electrical testing is most important in assessing the power and luminous efficacy of electric light sources coupled with different light output control devices, such as dimmers.

CLTC has extended capabilities in providing controlled power to light source power supplies and measuring voltage and amperage, including total harmonic distortion (THD), as well as active power and power factor.

CLTC has been using these capabilities to assess performance of LED replacement lamps operated by a variety of traditional dimming technologies, such as the triode alternating current (or TRIAC) switch. LED lamps at CLTC are measured in various orientations, in both continuous-ON and ON/OFF cycling modes. Some samples operate on dimmers at reduced power levels.

Evaluation of performance through the LED replacement lamp's dimming range is very important for consumer acceptance. Alternatives to incandescent lamps must function compatibly with dimmers in existing residences.

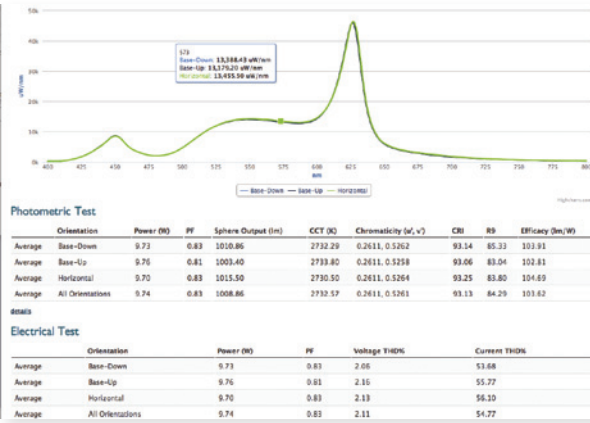


LIFE TESTING FACILITIES

The life of LED replacement lamps can vary greatly, having a significant impact on the cost-effectiveness of this emerging technology. Thermal conditions, lamp orientation, dimmer compatibility, and other factors can cause accelerated performance degradation and early failure. Testing under real-world conditions is critical for successful market transformation in California, as early failures in the field can significantly reduce consumer acceptance.

CLTC has two life testing facilities with two more under development. They are designed to measure large numbers of LED replacement lamps. These facilities support assessment of lamp life, through testing under conditions that simulate real-world installations. Lamps are tested using different dimmers and in different orientations: base-up, base-down and horizontal. LED replacement downlights are tested under realistic thermal conditions, in insulated downlight housings that comply with Title 24, Part 6 requirements for installation in the field.

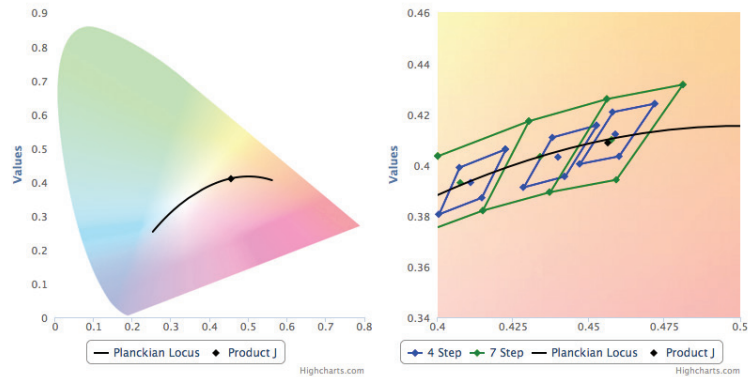
Life testing procedures at CLTC also include full photometric and electrical testing, including spectral power distribution and photometric flicker, conducted every 1000 hours of operation.



Product Characteristics

	CLTC	Energy Star	Product Packaging
Wattage	9.73	10	10
Luminous Flux	1010.86	1008	940
Color Rendering Index	93.14	92	Not Listed
Correlated Color Temperature	2732.29	2700	2700
Rated Life	N/A	25000	30000
Lamp Shape	N/A	A-Arbitrary	A19
Dimmable	N/A	Yes	Yes
Beam Distribution	N/A	Not Listed	Omni-Dir.
Warranty	N/A	3	6
Efficacy	101.10	100.80	94.00
R9	N/A	N/A	N/A

details



Products

Search/Filter

Set Table Source: Energy Star

Select Lamp Type ✓

ID	N	Omni Directional MR16	Watts	Lumens
<input type="checkbox"/> 101	Product A		14	800
<input type="checkbox"/> 102	Product B		Not Listed	Not Listed
<input type="checkbox"/> 103	Product C		9	810
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<input type="checkbox"/> 105	Product E		Not Listed	Not Listed
<input type="checkbox"/> 106	Product F		13	800

LED PERFORMANCE DATABASE

ledperformancedatabase.org

To improve the usefulness of photometric and electric test results of LED replacement lamps, CLTC has developed the LED Performance Database. The database houses all raw and derived data obtained from comprehensive testing of a representative sample of commercially available LED replacement lamps. This comprehensive data set from market-available products is continually updated as new products are released.

The database is accessible through the Internet using popular Web browsers. It has a very easy-to-use, intuitive user interface that supports comprehensive search, filtering and statistical functions. Performance data is presented in the form of tables and interactive graphics for effective visualization.

The LED Performance Database supports data provided by multiple testing laboratories. It is accessible to the public for use with utility rebate and consumer education programs. These programs are critical for establishing the California Quality LED lamp specification and realizing the promise of LED replacement lamps in meeting California's lighting efficiency goals.

For more information about CLTC's photometric and electrical testing capabilities and the LED Performance Database, please contact:

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ABOUT CLTC

CLTC is part of the Department of Design at the University of California, Davis. It was established in 2003 by the California Energy Commission in collaboration with the U.S. Department of Energy and the National Electrical Manufacturers Association.