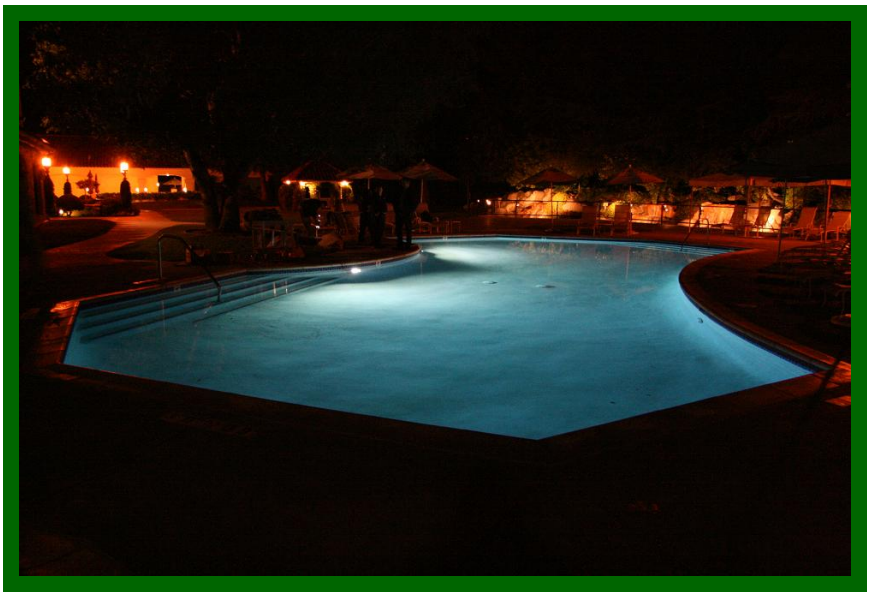
LED Pool Lighting Criteria

ET11SCE5010 Report



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What's Inside...

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Southern California Edison's (SCEs) Design & Engineering Services (DES) group is responsible for this project. It was developed as part of SCEs Emerging Technology program, sub-element Technology Development Support (TDS) under internal project number ET11SCE5010. DES project manager Yun Han conducted this technology evaluation with overall guidance and management from Paul Delaney. For more information on this project, contact yun.han@sce.com.

Disclaimer

ABBREVIATIONS AND ACRONYMS

CCT	Correlated Color Temperature
CRI	Color Rendering Index
DLC	Design Lights Consortium
DOE	Department of Energy
ET	Emerging Technology
fc	Foot candle
IES	Illuminating Engineering Society
IOU	Investor-Owned Utility
ISTMT	In Situ Temperature Measurement Test
K	Kelvin
LED	Light-Emitting Diode
Lm/W	Lumens per Watt
NVLAP	National Voluntary Laboratory Accreditation Program
OSHA	Occupational Safety and Health Administration
PF	Power Factor
TDS	Technology Development Support
THD	Total Harmonic Distortion
TMP	Temperature Measurement Point
UL	Underwriters Laboratories
W	Watt

EXECUTIVE SUMMARY

This emerging technology (ET) project focuses on developing minimum performance criteria for light-emitting diode (LED) pool lights. The project falls under the ET Technology Development Support (TDS) subprogram. It uses a previous LED pool lighting project findings,[1] as confirmation that the technology application is viable and demonstrates energy savings. However, to ensure correct deployment and realize claimed benefits, customers need guidelines. ENERGY STAR® or Design Lights Consortium (DLC) sets the minimum criteria for any LED technology application. However, because these two resources provide no criteria for LED pool lighting, Southern California Edison initiated this study.

The objective of this study is to develop a set of minimum criteria for LED pool lighting using prevailing conditions found in a typical commercial pool.[2] The project measures and analyzes the following parameters to develop the criteria.

- Amount of visible light output emitted by the LED fixture
- Zonal lumen density, or the percentage of light emitted within a certain degree
- Luminaire efficacy
- Correlated color temperature (CCT)
- Color rendering index (CRI)

LED pool lights are designed to operate under water with water as the heat sink. The ET10SCE1130 study revealed the average temperature of pool water to be 80°F. Therefore, a test methodology was created to measure the parameters that simulated the same operating temperature conditions. This was accomplished by submerging the LED lamps under 80°F water, and capturing the internal temperature of the LED pool lights at a stable state.

The resulting minimum criteria for LED pool lights display in Table 1. The format follows DLC's current requirements. The criteria were created using available LED pool lights that met the photometric requirements. Peer review by investor-owned utilities (IOUs), DLC, and industry partners is recommended before LED pool light criteria are finalized, released, and incorporated into an incentive program.

[1] ET10SCE1130 – LED Pool Lighting.

[2] The same criteria may be applied in residential pools.

TABLE 1. CRITERIA FOR LED POOL LIGHTING APPLICATION

Application	Minimum Light Output (lm)	Zonal Lumen Density (%)	Minimum Luminaire Efficacy (lm/W)	Allowable CCTs (ANSI C78.377-2008) (K)	Minimum CRI (%)	L-70 Lumen Maintenance (hours)	Minimum Luminaire Warranty (years)
LED Pool Light (300 Watt (W) equiv.)	2,100	0-90≥62	45	<6,500	70	50,000	5
LED Pool Light (400W equiv.)	3,000	0-90≥62	45	<6,500	70	50,000	5
LED Pool Light (500W equiv.)	3,600	0-90≥62	45	<6,500	70	50,000	5

INTRODUCTION

This emerging technology (ET) Technology Development Support (TDS) project developed minimum performance criteria for light-emitting diode (LED) pool lights. A previous ET Assessment project, ET10SCE1130 – LED Pool Lighting completed in December 2010 already established the technology application as viable with confirmed energy savings for customers with pool lighting. However, to ensure LED lamps are deployed correctly and provide the claimed benefits, customers need a set of criteria or guides. For any LED technology, either ENERGY STAR®, or Design Lights Consortium (DLC) sets the minimum criteria for its application. SCE initiated this study because the minimum criteria are not available for LED pool lights from these sources.

OBJECTIVES AND METHODOLOGY

For LED lighting, testing must be performed in accordance with the Illuminating Engineering Society's (IES) Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products" (IES LM-79-08).[1] Section 2.2 requires ambient air temperatures be maintained at 25 centigrade (77°F), plus or minus 1 centigrade, as measured 1 meter from the product and at the same height as the product.

LED pool lighting is different from most LED lighting applications. Designed for underwater use, the lights use water as a heat sink to cool down the light fixture. When the light is not submerged, some have an auto shut-off feature to protect it from overheating. Furthermore, in commercial sectors, LED pool lights operate in a heated pool of 80°F, which can vary the light output. Due to these reasons, the LM-79 testing alone - in an ambient temperature - is not sufficient to accurately measure the performance of the pool lights.

To specify the minimum performance of the pool lights, the LM-79 method was used along with extrapolation of data as explained in this section of the report.

OBJECTIVES

The objectives of the project are to determine:

- Amount of visible light output emitted by the LED fixture
- Zonal lumen density, or the percentage of light emitted within a certain degree
- Luminaire efficacy
- Correlated color temperature (CCT)
- Color rendering index (CRI)

METHODOLOGY

The light output of an LED lamp is highly dependent on the operating temperature. An LED pool lamp operating in ambient air temperature of 77°F versus 80°F water temperature can vary widely.

To read light measurements at 80°F water temperature, the stable internal operating temperature of the fixture was measured while submerged in 80°F water. After stabilization, the final internal temperature of the LED was recorded. This final internal temperature was then used as a reference during the light measurement.

The pool light was sent to a laboratory for testing.[2] The pool light was first fully tested at a room temperature and stabilized if no shut-down occurred. Full testing consisted of multiple light measurements at different angles. After the testing was complete, one single measurement on the goniometer at zero degrees angle is taken when the fixture reaches the specified internal temperature. This one reading was then used along with the complete test performed at room temperature to extrapolate the rest of the data.[3] The results are shown in Table 2.

TABLE 2. DATA EXTRAPOLATION

ITEM	READING AT AMBIENT TEMPERATURE (FC)	READING AT SPECIFIED OPERATING TEMPERATURE (FOOT CANDLE (FC))	RATIO
1	59.6	63.4	1.064
2	65.5	71.1	1.084
3	71.1	86.6	1.218 (generated)

Item 3 had a shut-down problem at a stable room temperature. Item 2's ambient temperature readings were used to extrapolate Item 3's data. Since the only difference between the lamps was the amount of light output by the fixtures, the ratio of light in different angles from Item 2 was applied to Item 3 to extrapolate.

PROJECT FINDINGS

The minimum criteria are based on the LED pool lights that were tested in the earlier study. The pool lights tested were verified in the field to perform on par to its incandescent counterpart.

FINDING 1: TECHNICAL REQUIREMENT APPLICABLE TO ALL LEDS

DLC specifies certain parameters that apply to all LED lamps qualified on the list, shown in Table 3.

TABLE 3. DLC TECHNICAL REQUIREMENT APPLICABLE TO ALL LEDS

PARAMETERS	MINIMUM
Power Factor (PF)	≥0.9
Total Harmonic Distortion (THD)	≤20%
Lumen Maintenance	Energy Star specified

Data from the earlier study is shown in Table 4. It lists the four items that were tested in the field that met the photometric performance of its incandescent counterparts.

TABLE 4. ET10SCE1130 DATA

PARAMETERS	ITEM 1	ITEM 2	ITEM 3	ITEM 4
Power Factor (PF)	0.7	0.7	0.7	0.9
Total Harmonic Distortion (THD)	100%	110%	110%	20%
Lumen Maintenance	NA	NA	NA	NA

Three of the four items do not meet the DLC technical requirements applicable to all LEDs in both PF and THD as shown in Table 3.[3]

FINDING 2: TECHNICAL REQUIREMENT APPLICABLE TO SPECIFIC CATEGORY

DLC's categories for different LED applications are bulleted below. These values currently do not exist under DLC for LED pool lighting applications. The lamps tested in the earlier study will be used as a basis for the minimum criteria.

- Application
- Minimum light output
- Zonal lumen density
- Minimum luminaire efficacy
- Allowable CCTs
- Minimum CRI
- L70 lumen maintenance
- Minimum luminaire warranty

Table 5 shows the photometric data of the LED pool lights. Items 1and 2 perform to a 300W, Item 3 to a 400W, and Item 4 to a 500W incandescent.

TABLE 5. PHOTOMETRIC DATA

PARAMETER	ITEM 1	ITEM 2	ITEM 3	ITEM 4
Light Output (lm)	2,175	2,590	3,021	3,680
Efficacy (lm/W)	48.3	61.7	56.6	53
CCT (K)	7,382	7,607	7,568	6,626
CRI	73.89	74.57	73.85	71.30
Zonal Lumen Density	0-90≥62	0-90≥62	0-90≥62	0-90≥62

[3] The ENERGY STAR's Integral LED Lamp specification[3] requires the PF to be ≥0.70.

Following the photometric data in Table 5, the minimum is specified as shown in Table 6. L70 lumen maintenance varies by the specified life of the fixture from the manufacturer. A 30,000 hour life fixture would require a 3-year warranty versus a 50,000 hour life fixture would require a 5-year warranty.

TABLE 6. TECHNICAL REQUIREMENTS FOR LED POOL LIGHTING APPLICATION

Application	Minimum Light Output (lm)	Zonal Lumen Density (%)	Minimum Luminaire Efficacy (lm/W)	Allowable CCTs (ANSI C78.377-2008) (K)	Minimum CRI (%)	L-70 Lumen Maintenance (hours)	Minimum Luminaire Warranty (years)
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The minimum CRI under the DLC categories vary by the application. The Energy Star's Integral LED lamp specification requires CRI to be ≥80. For outdoor lighting where no task work is involved, 70 CRI is a possible option.

FINDING 3: OTHER REQUIREMENTS

Following the existing guidelines mandated by DLC, independent testing lab requirements are listed in Table 7.

TABLE 7. INDEPENDENT LAB TEST REQUIREMENTS

	INDEPENDENT TESTING LAB REQUIREMENTS
In situ Temperature Measurement Test	Similar to ENERGY STAR requirements from before September 30, 2010, DLC will accept In Situ Temperature Measurement Test (ISTMT) results from laboratories approved by Occupational Safety and Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTLs). Alternatively, DLC will accept ISTMT results from independent laboratories qualified under the DOE CALiPER testing program as listed at http://www1.eere.energy.gov/buildings/ssl/test_labs.html under the heading "CALiPER Testing Laboratories, Laboratories Qualified, Verified, and Contracted for 2009 CALiPER LM-79 Testing and LM-79 Testing for ENERGY STAR for SSL". Alternatively, ISTMT may be carried out by laboratories recognized through Underwriters Laboratories' (UL) Data Acceptance Program.
LM 79	Testing must be conducted by a National Voluntary Laboratory Accreditation Program (NVLAP) accredited lab. If a lab does not officially have this accreditation then t must go through a CALiPER lab on this list: http://www1.eere.energy.gov/buildings/ssl/test_labs.html
LM 80	DLC will accept LED package in-house testing

Lumen Maintenance Data is also required to be listed on the qualified list as shown in Table 8.

TABLE 8. LUMEN MAINTENANCE DATA

LUMEN MAINTENANCE DATA
THE MANUFACTURER HAS TO CHOOSE ONE OF THE TWO OPTIONS IN ORDER TO SUPPORT ITS LUMEN MAINTENANCE DATA.

Option 1: Compliance through Component Performance

Under *option one* the manufacturer will need to provide three documents:

A complete LM-80 report of the same LED package that is used in the luminaire. Therefore, the LED package part number of the submitted luminaire must appear on this report. A complete LM-80 test report will include the relative light output over time, for at least 6,000 hours of continuous operation at three different temperatures measured at the LED package manufacturer-specified (Temperature Measurement Point) TMP. Following the IESNA LM-80 standard, the three TMP temperatures are 55C, 85C (131 ^{o}F, 185 ^{o}F) and a third temperature selected by the manufacturer. This data needs to be presented in a table format and in graph form. The graph must have time in hours on the x-axis, ranging from 0 to 6,000, and the lumen maintenance in percent on the y-axis ranging from 0 to 100. **Applicants must create the graph showing three lumen depreciation curves, one for each temperature using the data provided by the LED manufacturer. Each curve must have data points at least every 1000 hours. The lumen maintenance at the in situ temperature must be marked on the graph at 6000 hours.** To maintain the validity of this test report, the current at which the LEDs were tested must be included in the report and has to be greater or equal to the measured current on the LED package, array, or module used in the submitted SSL product.

The ISTMT report of the submitted luminaire including the measured temperature at the TMP of the hottest LED in the luminaire. The luminaire must have been tested under ANSI/UL 1598 and the report must contain the same model number of the submitted luminaire. **For track lighting systems, luminaires must be tested in compliance with ANSI/UL 1574**.

A photograph documenting the actual temperature measurement location such as a photograph of the luminaire with a thermo couple attached at the TMP point). For the validity of this document, it must contain the same model number of the submitted luminaire. This photograph can be incorporated in the ISTMT document.

A document with a schematic or photograph from the LED package manufacturer showing the specified TMP location. For the validity of this document, it must contain the same part number of the LED package used in the submitted luminaire.

Option 2: Compliance through Luminaire Performance

Under *option two* the manufacturer needs to provide two documents:

The first is an LM-79-08 test report at 0 hours of operation. In order for this document to be valid, the model number of the submitted luminaire must appear on this document.

The second is an LM-79-08 test report of the submitted luminaire after being continuously operated for a period of 6000 hours under the appropriate ANSI/UL 1598 environment. In order for this document to be valid, the model number of the submitted luminaire must appear on this document. **For track lighting systems, luminaires must be**

LUMEN MAINTENANCE DATA

THE MANUFACTURER HAS TO CHOOSE ONE OF THE TWO OPTIONS IN ORDER TO SUPPORT ITS LUMEN MAINTENANCE DATA.

tested under the appropriate ANSI/UL 1574 environment.

The LED package data subsection asks for information about the LED package used in the submitted product. This information can be obtained from the LED package manufacturer's literature.

CONCLUSIONS AND RECOMMENDATIONS

The existing technical requirements set by DLC and ENERGY STAR helps progress the LED market with aggressive standards. To create minimum criteria for LED pool lighting, the project referenced the parameters in DLC's requirements.

The LED pool lighting criteria were created using available LED pool lights that met the photometric performance of incandescent lighting. Although, the LED pool lights from the earlier study met the photometric requirements, other parameters such as PF, THD, and color temperature range were not met. The purpose of drafting the criteria is not to qualify the products tested, but to use the products as a reference to set the requirements.

The Project Findings section in this report lists the requirements to qualify LED pool lights. Peer review by IOUs, DLC, and industry partners is recommended before LED pool light criteria are finalized, released, and incorporated into an incentive program. The qualification process may be administered through DLC, or statewide IOUs.

REFERENCES

[1] http://www.ies.org/store/product/approved-method-electrical-and-photometric-measurements-of-solidstate-lighting-products-1095.cfm

[2] Light Laboratory Inc., 8165 East Kaiser Boulevard, Anaheim, CA 92808


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