STREET LIGHTING CONSORTIUM

Assessment of LED Technology in Ornamental Post-Top Luminaires

Host Site: Sacramento, California

Final Report prepared in support of the
U.S. DOE Municipal Solid-State Street Lighting Consortium,
in cooperation with the DOE GATEWAY Demonstration Program

Study Participants:
City of Sacramento, CA
Sacramento Municipal Utility District
Mary Matteson Bryan, P.E.
Pacific Northwest National Laboratory

December 2011

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

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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JR Tuenge
MM Bryan
DA Bisbee

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Pacific Northwest National Laboratory
Richland, Washington 99352

Preface

This document is a report of observations and results obtained from a lighting demonstration project conducted in cooperation with the U.S. Department of Energy (DOE) GATEWAY Demonstration Program. The program supports demonstrations of high-performance solid-state lighting (SSL) products in order to develop empirical data and experience with in-the-field applications of this advanced lighting technology. The DOE GATEWAY Demonstration Program focuses on providing a source of independent, third-party data for use in decision-making by lighting users and professionals; this data should be considered in combination with other information relevant to the particular site and application under examination. Each GATEWAY Demonstration compares SSL products against the incumbent technologies used in that location. Depending on available information and circumstances, the SSL product may also be compared to alternate lighting technologies. Though products demonstrated in the GATEWAY program have been prescreened for performance, DOE does not endorse any commercial product or in any way guarantee that users will achieve the same results through use of these products.

Executive Summary

A pilot project was conducted in Sacramento, CA, to assess the performance of light-emitting diode (LED) technology in ornamental post-top street lights. The goal of the study was to characterize best-in-class performance, as of March 2011, for two types of LED products relative to the existing 100 W high-pressure sodium (HPS) luminaires: lamp-ballast retrofits and complete luminaire replacements.

Three lamp-ballast replacements were initially selected by the City, in coordination with manufacturers and their sales representatives. An LED luminaire was subsequently selected by PNNL to represent best-in-class LED performance for this particular project. Before measurements were taken in the field and at a photometric testing laboratory, PNNL created a computer model using manufacturer-provided photometry and predicted that none of the LED products would match the photopic performance of the existing HPS luminaires. The measurements not only verified none of these products matched the initial light levels produced by the existing HPS luminaires, but also confirmed two of the products greatly reduced the uniformity of illumination. Any energy savings from the LED products examined are thus directly attributable to reduced photopic light levels.

The HPS-LED performance gap widened when light loss factors were considered. After several years in development, the IES-recommended method for predicting LED lumen maintenance was published in August 2011. Lumen maintenance was extrapolated from limited long-term test data using this new methodology, rated LED drive current, and laboratory temperature measurements. The three lamp-ballast retrofit kits are predicted to produce between 79 and 85 percent of initial light output after 36,000 hours of operation. Meanwhile, the LED luminaire is expected to offer 86 percent lumen maintenance after 63,000 hours of operation. By comparison, HPS lamps are expected to exhibit 85 percent lumen maintenance if proactively replaced at 16,800 hours (70 percent of rated life).

In another long-awaited development, the IES introduced guidance in June 2011 for the determination of mesopic multipliers, which are used to adjust photopic quantities to account for differences in light source spectral content and changes in spectral sensitivity when the eye adapts to the lower light levels encountered outside at night. The performance of all four LED products would be improved relative to HPS if photometry were evaluated in terms of mesopic adaptation, rather than making the customary assumption of photopic adaptation.

The manufacturers did not offer higher-output versions of the products which would match maintained HPS performance, so pricing and wattage were scaled hypothetically to allow for equitable economic comparisons. Both values were scaled proportionately to account for lumen maintenance and dirt depreciation (assuming either “early” or “later” replacement as defined later in this report) and visual adaptation (treating as either photopic or mesopic). Simple payback period and life cycle cost were then calculated for each product under each of the four scenarios. The results indicate the four LED products evaluated would not represent cost-effective replacements for the existing HPS.

The Municipal Solid-State Street Lighting Consortium and the GATEWAY Demonstration program will continue to monitor developments in this product category as LED efficacy and pricing improve.

Acronyms and Abbreviations

ANSI	American National Standards Institute
ANSLG	American National Standard Lighting Group
avg:min	Average-to-minimum ratio
BUG	Backlight, Uplight, and Glare
CALiPER	Commercially Available LED Product Evaluation and Reporting
CCT	Correlated color temperature
cd	Candela(s)
CIE	International Commission on Illumination
CLTC	California Lighting Technology Center
CRI	CIE General Color Rendering Index (R_a)
DLC	DesignLights™ Consortium
DOE	U.S. Department of Energy
Duv	Distance from the Planckian locus on the CIE 1960 (u, v) diagram
fc	Footcandle(s)
HID	High-intensity discharge
HPS	High-pressure sodium
IES or IESNA	Illuminating Engineering Society of North America
IP	Ingress protection
ISTMT	In Situ Temperature Measurement Testing
K	Kelvin
kWh	Kilowatt-hour(s)
LCS	Luminaire Classification System
LDD	Luminaire Dirt Depreciation
LED	Light-emitting diode
LLD	Lamp Lumen Depreciation
NGLIA	Next Generation Lighting Industry Alliance
NEMA	National Electrical Manufacturers Association
NVLAP	National Voluntary Laboratory Accreditation Program
lm	Lumen(s)
PNNL	Pacific Northwest National Laboratory
R_9	CIE Special Color Rendering Index for “Strong Red” Test Color Sample
S/P	Scotopic/photopic
SMUD	Sacramento Municipal Utility District
SSL	Solid-state lighting
T_s	In situ case temperature for the device under testing
W	Watt(s)

Contents

1.0 Introduction

A pilot project was conducted in Sacramento, CA, to assess the performance of light-emitting diode (LED) technology in ornamental post-top street lights. The project team consisted of:

- The City of Sacramento (the City), represented by Sompol Chatusripitak
- Mary Matteson Bryan, P.E. (MMB), contracted by the City as a consultant for this project
- The Sacramento Municipal Utility District (SMUD), represented by Dave Bisbee, Connie Samla, and Joe Tapia
- The U.S. Department of Energy (DOE) Municipal Solid-State Street Lighting Consortium, represented by Jason Tuenge of the Pacific Northwest National Laboratory (PNNL)

Additional field support was received from ADM Associates and the California Lighting Technology Center (CLTC) as detailed in section 3.0 of this report.

This project was funded by SMUD to provide the City with guidance regarding product selection under their ARRA grant. The goal of the study was to characterize best-in-class performance, as of March 2011, for two types of LED products relative to the existing high-pressure sodium (HPS) luminaires: lamp-ballast retrofits and complete luminaire replacements. Screw-in lamp replacements were not considered for the evaluation. It was expected that complete luminaire replacements would offer superior performance relative to lamp-ballast retrofit kits due to the fully integrated optical and thermal components. However, the City desired that the daytime appearance of the luminaires be maintained; this effectively ruled-out luminaires featuring a clear globe or a horizontal aperture.

Products were evaluated in a new residential development undergoing construction south-east of the intersection of Del Paso Road and Gateway Park Boulevard, as illustrated in Figure 1.1. Green arrows indicate poles retrofit to LED, between which measurements were taken for both the HPS and the LED products. Blue arrows indicate nearby poles that remained HPS throughout the demonstration.

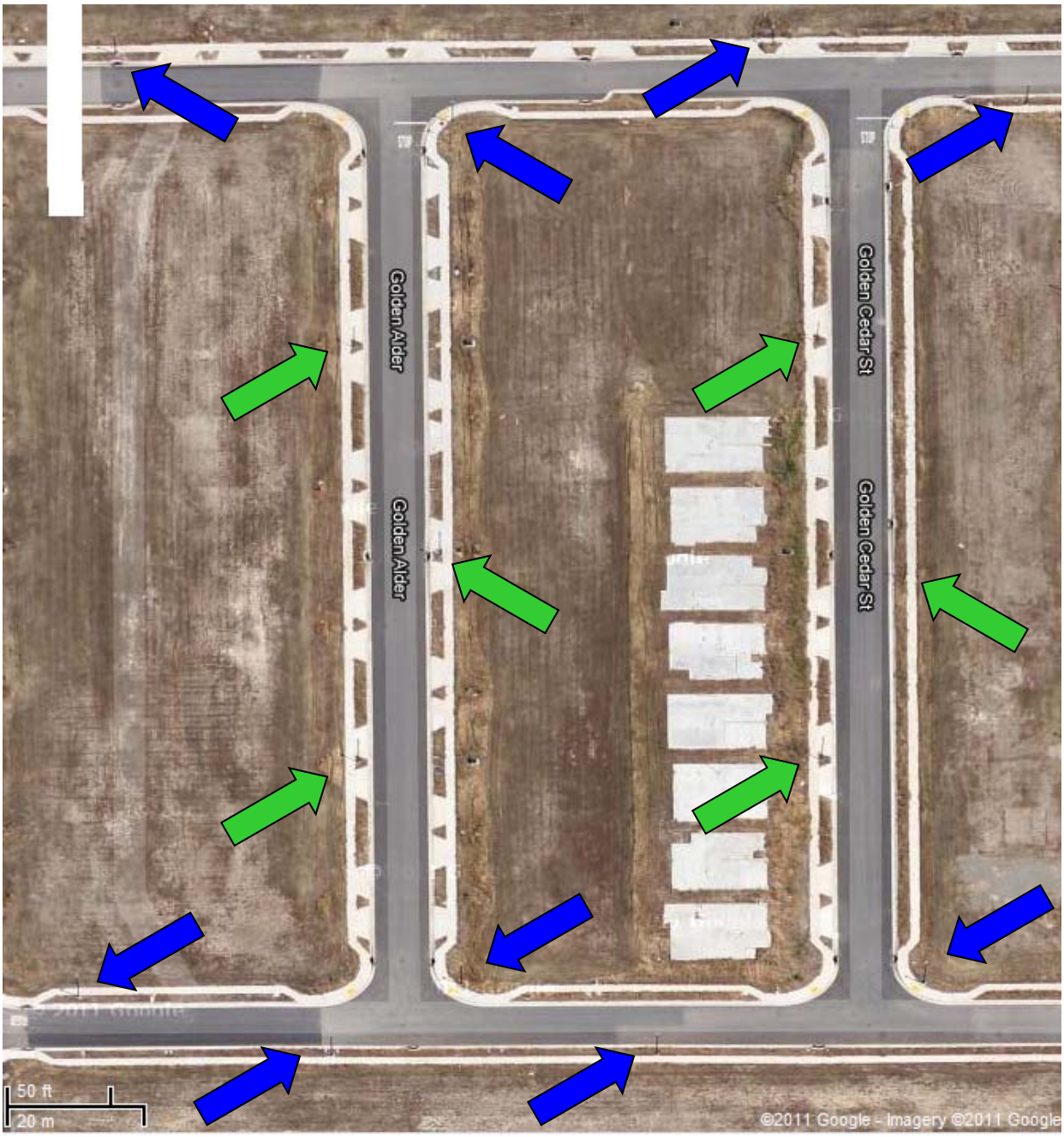


Figure 1.1. Pole locations (Adapted from Google satellite imagery)

The test streets, Golden Alder and Golden Cedar, are generally representative of typical City ornamental street lighting installations, where poles are arranged on both sides of the street in a staggered manner. The existing luminaires, which utilize 100W HPS lamps, are mounted on poles 12 feet in height (approximately 13.5 feet to optical center), as shown in Figure 1.2.

Figure 1.2. Northbound view of Golden Alder (Photo credit: MMB)

City pole drawings, manufacturer cutsheets, and dimensioned sketches of pole layouts are provided in Appendix A.

2.0 LED Product Selection and Modeling

LED products evaluated in the demonstration are listed in Table 2.1 below, and cutsheets are provided in Appendices B-E. The City does not have a standard make/model HPS lamp or ballast, so rated values for the existing products are assumed.

Table 2.1. Manufacturer ratings for products evaluated

Product	Catalog #	Light source type	Replaces	Nominal		
				Input power (W)	LED drive current (mA)	CCT (K)
Existing HPS	*Type III globe 100W coated lamp*	HPS	*n/a*	146	*n/a*	2100
Philips Hadco [2]	CA6730-T34L55	LED	Lamp and ballast	91	350	4000
Simply LEDs	ACN-60-C-T3			60	168	5000
Sylvania	LED55 RETROFIT-750-T5M-D6 (78628)			56	350	5000
Sternberg	A850ASRLED 6ARC45T3		Luminaire	96	350	4500

When this assessment was initiated in January 2011, the City of Sacramento had already selected – with input from manufacturers and sales representatives – and physically evaluated the Hadco, Simply LEDs, and Sylvania products for replacement of the HPS lamp and ballast.[3] A number of other lamp-ballast retrofit kits were rejected in the process, many on the basis of serviceability.

PNNL conducted a search for complete luminaire replacements in March 2011, assuming these products would represent more optimally integrated solutions relative to lamp-ballast retrofit kits. The search was based on use of existing poles and the following criteria:

- Form factor resembles existing (no flat lens luminaires)
- Tested per IES LM-79 in a textured or prismatic globe (IES 2008a)
- IES LM-63 format photometric file available (IES 2002)
- Nominal CCT of approximately 5000 K or lower[4]
- No compromise to maintained average horizontal drivelane illuminance (photopic)
- No compromise to drivelane avg:min uniformity ratio
- Input power less than existing.

Among the 19 manufacturers considered, no LED product was found to be equivalent to the existing HPS on the basis of maintained photopic illuminance. The Sternberg luminaire appeared to be closest, and was expected to generally outperform the lamp-ballast replacements, as illustrated in Table 2.2.

[2] The catalog number shown here is for a modified version of the standard Hadco RPTLD-RL32-4-L55 product, specially designed by the manufacturer for optical and mechanical compatibility with the existing HPS luminaire.
[3] See Appendix D, page 9 for a statement from Sylvania submitted in response to a courtesy preview of this report.
[4] The highest value already selected by the City. This value roughly corresponds to the average CCT of 5019 K for the 336 products listed under the category of "Outdoor area/roadway fixture" on the DOE Lighting Facts website as of September 7, 2011. Note that the "Outdoor decorative fixture" category may contain a variety of product types.

Table 2.2. Predicted maintained drivelane illumination for Golden Cedar

Product	LLD	LDD	Avg. Horizontal Illuminance (fc)	Avg:Min Uniformity
Existing HPS	0.85	0.90	0.47	6.7
Hadco	0.70		0.30	4.3
Simply LEDs			0.31	31.0
Sylvania			0.09	9.0
Sternberg			0.34	6.8

For preliminary design purposes, a lamp lumen depreciation (LLD) multiplier of 0.70 was applied to all LED products, assuming useful lifetime is based on 70 percent lumen maintenance (L_{70}).[5] Similarly, an LLD of 0.85 was assumed for HPS based on relamping at 70% of rated life per IES DG-4 (IES 2003). Additionally, a luminaire dirt depreciation (LDD) multiplier of 0.90 was applied to all products.[6] The calculation grid was per IES RP-8 and excluded the sidewalks for simplicity (IES 2000).[7] Golden Cedar was used for the calculations since maximum pole spacing was greater here than on Golden Alder.

It is important to evaluate photometry for lamp-ballast retrofit kits installed in a comparable globe, rather than as a bare lamp. Refractive globes were originally designed around high-intensity discharge (HID) lamps such as HPS. Although it is possible for these globes to redirect lamp flux downward, performance will likely differ for LED products due to the different form factors. For example, the Sylvania product would have been expected to produce 0.23 fc average maintained if installed without a globe (bare lamp), and the impact on intensity distribution is illustrated by the manufacturer-provided data in Figure 2.1. The black lines in the polar plots trace luminous intensity (candelas) in the vertical plane containing the point of maximum intensity, whereas the red lines trace intensity in the vertical-axis cone containing the point of maximum intensity. The plots share the same scale to facilitate comparison.

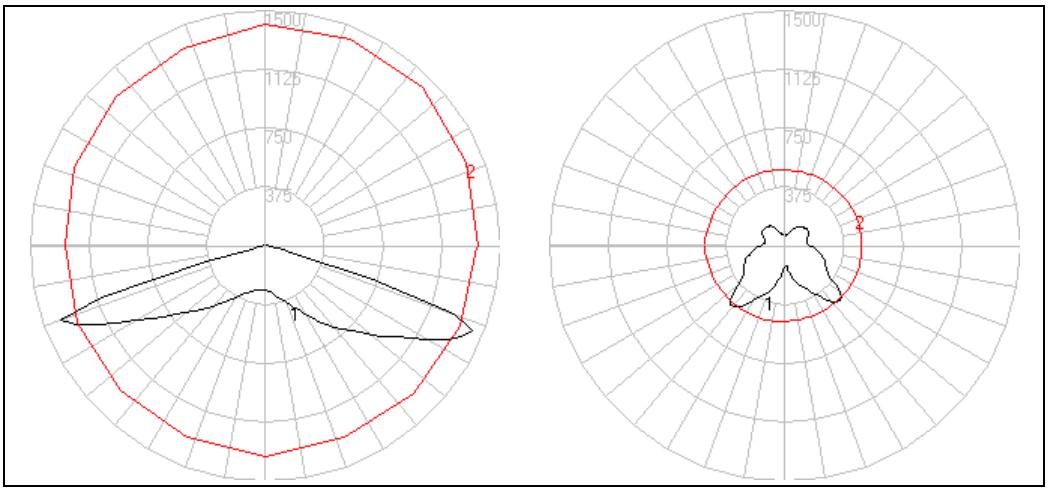


Figure 2.1. Sylvania intensity distribution without globe (left) and with globe (right)

[5] Consistent with industry practice. For example, see page 13.8 of IES HB-10-11.
[6] Consistent with IES DG-4 for an enclosed and gasketed roadway luminaire installed in an environment with airborne particulate matter less than 150 $\mu g/m^3$ and cleaned every four years.
[7] Additional guidance can be found in IESNA LM-50 (IES 1999).

3.0 Field Measurements

Products were installed on-site to allow for field measurement and visual evaluation. Hadco and Simply LEDs were measured on March 31 from 9:05 to 10:18 PM, under clear skies and at an ambient temperature of 68 to 71 °F (20 to 22 °C). The existing HPS luminaires were measured June 2 from 9:00 to 9:45 PM, under overcast skies. Sylvania and Sternberg were measured on July 6 from 9:48 to 10:15 PM, under clear skies and at an ambient temperature of 78 to 83 °F (26 to 28 °C). On one night the moon was approximately at quarter phase and was located near the horizon, producing negligible illuminance; no moon was present on the other nights.

Figures 3.1 and 3.2 illustrate the location of the horizontal illuminance measurement locations; the first and last columns of data were excluded from calculation of average values and avg:min ratios. Vertical illuminance was measured facing and perpendicular to centerline of street.[8] Horizontal illuminance was measured with back of detector housing flush with pavement, whereas vertical illuminance was measured 4.9 feet above pavement. Meters used are summarized in Table 3.1.

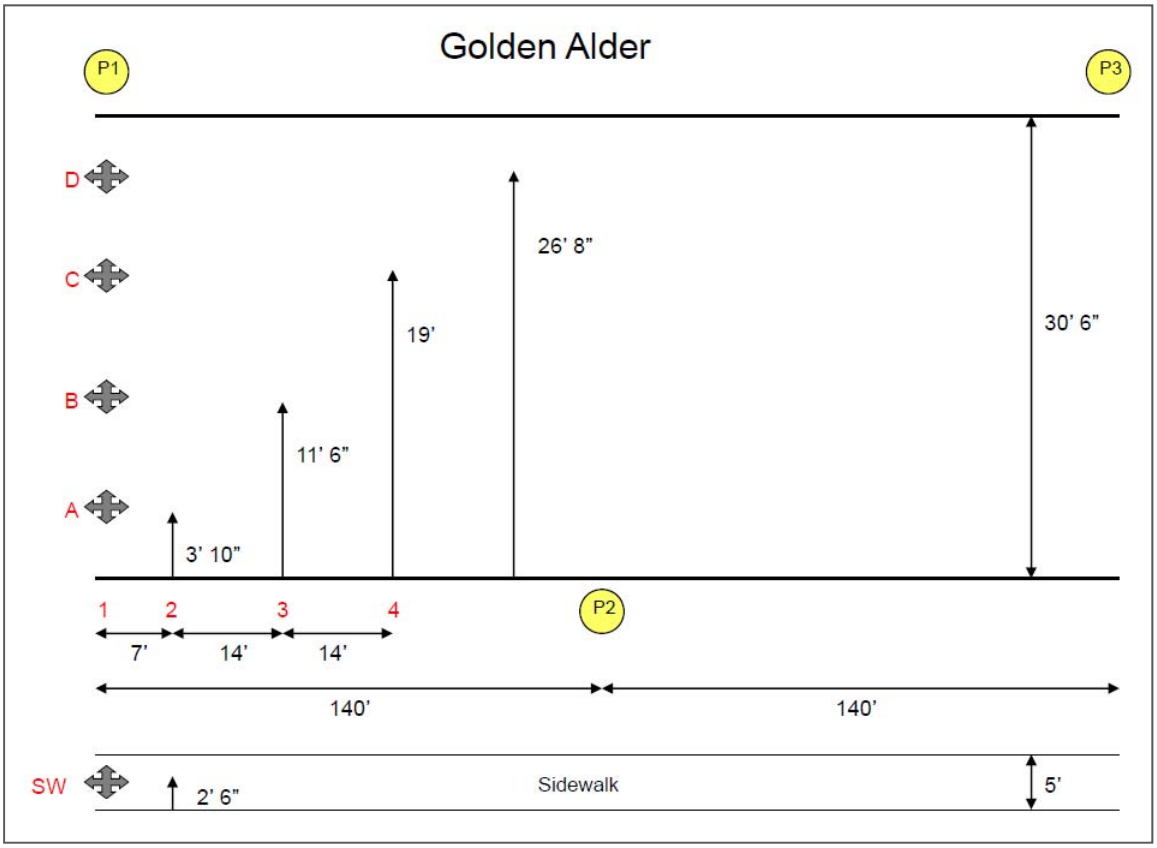


Figure 3.1. Horizontal illuminance grid for Golden Alder

[8] Note that the vertical illuminance criteria offered in IES RP-8 are for meter facing the direction(s) of travel and thus cannot be used for comparison.

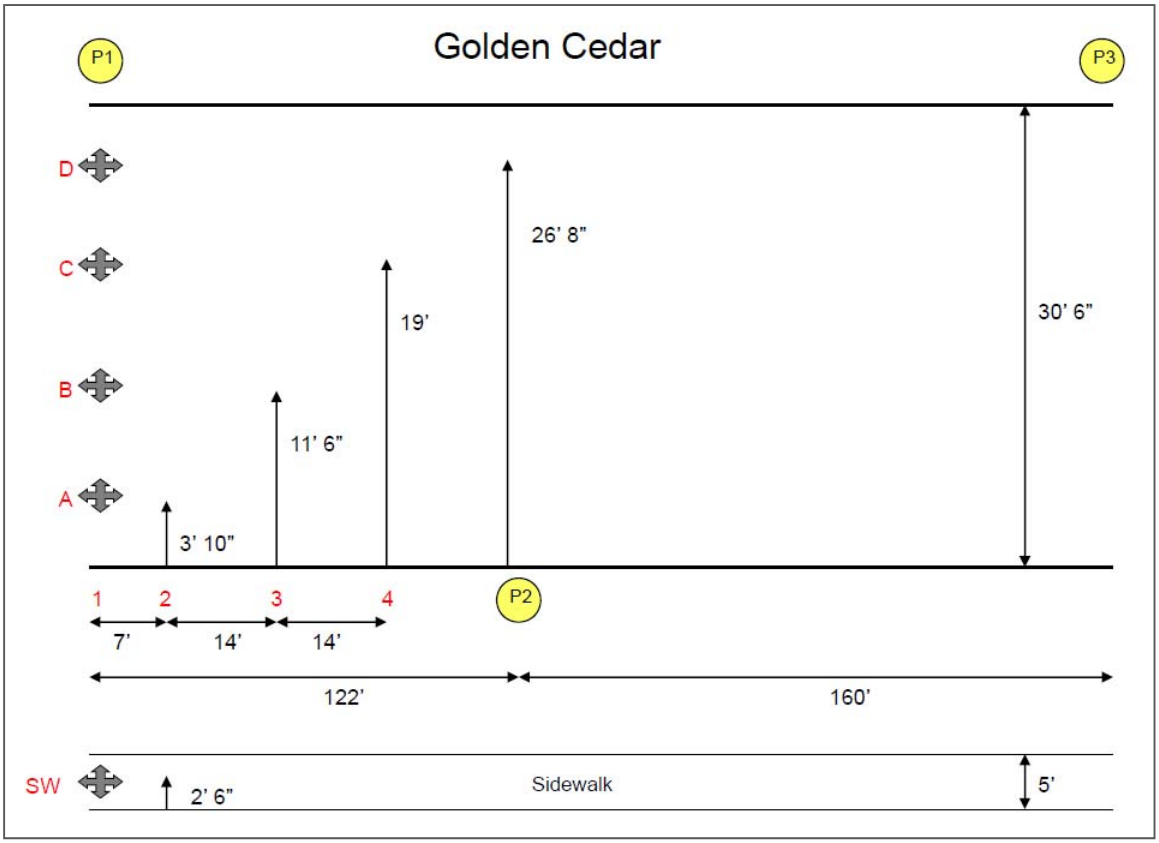


Figure 3.2. Horizontal illuminance grid for Golden Cedar

Table 3.1. Meters used for field measurements

Make/Model	Use	Notes
Minolta T-10	Photopic illuminance	Provided by SMUD Calibrated November 12, 2010
Solar Light PMA-2100 with 2130 and 2131 detectors	Scotopic and photopic illuminance	Provided by SMUD Calibrated March 1, 2011
Gigahertz Optik HCT-99 with CT-4501-4 detector	Chromaticity	Provided by SMUD Calibrated August 3, 2010
AEMC F09	Wattage	Provided by ADM Associates Calibrated by ADM Associates in-house March 30, 2011
Extech 421501	Ambient temperature	
AEMC 3910	Comparison with the AEMC F09	Provided by ADM Associates

Existing HPS luminaires were cleaned and relamped, and lamps were seasoned for 100 hours before measurements were performed. Products tested in March (HPS, Hadco, Simply LEDs) had been running all day before power measurements were taken; the products tested in July (HPS, Sternberg, Sylvania)

were given a minimum of 30 minutes to warm-up before taking power measurements, with most running for over an hour beforehand. Whereas the lamp-ballast retrofit kits utilized the City-standard prismatic acrylic globe, the Sternberg luminaire utilized a textured acrylic globe, as indicated in Figure 3.3 (photos courtesy of SMUD). Raw illuminance measurement data are presented in Appendix F. Calculations estimated zero contribution from neighboring HPS luminaires at the measurement points between the poles retrofit to LED, and this is supported by the presence of measured zero values (which would have been non-zero if contribution was significant).

Figure 3.3. Existing HPS with prismatic globe (left)
and Sternberg LED with textured globe (right)

Given the incomplete/unoccupied state of the residential development, and given the minimal volume of driver/pedestrian activity, a formal public survey of visual perceptions has not yet been conducted. Results for luminaire, drivelane, and sidewalk measurements are summarized in Tables 3.2 and 3.3. CCT for the HPS lamps was assumed to approximately reflect the rated value of 2100 K.

Table 3.2. Luminaire and drivelane field measurements (initial performance)[9]

Street	Product	Avg. input power (W)	Photopic horizontal illum.		CCT (K)
			Avg. (fc)	Avg:min	
Golden Alder	*Existing HPS*	146	0.58	4.4	
	Hadco	91	0.53	2.8	4000-4200
	Sylvania	55	0.22	7.9	5200
Golden Cedar	*Existing HPS*	146	0.57	7.3	
	Simply LEDs	59	0.40	15.2	5600-5800
	Sternberg	96	0.46	5.6	4300

[9] Illuminance values shown were derived from measurements taken with the Minolta meter.

Table 3.3. Sidewalk field measurements (initial performance)

Street	Product	Photopic horiz. illum.		Min. vertical illum. (fc)
		Avg. (fc)	Avg:min	
Golden Alder	*Existing HPS*	0.32	3.6	0.13
	Hadco	0.26	1.8	0.21
	Sylvania	0.17	6.4	0.03
Golden Cedar	*Existing HPS*	0.32	5.3	0.13
	Simply LEDs	0.12	4.3	0.08
	Sternberg	0.38	4.8	0.12

Figures 3.4 and 3.5 provide plan view contour plots of photopic horizontal illuminance measurements in the Golden Alder and Golden Cedar drivelanes, respectively. One of the Hadco units was improperly wired in the field, causing it to extinguish while field measurements were being performed, and thereby reducing the number of useable measurement points.

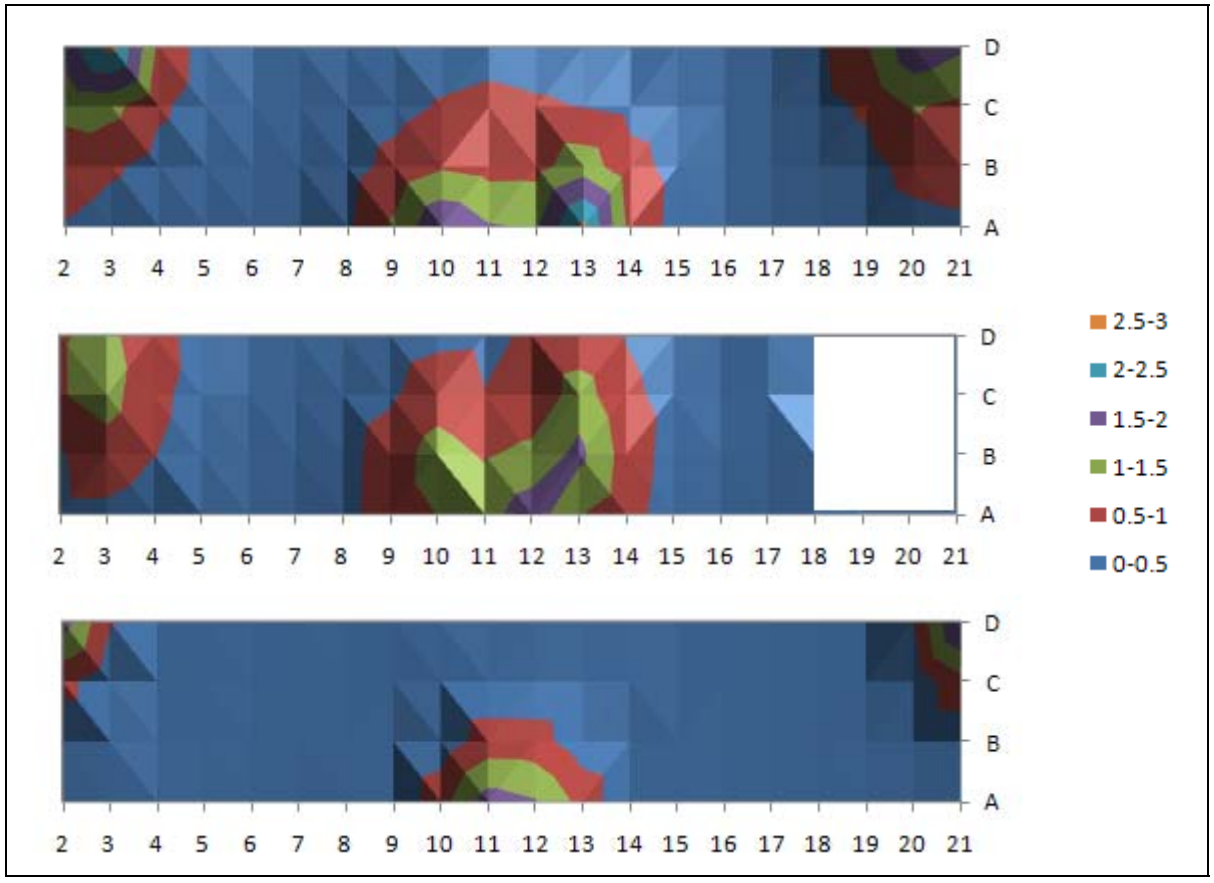


Figure 3.4. Plan view contour plots of drivelane horizontal illuminance measurements for HPS (top), Hadco (center), and Sylvania (bottom)

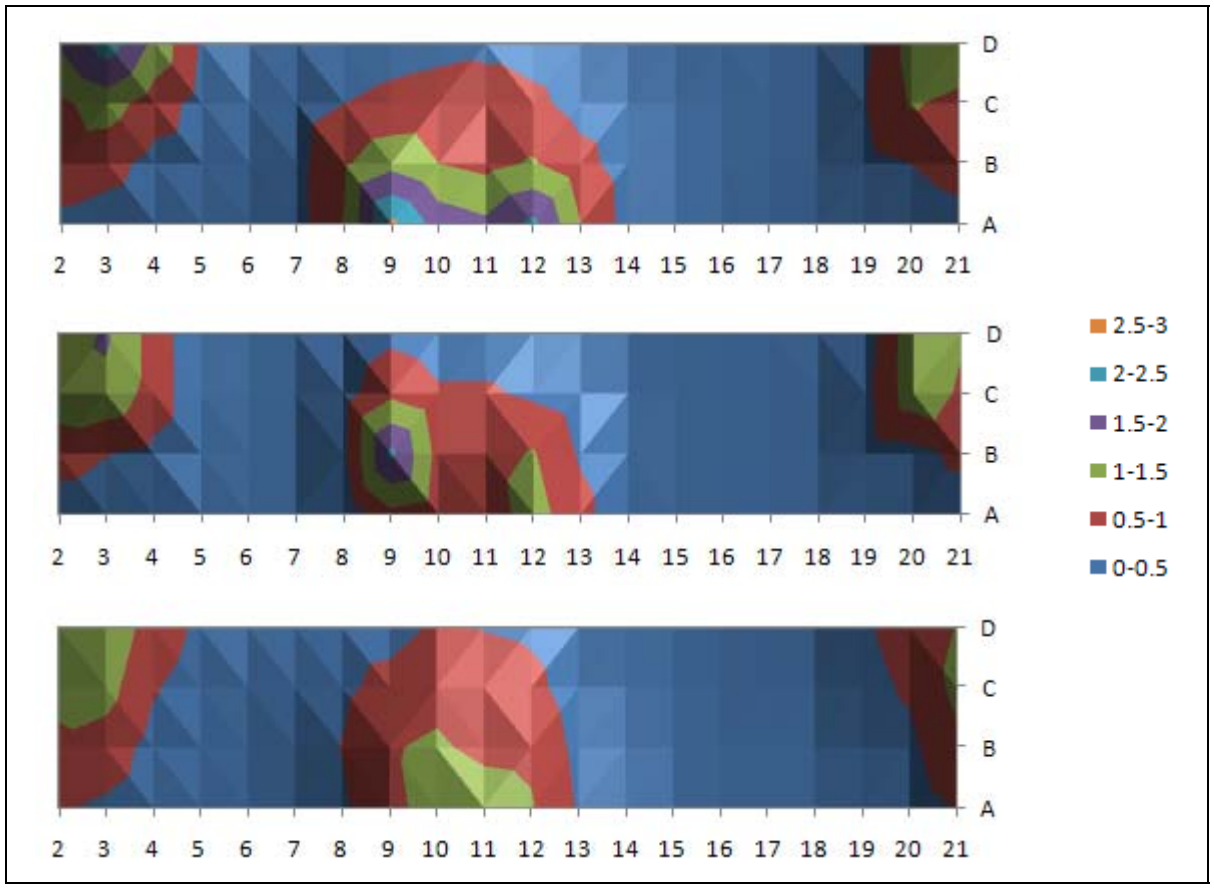


Figure 3.5. Plan view contour plots of drivelane horizontal illuminance measurements for HPS (top), Simply LEDs (center), and Sternberg (bottom)

Average drivelane illuminance and uniformity were visibly compromised using the Sylvania product, as illustrated in the photographs in Figures 3.6 and 3.7. The Simply LEDs product also yielded a uniformity ratio significantly higher than recommended by IES RP-8.

Figure 3.6. Sternberg luminaires on Golden Cedar
(Photo credit: SMUD)

Figure 3.7. Sylvania lamp-ballast retrofit kits on Golden Alder
(Photo credit: SMUD)

Camera settings for Figures 3.6 and 3.7 are summarized in Table 3.4.

Table 3.4. Camera settings for Figures 4.6 and 4.7

Photo	ISO	Aperture	Shutter	Lens (18-200 mm f/3)	White balance	Flash
Figure 3.6	800	f / 4.2	1/30 sec	34 mm	4000 K	No
Figure 3.7	1600	f / 4.0	1/13 sec	31 mm	4000 K	No

By accounting for the increased efficacy of short-wavelength light at low levels of illumination, mesopic multipliers can allow for the use of lower-cost and lower-wattage lighting products, depending on the spectral power distribution of the light emitted. IES HB-10 introduced guidance for the use of scotopic/photopic (S/P) ratios to determine mesopic multipliers (IES 2006, IES 2011c).[10] Although the City does not presently utilize mesopic multipliers, scotopic illuminance was measured in addition to photopic illuminance to allow for calculation of the ratio for each luminaire type. The dual-detector S/P meter used for field measurements is illustrated in Figure 3.8. Measurements are discussed in section 5.0 of this report.

Figure 3.8. S/P field measurements. (Photo credit: SMUD)

[10] The forthcoming updates to IES TM-12 and/or IES RP-8 may offer a different approach, applying multipliers point-by-point rather than on an average basis. Such guidance would supersede that offered in IES HB-10.

Both the S/P ratio and the photopic luminance must be known to determine mesopic multipliers. Figure 3.9 illustrates photopic luminance measurements performed by the CLTC using a Nikon 5400 camera with FC-E9 "fisheye" lens and Photolux 2.0 image-processing software.[11] A brief discussion of these measurements is provided in section 5.0 of this report. Note that the scale for the Hadco product differs slightly from the other three.

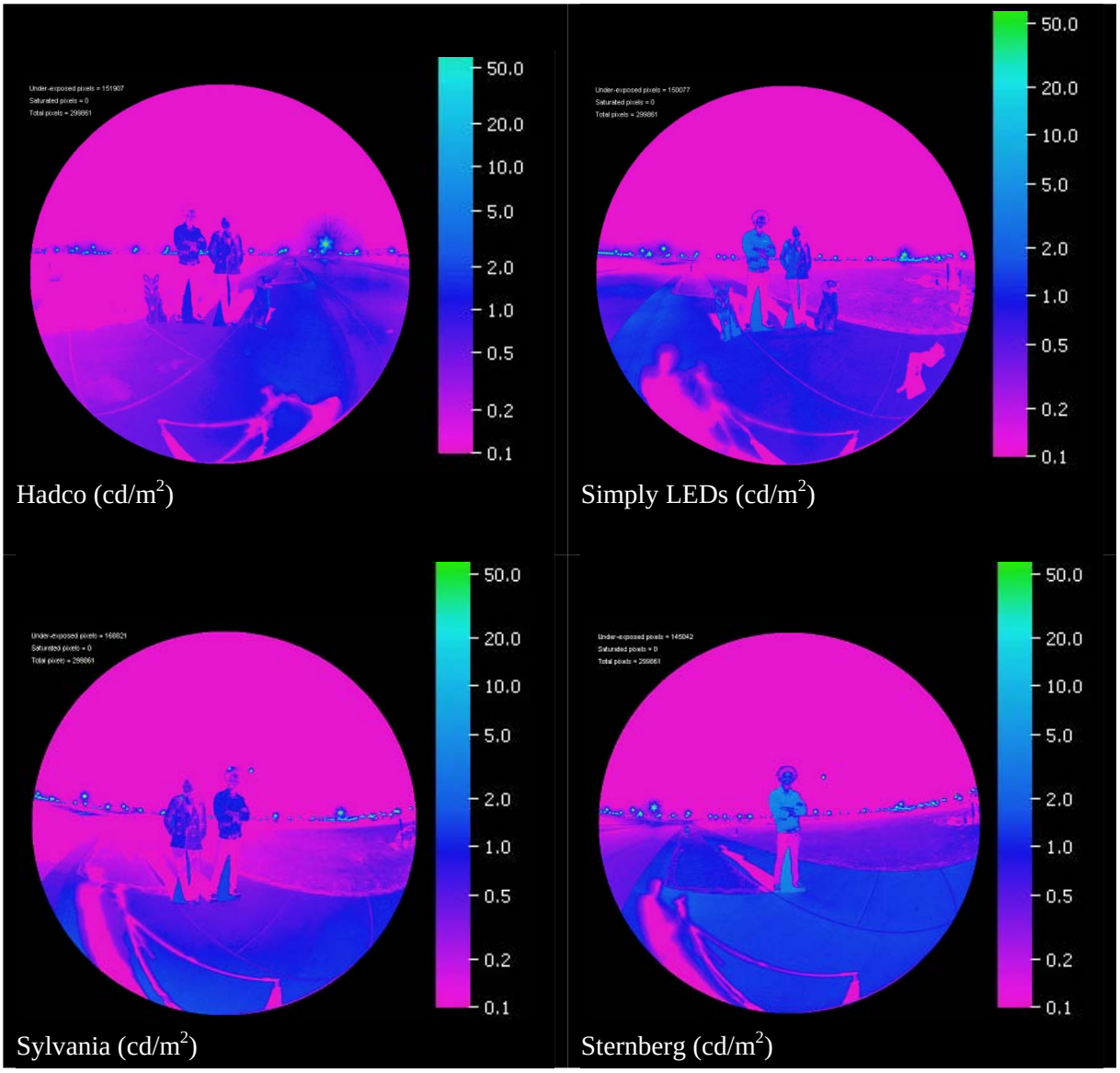


Figure 3.9. CCD luminance mapping (Adapted from images provided by the CLTC)

[11] Software developed for this particular camera-lens combination by the French ENTPE. For details, visit http://www.entpe.fr/fr/internet/contenu/departements/genie_civil_batiment/laboratoire_lash/domaines_d_action/lumiere_et_vision/qualite_des_ambiances.

4.0 Laboratory Measurements

Following completion of the field measurements, one specimen from each of the four LED manufacturers was laboratory-tested per IES LM-79; this serves as a check on field measurements and allows for more controlled monitoring of lumen maintenance in the future.[12] These specimens were also tested per the ENERGY STAR® In Situ Temperature Measurement Test (ISTMT) methodology, whereby the hottest LED in the product is measured to allow for estimation of useful lifetime.[13] The lamp-ballast retrofit kits were tested in the City-standard prismatic globe. Detailed laboratory reports are compiled in Appendices G-J.

The Simply LEDs specimen (one of the three used in the project), which was operational for the field measurements, failed to energize for the subsequent laboratory testing. This specimen was shipped back to the manufacturer, where it was repaired and then returned to the test lab.

Table 4.1 provides computer-modeled initial illuminance values (as opposed to the maintained "design" values in Table 3.2) using available manufacturer data, for comparison with the field measurements presented in Table 3.1. Note that manufacturer photometry was performed as follows:

- Existing HPS, Hadco, and Simply LEDs were all tested in the same Lexalite globe
- Sylvania was tested in a different globe (independent of this project)
- Sternberg was tested with the same Sternberg globe used for this project

Table 4.1. Modeled initial drivelane illumination (photopic)

Street	Manufacturer	Avg. horizontal illum. (fc)		Avg:min uniformity	
		Mfr. data	Lab. data	Mfr. data	Lab. data
Golden Alder	*Existing HPS*	0.62	-	4.8	-
	Hadco	0.47	0.53	2.9	3.3
	Simply LEDs	0.45	0.42	22.5	21.0
	Sylvania	0.13	0.23	13.0	23.0
	Sternberg	0.50	0.45	4.2	4.5
Golden Cedar	*Existing HPS*	0.61	-	6.8	-
	Hadco	0.47	0.52	4.3	4.7
	Simply LEDs	0.45	0.42	45.0	42.0
	Sylvania	0.13	0.23	13.0	23.0
	Sternberg	0.50	0.45	5.6	6.4

Table 4.2 summarizes laboratory measurements, including calculated downward efficacy; uplight is excluded from this calculation to more accurately characterize useful lumens per watt of input power.

[12] LM-79 testing was performed by a laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).

[13] ISTMT was performed by a laboratory qualified, verified, and recognized through DOE's CALiPER program. For more on the ISTMT procedure, see the ENERGY STAR® Manufacturer's Guide for Qualifying Solid State Lighting Luminaires, available at www.energystar.gov/lightfixtures.

Table 4.2. Photometry and colorimetry from laboratory testing of project specimens

Product	Input power (W)	Luminaire efficacy (lm/W)	Downward efficacy (lm/W)	CCT (K)	Duv	CRI	R_9
Hadco	92	62	46	4397	0.004	69	-17
Simply LEDs	60	57	48	6634	0.001	66	-53
Sylvania	56	56	46	5397	-0.002	80	19
Sternberg	96	54	49	4783	-0.003	81	26

Products generally performed as would be expected from photometric data obtained from the manufacturer. Exceptions include:

- Simply LEDs field-measured uniformity was somewhat better than would be expected from manufacturer data
- Sylvania field-measured average photopic illuminance was somewhat better than would be expected from manufacturer data but consistent with the laboratory data; field-measured uniformity was somewhat better than would be expected by either the manufacturer data or the laboratory data
- Sternberg had the lowest total efficacy and highest downward efficacy among LED products
- Laboratory-measured CCT relative to ANSI tolerances [14]
    - Hadco was slightly high (corresponding limit is 4260 K)
    - Simply LEDs was very high (corresponding limit is 5311 K)
    - Sylvania was slightly high (corresponding limit is 5311 K)
    - Sternberg was slightly high (corresponding limit is 4746 K).

HPS manufacturer photometric data and field measurements of input wattage indicate initial downward luminaire efficacy of 40 lm/W, compared to a range of 46 to 49 lm/W for the LED products. Comparing with Table 4.3 it is clear that the total luminaire efficacies of these products (including any uplight), ranging from 54 to 62 lm/W, also compared well with DesignLights™ Consortium (DLC) qualified products, which are required to produce at least 40 lm/W (photopic).[15] The histogram in Figure 4.1 illustrates the range of qualification dates, suggesting the dataset was representative of products available at the time product specimens were acquired for this project.

Table 4.3. DLC Qualified Products as of April 12, 2011

LED Product Category	Initial efficacy (lm/W)				Avg. CCT (K)	Data points
	Min.	Max.	Avg.	Std. Dev.		
Outdoor pole/arm-mounted decorative luminaires	41	71	52	8	4883	27
Retrofit kits for outdoor pole/arm-mounted area and roadway luminaires	52	82	66	10	5396	6

[14] ANSI provides tolerances for measured CCT and Duv as a function of rated CCT (ANSI 2011, ANSLG 2008).
[15] Products are tested with globe, but may include luminaires other than post-top. For more information, visit http://www.designlights.org/solidstate.about.php.

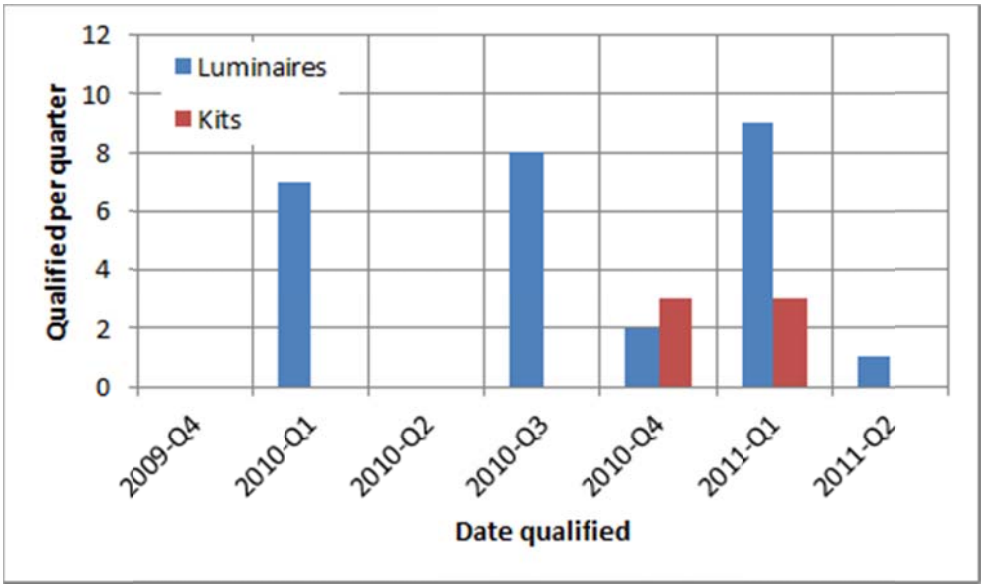


Figure 4.1. Qualification dates for selected data points from DLC list

Field measurements of CCT were consistently lower than laboratory-measured values, though within a few hundred Kelvin for the Hadco and Sylvania products. This may be attributable to the different types of detectors used; tri-stimulus detectors are generally used for portable meters, whereas more accurate bench-top spectroradiometers are generally used in the laboratory.

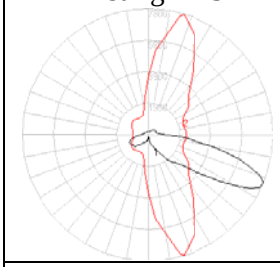
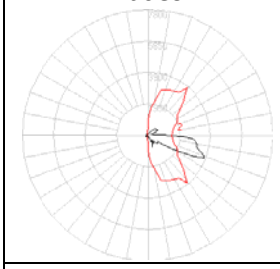
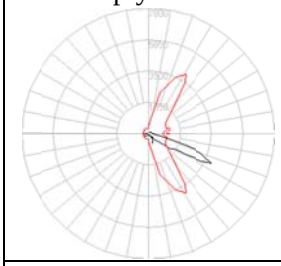
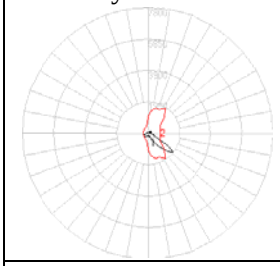
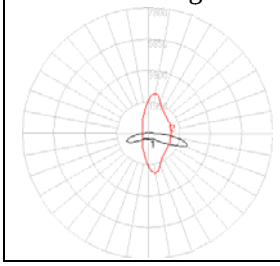
The CIE General Color Rendering Index (CRI or R_a) for the LED products is substantially higher than the rated value of 22 for HPS. However, note that the R_9 values are negative for the Hadco and Simply LEDs products, suggesting poor rendition of reds.[16]

Laboratory testing of the Hadco product indicated higher Uplight and Glare ratings than the rated values for the existing HPS luminaire; this is consistent with the percentages of luminaire output in these IES TM-15 Luminaire Classification System (LCS) zones (IES 2011a). Zonal lumen densities and BUG ratings are summarized in Table 4.4. The polar plots share the same scale to facilitate comparison. IES lateral and "vertical" classifications are also provided (IES 1995).[17]

[16] CRI and R_9 are defined by the CIE (CIE 1995). There is no standard for minimum R_9 in outdoor applications. A positive R_9 value is required for ENERGY STAR® qualification of LED integral replacement lamps; see http://www.energystar.gov/lightbulbs for details.

[17] See IESNA TM-3-1995 and IESNA HB-09-00 for definitions of these classifications, and recommendations against their usage in specifications. IES HB-10-11 introduces alternative definitions, which may soon be superseded by definitions added to the forthcoming update to IES RP-8.

Table 4.4. Photometric classifications and zonal lumen densities

Product	LCS				Lateral & "vertical" classification	Data source
	B-U-G Ratings	Back (%)	Up (%)	FVH (%)		
Existing HPS 	2-4-3	24.7	17.9	6.8	Type III Medium	Mfr.
Hadco 	1-5-5	6.9	25.6	15.1	Type IV Short	Lab.
Simply LEDs 	1-3-1	20.5	14.9	3.3	Type III Short	
Sylvania 	1-3-1	29.1	18.4	3.5	Type II Short	
Sternberg 	2-3-3	33.2	7.5	7.5	Type IV Medium	

5.0 Mesopic Multipliers

As noted in section 3.0, both the S/P ratio and the photopic luminance of the target (the road surface) must be known in order to determine an appropriate mesopic multiplier. Data collected during this project allows for a choice of the following S/P ratios for each of the LED products:

- Based on scotopic illuminance measured by the Solar Light meter and photopic illuminance measured by the Solar Light meter
- Based on scotopic illuminance measured by the Solar Light meter and photopic illuminance measured by the Minolta meter
- Using the ratio reported by the testing laboratory.

Figure 5.1 illustrates the good agreement between photopic illuminance measurements taken using the Minolta and Solar Light meters, even at lower illuminances where rounding by the latter is more significant. However, Figure 5.2 indicates these meters are not interchangeable in calculating S/P ratios; this may be largely attributable to rounding errors resulting from limited decimal resolution for the Solar Light photopic measurements. Regardless of the meter used for photopic measurements, and contrary to expectations, Figures 5.3 and 5.4 indicate the S/P ratio tended to increase with increasing photopic illuminance.

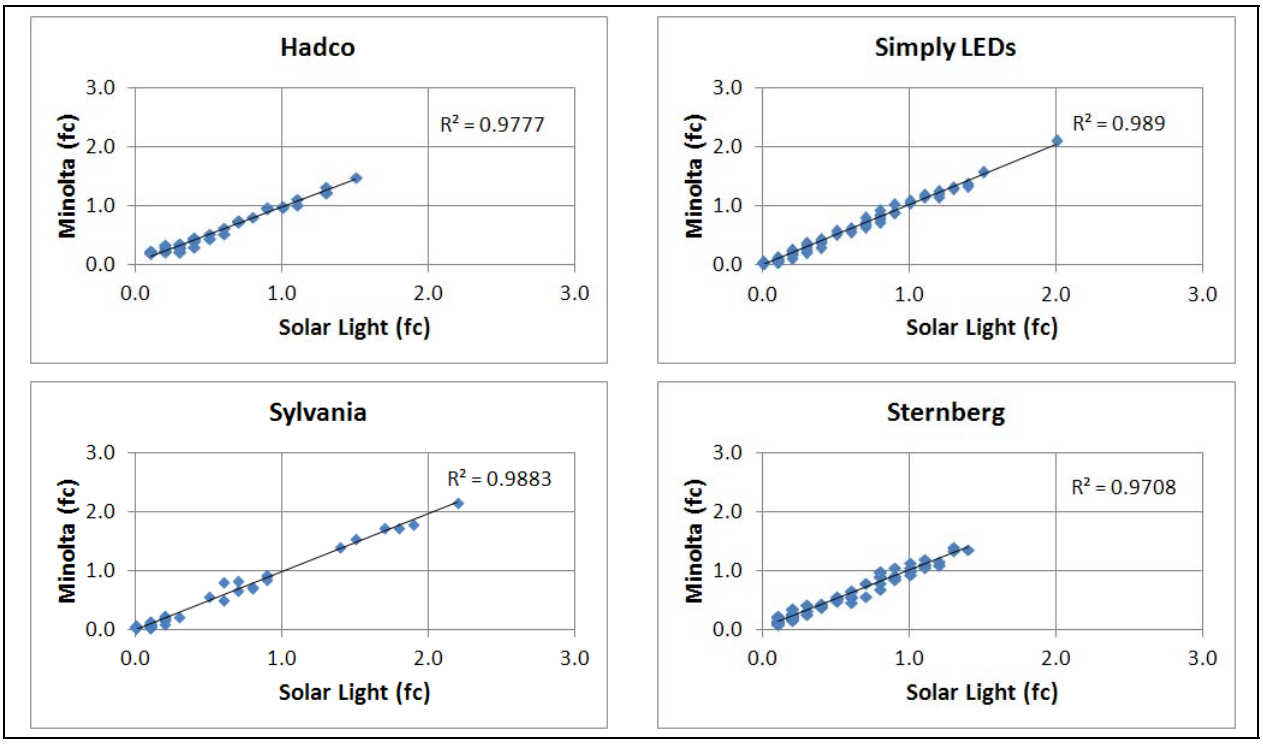


Figure 5.1. Drivelane illuminance measurements (photopic) using different meters

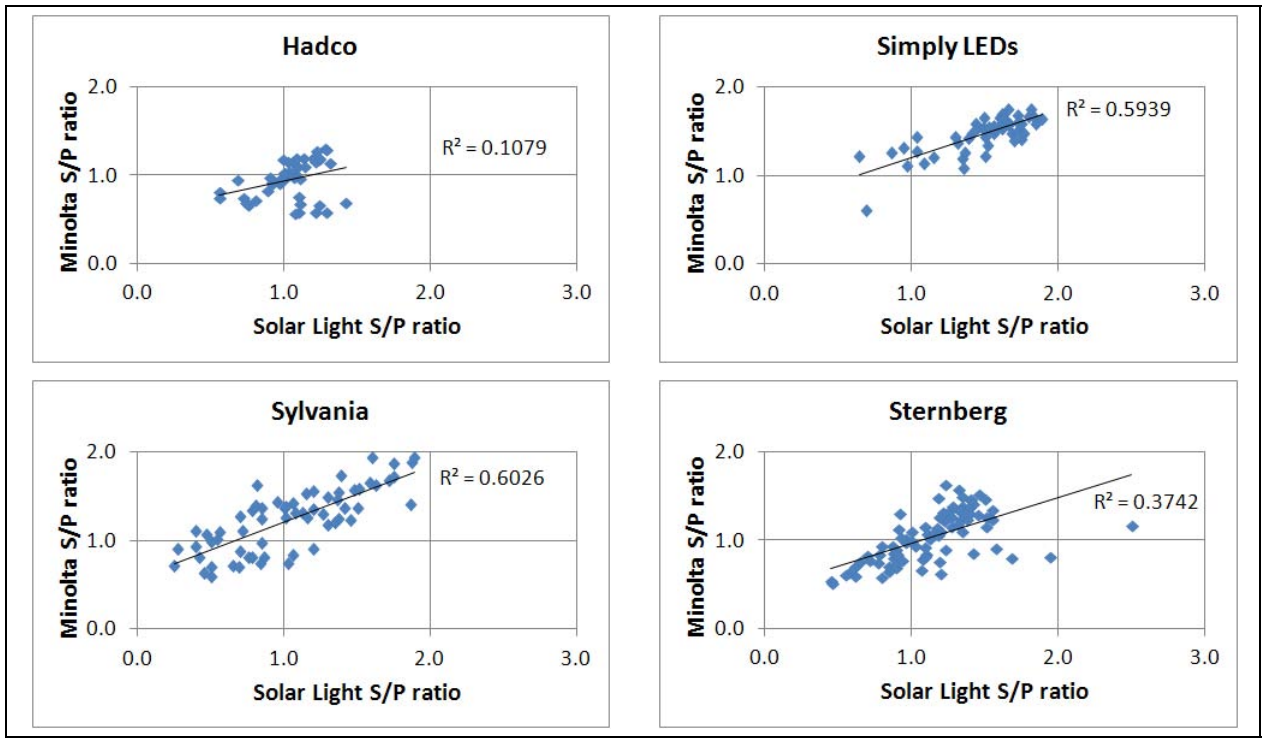


Figure 5.2. Drivelane S/P ratios using measurements from different meters for the denominator

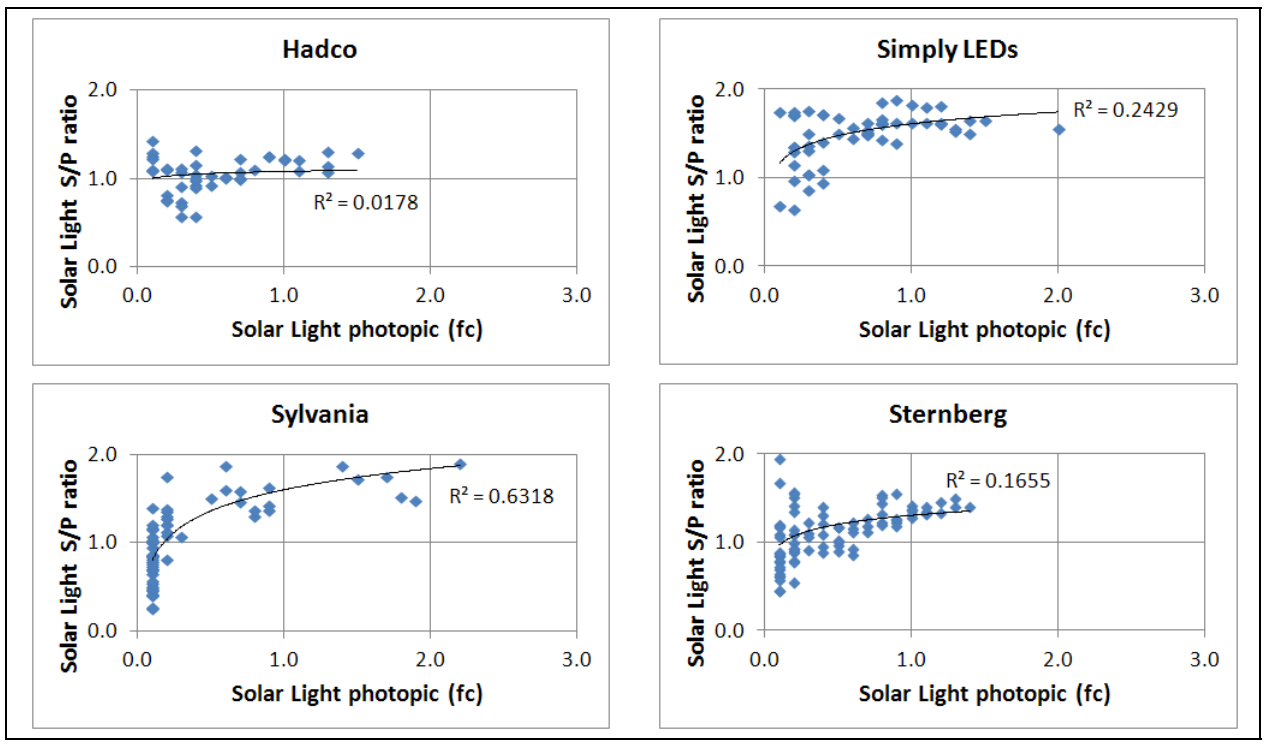


Figure 5.3. Drivelane S/P ratios as a function of Solar Light measurements (photopic)

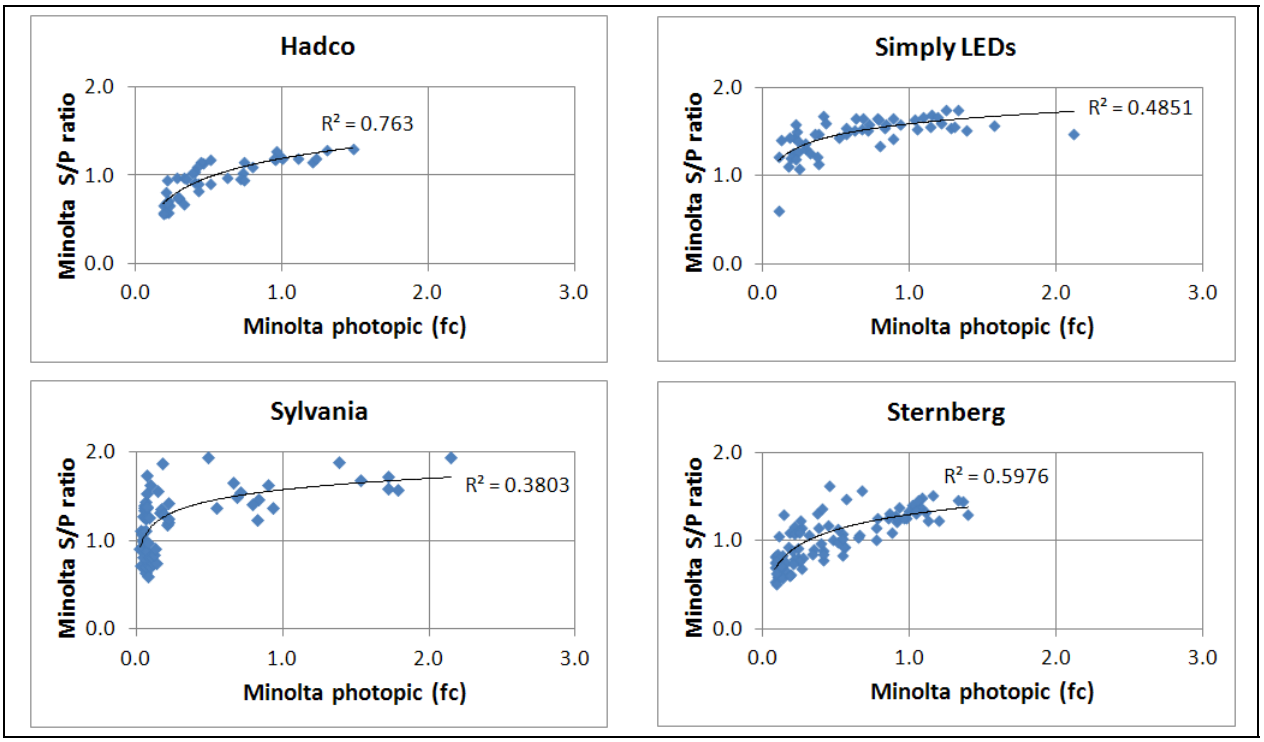


Figure 5.4. Drivelane S/P ratios as a function of Minolta measurements (photopic)

Compare with Figure 5.5, which presents the same information for the HPS luminaires, albeit based on the relatively limited set of Solar Light measurements. Correlation between photopic measurements using either meter would likely be improved if more measurements had been taken; however, note that the available data yields a curve-fitted line which does not start at the origin and pass through the (1,1) coordinate, but is rather offset. Unfortunately, since none of the measurements were below 0.20 fc, it is not clear whether S/P ratios under HPS would follow the same trend exhibited by the LED products, i.e., increasing with increased photopic illuminance.

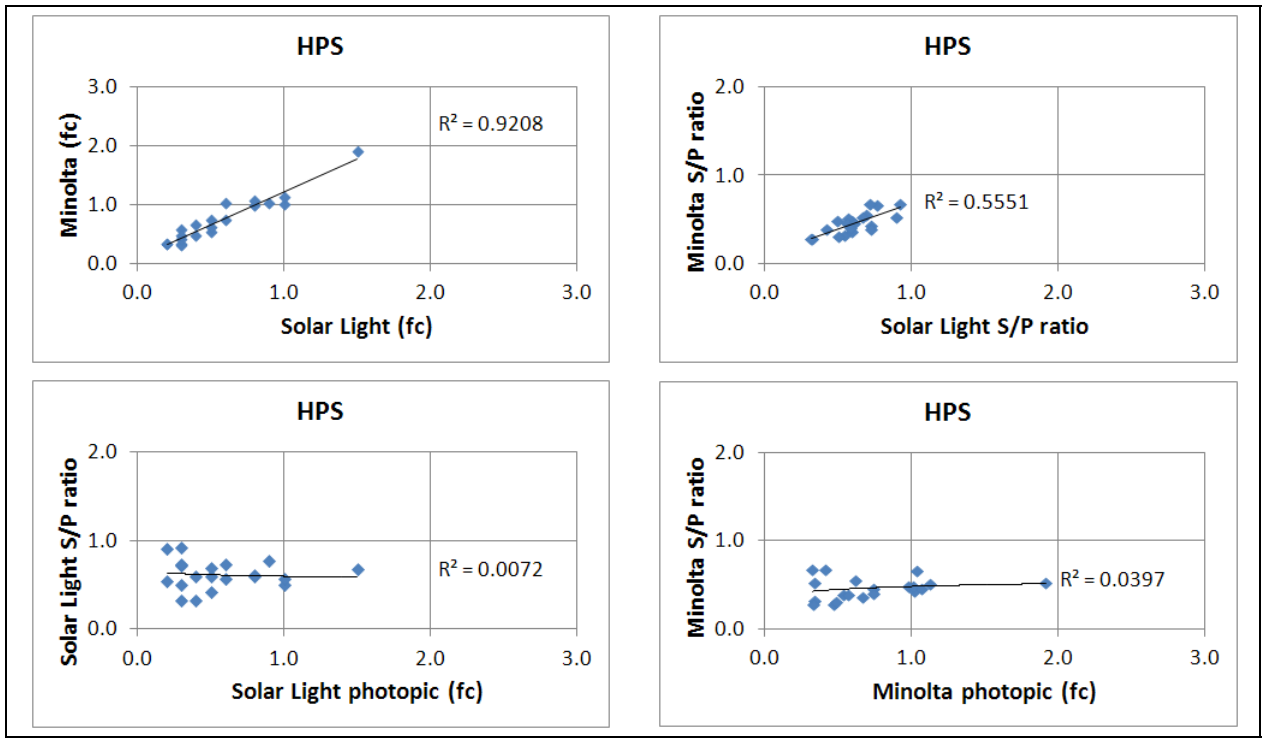


Figure 5.5. HPS data for comparison with LED data in Figures 6.1-6.4

Following are possible explanations for the apparent relationship between S/P ratio and photopic illuminance for the LED products:

- The accuracy of the scotopic meter is compromised at low photopic illuminances [18]
- The color of light emitted by these LED products is not spatially uniform, such that the portion of scotopic (blue) spectral content generally decreases with increased distance from pole (and increased angle from nadir)
- The relative contribution of sky glow (which likely differs in color) is greater at points of very low illuminance.

The laboratory data cannot be used to evaluate spatial uniformity of color since an integrating sphere (which does not record measurements in specific directions of emission) was used for colorimetry.[19] In addition, no photopic or scotopic measurements of sky glow illuminance contribution were recorded in the field. Consequently, a definitive explanation cannot be offered for the apparent relationship between S/P ratio and photopic illuminance for the LED products.

S/P ratios reported by the laboratory for the LED test specimens were significantly higher than the values calculated from field measurements, as shown in Table 5.1. LED ratios were calculated as the ratio of average scotopic and photopic illuminance, whereas HPS ratios were calculated as the average of ratios at the fewer and unevenly-spaced Solar Light measurement points.

[18] Solar Light indicates a range of 20 fc and a display resolution of 0.01 fc for the PMA-2131 detector.
[19] Although colorimetry can be performed via goniophotomer (allowing evaluation of spatial uniformity of color), few laboratories offer this service, and such data is rarely available from manufacturers.

Table 5.1. Measured S/P ratios

Product	S/P ratios	
	Laboratory	Field
Existing HPS	-	0.53
Hadco	1.577	1.05
Simply LEDs	2.006	1.46
Sylvania	1.963	1.42
Sternberg	1.846	1.21

S/P ratios varied significantly under HPS according to the limited field measurements taken using the Solar Light meter. IES HB-10 indicates an S/P ratio of 0.60 is representative for HPS having a CCT or 2000 K, and this value roughly aligns with the field measurements. By comparison, S/P ratios for CALiPER benchmarks 08-122 (2042 K) and 09-105 (2130 K) were slightly higher at 0.63 and 0.67, respectively.[20] For the purposes of this analysis, it is assumed that an S/P ratio of 0.65 would serve as a reasonable estimate of the S/P ratio for the existing HPS luminaires.

Figure 5.6 illustrates the logical and apparently strong relationship between CCT and S/P ratio. The curve-fit equation is not shown since the dataset is quite limited and there is no single mathematical relationship between these two metrics. It is possible for a variety of light sources, having unique spectral power distributions and unique S/P ratios, to share the same CCT and Duv. The form of the curve-fit equation is logarithmic, but the relationship could well prove linear given more data points. Note that an S/P ratio of 1.0 would be expected to roughly correspond to a CCT of 2700 K.

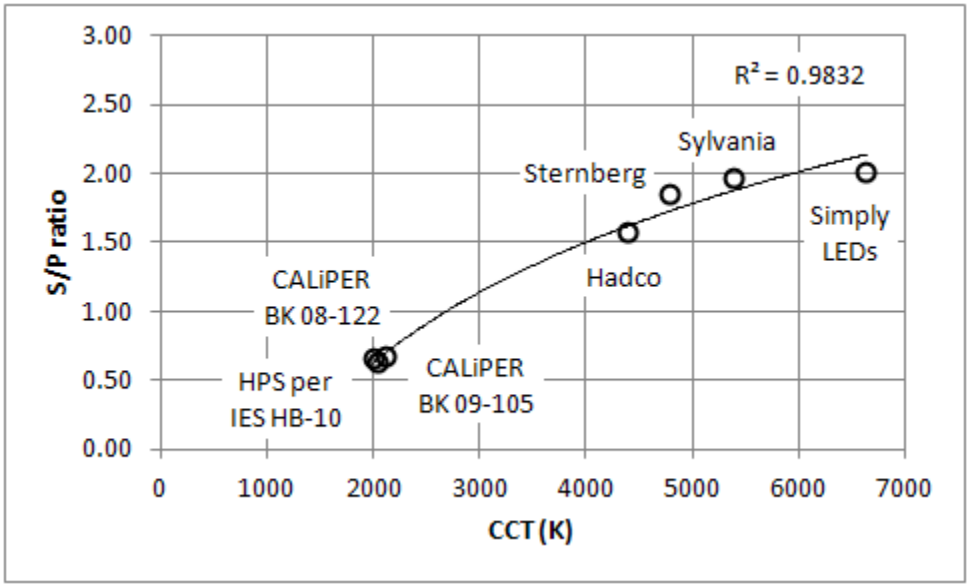


Figure 5.6. Apparent relationship between CCT and S/P ratio

[20] For more information, visit www.ssl.energy.gov/caliper.html.

Figure 5.7 plots mesopic multipliers from IES HB-10 as a function of S/P ratio and adaptation luminance. Note that multipliers approach 1.0 (no effect) when S/P ratio approaches 1.0 from above or below, or when photopic luminance approaches or exceeds 3.0 cd/m^2. Conversely, the effect is greatest (scaling photopic values up or down) at low adaptation luminances and for S/P ratios that are either very low or very high.

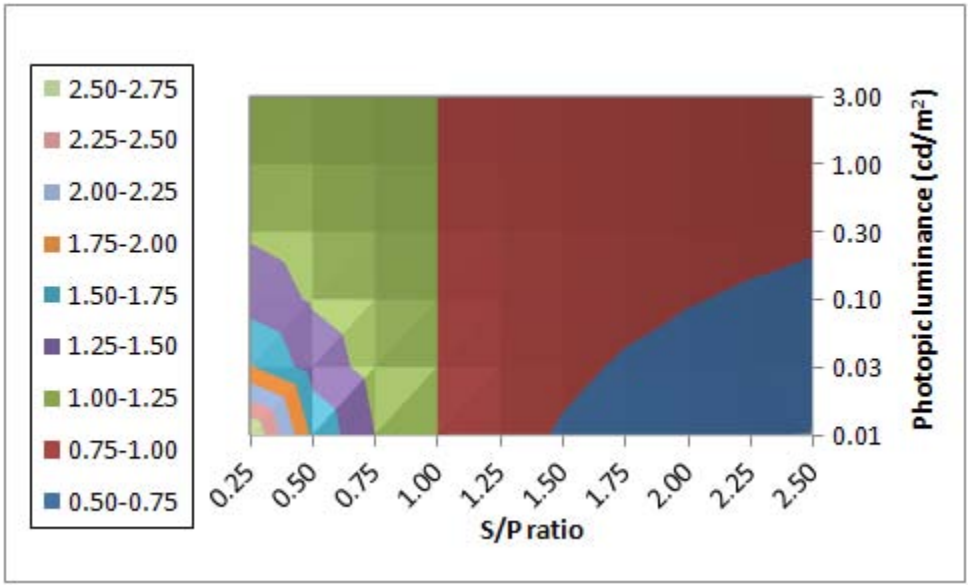


Figure 5.7. Mesopic multipliers as a function of S/P ratio and luminance

Table 5.2 illustrates adjustment of Minolta meter photopic measurements for comparison in terms of mesopic visual adaptation, assuming:

- Diffuse [21] pavement having the overall reflectance of R3 pavement (Q_0 = 0.07), calculated as 0.07 x 3.14159 = 0.22
- Spectrally neutral pavement reflectance
- Posted speed limit of 25 mph or less [22]
- S/P ratios gleaned from laboratory measurements are more accurate than those from field measurements, due to the greater environmental control and meter accuracy
- A single (averaged) S/P ratio for any given luminaire is sufficient for the use of mesopic multipliers.[23]

[21] It would be more accurate to account for the partially specular nature of asphalt pavement. However, IES HB-10 assumes diffuse pavement, and it is assumed diffuse pavement of equal reflectance will generally yield conservative or comparable estimates of mesopic multipliers via higher average luminance.
[22] Mesopic multipliers should not be applied where the speed limit exceeds 25 mph, per IES HB-10.
[23] Consistent with the methodology presented in section 4.12.3 of IES HB-10.

Table 5.2. Application of mesopic multipliers [24] to field measurements (initial performance)

Street	Product	Avg. photopic illum. (fc)	Avg. photopic lum. (cd/m^2)	Avg. S/P ratio	Inverse mesopic multiplier	Avg. adjusted illum. (fc)
Golden Alder	*Existing HPS*	0.58	0.44	0.65	0.9264	0.54
	Hadco	0.53	0.40	1.577	1.1065	0.59
	Sylvania	0.22	0.17	1.963	1.2601	0.28
Golden Cedar	*Existing HPS*	0.57	0.43	0.65	0.9260	0.53
	Simply LEDs	0.40	0.30	2.006	1.1923	0.48
	Sternberg	0.46	0.35	1.846	1.1581	0.53

Application of mesopic multipliers would effectively bridge the initial performance gap for three of the four LED products relative to HPS. Whereas illuminance for LED products was adjusted upward by 18 percent on average, HPS was adjusted downward by 7 percent. Although the 26 percent increase for Sylvania was the highest among LED products, its mesopic multiplier did not overcome the initial photopic performance gap. Photopic values shown were derived from measurements taken using the Minolta meter, which claims a greater low-end measuring range (to 0.001 fc) than the Solar Light meter.

The range of calculated luminance values for the LED products roughly aligns with the CCD camera measurements presented earlier in Figure 3.9. Computer simulations (using manufacturer data for HPS and laboratory data for LED) summarized in Table 5.3 suggest that the assumption of perfectly diffuse pavement (ignoring the partially specular nature of the asphalt pavement actually used on the test streets) results in overstated luminance values, which then yield conservative estimates of mesopic multipliers.

Table 5.3. Simulated luminance for perfectly diffuse versus partially specular pavement

Street	Product	Perfectly diffuse pavement		Partially specular pavement
		Avg. photopic illum. (fc)	Avg. photopic lum. (cd/m^2)	Avg. photopic lum. (cd/m^2)
Golden Alder	*Existing HPS*	0.62	0.47	0.46
	Hadco	0.53	0.40	0.40
	Simply LEDs	0.44	0.33	0.26
	Sylvania	0.23	0.17	0.11
	Sternberg	0.45	0.34	0.32

[24] Mesopic multipliers shown here are inverted from the values offered in Table 4.2 of IES HB-10.

6.0 Lumen Maintenance Life

Analogous to the use of mesopic multipliers, the assumed lumen maintenance has a significant impact on product cost and energy use. IES TM-21 provides a standard methodology for extrapolation of useful LED light source lifetime from IES LM-80 lumen maintenance data (IES 2011b, IES 2008b). Such estimates are liberal when applied directly to luminaires or lamp-ballast retrofit kits, even when combined with ISTMT data, since other unaccounted-for failure mechanisms may accelerate lumen depreciation (NGLIA 2011). The TM-21 methodology allows for determination of unique LLD values for each LED product, rather than an assumed value of 70 percent. For those products expected to maintain better than 70 percent of initial output at the end of an assumed service life, this could allow for further reductions in LED quantity, product price, energy use, and payback period. At the very least, TM-21 offers a means of identifying exaggerated or unsubstantiated claims of useful lifetime.

The following data were collected from manufacturers to allow for lumen maintenance extrapolation per IES TM-21:

- LED drive current
- ISTMT data
- LM-80 report.

As indicated in previous sections of this report, laboratory ISTMT measurements of project specimens were also performed for comparison with manufacturer data. Updated LM-80 reports were requested subsequent to completion of field and laboratory measurements, but no such updates were available at that time. It is important to note that IES TM-21 offers a standard means of estimating the in situ lumen maintenance of LED light sources, but does not account for other possible failure mechanisms such as degradation of external thermal management, optical, electrical, or electronic components.[25]

Table 6.1 shows that, relative to laboratory measurements of project specimens, accuracy of T_s ratings varied from manufacturer to manufacturer. Such discrepancies may be attributable to testing of replacement kits without a surrounding globe (i.e., not actually in situ) or to differences in globes used for ISTMT. Interestingly, the relatively inaccurate ratings (Hadco and Sylvania) both understated case temperature, whereas the accurate ratings slightly overstated case temperature.

Table 6.1. LED drive current and case temperature

Product	Replaces	Rated LED drive current [26] (mA)	T_s (°C)			
			Rating (mfr. data)	Project specimen	LM-80 Low	LM-80 high
Hadco	Lamp and ballast	350	82.4	89.8	85	120
Simply LEDs		168	47.4	46.9	n/a	55
Sylvania		350	66.0	75.9	55	85
Sternberg	Luminaire	350	59.7	58.2	45	85

[25] For more information, download the report, "LED Luminaire Lifetime: Recommendations for Testing and Reporting, Second Edition," available online at www.ssl.energy.gov/performance_guides.html.

[26] TM-21 assumes constant LED drive current. Although these products were designed for constant drive current, some products compensate for lumen depreciation by gradually increasing drive current (and wattage) over time.

Figure 6.1 illustrates the relevant LM-80 data for each product, based on ISTMT measurements of project specimens. Following are a few clarifying notes:

- Whereas Hadco indicated T_s = 82 °C, the project specimen was found to be 90 °C, so the higher pair of T_s points (85 and 120°C) was used in lieu of the lower T_s pair (55 and 85 °C).
- Data for the Simply LEDs product was not available for T_s below 55 °C. The manufacturer submitted LM-80 data for a drive current of 350 mA in March 2011, and then submitted data for 263 mA in December 2011 after reviewing a draft of this report.[27]
- Data for the Sylvania product driven at 350 mA was not available for T_s above 55 °C, so the 700 mA was (conservatively) used instead.
- Data for the Sternberg product was of greater duration at T_s = 85 °C than at 45 °C.

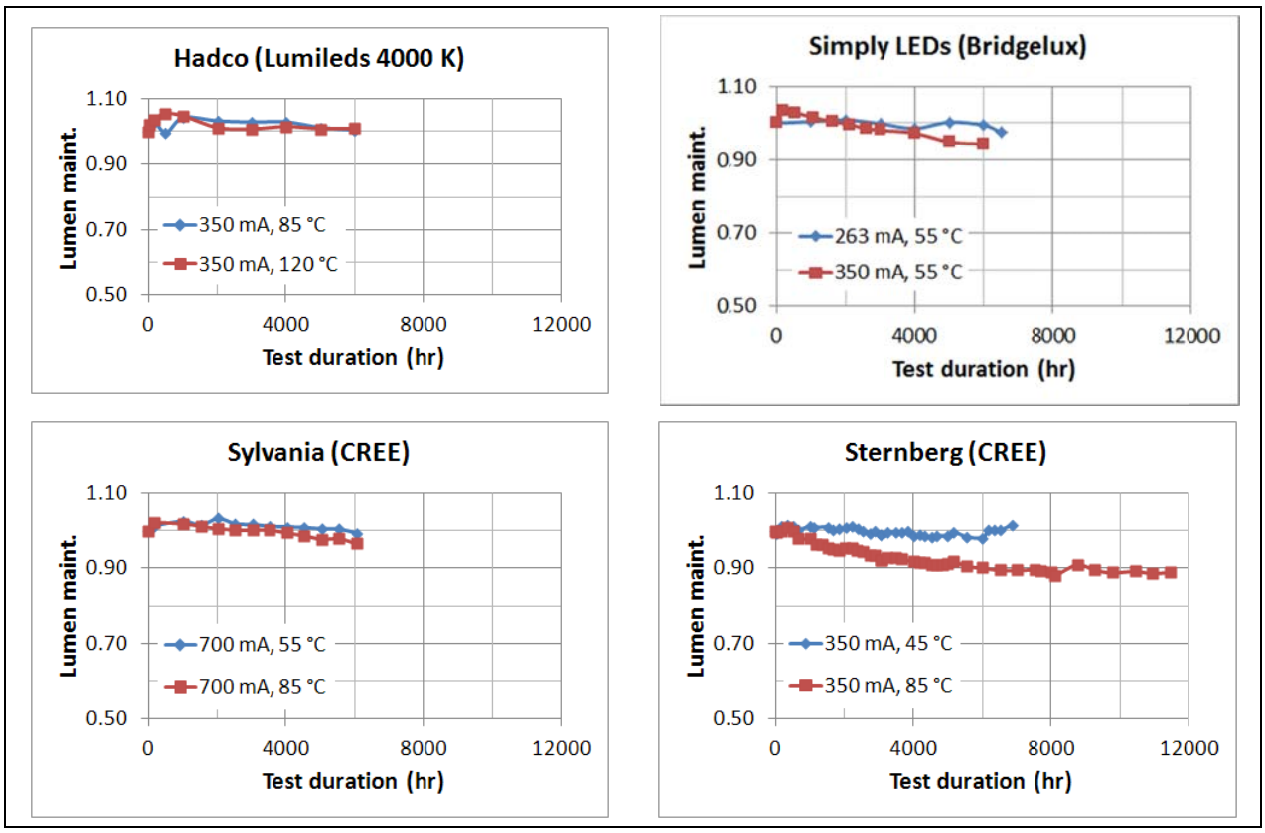


Figure 6.1. LM-80 data

TM-21 provides a methodology for determination of two lumen maintenance life values, "Projected" and "Reported." Whereas Reported L_{xx} values are constrained by the duration of LM-80 testing, no such restriction is applied to the extent of extrapolation for Projected L_{xx}. Reported L_{xx} values are always less than or equal to the corresponding Projected values. For LM-80 data based on 20 or more test specimens, extrapolation is limited to a value no greater than 6.0 times the duration of testing. This "extrapolation limit" multiplier is reduced to 5.5 for smaller sets of 10 (the TM-21 minimum) to 19 specimens. All four manufacturers confirmed they hold LED drive current constant over time. Given that manufacturer

[27] See Appendix C for an explanation from the manufacturer.

literature gathered at the beginning of the project was published before TM-21 was finalized, manufacturer-rated lumen maintenance life are not considered as part of this analysis.

As illustrated in Figure 6.2, the TM-21 methodology predicts better lumen maintenance for the Hadco LED light sources at T_s = 120 °C than for T_s = 85 °C. Since it is doubtful or perhaps impossible that lumen maintenance would actually improve due to increased operating temperature, the more conservative model (T_s = 85 °C) is assumed to be the more accurate of the two, and no interpolation is performed for the measured T_s of 89.8 °C. Lumen maintenance of 81 percent is projected at 36,000 hours of operation, which equates to roughly 9 years at 11 hours of operation per day.[28]

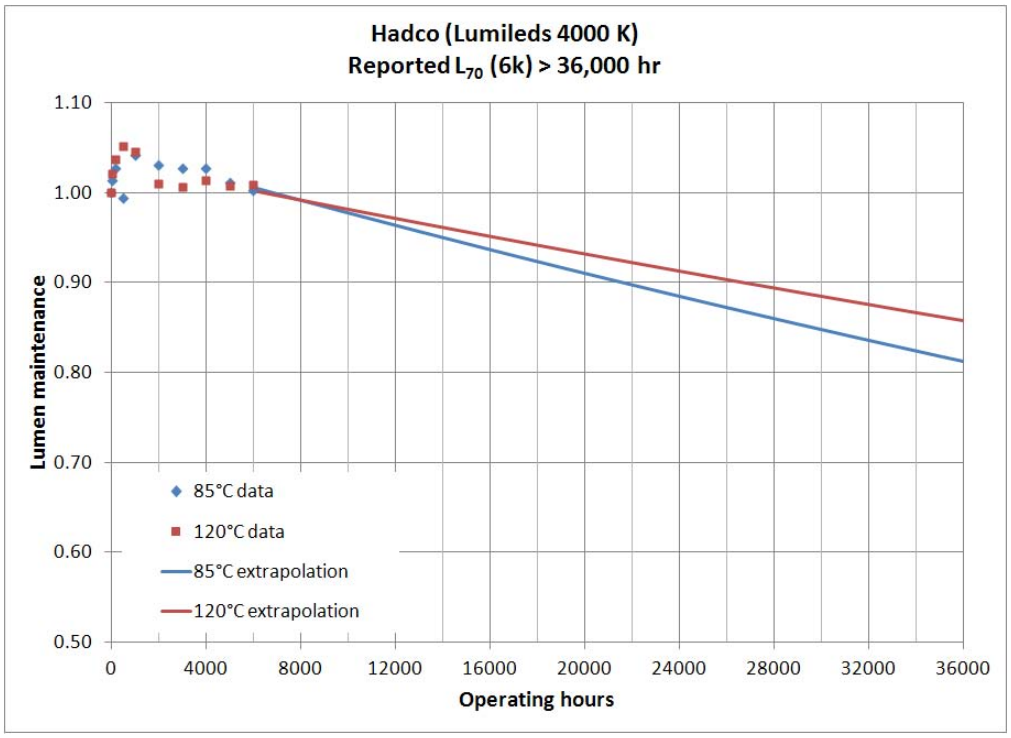


Figure 6.2. TM-21 extrapolations for Hadco specimen

Figure 6.3 shows that, when using the 350 mA data originally provided by the manufacturer, the Simply LEDs product would be expected to diminish to 60 percent of initial output at the extrapolation limit of 33,000 hours (based on 6,000 hours of LM-80 data for fewer than 20 test specimens). Using the 263 mA data subsequently provided by Simply LEDs to more closely match the rated 168 mA LED drive current, the calculated lumen maintenance improves to 85 percent after 36,000 hours of operation (the extrapolation limit for 6,500 hours of LM-80 data for fewer than 20 test specimens). By comparison, Figure 6.4 illustrates the 77 percent lumen maintenance predicted for the Sylvania product after 36,000 hours of operation.

[28] Rated life for HPS lamps is based on 11 hours of operation per start. In terms of cost analysis, this value is slightly conservative relative to the approximate 11.5 hours per start indicated in IES DG-13 (IES 1998).

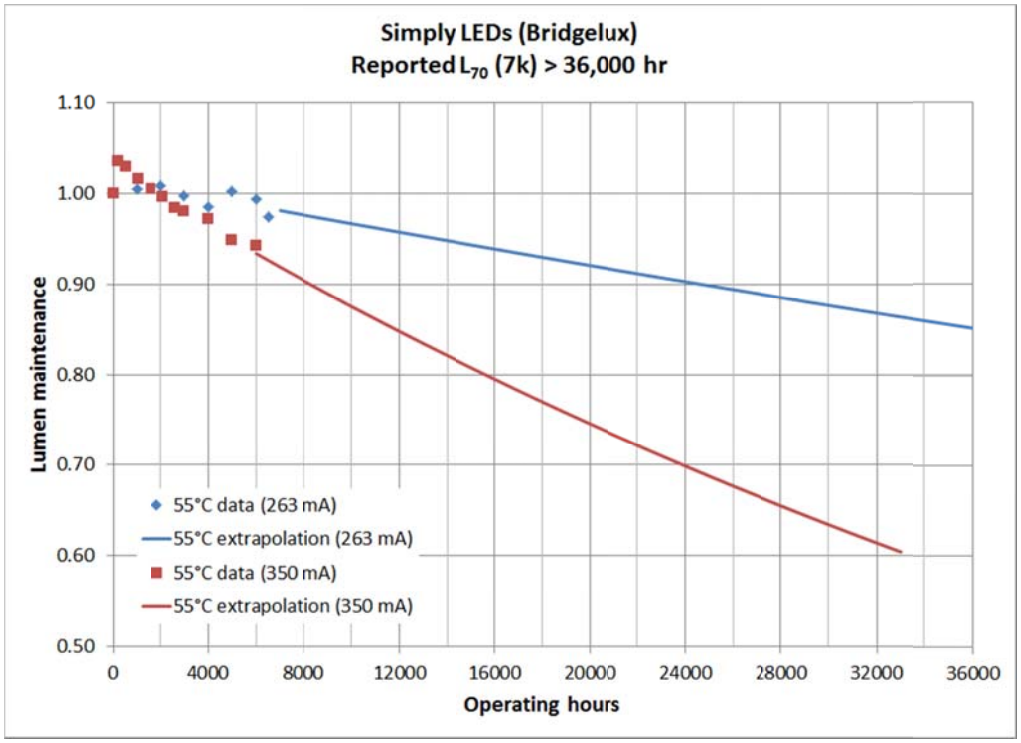


Figure 6.3. TM-21 extrapolation for Simply LEDs specimen

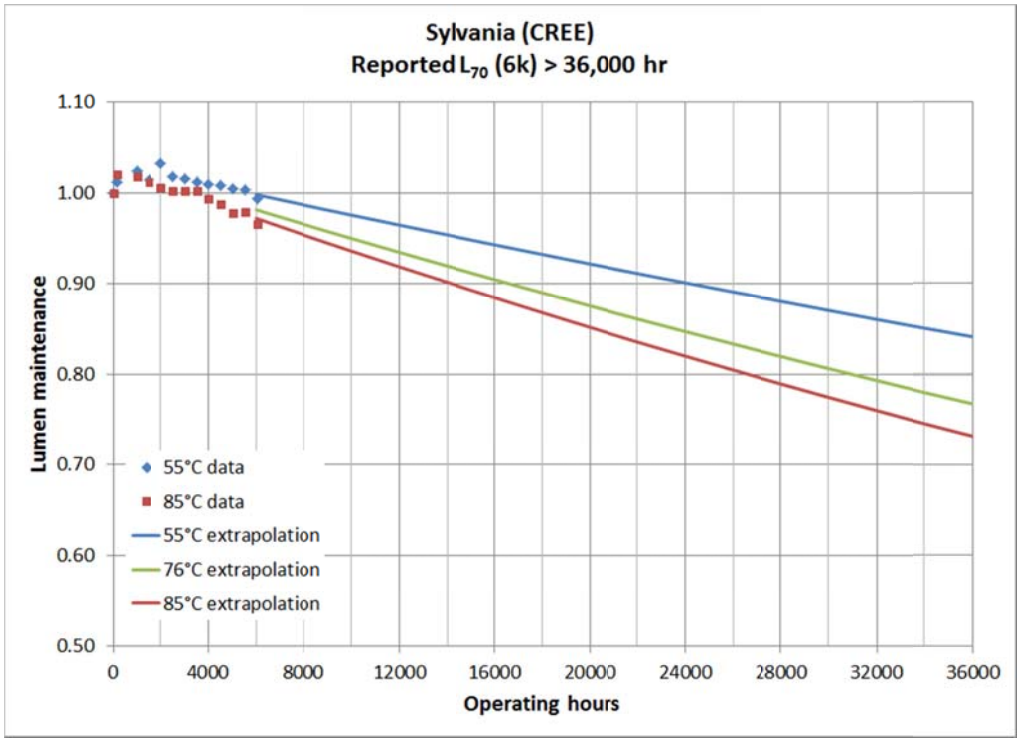


Figure 6.4. TM-21 extrapolations for Sylvania specimen

Figures 6.5 and 6.6 demonstrate the significance of LM-80 test duration for the Sternberg product. Using the complete set of data, lumen maintenance would be estimated at 82 percent after 63,000 hours of operation.[29] By comparison, the same lumen depreciation would be expected after just 33,000 hours of operation if only the first 6,000 hours of LM-80 data had been available.

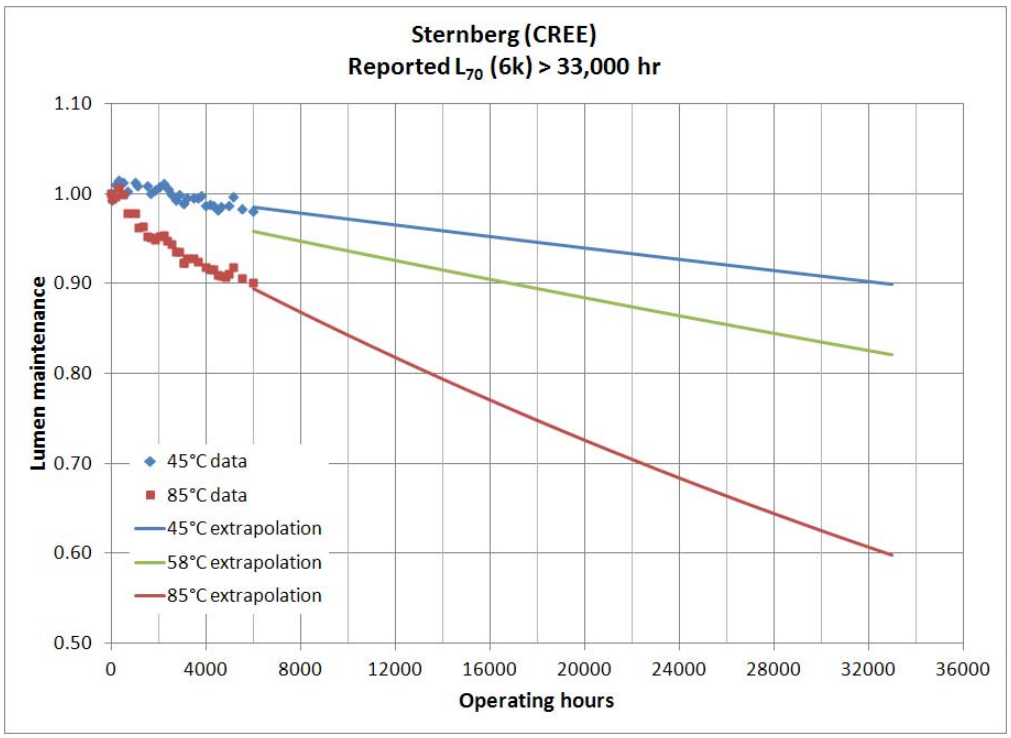


Figure 6.5. TM-21 extrapolations for Sternberg specimen
(based on first 6000 hours of LM-80 data)

[29] Note the raw Sternberg LM-80 data exhibits discontinuity at 3,050 hours; a scaling factor was used by CREE to adjust data points at/beyond 3,051 hours. Although no explanation has been offered by the manufacturer, such a discrepancy may be attributable to the replacement of a measurement device.

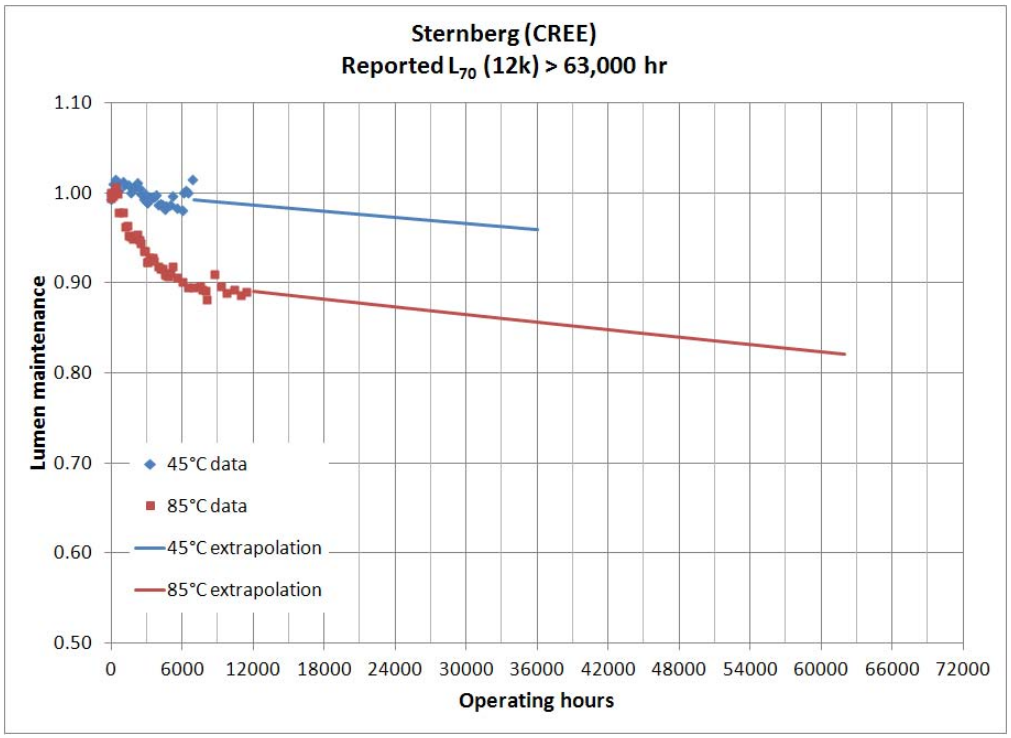


Figure 6.6. TM-21 extrapolations for Sternberg specimen
(based on full set of LM-80 data)

As noted in section 2.0 of this report, it is common practice to rate the useful lifetime of LED products based on the hours of operation until light output diminishes to 70 percent of initial. However, as demonstrated in Table 6.2, it is not unusual for TM-21 extrapolations to indicate less depreciation at the extrapolation limit. To allow for evaluation to L_{70} per IES HB-10, Projected lumen maintenance lifetimes are also provided.

Table 6.2. LED lumen maintenance life and extrapolation limit (rounded to the nearest 1,000 hr)

Product	Replaces	Extrapolation limit (hr)	Reported L_{70} life (hr)	Projected L_{70} life (hr)
Hadco	Lamp and ballast	36,000	> 36,000	57,000
Simply LEDs [30]		36,000	> 36,000	77,000
Sylvania		36,000	> 36,000	48,000
Sternberg	Luminaire	63,000	> 63,000	160,000

[30] Only the 263 mA LM-80 data for the Simply LEDs product is used henceforth.

7.0 Adjusting for Equivalence

Equivalence must be established before products can be equitably compared. Unfortunately, the product search conducted in March 2011 found no lower-wattage LED products that were photopically equivalent to the existing HPS. Energy savings from these LED products was largely attributable to reduced photopic light levels. However, the purpose of this study was to characterize best-in-class performance for LED products in this application, rather than to demonstrate their market-readiness.

The following analysis levels the playing field by one or both of the following methods:

- Normalizing for equal maintained photopic illuminance
- Normalizing for equal maintained mesopic illuminance.

Constant-wattage luminaires exhibit a gradual reduction in light output over time and thus must be "oversized" initially to ensure adequate maintained illumination for the duration of operation. The primary light loss factors associated with outdoor lighting are LLD (or lumen maintenance) and LDD.

Whereas HPS lamps generally fail before exhibiting unacceptable lumen depreciation, LED light sources are generally expected to continue operating well after they have ceased to produce adequate illumination. IES HB-10 recommends assigning an LLD of not higher than 0.70 to LED products, assuming that higher values would not reflect the likely service life, i.e., replacement will only occur after illumination has visibly diminished. However, economic analyses require accurate estimates of service life, and the extrapolation limits established by IES TM-21 effectively discourage evaluation of L_{70} ratings for some LED products since these values must be Projected rather than Reported. Consequently, the following analysis considers two scenarios for both photopic and mesopic equivalence:

- "Early" replacement (group relamping) of HPS at 70 percent of rated life, and of LED products at the IES TM-21 extrapolation limit
- "Later" replacement (spot relamping) of HPS at end of rated life, and of LED products at the Projected L_{70} lumen maintenance life.

Figures 7.1 and 7.2 illustrate lumen maintenance for each LED product relative to HPS for a number of replacement cycles. Note that:

- HPS lumen maintenance is assumed to follow the curve provided in Figure 1 of IES DG-4 for a clear 400 W HPS lamp operated horizontally
- HPS lumen maintenance would differ from what is shown in the later replacement scenario due to the required spot-replacement for a significant portion of the lamp population
- Rated life for HPS lamps is typically based on 11 hours of operation per start and survival of approximately 67 percent of the test population (when indicated with a plus "+" sign)
- If the LED light sources in the Sternberg luminaire maintain 70 percent of initial output for the Projected 160,000 hours of operation (roughly 40 years at 11 hours of operation per day), the LED driver(s) would likely require replacement in the interim.[31]

[31] The City drawings do not indicate photocontrol is integral to luminaire or pole.

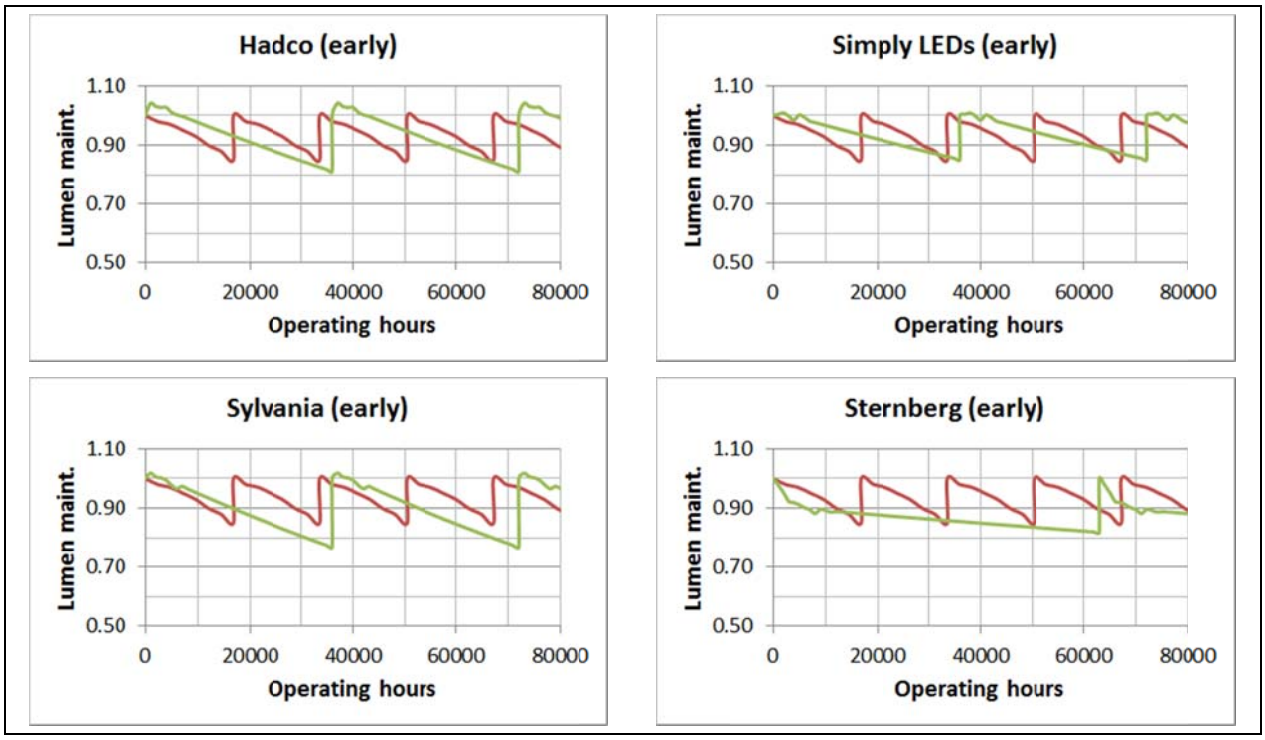


Figure 7.1. Lumen maintenance for replacement of LEDs at extrapolation limit (green) and for replacement of HPS at 70 percent of rated life (red)

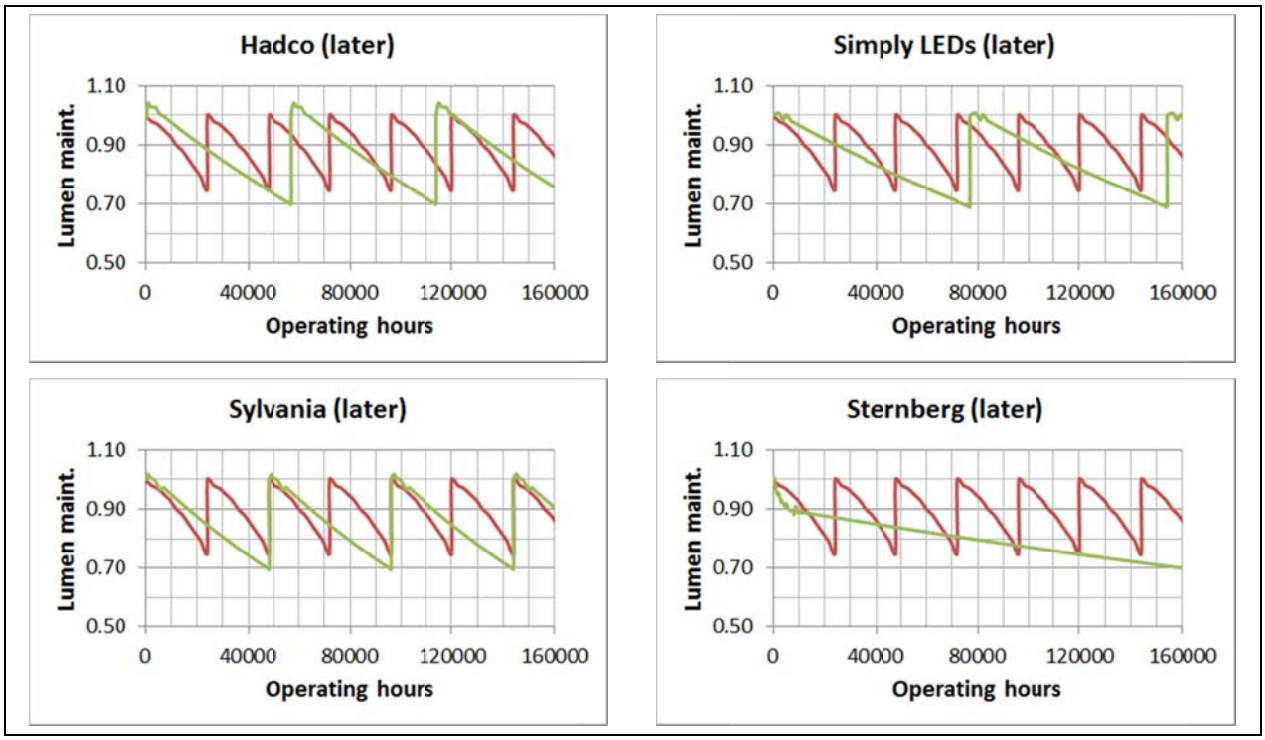


Figure 7.2. Lumen maintenance for replacement of LEDs at L_{70} life (green) and for replacement of HPS at end of rated life (red)

Luminaire dirt depreciation is a function of luminaire design, time between cleanings, and ambient particulate level. According to data published by the Environmental Protection Agency (EPA), concentrations of airborne particulate matter in Sacramento appear to be well below 150 μg/m^3, indicating a "Very Clean" environment per IESNA DG-4.[32] Estimates of LDD are illustrated in Figure 7.3 as a function of luminaire design and cleaning interval (IES 1971).[33] The Sternberg luminaire has an ingress protection rating of IP-65 and could thus be considered "tightly sealed," whereas the existing globe (which houses the other LED products and the HPS lamp) is not sealed but is effectively enclosed and thus could be reasonably considered "semi-sealed" (NEMA 2002).

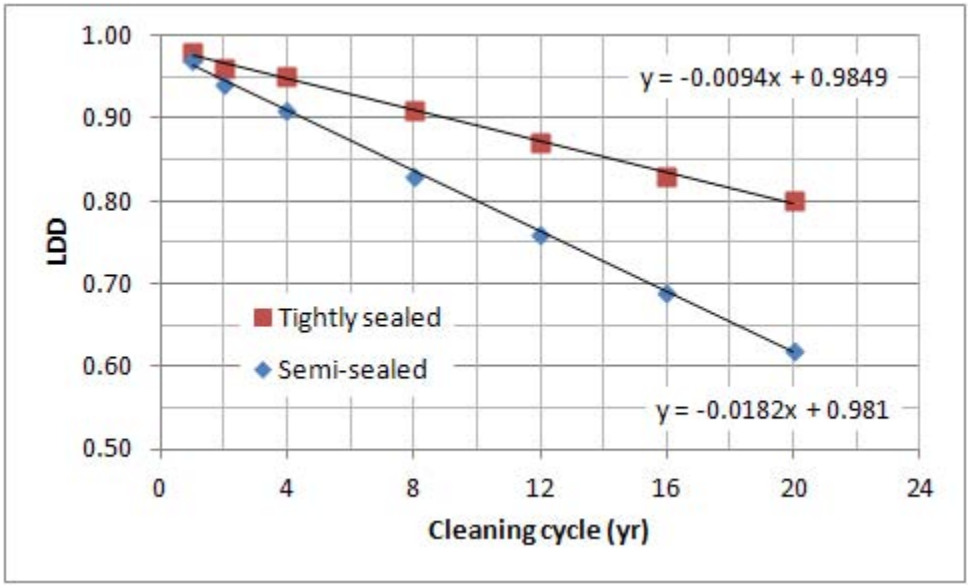


Figure 7.3. Luminaire Dirt Depreciation for < 150 μg/m^3 environment

Geometries differed between Golden Alder (where Hadco and Sylvania were installed) and Golden Cedar (where Simply LEDs and Sternberg were installed). To allow for apples-to-apples comparison of products, the following analysis considers average horizontal illuminance on Golden Alder, based on field-measured values for HPS and calculated values for LED (derived from laboratory test data).

Table 7.1 summarizes quoted pricing and initial photopic drivelane illumination for products tested as part of this project. Pricing shown excludes sales tax and distributor/contractor markups, and may vary based on region, size of order, customer/project profile, competition, and other factors. In addition, the cost per lumen of LED products is expected to continue to decrease substantially over time (DOE 2011a).

[32] Based on "coarse" particles between 2.5 and 10 μm in diameter (PM10) at site 060670010. Data is available online at http://www.epa.gov/airtrends/pm.html.

[33] The linear decay differs from the exponential decay indicated in IES DG-4 but aligns at 8 years for "enclosed and gasketed" luminaires and provides a conservative means for evaluating longer intervals and other luminaire types.

Table 7.1. Pricing in relation to initial photopic performance

Product	Unit price	Avg. horiz. illum (fc)
Existing HPS	-	0.58
Hadco	$656	0.53
Simply LEDs	$475	0.42
Sylvania	$500	0.23
Sternberg	$1168	0.45

Whereas HPS luminaire pricing generally does not vary greatly as a function of light output, LED luminaire pricing can be nearly proportional to light output. Since the LEDs themselves represent a significant portion of the luminaire cost, doubling the number of LEDs to produce twice the light output can also result in nearly twice the cost. As a cost-saving alternative, LED drive current could be roughly doubled without increasing the number of LEDs, but this approach generally compromises both efficacy and lifetime.

Table 7.2 scales LED products in output, wattage, and price to match HPS in terms of maintained photopic performance, rather than targeting IES RP-8 recommendations, assuming "early" replacement as described above. These three values are scaled-up proportionately to approximate yield an equivalent product, assuming increased LED light source quantity. Note that this method assumes LED light source quantity is sufficiently granular to "right-size" products, thereby eliminating unnecessary wattage and cost. Some LED luminaire manufacturers offer a more limited variety of lumen packages, akin to the available HID wattage increments. It is important to note that this method also ignores the inferior uniformity produced by the Simply LEDs and Sylvania products.

Table 7.2. Scaling for maintained photopic equivalence (early replacement)

Product (interval)	As received			Scaling factor	Scaled for maint. equivalence		
	LLD	LDD	Maint. illum. (fc)		Price ($)	Input power (W)	Initial illum. (fc)
Existing HPS (16,800 hr)	0.85	0.90	0.45	1.00	-	146	0.58
Hadco (36,000 hr)	0.83	0.82	0.36	1.24	813	114	0.66
Simply LEDs (36,000 hr)	0.85	0.82	0.29	1.53	725	92	0.64
Sylvania (36,000 hr)	0.79	0.82	0.15	3.00	1500	168	0.69
Sternberg (63,000 hr)	0.86	0.84	0.33	1.37	1606	132	0.62

Table 7.3 further scales LED products in output and price to match HPS in terms of maintained mesopic performance, again assuming "early" replacement. Mesopic multipliers can be calculated based on initial or maintained light levels, or for any point between. Given that mesopic multipliers would be higher as products near the end of a replacement cycle (when photopic illumination levels are lowest), and given that some LED products can exhibit substantial color shift over time (CALiPER 2011), the

following mesopic multipliers were determined using initial light levels for conservative and accurate adjustment of photopic values.

Table 7.3. Scaling for maintained mesopic equivalence (early replacement)

Product (interval)	Mesopic multiplier	Maint. illum. adjusted (fc)	Scaling Factor	Scaled	
				Price ($)	Input power (W)
Existing HPS (16,800 hr)	0.9265	0.41	1.00	40	146
Hadco (36,000 hr)	1.0981	0.40	1.05	686	96
Simply LEDs (36,000 hr)	1.1352	0.33	1.25	592	75
Sylvania (36,000 hr)	1.1522	0.17	2.41	1206	135
Sternberg (63,000 hr)	1.1425	0.37	1.11	1302	107

The analysis is repeated in Tables 7.4 and 7.5, this time evaluating replacement of HPS at end of rated life and LED at the Projected L_{70} lumen maintenance life. It is assumed that the Sternberg luminaire would be cleaned before 80,000 hours of operation – perhaps upon replacement of failed LED driver(s).

Table 7.4. Scaling for maintained photopic equivalence (later replacement)

Product (interval)	As received			Scaling factor	Scaled for maint. equivalence		
	LLD	LDD	Maint. illum. (fc)		Price ($)	Input power (W)	Initial illum. (fc)
Existing HPS (24,000 hr)	0.75	0.87	0.38	1.00	-	146	0.58
Hadco (57,000 hr)	0.70	0.72	0.27	1.43	936	131	0.76
Simply LEDs (77,000 hr)		0.63	0.19	2.06	978	123	0.86
Sylvania (48,000 hr)		0.76	0.12	3.12	1558	174	0.72
Sternberg (160,000 hr)		0.80	0.25	1.51	1767	145	0.68

Table 7.5. Scaling for maintained mesopic equivalence (later replacement)

Product (interval)	Mesopic multiplier	Maint. illum. adjusted (fc)	Scaling Factor	Scaled	
				Price ($)	Input power (W)
Existing HPS (24,000 hr)	0.9265	0.35	1.00	40	146
Hadco (57,000 hr)	1.0916	0.29	1.21	795	111
Simply LEDs (77,000 hr)	1.1657	0.22	1.64	777	98
Sylvania (48,000 hr)	1.1493	0.14	2.51	1256	141
Sternberg (160,000 hr)	1.1365	0.29	1.23	1440	118

Figure 7.4 illustrates the effect of scaling LED product price for maintained equivalence to HPS, both in terms of photopic and mesopic visual adaptation, and as a function of "early" or "later" replacement. Observations:

- Scaled product price was always lower in the early replacement scenarios than in the later replacement scenarios
- The Sylvania product had the second-lowest quoted price but jumped to second-highest when scaled for maintained equivalence to HPS
- Quoted product price was not reduced in any scenario.

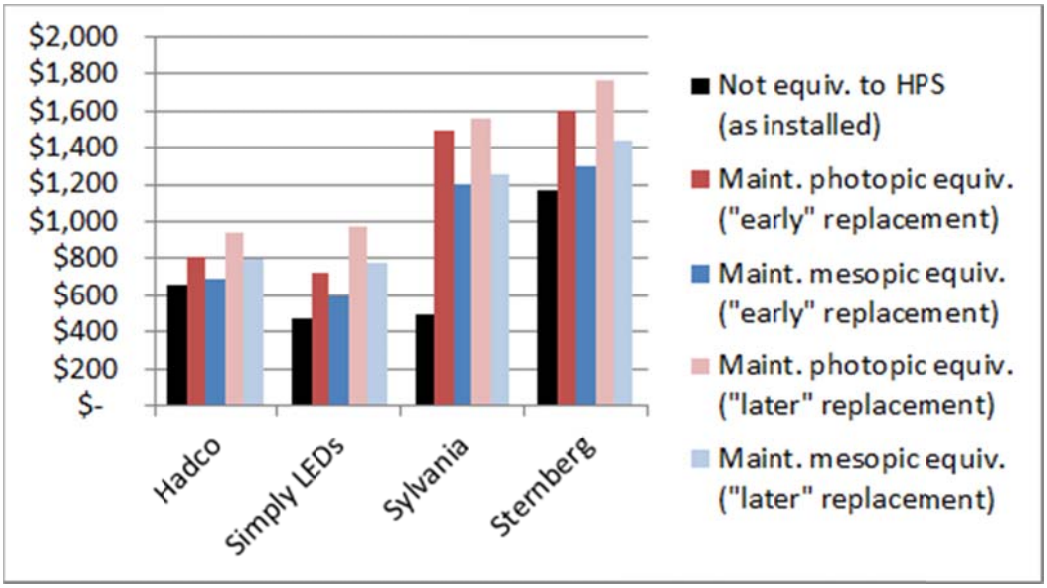


Figure 7.4. LED product costs scaled for maintained equivalence to HPS

None of the LED products tested as part of this project were equivalent to the existing HPS in terms of maintained photopic illumination, and all but the Hadco product would still need to be upgraded to higher-output versions to yield maintained mesopic equivalence. It appears that, holding LED drive current constant for the four LED manufacturers, alternative versions of these products available at the time of product selection may have improved performance but would not have changed the overall outcome:

- A 5000 K version of the Hadco product would have been comparable to the CCT of the other LED products; a corresponding increased S/P ratio would have further reduced the price for mesopic equivalence, but manufacturer photometry indicates photopic output would actually decrease by approximately 5 percent [34]
- No photometry was available for the 80 W version of the Simply LEDs product; assuming equal efficacy, the approximate 33 percent increase in output would not have overcome the ≥ 49 percent deficiency in maintained photopic illumination
- Analysis of photometry published by Sylvania suggests the "Type III" (asymmetric) version would not have improved uniformity but would have produced higher drivelane illuminance than the higher-output "Type V" (symmetric) version selected; however, the approximate 13 percent increase would not have overcome the ≥ 200 percent deficiency in maintained photopic illumination [35]
- A 6000 K version of the Sternberg product would have offered approximately 21 percent higher photopic output, but this CCT would not have been consistent with the other products.

[34] Based on data for the standard RPTLD product. Within a given LED product family utilizing phosphor down-conversion, photopic luminous efficacy generally decreases with decreased CCT. The Hadco product appears to offer an exception to the rule.

[35] Tested without globe, i.e., "bare-lamp." The prismatic globe would be expected to impact performance.

8.0 Economics

The City indicated it is billed at a flat rate of $0.12/kWh under the SMUD street light schedule for customer owned and maintained street lights,[36] slightly higher than the national average of $0.10/kWh (DOE 2011b). According to the City, the cost of spot replacement and repair of HPS luminaires ranges from $400 - $750 per incident, including an average labor rate of approximately $165/hr fully burdened (overtime is approximately $250/hr) and vehicle costs ranging from $200 to $300 per trip. The total annual budget for street light maintenance is $1.7 million for approximately 35,000 to 40,000 street lights, yielding an estimated $45 annual cost of maintenance per HPS luminaire.

Estimated annual maintenance costs are summarized in Table 8.1. Assuming an approximate 27,500-hour service life for HPS lamps (extrapolating from 67 percent survival at the 24,000+ hour rated life) and a 60,000-hour service life for HPS ballasts, and assuming lamps are not replaced as ballasts are replaced, the maintenance cycle can be estimated at 4.7 years.[37] This yields a significantly lower figure of roughly $213 on average to service a luminaire.[38] Holding this value constant, the City budget would need to be increased to accommodate the higher annual cost of maintenance for the early and later replacement scenarios, due to the reduced service lifetimes of HPS lamps. Note that whereas these values include HPS luminaire components, the labor and transportation rates do not.

Table 8.1. Estimated annual HPS maintenance cost for each replacement scenario

Replace. scenario	Mean lamp life		Serviced annually		Service cycle (yr)	Annual maint. ($)	
	(hr)	(yr)	Lamps	Luminaires		Overall budget	Per unit
Actual	27,500	6.84	5,479	7,990	4.7	1,700,000	45
Later	24,000	5.97	6,278	8,789	4.3	1,870,000	50
Early	16,800	4.18	8,968	11,479	3.3	2,442,449	65

Estimated cost to prepare and install each product is provided in Table 8.2, assuming $2,890 cost for a two-person crew replacing products for the duration of an eight hour day. Based on the survey of City installation personnel (see Appendix F), substantial preparation time in the shop was required for the three lamp-ballast replacement products. To account for the learning curve associated with these new products, it is assumed that only one employee would ultimately be needed to perform this work.

Table 8.2. Estimated cost to prepare and install each product (excluding product price)

Product	Field install time (hr)	Installed per day	Shop prep. time (hr)	Shop prep. cost ($)	Prep. and install ($)
Hadco	0.25	16.0	0.50	1,320	263
Simply LEDs	0.50	10.7	1.00	1,760	436
Sylvania	0.75	8.0	1.25	1,650	568
Sternberg	1.00	6.4	0.00	0	452

Simple payback period for each of the four scenarios is shown in Tables 8.3-8.6. Installed cost is calculated as the sum of the cost to prepare and install and the scaled product price. Annual maintenance

[36] Standard rates are accessible online at http://www.smud.org/en/residential/rates/Documents/1-SLS.pdf.
[37] For simplicity, photocontrols and knock-downs are not considered in this analysis.
[38] Administrative overhead is assumed to be separate or represent a relatively small portion of the annual budget.

savings are calculated assuming no replacement of LED products, i.e., stopping just short of one LED replacement cycle. For this reason, no value is shown if simple payback period exceeds the corresponding LED replacement cycle, i.e., if the product does not pay for itself before it is to be replaced. For simplicity, disposal costs are not considered as part of this analysis.

Table 8.3. Simple payback period for early replacement and maintained photopic equivalence

Product	Installed cost ($)	Replace. cycle (yr)	Annual cost ($)		Annual savings ($)			Payback (yr)
			Power	Maint.	Power	Maint.	Net	
HPS (base)	65	1.0	70	65	0	0	0	
Hadco	1,076	9.0	55	0	15	65	80	> cycle
Simply LEDs	1,161	9.0	44	0	26	65	91	> cycle
Sylvania	2,067	9.0	81	0	-11	65	54	> cycle
Sternberg	2,057	15.7	64	0	7	65	72	> cycle

Table 8.4. Simple payback period for early replacement and maintained mesopic equivalence

Product	Installed cost ($)	Replace. cycle (yr)	Annual cost ($)		Annual savings ($)			Payback (yr)
			Power	Maint.	Power	Maint.	Net	
HPS (base)	65	1.0	70	65	0	0	0	
Hadco	949	9.0	46	0	24	65	89	> cycle
Simply LEDs	1,028	9.0	36	0	34	65	99	> cycle
Sylvania	1,773	9.0	65	0	5	65	70	> cycle
Sternberg	1,754	15.7	52	0	19	65	84	> cycle

Table 8.5. Simple payback period for later replacement and maintained photopic equivalence

Product	Installed cost ($)	Replace. cycle (yr)	Annual cost ($)		Annual savings ($)			Payback (yr)
			Power	Maint.	Power	Maint.	Net	
HPS (base)	50	1.0	70	50	0	0	0	
Hadco	1,199	14.2	63	0	7	50	57	> cycle
Simply LEDs	1,413	19.2	60	0	11	50	61	> cycle
Sylvania	2,125	11.9	84	0	-14	50	36	> cycle
Sternberg	2,218	39.8	70	0	0	50	50	> cycle

Table 8.6. Simple payback period for later replacement and maintained mesopic equivalence

Product	Installed cost ($)	Replace. cycle (yr)	Annual cost ($)		Annual savings ($)			Payback (yr)
			Power	Maint.	Power	Maint.	Net	
HPS (base)	50	1.0	70	50	0	0	0	
Hadco	1,058	14.2	54	0	17	50	67	> cycle
Simply LEDs	1,213	19.2	47	0	23	50	73	16.6
Sylvania	1,823	11.9	68	0	3	50	53	> cycle
Sternberg	1,892	39.8	57	0	13	50	63	29.9

Again, note that while their light output has been scaled for maintained equivalence to HPS, the Simply LEDs and Sylvania products greatly compromise uniformity of illumination in this application, so they would not be truly equivalent without a redesign of their optical systems.

To account for the time value of money, life cycle cost analysis was performed in addition to calculation of simple payback period. Whereas HPS lamp-ballast technology has largely matured, LED source-driver technology continues to rapidly evolve. For this reason, it is conservatively assumed that LED drivers will be replaced as LED light sources are replaced to ensure compatibility. Although LED pricing is expected to decrease roughly 22 percent annually through 2020 (DOE 2011a), real pricing is conservatively held constant for this analysis.

Life cycle calculations are summarized in Tables 8.7-8.10, based on the following assumptions:

- End-of-year discounting
- Constant-dollar analysis, with a real discount rate of 3.0 percent
- Constant real pricing for products and labor
- NIST projections for future commercial sector electricity prices (NIST 2011c)
- Whereas HPS costs are annualized, residual value is used to credit LED products which happen to be part way through a replacement cycle at the end of the evaluation period.

Table 8.7. Life cycle cost for early replacement and maintained photopic equivalence

Product	Life cycle cost (2011 $)	Net savings (2011 $)	Analysis period (yr)
Existing HPS ($65 annual maint.)	1960	n/a	20
Hadco	2840	-879	
Simply LEDs	2853	-893	
Sylvania	5108	-3148	
Sternberg	3373	-1413	

Table 8.8. Life cycle cost for early replacement and maintained mesopic equivalence

Product	Life cycle cost (2011 $)	Net savings (2011 $)	Analysis period (yr)
Existing HPS ($65 annual maint.)	1960	n/a	20
Hadco	2474	-513	
Simply LEDs	2482	-520	
Sylvania	4320	-2359	
Sternberg	2839	-878	

Table 8.9. Life cycle cost for later replacement and maintained photopic equivalence

Product	Life cycle cost (2011 $)	Net savings (2011 $)	Analysis period (yr)
Existing HPS ($50 annual maint.)	2274	n/a	30
Hadco	3220	-945	
Simply LEDs	3012	-737	
Sylvania	5742	-3468	
Sternberg	3171	-896	

Table 8.10. Life cycle cost for early replacement and maintained mesopic equivalence

Product	Life cycle cost (2011 $)	Net savings (2011 $)	Analysis period (yr)
Existing HPS ($50 annual maint.)	2274	n/a	30
Hadco	2800	-526	
Simply LEDs	2518	-244	
Sylvania	4853	-2579	
Sternberg	2654	-380	

9.0 Conclusions

The four products evaluated as part of this study are considered to have represented best-in-class LED performance for this application as of March 2011, when product selections were finalized. However, the resulting energy savings were found to be directly attributable to reduced illumination levels relative to the existing HPS ornamental post-top street lights. Cost-effectiveness was also found to be inadequate when the LED products were hypothetically scaled to match maintained HPS illumination, with pricing and wattage scaled proportionately. The performance gap remained even when mesopic visual adaptation and unrestricted extrapolation of LM-80 data were considered.

It is important to note, however, that the LED industry continues to improve rapidly – initial efficacy is increasing even as the cost per lumen decreases. As a result, the potential for identification of a cost-effective LED replacement in any given application can be expected to increase with time. Similarly, this evaluation was restricted to products yielding an appearance similar to the existing HPS when viewed during the day or at night. It is possible that superior alternatives were available, albeit in a format considered incompatible with this particular application.

An important lesson reinforced by this project was the benefit of coordination between the manufacturer and the customer to ensure optimal performance for a given LED product in this particular application. This is especially critical for lamp-ballast retrofit kits, which are not necessarily compatible with existing luminaires when essentially purchased "off-the-shelf." The issue is of somewhat lesser significance for complete luminaire replacements, since most components are already integrated by the manufacturer for thermal, optical, electrical, and mechanical compatibility.

Considerable resources were required for this project, from product selection and evaluation to the production of this report. The Municipal Solid-State Street Lighting Consortium recently issued the first draft of the Model Specification for LED Roadway Luminaires, which is intended to minimize the burden for municipalities and utilities considering LED products for similar applications.[39] The template can be customized to meet the particular needs of individual organizations in order to help them put together effective bid documents. Some guidance is offered in the form of default criteria, which, for example, effectively discourage specification of parameters such as LED drive current and operating temperature (which should instead be clearly communicated by the manufacturer).

IES HB-10 and IES TM-21 were released during the course of this demonstration. Data generated as part of this project may prove useful to standards organizations, manufacturers, and those considering retrofitting to LED technology. For example, it is not clear whether measurement of the spatial variation of color is feasible or of practical importance in terms of mesopic visual adaptation. Similarly, owners would benefit from additional guidance when establishing parameters for lighting design and economic analysis. Individuals responsible for the evaluation of product submittals must understand the nuances and limitations of lumen maintenance life ratings.

[39] For more information, visit www.ssl.energy.gov/specification.html and www.ssl.energy.gov/msslc_model-spec2011_webinar.html.

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Appendices

Appendix A

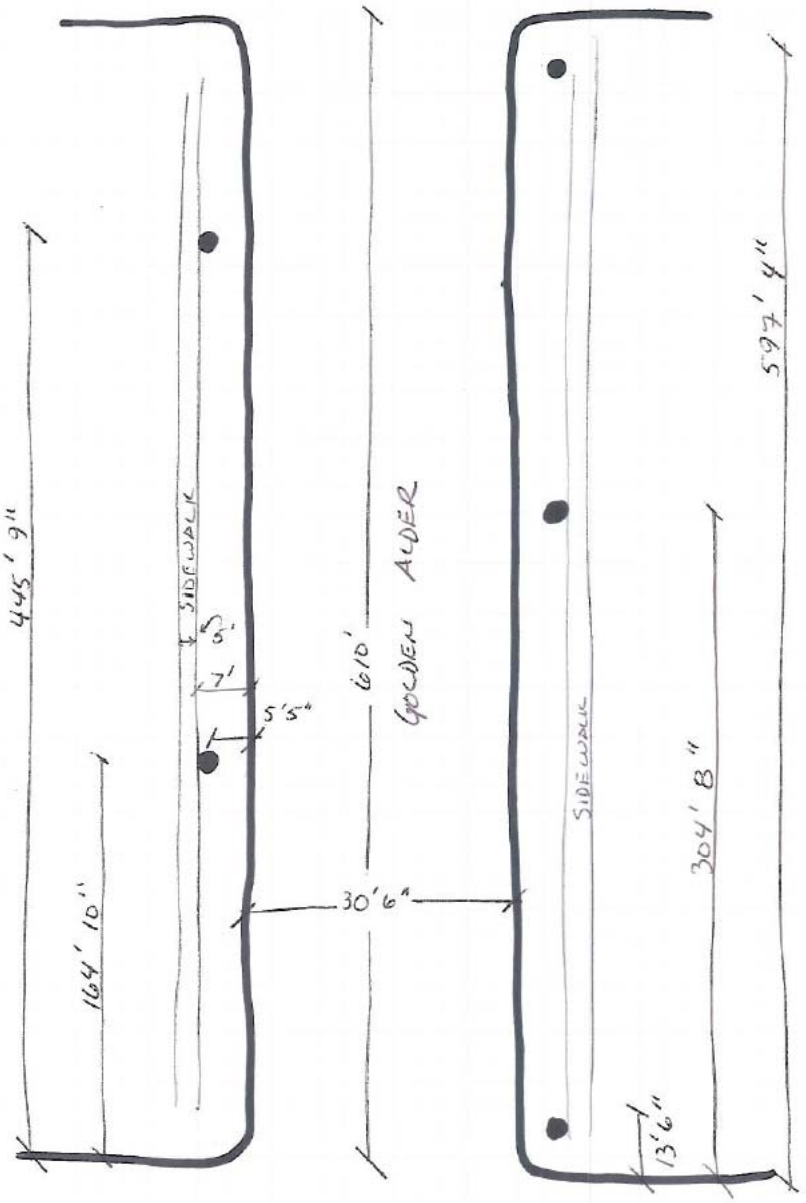
Existing HPS Luminaires, Poles, and Locations

Energy & Technology Center

1-26-11

Sacramento Municipal Utility District

RED ALDER



GOLDEN POPLAR

6301 S Street, Sacramento, CA • (916) 732-6738 • www.smud.org/etc

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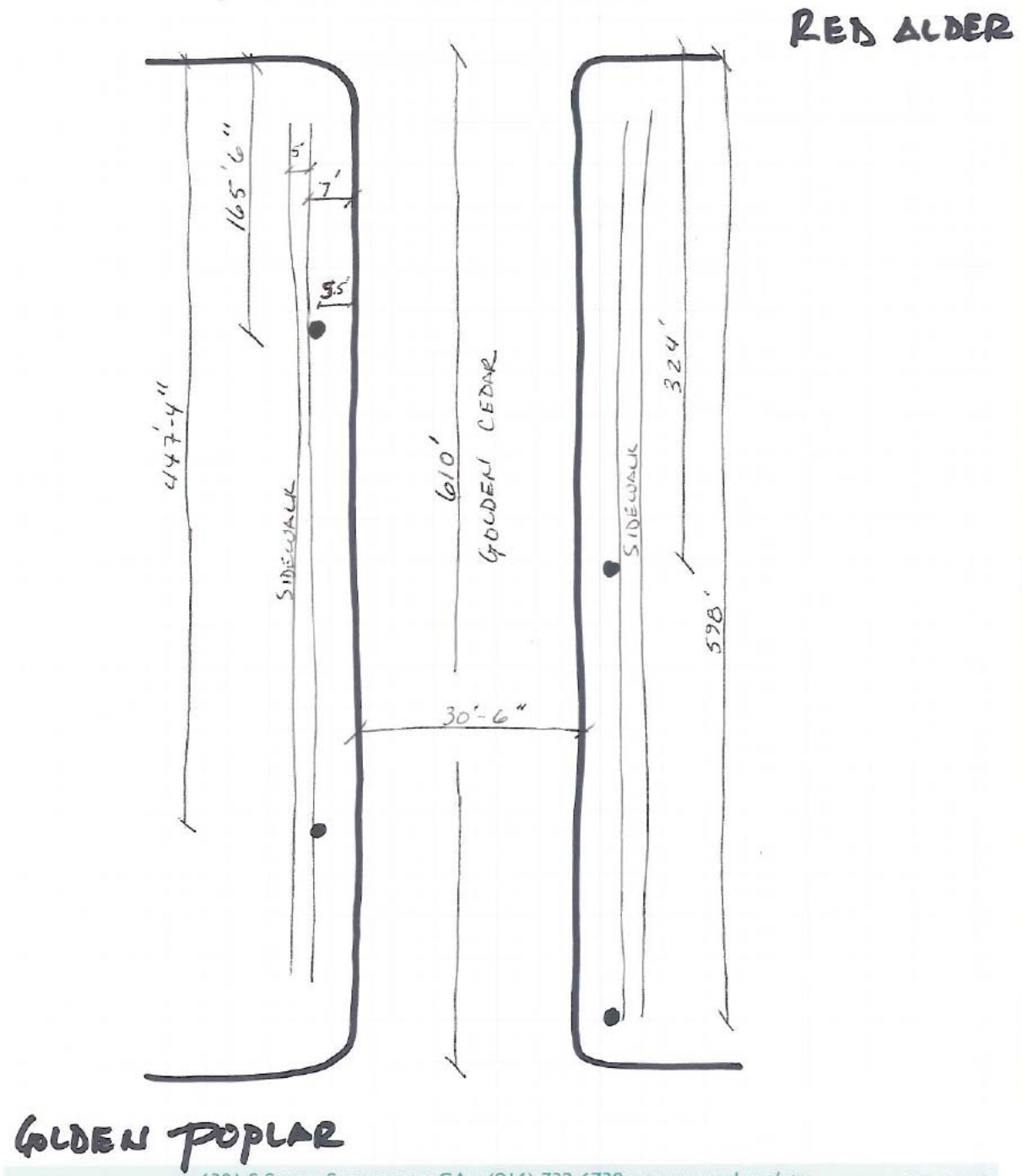
Energy & Technology Center

1-26-11

Sacramento Municipal Utility District



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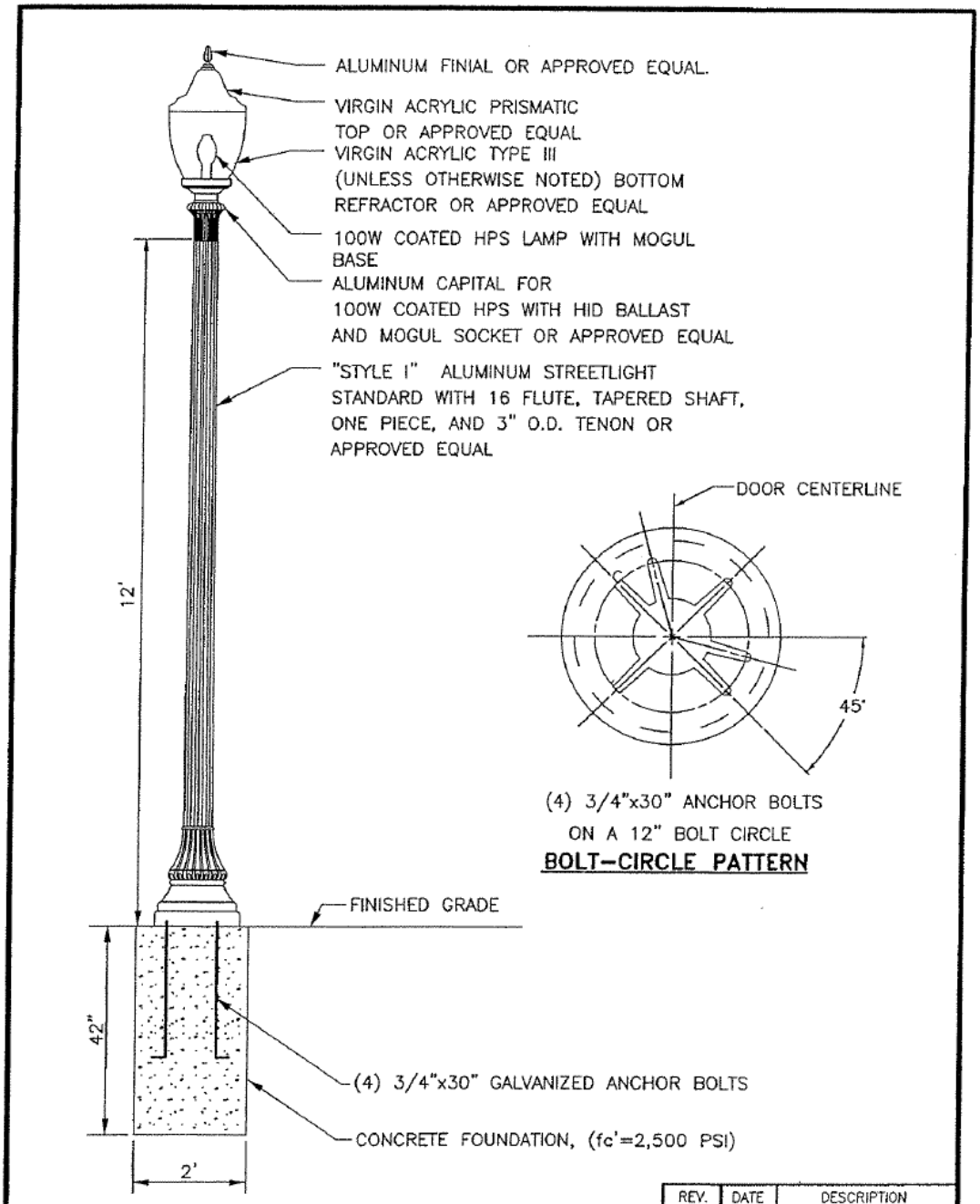
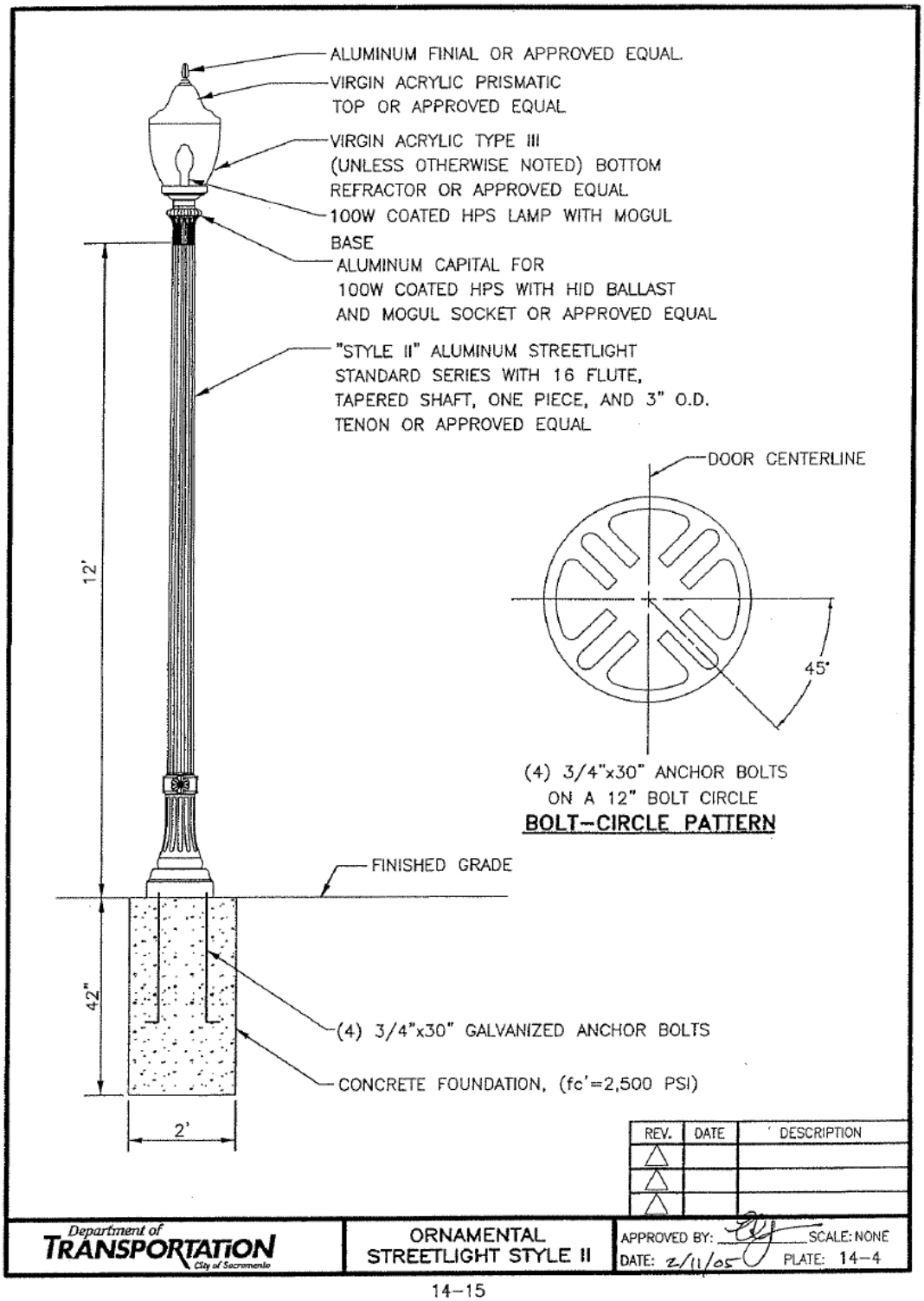

ALUMINUM FINIAL OR APPROVED EQUAL.
VIRGIN ACRYLIC PRISMATIC TOP OR APPROVED EQUAL
VIRGIN ACRYLIC TYPE III (UNLESS OTHERWISE NOTED) BOTTOM REFRACTOR OR APPROVED EQUAL
100W COATED HPS LAMP WITH MOGUL BASE
ALUMINUM CAPITAL FOR 100W COATED HPS WITH HID BALLAST AND MOGUL SOCKET OR APPROVED EQUAL
"STYLE I" ALUMINUM STREETLIGHT STANDARD WITH 16 FLUTE, TAPERED SHAFT, ONE PIECE, AND 3" O.D. TENON OR APPROVED EQUAL
12'
DOOR CENTERLINE
45°
(4) 3/4"x30" ANCHOR BOLTS ON A 12" BOLT CIRCLE
BOLT-CIRCLE PATTERN
FINISHED GRADE
42"
(4) 3/4"x30" GALVANIZED ANCHOR BOLTS
CONCRETE FOUNDATION, (fc'=2,500 PSI)
2'
REV.
DATE
DESCRIPTION
Department of TRANSPORTATION City of Sacramento
ORNAMENTAL STREETLIGHT STYLE I
APPROVED BY:
DATE: 2/11/05
SCALE: NONE
PLATE: 14-3

14-14

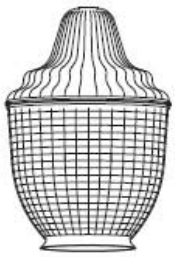

ALUMINUM FINIAL OR APPROVED EQUAL.
VIRGIN ACRYLIC PRISMATIC TOP OR APPROVED EQUAL
VIRGIN ACRYLIC TYPE III (UNLESS OTHERWISE NOTED) BOTTOM REFRACTOR OR APPROVED EQUAL
100W COATED HPS LAMP WITH MOGUL BASE
ALUMINUM CAPITAL FOR 100W COATED HPS WITH HID BALLAST AND MOGUL SOCKET OR APPROVED EQUAL
"STYLE II" ALUMINUM STREETLIGHT STANDARD SERIES WITH 16 FLUTE, TAPERED SHAFT, ONE PIECE, AND 3" O.D. TENON OR APPROVED EQUAL
DOOR CENTERLINE
45°
(4) 3/4"x30" ANCHOR BOLTS ON A 12" BOLT CIRCLE
BOLT-CIRCLE PATTERN
12'
FINISHED GRADE
42"
(4) 3/4"x30" GALVANIZED ANCHOR BOLTS
CONCRETE FOUNDATION, (fc'=2,500 PSI)
2'
REV.
DATE
DESCRIPTION
Department of TRANSPORTATION City of Sacramento
ORNAMENTAL STREETLIGHT STYLE II
APPROVED BY:
DATE: 2/11/05
SCALE: NONE
PLATE: 14-4

14-15

PRISMATIC POST TOP

The Lindy® Model 424

Model 424 Type V



-Model 424

23.16" high
15.9" diameter

NOSTALGIC POST TOP
FOR STREET AND
AREA LIGHTING

TYPE III AND TYPE V
DISTRIBUTIONS

Model 424 Type III
Medium non-cutoff
81.25% Efficiency
14.57% Uplight with LiteLid®
66.68% Downlight

Materials: Acrylic,
Acrylic Moon Glow ™
and Polycarbonate

Description

LexaLite's The Lindy® Model 424 refractor and prismatic top feature a traditional turn-of-the-century shape and state-of-the-art photometric performance. The 424 Series is available in IES Type III and Type V distributions, and will classify as medium, non-cutoff or semi-cutoff, depending upon lamp type and lamp center location. The assembled refractor bottom and top are 15.9" in diameter, 23.16" high and are available in 8" or 9" diameter fitters for pole heights 10'–20'. Both the refractor and prismatic top are available in polycarbonate, for use in areas where breakage is a concern; and HID acrylic and acrylic Moon Glow™ (diffuse acrylic), for high efficiency in general lighting applications. Both components can be produced in high heat acrylic and impact acrylics.

Application

LexaLite's Model 424 refractor and Model 424 prismatic top are for use in parks, along walkways, roadways or areas where a distinctive nostalgic theme is prevalent.

Lamp Data

The Model 424 is capable of being used with 150W diffuse HPS or 175W coated MH vertical base down lamps and can be used with up to 250W lamps. Luminaire design, reflector configuration, lamp position and ambient temperature will affect the inside surface temperature. Thermal tests should be conducted on each luminaire design to confirm appropriate lamp size for the application.

Ordering Information

Please call 877-257-5841 for price and delivery. Typical lead time is four to six weeks.

Service Life

The service life of acrylic refractors is virtually unlimited when used within the recommended temperature limit. Acrylic versions are covered by our 10 year limited warranty. Polycarbonate refractors are subject to yellowing especially when used with high ultraviolet output light sources; this effect is enhanced at high temperatures.

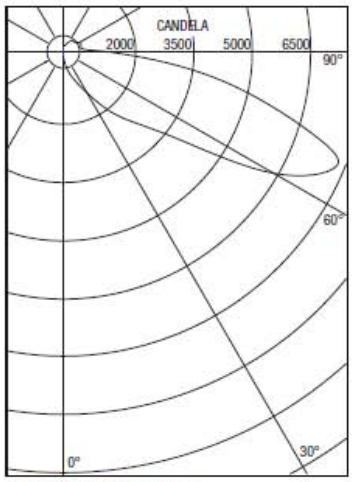
Notice

A.L.P. Lighting Components, Inc. assumes no responsibility for suitability of luminaires and applications. The use of our molded products at excessive temperatures with high UV output light sources will cause degradation of the material. Information regarding the use of lenses and refractors with Metal Halide lamps can be found in the Products/Technical Resources section of our web site at www.alplighting.com. *See second page for important UL information.

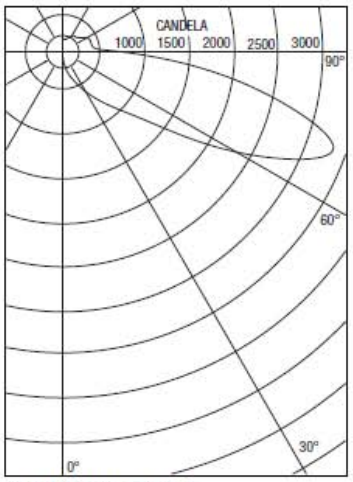
A.L.P.
LIGHTING COMPONENTS, INC.
WEB SITE: WWW.ALPLIGHTING.COM

LEXALITE

Model 424



Report Number: ITL48610
Total Luminaire Efficiency = 81.25%
IES Classification: Type III, Medium, Non-Cutoff



Report Number: ITL48623
Total Luminaire Efficiency = 81.72%
IES Classification: Type V, Semi-cutoff

Photometrics:

The Model 424 Type III, coupled with the perforated LiteLid, Model 424 top and a 150W diffuse HPS lamp, produces 7792 candela at 67.5° vertical and 73.3° lateral (ITL48610). The Model 424 Type V, coupled with the perforated LiteLid, Model 424 top and a 150W diffuse HPS lamp, produces 3337 candela at 70° vertical (ITL48623). Both the Type III and V distributions are optimized with diffuse HPS and coated MH lamps. Use of clear lamps may produce reduced uniformity. Individual luminaire performance depends on the lamp center position and the reflector design chosen. Each luminaire design should be individually tested for proper classification. Please call for additional photometric data. Light center location for the Type V shown in report ITL 48623 is 2.7" down from upper rim.

Accessories

LiteLid® should be utilized in light pollution-sensitive areas to redirect potentially wasted uplight into increased downward efficiencies. The LiteLid allows just enough uplight for a pleasing glow. LiteLids are patented, aluminum reflectors which fit between the top and bottom components.

4245P Perforated LiteLid

4245N Non-perforated LiteLid

Stainless Steel Clamp Band For attachment of top.

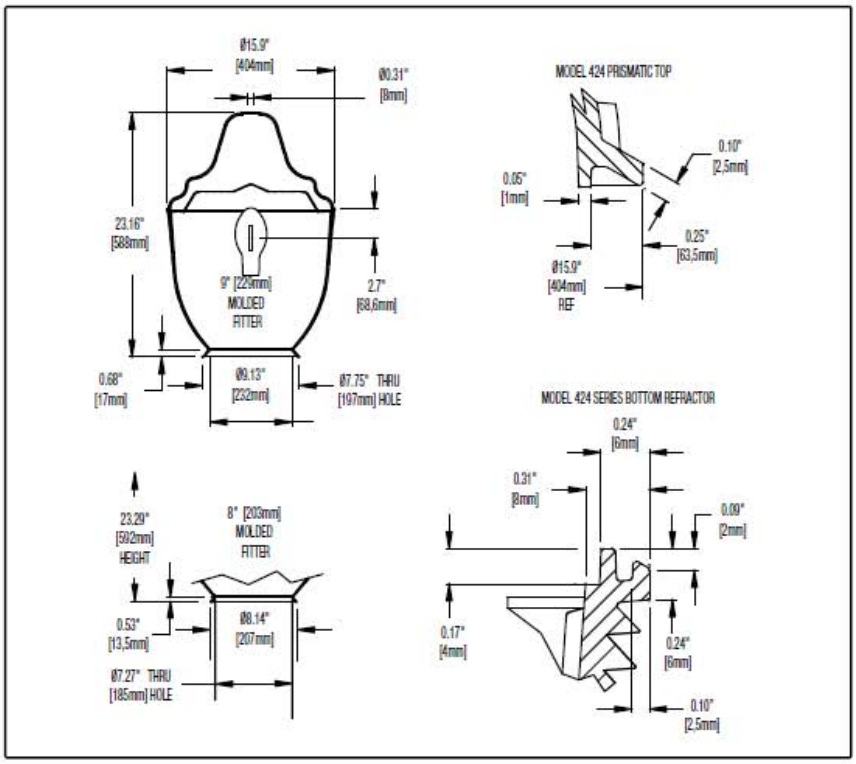
Finials Available in either black flame or black spike design.

Neck Ring Protects fitter from metal screws.

Materials

See the LexaLite® brand price list for current part numbers and material offerings. Up-to-date and detailed material specifications can be found in the Products/Technical Resources section of our web site at www.alplighting.com.

When using an acrylic Model 424, the surface temperature of the refractor should not exceed 80°C. When using a polycarbonate Model 424, the surface temperature of the refractor should not exceed 90°C.



This drawing is for reference only. Actual part dimensions will vary. Customer is urged to review actual samples to confirm fit and function. All specifications and dimensions are subject to change without notice.

***Effective June 30, 2010, lenses associated with this product will no longer be UL recognized components. A.L.P. LexaLite recommends the use of open rated lamps with any polymeric lens. These lenses should not be used as arc retention devices.**

A.L.P.
LIGHTING COMPONENTS, INC.
WWW.ALPLIGHTING.COM

LEXALITE
6333 Gross Point Road • Niles, IL 60714
877-257-5841 TeL • 800-438-2500 Fax • www.alplighting.com

Appendix B

Manufacturer Product Data – Hadco LED

(Lamp-Ballast Retrofit Kit)

Retrofit Program
Refractive Globe LumiLock™ LED

Learn more about Hadco's Retrofit Program at Hadco.com.

PHILIPS
HADCO
sense and simplicity

Why Retrofit?

Key Features and Benefits

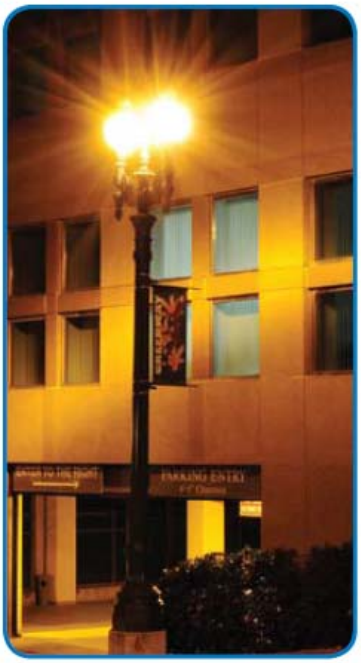
Lighting can play an important role in transforming the look of an outdoor space. Whether you are looking to create a unique identity for your town, school campus, or shopping area, Philips Hadco has a greener solution for you. Retrofitting to the LumiLock™ LED will help you to beautify and add a sense of well being and security to your outdoor space while at the same time offering energy savings and sustainability.

Philips Hadco's LumiLock™ LED engine is an energy efficient choice for updating your outdoor lighting. The LumiLock™ LED engine is an ideal alternative to HID sources and will provide 50% or more energy savings.

The LumiLock™ provides a quick and simple retrofit solution while maintaining excellent light levels. This solution also creates a maintenance friendly fixture that provides 60,000 hours of life.

Concord, NC Retrofit Example

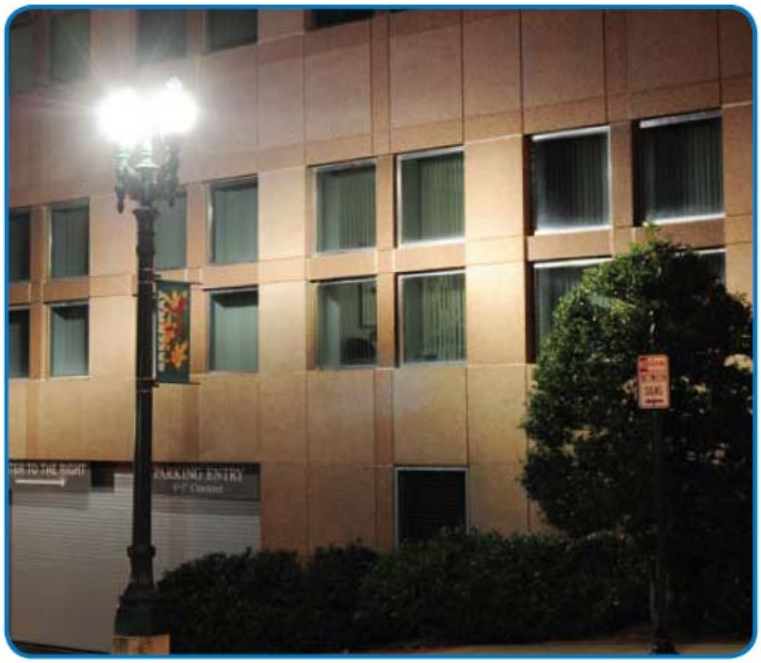
Before



HPS

- Multiple re-lampings
- Poor CRI
- Warm-up time
- Non-dimmable
- Avg lamp life (24k hrs)

After



LED

- Energy efficient
- Low maintenance
- Crisp, white light
- Instant on / off
- Dimmable capability
- Total system life (60k hrs)

"This installation proved to be very simple and was completed in half the time expected. The lighting levels and uniformity have met or exceeded our initial expectations, while receiving many positive reviews."

Scott Chunn
Electrical Systems Manager
City of Concord, NC

LED Specifications

Simple Retrofit and Upgrade Installation

Upgrading a luminaire from a traditional lamp source to LED doesn't have to mean a replacement of an entire luminaire. Philips Hadco's LumiLock™ provides a quick retrofit solution. Just twist out the existing LumiLock™ assembly and replace it with the GX1 LED system.

Asymmetric or Symmetric - when you have the GX1 LED, you have both.

The patent-pending design of the Opt-Adjust™ system offers the ultimate in versatility. With this design one GX1 LED system can be quickly converted from symmetric to asymmetric distribution or vice-versa.

Simply remove four screws, move two LED bars to the open locations and replace the screws. Tabs lock the light bars at their proper position to ensure optimum optical performance. For more detailed information, download the instruction sheet from www.hadco.com.

LumiLock™ GX1 LED Specifications

- (10) 100 lumen LUXEON Rebel LEDs on each aluminum core PCB.
- Cast aluminum heat sink design.
- Sealed, acrylic lens; IP66 rated.
- Symmetric & asymmetric distribution patterns (field adjustable).
- 3000K, 4000K, 5000K color temperature (CCT).
- Min. 70 color rendering index (CRI).
- Approximately 60,000* hours of operational life.
- Operating temperature range: -40°C to +50°C.
- Smart Select™ electronic driver 120 - 277 VAC; 50 - 60 Hz; auto-sensing.
- ETL and cETL listed.
- 5 year extended warranty.
- 6KV surge protection.

* 25°C ambient temperature

Custom Lamping Options

Philips QL Induction
- 100,000 hours rated average life
- Maintenance free
- Instant hot or cold start
- No color shift
- Crisp white light

Philips MasterColor CDM Elite
- High quality and high efficient white light
- Lamp, ballast and socket system
- Long life
- Two color temperatures & wattages

Philips CosmoPolis™
- 65% smaller than respective quartz metal halide, ceramic metal halide, high pressure sodium, and mercury vapor lamps
- Step dimming capability with three possible dimming times of 6 hours

LED Ordering Guide

Example: RPTLD RL32 5 L55

LumiLock LED Engine	Model No. RL32 (Narrow Body Type 3) RL52 (Narrow Body Type 5) RL34 (Wide Body Type 3) RL54 (Wide Body Type 5)	Color Temperature 3 (3000K) 4 (4000K) 5 (5000K)	Source/ Lumens L30 (3000 LM) L55 (5500 LM)
RPTLD	( )	( )	L30
RPTLD	( )	( )	L55

Example: RLG32AEAA

Replacement LED Refractive Globe RLG32 (Narrow Body Type 3) RLG52 (Narrow Body Type 5) RLG34 (Wide Body Type 3) RLG54 (Wide Body Type 5)	Roof A (Victorian, Clear Acrylic) B (Acorn, Clear Acrylic) C (Tall Spun Aluminum) D (Short Spun Aluminum) N (None)	Band E (Band w/ Sq Flower Block) F (Band w/ Rnd Flower Block) N (None)	Finial A (Maple Leaf) B (Hagerstown) *C (Capitol) *D (Old Boston) *E (Franklin) F (Short Urn) G (Short Urn) H (Min-Hagerstown) N (None)	Finish A (Black) B (White) G (Verde) H (Bronze) I (Gray) J (Green) N (None)
( )	( )	( )	( )	( )
( )	( )	( )	( )	( )
( )	( )	( )	( )	( )

*Can't be used with roof B

LumiLock LED Engine

Asymetric (Type 3) Symmetric (Type 5)

Narrow Body Globe / Wide Body Globe

RL32 RL52 RL34 RL54

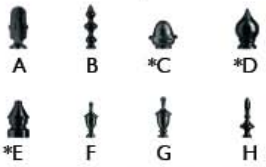
Roof Options

A B C D

Band Options

F E

Finial Options



A B *C *D *E F G H

Program Details

- Custom options are available for QL, Master Color Elite and Cosmopolis. Lamping options and other Hadco post tops, contact factory for pricing.
- For Hadco products greater than 10 years old and/or retro fitting other existing products please consult factory.

PHILIPS HADCO

www.hadco.com
100 Craftway Drive, P.O. Box 128, Littlestown, PA 17340
Phone: 1-866-423-2658 • Fax: 717-359-0618
Printed in U.S.A. PH-1024-1008-7H

LUXEON Rebel
IES LM-80 Test Report

Design Resource DR04

LUXEON
never before possible

LUXEON® Rebel

IES LM-80 Test Report

1. Number of LED light sources tested

Eighty or 160 units per test / 25 units reported. Units reported are selected as follows:

a) Units are assigned to nominal CCT bins of 2650K, 3000K, 3500K, 4000K, or 6000K.

b) The first 25 units from each CCT bin are reported. See section 14 below for more detail.

2. Description of LED light sources

Devices tested:

LUXEON Rebel p/n: LXM8-PW27 (nominal CCT 2700K)
LUXEON Rebel p/n: LXM8-PW30 (nominal CCT 3000K)
LUXEON Rebel p/n: LXM3-PW61 (nominal CCT 3500K)
LUXEON Rebel p/n: LXM3-PW51 (nominal CCT 4000K)
LUXEON Rebel p/n: LXML-PWC1 (nominal CCT 6000K)

This IES LM-80 Test Report applies to the LUXEON Rebel part numbers in Table 1.

PHILIPS
LUMILEDS

$T_S = T_{AIR} = 85°C$, $I_F = 0.35A$

$T_S \geq 83C$, $T_{AIR} \geq 80C$ in compliance with LM-80-08

		CCT (t=0)	Normalized flux 0	24	168	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
DATA SET 26: CCT = 4000K, T_J = 98C	A26	3881	1.0000	1.0043	1.0185	1.0284	1.0363	1.0376	1.0363	1.0409	1.0323	1.0073				
	A27	3917	1.0000	1.0039	1.0164	1.0247	1.0307	1.0384	1.0373	1.0350	1.0145	1.0134				
	A35	3973	1.0000	1.0119	1.0288	1.0370	1.0421	1.0499	1.0437	1.0285	1.0193	1.0171				
	A36	4199	1.0000	1.0140	1.0306	1.0403	1.0462	1.0015	1.0015	0.9956	0.9790	0.9776				
	A37	4253	1.0000	1.0120	1.0304	1.0398	1.0467	0.9185	0.9215	0.9099	0.8967	0.8947				
	A38	4223	1.0000	1.0119	1.0278	1.0377	1.0458	0.9654	0.9584	0.9626	0.9518	0.9532				
	A39	4145	1.0000	1.0156	1.0268	1.0366	1.0443	1.0447	1.0494	1.0447	1.0340	1.0314				
	A43	3953	1.0000	1.0301	1.0545	1.0669	1.0761	1.0541	1.0519	1.0552	1.0455	1.0224				
	A44	3851	1.0000	1.0219	1.0420	1.0562	1.0618	1.0379	1.0402	1.0308	1.0109	1.0042				
	A50	4061	1.0000	1.0106	1.0228	1.0255	1.0300	1.0491	1.0433	1.0456	1.0266	1.0180				
	A63	3968	1.0000	1.0246	1.0432	1.0511	1.0549	1.0658	1.0662	1.0660	1.0556	1.0430				
	A64	3930	1.0000	1.0224	1.0442	1.0543	1.0624	1.0779	1.0785	1.0740	1.0460	1.0435				
	B30	4256	1.0000	1.0142	1.0246	1.0353	1.0390	1.0425	1.0425	1.0561	1.0409	1.0219				
	B31	4072	1.0000	1.0184	1.0312	0.0000	1.0421	0.9961	0.9886	0.9944	0.9850	0.9673				
	B32	4111	1.0000	1.0183	1.0345	1.0404	1.0460	1.0077	1.0024	1.0051	0.9866	0.9734				
	B33	4027	1.0000	1.0102	1.0212	1.0271	1.0325	0.9958	0.9877	0.9801	0.9683	0.9663				
	B34	4173	1.0000	1.0181	1.0312	1.0381	1.0414	1.0508	1.0442	1.0477	1.0259	1.0196				
	B40	4281	1.0000	1.0120	1.0229	1.0347	1.0392	1.0652	1.0627	1.0641	1.0496	1.0299				
	B50	4287	1.0000	1.0128	1.0266	1.0360	1.0405	1.0734	1.0699	1.0782	1.0440	1.0427				
	B52	3917	1.0000	1.0100	1.0214	1.0314	1.0372	1.0138	1.0153	1.0176	0.9907	0.9840				
	B53	3865	1.0000	1.0013	1.0089	1.0184	1.0245	1.0097	1.0034	0.9953	0.9824	0.9819				
	B54	3877	1.0000	1.0033	1.0095	1.0175	1.0218	1.0118	0.9871	0.9917	0.9760	0.9766				
	B55	3919	1.0000	1.0043	1.0113	1.0193	1.0227	1.0605	1.0561	1.0622	1.0371	1.0341				
	B60	4192	1.0000	1.0193	1.0352	1.0438	1.0479	1.0856	1.0826	1.0851	1.0581	1.0431				
	B69	3900	1.0000	1.0045	1.0182	1.0233	1.0255	1.0212	1.0201	1.0267	1.0117	1.0002				
	ave	**4049**	**1.0000**	**1.0132**	**1.0273**	**0.9946**	**1.0415**	**1.0310**	**1.0276**	**1.0277**	**1.0108**	**1.0027**				
DATA SET 32: CCT > 5000K, T_J = 98C	A8	6331	1.0000	0.9858	1.0074	1.0099	1.0067	0.9975	0.9979	0.9920	0.9923	0.9658	0.9805	0.9802	0.9819	
	A9	6217	1.0000	0.9864	1.0092	1.0118	1.0080	1.0000	1.0066	1.0033	1.0069	0.9861	0.9883	0.9897	0.9908	
	A10	5932	1.0000	0.9888	1.0103	1.0130	1.0091	1.0032	1.0099	1.0065	1.0093	0.9864	0.9848	0.9904	0.9935	
	A11	5669	1.0000	0.9954	0.9983	0.9987	0.9938	0.9769	0.9723	0.9687	0.9703	0.9429	0.9450	0.9555	0.9562	
	A12	5623	1.0000	0.9942	0.9895	0.9985	0.9936	0.9788	0.9804	0.9736	0.9753	0.9614	0.9647	0.9601	0.9611	
	A13	5694	1.0000	0.9968	0.9922	1.0009	0.9968	0.9818	0.9838	0.9800	0.9792	0.9641	0.9652	0.9671	0.9658	
	A14	5629	1.0000	0.9972	1.0011	1.0020	0.9973	0.9823	0.9868	0.9762	0.9830	0.9689	0.9760	0.9724	0.9725	
	A15	5630	1.0000	0.9954	0.9988	0.9999	0.9958	0.9836	0.9872	0.9826	0.9817	0.9675	0.9648	0.9685	0.9711	
	A18	6481	1.0000	1.0029	1.0109	1.0165	1.0148	1.0129	1.0181	1.0152	1.0180	1.0155	1.0054	1.0084	1.0095	
	A19	6412	1.0000	1.0039	1.0138	1.0204	1.0190	1.0179	1.0218	1.0182	1.0189	1.0164	1.0005	1.0073	1.0078	
	A20	6391	1.0000	1.0048	1.0153	1.0221	1.0214	1.0222	1.0282	1.0283	1.0296	1.0257	1.0202	1.0174	1.0189	
	A21	6379	1.0000	1.0049	1.0134	1.0175	1.0156	1.0019	1.0044	0.9990	0.9980	0.9792	0.9841	0.9770	0.9741	
	A22	6488	1.0000	1.0039	1.0113	1.0146	1.0114	0.9990	1.0018	0.9963	0.9933	0.9880	0.9835	0.9751	0.9766	
	A23	6306	1.0000	1.0038	1.0117	1.0147	1.0115	0.9991	0.9989	0.9921	0.9921	0.9876	0.9833	0.9762	0.9764	
	A24	6088	1.0000	1.0043	1.0117	1.0156	1.0103	0.9993	1.0001	0.9962	0.9948	0.9866	0.9785	0.9723	0.9709	
	A25	5641	1.0000	1.0045	1.0128	1.0164	1.0128	1.0033	1.0032	0.9996	0.9977	0.9917	0.9797	0.9831	0.9848	
	A29	5504	1.0000	0.9982	1.0086	1.0099	1.0064	1.0020	1.0037	0.9990	0.9975	0.9832	0.9739	0.9811	0.9835	
	A30	5606	1.0000	0.9990	1.0080	1.0279	1.0298	1.0236	1.0232	1.0193	1.0189	1.0119	0.9984	1.0011	1.0043	
	A31	6115	1.0000	0.9985	1.0037	1.0063	1.0019	0.9872	0.9867	0.9842	0.9862	0.9813	0.9693	0.9754	0.9736	
	A32	5821	1.0000	0.9985	1.0039	1.0063	1.0025	0.9887	0.9900	0.9867	0.9860	0.9821	0.9658	0.9763	0.9767	
	A33	5853	1.0000	0.9994	1.0049	1.0074	1.0026	0.9901	0.9916	0.9878	0.9874	0.9833	0.9600	0.9782	0.9773	
	A34	5884	1.0000	0.9990	1.0048	1.0062	1.0009	0.9900	0.9941	0.9921	0.9905	0.9862	0.9785	0.9788	0.9789	
	A35	5688	1.0000	0.9964	1.0054	1.0076	1.0032	0.9934	0.9977	0.9965	0.9999	0.9856	0.9958	0.9975	0.9994	
	A36	6164	1.0000	1.0092	1.0218	1.0294	1.0289	1.0215	1.0286	1.0268	1.0297	1.0268	1.0114	1.0190	1.0206	
	A37	6136	1.0000	1.0093	1.0223	1.0302	1.0295	1.0225	1.0293	1.0277	1.0280	1.0118	1.0015	1.0187	1.0205	
	ave	**5987**	**1.0000**	**0.9992**	**1.0076**	**1.0121**	**1.0089**	**0.9992**	**1.0018**	**0.9979**	**0.9986**	**0.9874**	**0.9824**	**0.9851**	**0.9859**	

$T_S = T_{AIR} = 120°C$, $I_F = 0.35A$ (CCT = 5000°K set: $T_S = T_{AIR} = 98C$)

$T_S \geq 118C$, $T_{AIR} \geq 115C$ in compliance with LM-80-08

CCT = 5000K Data Set: $T_S \geq 98C$, $T_{AIR} \geq 93C$ in compliance with LM-80-08

			Normalized flux													
		CCT (t=0)	0	24	168	500	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
DATA SET 25: CCT = 4000K, T_J = 133C	A11	3988	1.0000	1.0196	1.0335	1.0424	1.0345	0.9969	0.9926	1.0005	0.9890	1.0171				
	A12	3889	1.0000	1.0162	1.0331	1.0516	1.0330	1.0563	1.0507	1.0585	1.0535	1.0647				
	A14	3884	1.0000	1.0246	1.0385	1.0483	1.0430	0.9625	0.9627	0.9731	0.9677	0.9691				
	A15	3851	1.0000	1.0206	1.0282	1.0216	1.0544	1.0143	1.0136	1.0180	1.0133	1.0090				
	A16	4002	1.0000	1.0223	1.0375	1.0420	1.0401	0.9704	0.9600	0.9679	0.9650	0.9624				
	A17	3904	1.0000	1.0258	1.0436	1.0555	1.0577	0.9825	0.9844	0.9929	0.9884	0.9888				
	A18	3931	1.0000	1.0140	1.0290	1.0444	1.0413	0.9910	0.9893	0.9957	0.9889	0.9894				
	A19	3850	1.0000	1.0177	1.0315	1.0369	1.0280	1.0326	1.0234	1.0310	1.0271	1.0263				
	A20	3893	1.0000	1.0171	1.0299	1.0390	1.0321	1.0388	1.0310	1.0401	1.0326	1.0299				
	A21	3951	1.0000	1.0214	1.0344	1.0464	1.0497	1.0220	1.0111	1.0132	1.0042	1.0019				
	A22	3986	1.0000	1.0254	1.0377	1.0623	1.0687	1.0716	1.0933	1.0853	1.0700	1.0899				
	A25	3967	1.0000	1.0203	1.0340	1.0575	1.0531	0.9813	0.9810	0.9869	0.9734	0.9626				
	A26	3944	1.0000	1.0202	1.0332	1.0563	1.0613	0.9958	0.9842	0.9886	0.9751	0.9658				
	A33	3916	1.0000	1.0192	1.0459	1.0532	1.0424	0.9898	0.9872	0.9975	0.9949	0.9918				
	A34	3916	1.0000	1.0217	1.0354	1.0402	1.0366	1.0155	1.0117	1.0217	1.0139	1.0130				
	A35	3851	1.0000	1.0235	1.0376	1.0653	1.0557	1.1228	1.1251	1.1300	1.1247	1.1217				
	A41	3941	1.0000	1.0197	1.0342	1.0591	1.0420	1.0522	1.0318	1.0347	1.0307	1.0261				
	A42	3877	1.0000	1.0214	1.0373	1.0630	1.0483	1.0571	1.0488	1.0503	1.0453	1.0419				
	A43	3885	1.0000	1.0295	1.0437	1.0753	1.0419	0.9715	0.9764	0.9821	0.9786	0.9786				
	A48	3877	1.0000	1.0221	1.0380	1.0620	1.0451	0.9779	0.9713	0.9791	0.9766	0.9839				
	A49	3884	1.0000	1.0271	1.0431	1.0640	1.0438	1.0067	1.0089	1.0193	1.0147	1.0117				
	A50	3901	1.0000	1.0262	1.0403	1.0647	1.0452	1.0300	1.0323	1.0445	1.0423	1.0386				
	A51	3921	1.0000	1.0198	1.0423	1.0548	1.0507	0.9721	0.9623	0.9718	0.9705	0.9651				
	A52	3996	1.0000	1.0211	1.0341	1.0469	1.0433	0.9722	0.9730	0.9824	0.9766	0.9805				
	A53	3892	1.0000	1.0182	1.0403	1.0544	1.0428	0.9692	0.9609	0.9740	0.9695	0.9778				
	ave	**3916**	**1.0000**	**1.0214**	**1.0367**	**1.0523**	**1.0454**	**1.0101**	**1.0067**	**1.0136**	**1.0075**	**1.0083**				
DATA SET 31: CCT > 5000K, T_J = 123C	1	6742	1.0000	0.9748	0.9938	0.9890	0.9915	0.9915	0.9875	0.9841	0.9949	0.9895	0.9715	0.9809	0.9524	
	2	6638	1.0000	0.9829	0.9928	0.9880	0.9904	0.9893	1.0047	0.9832	1.0024	0.9883	0.9798	0.9740	0.9569	
	3	6769	1.0000	0.9821	0.9924	0.9880	0.9906	0.9885	0.9974	1.0005	1.0042	0.9826	0.9783	0.9767	0.9607	
	18	6437	1.0000	0.9859	0.9942	0.9917	0.9955	0.9965	1.0024	1.0018	1.0084	0.9940	0.9883	0.9863	0.9716	
	19	6415	1.0000	0.9852	0.9938	0.9911	0.9947	0.9975	1.0000	1.0025	1.0113	0.9978	0.9939	0.9929	0.9743	
	20	6207	1.0000	0.9841	0.9942	0.9923	0.9955	0.9997	1.0015	1.0024	1.0122	0.9982	0.9923	0.9917	0.9729	
	23	6626	1.0000	0.9959	1.0035	1.0014	1.0026	1.0093	1.0174	1.0253	1.0341	1.0212	1.0129	1.0077	0.9956	
	24	6375	1.0000	0.9956	1.0029		1.0028	1.0088	1.0214	0.9955	1.0161	1.0022	0.9954	1.0069	1.0005	
	25	6324	1.0000	0.9952	1.0022	0.9994	1.0007	1.0071	1.0176	1.0205	1.0149	1.0160	1.0080	1.0044	0.9966	
	33	6687	1.0000	0.9856	0.9939	0.9918	0.9939	0.9969	1.0087	1.0129	1.0084	1.0071	0.9863	0.9947	0.9735	
	34	6633	1.0000	0.9850	0.9932	0.9914	0.9934	0.9963	0.9984	0.9983	1.0049	0.9938	0.9782	0.9858	0.9741	
	35	6619	1.0000	0.9854	0.9931	0.9908	0.9906	0.9931	1.0063	1.0049	1.0025	1.0020	0.9918	0.9912	0.9760	
	39	5284	1.0000	0.9864	0.9895	0.9839	0.9824	0.9834	0.9956	0.9813	0.9756	0.9742	0.9542	0.9671	0.9585	
	40	5283	1.0000	0.9883	0.9907	0.9842	0.9821	0.9829	0.9952	0.9884	0.9941	0.9820	0.9737	0.9715	0.9359	
	41	6330	1.0000	0.9909	0.9961	0.9931	0.9937	0.9971	0.9980	0.9957	1.0067	0.9965	0.9783	0.9857	0.9665	
	42	6172	1.0000	0.9893	0.9950	0.9920	0.9927	0.9947	1.0015	1.0016	1.0067	0.9954	0.9878	0.9853	0.9731	
	43	6376	1.0000	0.9855	0.9929	0.9883	0.9917	0.9929	1.0039	1.0050	1.0123	0.9960	0.9860	0.9851	0.9748	
	44	6562	1.0000	0.9870	0.9932	0.9895	0.9921	0.9927	1.0123	1.0054	1.0125	0.9982	0.9872	0.9836	0.9725	
	45	6518	1.0000	0.9866	0.9930	0.9880	0.9888	0.9896	0.9991	0.9984	0.9857	0.9913	0.9828	0.9804	0.9670	
	52	6772	1.0000	0.9877	0.9948	0.9922	0.9914	0.9963	1.0080	1.0115	1.0197	1.0069	0.9979	0.9950	0.9875	
	61	6611	1.0000	0.9961	1.0014	0.9989	0.9981	1.0034	1.0041	1.0131	1.0172	1.0032	0.9943	0.9898	0.9749	
	62	6687	1.0000	0.9952	1.0008	0.9895	0.9905	1.0029	1.0190	0.9712	1.0195	1.0032	0.9890	0.9895	0.9841	
	63	6640	1.0000	0.9951	1.0011	0.9984	0.9981	1.0021	1.0093	1.0096	1.0012	0.9929	0.9833	0.9851	0.9805	
	64	6724	1.0000	0.9950	1.0002	0.9975	0.9972	1.0017	1.0155	1.0136	1.0210	0.9855	0.9882	0.9876	0.9813	
	65	6756	1.0000	0.9968	1.0006	0.9971	0.9962	1.0008	1.0168	1.0078	1.0162	1.0043	0.9964	0.9932	0.9878	
	ave	**6447**	**1.0000**	**0.9887**	**0.9960**	**0.9920**	**0.9935**	**0.9966**	**1.0057**	**1.0014**	**1.0081**	**0.9969**	**0.9870**	**0.9877**	**0.9740**	

Appendix C

Manufacturer Product Data – Simply LEDs

(Lamp-Ballast Retrofit Kit)

LED Lighting Solutions

Anello LED Acorn Series

THE GREEN ALTERNATIVE TO HIGH INTENSITY DISCHARGE LIGHTING WITH A FAST RETURN ON YOUR INVESTMENT

APPLICATIONS

- Acorn Street and Sidewalk Lights
- Type III & V Light Patterns

CONFIGURATIONS

- LED Upgrade Kit
- New LED Globe
- New LED Light Fixture

ECONOMICS

- More than 50% Power and Maintenance Savings
- Guaranteed Return on Investment

The SimplyLEDs Anello Acorn Series LED Lights are a brilliant choice to replace wasteful metal halide, mercury vapor and high pressure sodium lighting. Anello Lights improve light quality at a fraction of the operational and maintenance costs.

The Anello Light Architecture with its advanced thermal design and highest grade LEDs ensures optimal operating temperature even in the most demanding environments. The result is many years of lifetime, virtually maintenance free.

Anello Lights contain no hazardous material or toxic waste. Anello Lights fully meet the Buy American Act and are manufactured in the USA.

Scalable Architecture

Wattage	50W - 100W
Lumen Output	4000 - 6600 (at max. operating temp.)
Color Temperature	2850°K - 7000°K
CRI	Up to 82
Expected Lifetime*	Minimum 70% lumen at 50,000 hours (10 ½ years at 13 hours per Day)
Operating Temperature	-40°C to +50°C (-40°F to +122°F)
Electrical	120-277 VAC, 50/60 HZ
Configurations	LED Upgrade Kit –LED Globe –LED Fixture
Controller	Thermal Management -> Dimming -> Light Management
Warranty	5 Years

SIMPLYLEDS, LLC
3313 Brown St., Suite 5
Garden City, ID. 83714
Phone 208-344-7533
simplyleds.com

LED Lighting Solutions

Installation & Maintenance

- 30 Minute Installation
- Long Maintenance Free Life
- 5 Year Limited Warranty

Green

- Efficient, Less Energy per Lumen
- No Hazardous Material or Toxic Waste
- ROHS Compliant
- Designed for Recyclability
- Upgrade Kits Leverage Existing Fixture
- Instant On, No Warm-up
- Dark Sky Compliant and Configurable

SimplyLEDs, LLC
3313 Brown St., Suite 5
Garden City, ID. 83714
Phone 208-344-7533
simplyleds.com

Key Benefits, 60W Configuration

Type III Light for up to 4 Lane Streets, Spaced 60' Across

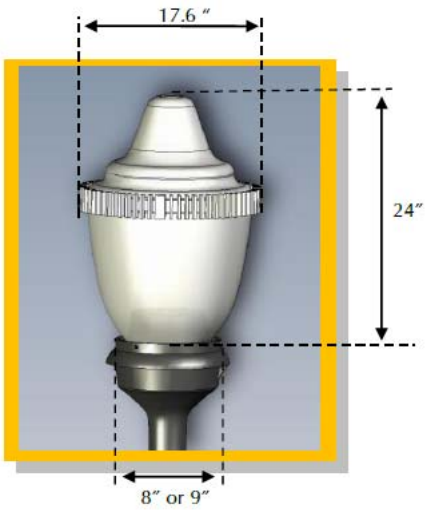
- **Significant Energy Savings**
  - > 50% .
- **Longer Lifetime**
  - More than 50,000 Hours at Minimum 70% Lumen
- **Excellent Light on Street Side**
  - Forward Light Ratio: 63.9 %.
  - Maximum Candela at 57.4 Horizontal and 64 Vertical Degrees.
- **Less Light Pollution & Glare**
  - Back Light Ratio: 20.2% or 756 Lm
  - Uplight Ratio: 15.9% or 592 Lm
- **Bright, Natural Night Light:**
  - Max FC: 3.84
  - Max Candela: 4638
  - Total Flux: 3732 Lm
  - Efficacy: 61.9 Lm/Watt
  - CRI 67
- **Environmentally Save**
  - No Hazardous Materials
  - Less Resource Consumption over Lifecycle

Photometric Data from ITL66069.IES

LED Lighting Solutions

simply brilliant

MADE IN THE
USA
BUY AMERICAN



ORDERING INFORMATION

LED upgrade kit:

ACN	- Wattage	- Color Type		- IES TYPE	- LG
	60	3000+ ºK	W	T3	
	80	4000+ ºK	N	T5	
		5000+ ºK	C		

e.g. ACN-60-C-T3-LG

Optional new globe:

Globe -		IES TYPE	Neck Size ″	- Finial	
Acrylic	A	3	8	Flame	F
Polycarbonate	P	5	9	Spike	S
				No finial	O
				1/3″ hole	H
				Neck Ring	R

e.g. A-3-8-O

SimplyLEDs' Anello Series Acorn Lights are designed to address a wide variety of lighting requirements. They are highly customizable to fit many more lighting applications. They come as LED upgrade kits, with an optional globe or as a completely new street light with many fitter, pole and base styles, heights, widths.

Please call 208 344 7533 or email sales@simplyLEDs.com for more information and pricing.

SIMPLYLEDS. LLC
3313 Brown St., Suite 5
Garden City, ID. 83714
Phone 208-344-7533
simplyleds.com

Report Number: BL-LM80-002 December 3, 2010

Bridgelux LM80 Report: 6,000 Hour Test Data

Bridgelux ES LED Array BXRA – W0802

Contents:

Operating Cycle

Test Condition

Number of units: 14 at 55ºC, 14 at 85ºC and 14 at 105ºC.
Drive current: 1400 mA, per array
Typical Voltage: 12.2V

Ambient Conditions

Summary of temperature and humidity conditions:

Table 1: Test Environment

Surrounding Temperature	Actual Case Temperature	Nominal Case Temperature	Relative Humidity
53ºC	55ºC	55ºC	7.9%
83ºC	85ºC	85ºC	3.4%
103ºC	105ºC	105ºC	2.8%

Airflow

Note: Airflow is kept to minimum required to maintain the required temperature uniformity as defined in the LM80 requirements document.

The temperature of the air surrounding DUTs is controlled to be less than 5ºC below the case temperature as required by LM80 specification.

Physical condition of parts at read-points

- No cracks
- No discoloration
- No electrical discontinuity

Case Temperature (Test Point Temperature)

Refer to Table 1 (Test Environment)

Drive Current

A drive current of 350mA per diode was used during lifetime test.

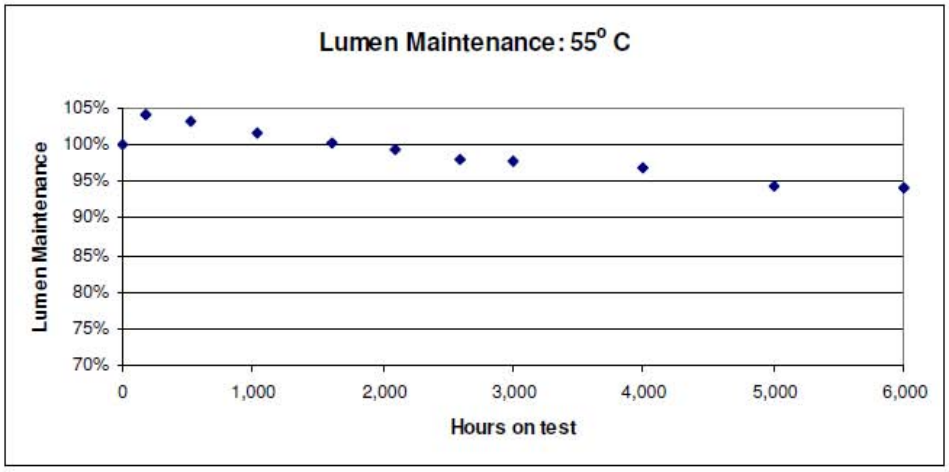
Lumen Maintenance

Ambient temperature during lumen measurements was maintained at 25ºC ±2ºC

Table 3: Lumen Maintenance at actual case temperature 55ºC

Hours	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14	Median	Standard Deviation	Max	Min
0	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.00%	100.0%	100.0%
184	104.4%	103.7%	102.0%	101.3%	102.2%	103.3%	104.3%	102.7%	104.3%	104.4%	104.3%	104.8%	102.7%	105.0%	104.0%	1.17%	105.0%	101.3%
522	103.7%	103.1%	101.3%	100.6%	101.3%	102.9%	103.8%	102.2%	103.5%	104.0%	103.3%	104.2%	102.4%	104.4%	103.2%	1.19%	104.4%	100.6%
1040	102.7%	102.2%	100.5%	99.8%	100.2%	101.9%	102.5%	101.2%	101.3%	102.9%	101.0%	102.5%	101.0%	101.8%	101.5%	0.97%	102.9%	99.8%
1608	102.1%	101.5%	100.1%	99.4%	99.6%	101.1%	101.6%	100.2%	99.7%	101.4%	98.8%	100.7%	99.7%	100.3%	100.3%	0.97%	102.1%	98.8%
2095	101.6%	101.1%	99.8%	99.2%	98.9%	100.5%	100.7%	99.1%	98.7%	99.7%	97.7%	99.2%	98.8%	99.4%	99.3%	1.07%	101.6%	97.7%
2597	100.7%	100.3%	99.0%	98.4%	98.1%	99.6%	99.7%	97.8%	97.4%	97.5%	96.7%	97.3%	97.8%	97.9%	98.0%	1.23%	100.7%	96.7%
3000	100.5%	100.2%	99.0%	98.1%	97.8%	99.3%	99.2%	97.4%	96.8%	96.5%	96.4%	96.3%	97.6%	97.3%	97.7%	1.40%	100.5%	96.3%
4000	99.4%	99.5%	98.1%	97.2%	96.8%	98.9%	98.8%	96.8%	96.5%	94.9%	96.0%	94.6%	96.9%	96.7%	96.9%	1.54%	99.5%	94.6%
5000	98.1%	96.1%	93.1%	98.4%	94.4%	92.6%	93.6%	96.8%	93.3%	94.1%	94.6%	95.3%	94.4%	92.8%	94.4%	1.89%	98.4%	92.6%
6000	97.3%	96.0%	92.7%	98.0%	89.6%	94.3%	92.3%	93.2%	96.3%	92.9%	93.5%	94.5%	94.9%	93.9%	94.1%	2.19%	98.0%	89.6%

Figure 1: Lumen Maintenance at actual case temperature 55ºC



BRIDGELUX
The Magic of Light®

Dec. 7th, 2011

Bridgelux LED Arrays

BXRA-C2002 and QXRA-C0193: Lumen Maintenance

Bridgelux projects that under the following operating conditions of maximum case temperature of 85ºC with datasheet operating drive currents for BXRA-C2002, QXRA-C0193, these products would support a 70% lumen maintenance (L70) rating for a minimum of 36,000 hours based on the 6500 hour BXRA-W3000 test results from the ICE test lab LM-80 report dated Nov. 2nd, 2011.

The W3000 lifetime projection, in accordance to the TM-21-11 document for projecting long term lumen maintenance of LED light sources, predicts L70 (30% degradation) at 50,000 hours. However, the TM-21 draft does not allow beyond 5.5x predictions of actual test time. Therefore, 35,750 hours prediction for 6,500 hours of LM80 data is only allowed. This would translate to much better than 30% light output degradation at 35,750 hours when performing an exponential least squares fit through the following equation in accordance to the TM21 document.

$$\Phi(t) = B \exp(-\alpha t)$$

t = time in hours
Phi (t) = averaged normalized luminous flux output at time t.
B = projected initial constant derived by the least squares fit
Alpha = decay rate constant derived by least squares curve-fit

The Bridgelux LM80 Report at 6,500 hours was published in Nov 2nd 2011 with the IEC test lab signatures. This LM80 data was taken at 265mA per die and adheres to the Energy Star Program requirements as listed in the Sept 9th, 2011 Energy Star Program Guidance document (see Section 3, Item #7). The previous data supplied by SimplyLEDs to PNNL, published in December 2010, was taken at a higher die current of 350mA/die.

The Nov, 2nd 2011 ICE test lab LM80 report tested at 265 mA/die more closely resembles SimplyLEDs operating current of 168mA per die. Due to SimplyLEDs lower drive current it is more appropriate to use the Nov 2nd, 2011 LM80 data for lumen maintenance calculations.

BRIDGELUX

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Here is an excerpt from the " ENERGY STAR® Program Guidance Regarding LED Package, LED Array and LED Module Lumen Maintenance Performance Data Supporting Qualification of Lighting Products " September 9, 2011. Section 3, Item 7:

For LED arrays constructed as an assembly of LED dies on a printed circuit board (PCB) (a.k.a. chip-on-board) or substrate (e.g. ceramic panel or molded surface-mounted device) with one common phosphor layer overlaying all dies; or, with phosphor layers overlaying individual dies with or without single-color dies also incorporated:

One LM-80 test report may represent a range of LED array sizes (i.e. arrays with a varying number of LED dies) and other subcomponent series if each of the following is satisfied:

a. LM-80 testing has been conducted on the largest LED array (i.e. the array with the greatest number of LED dies) that the manufacturer believes will be used in a qualified product; and,
b. the complete model number of the tested LED array is reported, and is noted as the tested model. The reported number must include the complete ordering code/nomenclature required by the subcomponent manufacturer to sell the exact subcomponent tested; and,
c. the average calculated current-per-die of the tested model or series is reported; and,
d. the model numbers for the other LED array sizes and series for which the test data is deemed applicable are detailed in the report, and they exhibit each of the following:
i. equal or fewer LED dies; and,
ii. die spacing greater than or equal to the tested LED array; and,
iii. power density (i.e. W/mm2 of PCB or substrate total area, or equivalent calculation) less than or equal to the tested LED array; and,
iv. identical materials used (note: this does not constrain quantity and/or dimensional adjustments); and,
v. identical construction processes used; and,
e. the model numbers for the other LED array sizes for which the test data is deemed applicable may not be represented

Phil Elizondo
Director of Reliability
Bridgelux, Inc.

Report Number: ICE-LM80-003 November 2, 2011

Bridgelux LM80 Report: 6,500 Hour Test Data
Bridgelux RS LED Array BXRA – W3000

Contents:

Operating Cycle

Test Condition

Number of units: 10 at 55ºC, 10 at 85ºC and 10 at 105ºC.
Drive current: 2100mA, per array
Typical Voltage: 25.6V

Ambient Conditions

Summary of temperature and humidity conditions:

Table 1: Test Environment

Surrounding Temperature	Actual Case Temperature	Nominal Case Temperature	Relative Humidity
53ºC	55ºC	55ºC	7.9%
83ºC	85ºC	85ºC	3.4%
103ºC	105ºC	105ºC	2.8%

Airflow

Note: Airflow is kept to minimum required to maintain the required temperature uniformity as defined in the LM80 requirements document.

The temperature of the air surrounding DUTs is controlled to be less than 5ºC below the case temperature as required by LM80 specification.

Physical condition of parts at read-points

- No cracks
- No discoloration
- No electrical discontinuity

Case Temperature (Test Point Temperature)

Refer to Table 1 (Test Environment)

Drive Current

A drive current of 262.5mA per diode was used during lifetime test.

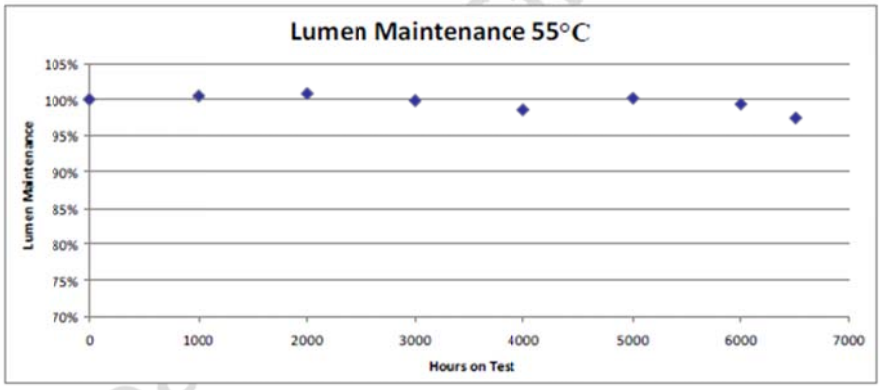
Lumen Maintenance

Ambient temperature during lumen measurements was maintained at 25ºC ±2ºC

Table 3: Lumen Maintenance at actual case temperature 55ºC

Hours	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Median	Standard Deviation	Max	Min
0	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.00%	100.00%	100.00%
1000	100.91%	100.86%	100.52%	101.01%	100.35%	99.96%	100.28%	100.15%	100.62%	99.93%	100.43%	0.39%	101.01%	99.93%
2000	101.82%	101.72%	101.04%	102.02%	100.69%	99.89%	100.55%	100.30%	101.25%	99.86%	100.87%	0.78%	102.02%	99.86%
3000	96.69%	99.78%	98.79%	97.59%	104.64%	99.08%	99.83%	102.37%	102.28%	102.53%	99.81%	2.51%	104.64%	96.69%
4000	98.09%	97.67%	93.53%	100.00%	103.40%	97.29%	100.36%	97.16%	98.97%	99.01%	98.33%	2.56%	103.40%	93.53%
5000	101.07%	98.75%	94.46%	101.32%	104.55%	99.05%	100.97%	98.60%	99.50%	103.04%	100.24%	2.77%	104.55%	94.46%
6000	97.04%	98.71%	94.70%	100.17%	103.61%	98.68%	101.16%	98.16%	100.09%	101.93%	99.40%	2.55%	103.61%	94.70%
6500	96.87%	96.17%	92.83%	98.40%	101.35%	94.54%	100.00%	95.51%	97.98%	100.57%	97.43%	2.75%	101.35%	92.83%

Figure 1: Lumen Maintenance at actual case temperature 55ºC



Appendix D

Manufacturer Product Data – Sylvania LED

(Lamp-Ballast Retrofit Kit)

www.sylvania.com/ledr

D6 Area Light LED Retrofit Kit

Key Features & Benefits

- Reduces energy consumption up to 68%
- Provides significant maintenance cost savings by lasting 2-6 times longer than HID lamps
- UL1598 Classified and IP44 rated
- 50,000 hours life at 70% lumen maintenance
- 120-277V AC input voltage at 60Hz with surge protection
- UL1310 recognized Class 2 OPTOTRONIC® power supply
- Mercury free
- UV and IR free
- RoHS compliant
- Up to 30 feet mounting height
- Ability to power down for sunrise and sunset to save energy with dual ballast
- Smaller diameter for easier retrofit into more applications
- Mounting hardware included in kit and for all three methods: Top, Middle, Bottom

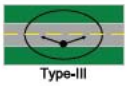
The D6 Area Light LED Retrofit Kit from SYLVANIA is an alternative to high-intensity discharge (HID) lamps up to 175W at pole heights up to 30 feet. The directional light distribution of high power LEDs allows the delivery of light only where needed, reducing wasted light and minimizing light trespass and upward emissions. The D6 is an environmentally friendly lighting solution as it contains no mercury or lead. It is an excellent solution for communities that wish to convert their existing lighting systems as it offers substantial energy and maintenance cost savings as well as minimizes waste in landfills.

For purposes of ARRA, this product is made in the US.

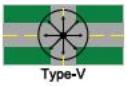
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. For FCC Part 15 user information, please see www.sylvania.com/fcc15b.

Product Offering

Ordering Abbreviation	Wattage (W)	Color Temperature	Light Distribution
LED55RETROFIT/750	55	5000K	Type-V Medium and Type-III Medium
LED55RETROFIT/656	55	5600K	Type-V Short and Type-III Short
LED55RETROFIT/741	55	4100K	Type-V Medium
LED35RETROFIT/750	35	5000K	Type-V Medium
LED35RETROFIT/741	35	4100K	Type-V Medium



Type-III



Type-V

Application Information

Applications

- College and business park campuses
- Historic restorations and downtown business districts
- Public lots and garages
- Residential roadways, walkways and bikeways
- Shopping centers, malls and plazas

Application Notes

1. Maximum mean ambient operating temperature outside the fixture is 40°C
2. Maximum ambient operating temperature outside the fixture can not exceed 60°C
3. To prevent personal injury or product damage only licensed electricians should provide all installation services
4. Please read installation manual before attempting installation
5. Recommended mounting height up to 30 feet
6. UL classification for post top and shoebox fixtures

SEE THE WORLD IN A NEW LIGHT SYLVANIA

RETR0017R3 11/10

Specification Data

Catalog # Type

Project

Comments

Prepared by Date

Ordering Information

Item Number	Ordering Abbreviation	Wattage (W)[1]	Input Voltage (VAC)	Power Factor[2]	Efficacy (lm/W)[3]	Average Rated Life (hrs.)[4]	Typical Lumens (lm)[5]	CCT[6]	CRI	Operating Temperature	BUG Rating
78628	LED55RETROFIT/750/T5M/D6	55	120-277	0.98	69	50,000	3900	5000K	77	-30°C to 40°C	B2 U2 G1
78629	LED55RETROFIT/656/T5S/D6	55	120-277	0.97	64	50,000	3700	5600K	69	-30°C to 40°C	B2 U2 G1
78630	LED55RETROFIT/750/T3M/D6	55	120-277	0.98	69	50,000	3800	5000K	78	-30°C to 40°C	B2 U2 G1
78631	LED55RETROFIT/756/T3S/D6	55	120-277	0.98	62	50,000	3600	5600K	71	-30°C to 40°C	B2 U2 G1
78645	LED55RETROFIT/741/T5M/D6	55	120-277	0.98	67	50,000	3600	4100K	78	-30°C to 40°C	B2 U2 G1
78646	LED35RETROFIT/750/T5M/D6	35	120-277	0.98	74	50,000	2600	5000K	76	-30°C to 40°C	B2 U2 G1
78647	LED35RETROFIT/741/T5M/D6	35	120-277	0.98	78	50,000	2600	4100K	78	-30°C to 40°C	B2 U2 G1

1. Typical wattage while operated at 120VAC is 54W (±10%). Typical wattage while operated at 277VAC is 59W (±10%).
2. Power factor at 120V AC supply voltage
3. Thermally stable typical efficacy (±10%)
4. Hours lifetime with 70% lumen maintenance. Based on operation temperature at 104°F (40°C).
5. Thermally stable typical lumens (±10%)
6. Thermally stable typical CCT (±10%)

Ordering Guide

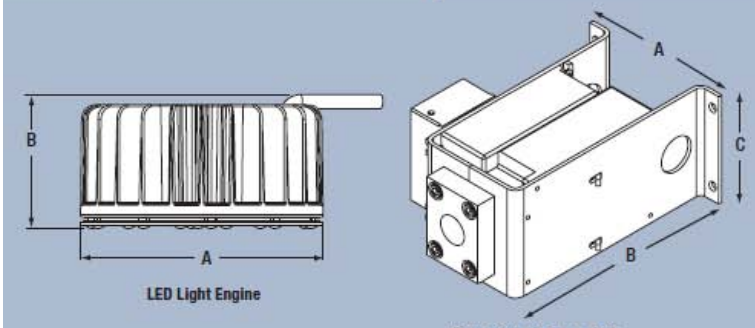
LED	55	RETROFIT	/	750	/	T5M	/	D6
LED Lamps and Retrofits	Wattage: 55W	Retrofit Kit		CRI, CCT: 750: 79CRI, 5000K CCT		Light Distribution: T5M: Type-V Medium		Diameter: 6 inches

Power Supply Ordering Information

Item Number	Ordering Abbreviation	Power Supply IP Rating
51530-2	OT40/UNV/1110E*	IP66

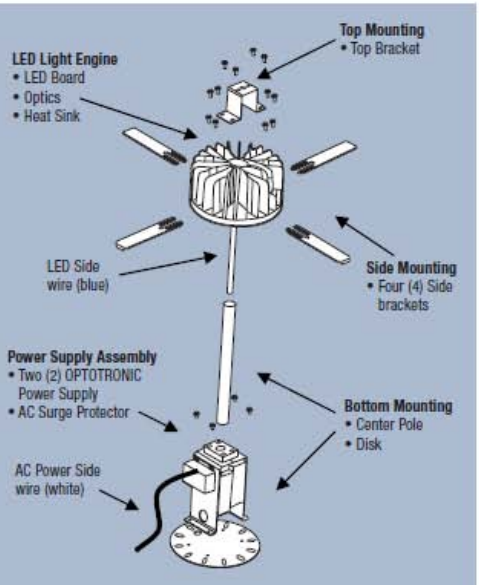
* Constant current power supply (1.11A). UL 1310 and UL 48 recognized for US & Canada. Class 2 unit

Technical Information



	(A) Width/Diameter	(B) MOL	(C) Length
LED Light Engine	6.8"	3.7"	—
Power Supply Assembly	4.2"	6.1"	2.8"

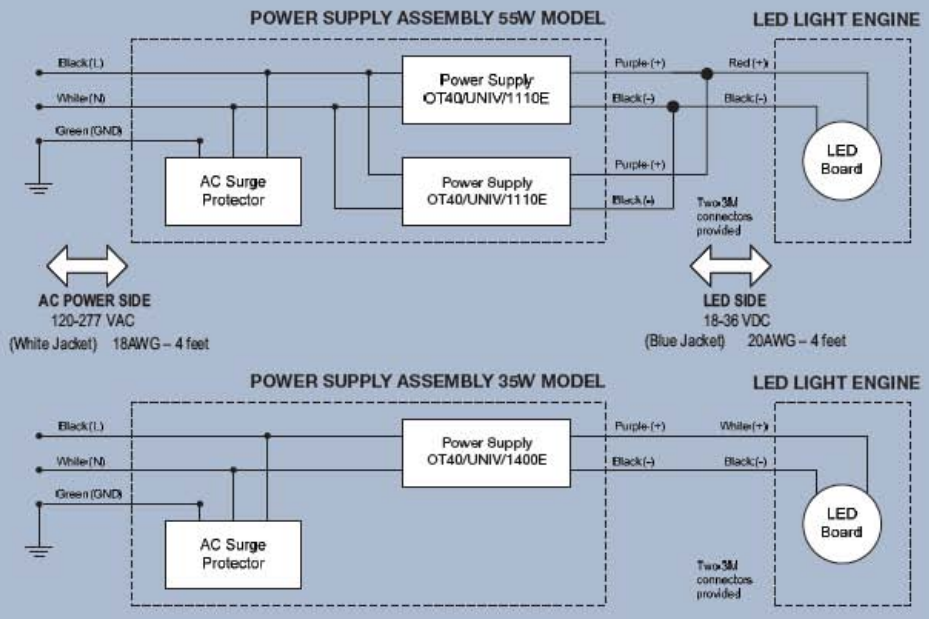
* Power supply assemblies in images above are for 55W model. Assembly for 35W model will contain only one power supply, but retain the same overall bracket dimensions.



Wiring Diagram

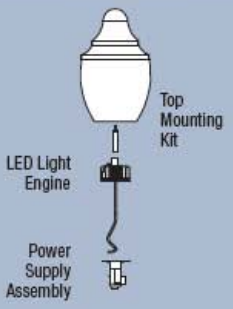
Notes:

1. AC surge protector and OPTOTRONIC® power supplies are pre-wired in Power Supply Assembly.



Assembly Diagram

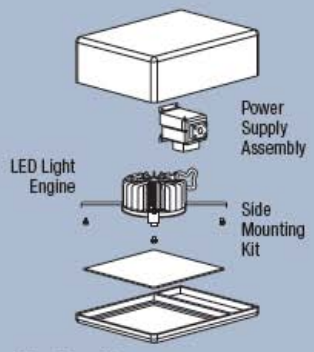
*Refer to Installation Manual for mounting instructions



Top Mounting

Recommended fixtures:

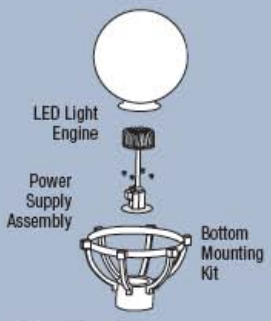
- Canopy light
- Cobra head
- High/Low bay
- Parking garage
- Pendant
- Post Top
- Shoebox
- Wall pack



Side Mounting

Recommended fixtures:

- Canopy light
- Cobra head
- High/Low bay
- Parking garage
- Pendant
- Post Top
- Shoebox
- Wall pack



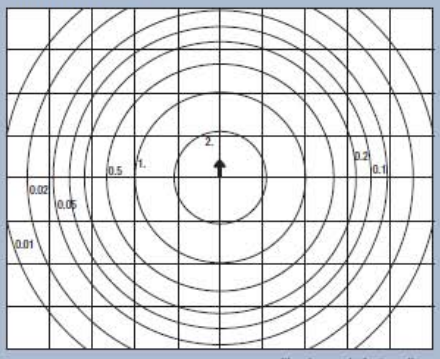
Bottom Mounting

Recommended fixtures:

- Post Top

Photometric Distribution

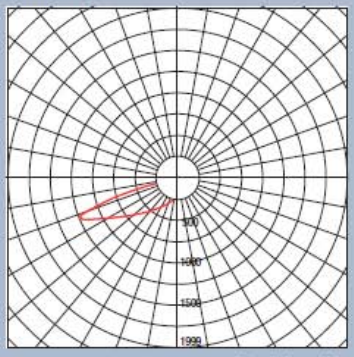
LED55RETROFIT/750/T5M/D6:
Illuminance Diagram
(Without a fixture)



Illuminance in footcandles

Mounting Height = 10'
Each box is one mounting height.
Type V Medium, 5000K CCT
(Distribution might change when fixture globe is present)

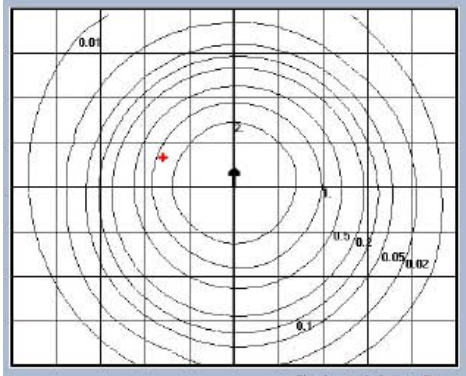
Luminous Intensity Distribution
(Without a fixture)



Intensity in candelas

Max. plane at H = 0 Max. cone at V = 71
Max. candlepower = 1326
Type V Medium, 5000K CCT
(Distribution might change when fixture globe is present)

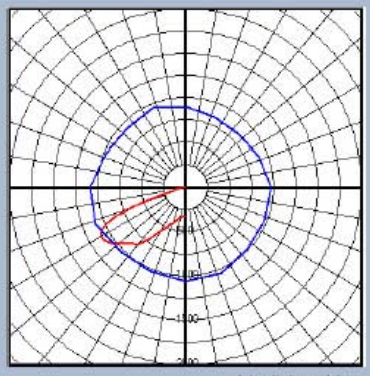
LED55RETROFIT/757/T5S/D6:
Illuminance Diagram
(Without a fixture)



Illuminance in footcandles

Mounting Height = 10'
Each box is one mounting height.
Type V Short, 5700K CCT
(Distribution might change when fixture globe is present)

Luminous Intensity Distribution
(Without a fixture)



Intensity in candelas

Max. plane at H = 292.5 Max. cone at V = 60
Max. candlepower = 1102
Type V Short, 5700K CCT
(Distribution might change when fixture globe is present)

Warranty

Refer to OSI Post-Top LED Retrofit Kit Statement of Limited Warranty.

United States
OSRAM SYLVANIA
100 Endicott Street
Danvers, MA 01923

Trade
Phone: 1-800-255-5042
Fax: 1-800-255-5043

National Accounts
Phone: 1-800-562-4671
Fax: 1-800-562-4674

OEM/Special Markets
Phone: 1-800-762-7191
Fax: 1-800-762-7192

Display/Optic
Phone: 1-888-677-2627
Fax: 1-800-762-7192

Canada
OSRAM SYLVANIA LTD.
2001 Drew Road
Mississauga, ON L5S 1S4

Trade
Phone: 1-800-263-2852
Fax: 1-800-667-6772

OEM/Special Markets/Display/Optic
Phone: 1-800-265-2852
Fax: 1-800-667-6772

www.sylvania.com

Cree, Inc.
4600 Silicon Drive
Durham, NC 27703

IES LM-80-08 Test Summary
Cree XP-E White XLamp
2010.8 LM-80 Summary Cree XPE.XLS

1. Number of LED Sources Tested	See Table 1	
2. Description of LED light sources	Cree XP-E XLamp LEDs	
3. Description of auxiliary equipment	Instrument Systems ISP-500 Integrating Sphere Instrument Systems CAS-140 Spectrometer Keithley 2420 Sourcemeter	
4. Operating Cycle	Constant Current	
5. Ambient Contitions	for 45°C Test: for 55°C Test: for 85°C Test:	Tair = 45°C, RH < 45%, air flow = 800CFM Tair = 55°C, RH ≤ 45%, air flow = 800CFM Tair = 85°C, RH ≤ 45%, air flow = 800CFM
6. Case Temperature	for 45°C Test: for 55°C Test: for 85°C Test:	45°C 55°C 85°C
7. Drive Current During Test	See Table 1	
8. Initial LF and Vf	See Table 1	
9. Lumen Maintenance	See individual worksheets	
10. LED failures	NONE	
11. LED monitoring interval	See individual worksheets	
12. Photometric uncertainty	±2.0%	
13. Tsp Measurement Location	See Table 1	

14. Projected L70*

product	test conditions	total test time	% LF at time	L70
XP-E XLamp	700mA @ 45C	6,048 hours	97.7	92,708 hours
XP-E XLamp	700mA @ 55C	6,048 hours	99.3	>100,000 hours
XP-E XLamp	350mA @ 85C	6,048 hours	97.9	>100,000 hours
XP-E XLamp	700mA @ 85C	6,048 hours	96.6	62,361 hours

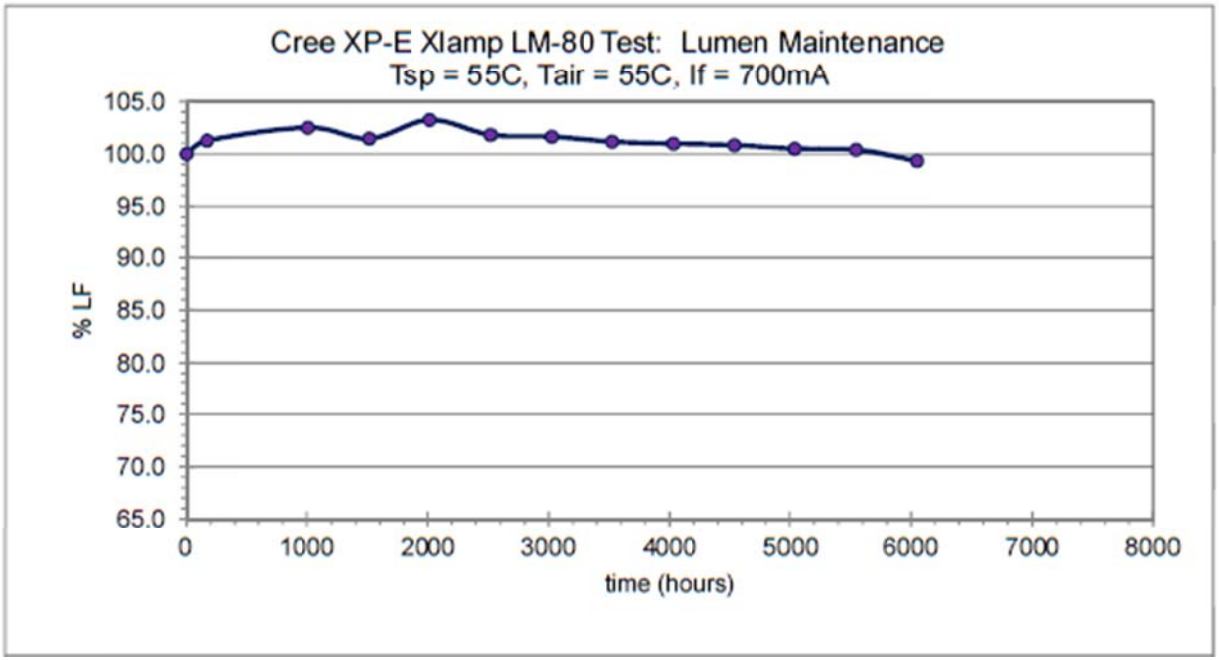
* Using the Energy Star Exponential Curve Fit Projection Method
and the maximum test time as shown on individual worksheets

TABLE 1

Board ID #	Ambient Temp	Drive Current	# of LED's	Initial Ave. Vf (volts)	Initial Ave. LF (Lum.)
DUR0GZU	45°C	700mA	9	3.10	74.6
DUR0GZV	45°C	700mA	10	3.09	74.7
DUR0GZW	45°C	700mA	10	3.09	73.5
DUR0H06	55°C	700mA	10	3.09	74.6
DUR0H07	55°C	700mA	10	3.10	74.2
DUR0H08	55°C	700mA	10	3.10	73.3
DUR0KFR	85°C	350mA	10	3.10	74.3
DUR0KFS	85°C	350mA	10	3.08	75.4
DUR0KFT	85°C	350mA	10	3.07	76.8
DUR0GZX	85°C	700mA	9	3.09	75.2
DUR0GZY	85°C	700mA	10	3.11	74.9
DUR0GZZ	85°C	700mA	9	3.09	74.7

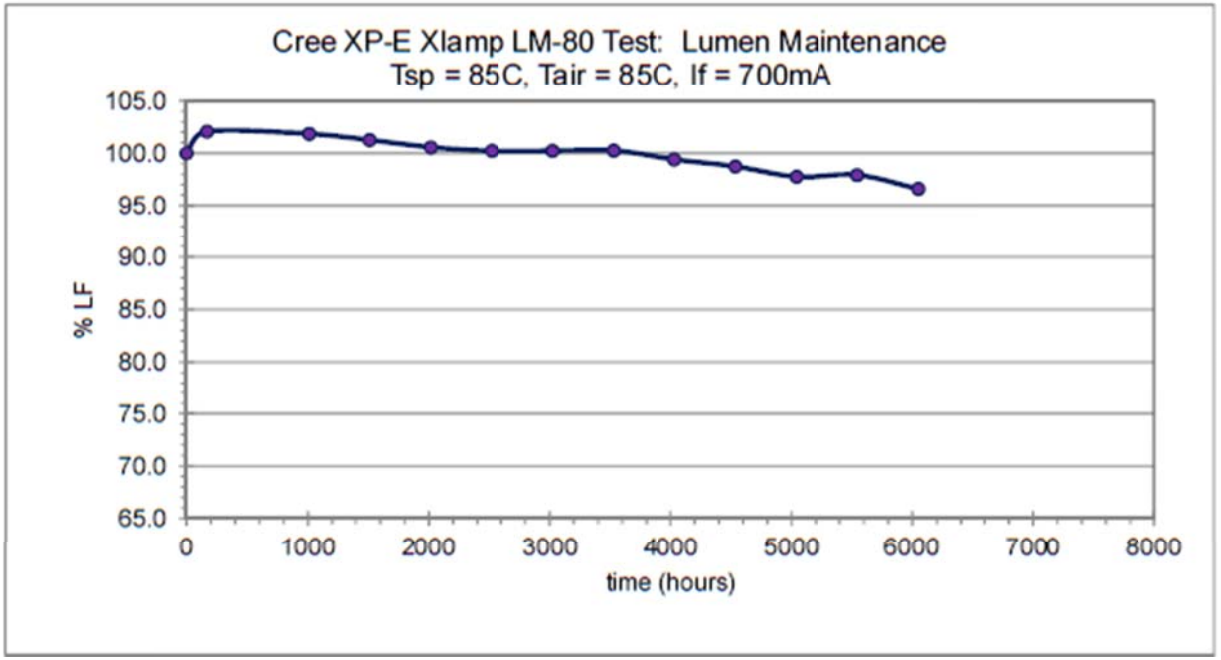
Product	**XP-E Xlamp**
Temperature	**55°C**
Drive Current (mA)	**700**

	Luminous Flux	**time (hours)**											
	0	**168**	**1008**	**1512**	**2016**	**2520**	**3024**	**3528**	**4032**	**4536**	**5040**	**5544**	**6048**
Average	74.0	75.0	75.9	75.1	76.4	75.4	75.2	74.9	74.8	74.7	74.4	74.3	73.5
Minimum	63.9	63.7	63.8	63.4	66.2	64.0	64.2	64.3	63.7	63.5	63.1	63.0	62.4
Maximum	81.4	83.3	84.1	82.4	85.2	82.5	82.5	82.5	82.5	82.2	81.6	81.3	80.6
Std. Deviation	5.1	5.3	5.2	4.9	5.0	4.8	4.9	4.8	4.8	4.8	4.9	4.9	5.0
% LF	100.0	101.3	102.5	101.4	103.2	101.8	101.6	101.2	101.0	100.8	100.5	100.4	99.3



Product	**XP-E Xlamp**
Temperature	**85°C**
Drive Current (mA)	**700**

	Luminous Flux	time (hours)											
	0	**168**	**1008**	**1512**	**2016**	**2520**	**3024**	**3528**	**4032**	**4536**	**5040**	**5544**	**6048**
Average	74.9	76.5	76.3	75.9	75.4	75.1	75.1	75.1	74.5	74.0	73.3	73.4	72.4
Minimum	66.2	67.1	67.8	66.2	66.3	66.5	66.9	67.0	65.6	66.5	65.8	64.5	63.9
Maximum	81.1	84.7	82.6	84.8	83.2	82.9	82.9	82.4	81.6	81.0	79.8	80.2	79.8
Std. Deviation	4.4	5.0	4.5	4.8	4.4	4.3	4.3	4.1	4.1	4.2	4.0	4.3	4.4
% LF	100.0	102.1	101.8	101.3	100.6	100.2	100.2	100.3	99.4	98.7	97.8	97.9	96.6



Sylvania provided the following statement in response to reviewing a preliminary draft of the GATEWAY report.

Dec 15, 2011

Thank you for providing the opportunity to have a preliminary review of your DOE Gateway report. The SYLVANIA Area Light LED retrofit kit is designed to fit most exterior post top fixtures at mounting heights up to 30'. This LED retrofit kit is also designed with the flexibility to adjust position within the fixture along with two optics options to optimize the photometric distribution for the application.

Our 'Buy 4' program allows the end customer to purchase 4 of our LED retrofit kit products and then install them to test to see if there is additional application support required. Additionally, we offer to retrofit the end users fixture and provide a photo journal to ensure proper installation. These options and services allow the end user to have the best possible solution for their post top lighting applications.

Due to the nature of the Gateway program test, SYLVANIA was not able to fully engage with the end user to demonstrate the full support typically provided to our customers, ultimately ending in a less than satisfying performance review.

We request that when you publish this report, you also note that SYLVANIA provides application support along with trial purchasing programs with their LED Street lighting retrofit kits and due to the nature of this test this additional support was not utilized to optimize the performance.

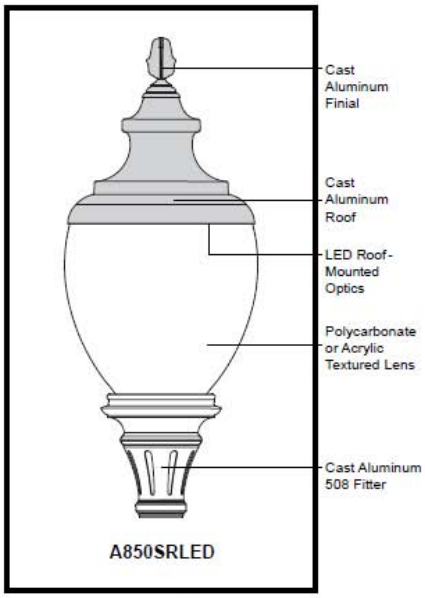
Readers should contact their Sylvania representative with any questions or requests for additional information.

Appendix E

Manufacturer Product Data – Sternberg LED

(Luminaire)

A850SR LED OLD TOWN SERIES SPECIFICATIONS



Rated IP65

LUMINAIRE DESIGN

- The luminaire shall be a traditional acorn style fixture provided with a decorative cast aluminum fitter, a polycarbonate or acrylic clear textured acorn and a cast aluminum roof.
- The luminaire shall have LED light sources and roof mounted, down-lighting optics.
- The luminaire shall be 16" diameter and 40 1/2" overall height.
- The luminaire shall be supplied with line-ground, line-neutral and neutral-ground electrical surge protection in accordance with IEEE/ANSI C62.41.2 guidelines.
- The luminaire shall be U.L. or E.T.L. listed in U.S. and Canada.

POST FITTER

- The fitter shall be heavy wall cast aluminum for high tensile strength.
- The fitter shall have an inside diameter opening of 8 1/2" to attach to the 8" neck of the acorn globe.
- When ordered with a Sternberg pole, the fitter shall be welded to the pole top or tenon to ensure safety and to ensure the luminaire will remain plumb and level over the luminaire life.

DRIVER

- The LED driver shall be securely mounted inside the fitter, for optimized performance and longevity.
- The LED driver shall be supplied with a quick-disconnect electrical connector on the power supply, providing easy power connections and fixture installation.

LIGHT SOURCES

- The luminaire shall use high output, high brightness LEDs.
- The LEDs shall be mounted in arrays, on printed circuit boards designed to maximize heat transfer to the heat sink surface.
- The LEDs shall be attached to the printed circuit board with not less than 90% pure silver to insure optimal electrical and thermal conductivity.
- The LEDs and printed circuit boards shall be protected from moisture and corrosion by a conformal coating of 1 to 3 mils.
- The LEDs and printed circuit board construction shall be environmentally friendly and 100% recyclable. They shall not contain lead, mercury or any other hazardous substances and shall be RoHS compliant.
- The LED life rating data shall be determined in accordance with IESNA LM-80-08.

LIST NO. A850SR LED OLD TOWN SERIES

8-10

(Continued on next page)

A850SR LED OLD TOWN SERIES SPECIFICATIONS

LIST NO. A850SR LED OLD TOWN SERIES

OPTICS

- The luminaire shall be provided with individual, acrylic, refractor type optics applied to each LED.
- The luminaire shall provide Type ___ (III or V) light distribution per the IESNA classifications. Testing shall be done in accordance with IESNA LM-79-08.

PERFORMANCE

- The LED arrays are built in series-parallel circuits which maintain overall light output in the event of single LED failures.
- The LEDs and LED driver shall operate over a -40°C (-40°F) to +50°C (122°F) ambient air temperature range.
- The High Performance white LEDs will have a life expectancy of approximately 70,000 hours with not less than 70% of original brightness (lumen maintenance), rated at 25°C.
- The High Brightness, High Output LED's shall be 4500K (3500K or 6000K option) color temperature with a minimum of 75 CRI.
- The luminaire shall have a minimum _____ (see table) initial delivered lumen rating when operated at steady state with an average ambient temperature of 25°C (77°F).

Light Source	Initial Delivered Lumens	Fixture Watts	Light Source	Initial Delivered Lumens	Fixture Watts
6ARC60T5	6520	96	6ARC60T3	6320	96
6ARC45T5	5420	96	6ARC45T3	5210	96
6ARC35T5	4840	96	6ARC35T3	4650	96
4ARC60T5	4410	66	4ARC60T3	4270	66
4ARC45T5	3680	66	4ARC45T3	3530	66
4ARC35T5	3300	66	4ARC35T3	3160	66
3ARC60T5	3460	51	3ARC60T3	3210	51
3ARC45T5	2910	51	3ARC45T3	2660	51
3ARC35T5	2600	51	3ARC35T3	2380	51
2ARC60T5	2290	35	2ARC60T3	2110	35
2ARC45T5	1920	35	2ARC45T3	1750	35
2ARC35T5	1730	35	2ARC35T3	1560	35

ELECTRONIC DRIVERS

- The driver shall be UL Listed or Recognized.
- The driver shall have overload as well as short circuit protection.
- The driver shall be a DC voltage output, constant current design, 50/60HZ.

For 3ARC thru 6ARC LED Light Sources

- The driver shall have a minimum efficiency of 90%.

The driver shall be rated at full load with THD<20% and a power factor of greater than 0.90.

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555 Lawrence Ave. Roselle, IL 60172 • 847-588-3400 • Fax 847-588-3440
www. sternberglighting.com Email: info@sternberglighting.com 8-10

A850SR LED OLD TOWN SERIES SPECIFICATIONS

LIST NO. A850SR LED OLD TOWN SERIES

• The driver shall contain over-heat protection which reduces output to less than half rating if the case temperature reaches 85°C.

For 2ARC LED Light Sources

• The driver shall have a minimum efficiency of 88%.

ACORN

• The acorn shall be 16" diameter and 31 1/2" tall with an 8" diameter neck.
• *The acorn LED assembly shall be retro-fitted to a _____ (competitor) fitter which accepts the standard 8" diameter acorn neck. Consult Sternberg factory.
• The acorn shall be made of _____ (vandal resistant, clear textured poly-carbonate or dent resistant (DR) clear textured acrylic. For Acrylic add "A" to model number.
• The acorn shall be supplied with a cast aluminum finial and a solid, cast aluminum roof which includes optimized heat sinks to provide maximum life and performance for the LED light sources.
• The acorn shall be sealed to the cast aluminum roof to provide a moisture-free and bug-free optics chamber for the LED light sources and **Rated IP65.**
• *The acorn shall be provided with a perforated brass decorative ring (PBDR) supplied in a _____ (polished brass or painted) finish. The 2 1/4" wide brass filigree shall allow light transfer through the decorative openings.
• *The acorn shall be provided with a heavy cast decorative ring (CDR) which includes four (4) cast medallions finished in accent gold. The medallions can be customized with name, initials or logo. * (OPTION)

ARMS

• The arms shall be cast aluminum and/or extruded aluminum.
• Arms with decorative filigree shall have meticulously detailed scroll work and gracefully curved brackets.
• **(All except BAPT and 779 arms)** The arms shall be bolted to a post mount adaptor which is welded to the pole to ensure proper alignment.
• **(Twin TA and twin 579 arms)** The arms shall be attached to a decorative center hub which will fit the center tenon of the pole (not shown).

PHOTOCELL OPTIONS

Bi-metal Button Cell Option

• Photocells shall be thermo bi-metal button type.
• On single post-top fixtures, the photocell shall be mounted in the fitter and pre-wired to the driver.

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A850SR LED OLD TOWN SERIES SPECIFICATIONS

LIST NO. A850SR LED OLD TOWN SERIES

- On multiple head fixtures, photocells shall be mounted in the pole shaft, on an access plate. The photocell is not pre-wired since drivers are mounted in the fitters and packaged separately.
- The photocell shall turn on at 1.0 foot-candle and turn off at not more than 5 foot-candles.
- The photocell is 120V or 208-277 volt.

Electronic Button Cell Option

- Photocells shall be electronic button type.
- On single post-top fixtures, the photocell shall be mounted in the fitter and pre-wired to the driver.
- On multiple head fixtures, photocells shall be mounted in the pole shaft, on an access plate. The photocell is not pre-wired since drivers are mounted in the fitters and packaged separately.
- The photocell is instant-on at 1.5 foot-candles and turns off 5-10 seconds at 2-3 foot-candles.
- The photocell is 120V or 208-277 volt.

Roto-Lock Type Option (980 fitter only)

- Photocells shall be roto-lock design.
- They shall be thermal-bimetallic switch type.
- Photocells shall be mounted in the housing on the photocell bracket and pre-wired to the driver.
- On multi-fixture poles the photocell shall be mounted in the pole shaft on an access plate. The photocell is not pre-wired since drivers are mounted in the fitters and packaged separately.
- Photocell time delay is 2 minutes to turn on at 1.5 foot-candles and 2 minutes to turn off at no more than 6 foot-candles.
- The photocell is 120-277 volt.

FINISH

- Prior to coating, the luminaire shall be chemically cleaned and etched in a 5-stage washing system which includes alkaline cleaning, rinsing, phosphoric etching, reverse-osmosis water rinsing and non-chrome sealing to ensure corrosion resistance and excellent adhesion for the finish coat.
- The finish coat shall be an electrostatically applied semi-gloss, super durable polyester powder coat, baked on at 400°F, to provide a durable, color retentive finish.
- *The optional _____ (Verde Green or Swedish Iron) finish shall be hand-brushed using a 3-step process. * (OPTION)

WARRANTY

- The luminaire shall be free from all defects in materials and workmanship for a period of seven (7) years from the date of manufacture.
- The luminaire manufacturer shall warrant the LED boards/system, during the stated warranty period, against failure defined as more than three (3) simultaneous non-operating LEDs.
- The driver shall be warranted for seven (7) years.

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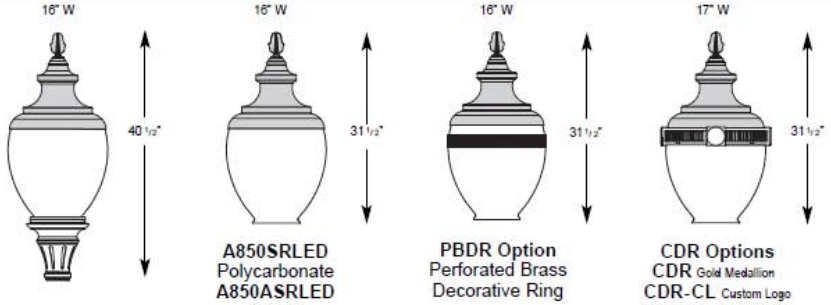
www. sternberglighting.com Email: info@sternberglighting.com 8-10

A850SR LED OLD TOWN ACORNS / FITTERS / ARMS PM - WB

ACORNS / OPTIONAL TOPS

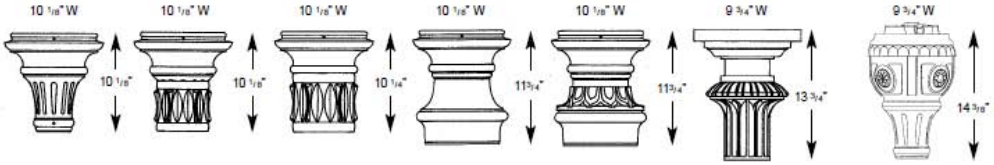


A850SRLED
Polycarbonate
A850ASRLED
Acrylic

PBDR Option
Perforated Brass
Decorative Ring

CDR Options
CDR Gold Medallion
CDR-CL Custom Logo
Cast Aluminum Deco. Rings

FITTERS



5P or 5T*
(508)
Fits 3" poles
or tenons and
arms below

BD4
(508BD4)
Fits 4" poles
or tenons

BD5
(508BD5)
Fits 5" poles
or tenons

B7
(508B7)
Fits 7" poles
or tenons

BD7
(508BD7)
Fits 7" poles
or tenons

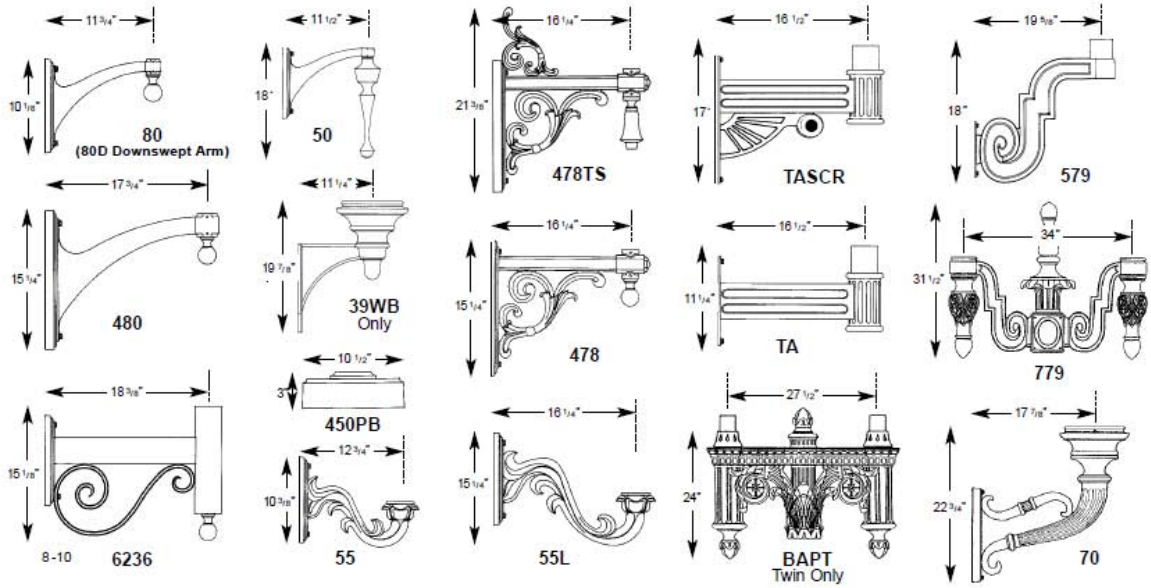
7 or 7T*
(708)
Fits 4" poles or
tenons - 3" with
adapter & large arms

9 or 9T*
(980)
Fits 3" poles
or tenons and
large arms

*Twist Lock Acorn (Fitter TL)

ARMS - POST MOUNT (PM) or WALL BRACKETS (WB)

See Arms Section for more information



BUILDING A PART NUMBER

POST & ARM FIXTURES

ARM MOUNTED FIXTURE		CENTER POST TOP FIXTURE (PT)		POST	POST CAP	LIGHT SOURCE	DRIVER	OPTIONS	FINISH
NO. OF ARMS	ACORN / FITTER / POSTARM		ACORN / FITTER		(See Post Section)				
2	— A850SRLED/5P/50PM /	PT	A850SRLED/5P	/	4212FP4	/	/ 6ARC45T5	/ ML	/	/ BK

WALL FIXTURES

ACORN / FITTER / WALL BRACKET		LIGHT SOURCE		DRIVER	OPTIONS		FINISH
A850SRLED/5P/50WB	/	4ARC45T3	/	ML	/	/	BK

PIER FIXTURES

Uses same information boxes as wall fixture

A850SRLED/5P/450PB

ACORN / FITTER / PIER BASE

PART NUMBER SELECTIONS

ACORNS
- A850SRLED[1]
- A850ASRLED

FITTERS
- 5P
- 7
- 9
- BD4
- BD5
- BD7
- B7

DRIVERS
- ML - 120-277
- MH - 347-480
- MDL - Dimming 120-277
- MDH - Dimming 347-480

POST ARMS
- 50PM
- 50DPM
- 478PM
- 478TSPM
- 70PM*
- 80PM
- 80DPM
- 480PM
- 480DPM
- 55PM
- 55LPM
- 6236PM
- 579PT
- TAPT
- TASCRPT
- BAPT

PIER BASE
- 450PB

WALL BRACKET ARMS
- 50WB
- 50DWB
- 478WB
- 478TSWB
- 70WB*
- 80WB
- 80DWB
- 480WB
- 480DWB
- 55WB
- 55LWB
- 6236WB
- 579WB
- TAWB
- TASCRWB
- 39WB*

*No fitter required

LIGHT SOURCES T5
- 6ARC60T5 96W, 6000K Type V Optics
- 6ARC45T5 96W, 4500K Type V Optics
- 6ARC35T5 96W, 3500K Type V Optics
- 4ARC60T5 66W, 6000K Type V Optics
- 4ARC45T5 66W, 4500K Type V Optics
- 4ARC35T5 66W, 3500K Type V Optics
- 3ARC60T5 51W, 6000K Type V Optics
- 3ARC45T5 51W, 4500K Type V Optics
- 3ARC35T5 51W, 3500K Type V Optics
- 2ARC60T5 35W, 6000K Type V Optics
- 2ARC45T5 35W, 4500K Type V Optics
- 2ARC35T5 35W, 3500K Type V Optics

LIGHT SOURCES T3
- 6ARC60T3 96W, 6000K Type III Optics
- 6ARC45T3 96W, 4500K Type III Optics
- 6ARC35T3 96W, 3500K Type III Optics
- 4ARC60T3 66W, 6000K Type III Optics
- 4ARC45T3 66W, 4500K Type III Optics
- 4ARC35T3 66W, 3500K Type III Optics
- 3ARC60T3 51W, 6000K Type III Optics
- 3ARC45T3 51W, 4500K Type III Optics
- 3ARC35T3 51W, 3500K Type III Optics
- 2ARC60T3 35W, 6000K Type III Optics
- 2ARC45T3 35W, 4500K Type III Optics
- 2ARC35T3 35W, 3500K Type III Optics

FINISHES STANDARD
- BKT Black Textured
- BK Black
- VG Verde Green
- PGT Park Green Textured
- PG Park Green
- ABZT Architectural Medium Bronze Textured
- ABZ Architectural Medium Bronze
- SI Swedish Iron
- DBT Dark Bronze Textured
- DB Dark Bronze
- OWGT Old World Gray Textured
- OWG Old World Gray

FINISHES CUSTOM
- WHT White Textured
- WH White
- CV Copper Vein
- WBK Weathered Black
- WBR Weathered Brown
- CD Cedar
- RT Rust
- OI Old Iron
- TT Two Tone
- CM Custom Match

OPTIONS
- CDR Cast Decorative Ring
- CDR-CL[2] Cast Decor Ring with Custom Logo
- PBDR[3] Perforated Brass Decoratice Ring
- PEC1 Photocell-Bimetal 120 Volt
- PEC2 Photocell-Bimetal 208-277 Volt
- PEC1-E Photocell-Electronic 120 Volt
- PEC2-E Photocell-Electronic 208-277 Volt
- R[4] Receptacle Only for Rotolock Photo Cell
- R1[4] Rotolock Photo Cell 120-277 Volt
- FHD Dual Fuse & Holder
- PF per arm Pineapple Finial or Font (for TA, TASCR)
- BF per arm Ball Finial or Font (for TA, TASCR)
- G[4] GFI
- HL[5] Hi - Low Operation

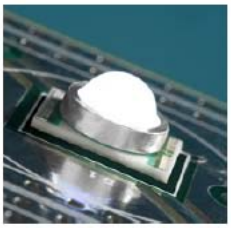
NOTES:
1. White polycarbonate acorns are available. Specify WP after acorn number.
2. Consult factory for Specification Details.
3. Standard is polished. If painted specify PBDR-P.
4. For 9 or fitter only.
5. Not available on 3ARC sources.

STERNBERG LIGHTING

555 Lawrence Ave. Roselle, IL 60172 • 847-588-3400 • Fax 847-588-3440
www. sternberglighting.com Email: info@sternberglighting.com

8-10

Cree® XLamp® XR-E LED



PRODUCT DESCRIPTION

The XLamp XR-E LED is leading the LED lighting revolution with its unprecedented lighting-class brightness, efficacy, lifetime and quality of light. These lighting-class features enable the XLamp XR-E LED to replace many traditional light sources and save money with energy-efficient light and long lifetimes.

Cree XLamp LEDs bring high performance and quality of light to a wide range of lighting applications, including color-changing lighting, portable and personal lighting, outdoor lighting, indoor directional lighting, commercial lighting and emergency-vehicle lighting.

FEATURES

- Guaranteed minimum flux order codes up to 114 lm in white, 30.6 lm in blue and 67.2 lm in green at 350 mA
- Available in white (2,600 K to 10,000 K CCT), blue, royal blue and green
- Maximum drive current: up to 1000 mA
- Industry's lowest thermal resistance: 8°C/W
- Max junction temperature: 150°C
- Industry-leading JEDEC standard pre-qualification testing
- Reflow solderable – JEDEC J-STD-020C compatible
- Electrically neutral thermal path
- RoHS-compliant
- Lumen maintenance of greater than 70% after 50,000 hours

TABLE OF CONTENTS

Cree, Inc.
4600 Silicon Drive
Durham, NC 27703
USA Tel: +1.919.313.5300

Cree XR-E XLamp

45 °C Lumen Maintenance Test. Solder point (Ts) = 45°C and Ambient Temperature = 45° C

Luminous Flux	*If = 700mA*										*hours*								
Board Number	**Lamp**	**0**	**24**	**168**	**336**	**504**	**672**	**1000**	**1124**	**1514**	**1682**	**1850**	**2042**	**2210**	**2402**	**2546**	**2738**	**2882**	
PDWLT1106-RTOL-03	**1**	157.1	152.0	149.2	148.3	146.9	144.9	144.9	144.7	145.5	143.1	143.8	144.8	144.3	144.3	144.7	142.6	143.7	
PDWLT1106-RTOL-03	**2**	151.8	150.6	150.1	149.5	148.3	146.3	145.9	145.9	146.1	144.3	144.8	145.6	145.4	144.5	143.6	142.5	143.0	
PDWLT1106-RTOL-03	**3**	141.4	140.4	141.1	141.5	139.9	138.1	138.1	137.1	135.9	135.5	135.9	135.7	135.6	136.6	135.3	133.6	134.9	
PDWLT1106-RTOL-03	**4**	143.5	144.2	144.8	145.9	145.8	144.1	144.4	143.7	141.6	142.4	143.0	142.8	142.6	143.3	142.3	141.3	142.1	
PDWLT1106-RTOL-03	**5**	138.7	137.4	141.3	141.6	142.0	141.3	142.0	141.1	140.9	139.9	140.1	140.5	140.2	140.3	138.9	138.0	138.8	
PDWLT1106-RTOL-03	**6**	143.5	142.9	147.1	146.4	145.9	144.2	144.1	143.9	144.7	143.1	143.6	144.5	144.3	143.6	142.8	142.2	143.1	
PDWLT1106-RTOL-03	**7**	147.5	147.1	147.1	147.0	145.8	143.9	144.2	143.4	143.3	142.3	143.0	143.5	143.3	142.6	141.7	141.1	141.5	
PDWLT1106-RTOL-03	**8**	131.9	129.3	129.1	129.5	128.7	126.9	127.4	126.8	126.7	125.2	125.9	126.1	125.6	126.7	126.2	124.1	125.0	
PDWLT1106-RTOL-03	**9**	151.1	149.2	149.0	147.9	146.0	144.1	144.4	143.7	142.6	142.1	141.9	142.4	142.3	142.4	141.1	140.4	141.0	
PDWLT1106-RTOL-03	**10**	132.6	132.4	136.9	138.8	139.6	138.4	138.1	137.7	138.1	135.7	135.7	136.1	135.8	135.6	134.6	133.3	133.9	
	AVERAGE	143.9	142.6	143.6	143.6	142.9	141.2	141.4	140.8	140.5	139.4	139.8	140.2	139.9	140.0	139.1	137.9	138.7	
	% LF	**100.0**	**99.1**	**99.8**	**99.8**	**99.3**	**98.1**	**98.2**	**97.8**	**97.7**	**96.8**	**97.1**	**97.4**	**97.2**	**97.3**	**96.7**	**95.8**	**96.4**	

	3050	**3051**	**3218**	**3486**	**3654**	**3822**	**3990**	**4158**	**4326**	**4528**	**4662**	**4988**	**5156**	**5540**	**6000**	**6170**	**6338**	**6506**	**6846**
	142.6	130.7	130.5	131.7	131.4	131.2	130.6	130.4	130.0	129.6	130.2	130.4	132.5	130.6	130.7	131.8	131.8	131.9	133.8
	141.7	130.5	130.6	130.6	131.3	131.1	129.7	130.1	130.0	129.5	130.0	129.7	130.6	128.8	129.0	130.2	130.0	130.3	131.0
	133.0	122.7	123.0	122.7	122.7	123.2	122.1	120.7	121.3	120.3	120.8	120.4	122.4	120.6	119.9	121.5	120.6	121.3	122.9
	140.7	129.5	129.9	129.6	129.7	130.4	129.5	128.8	128.8	127.9	128.5	128.4	130.7	128.8	128.0	129.6	128.7	128.9	130.9
	136.8	125.9	126.3	126.8	126.9	126.3	125.8	125.7	125.6	124.9	125.6	125.4	126.9	124.9	124.6	125.6	125.4	125.5	127.1
	141.1	130.0	130.5	130.8	130.5	130.7	129.7	129.5	129.6	128.9	129.2	128.8	130.9	129.0	128.3	129.4	129.0	129.2	130.6
	140.4	129.2	129.6	130.3	130.4	130.2	129.5	129.1	129.2	128.6	129.2	128.9	130.7	128.6	128.4	129.9	129.4	129.8	131.1
	123.6	113.3	113.6	114.2	113.8	114.1	113.6	112.8	112.0	111.3	111.9	112.1	113.5	112.1	112.1	113.5	112.5	112.8	113.7
	139.3	128.1	128.6	128.4	128.6	128.9	127.4	127.5	127.4	126.6	127.2	126.4	128.0	125.9	126.4	127.2	126.7	127.1	128.6
	132.4	121.6	122.1	122.0	121.8	121.4	121.0	120.7	120.4	119.7	120.2	119.8	121.3	119.3	118.8	119.6	119.7	119.7	120.9
	137.2	126.1	126.5	126.7	126.7	126.8	125.9	125.5	125.4	124.7	125.3	125.0	126.7	124.8	124.6	125.8	125.4	125.7	127.0
scaling factor	1.087	137.2	137.5	137.8	137.8	137.8	136.9	136.5	136.4	135.6	136.2	136.0	137.8	135.8	135.5	136.8	136.3	136.6	138.2
	95.3	**95.3**	**95.6**	**95.7**	**95.7**	**95.8**	**95.1**	**94.9**	**94.8**	**94.3**	**94.7**	**94.5**	**95.8**	**94.3**	**94.2**	**95.1**	**94.7**	**94.9**	**96.0**

Cree XR-E XLamp

85 °C Lumen Maintenance Test. Solder point (Ts) = 85°C and Ambient Temperature = 85 C

Luminous Flux	If = 700mA												hours						
Board Number	Lamp	0	24	168	336	504	672	1000	1176	1344	1514	1682	1850	2018	2210	2378	2546	2738	2882
PDWLT1106-HTOL-01	1	130.3	128.2	131.4	131.8	132.3	129.3	131.3	128.6	130.5	129.1	129.0	128.6	129.3	129.7	128.4	127.9	127.5	126.1
PDWLT1106-HTOL-01	2	142.7	138.8	144.8	144.1	142.4	138.2	138.4	135.1	136.7	134.4	134.4	134.0	134.6	134.9	133.5	132.8	132.3	131.4
PDWLT1106-HTOL-01	3	139.1	138.0	143.3	141.7	142.7	140.5	140.8	138.3	139.3	138.0	137.8	137.6	138.1	138.3	137.0	136.6	135.8	135.4
PDWLT1106-HTOL-01	4	159.8	155.5	154.8	153.3	152.0	149.3	148.7	146.8	147.0	145.6	145.2	144.7	145.5	145.3	144.1	143.6	142.5	142.4
PDWLT1106-HTOL-01	5	162.9	157.6	159.6	158.2	156.2	151.5	151.5	148.4	149.0	146.9	146.5	146.3	146.8	146.8	145.6	144.7	144.1	143.1
PDWLT1106-HTOL-01	6	157.9	153.5	154.9	153.9	151.4	146.4	146.6	143.5	144.2	143.0	142.6	142.5	142.9	143.3	142.2	140.6	139.9	138.8
PDWLT1106-HTOL-01	7	150.7	150.0	153.5	151.8	150.3	148.1	147.4	145.2	145.2	143.5	143.0	142.7	143.1	143.2	142.2	141.8	140.7	140.6
PDWLT1106-HTOL-01	8	152.1	152.5	158.3	159.0	157.5	152.9	153.1	150.7	151.0	148.7	148.3	148.0	148.2	148.2	147.0	146.0	145.4	144.2
PDWLT1106-HTOL-01	9	147.2	146.2	152.8	151.5	149.8	146.3	145.4	142.7	143.1	142.3	140.8	140.5	141.7	141.0	139.8	139.9	138.6	138.0
PDWLT1106-HTOL-01	10	161.5	157.5	158.4	156.6	154.3	150.1	150.8	147.7	148.1	145.6	145.2	147.4	144.9	145.4	144.4	142.7	141.6	140.6
PDWLT1106-HTOL-02	1	141.8	140.5	143.8	141.9	140.5	137.1	138.1	135.7	136.2	133.6	133.8	133.2	134.1	134.5	133.6	132.6	132.1	131.6
PDWLT1106-HTOL-02	2	133.4	134.9	139.1	140.1	139.8	136.5	138.0	135.7	136.0	134.6	135.0	134.3	135.0	135.3	134.5	133.2	132.8	132.0
PDWLT1106-HTOL-02	3	128.1	130.0	132.2	131.2	131.1	128.9	128.9	127.6	127.8	127.5	126.9	126.4	128.6	127.4	126.5	126.2	125.6	125.8
PDWLT1106-HTOL-02	4	173.7	170.5	164.9	162.1	160.0	156.6	155.9	153.7	153.7	152.1	151.7	151.2	151.6	151.2	150.2	149.4	148.3	148.0
PDWLT1106-HTOL-02	5	131.3	131.7	131.6	130.8	130.8	129.2	131.1	129.2	129.9	128.7	128.5	128.5	129.3	129.4	128.8	127.7	127.4	127.0
PDWLT1106-HTOL-02	6	152.9	151.5	155.5	154.2	152.4	148.7	148.9	146.1	146.2	144.4	144.2	144.1	144.6	144.3	143.4	142.7	142.0	141.5
PDWLT1106-HTOL-02	7	161.5	162.1	164.5	163.7	161.8	157.1	155.9	153.5	153.1	150.7	150.4	149.7	149.9	149.7	148.5	147.6	146.7	146.1
PDWLT1106-HTOL-02	8	123.6	123.9	125.6	126.0	124.7	122.2	122.9	120.6	121.0	119.2	119.0	119.1	119.5	119.9	119.3	118.2	117.8	117.1
PDWLT1106-HTOL-02	9	136.8	134.6	133.0	132.7	132.7	129.5	130.5	129.2	129.0	127.4	128.0	128.0	127.6	128.0	127.5	126.4	125.3	125.9
PDWLT1106-HTOL-02	10	147.1	147.0	150.3	149.4	147.8	145.0	145.8	143.5	143.9	142.1	141.7	141.9	142.2	142.8	142.2	141.0	140.2	139.8
	AVERAGE	146.7	145.2	147.6	146.7	145.5	142.2	142.5	140.1	140.6	138.9	138.6	138.4	138.9	138.9	137.9	137.1	136.3	135.8
	% LF	100.0	99.0	100.6	100.0	99.2	96.9	97.1	95.5	95.8	94.6	94.5	94.3	94.7	94.7	94.0	93.4	92.9	92.5
		100.0	99.0	100.6	100.0	99.2	96.9	97.1	95.5	95.8	94.6	94.5	94.3	94.7	94.7	94.0	93.4	92.9	92.5

	3050	3051	3218	3486	3654	3990	4158	4326	4528	4662	4820	4988	5156	5540	6000	6504	7008	7512	7680	8016	8112	8760	9264	9768	10440	10944	11448
	125.5	116.5	116.9	117.2	115.1	116.0	116.0	115.7	115.0	115.1	114.2	115.4	116.5	114.2	113.2	112.8	112.3	112.3	112.3	112.7	111.7	115.7	113.7	112.0	112.5	111.1	111.0
	130.6	121.1	121.6	122.0	120.0	120.4	120.5	120.4	119.5	119.5	119.2	120.1	121.5	119.1	117.8	117.8	117.8	117.8	117.6	116.9	115.5	119.1	117.6	116.4	115.0	115.4	115.7
	134.4	124.2	124.7	124.9	123.8	123.7	123.3	123.2	122.5	122.1	122.0	122.6	123.9	121.8	120.7	123.3	120.2	120.2	120.2	120.1	119.5	123.6	121.9	121.0	119.7	120.1	120.2
	141.1	130.4	130.9	130.9	130.0	129.5	129.2	129.2	128.3	128.1	128.2	128.6	129.7	127.7	126.6	125.9	125.8	125.2	125.7	125.6	124.0	129.2	127.2	124.8	125.3	124.8	124.8
	141.9	131.5	132.1	132.2	130.6	130.5	130.7	130.5	129.5	129.7	129.4	130.1	131.0	128.3	127.7	127.4	126.8	126.9	127.0	126.6	124.9	129.2	127.6	125.3	125.2	124.4	124.7
	137.5	127.6	128.2	128.1	126.2	126.5	126.7	126.6	125.1	125.8	125.2	126.2	127.1	124.8	123.8	123.7	123.1	123.5	123.5	123.2	122.0	126.6	124.9	122.0	121.4	120.1	120.2
	139.5	128.7	129.4	129.6	128.8	128.2	127.8	128.0	127.2	126.8	127.1	127.3	128.5	126.7	124.8	125.0	125.2	124.7	124.5	124.2	123.2	127.3	124.9	123.2	120.5	119.1	119.4
	142.7	131.8	132.2	132.0	130.7	129.9	129.2	129.5	127.8	127.4	127.2	127.8	128.8	126.1	125.0	124.9	124.4	123.1	124.1	123.6	121.6	125.6	123.3	121.4	120.4	118.8	119.0
	136.2	125.9	126.4	126.2	124.6	124.0	124.0	123.8	122.1	121.7	121.4	122.1	123.0	120.4	119.1	118.4	117.8	117.5	118.0	117.1	115.7	119.8	118.0	116.0	115.3	115.3	115.3
	138.7	128.5	128.9	128.7	127.2	126.9	127.0	126.8	124.9	125.0	124.4	125.4	126.3	123.4	122.0	121.8	120.8	120.7	121.2	120.9	119.2	123.2	121.4	119.5	118.4	114.1	114.8
	131.3	121.9	122.6	122.8	121.8	122.0	121.6	121.4	120.5	120.5	120.3	121.1	122.3	120.3	118.6	119.1	119.1	119.1	119.1	118.4	116.7	119.1	119.1	119.1	120.5	120.5	120.5
	131.2	121.9	122.7	122.8	121.9	122.1	121.7	121.5	120.5	120.6	120.3	121.1	122.1	120.0	118.3	118.7	118.7	118.7	118.7	118.5	118.5	120.8	119.6	118.1	116.5	115.7	117.0
	125.1	115.5	116.2	116.1	115.8	115.2	114.3	114.7	114.0	113.6	113.9	114.3	115.4	113.9	114.1	112.7	112.7	112.3	112.4	112.2	111.2	115.0	113.4	112.2	112.5	112.2	112.6
	146.6	135.6	135.9	135.5	134.8	133.9	133.2	133.2	131.6	131.4	131.2	131.9	132.6	130.0	128.6	127.3	126.8	125.9	126.3	125.4	123.5	127.1	125.9	124.0	123.8	123.0	123.2
	125.7	116.6	117.2	117.2	116.5	116.6	116.4	116.3	115.0	115.3	114.9	115.6	116.6	114.5	113.9	113.3	112.9	113.2	113.1	113.0	111.7	115.3	114.0	113.2	113.3	113.0	112.9
	140.2	129.7	130.5	130.4	129.7	129.6	129.0	128.8	127.8	128.0	127.3	128.2	129.4	126.9	126.2	125.6	125.3	125.2	125.1	124.8	123.2	127.5	125.9	124.5	124.9	124.7	124.7
	144.3	133.5	134.1	134.1	133.0	132.7	132.5	132.4	131.3	131.3	130.8	131.6	132.7	130.2	129.3	128.5	128.3	128.2	128.5	128.3	127.1	132.2	130.9	129.5	130.1	129.1	129.1
	116.0	107.4	107.9	108.0	107.2	107.4	107.2	107.0	105.8	106.3	105.7	106.5	107.2	105.4	104.8	104.3	104.0	104.5	104.1	104.0	102.6	106.6	105.1	104.2	104.4	103.7	103.7
	124.6	116.0	115.8	116.5	115.9	115.7	115.4	115.3	114.1	114.5	114.2	115.0	115.5	113.6	112.9	112.4	112.3	112.3	112.2	112.0	110.9	115.7	113.9	112.4	113.0	112.5	112.5
	138.1	128.0	128.3	128.4	127.8	127.9	127.4	127.2	126.0	126.3	125.6	126.6	127.5	125.0	124.3	123.8	123.5	123.9	123.6	124.0	122.9	127.8	125.9	124.4	124.9	123.9	123.9
	134.6	124.6	125.1	125.2	124.1	123.9	123.7	123.6	122.4	122.4	122.1	122.9	123.9	121.6	120.6	120.3	119.9	119.8	119.9	119.6	118.3	122.3	120.7	119.2	118.9	118.1	118.3
scaling factor	1.080	134.6	135.1	135.2	134.0	133.8	133.5	133.4	132.2	132.2	131.9	132.7	133.8	131.3	130.2	129.9	129.5	129.3	129.4	129.1	127.7	132.1	130.3	128.7	128.4	127.5	127.7
		91.7	91.7	92.1	92.1	91.3	91.2	91.0	91.0	90.1	90.1	89.9	90.4	91.2	89.5	88.7	88.6	88.2	88.1	88.2	88.0	87.0	90.0	88.8	87.7	87.5	86.9	87.0
		91.7	84.9	85.3	85.3	84.6	84.5	84.3	84.2	83.4	83.5	83.2	83.7	84.4	82.9	82.2	82.0	81.7	81.6	81.7	81.5	80.6	83.4	82.3	81.2	81.0	80.5	80.6

Appendix F

Field Measurement Data and

Installation Personnel Feedback

GOLDEN ALDER ILLUMINANCE MEASUREMENTS

horizontal except where noted - grayed cells excluded from statistics - red text indicates measurements taken after failure of unit

		row\col.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
HPS	Minolta photopic (fc)	D	1.777	1.745	2.674	0.888	0.295	0.150	0.142	0.138	0.198	0.239	0.346	0.278	0.257	0.199	0.224	0.184	0.216	0.412	0.953	1.888	1.584	1.915
		C	1.036	1.094	1.158	0.586	0.270	0.169	0.162	0.231	0.347	0.548	0.621	0.561	0.486	0.377	0.294	0.203	0.218	0.339	0.571	1.043	0.878	1.072
		B	0.745	0.803	0.575	0.323	0.202	0.159	0.186	0.319	0.644	0.935	0.817	0.835	1.288	0.636	0.373	0.199	0.187	0.250	0.339	0.655	0.691	0.739
		A	0.399	0.476	0.276	0.191	0.133	0.138	0.171	0.410	1.090	1.954	1.535	1.455	2.610	0.835	0.343	0.176	0.149	0.184	0.235	0.364	0.427	0.485
	Solar photopic (fc)	D																						1.5
		C	0.9										0.5								0.3			0.8
		B				0.3																		0.5
		A								0.3							0.2							0.3
	Solar scotopic (mfc)	D																						1002
		C	688										344								218			487
		B				215																		294
		A								276							180							150
	Minolta photopic (fc)	SW	0.182	0.196	0.144	0.113	0.087	0.088	0.121	0.194	0.433	0.667	0.953	1.000	0.683	0.431	0.192	0.130	0.115	0.125	0.160	0.210	0.271	0.275
		SW vertical	0.538	0.558	0.382	0.265	0.174	0.148	0.132	0.133	0.221	0.399	0.573	0.534	0.349	0.203	0.133	0.132	0.158	0.201	0.294	0.387	0.561	0.587
Hadco	Minolta photopic (fc)	D	1.486	0.959	1.109	0.730	0.293	0.191	0.189	0.208	0.300	0.403	0.430	0.543	0.683	0.476	0.264	0.219	0.209					
		C	0.997	0.958	1.208	0.623	0.327	0.226	0.209	0.280	0.431	0.740	0.510	0.598	1.239	0.617	0.343	0.207	0.197					
		B	0.460	0.446	0.797	0.514	0.292	0.209	0.227	0.332	0.715	1.236	0.944	1.137	1.635	0.785	0.313	0.201	0.179	0.245				
		A	0.419	0.401	0.391	0.215	0.231	0.191	0.217	0.351	0.737	1.006	1.306	1.788	1.034	0.688	0.266	0.157	0.148	0.192				
	Solar photopic (fc)	D	1.5	1.0	1.1	0.7	0.2	0.1	0.1	0.3	0.4	0.4	0.4	0.6	0.6	0.3	0.2	0.0	0.0					
		C	1.0	0.9	1.3	0.6	0.2	0.1	0.1	0.3	0.4	0.7	0.6	0.6	1.2	0.5	0.2	0.0	0.1					
		B	0.4	0.5	0.8	0.5	0.3	0.1	0.2	0.3	0.7	1.3	0.9	0.9	1.5	0.6	0.1	0.1	0.0					
		A	0.4	0.4	0.4	0.3	0.2	0.1	0.2	0.3	0.7	1.1	1.3	1.7	1.0	0.6	0.2	0.1	0.0					
	Solar scotopic (mfc)	D	1920	1221	1320	750	220	110	124	167	224	369	388	580	694	405	142	62	38					
		C	1205	1120	1382	606	222	129	142	272	354	852	597	722	1586	641	285	85	34					
		B	525	512	877	461	217	122	161	321	687	1473	1118	1259	2195	928	251	98	50					
		A	458	416	401	204	152	108	148	334	698	1194	1682	2113	1472	844	211	82	34					
	Minolta photopic (fc)	SW	0.327	0.301	0.288	0.203	0.155	0.145	0.144	0.207	0.400	0.380	0.425	0.443	0.255	0.164	0.110	0.099	0.106	0.135				
		SW vertical	1.039	0.975	0.749	0.516	0.396	0.327	0.231	0.207	0.208	0.234	0.361											
Sylvania	Minolta photopic (fc)	D	1.392	1.725	0.553	0.062	0.051	0.028	0.031	0.036	0.072	0.091	0.087	0.114	0.099	0.084	0.043	0.035	0.034	0.043	0.073	0.495	2.154	1.792
		C	0.904	0.669	0.178	0.055	0.046	0.031	0.032	0.044	0.071	0.127	0.164	0.171	0.132	0.096	0.045	0.037	0.035	0.042	0.066	0.187	0.838	0.934
		B	0.223	0.154	0.140	0.051	0.043	0.030	0.032	0.051	0.065	0.224	0.713	0.695	0.221	0.068	0.049	0.037	0.034	0.039	0.058	0.100	0.195	0.220
		A	0.092	0.080	0.080	0.062	0.038	0.028	0.030	0.053	0.073	0.797	1.723	1.538	0.830	0.075	0.052	0.035	0.032	0.035	0.058	0.080	0.094	0.106
	Solar photopic (fc)	D	1.4	1.7	0.5	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.6	2.2	1.9
		C	0.9	0.7	0.2	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.2	0.9	0.9
		B	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.8	0.8	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2
		A	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.6	1.8	1.5	0.7	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	Solar scotopic (mfc)	D	2625	2970	752	85	0	0	0	40	45	65	85	84	69	50	0	0	0	40	101	960	4160	2810
		C	1466	1108	240	70	0	0	0	47	50	106	216	225	120	78	0	0	25	0	95	350	1225	1275
		B	318	240	103	50	0	0	0	56	72	270	1095	1037	275	85	0	0	0	0	78	163	253	260
		A	116	101	70	0	0	0	27	54	100	1120	2720	2572	1018	115	42	0	0	0	81	139	76	86
	Minolta photopic (fc)	SW	0.071	0.072	0.069	0.052	0.037	0.028	0.027	0.034	0.060	0.287	0.872	1.021	0.502	0.096	0.047	0.035	0.031	0.033	0.042	0.058	0.074	0.081
		SW vertical	0.228	0.230	0.202	0.147	0.105	0.073	0.063	0.060	0.062	0.158	0.436	0.273	0.167	0.082	0.066	0.067	0.034	0.095	0.133	0.198	0.231	0.236

GOLDEN CEDAR ILLUMINANCE MEASUREMENTS

horizontal except where noted - grayed cells excluded from statistics

		row\col.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
HPS	Minolta photopic (fc)	D	1.525	1.571	2.278	1.369	0.425	0.196	0.200	0.246	0.335	0.392	0.440	0.296	0.190	0.121	0.090	0.082	0.078	0.133	0.358	1.164	1.385	1.128
		C	0.980	0.899	1.233	0.741	0.324	0.227	0.286	0.497	0.608	0.666	0.615	0.618	0.328	0.212	0.125	0.089	0.101	0.160	0.471	1.049	0.865	0.740
		B	0.701	0.711	0.671	0.341	0.232	0.214	0.344	0.934	1.344	1.000	0.851	1.046	0.657	0.286	0.157	0.109	0.115	0.174	0.352	0.504	0.662	0.534
		A	0.414	0.421	0.295	0.181	0.158	0.166	0.308	1.023	2.605	1.784	1.600	2.115	1.015	0.324	0.170	0.105	0.114	0.143	0.218	0.267	0.374	0.334
	Solar photopic (fc)	D																						1.0
		C	0.8									0.4									0.4			0.6
		B				0.2																		0.5
		A								0.6					1.0									0.3
	Solar scotopic (mfc)	D																						570
		C	475									237									130			338
		B				108																		209
		A								435					495									94
	Minolta photopic (fc)	SW	0.185	0.184	0.124	0.122	0.102	0.105	0.145	0.310	0.590	1.002	1.117	0.972	0.589	0.212	0.116	0.060	0.084	0.094	0.113	0.141	0.150	0.165
		SW vertical	0.482	0.474	0.347	0.256	0.192	0.163	0.177	0.236	0.518	0.528	0.364	0.262	0.138	0.129	0.143	0.144	0.184	0.241	0.261	0.339	0.408	0.414
Simply LEDs	Minolta photopic (fc)	D	1.252	1.150	1.577	0.794	0.086	0.032	0.037	0.106	0.370	0.216	0.230	0.182	0.090	0.035	0.028	0.026	0.029	0.050	0.227	1.333	1.055	1.218
		C	1.097	1.284	1.385	0.797	0.113	0.043	0.049	0.288	0.885	0.565	0.570	0.411	0.221	0.054	0.033	0.030	0.033	0.071	0.358	1.306	0.936	1.145
		B	0.637	0.725	0.521	0.382	0.086	0.044	0.050	0.382	2.120	0.835	0.840	1.035	0.433	0.083	0.035	0.031	0.032	0.063	0.250	0.326	0.625	0.716
		A	0.244	0.244	0.191	0.113	0.056	0.043	0.043	0.125	0.887	0.687	0.779	1.193	0.679	0.073	0.035	0.032	0.033	0.043	0.091	0.175	0.207	0.288
	Solar photopic (fc)	D	1.2	1.2	1.5	0.8	0.1	0.0	0.0	0.2	0.3	0.3	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.2	1.4	1.0	1.2
		C	1.0	1.3	1.4	0.7	0.1	0.0	0.1	0.3	0.9	0.6	0.5	0.4	0.2	0.1	0.0	0.0	0.0	0.1	0.3	1.3	0.8	1.1
		B	0.7	0.8	0.5	0.4	0.1	0.0	0.1	0.4	2.0	0.8	0.8	0.9	0.4	0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.6	0.7
		A	0.2	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.9	0.7	0.8	1.1	0.7	0.1	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4
	Solar scotopic (mfc)	D	2179	1941	2483	1300	0	0	0	129	450	310	345	260	0	0	0	0	0	0	270	2320	1620	1939
		C	1828	1987	2099	1062	0	0	0	394	1253	871	840	690	350	0	0	0	0	0	530	2030	1480	1788
		B	1049	1151	750	435	0	0	0	564	3123	1286	1335	1700	690	0	0	0	0	0	271	410	945	1083
		A	340	311	230	69	0	0	0	175	1462	1135	1283	1980	1040	0	0	0	0	0	0	194	260	378
	Minolta photopic (fc)	SW	0.080	0.081	0.068	0.036	0.040	0.041	0.043	0.082	0.216	0.474	0.433	0.404	0.167	0.051	0.031	0.028	0.030	0.034	0.038	0.052	0.069	0.078
		SW vertical	0.019	0.197	0.164	0.128	0.102	0.087	0.080	0.081	0.132	0.260	0.304											
Sternberg	Minolta photopic (fc)	D	1.086	1.360	1.396	0.774	0.413	0.241	0.214	0.263	0.312	0.562	0.479	0.409	0.173	0.132	0.083	0.085	0.132	0.183	0.447	0.675	1.017	1.330
		C	1.080	1.109	1.202	0.548	0.273	0.212	0.262	0.399	0.660	0.911	0.784	0.647	0.245	0.161	0.094	0.086	0.122	0.143	0.348	0.565	1.129	0.993
		B	0.861	0.916	0.775	0.336	0.195	0.157	0.254	0.515	0.980	1.043	0.930	0.904	0.369	0.201	0.103	0.088	0.105	0.110	0.245	0.378	0.881	0.853
		A	0.510	0.553	0.416	0.211	0.138	0.125	0.213	0.408	0.962	1.058	1.155	1.045	0.454	0.247	0.112	0.091	0.091	0.094	0.181	0.239	0.545	0.548
	Solar photopic (fc)	D	1.2	1.4	1.3	0.7	0.3	0.1	0.1	0.2	0.3	0.6	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.4	0.8	1.0	1.3
		C	1.1	1.1	1.1	0.5	0.2	0.1	0.2	0.4	0.6	0.9	0.8	0.6	0.3	0.1	0.1	0.1	0.1	0.2	0.2	0.7	1.0	1.0
		B	0.9	0.9	0.7	0.2	0.1	0.1	0.2	0.5	0.8	1.0	1.0	0.8	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.4	0.8	0.9
		A	0.5	0.5	0.4	0.2	0.1	0.1	0.2	0.4	0.8	1.1	1.2	0.9	0.6	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.5	0.6
	Solar scotopic (mfc)	D	1613	1962	1820	889	370	195	250	179	334	521	483	322	160	85	45	70	110	200	525	1058	1424	1950
		C	1484	1464	1477	591	219	168	302	385	700	1104	987	676	275	107	78	65	85	185	315	830	1381	1328
		B	1127	1147	788	284	120	119	311	587	1229	1365	1278	1161	486	180	88	62	62	88	187	436	958	1071
		A	503	513	356	155	80	89	230	560	1212	1547	1752	1398	738	270	118	58	46	72	110	219	452	560
	Minolta photopic (fc)	SW	0.253	0.245	0.203	0.123	0.105	0.096	0.122	0.280	0.743	1.403	1.488	0.991	0.652	0.287	0.159	0.097	0.079	0.079	0.098	0.145	0.214	0.261
		SW vertical	0.521	0.524	0.415	0.276	0.190	0.148	0.124	0.130	0.223	0.616	0.545	0.529	0.307	0.171	0.130	0.123	0.124	0.162	0.228	0.331	0.481	0.585

Product	Street	Date	Meter	Pole	Time	Air Temp. (°F)	Volts	Amps *	Watts *	PF	Loops *	W	Meter Δ	F09 Avg W
Existing HPS	Alley to East	4/1/2015	AEMC F09	North	9:15 PM	67.9	122.1	2.50	289	0.94	2	144.5		146
				Middle	9:35 PM	66.8	121.7	2.46	291	0.97	2	145.5		
				South	9:49 PM	65.9	122.5	2.63	296	0.93	2	148.0		
			AEMC 3910	North	9:15 PM	67.9	122	2.58	287	0.91	2	143.5	0.7%	
				Middle	9:35 PM	66.8	122	2.53	291	0.94	2	145.5	0.0%	
				South	9:49 PM	65.9	123	2.68	301	0.91	2	150.5	1.7%	
		7/7/2015	AEMC F09	North	10:15 PM	76.2	122.0	2.52	290	0.95	2	145.0		146
				Middle	10:30 PM	75.8	121.3	2.41	287	0.97	2	143.5		
				South	10:42 PM	75.1	121.7	2.57	297	0.95	2	148.5		
Hadco	Golden Alder	4/1/2015	AEMC F09	North	7:40 PM	70.9	121	2.29	274	0.99	3	91.3		91
				Middle	8:05 PM	70.1	121.7	2.27	271	0.99	3	90.3		
				South	8:20 PM	69.8	121.9	2.26	273	0.99	3	91.0		
			AEMC 3910	North	7:40 PM	70.9	122	2.31	272	0.97	3	90.7	0.7%	
				Middle	8:05 PM	70.1	122	2.30	271	0.96	3	90.3	0.0%	
				South	8:20 PM	69.8	123	2.27	268	0.96	3	89.3	1.8%	
Sylvania	Golden Alder	7/7/2015	AEMC F09	North	8:40 PM	82.6	120.5	2.27	267	0.97	5	53.4		55
				Middle	8:57 PM	81.1	120.8	2.44	284	0.98	5	56.8		
				South	9:13 PM	80.2	120.6	2.37	280	0.98	5	56.0		
Simply LED	Golden Cedar	4/1/2015	AEMC F09	North	8:36 PM	68.7	122.3	2.50	302	0.99	5	60.4		59
				Middle	8:52 PM	68.2	122.2	2.41	290	0.99	5	58.0		
				South								**		
			AEMC 3910	North	8:36 PM	68.7	123	2.51	300	0.97	5	60.0	0.7%	
				Middle	8:52 PM	68.2	123	2.44	290	0.97	5	58.0	0.0%	
				South	10:00 PM			2.46			5	**		
Sternberg	Golden Cedar	7/7/2015	AEMC F09	North	10:00 PM	78.0	119.3	2.46	290	0.99	3	96.7		96
				Middle	9:48 PM	78.5	121.6	2.37	285	0.99	3	95.0		
				South	9:33 PM	79.6	120.2	2.38	288	0.99	3	96.0		

NOTES

* Measurements used # of wire loops indicated to increase measurement sensitivity.

** Power to lights went out at 10:00 PM before final measurements were completed.

Table F.1. Responses to questionnaire item #1 by City installation personnel on 2011-09-13

Question How easy or difficult were the retrofit kits to install? Describe any issues encountered with installation.	
Manufacturer	Response from City personnel
Hadco	The installation was relatively easy with a short learning curve for the first two units. There was a preparation that needed to be done in the shop before the field installation. Once the prep work was done, the installation was completed in about 15 minutes. The only drawback was the overall weight of the kit. It was a challenge handling the kit during the installation due to the weight.
Simply LEDs	This product consisted of several discrete components that needed to be prepared in the shop prior to field installation. The installation process was not difficult but rather time consuming. The installation could be improved by redesigning the mounting ring that interfaces the globe and the dome top. It needed to be better secured to withstand vibration and gusty winds in the field.
Sylvania	The kits were not designed to fit the City of Sacramento's light standards. The mounting plate for each kit was modified to match the City's light standard, a process that took several weeks. The center shaft holding the light engine also required an adjustment to match the globe. The installation required significant shop preparation. The field installation would not be successful without a lengthy shop preparation.
Sternberg	The kit was supposed to be designed for ease of installation thereby it was available only as a fully assembled, self contained, unit complete with a globe, a light engine, and a capital. But the total weight of the entire assembly and the size of it made it very difficult to install in the field. Field personnel found it very challenging to balance the heavy assembly with one hand while trying to make electrical connections necessary for the installation in the field.

Table F.2. Responses to questionnaire item #2 by City installation personnel on 2011-09-13

Question How easy or difficult was it to align the fixtures for proper lighting along the street?	
Manufacturer	Response from City personnel
Hadco	The alignment was simple. The kits were configured to be Type III. The position of the light engine was predetermined and the mounting was designed to snap in place.
Simply LEDs	Aligning the kits was very simple because the kits were integrated into the globes and dome tops. Any technicians familiar with installing the Lexalite 424 series globes would have no difficulty aligning the kits.
Sylvania	The alignment was relatively simple as the light engine was designed to mimic a HID.
Sternberg	There was no alignment issue as the kit was designed to mimic a HID in a typical textured globe.

Table F.3. Responses to questionnaire item #3 by City installation personnel on 2011-09-13

Question Approximately how long did it take (man-hours), on average, to install one retrofit kit?	
Manufacturer	Response from City personnel
Hadco	It took a two – person crew about 30 minutes to prep and 15 minutes to install in the field.
Simply LEDs	It took a two - person crew about one hour to prepare the kit in the shop and thirty minutes in the field to install and align the kit.
Sylvania	It took a two-person crew over an hour of shop prep and 45 minutes of field installation.
Sternberg	It took a two-person crew about one hour to install.

Appendix G

Project Specimen Testing – Hadco LED

(Lamp-Ballast Retrofit Kit)

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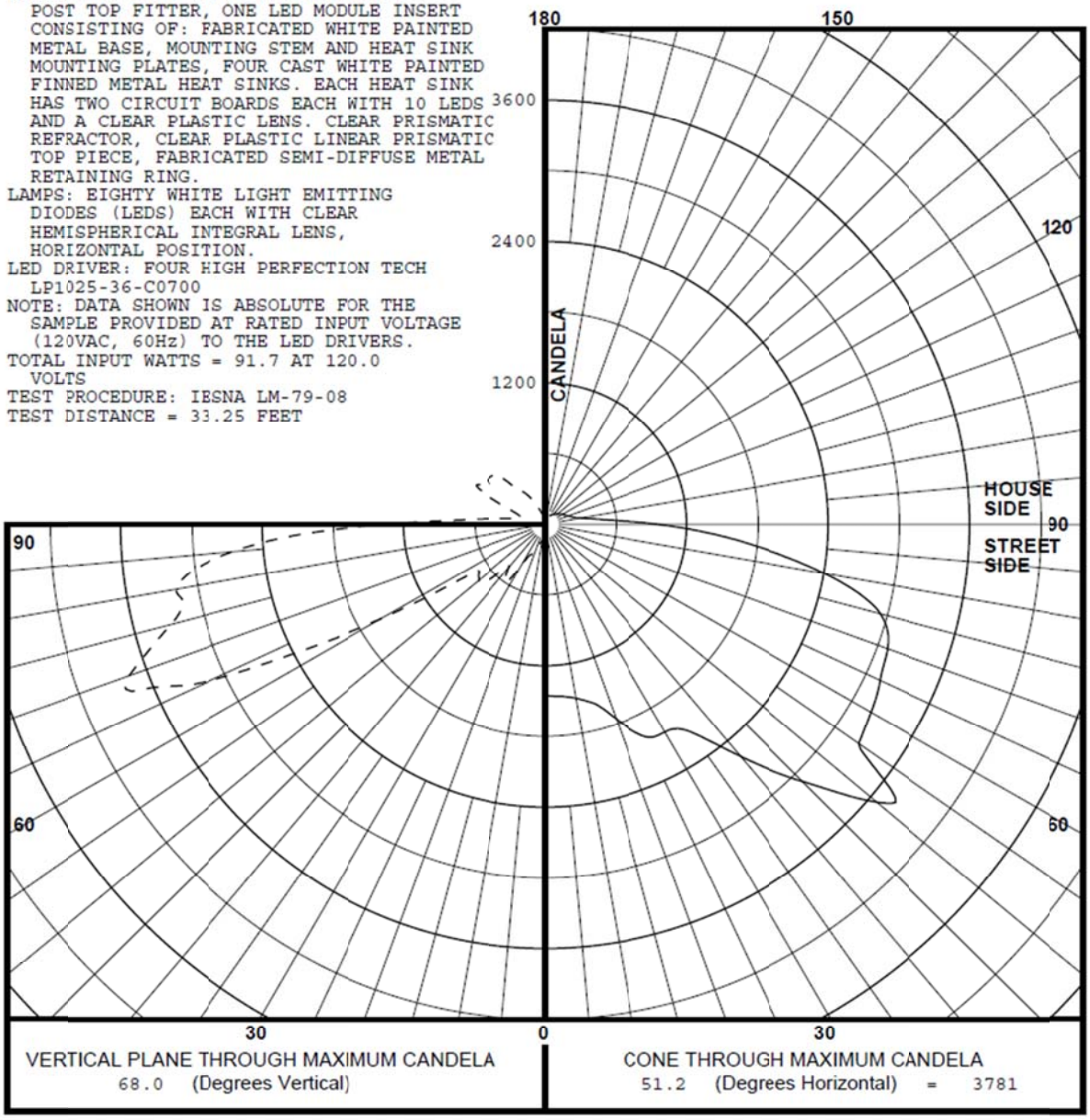
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL69037
ISSUE DATE: 08/05/11 PAGE: 2 OF 6
PREPARED FOR: CITY OF SACRAMENTO
(HADCO)
CATALOG NUMBER: RPTLD-RL32-4-L55
(CA6730-T34L55)
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED WHITE PAINTED METAL BASE, MOUNTING STEM AND HEAT SINK MOUNTING PLATES, FOUR CAST WHITE PAINTED FINNED METAL HEAT SINKS. EACH HEAT SINK HAS TWO CIRCUIT BOARDS EACH WITH 10 LEDS AND A CLEAR PLASTIC LENS. CLEAR PRISMATIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.
LAMPS: EIGHTY WHITE LIGHT EMITTING DIODES (LEDS) EACH WITH CLEAR HEMISPHERICAL INTEGRAL LENS, HORIZONTAL POSITION.
LED DRIVER: FOUR HIGH PERFECTION TECH LP1025-36-C0700
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVERS.
TOTAL INPUT WATTS = 91.7 AT 120.0 VOLTS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET

MAXIMUM PLANE AND MAXIMUM CONE PLOTS OF CANDELA



VERTICAL PLANE THROUGH MAXIMUM CANDELA
68.0 (Degrees Vertical)

CONE THROUGH MAXIMUM CANDELA
51.2 (Degrees Horizontal) = 3781

THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

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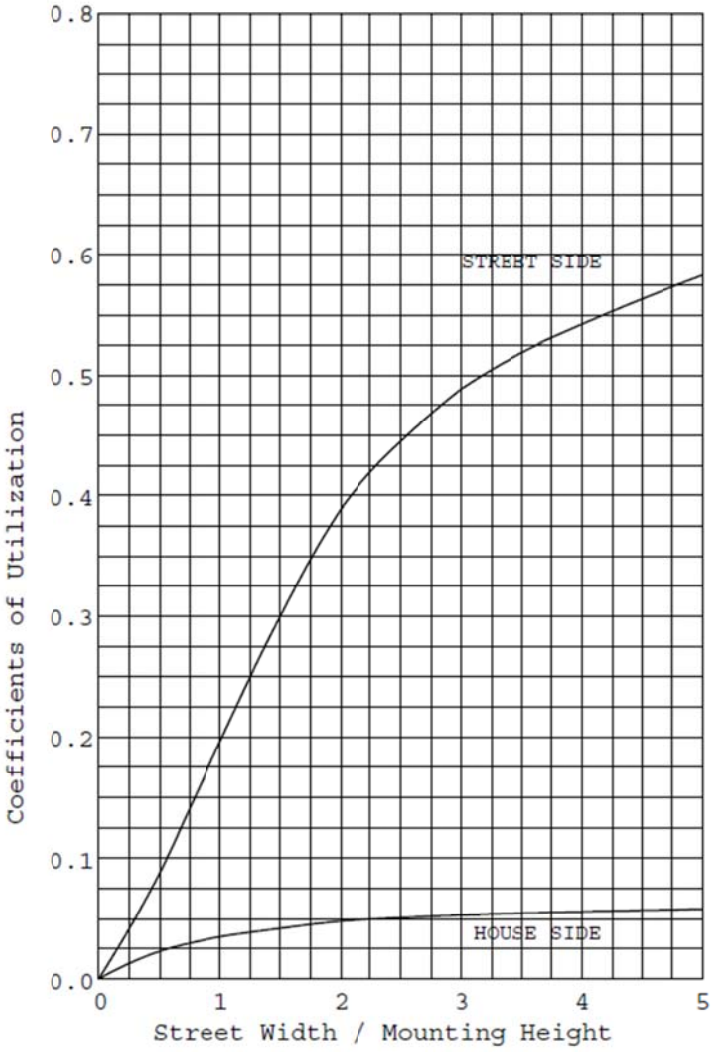
ISSUE DATE: 08/05/11
PREPARED FOR: CITY OF SACRAMENTO (HADCO)

COEFFICIENTS OF UTILIZATION AND FLUX DISTRIBUTION



	LUMENS	PERCENT OF FIXTURE
DOWNWARD STREET SIDE	3808	67.5
DOWNWARD HOUSE SIDE	388	6.9
DOWNWARD TOTAL	4195	74.4
UPWARD STREET SIDE	1101	19.5
UPWARD HOUSE SIDE	343	6.1
UPWARD TOTAL	1444	25.6
TOTAL FLUX	5639	100.0

EFFICACY = 61.5 Lm/W

ALL CANDELA AND LUMENS IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS LUMINAIRE SAMPLE.

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3386 LONGHORN ROAD, BOULDER, CO 80302 USA
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FLUX DISTRIBUTION BY SOLID ANGLE

(PER IESNA TM-15-07, LUMINAIRE CLASSIFICATION SYSTEM FOR OUTDOOR LUMINAIRES)

	LUMENS	PERCENT OF FIXTURE	BUG ZONE RATINGS
FORWARD LIGHT	3808.	67.5	
FL (0- 30)	88.8	1.6	
FM (30- 60)	688.0	12.2	
FH (60- 80)	2179.7	38.7	G2
FVH(80- 90)	851.4	15.1	U3 G5
BACK LIGHT	388.	6.9	
BL (0- 30)	24.6	0.4	B0
BM (30- 60)	99.1	1.8	B0
BH (60- 80)	180.5	3.2	B1 G1
BVH(80- 90)	83.3	1.5	U2 G1
UPLIGHT	1444.	25.6	
UL (90-100)	281.4	5.0	U3
UH (100-180)	1162.3	20.6	U5
TRAPPED LIGHT	0.	0.0	
TOTAL FLUX	5639.	100.0	

BACKLIGHT, UPLIGHT, AND GLARE (BUG) RATINGS
(PER ADDENDUM A FOR IESNA TM-15-07)

BUG RATING: B1 U5 G5

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REPORT NUMBER: ITL69040
DATE: 08/24/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (HADCO)

ADDRESS: 82 BERENS DRIVE
KENTFIELD, CA 94804

CATALOG NUMBER: RPTLD-RL32-4-L55 (CA6730-T34L55)

LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED WHITE PAINTED METAL BASE, MOUNTING STEM AND HEAT SINK MOUNTING PLATES, FOUR CAST WHITE PAINTED FINNED METAL HEAT SINKS. EACH HEAT SINK HAS TWO CIRCUIT BOARDS EACH WITH 10 LEDS AND A CLEAR PLASTIC LENS. CLEAR PRISMATIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.

LAMPS: EIGHTY WHITE LIGHT EMITTING DIODES (LEDS) EACH WITH CLEAR HEMISPHERICAL INTEGRAL LENS, HORIZONTAL POSITION.

DRIVERS: FOUR HIGH PERFECTION TECH LP1025-36-C0700

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60HZ) TO THE LED DRIVERS.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #6	08/23/11
	Ocean Optics QE65000 Spectroradiometer	03/26/12
	ITL 2.0 Meter Diameter Integrating Sphere, 4π Geometry	N/A

OBJECT OF TEST: Measure the Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y), ANSI C78.377 Duv, Scotopic / Photopic Lumen Ratio, and electrical data including Power Factor (PF) to the luminaire.

PROCEDURE: The luminaire was provided by the customer and had an unknown number of burn hours. The luminaire was mounted inside the integrating sphere in a vertical base-up position (LEDs facing horizontal position). The luminaire was allowed to stabilize at 120VAC input. After stabilization occurred, Spectral Power Distribution (SPD), Correlated Color Temperature (CCT), Color Rendering Indices (CRI), Chromaticity Coordinates (x,y), ANSI C78.377 Duv, and electrical data including Power Factor (PF) were measured with the luminaire operating in the integrating sphere. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the luminaire operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-79-08. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

Checked *T Berger*
Approved *N Gully*
Lighting Engineer

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REPORT NUMBER: ITL69040
DATE: 08/24/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (HADCO)
CATALOG NUMBER: RPTLD-RL32-4-L55 (CA6730-T34L55)
RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.3663
Chromaticity Ordinate y	0.3755
Correlated Color Temp CCT (K)	4397
Color Rendering Index (CRIa)	69
Color Rendering Index 1 (Light greyish red)	68
Color Rendering Index 2 (Dark greyish yellow)	73
Color Rendering Index 3 (Strong yellowish green)	76
Color Rendering Index 4 (Moderate yellowish green)	70
Color Rendering Index 5 (Light bluish green)	67
Color Rendering Index 6 (Light blue)	62
Color Rendering Index 7 (Light violet)	80
Color Rendering Index 8 (Light reddish purple)	60
Color Rendering Index 9 (Strong red)	-17
Color Rendering Index 10 (Strong yellow)	35
Color Rendering Index 11 (Strong green)	65
Color Rendering Index 12 (Strong blue)	37
Color Rendering Index 13 (Light yellowish pink (skin))	67
Color Rendering Index 14 (Moderate olive green (leaf))	86
ANSI C78.377-2008 Duv	0.004
Scotopic / Photopic Lumen Ratio	1.577
ELECTRICAL	
Input Voltage (Volts AC)	120.0
Input Current (mA AC)	768
Input Power (Watts)	91.4
Input Power Factor (%)	99.2

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REPORT NUMBER: ITL69043
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: RPTLD-RL32-4-L55 (CA6730-T34L55)

LUMINAIRE: Cast black painted metal post top fitter, one LED module insert consisting of: fabricated white painted metal base, mounting stem and heat sink mounting plates, four cast white painted finned metal heat sinks. Each heat sink consists of: two circuit boards each with 10 LEDs, clear plastic lens. fabricated semi-diffuse metal lens retaining ring. Clear prismatic refractor, clear plastic linear prismatic top piece.

LAMPS: Eighty white light emitting diodes (LEDs) each with clear hemispherical integral lens, horizontal position.

LED DRIVER: Four High Perfection Tech LP1025-36-C0700

OBJECT OF TEST: Measure temperature of hottest single LED in the luminaire for correlation to the LED manufacturer's lumen depreciation curves. Also measure two additional LED temperatures and the hot spot on the LED driver. City of Sacramento provided direction as to which LEDs to measure and where to place the thermocouple on each LED. City of Sacramento also provided direction regarding which driver to use and the location on that driver to place the thermocouple. Type K thermocouples were utilized for all thermal measurements.

INSTRUMENTATION:

	Calibration Due
Elgar CW1251 AC Power Source	NA
Yokogawa WT210 Power Analyzer	10/27/2011
Omega HH802U Digital Thermometer	07/18/2012

PROCEDURE: In Situ Temperature Measurement Test on post top mounted luminaire. The luminaire was mounted in free air per UL 1598 specifications and the Energy Star Manufacturer's Guide for Qualifying Solid State Lighting Luminaires. After mounting, the luminaire was energized at 120VAC 60Hz input to the LED drivers and allowed to stabilize in a 25 +/-1 degree Celsius free air ambient. Once stabilization was verified the LED, driver, and ambient temperatures were recorded.

RESULTS: Refer to following pages

Checked: P. Hayes
Approved: C. Stout

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PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL69043
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: RPTLD-RL32-4-L55 (CA6730-T34L55)

RESULTS: Performance Data

Thermocouple Location		Temperature in Degrees C	Temperatures Corrected to Reflect a 25°C Ambient
T_A	(ambient)	25.9	25.0
T_{LD1}	(LED1)	86.7	85.8
T_{LD2}	(LED2)	90.7	89.8
T_{DR}	(driver)	66.9	66.0

Driver Input Electrical	
Volts:	120.0
Amps:	0.769
Watts:	91.71
PF:	0.992

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REPORT NUMBER: ITL69043
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: RPTLD-RL32-4-L55 (CA6730-T34L55)

RESULTS: Photographs

LUMINAIRE WITH LENS

LED 2

LED 1

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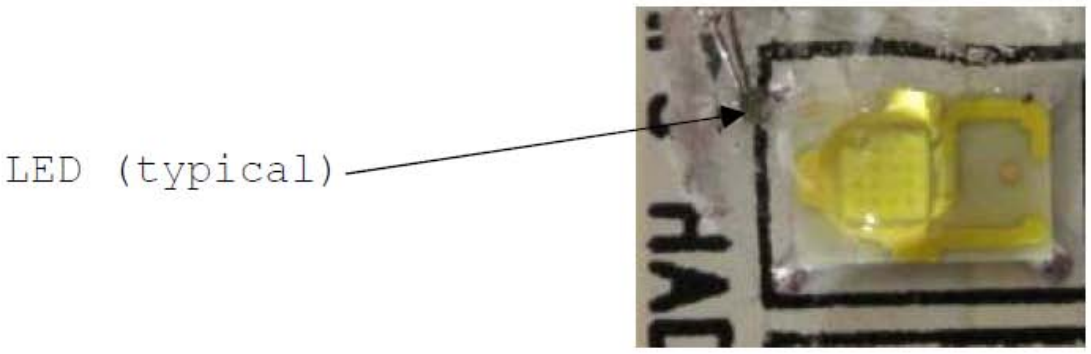
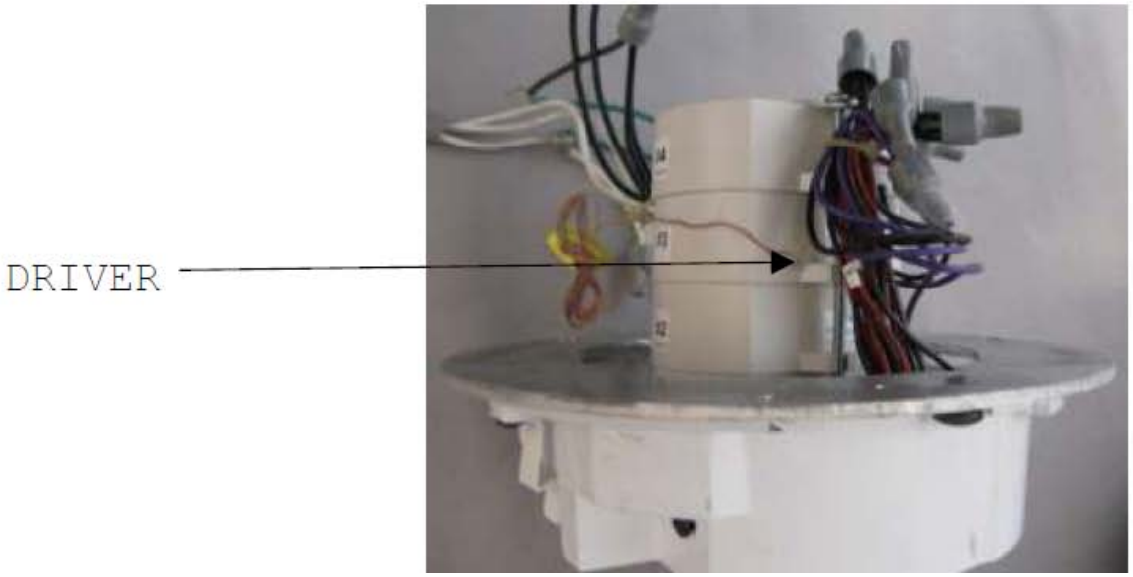
REPORT NUMBER: ITL69043
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: RPTLD-RL32-4-L55 (CA6730-T34L55)

RESULTS: Photographs (continued)





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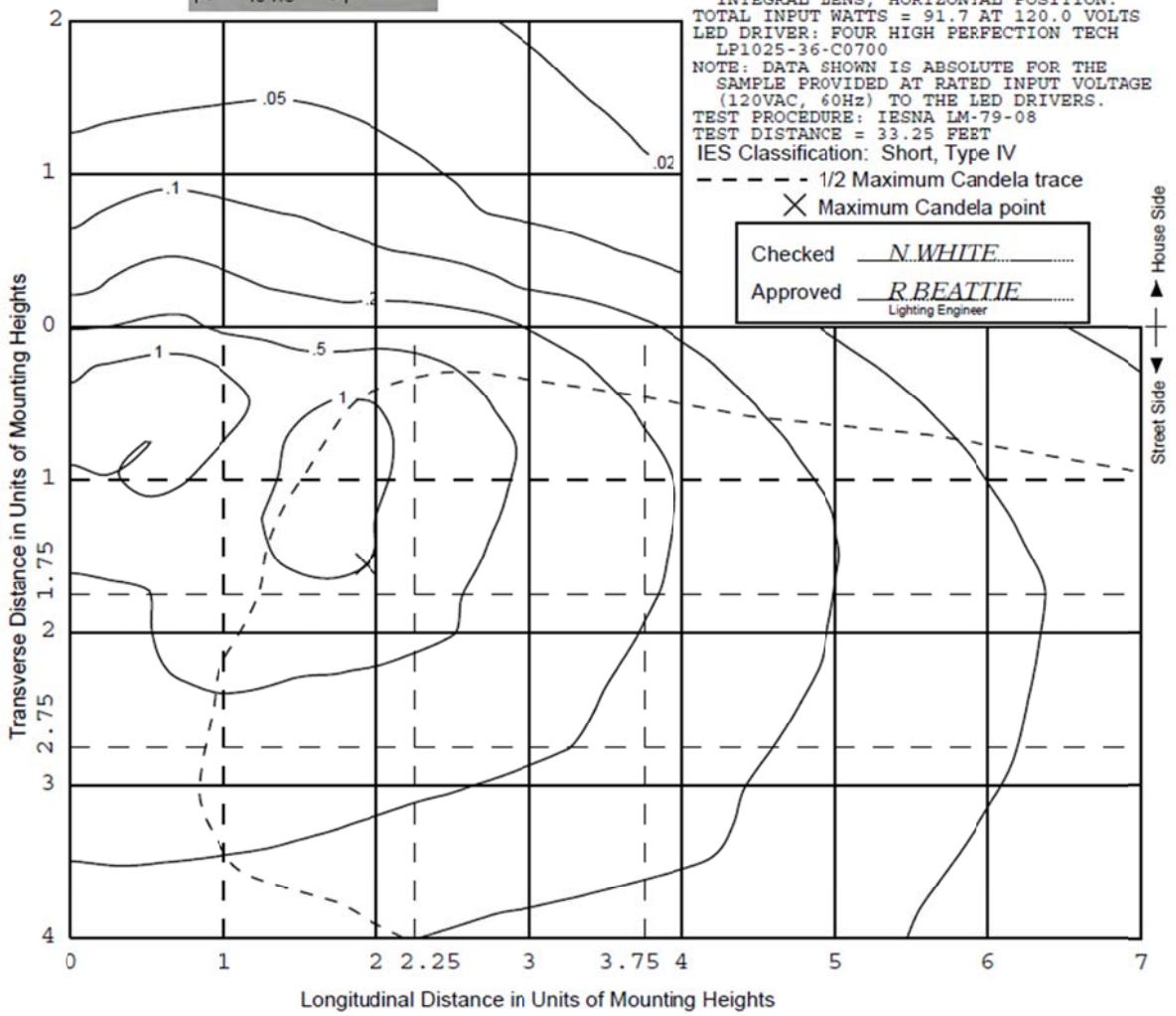
ISOFOOTCANDLE LINES OF HORIZONTAL ILLUMINATION

Values based on 13.5 foot mounting height.

REPORT NUMBER: ITL69037
ISSUE DATE: 08/05/11 PAGE: 1 OF 6
PREPARED FOR: CITY OF SACRAMENTO (HADCO)
CATALOG NUMBER: RPTLD-RL32-4-L55
(CA6730-T34L55)
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED WHITE PAINTED METAL BASE, MOUNTING STEM AND HEAT SINK MOUNTING PLATES, FOUR CAST WHITE PAINTED FINNED METAL HEAT SINKS. EACH HEAT SINK HAS TWO CIRCUIT BOARDS EACH WITH 10 LEDS AND A CLEAR PLASTIC LENS. CLEAR PRISMATIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.
LAMPS: EIGHTY WHITE LIGHT EMITTING DIODES (LEDS) EACH WITH CLEAR HEMISPHERICAL INTEGRAL LENS, HORIZONTAL POSITION.
TOTAL INPUT WATTS = 91.7 AT 120.0 VOLTS
LED DRIVER: FOUR HIGH PERFECTION TECH LP1025-36-C0700
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVERS.
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET
IES Classification: Short, Type IV
- - - - 1/2 Maximum Candela trace
X Maximum Candela point

Checked N.WHITE
Approved R.BEATTIE
Lighting Engineer



THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

Appendix H

Project Specimen Testing – Simply LEDs

(Lamp-Ballast Retrofit Kit)

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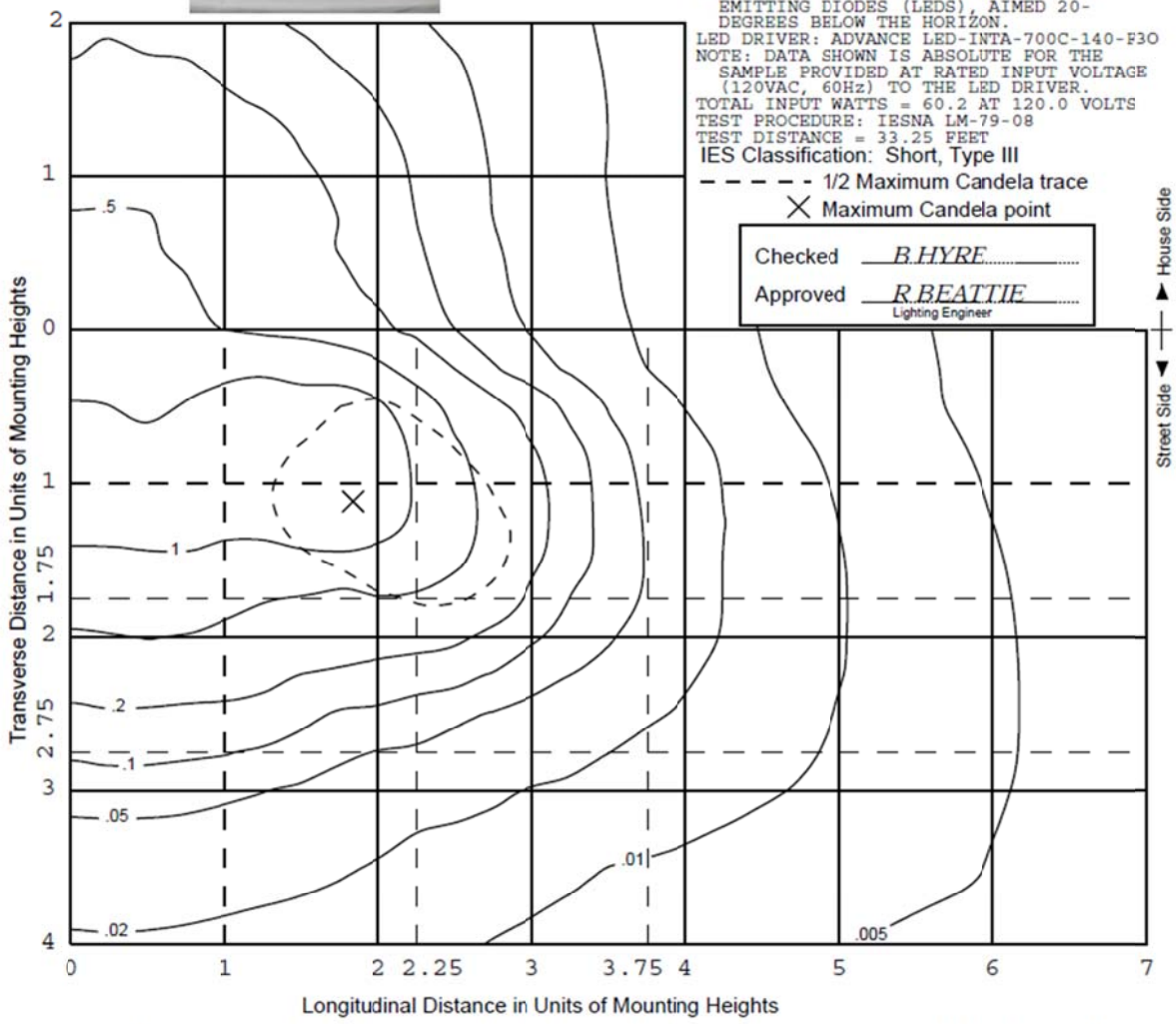
ISOFOOTCANDLE LINES OF HORIZONTAL ILLUMINATION

Values based on 13.5 foot mounting height.

REPORT NUMBER: ITL69039
ISSUE DATE: 08/09/11 PAGE: 1 OF 6
PREPARED FOR: CITY OF SACRAMENTO
(SIMPLY LEDS)
CATALOG NUMBER: ACN-60-C-T5
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, FLAT PREMIUM SPECULAR METAL FITTER TOP PLATE AND UPPER REFLECTOR WITH 6-INCH ROUND CENTER CUT-OUT, CAST BLACK PAINTED FINNED CIRCUIT BOARD MOUNTING RING/HEAT SINK WITH DIFFUSE INTERIOR SURFACE, NINE CIRCUIT BOARDS EACH WITH ONE 4X3 LED ARRAY, ONE MOLDED TIERED MULTI-FACETED PLASTIC REFLECTOR WITH SPECULAR FINISH BELOW 4 LED ARRAYS, FABRICATED DIFFUSE METAL WIREWAY, CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR LINEAR PRISMATIC PLASTIC TOP PIECE.
LAMPS: ONE HUNDRED EIGHT WHITE LIGHT EMITTING DIODES (LEDS), AIMED 20-DEGREES BELOW THE HORIZON.
LED DRIVER: ADVANCE LED-INTA-700C-140-F3O
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVER.
TOTAL INPUT WATTS = 60.2 AT 120.0 VOLTS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET
IES Classification: Short, Type III



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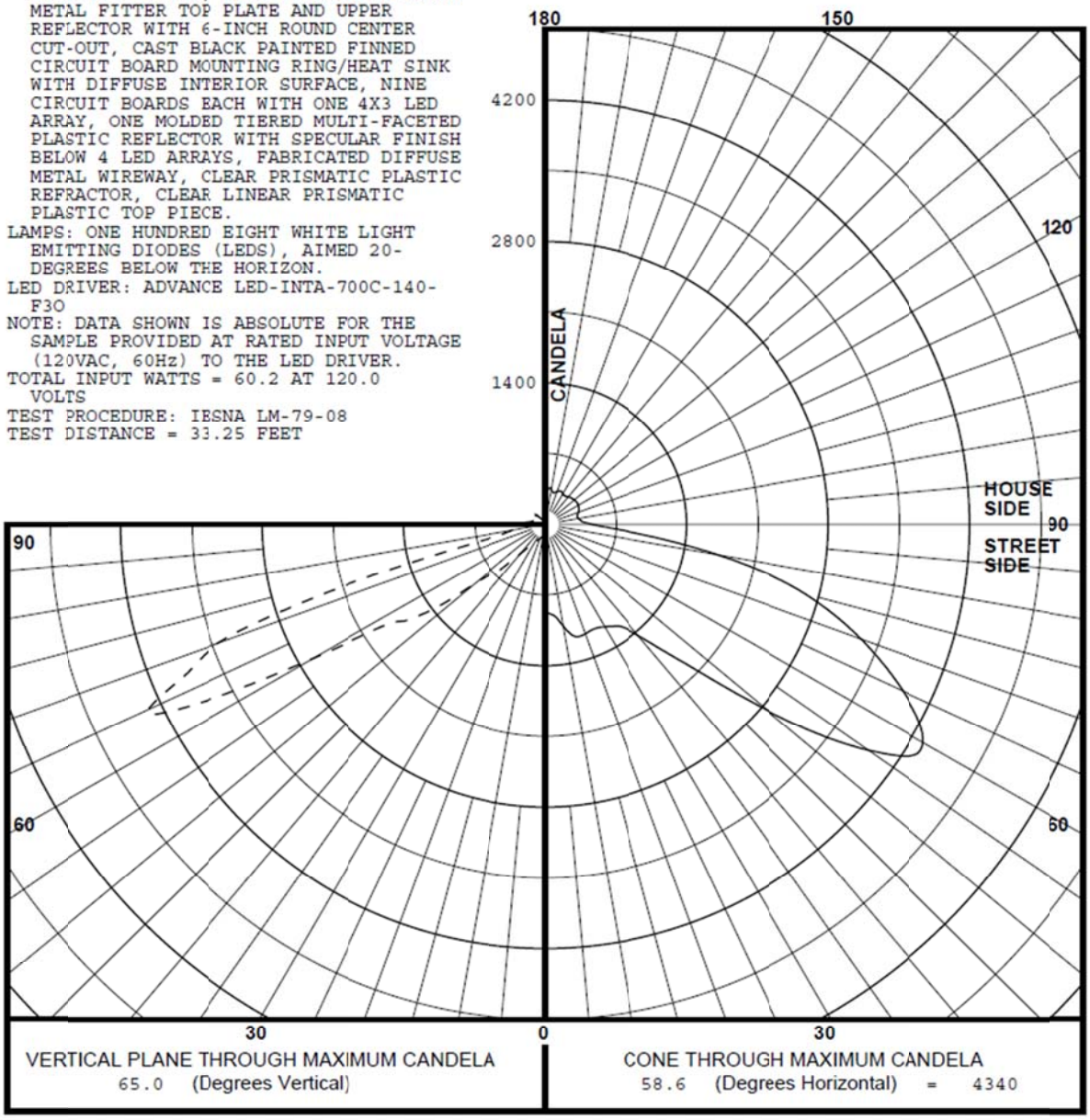
REPORT NUMBER: ITL69039
ISSUE DATE: 08/09/11 PAGE: 2 OF 6
PREPARED FOR: CITY OF SACRAMENTO
(SIMPLY LEDS)
CATALOG NUMBER: ACN-60-C-T5
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, FLAT PREMIUM SPECULAR METAL FITTER TOP PLATE AND UPPER REFLECTOR WITH 6-INCH ROUND CENTER CUT-OUT, CAST BLACK PAINTED FINNED CIRCUIT BOARD MOUNTING RING/HEAT SINK WITH DIFFUSE INTERIOR SURFACE, NINE CIRCUIT BOARDS EACH WITH ONE 4X3 LED ARRAY, ONE MOLDED TIERED MULTI-FACETED PLASTIC REFLECTOR WITH SPECULAR FINISH BELOW 4 LED ARRAYS, FABRICATED DIFFUSE METAL WIREWAY, CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR LINEAR PRISMATIC PLASTIC TOP PIECE.
LAMPS: ONE HUNDRED EIGHT WHITE LIGHT EMITTING DIODES (LEDS), AIMED 20-DEGREES BELOW THE HORIZON.
LED DRIVER: ADVANCE LED-INTA-700C-140-F3O
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVER.
TOTAL INPUT WATTS = 60.2 AT 120.0 VOLTS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET

MAXIMUM PLANE AND MAXIMUM CONE PLOTS OF CANDELA



VERTICAL PLANE THROUGH MAXIMUM CANDELA
65.0 (Degrees Vertical)

CONE THROUGH MAXIMUM CANDELA
58.6 (Degrees Horizontal) = 4340

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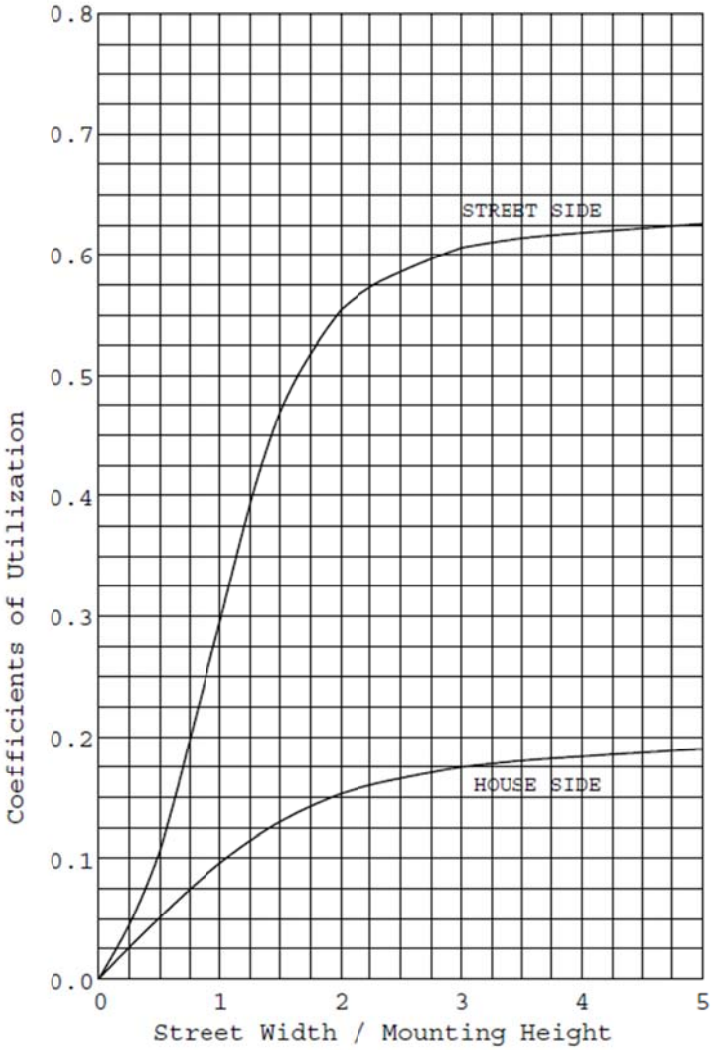
ISSUE DATE: 08/09/11
PREPARED FOR: CITY OF SACRAMENTO (SIMPLY LEDS)

COEFFICIENTS OF UTILIZATION AND FLUX DISTRIBUTION



	LUMENS	PERCENT OF FIXTURE
DOWNWARD STREET SIDE	2212	64.6
DOWNWARD HOUSE SIDE	700	20.5
DOWNWARD TOTAL	2912	85.1
UPWARD STREET SIDE	332	9.7
UPWARD HOUSE SIDE	179	5.2
UPWARD TOTAL	511	14.9
TOTAL FLUX	3423	100.0

EFFICACY = 56.9 Lm/W

ALL CANDELA AND LUMENS IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS LUMINAIRE SAMPLE.

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FLUX DISTRIBUTION BY SOLID ANGLE

(PER IESNA TM-15-07, LUMINAIRE CLASSIFICATION SYSTEM FOR OUTDOOR LUMINAIRES)

	LUMENS	PERCENT OF FIXTURE	BUG ZONE RATINGS
FORWARD LIGHT	2212.	64.6	
FL (0- 30)	74.9	2.2	
FM (30- 60)	847.7	24.8	
FH (60- 80)	1177.2	34.4	G1
FVH(80- 90)	111.9	3.3	U2 G1
BACK LIGHT	700.	20.5	
BL (0- 30)	56.1	1.6	B0
BM (30- 60)	283.2	8.3	B1
BH (60- 80)	289.9	8.5	B1 G1
BVH(80- 90)	70.9	2.1	U1 G1
UPLIGHT	511.	14.9	
UL (90-100)	138.7	4.1	U3
UH (100-180)	372.6	10.9	U3
TRAPPED LIGHT	0.	0.0	
TOTAL FLUX	3423.	100.0	

BACKLIGHT, UPLIGHT, AND GLARE (BUG) RATINGS
(PER ADDENDUM A FOR IESNA TM-15-07)

BUG RATING: B1 U3 G1

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NVLAP LAB CODE: 200925-0
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REPORT NUMBER: ITL69042
DATE: 08/25/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (SIMPLY LEDS)

ADDRESS: 82 BERENS DRIVE
KENTFIELD, CA 94804

CATALOG NUMBER: ACN-60-C-T5

LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, FLAT PREMIUM SPECULAR METAL FITTER TOP PLATE AND UPPER REFLECTOR WITH 6-INCH ROUND CENTER CUT-OUT, CAST BLACK PAINTED FINNED CIRCUIT BOARD MOUNTING RING/HEAT SINK WITH DIFFUSE INTERIOR SURFACE, NINE CIRCUIT BOARDS EACH WITH ONE 4X3 LED ARRAY, ONE MOLDED TIERED MULTI-FACETED PLASTIC REFLECTOR WITH SPECULAR FINISH BELOW 4 LED ARRAYS, FABRICATED DIFFUSE METAL WIREWAY, CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR LINEAR PRISMATIC PLASTIC TOP PIECE.

LAMPS: ONE HUNDRED EIGHT WHITE LIGHT EMITTING DIODES (LEDS), AIMED 20-DEGREES BELOW THE HORIZON.

DRIVER: ADVANCE LED-INTA-700C-140-F3O

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60HZ) TO THE LED DRIVER.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #6	08/23/11
	Ocean Optics QE65000 Spectroradiometer	03/26/12
	ITL 2.0 Meter Diameter Integrating Sphere, 4π Geometry	N/A

OBJECT OF TEST: Measure the Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y), ANSI C78.377 Duv, Scotopic / Photopic Lumen Ratio, and electrical data including Power Factor (PF) to the luminaire.

PROCEDURE: The luminaire was provided by the customer and had an unknown number of burn hours. The luminaire was mounted inside the integrating sphere in a horizontal position (LEDs aimed 20-degrees below the horizon). The luminaire was allowed to stabilize at 120VAC input. After stabilization occurred, Spectral Power Distribution (SPD), Correlated Color Temperature (CCT), Color Rendering Index (CRIa), Chromaticity Coordinates (x,y,u',v'), ANSI C78.377 Duv, and electrical data including Power Factor (PF) were measured with the luminaire operating in the integrating sphere. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the luminaire operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-79-08. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

Checked *T Berger*
Approved *N Gully*
Lighting Engineer

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NVLAP LAB CODE: 200925-0
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REPORT NUMBER: ITL69042
DATE: 08/25/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (SIMPLY LEDS)
CATALOG NUMBER: ACN-60-C-T5
RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.3111
Chromaticity Ordinate y	0.3238
Correlated Color Temp CCT (K)	6634
Color Rendering Index (CRIa)	66
Color Rendering Index 1 (Light greyish red)	62
Color Rendering Index 2 (Dark greyish yellow)	72
Color Rendering Index 3 (Strong yellowish green)	75
Color Rendering Index 4 (Moderate yellowish green)	65
Color Rendering Index 5 (Light bluish green)	64
Color Rendering Index 6 (Light blue)	60
Color Rendering Index 7 (Light violet)	80
Color Rendering Index 8 (Light reddish purple)	54
Color Rendering Index 9 (Strong red)	-53
Color Rendering Index 10 (Strong yellow)	30
Color Rendering Index 11 (Strong green)	57
Color Rendering Index 12 (Strong blue)	31
Color Rendering Index 13 (Light yellowish pink (skin))	64
Color Rendering Index 14 (Moderate olive green (leaf))	85
ANSI C78.377-2008 Duv	0.001
Scotopic / Photopic Lumen Ratio	2.006
ELECTRICAL	
Input Voltage (Volts AC)	120.0
Input Current (mA AC)	508
Input Power (Watts)	60.1
Input Power Factor (%)	98.6

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REPORT NUMBER: ITL69045
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: ACN-60-C-T5

LUMINAIRE: Cast black painted metal post top fitter, flat premium specular metal fitter top plate and upper reflector with 6-inch round center cut-out, cast black painted finned circuit board mounting ring/heat sink with diffuse interior surface, nine circuit boards each with one 4x3 LED array, one molded tiered multi-faceted plastic reflector with specular finish below 4 LED arrays, fabricated diffuse metal wireway, clear prismatic plastic refractor, clear linear prismatic plastic top piece.

LAMPS: One hundred-eight white light emitting diodes (LEDs), aimed 20-degrees below the horizon.

LED DRIVER: Advance LED-INTA-700C-140-F3O

OBJECT OF TEST: Measure temperature of hottest single LED in the luminaire for correlation to the LED manufacturer's lumen depreciation curves. Also measure two additional LED temperatures and the hot spot on the LED driver. City of Sacramento provided direction as to which LEDs to measure and where to place the thermocouple on each LED. City of Sacramento also provided direction for thermocouple placement on the LED driver. Type K thermocouples were utilized for all thermal measurements.

INSTRUMENTATION:

	Calibration Due
Elgar CW1251 AC Power Source	NA
Yokogawa WT210 Power Analyzer	10/27/2011
Omega HH802U Digital Thermometer	07/18/2012

PROCEDURE: In Situ Temperature Measurement Test on post top mounted luminaire. The luminaire was mounted in free air per UL 1598 specifications and the Energy Star Manufacturer's Guide for Qualifying Solid State Lighting Luminaires. After mounting, the luminaire was energized at 120VAC 60Hz input to the LED driver and allowed to stabilize in a 25 +/-1 degree Celsius free air ambient. Once stabilization was verified the LED, driver, and ambient temperatures were recorded.

RESULTS: Refer to following pages

Checked: P. Hayes
Approved: C. Stout

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REPORT NUMBER: ITL69045
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: ACN-60-C-T5
RESULTS: Performance Data

Thermocouple Location		Temperature in Degrees C	Temperatures Corrected to Reflect a 25°C Ambient
T_A	(ambient)	25.8	25.0
T_{LD1}	(LED1)	42.0	41.2
T_{LD2}	(LED2)	46.4	45.6
T_{LD3}	(LED3)	47.7	46.9
T_{DR}	(driver)	47.2	46.4

Driver Input Electrical	
Volts:	120.0
Amps:	0.507
Watts:	60.38
PF:	0.992

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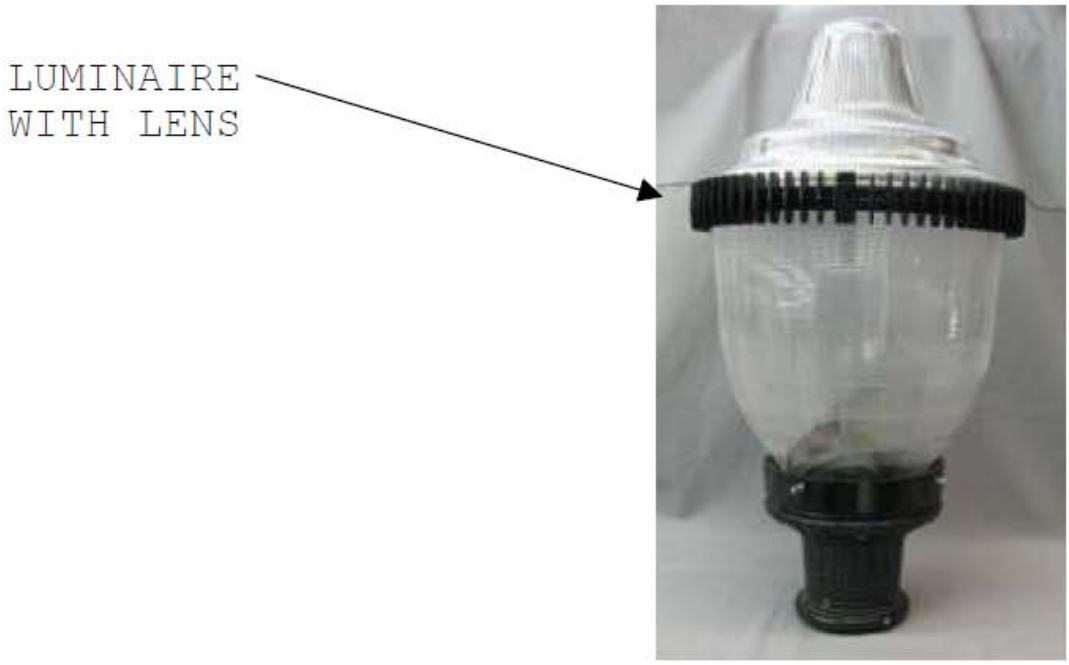
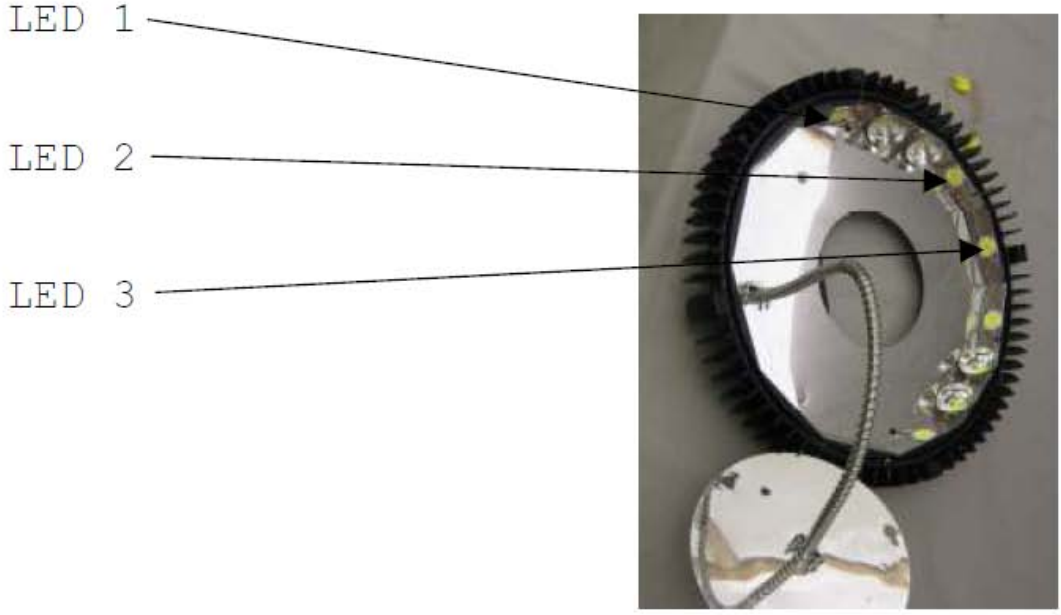
REPORT NUMBER: ITL69045
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: ACN-60-C-T5

RESULTS: Photographs





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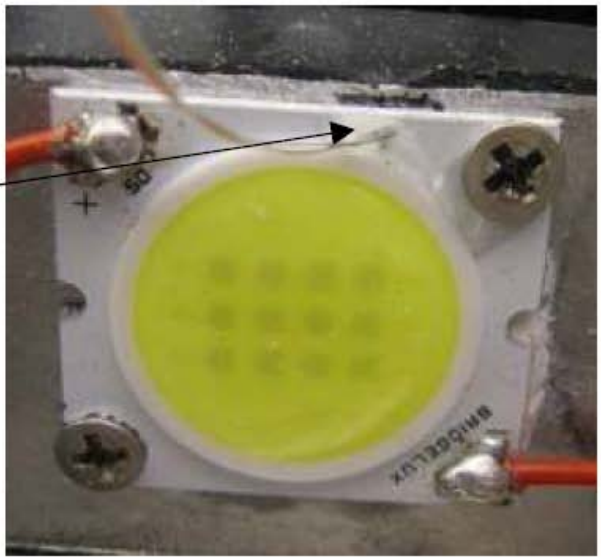
REPORT NUMBER: ITL69045
DATE: 08/24/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: ACN-60-C-T5

RESULTS: Photographs (continued)

LED (typical)



DRIVER

Appendix I

Project Specimen Testing – Sylvania LED

(Lamp-Ballast Retrofit Kit)

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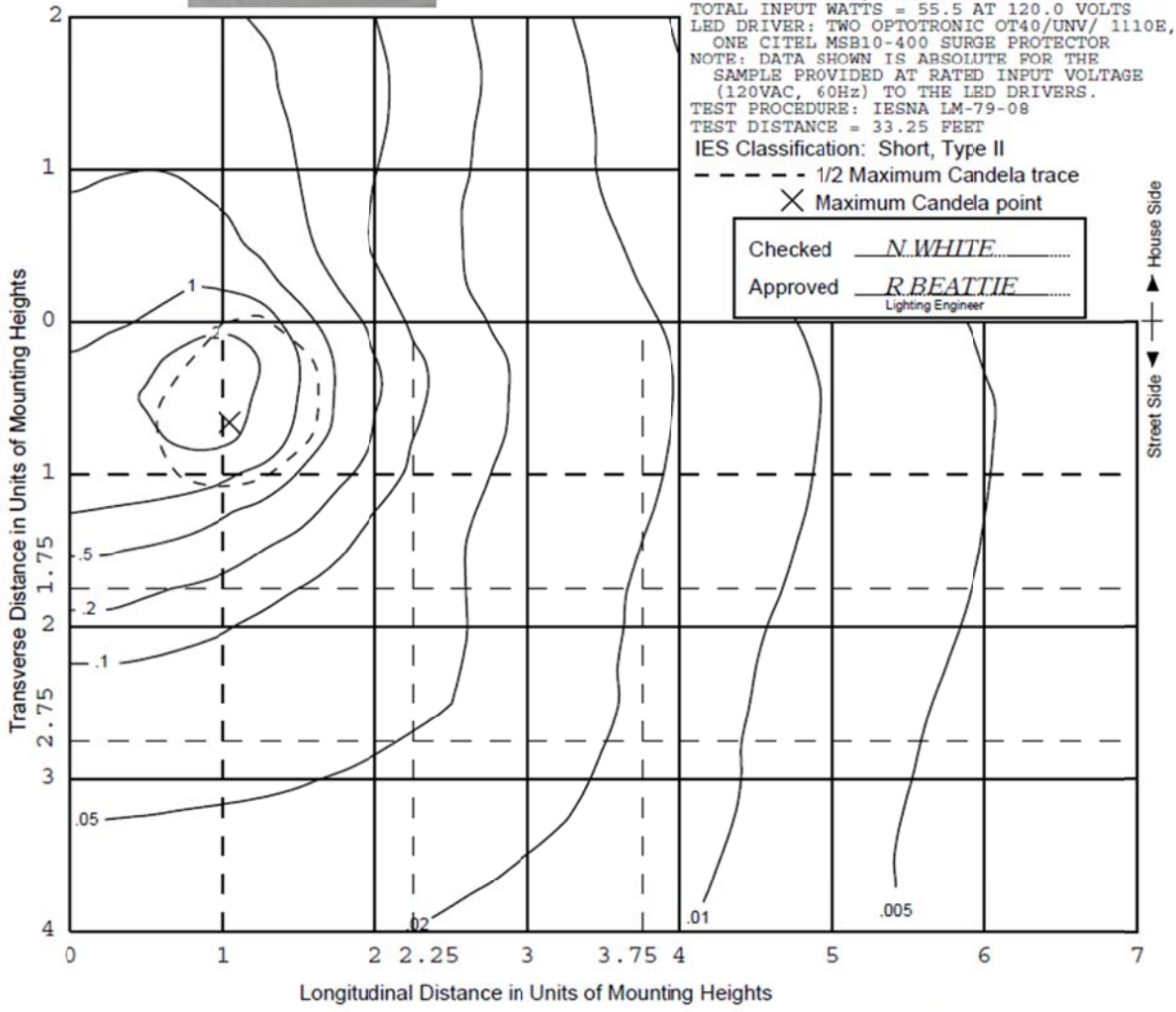
ISOFOOTCANDLE LINES OF HORIZONTAL ILLUMINATION

Values based on 13.5 foot mounting height.

REPORT NUMBER: ITL69038
ISSUE DATE: 08/08/11 PAGE: 1 OF 6
PREPARED FOR: CITY OF SACRAMENTO (SYLVANIA)
CATALOG NUMBER: LED55 RETROFIT-750-T5M-D6 (78628)
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED GRAY PAINTED METAL MOUNTING PLATE, FABRICATED SEMI-SPECULAR METAL LED DRIVER COVER, FABRICATED WHITE PAINTED METAL MOUNTING STEM, CAST BLACK PAINTED FINNED METAL HEAT SINK, ONE CIRCUIT BOARD WITH 42 LEDS, FROSTED PLASTIC LENS WITH ONE CLEAR OPTIC BELOW EACH LED. CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.
LAMPS: FORTY-TWO WHITE LIGHT EMITTING DIODES (LEDS), VERTICAL BASE-UP POSITION.
TOTAL INPUT WATTS = 55.5 AT 120.0 VOLTS
LED DRIVER: TWO OPTOTRONIC OT40/UNV/ 1110E, ONE CITEL MSB10-400 SURGE PROTECTOR
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVERS.
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET
IES Classification: Short, Type II



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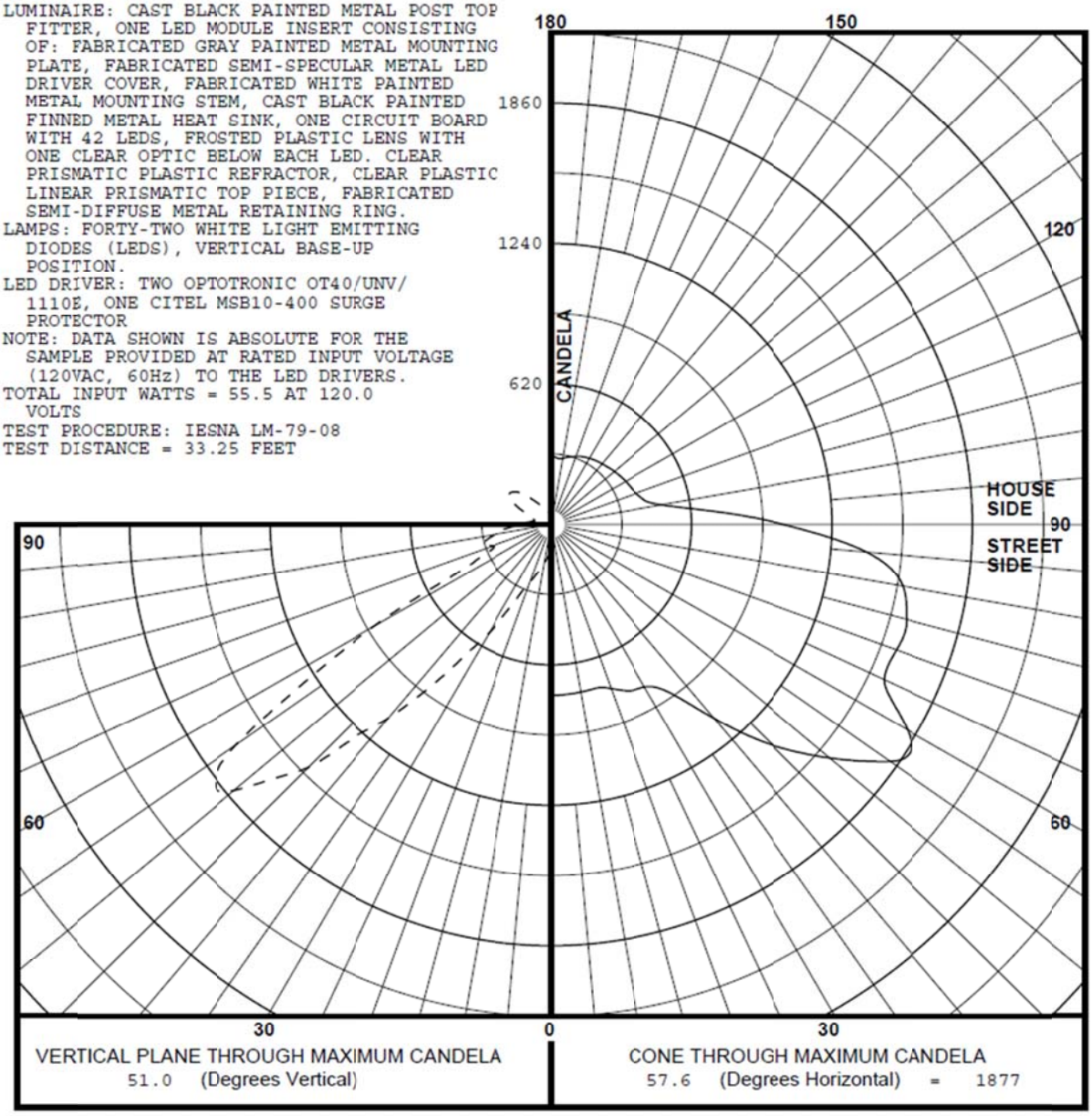
REPORT NUMBER: ITL69038
ISSUE DATE: 08/08/11 PAGE: 2 OF 6
PREPARED FOR: CITY OF SACRAMENTO (SYLVANIA)
CATALOG NUMBER: LED55 RETROFIT-750-T5M-D6 (78628)
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED GRAY PAINTED METAL MOUNTING PLATE, FABRICATED SEMI-SPECULAR METAL LED DRIVER COVER, FABRICATED WHITE PAINTED METAL MOUNTING STEM, CAST BLACK PAINTED FINNED METAL HEAT SINK, ONE CIRCUIT BOARD WITH 42 LEDS, FROSTED PLASTIC LENS WITH ONE CLEAR OPTIC BELOW EACH LED. CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.
LAMPS: FORTY-TWO WHITE LIGHT EMITTING DIODES (LEDS), VERTICAL BASE-UP POSITION.
LED DRIVER: TWO OPTOTRONIC OT40/UNV/1110E, ONE CITEL MSB10-400 SURGE PROTECTOR
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE LED DRIVERS.
TOTAL INPUT WATTS = 55.5 AT 120.0 VOLTS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET

MAXIMUM PLANE AND MAXIMUM CONE PLOTS OF CANDELA

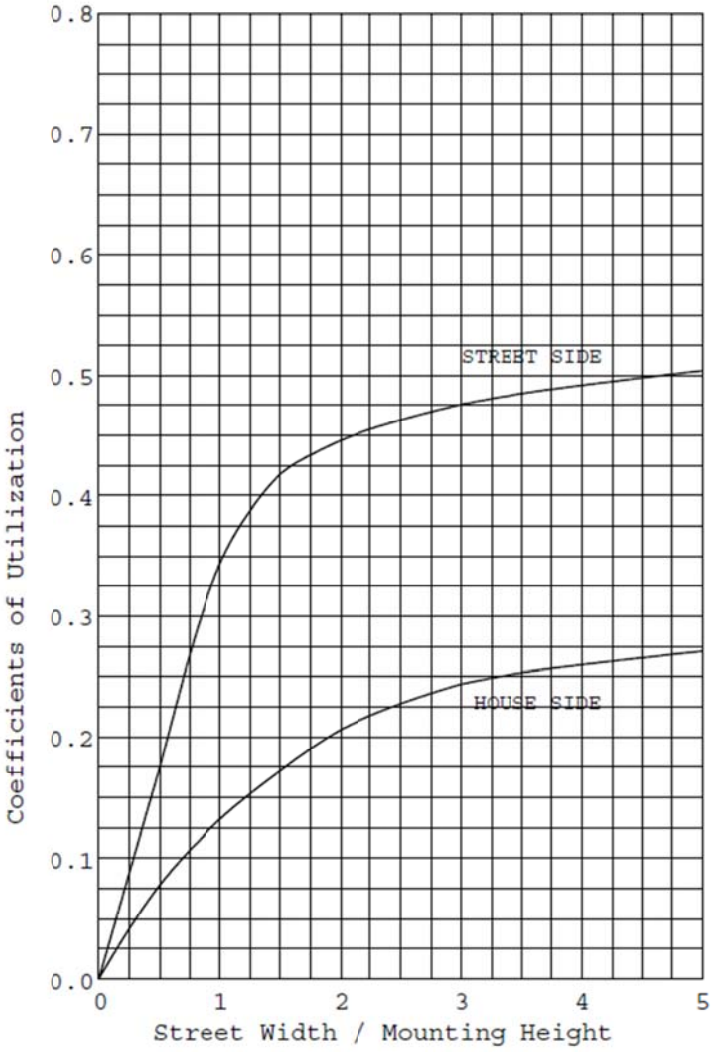


THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

ISSUE DATE: 08/08/11
PREPARED FOR: CITY OF SACRAMENTO (SYLVANIA)

COEFFICIENTS OF UTILIZATION AND FLUX DISTRIBUTION



	LUMENS	PERCENT OF FIXTURE
DOWNWARD STREET SIDE	1634	52.5
DOWNWARD HOUSE SIDE	907	29.1
DOWNWARD TOTAL	2541	81.6
UPWARD STREET SIDE	340	10.9
UPWARD HOUSE SIDE	232	7.5
UPWARD TOTAL	572	18.4
TOTAL FLUX	3114	100.0

EFFICACY = 56.1 Lm/W

ALL CANDELA AND LUMENS IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS LUMINAIRE SAMPLE.

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THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
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ISSUE DATE: 08/08/11
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FLUX DISTRIBUTION BY SOLID ANGLE

(PER IESNA TM-15-07, LUMINAIRE CLASSIFICATION SYSTEM FOR OUTDOOR LUMINAIRES)

	LUMENS	PERCENT OF FIXTURE	BUG ZONE RATINGS
FORWARD LIGHT	1634.	52.5	
FL (0- 30)	120.3	3.9	
FM (30- 60)	1045.8	33.6	
FH (60- 80)	360.1	11.6	G0
FVH(80- 90)	108.2	3.5	U2 G1
BACK LIGHT	907.	29.1	
BL (0- 30)	69.2	2.2	B0
BM (30- 60)	392.4	12.6	B1
BH (60- 80)	381.8	12.3	B1 G1
BVH(80- 90)	63.5	2.0	U1 G1
UPLIGHT	572.	18.4	
UL (90-100)	104.4	3.4	U3
UH (100-180)	467.8	15.0	U3
TRAPPED LIGHT	0.	0.0	
TOTAL FLUX	3114.	100.0	

BACKLIGHT, UPLIGHT, AND GLARE (BUG) RATINGS
(PER ADDENDUM A FOR IESNA TM-15-07)

BUG RATING: B1 U3 G1

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NVLAP LAB CODE: 200925-0

REPORT NUMBER: ITL69041
DATE: 08/24/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (SYLVANIA)

ADDRESS: 82 BERENS DRIVE
KENTFIELD, CA 94804

CATALOG NUMBER: LED55 RETROFIT-750-T5M-D6 (78628)

LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, ONE LED MODULE INSERT CONSISTING OF: FABRICATED GRAY PAINTED METAL MOUNTING PLATE, FABRICATED SEMI-SPECULAR METAL LED DRIVER COVER, FABRICATED WHITE PAINTED METAL MOUNTING STEM, CAST BLACK PAINTED FINNED METAL HEAT SINK, ONE CIRCUIT BOARD WITH 42 LEDS, FROSTED PLASTIC LENS WITH ONE CLEAR OPTIC BELOW EACH LED. CLEAR PRISMATIC PLASTIC REFRACTOR, CLEAR PLASTIC LINEAR PRISMATIC TOP PIECE, FABRICATED SEMI-DIFFUSE METAL RETAINING RING.

LAMPS: FORTY-TWO WHITE LIGHT EMITTING DIODES (LEDS), VERTICAL BASE-UP POSITION.

DRIVERS: TWO OPTOTRONIC OT40/UNV/1110E, ONE CITEL MSB10-400 SURGE PROTECTOR

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60HZ) TO THE LED DRIVERS.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #6	08/23/11
	Ocean Optics QE65000 Spectroradiometer	03/26/12
	ITL 2.0 Meter Diameter Integrating Sphere, 4π Geometry	N/A

OBJECT OF TEST: Measure the Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y), ANSI C78.377 Duv, Scotopic / Photopic Lumen Ratio, and electrical data including Power Factor (PF) to the luminaire.

PROCEDURE: The luminaire was provided by the customer and had an unknown number of burn hours. The luminaire was mounted inside the integrating sphere in a horizontal position (LEDs facing down). The luminaire was allowed to stabilize at 120VAC input. After stabilization occurred, Spectral Power Distribution (SPD), Correlated Color Temperature (CCT), Color Rendering Index (CRIa), Chromaticity Coordinates (x,y,u',v'), ANSI C78.377 Duv, and electrical data including Power Factor (PF) were measured with the luminaire operating in the integrating sphere. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the luminaire operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-79-08. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

Checked *T Berger*
Approved *N Gully*
Lighting Engineer

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NVLAP LAB CODE: 200925-0
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REPORT NUMBER: ITL69041
DATE: 08/24/11
REVISED: 09/27/11
PREPARED FOR: CITY OF SACRAMENTO (SYLVANIA)
CATALOG NUMBER: LED55 RETROFIT-750-T5M-D6 (78628)
RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.3347
Chromaticity Ordinate y	0.3387
Correlated Color Temp CCT (K)	5397
Color Rendering Index (CRIa)	80
Color Rendering Index 1 (Light greyish red)	80
Color Rendering Index 2 (Dark greyish yellow)	83
Color Rendering Index 3 (Strong yellowish green)	82
Color Rendering Index 4 (Moderate yellowish green)	81
Color Rendering Index 5 (Light bluish green)	80
Color Rendering Index 6 (Light blue)	76
Color Rendering Index 7 (Light violet)	86
Color Rendering Index 8 (Light reddish purple)	73
Color Rendering Index 9 (Strong red)	19
Color Rendering Index 10 (Strong yellow)	57
Color Rendering Index 11 (Strong green)	79
Color Rendering Index 12 (Strong blue)	57
Color Rendering Index 13 (Light yellowish pink (skin))	80
Color Rendering Index 14 (Moderate olive green (leaf))	90
ANSI C78.377-2008 Duv	-0.002
Scotopic / Photopic Lumen Ratio	1.963
ELECTRICAL	
Input Voltage (Volts AC)	120.0
Input Current (mA AC)	475
Input Power (Watts)	55.5
Input Power Factor (%)	97.4

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REPORT NUMBER: ITL69044
DATE: 08/23/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: LED55 RETROFIT-750-T5M-D6 (78628)

LUMINAIRE: Cast black painted metal post top fitter, one LED module insert consisting of: fabricated gray painted metal mounting plate, fabricated semi-specular metal LED driver cover, fabricated white painted metal mounting stem, cast black painted finned metal heat sink, one circuit board with 42 LEDs, frosted plastic lens with one clear semi-hemipsherical optic with recessed bottom center below each LED. Fabricated semi-diffuse metal lens retaining ring. Clear prismatic plastic refractor, clear plastic linear prismatic top piece.

LAMPS: Forty-two white light emitting diodes (LEDs), vertical base-up position.

LED DRIVER: Two Optotronic OT40/unv/111ce, one Citel msb10-400 surge protector

OBJECT OF TEST: Measure temperature of hottest single LED in the luminaire for correlation to the LED manufacturer's lumen depreciation curves. Also measure two additional LED temperatures and the hot spot on the LED driver. City of Sacramento provided direction as to which LEDs to measure and where to place the thermocouple on each LED. City of Sacramento also provided direction regarding which driver to use and the location on that driver to place the thermocouple. Type K thermocouples were utilized for all thermal measurements.

INSTRUMENTATION:

	Calibration Due
Elgar CW1251 AC Power Source	NA
Yokogawa WT210 Power Analyzer	10/27/2011
Omega HH802U Digital Thermometer	07/18/2012

PROCEDURE: In Situ Temperature Measurement Test on post top mounted luminaire. The luminaire was mounted in free air per UL 1598 specifications and the Energy Star Manufacturer's Guide for Qualifying Solid State Lighting Luminaires. After mounting, the luminaire was energized at 120VAC 60Hz input to the LED drivers and allowed to stabilize in a 25 +/-1 degree Celsius free air ambient. Once stabilization was verified the LED, driver, and ambient temperatures were recorded.

RESULTS: Refer to following pages

Checked: P. Hayes
Approved: C. Stout

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REPORT NUMBER: ITL69044
DATE: 08/23/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: LED55 RETROFIT-750-T5M-D6 (78628)

RESULTS: Performance Data

Thermocouple Location		Temperature in Degrees C	Temperatures Corrected to Reflect a 25°C Ambient
T_A	(ambient)	24.5	25.0
T_{LD1}	(LED1)	75.4	75.9
T_{LD2}	(LED2)	74.1	74.6
T_{LD3}	(LED3)	75.3	75.8
T_{DR}	(driver)	51.6	52.1

Driver Input Electrical	
Volts:	120.0
Amps:	0.481
Watts:	55.65
PF:	0.966

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REPORT NUMBER: ITL69044
DATE: 08/23/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: LED55 RETROFIT-750-T5M-D6 (78628)

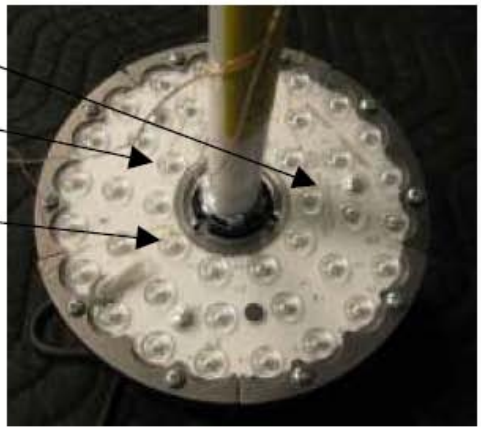
RESULTS: Photographs

LUMINAIRE WITH LENS

LED 3

LED 1

LED 2



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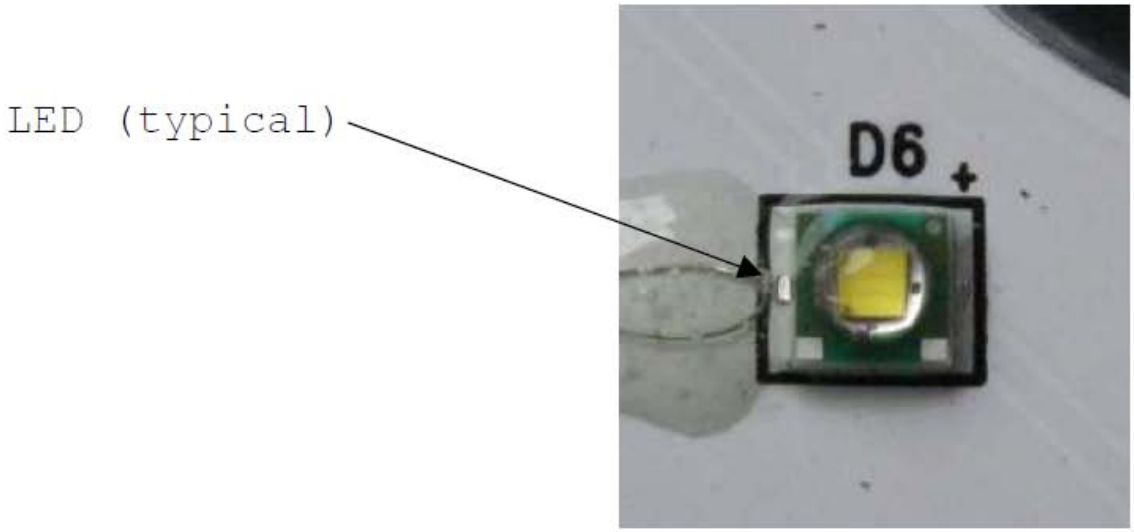
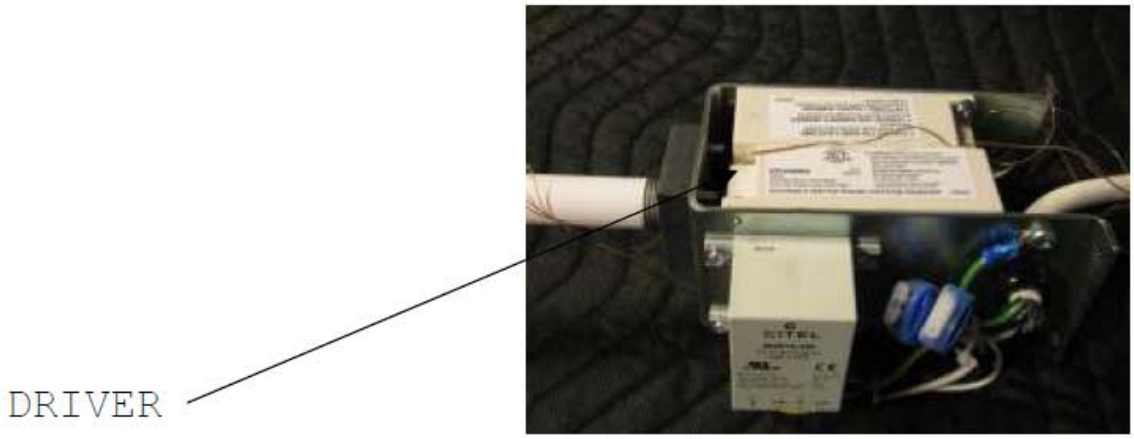
REPORT NUMBER: ITL69044
DATE: 08/23/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: LED55 RETROFIT-750-T5M-D6 (78628)

RESULTS: Photographs (continued)





Appendix J

Project Specimen Testing – Sternberg LED

(Luminaire)

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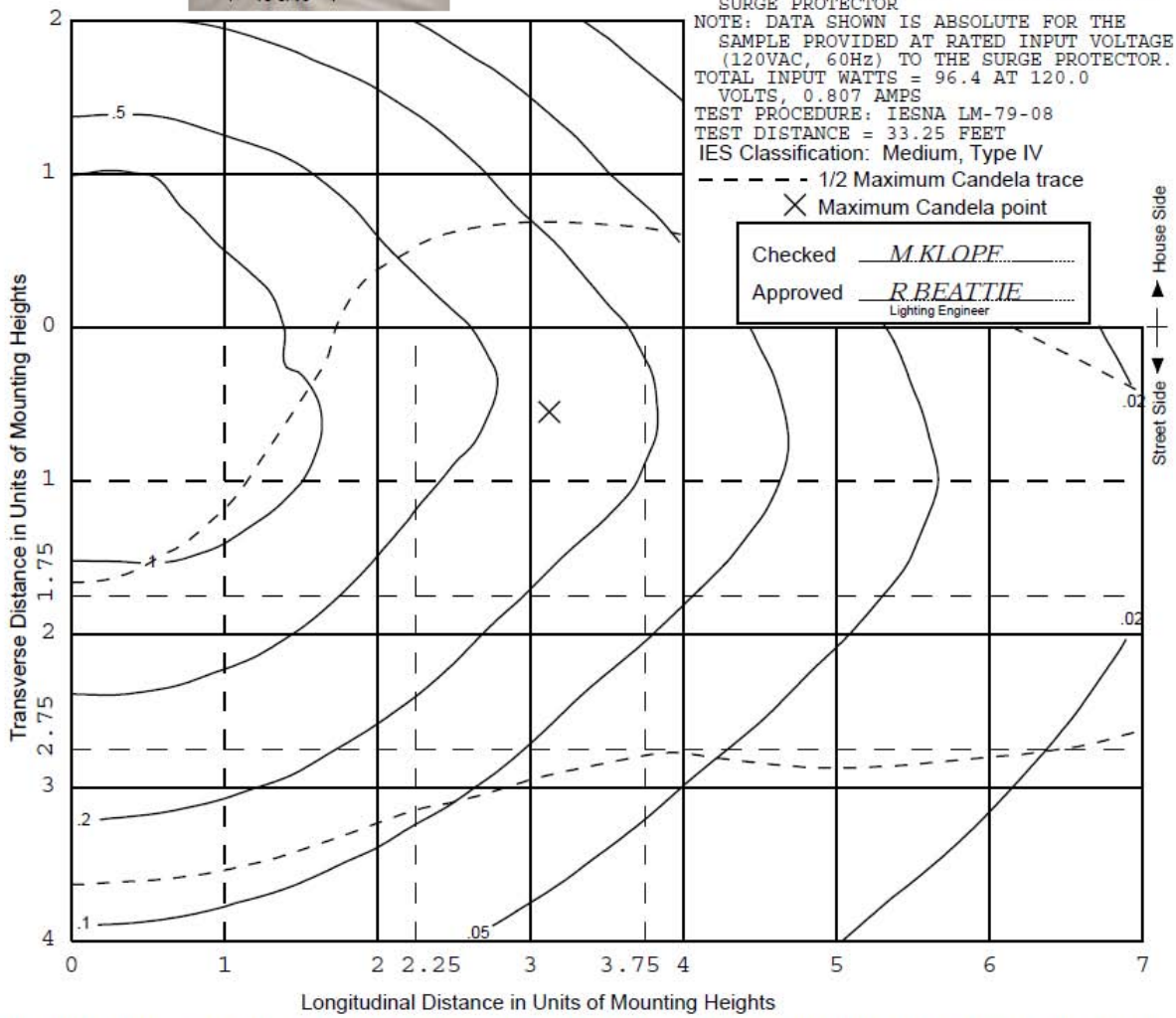
NVLAP LAB CODE: 200925-0

ISOFOOTCANDLE LINES OF HORIZONTAL ILLUMINATION

Values based on 13.5 foot mounting height.

REPORT NUMBER: ITL69592
ISSUE DATE: 09/08/11 PAGE: 1 OF 7
PREPARED FOR: CITY OF SACRAMENTO (PNNL)
CATALOG NUMBER: A850ASRLED 6ARC45T3
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, CLEAR TEXTURED PLASTIC GLOBE LENS WITH CAST BLACK PAINTED METAL MOUNTING COLLAR, CAST BLACK PAINTED METAL TOP AND FINIAL. LUMINAIRE NOT DISASSEMBLED FOR INSPECTION, INTERIOR PROPERTIES UNKNOWN.
LAMPS: UNKNOWN NUMBER OF WHITE LIGHT EMITTING DIODES (LEDS), UNKNOWN ORIENTATION.
LED DRIVER: ADVANCE LED-INTA-0700C-210-FO, THOMAS RESEARCH PRODUCTS BSP3-277 SURGE PROTECTOR
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE SURGE PROTECTOR.
TOTAL INPUT WATTS = 96.4 AT 120.0 VOLTS, 0.807 AMPS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET
IES Classification: Medium, Type IV



THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

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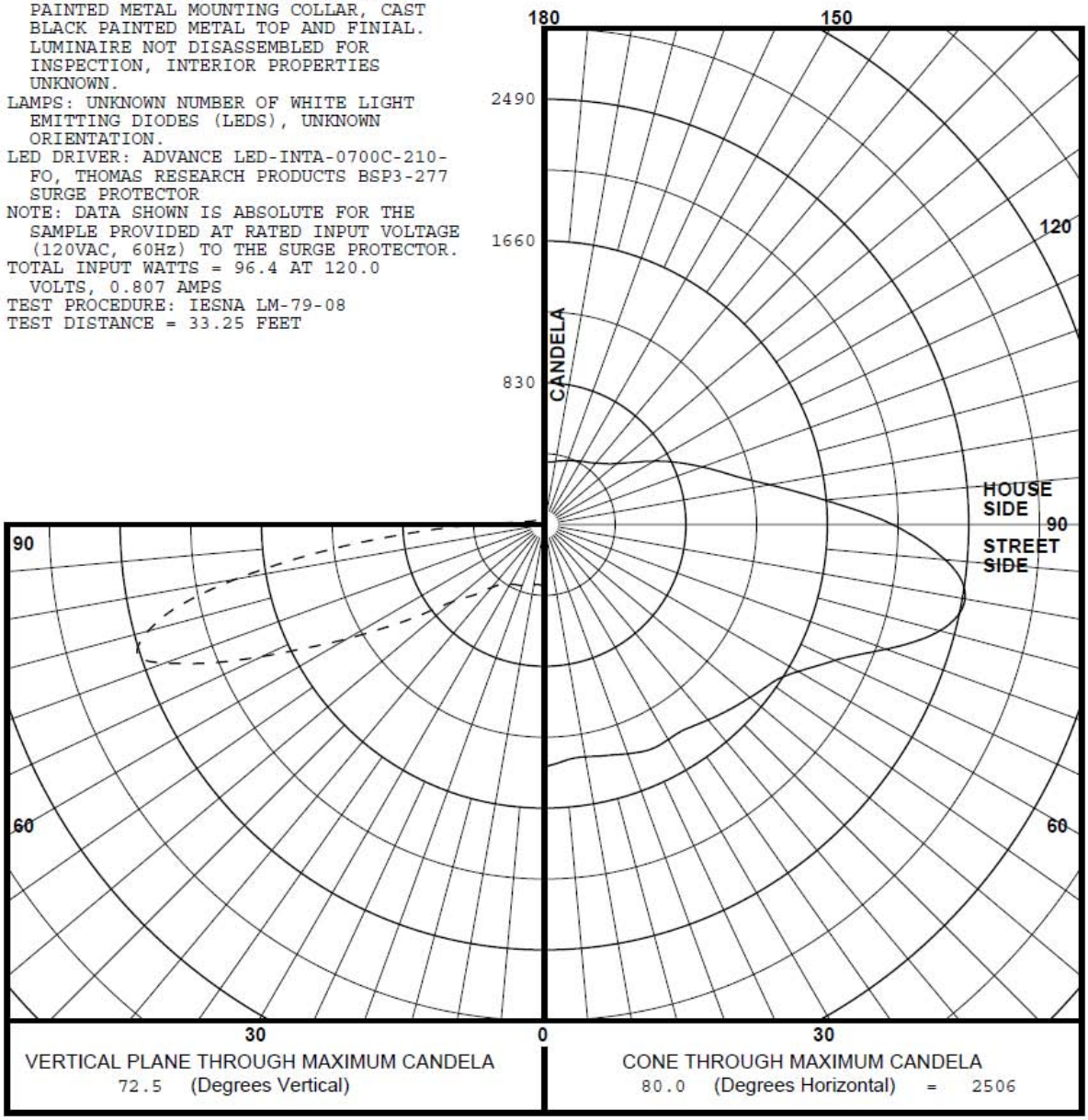
REPORT NUMBER: ITL69592
ISSUE DATE: 09/08/11 PAGE: 2 OF 7
PREPARED FOR: CITY OF SACRAMENTO (PNNL)
CATALOG NUMBER: A850ASRLED 6ARC45T3
LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, CLEAR TEXTURED PLASTIC GLOBE LENS WITH CAST BLACK PAINTED METAL MOUNTING COLLAR, CAST BLACK PAINTED METAL TOP AND FINIAL. LUMINAIRE NOT DISASSEMBLED FOR INSPECTION, INTERIOR PROPERTIES UNKNOWN.
LAMPS: UNKNOWN NUMBER OF WHITE LIGHT EMITTING DIODES (LEDS), UNKNOWN ORIENTATION.
LED DRIVER: ADVANCE LED-INTA-0700C-210-FO, THOMAS RESEARCH PRODUCTS BSP3-277 SURGE PROTECTOR
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE SURGE PROTECTOR.
TOTAL INPUT WATTS = 96.4 AT 120.0 VOLTS, 0.807 AMPS
TEST PROCEDURE: IESNA LM-79-08
TEST DISTANCE = 33.25 FEET

MAXIMUM PLANE AND MAXIMUM CONE PLOTS OF CANDELA



VERTICAL PLANE THROUGH MAXIMUM CANDELA
72.5 (Degrees Vertical)

CONE THROUGH MAXIMUM CANDELA
80.0 (Degrees Horizontal) = 2506

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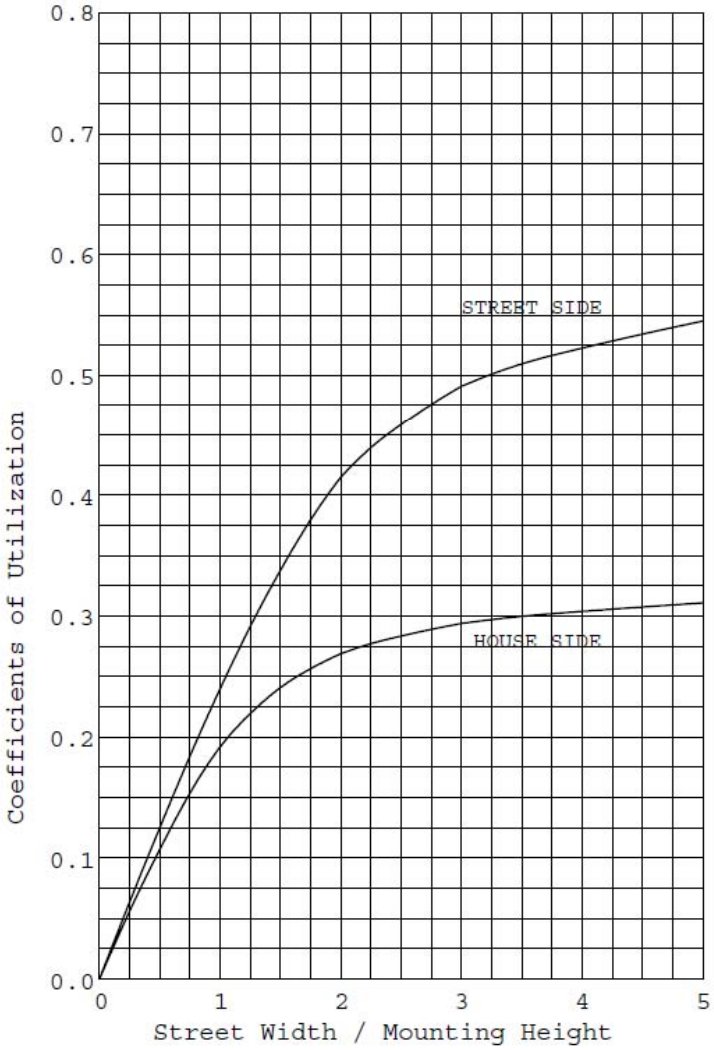
COEFFICIENTS OF UTILIZATION AND FLUX DISTRIBUTION



	LUMENS	PERCENT OF FIXTURE
DOWNWARD STREET SIDE	3057	59.3
DOWNWARD HOUSE SIDE	1713	33.2
DOWNWARD TOTAL	4770	92.5
UPWARD STREET SIDE	211	4.1
UPWARD HOUSE SIDE	176	3.4
UPWARD TOTAL	387	7.5
TOTAL FLUX	5157	100.0

EFFICACY = 53.5 Lm/W

ALL CANDELA AND LUMENS IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS LUMINAIRE SAMPLE.

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FLUX DISTRIBUTION BY SOLID ANGLE

(PER IESNA TM-15-11, LUMINAIRE CLASSIFICATION SYSTEM FOR OUTDOOR LUMINAIRES)

	LUMENS	PERCENT OF FIXTURE	BUG ZONE RATINGS	
FORWARD LIGHT	3057.	59.3		
FL (0- 30)	161.7	3.1		
FM (30- 60)	858.8	16.7		
FH (60- 80)	1650.7	32.0		G1
FVH(80- 90)	385.6	7.5		G3
BACK LIGHT	1713.	33.2		
BL (0- 30)	154.5	3.0	B1	
BM (30- 60)	664.6	12.9	B1	
BH (60- 80)	722.6	14.0	B2	G2
BVH(80- 90)	171.6	3.3		G2
UPLIGHT	387.	7.5		
UL (90-100)	166.4	3.2	U3	
UH (100-180)	220.4	4.3	U3	
TRAPPED LIGHT	0.	0.0		
TOTAL FLUX	5157.	100.0		

BACKLIGHT, UPLIGHT, AND GLARE (BUG) RATINGS
(PER ADDENDUM A FOR IESNA TM-15-11)

BUG RATING: B2 U3 G3

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NVLAP LAB CODE: 200925-0

REPORT NUMBER: ITL70139
DATE: 09/28/11
PREPARED FOR: CITY OF SACRAMENTO (PNNL)

ADDRESS: 5730 24TH STREET
BLDG 11
SACRAMENTO, CA 95822

CATALOG NUMBER: A850ASRLED 6ARC45T3

LUMINAIRE: CAST BLACK PAINTED METAL POST TOP FITTER, CLEAR TEXTURED PLASTIC GLOBE LENS WITH CAST BLACK PAINTED METAL MOUNTING COLLAR, CAST BLACK PAINTED METAL TOP AND FINIAL. LUMINAIRE NOT DISASSEMBLED FOR INSPECTION, INTERIOR PROPERTIES UNKNOWN.

LAMP: UNKNOWN NUMBER OF WHITE LIGHT EMITTING DIODES (LEDS), UNKNOWN ORIENTATION.

DRIVER: ADVANCE LED-INTA-0700C-210-FO, THOMAS RESEARCH PRODUCTS BSP3-277 SURGE PROTECTOR

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60HZ) TO THE SURGE PROTECTOR.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #7	09/07/12
	Ocean Optics QE65000 Spectroradiometer	03/26/12
	ITL 2.0 Meter Diameter Integrating Sphere, 4π Geometry	03/26/12

OBJECT OF TEST: Measure the Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y), ANSI C78.377 Duv, Scotopic / Photopic Lumen Ratio, and electrical data including Power Factor (PF) to the luminaire.

PROCEDURE: The luminaire was provided by the customer and had an unknown number of burn hours. The luminaire was mounted inside the integrating sphere in a horizontal position (see luminaire description for LED orientations) and allowed to stabilize. After stabilization occurred, measurements were taken with the luminaire operating in the integrating sphere. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the luminaire operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-79-08. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

Checked T BERGER
Approved N GULLY
Lighting Engineer

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NVLAP LAB CODE: 200925-0
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REPORT NUMBER: ITL70139
DATE: 09/28/11
PREPARED FOR: CITY OF SACRAMENTO (PNNL)
CATALOG NUMBER: A850ASRLED 6ARC45T3

RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.3506
Chromaticity Ordinate y	0.3496
Correlated Color Temp CCT (K)	4783
Color Rendering Index (CRIa)	81
Color Rendering Index 1 (Light greyish red)	81
Color Rendering Index 2 (Dark greyish yellow)	84
Color Rendering Index 3 (Strong yellowish green)	84
Color Rendering Index 4 (Moderate yellowish green)	82
Color Rendering Index 5 (Light bluish green)	81
Color Rendering Index 6 (Light blue)	77
Color Rendering Index 7 (Light violet)	88
Color Rendering Index 8 (Light reddish purple)	74
Color Rendering Index 9 (Strong red)	26
Color Rendering Index 10 (Strong yellow)	60
Color Rendering Index 11 (Strong green)	79
Color Rendering Index 12 (Strong blue)	56
Color Rendering Index 13 (Light yellowish pink (skin))	81
Color Rendering Index 14 (Moderate olive green (leaf))	90
ANSI C78.377-2008 Duv	-0.003
Scotopic / Photopic Ratio	1.846
ELECTRICAL	
Input Voltage (Volts AC)	120.0
Input Current (mA AC)	808
Input Power (Watts)	96.0
Input Power Factor (%)	99.0

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REPORT NUMBER: ITL69669
DATE: 09/12/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: A850A8RLED 6ARC45T3

LUMINAIRE: Cast black painted metal post top fitter, clear plastic globe lens with cast black painted metal mounting collar, cast black painted metal top and finial, fabricated diffuse metal center post, machined diffuse metal led mounting plate, six circuit boards each with 14 LEDs and cast diffuse metal trim plate, one clear plastic lens below each led.

LAMPS: Eighty-four white light emitting diodes (LEDs) each with clear hemispherical integral lens, vertical base-up position.

LED DRIVER: Advance LED-INTA-0700C-210-FO, Thomas Research Products B8P3-277 surge protector.

OBJECT OF TEST: Measure temperature of hottest single LED in the luminaire for correlation to the LED manufacturer's lumen depreciation curves. Also measure two additional LED temperatures and the hot spot on the LED driver. City of Sacramento provided direction as to which LEDs to measure and where to place the thermocouple on each LED. City of Sacramento also provided direction for thermocouple placement on the LED driver. Type K thermocouples were utilized for all thermal measurements.

INSTRUMENTATION:

	Calibration Due
Elgar CW1251 AC Power Source	NA
Xitron 2503H Power Analyzer	06/16/2012
Omega HH802U Digital Thermometer	07/18/2012

PROCEDURE: In Situ Temperature Measurement Test on post top mounted luminaire. The luminaire was mounted in free air per UL 1598 specifications and the Energy Star Manufacturer's Guide for Qualifying Solid State Lighting Luminaires. After mounting, the luminaire was energized at 120VAC 60Hz input to the LED driver and allowed to stabilize in a 25 +/-1 degree Celsius free air ambient. Once stabilization was verified the LED, driver, and ambient temperatures were recorded.

RESULTS: Refer to following pages

Checked: P. Hayes
Approved: C. Stout

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THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL69669
DATE: 09/12/2011
PREPARED FOR: City of Sacramento
LUMINAIRE CAT NO: A850A8RLED 6ARC45T3

RESULTS: Performance Data

Thermocouple Location		Temperature in Degrees C	Temperatures Corrected to Reflect a 25°C Ambient
T_A	(ambient)	25.6	25.0
T_{LD1}	(LED1)	58.6	58.0
T_{LD2}	(LED2)	55.6	55.0
T_{LD3}	(LED3)	58.8	58.2
T_{DR}	(driver)	56.4	55.8

Driver Input Electrical	
Volts:	120.0
Amps:	0.807
Watts:	96.32
PF:	0.995

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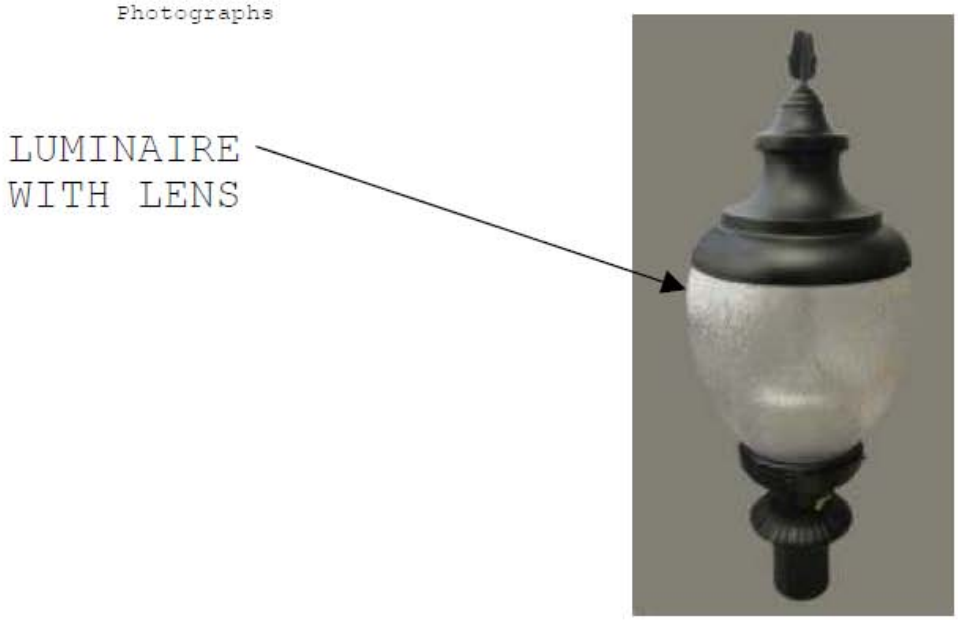
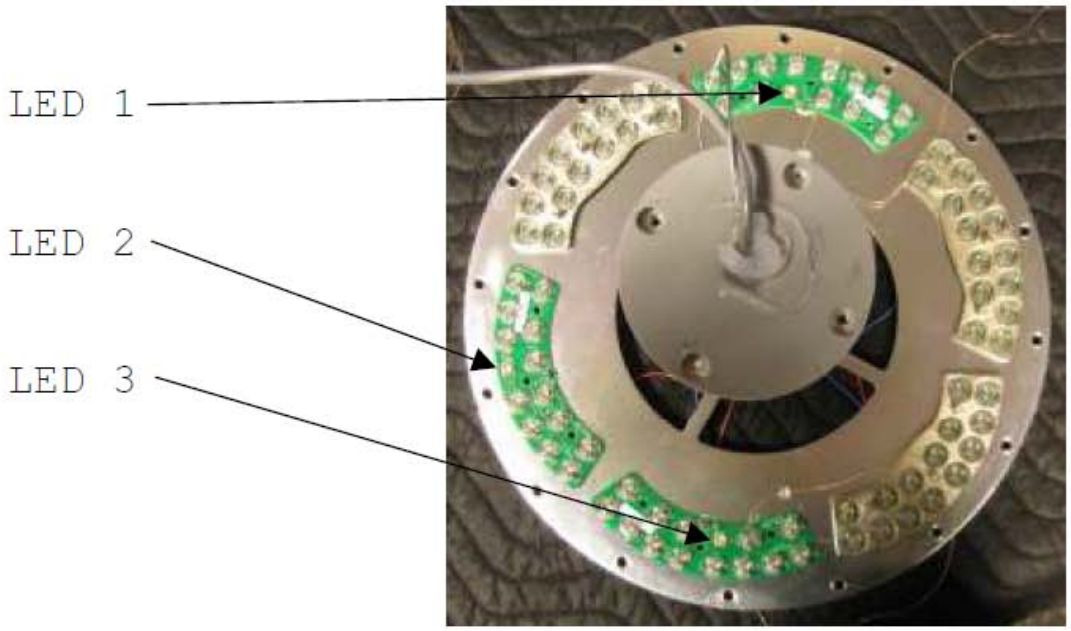
RESULTS: Photographs





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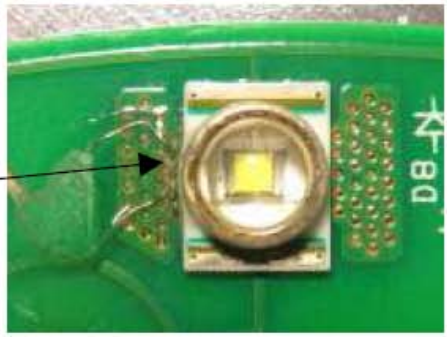
RESULTS: Photographs (continued)

LED (typical)



DRIVER

DRIVER LOCATION
IN LUMINAIRE