U.S. DEPARTMENT OF ENERGY

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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Baker-Barry Tunnel Lighting: Evaluation of a Potential GATEWAY Demonstrations Project

JR Tuenge

June 2011

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Pacific Northwest National Laboratory
Richland, Washington 99352

Acronyms and Abbreviations

AADT	Average Annual Daily Traffic
ANSI	American National Standards Institute
CCT	correlated color temperature
cd	candela(s)
CRI	color rendering index
DOE	U.S. Department of Energy
FLH	Office of Federal Lands Highway
HID	high-intensity discharge
HPS	high-pressure sodium
IES or IESNA	Illuminating Engineering Society of North America
IP	Ingress Protection
LED	light-emitting diode
NFPA	National Fire Protection Association
NEMA	National Electrical Manufacturers Association
NPS	National Park Service
lm	lumen(s)
lx	lux
m^2	square meter
PNNL	Pacific Northwest National Laboratory
SSL	solid-state lighting
W	watt(s)
Wh	Watt-hour(s)

Contents

1.0 Executive Summary

The U.S. Department of Energy (DOE) is evaluating the Baker-Barry Tunnel as a potential GATEWAY Demonstrations project for deployment of solid-state lighting (SSL) technology. The National Park Service (NPS) views this project as a possible proving ground and template for implementation of light-emitting diode (LED) luminaires in other NPS tunnels, thereby expanding the estimated 40% energy savings from 132 MWh/yr for this tunnel to a much larger figure nationally.

Most of the energy savings in this application is attributable to the instant-restrike capability of LED products and to their high tolerance for frequent on/off switching. Rather than brightly lighting both ends of the single-lane tunnel during the day (treating both as entrances), the traffic signals already used to determine the direction of traffic could also be utilized to reduce light levels at the tunnel exit. Some LED luminaires rival or outperform their high-intensity discharge (HID) counterparts in terms of efficacy, but options are limited, and smaller lumen packages preclude true one-for-one equivalence. However, LED products continue to improve in efficacy and affordability at a rate unmatched by other light source technologies; the estimated simple payback period of 20 years (given a $0.17/kWh electricity rate and excluding both installation costs and maintenance savings) can be expected to improve with time.[1]

The proposed revisions to the existing high-pressure sodium (HPS) lighting system would require slightly increased controls complexity and significantly increased luminaire types and quantities. In exchange, substantial annual savings (from reduced maintenance and energy use) would be complemented by improved quantity and quality of illumination. Although more advanced lighting controls could offer additional savings, it is unclear whether such a system would prove cost-effective; this topic may be explored in future work.

This document was revised in March 2012 to correct the reported payback periods, which exclude installation costs and maintenance savings.

[1] Detailed DOE SSL forecasts can be found at www.ssl.energy.gov/tech_reports.html.

2.0 Background and Purpose

In March 2010, GATEWAY performed a preliminary analysis of the existing high-pressure sodium (HPS) lighting system on behalf of NPS. This report supersedes the previous analysis by incorporating its contents and providing revised, updated, or expanded material as follows:

- Per documents received from NPS on April 28, 2010
  - Estimated tunnel height revised from 17 to 16 feet
  - Centerline of drivelane offset 18 inches from centerline of luminaires and tunnel
  - Widths revised as follows: 10.5 feet for drivelane, 3.5 feet for north bikelane, 4.5 feet for south bikelane
  - Estimated daily traffic revised from greater than 2,400 to less than 2,400 vehicles
  - Estimated distance from entrance to first (existing) energized luminaire encountered at night revised from 16.5 to 35 feet
- Per changes to the recently updated ANSI/IES RP-22
  - Revised criteria for the transition zone gradient
  - Revised wall illumination criteria
- Veiling luminance calculations corrected to exclude areas outside the interior zone
- Estimated surface reflectances revised
- Minimum ingress protection (IP) rating revised from 65 to 66 for power-wash cleaning
- Evaluation of alternative light-emitting diode (LED) luminaires
- Evaluation of illumination levels under emergency power
- Incorporation of simple traffic-signal-based on/off lighting controls

The potential for advanced lighting controls as a supplemental energy-savings measure may be detailed in a follow-up report.

3.0 Existing Tunnel and Lighting System

The Baker-Barry Tunnel was constructed in 1918 in what is now the Golden Gate National Recreation Area. The tunnel allows Bunker Road to pass under Highway 101 and through a hill on the north side of the Golden Gate Bridge. According to a recent inspection by the Office of Federal Lands Highway, the tunnel is 2,690 feet long, 16 feet in height (approximately 15 feet clearance), and 20 feet wide, as indicated in Figure 3.1 (FLH 2002).

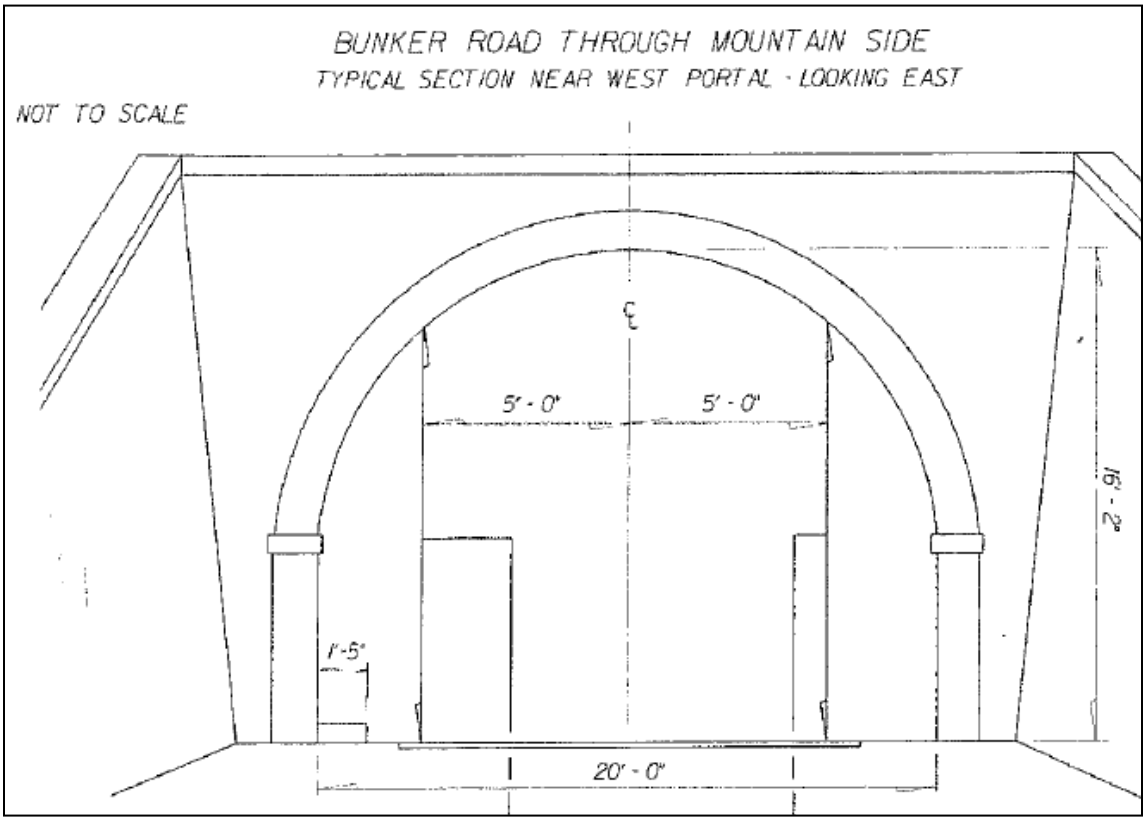

Figure 3.1. Tunnel cross-section (Image credit: FLH)

Separate construction drawings produced for NPS in 1993 indicate a tunnel length of 2,360 feet, consistent with analysis by GATEWAY indicating an approximate length of 2,346 feet (using satellite imagery from Google). It is assumed this NPS length measurement is accurate.

A single driving lane is bounded on either side by unprotected bicycle lanes. Posted speed limit is 25mph for both approaches and within the tunnel, with vehicular traffic flow running roughly NW to/from SE (aligning more closely with the East-West axis than with the North-South axis). The direction of one-way traffic reverses periodically via traffic signals at either end, as indicated in Figure 3.2.[2] Elimination of oncoming traffic allows the tunnel to be classified as "divided," and the approach can be classified as "mountain" as illustrated by Figures 3.3 and 3.4. It appears neither of the two approaches to the tunnel is illuminated by pole-mounted luminaires. Average annual daily traffic (AADT) is

[2] Images captured using the Street View tool in Google Maps, for Bunker Road at Danes Drive.

approximately 600 vehicles. Pavement surface is asphalt (assumed R3), and the walls and arched ceiling are concrete, for estimated ceiling/walls/pavement reflectances of 30/30/20. Average ambient temperature is approximately 14°C and maximum is approximately 40°C.[3] Tunnel and luminaires are periodically cleaned via hose-down.

Figure 3.2. View from SE opening (Photo credit: Google)

Figure 3.3. View of SE entrance to mountain tunnel (Photo credit: Google)

[3] From http://www.wrcc.dri.edu/htmlfiles/citycomptemp.html for San Fran Mission Dolore, accessed 2010-03-25.

Figure 3.4. View of NW entrance, just past signal (Photo credit: Google)

The lighting system is divided into different zones for visual adaptation purposes. Upon entering the tunnel vehicles first pass through a 200-foot threshold zone, followed by a 250-foot transitional zone and 1,460-foot interior zone, and then another 250-foot transition zone and 200-foot threshold zone before exiting the tunnel. Luminaires on the emergency panel and panel L3 are operated continuously; all others are switched off at night. Existing luminaire types and operation are summarized in Table 3.1. Product cutsheets are also provided in Appendix B. Note that the cutsheet for the 100W ballast specified by NPS indicates the product is not offered in 480V; this suggests that either two ballast types are used for the 100W luminaires, or luminaire types indicated 480V (phase to phase) may actually be wired 277V (phase to neutral).

Table 3.1. Existing GE Lighting Solutions HPS luminaires

Type	Catalog #	HPS Lamp	Initial Output (lm)	Input Power (W)	Initial Efficacy (lm/W)	Location	Operation	Voltage
H4D	TUN40S5	400W	39,616	464	85	Threshold zone	Daytime only	480V
H2D	TUN25S5	250W	21,750	300	73	Transition zone	Daytime only	480V
H1D	TUN10S5	100W	7,379	130	57	All zones	Daytime only	480V
H1C	TUN10S5	100W	7,379	130	57	All zones	Continuous	480V
H1E	TUN10S5	100W	7,379	126	59	All zones	Continuous and Emergency	277V

A more detailed overview of the luminaire layout and circuiting is provided in Figure 3.5, where zones are represented by blocks, and rows within each block correspond to mode of operation.

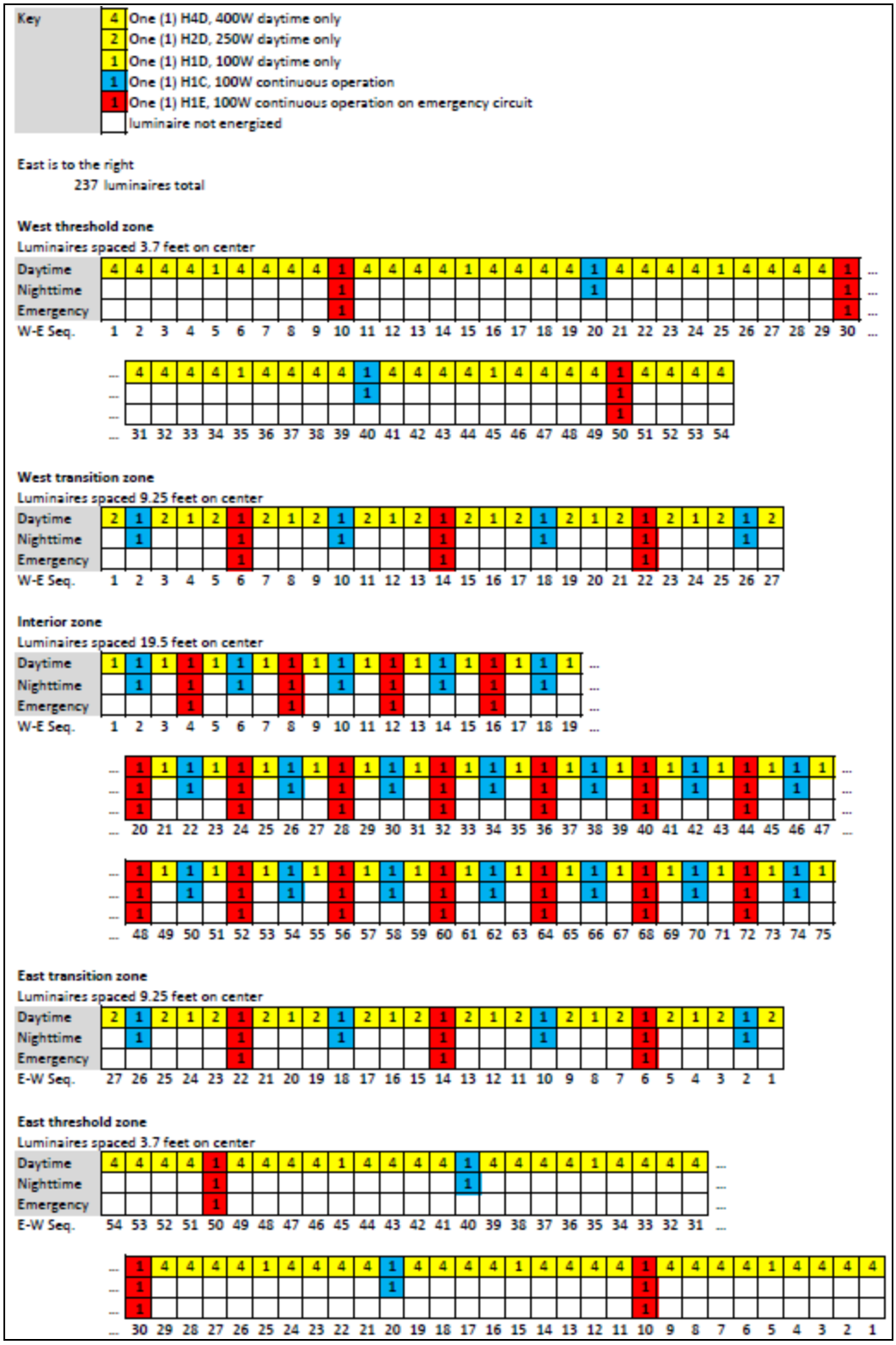

Figure 3.5. Existing luminaire layout and circuiting (derived from NPS drawings[4])

[4] According to Sheet E1 of the 1993 NPS set, every fourth luminaire in the threshold zone is 100W. It is assumed that in fact every fifth luminaire in this zone is 100W.

The diagram can be more readily understood via some examples: Upon entering either entrance during the day, the first four luminaires encountered are 400W, followed by one 100W luminaire; this series is repeated until the transition zone is reached (200 feet into the tunnel). Upon entering the tunnel, the 20th luminaire encountered during the day is the first energized luminaire encountered at night. Similarly, the 10th luminaire encountered during the day is the first energized luminaire encountered when the tunnel is running solely on emergency power.

The existing luminaires are available in a variety of distributions; it is not clear which specific distributions were installed.[5] Given the periodically reversing flow of traffic and the location of luminaires over the single drive lane, a symmetric (as opposed to asymmetric) distribution would be appropriate. The only bilaterally symmetric distribution for which GE offers photometry is their 150W STM optic, characterized in Figure 3.6 below and featuring 78% efficiency. The following calculations approximate 100W, 250W, and 400W by scaling down or up from the 150W output based on rated lamp lumens.[6] It is also not clear which ballasts were used for this project; this determines input wattage and efficacy. Lacking detailed luminaire specifications, initial luminaire efficacy is estimated at 59 lm/W for 100W HPS, 71 lm/W for 250W HPS, and 85 lm/W for 400W HPS.

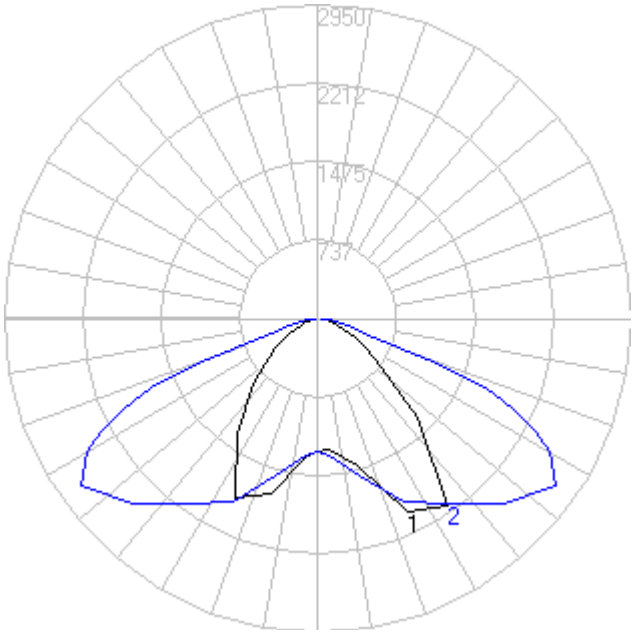

Figure 3.6. Elongated (elliptical) bilaterally symmetric intensity distribution for 150W HPS, represented by candela traces for two vertical planes, one at 0-180 degrees horizontal (slightly asymmetric curve 1 in black) and 90-270 (curve 2 in blue).

[5] Note that the asymmetric CBM counter-beam optic indicated on the manufacturer cut-sheet is an example only.
[6] Analysis of the CBM optic, for which GE offers photometry at more than one wattage, suggests that optical efficiency may not be significantly influenced by lamp wattage.

FY09 electric billing data for the tunnel lighting system (provided by NPS on April 13, 2010) is shown in Table 3.2.

Table 3.2. FY09 electrical energy cost

Year	Month	kWh/mo	$/mo
2008	10	20,576	3,876.29
	11	21,746	3,545.31
	12	19,374	2,644.43
2009	1	20,320	2,751.59
	2	22,499	3,022.98
	3	20,763	2,846.09
	4	25,091	3,474.24
	5	23,680	4,242.11
	6	26,015	5,216.83
	7	28,491	5,712.96
	8	24,900	4,993.36
	9	24,511	4,916.00
	Year total:	277,966	47,242.19

4.0 IES Recommendations and Existing HPS

Given that there appear to be no pole-mounted luminaires outside the tunnel, the nighttime tunnel drivelane luminance is more than three times higher than the tunnel approach luminance; it is assumed that the traffic signals and low speed limit effectively mitigate this abrupt change from normal roadway illumination inside the tunnel to zero fixed lighting outside the tunnel.

Pertinent criteria are provided in IESNA RP-22 (tunnels) and RP-8 (bikeways). Luminaires should be listed for wet locations and have an ingress protection (IP) rating of 65 or better to exclude dirt and to be "protected against water jets" during hose-down cleaning; an IP-66 rating is recommended by GATEWAY to be "protected against powerful water jets" (NEMA 2002).

Luminaires should be arranged and controlled in a manner that does not result in luminaires disappearing over the windshield at a "frequency effect" of less than 4 Hz or greater than 11 Hz; additional measures should be considered if drivers are exposed to more than 20 seconds of such flicker. Frequency effect is not expected to be problematic, as indicated in Table 4.1.

Table 4.1. Frequency effect and duration of exposure for 25 mph traffic

Parameter	IES	Threshold Zone		Transition Zone		Interior Zone	
		Day	Night	Day	Night	Day	Night
Spacing (ft)	n/a	3.7	37	9.25	37	19.5	39
Frequency effect (Hz)	≤ 4 or ≥ 11	9.9	1.0	4.0	1.0	1.9	0.9
Duration (s)	≤ 20	5.5		6.8		39.8	

Drivelane photometric criteria and calculations are summarized in Table 4.2. Luminance calculation grids span the first quarter of each zone; the veiling luminance grid spans the second quarter of the lengthy interior zone in order to keep the driver in this zone (per IES).

A light loss factor (LLF) of 64% was used for the existing HPS luminaires, based on a lamp lumen depreciation (LLD) factor of 85% and a luminaire dirt depreciation factor (LDD) of 75% for a "Moderate" level of smoke/dust generating activities nearby.[7] This assumes group cleaning and relamping at approximately 70% of rated life (per IESNA DG-4-03), whereby daytime-only luminaires are serviced less frequently than continuous-operation luminaires. Spot relamping may be enabled by the traffic signals and low nighttime usage (possibly reducing the cost of tunnel closures), but this could compromise light levels and uniformity.[8] Regular hose-down cleaning is assumed to occur every 4 years, based on 13 hours of operation per day for daytime-only luminaires.

[7] Assumes less than 600 micrograms of air particulate per cubic meter.

[8] According to the data in Table 3.2., system energy use in FY09 averaged 18% below expected and was at best 1% below expected. This suggests that at any given moment during that period, approximately 18% of luminaires appear to have had failed lamps.

Table 4.2. IES recommendations vs. estimated existing HPS illumination for the vehicular lane

Operating Mode	Zone	Average Maintained Roadway Luminance (cd/m^2)		Roadway Avg:Min Uniformity		Roadway Max:Min Uniformity		Veiling Luminance Ratio	
		Target	Predict.	Target	Predict.	Target	Predict.	Target	Predict.
Day	Threshold	140 to 170	**134**	≤ 2.0	1.3	≤ 3.5	1.5	n/a	-
	Transition (1^{st} step)	ratio ≤ 2.5	**4.1** ratio		1.4		2.5		-
	Interior (2nd step)	≥ 3	6.3		1.1		2.1	≤ 0.3	0.11
		ratio ≤ 2.5	**5.3** ratio						
Night	Threshold	≥ 2.5	2.7	≤ 2.0	2.0	≤ 3.5	3.0	n/a	-
	Transition		3.2		1.2		1.5		-
	Interior		3.0		1.3		1.7	≤ 0.3	0.17

The current level of illumination in the threshold zone appears to fall just short of current IES recommendations for daytime operation. However, these calculations conservatively assume no daylight contribution, so field measurements will likely yield somewhat higher levels than predicted. IES indicates daylight can provide adequate illumination for approximately the first 23 and the last 49 feet of the tunnel. Nighttime threshold uniformity appears slightly sub-standard but is probably adequate.

The luminance gradients from threshold zone to transition zone and from transition zone to interior zone are both considered excessive. The transition zone length is clearly inadequate by current IES standards, as indicated in Table 4.3. The transition zone should be divided into a minimum of four "steps" to allow drivers to gradually adapt to interior zone levels, and a fifth step should be added to the threshold zone. Table 4 summarizes existing and recommended zone lengths.

Table 4.3. Zone lengths and transitional luminance "steps"

Zone	Existing per NPS		IES minimum[9]	
	Length (ft)	# steps	Length (ft)	# steps
Threshold	200	**0**	176	1
Transition	**250**	**1**	660	4
Interior	1460	1	n/a	1

Photometric criteria and calculations for bikelanes and non-roadway surfaces are summarized in Table 4.4.

[9] See Appendix A for spreadsheet calculations.

Table 4.4. IES recommendations vs. estimated existing HPS illumination for non-vehicular surfaces

Operating Mode	Zone	Bikeway *Average Horizontal* Illuminance (lux)		Bikeway Avg:Min Uniformity		Bikeway *Minimum Vertical* Illuminance (lux)		Roadway / Wall Luminance Ratio[10]	
		Target	Predict.	Target	Predict.	Target	Predict.	Target	Predict.
Day (IES)	Threshold	≥ 20.0	1877	≤ 4.0	1.7	≥ 10.0	376	≤ 2.5	1.1
	Transition		388		1.6		82		1.0
	Interior		86		1.1		33		1.0
Night (IES)	Threshold	≥ 20.0	41	≤ 4.0	**12.1**	≥ 10.0	**3.9**	≤ 2.5	1.3
	Transition		45		1.3		**7.9**		1.0
	Interior		42		1.4		**7.4**		1.1

Vertical illuminance in the bikelanes is compromised at night by the increased luminaire spacing that results from the extinguishing of daytime-only luminaires, particularly in the interior zone.

Uniformity of horizontal illuminance in the bikelane is compromised at night by the absence of an energized luminaire at the tunnel entrance, as illustrated in Figure 4.1. Note, however, that uniformity of drivelane luminance does meet IES recommendations.

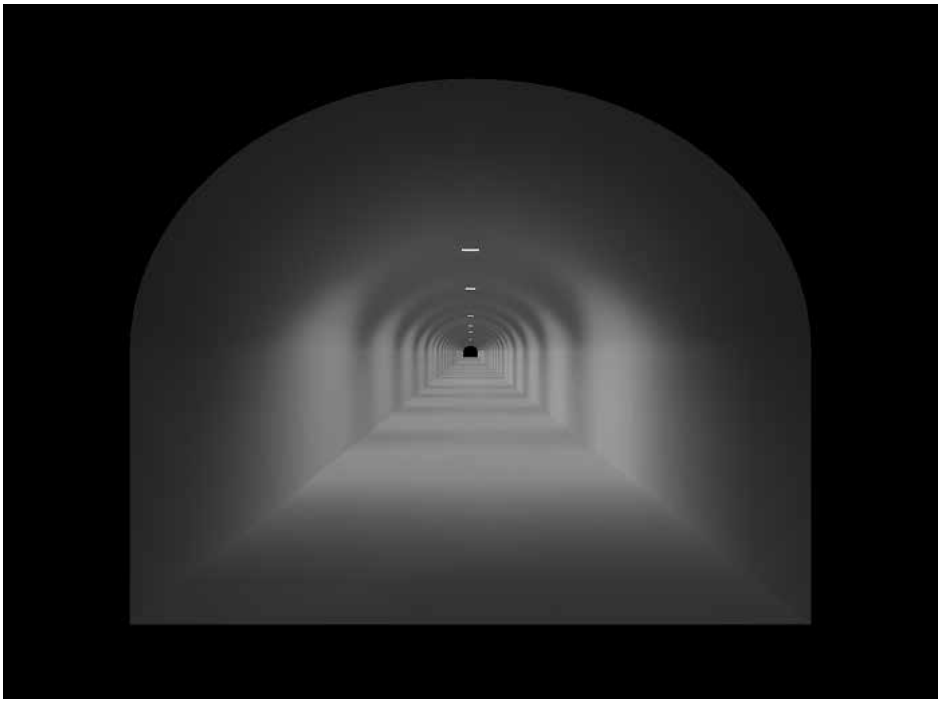

Figure 4.1. Low nighttime light levels at tunnel entrance

[10] Wall measurements taken vertically at 3.3 and 6.6 feet above pavement.

Emergency luminaire spacing generally ranges from 74 feet in the threshold and transition zones to 78 feet in the interior zone. However, the emergency luminaires spanning the border between transition and interior zones are spaced 118 feet on center, resulting in measurement points and uniformity ratios which do not comply with National Fire Protection Association (NFPA) requirements, as indicated in Table 4.5. This could be resolved by using luminaires with broader distributions and/or by moving more luminaires to the emergency circuit.

Table 4.5. NFPA requirements vs. estimated existing HPS emergency illumination

Operating Mode	Zone	Bikeway *Average* Horizontal Illuminance (lux)		Bikeway *Minimum* Horizontal Illuminance (lux)		Bikeway Max:Min Uniformity	
		Target	Predict.	Target	Predict.	Target	Predict.
Emergency	All	≥ 10	21	≥ 1	**0.4**	≤ 40	**132**

It is assumed that the emergency circuit is on an adequately sized uninterruptible inverter-type power source, as opposed to a generator, designed to maintain the arc in the event of normal power failure. If the arc were allowed to extinguish, this would result in an unacceptable time delay before restrike, leaving the tunnel in darkness for several minutes.

Note that given the following tunnel characteristics, the simpler IES methods were chosen for determination of required threshold zone luminance (Table vs L_{seq}) and transitioning (Step Down vs Reduction Curve):

- Traffic signals at entrances
- Low speed limit
- Divided traffic
- Existing lighting system serves as baseline
- LED luminaires offer improved color characteristics

New or more demanding tunnels may merit a more extensive analysis by a qualified professional.

5.0 LED Alternatives

Many LED products are available on the market, but few feature performance approaching the challenging requirements of this project. Following is a summary of traits sought as a first-pass filter during the product search:

- Mounts directly to ceiling (preferably not via an "elbow" bracket)
- Less than 12 inches height (for vehicle clearance)
- LED-tailored optical components (as opposed to repurposed HID refractors)
- Photometry and cutsheets available online (not strictly by request)
- IP-65 or better (IP-66 preferred for ease of maintenance)
- Elongated bilaterally symmetric intensity distribution (luminaires are centered across tunnel and the existing fixture spacing is based on an oval-shaped "footprint" of coverage)
- Wide variety of lumen packages offered at same drive current (dimming would add cost)
- Initial output of 20,000 lumens or more (to approach half of 400W HPS)
- Luminaire efficacy comparable or superior to HPS

The search included floodlights, pole-mounted luminaires, and products marketed for application in tunnels, parking structures, canopies, and high-bay or low-bay industrial facilities; a tabulated summary and selected product cutsheets are provided in Appendix D.

As of June 21, 2011, only three of 279 products listed on the Lighting Facts website under fixture type "Outdoor area/roadway fixture" featured initial output exceeding 20,000 lumens.[1] Two of these products were made by Visionaire Lighting, and the other was made by BetaLED. GATEWAY received confirmation from Visionaire that the high-output ELE-2 and ELE-3 luminaires, which are typically pole-mounted, could be modified for ceiling-mounting (standard for the smaller ELE-1); however, the approximate 60 lm/W efficacy of these products falls short of HPS.

The nearly 30,000 lumen ALX2 from Lithonia Lighting was the highest lumen package found by GATEWAY, but it offers 66 lm/W efficacy, is not available in an elliptical intensity distribution, and does not appear to be capable of ceiling-mounting. The 78 lm/W efficacy of the over 22,000 lumen ceiling-mounted HBL-192G from Day-Brite Lighting is better, but elliptical "aisle" photometry was not available online.

BetaLED came closest to meeting the above criteria; models used in this analysis are summarized in Table 5.1, and cutsheets are provided in Appendix C.[2] Although existing locations are utilized where possible, not all luminaires could be simply replaced one-for-one. Also, several new types are introduced to accommodate the added transition zone steps. Note that whereas HPS lamp efficacy increases with increasing nominal wattage, the efficacy of these LED products is not a function of wattage.

[1] Average initial output for this dataset was 6373 lm (SD 3242); average efficacy was 66 lm/W (SD 12); average CCT was 5034K (SD 892).

[2] The optic used in this analysis is already available in the LEDway product line, and according to the manufacturer will soon be added to the CAN-EDG product line.

Table 5.1. BetaLED luminaires used in this analysis

Type	Catalog #	Initial output (lm)	Input power (W)	Initial efficacy (lm/W)	Location	Operation	Voltage
L4D0	CAN-EDG-1S-DM-16-D-UH-525-60K	24,820	265	94	Threshold start	Daytime only	480V
L4D1	CAN-EDG-1S-DM-12-D-UH-525-60K	18,700	204	92	Threshold step	Daytime only	480V
L2D0	CAN-EDG-1S-DM-14-D-UH-525-60K	21,718	233	93	Transition start	Daytime only	480V
L2D1	CAN-EDG-1S-DM-14-D-UH-525-60K	21,718	233	93	Transition step 1	Daytime only	480V
L2D2	CAN-EDG-1S-DM-16-D-UH-525-60K	24,820	265	94	Transition step 2	Daytime only	480V
L2D3	CAN-EDG-1S-DM-08-D-UH-525-60K	12,498	133	94	Transition step 3	Daytime only	480V
L1C	CAN-EDG-1S-DM-06-D-UH-525-60K	9,374	102	92	All zones	Continuous	480V
L1E	CAN-EDG-1S-DM-06-D-UL-525-60K	9,374	102	92	All zones	Continuous and Emergency	277V

A correlated color temperature (CCT) of 6000K was selected for optimal efficacy; this is offset by the conservatively assumed lumen maintenance or "lamp" lumen depreciation (LLD) of 70%. Upon release of the forthcoming IES TM-21-11, LED luminaires may be evaluated by one of the following two methodologies:

- Assume the same percentage lumen maintenance for all products, and credit longer-lived products during economic analysis, or
- Assume the same service life (in hours) for all products, and calculate appropriate lumen maintenance percentages for each product separately.

The latter approach may allow for the use of a higher LLD value, which would in turn allow for the use of lower-cost products. In either case, IES LM-80 reports and in-situ temperature measurement test data will be needed for more detailed evaluation of useful lifetime claims when TM-21 is released.

The frequency of hose-down cleaning is liberally assumed to be the same for LED as for HPS, i.e., approximately every 16,800 hours. However, note that whereas the "breathing" effect exhibited by HID luminaires can cause dirt accumulation in the optical chamber, many LED luminaires (like those offered by BetaLED) have no such cavity and only collect dirt on the outside of the lens. Luminaire dirt depreciation is thus assumed to be the same for LED as for HPS.

The 400W HPS luminaires provide just enough light, and cannot be replaced one-for-one by the substantially lower-output LED luminaires. The same LED optic (illustrated in Figure 5.1) was used throughout.

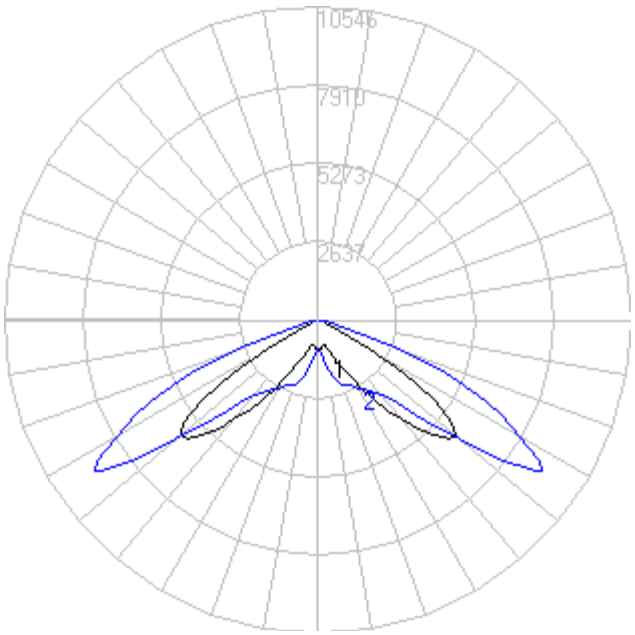

Figure 5.1. Elongated (elliptical) bilaterally symmetric intensity distribution for 191W BetaLED, represented by candela traces for two vertical planes, one at 0-180 degrees horizontal (curve 1 in black) and 90-270 (curve 2 in blue).

GATEWAY analysis indicates more focused beams would neither produce adequate uniformity nor allow for reduced wattage.

Similarly, the use of asymmetric intensity distributions for negative contrast (vertical face of obstacles dark) or positive contrast (vertical face of obstacles luminous) would likely result in increased equipment cost. In theory, an LED luminaire could be designed such that the asymmetric optics reverse direction according to the direction of traffic flow (controlled via the traffic signals); GATEWAY is not aware of any such products. In practice, more LEDs (and more money) would likely be required to achieve this effect.

The 100W HPS luminaires in the interior zone provide too much light by day and just enough light by night. Daytime-only locations in this zone were consequently abandoned, thereby reducing both initial system cost and daytime energy use.

Given the inadequate transition zone, and given the poor bikelane/egress uniformity produced by the nighttime and emergency systems (due to gaps in the layouts), it would be prudent to do some re-circuiting if at all possible. The following design assumes that while it is feasible to rewire, it is desirable to either abandon or reuse existing locations, minimizing the creation of new locations – particularly in the interior zone where luminaires are more broadly spaced. Bidding contractors will need to determine whether it would be more cost-effective to simply replace all conduit and junction boxes; if this is the case, luminaire spacing could be revised for improved uniformity and aesthetics.

Transitional lighting is not required for traffic exiting the tunnel; periodic switching of LED luminaires (on at entrance and off at exit) is enabled by the instant-restrike capability of these light sources.

Proposed revisions to the lighting layout are illustrated in Figure 5.2 below, and are summarized as follows:

- Threshold zone
  - Moved two entrance luminaires from daytime circuit to continuous-operation circuit
  - Increased number of (lower-output) luminaires as needed
  - Switched daytime-only luminaires off approaching tunnel exit
  - Divided into two sub-zones per Table 5.2
- Transition zone
  - Expanded zone length
  - Divided into four sub-zones per Table 5.2
  - Increased number of luminaire types and locations as needed
  - Moved two luminaires from continuous-operation circuit to emergency circuit
  - Switched daytime-only luminaires off approaching tunnel exit
- Interior zone
  - Deleted daytime-only luminaire locations

Table 5.2. Revised tunnel zones

Zone	Sub-Zone	Minimum step duration (seconds)	Length (feet)
Threshold	Start	n/a	120
	Step	2	80
Transition	Start	3	110
	Step 1	4	150
	Step 2	5	190
	Step 3	6	220
Interior	n/a	n/a	620

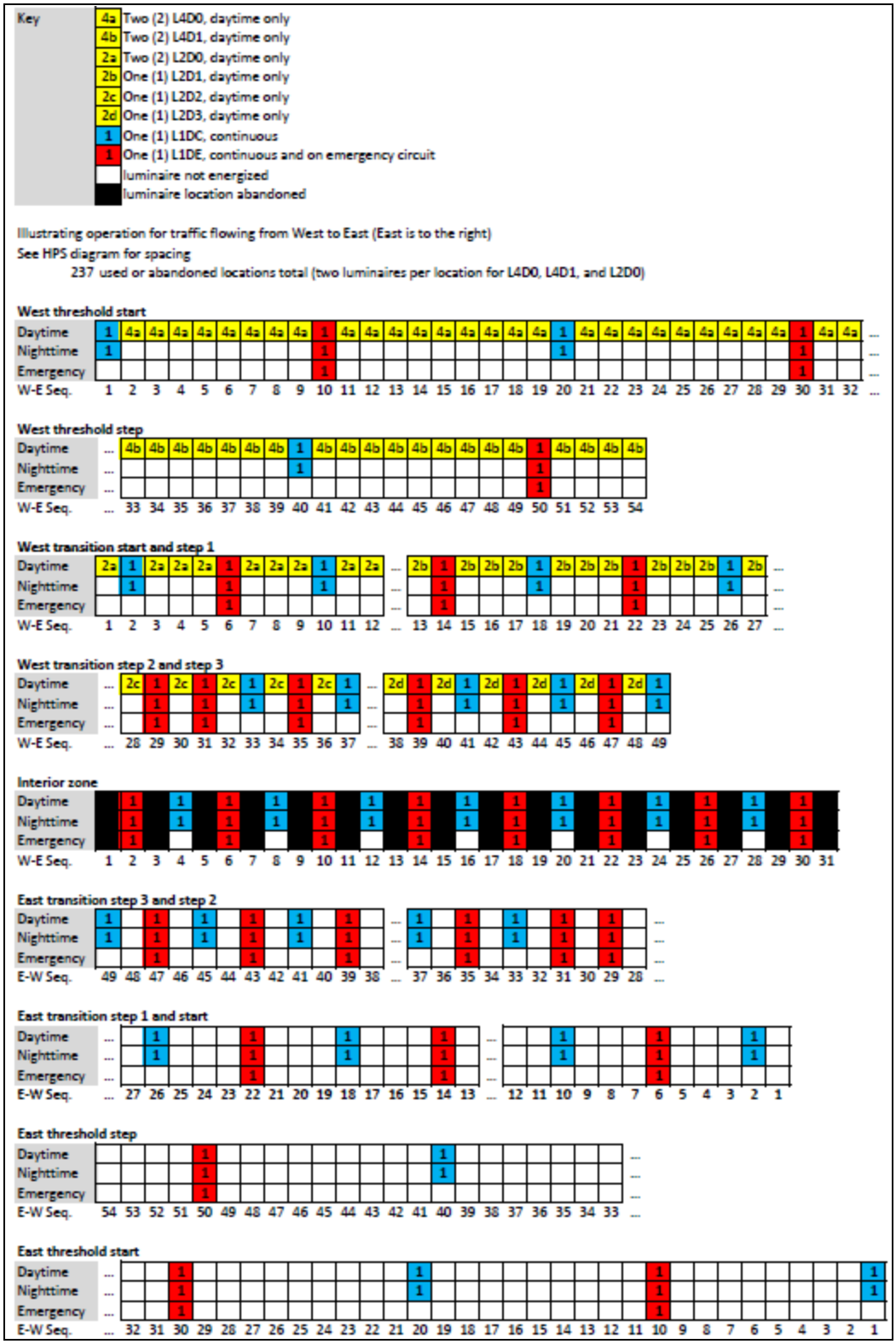

Figure 5.2. Revised layout and circuiting for LED lighting system

Note that traffic is shown flowing from West to East. In this scenario, daytime transitional lighting is only required on the West end of the tunnel, so daytime-only luminaires (types L4DX and L2DX) in the threshold and transitional zones at the East end of the tunnel are temporarily extinguished.

Also note that luminaire types L4D0, L4D1, and L2D0 are used in pairs – effectively doubling the quantities of existing type H4D and H2D luminaires in these locations. Conduit and/or junction boxes would need to be added accordingly. Luminaires in each L2D0 pair should be located close together (effectively combining to simulate a single luminaire) to prevent issues with flicker effect.

Table 5.3 summarizes the resulting predicted drivelane lighting performance. Daytime luminance in the first part of the threshold zone is slightly below target, but as with the HPS system, this (conservatively) assumes no daylight contribution and is not expected to be problematic.

Table 5.3. IES recommendations vs. estimated LED illumination for the vehicular lane

Operating Mode	Zone	Average Maintained Roadway Luminance (cd/m^2)		Roadway Avg:Min Uniformity		Roadway Max:Min Uniformity		Veiling Luminance Ratio	
		Target	Predict.	Target	Predict.	Target	Predict.	Target	Predict.
Day	Threshold start	≥ 140	**132**	≤ 2.0	1.2	≤ 3.5	1.5	n/a	-
	Threshold step	≥ 119	120		1.1		1.2		-
	Transition start[1]	ratio ≤ 2.5	2.3		1.3		1.6		-
	Transition step 1	ratio ≤ 2.5	2.0		1.2		1.5		-
	Transition step 2	ratio ≤ 2.5	2.4		1.3		1.9		-
	Transition step 3	ratio ≤ 2.5	1.7		1.1		1.4		-
	Interior	≥ 3	3.1		1.9		3.4	≤ 0.3	0.21
		ratio ≤ 2.5	2.3						
Night	Threshold	≥ 2.5	3.3	≤ 2.0	1.6	≤ 3.5	2.6	n/a	-
	Transition		3.1		1.6		2.7		-
	Interior		3.0		1.9		3.2	≤ 0.3	0.21

Table 5.4 summarizes the predicted illumination of bikelanes and vertical surfaces. Daytime vertical illuminance in the bikelanes is compromised slightly by the elimination of daytime-only luminaires in the interior zone. Performance would now be consistent across daytime and nighttime operation, and superior to the existing HPS luminaires at night. For greater system cost, but comparable energy use and

[1] The ratio for transition start is taken relative to threshold start, not threshold step.

improved vertical illumination, NPS could instead retain all existing locations and use lower-output luminaires.

Table 5.4. IES recommendations vs. estimated LED illumination for non-vehicular surfaces

Operating Mode	Zone	Bikeway *Average Horizontal* Illuminance (lux)		Bikeway Avg:Min Uniformity		Bikeway *Minimum Vertical* Illuminance (lux)		Roadway / Wall Luminance Ratio[1]	
		Target	Predict.	Target	Predict.	Target	Predict.	Target	Predict.
Day (IES)	Threshold start	≥ 20.0	1474	≤ 4.0	1.5	≥ 10.0	**9.0**	≤ 2.5	0.7
	Threshold step		1699		1.0				0.6
	Transition start		879		1.3				0.7
	Transition step 1		415		1.3				0.6
	Transition step 2		166		1.3				0.7
	Transition step 3		95		1.1				0.7
	Interior		42		1.6				0.7
Night (IES)	Threshold	≥ 20.0	42	≤ 4.0	1.8	≥ 10.0	**8.7**	≤ 2.5	0.6
	Transition								0.6
	Interior								0.7

Table 5.5 demonstrates the improved uniformity resulting from the revised emergency lighting.

Table 5.5. NFPA requirements vs. estimated LED emergency illumination

Operating Mode	Zone	Bikeway *Average* Horizontal Illuminance (lux)		Bikeway *Minimum* Horizontal Illuminance (lux)		Bikeway Max:Min Uniformity	
		Target	Predict.	Target	Predict.	Target	Predict.
Emergency	All	≥ 10	22	≥ 1	4.8	≤ 40	12

Energy savings are summarized in Table 5.6. In instances where LED luminaires replace 100W HPS luminaires one-for-one, the increased efficacy allows for 20% lower wattage. Substantial savings are realized by simply using the traffic signals to toggle daytime-only luminaires (types L4DX and L2DX) on or off based on the direction of traffic flow. Additional savings are attributable to reduced light levels in the interior zone (consistent with IES), but some of these savings are negated by the extended length of the brightly illuminated transition zone. Daytime-only luminaires are assumed to operate 13 hours per day.

[1] Wall measurements taken vertically at 3.3 and 6.6 feet above pavement.

Table 5.6. Estimated energy usage by luminaire type

HPS type	Watts per location	# of locations	# operating			Load (kW)			Electrical Energy	
			Day	Night	EM	Day	Night	EM	kWh/yr	Annual cost
H4D	464	88	88			40.8			193,881	$ 32,960
H2D	300	28	28			8.4			39,885	$ 6,781
H1D	130	60	60			7.8			37,036	$ 6,296
H1C	130	31	31	31		4.0	4.0		35,327	$ 6,006
H1E	126	30	30	30	30	3.8	3.8	3.8	33,135	$ 5,633
					Totals:	64.8	7.8	3.8	339,265	$ 57,675
LED type	Watts per location	# of locations	# operating			Load (kW)			Electrical Energy	
			Day	Night	EM	Day	Night	EM	kWh/yr	Annual cost
L4D0	530	56	28			14.8			70,464	$ 11,979
L4D1	408	40	20			8.2			38,746	$ 6,587
L2D0	466	18	9			4.2			19,914	$ 3,385
L2D1	233	22	11			2.6			12,170	$ 2,069
L2D2	265	10	5			1.3			6,291	$ 1,070
L2D3	133	12	6			0.8			3,789	$ 644
L1C	102	31	31	31		3.2	3.2		27,718	$ 4,712
L1E	102	32	32	32	32	3.3	3.3	3.3	28,612	$ 4,864
					Totals:	38.3	6.4	3.3	207,705	$ 35,310

There appears to be no need to add load to any of the circuits. Assuming the electricity rate is flat, the percent electricity cost savings would equal the estimated 39% energy savings. Estimated LED product cost is summarized in Table 5.7, based on an informal distributor-net price quote from the manufacturer, and assuming luminaires are not purchased (and marked-up) by the contractor. Excluding installation cost and maintenance savings, and given an average electricity rate of $0.17/kWh (per Table 3.2), the simple payback period is estimated at 20 years.

Table 5.7. LED luminaire cost

Type	# of heads	Product cost	
		Per head	By type
L4D0	112	$ 1,620	$ 181,440
L4D1	80	$ 1,300	$ 104,000
L2D0	36	$ 1,460	$ 52,560
L2D1	22	$ 1,460	$ 32,120
L2D2	10	$ 1,620	$ 16,200
L2D3	12	$ 980	$ 11,760
L1C	31	$ 820	$ 25,420
L1E	32	$ 755	$ 24,160
		Total:	$ 447,660

6.0 Conclusions

It appears the use of LED luminaires in tunnel lighting applications can be both photometrically viable and economically feasible. Much of the nearly 40% energy savings (132 MWh/yr) is attributable to the technology's instant-restrike capability and its high tolerance for frequent switching, which can allow for a 50% reduction in operating time for daytime-only luminaires in the threshold and transition zones. However, at this time there appears to be only one manufacturer meeting (and a few others approaching) the requirements of this particular project. The shortage of equivalent products may be problematic if three names are required for bidding purposes.

In addition to energy savings and reduced maintenance, the proposed LED lighting system offers the following improvements:

- Duration and gradient of transition brought in line with current IES recommendations
- Bikelane uniformity brought in line with current IES recommendations
- Emergency egress uniformity brought in line with current NFPA requirements.

This analysis relies on a number of assumptions. Following is a summary of items to be physically verified (by others) in the field:

- Tunnel length (opening to opening)
- Surface reflectances
- Airborne particulate density
- Ambient temperature range
- Physical condition of existing junction boxes, conduit, and wiring
- Circuit load capacities
- Luminaire locations and types (optic, ballast, voltage, and circuit)
- Feasibility of interfacing with traffic signals for control of luminaires.

Supplemental to contractor estimates of installation costs for the proposed LED lighting system, the economic analysis would benefit from NPS maintenance cost data for the existing HPS lighting system.

Equipment cost would be reduced and energy savings would be increased if a higher lumen maintenance value were justified per the forthcoming IES TM-21. However, this apparently would not dramatically improve payback. For example, if 85% lumen maintenance (rather than 70%) was estimated this would result in energy savings of approximately 151 MWh/yr, a total cost of $407,500 for luminaires, and a simple payback period of 16 years (instead of 20).[1]

[1] Note that according to the so-called "six times rule" in the draft IES TM-21, a luminaire utilizing light sources backed by 10,000 hours of LM-80 data cannot be rated for more than 60,000 hours useful lifetime. For a continuously-operated luminaire, this would translate to just under seven years maximum rated useful life. Also, note that lumen maintenance is just one of a number of possible luminaire failure mechanisms.

Alternatively, luminaires could be proactively dimmed to the assumed level of lumen maintenance, effectively harvesting the otherwise wasted energy in the early years of operation, and extending useful life. As the system ages, the degree of dimming would need to be reduced to maintain light levels.

A more elaborate control system could be implemented for increased energy savings, but it is not yet clear whether such a system would prove cost-effective. For example, a system with digitally addressable luminaires and motion sensors could allow for dynamic and automated changes to control zones, thus enabling "chasing" effects whereby luminaires are brought to full power when approached by vehicles and then dimmed (again) to partial output once passed. Wireless controls may offer additional advantages, but application compatibility would need to be verified. However, such advanced control systems may face challenges including sensor coverage (and quantity), sensor degradation, system compatibility, system cost, and possible liability issues. Installation of data-loggers or similar equipment to monitor/reveal the tunnel usage profile would greatly facilitate decision making.

7.0 References

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Appendix A

Spreadsheet Calculations

VALUE	PARAMETER	NOTES
25	mph posted speed limit	
36.7	ft/second	
200	SSSD at 30mph (ft)	
200	existing threshold zone (ft)	
250	existing transition zone (ft)	
1460	existing interior zone (ft)	
2360	tunnel length (ft)	
yes	tunnel > 410 ft	
1.00	adjustment factor	
n/a	average annual daily traffic (AADT)	
n/a	cyclist presence	
n/a	exit visible from 1-SSSD	
n/a	daylight penetration	
n/a	wall reflectance	
mountain	tunnel approach scene	
E/W	driver direction	
140	threshold luminance (cd/m^2)	compare with 170 for N/S
4.76	driver eye height (ft)	
16	tunnel height	
25	from horizontal sight line at adaptation point to top of tunnel (based on 22° to 25° windshield cutoff)	
24	adaptation distance (ft)	
176	minimum threshold zone length (ft)	
40.7%	minimum luminance at transition start relative to threshold	
2.5	max ratio from step to step	
1	second increased duration for each step	
3	interior zone luminance (cd/m^2)	
140	threshold step (cd/m^2)	threshold
2	duration of step (seconds)	
73	length of step (ft)	
57.0	transition start (cd/m^2)	transition
3	duration of step (seconds)	
110	length of step (ft)	
22.8	transition step 1 (cd/m^2)	
4	duration of step (seconds)	
147	length of step (ft)	
9.1	transition step 2 (cd/m^2)	
5	duration of step (seconds)	
183	length of step (ft)	
3.6	transition step 3 (cd/m^2)	
6	duration of step (seconds)	
220	length of step (ft)	
660	minimum transition zone length (ft)	

Appendix B

Luminaire Data – Existing HPS

TUNNEL GUARD™ LUMINAIRE

APPLICATIONS
- For tunnels and underpasses

SPECIFICATION FEATURES
- Ⓤ/ⓤ 1598 Listed **Suitable for Wet Locations**
- Available with option for Ⓤ 1598A "Suitable for Outdoor, Salt Water Marine Locations" Contact factory
- Low-glare, specialized photometrics
- Flat surface for semi-recessed ceiling mounting
- No-tool fixture removal for quick maintenance (surface mounted only)
- Heavy-duty die-cast aluminum housing
- Zinc-rich epoxy charcoal gray powder paint finish on housing
- Stainless steel external hardware
- Door assembly hinged and latched for no-tool installation and removal
- Terminal Board is standard
- Tempered glass lens
- ALGLAS® finish on aluminum reflector
- No-tool lamp replacement
- Plug-in no-tool replaceable ignitor
- Standard unit comes with 4 feet of #12-3 cable out the top of the unit
- Unistrut mounting adapter kit available – contact factory
- Luminaire normally shipped with hinges and latches. **CEILING MOUNTING PLATE (CMPxxx) IS REQUIRED AND MUST BE ORDERED SEPARATELY.** (See Mounting Accessory Selection Table listing.)

ORDERING NUMBER LOGIC

TUN	40	S	4	A	4	CBM	XX	CG	F
PRODUCT IDENT	WATTAGE	LIGHT SOURCE	VOLTAGE	BALLAST TYPE	AMBIENT °C	IES DISTRIBUTION TYPE	BEAM ROTATION	COLOR	OPTIONS
XXX	XX	X	X	X	X	XXX	XX	XX	XXX
TUN= Tunnel Guard Luminaire	07 = 70 10 = 100 15 = 150 (55V) 20 = 200 25 = 250 40 = 400	E = Energy Act Compliant Pulse MH (EPMH) S = HPS Standard: Lamp not included.	60Hz 1 = 120 2 = 208 3 = 240 4 = 277 5 = 480 D = 347	See Ballast and Photometric Selection Table A = Autoreg G = Mag-Reg with Grounded Socket Shell H = HPF Reactor or Lag K = Hot Restart M = Mag-Reg N = NPF Reactor or Lag P = CWI with Grounded Socket Shell	4 = 40	See Ballast and Photometric Selection Table CBM = Counter-Beam HTV = Horizontal Type V SYM = Symmetrical (Medium Base Lamp) STM = Symmetrical (Mogul Base Lamp) MC3 = Medium, Cutoff, Type III MC4 = Medium, Cutoff, Type IV	NOTE: Determined by the orientation of luminaire on tunnel ceiling. Tunnel drawings of mounting configurations required.	CG = Charcoal Gray	F = Fusing

R

PHOTOMETRIC SELECTION TABLE

Wattage	Light Source	Socket Base Size	Photometric Distribution	Photometric Curve Number 35-17-----
70, 100, 150 (55V)	HPS	Mogul	STM	7701
70, 100, 150 (55V)	HPS	Mogul	MC4	8045
70, 100, 150 (55V)	HPS	Mogul	CBM	9111
200, 310	HPS	Mogul	CBM	7734
200, 310	HPS	Mogul	MC3	8044
250, 400	HPS	Mogul	CBM	7734
250, 400	HPS	Mogul	MC3	8044
400	EPMH*	Mogul	CBM	8581
400	EPMH*	Mogul	MC3	9162

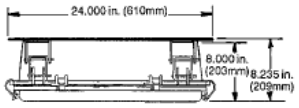
NOTE: All light sources are clear unless otherwise indicated.
*Lamp for 400 watt MH fixture must be E-18 or ED-28 only.

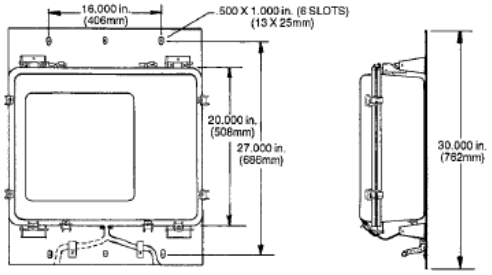
GE Lighting Systems, Inc.
www.gelightingsystems.com

R-34/2008

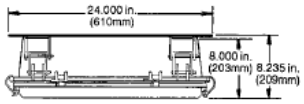
FIXTURE DIMENSIONS

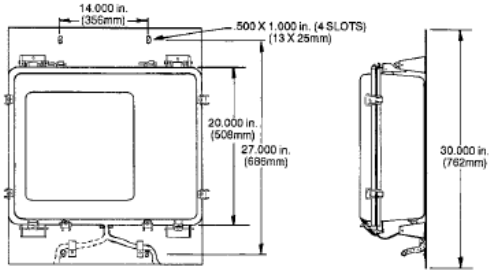
CMP001 - Ceiling Mounting Plate (Top Cable Entrance)





CMP002 - Ceiling Mounting Plate (Side Cable Entrance on Latch Side of Housing)





DATA

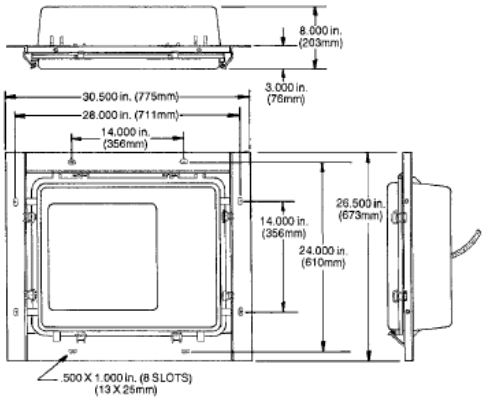
Approximate Net Weight	60 lbs	27 kgs
Suggested Mounting Height	16 ft.	5 M

MOUNTING ACCESSORY SELECTION TABLE

ONE REQUIRED PER LUMINAIRE

CMP001 = Ceiling Mounting Plate (with six bolts)
CMP002 = Ceiling Mounting Plate (with four bolts)

Semi-Recessed Mounting (No UL)



REFERENCES

See Page R-48 for start of Accessories.
See Page R-52 for Explanation of Options and Other Terms Used.

BALLAST SELECTION TABLE

Wattage	Light Source	Ballast Type / Voltage 60HZ 120,208,240, 277,480	347 120 x 347
70, 100, 150 (55V)	HPS	G, H, K, M,N	G,H,M*,N
200, 310	HPS	A, M	N/A
200, 310	HPS	A, M	N/A
250, 400	HPS	A, G, K**, M	A, G, M
250, 400	HPS	A, G, K**, M	A, G, M
250	EPMH	A	N/A
400	EPMH	A	N/A

NOTE: N/A = Not available
*Not available in 120X347V
**400W watt only

IES ROAD REPORT
PHOTOMETRIC FILENAME : GE177701.IES

DESCRIPTIVE INFORMATION (From Photometric File)

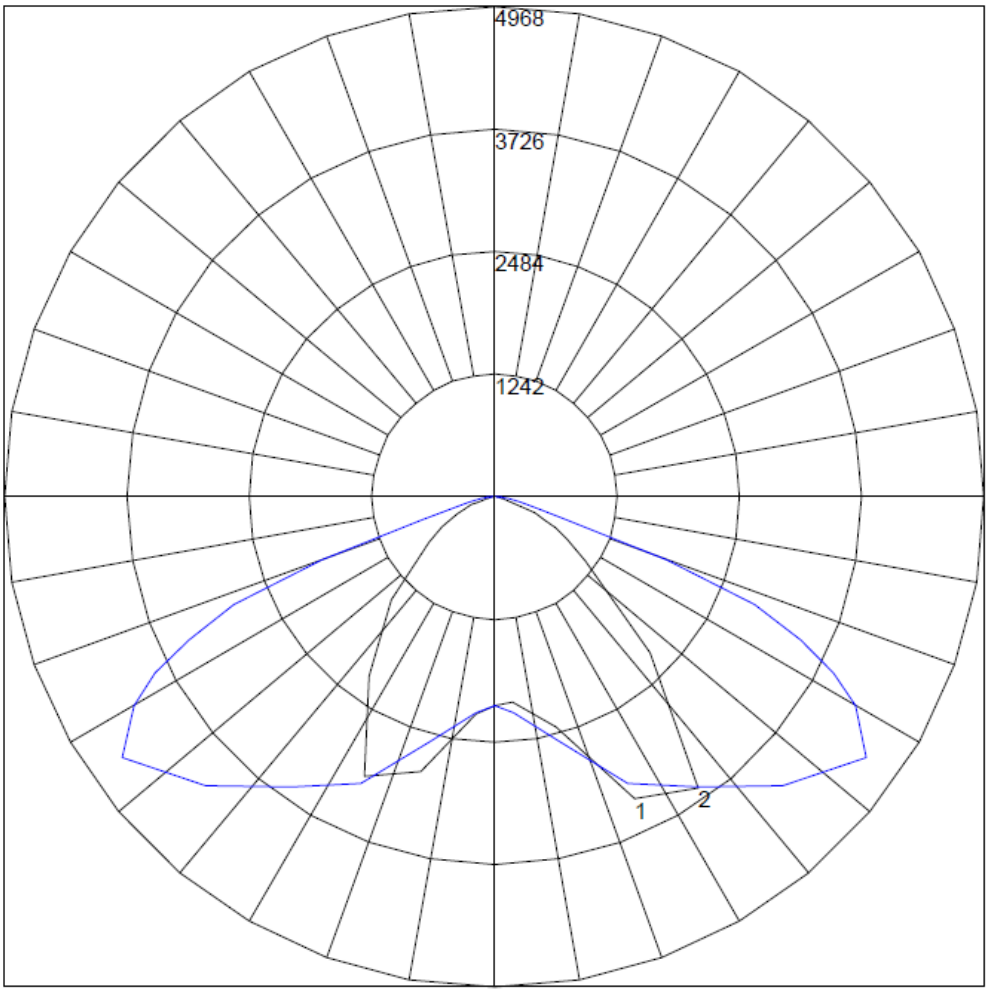
IESNA:LM-63-1995
[TEST] 89022302 PUBLISHED CURVE CREATED
[MANUFAC] GE C&I, LIGHTING SYSTEMS - EAST FLAT ROCK, NC, USA
[SEARCH] ROADWAY TUN
[LUMINAIRE] TUNNEL GUARD
[DISTRIBUTION] XC2
[LUMCAT] TUN15S***SYM****
[LAMP] 1; 150W HPS, CLEAR ED23.5, HORZ
[LAMPCAT] GE LU150/55
[OTHER] HSNG: CAST HOUSING CAST DOOR/COVER
[MORE] REFL: SEMI-SPEC HYDROFRM ALUM
[MORE] ENCL: CLEAR SHEET GLASS
[MORE] ACSY:
[MORE] SOCKET POSITION: FIXED
[MORE] COMMENT:

CHARACTERISTICS

IES Classification	Type II
Longitudinal Classification	Very Short
Cutoff Classification (deprecated)	Cutoff
Lumens Per Lamp	16000 (1 lamp)
Total Lamp Lumens	16000
Luminaire Lumens	12428
Total Luminaire Efficiency	78 %
Downward Total Efficiency	78 %
Maximum Candela	4968
Maximum Candela Angle	35H 35V
Maximum Candela (<90 Degrees Vertical)	4968
Maximum Candela Angle (<90 Degrees Vertical)	35H 35V
Maximum Candela At 90 Degrees Vertical	22.4 (0.1% Lamp Lumens)
Maximum Candela from 80 to <90 Degrees Vertical	163.2 (1.0% Lamp Lumens)
Total Luminaire Watts	183
Ballast Factor	1.00

IES ROAD REPORT
PHOTOMETRIC FILENAME : GE177701.IES

POLAR GRAPH



Maximum Candela = 4968 Located At Horizontal Angle = 35, Vertical Angle = 35
1 - Vertical Plane Through Horizontal Angles (0 - 180)
2 - Vertical Plane Through Horizontal Angles (90 - 270)

100W S54

FHJ-HX-HPFHPS100MT

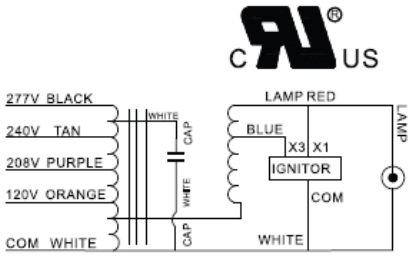
High Pressure Sodium

120/208/240/277V 60Hz

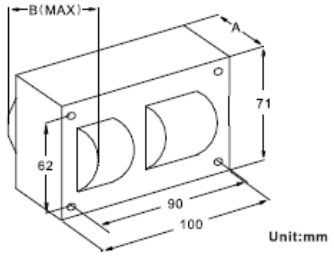
Specification Sheet

Input Volts	120	208	240	277	
Regulation					
Line Volts	±5%	±5%	±5%	±5%	
Lamp Watts	±10%	±10%	±10%	±10%	
Power Factor(min)	90%	90%	90%	90%	
Input Watts	126	126	126	126	
NOM.Open Circuit Voltage	115	115	115	115	
Line Current(Amps)					
Operating	1.20	0.70	0.60	0.50	
Open Circuit	2.15	1.30	1.10	1.00	
Starting	0.90	0.60	0.50	0.40	
UL Temperature Ratings					
Insulation Class	H 180°C	H 180°C	H 180°C	H 180°C	
Temperature Code	A	A	A	A	
MIN.Starting Temperature	-20F-30°C	-20F-30°C	-20F-30°C	-20F-30°C	
CAPACITOR Specifications					
Microfarads	10μF	10μF	10μF	10μF	
Volts(min.)	300V	300V	300V	300V	
60Hz Test Procedures					
High Potential Test 1 Minute	1600	1600	1600	1600	
High Potential Test 1 Second	2300	2300	2300	2300	
Secondary Open Ckt Voltage(V)	100-140	100-140	100-140	100-140	
Secondary Current Shorted(A)	3.00-3.4	3.00-3.4	3.00-3.4	3.00-3.4	
Input Open Circuit Current(A)	1.80-2.3	1.00-1.5	0.80-1.3	0.70-1.2	
Input short Circuit Current(A)	0.70-1.3	0.40-0.8	0.30-0.7	0.25-0.6	
Core and Coil Specifications					
Dimension A	57mm	57mm	57mm	57mm	
Dimension B	95mm	95mm	95mm	95mm	
Weight	2.75kg	2.75kg	2.75kg	2.75kg	
Coil Material(Pri./Sec.)	AL/AL	AL/AL	AL/AL	AL/AL	

HX-HPS100W



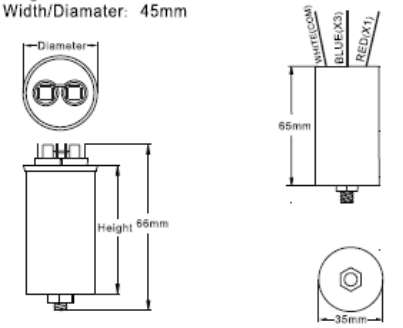
Wiring Diagram



Reference Drawing

Capacitor:
Rated Temp: 105℃
Height: 88mm
Width/Diamater: 45mm

Ignitor:FHJ-HPS35W-150W
Rated: 105℃
BLT: 2ft



For alternate capacitor construction consult sales

Performance specification information is subject to change without notification.

Xiamen FHJ Lighting Electric CO.,LTD.

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Appendix C

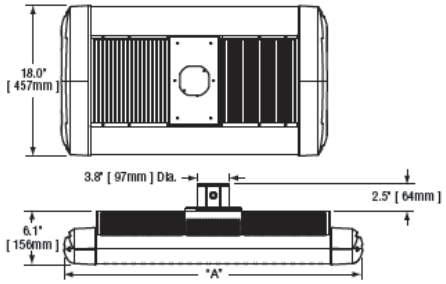
Luminaire Data – LED Evaluated

CAN-EDG-5S-DM THE EDGE™ LED Canopy Light – Type V Short

Rev. Date: 01/27/10

BetaLED Catalog #: CAN - EDG - 5S - DM - - C - - - -

Reset



# of LEDs	Dim. "A"
40	15.75"
60	17.75"
80	15.75"
100	17.75"
120	19.75"
140	21.75"
160	23.75"
180	25.75"
200	27.75"
220	29.75"
240	31.75"

Notes:

Product	Family	Optic	Mounting	# of LEDs (x 10)	LED Series	Voltage	Color Options	Factory-Installed Options
CAN	EDG	5S[1]	DM[2]	☐ 04[3] ☐ 06[4] ☐ 08 ☐ 10 ☐ 12 ☐ 14 ☐ 16 ☐ 18 ☐ 20 ☐ 22 ☐ 24	C	☐ UL Universal 120–277V ☐ UH Universal 347–480V ☐ 12 120V ☐ 24 240V ☐ 27 277V ☐ 34 347V	☐ SV Silver ☐ BK Black ☐ BZ Bronze ☐ PB Platinum Bronze ☐ WH White	Please type additional options in manually on the lines provided above. ☐ 43K 4300K Color Temperature[4] ☐ 525 525mA Drive Current[6,7] ☐ DIM 0–10V Dimming[8,9] ☐ F Fuse[10] ☐ HL Hi/Low (175/350/525, dual circuit input)[7,11,12] ☐ P Photocell[13-15] ☐ TL Two-Level (175/525 w/ integrated sensor control)[12,16,17] ☐ TL2 Two-Level (0/350 w/ integrated sensor control)[7,12] ☐ TL3 Two-Level (0/525 w/ integrated sensor control)[12,16,17]

Footnotes

1. IESNA Type V Short distribution
2. Direct mount
3. Uses 80 LED size with two blanks in outside positions
4. Uses 100 LED size with two blanks in outside positions
5. Color temperature per fixture; minimum 70 CRI
6. Driver operates at 525mA instead of the standard 350mA providing a higher lumen output and a shorter life
7. Available on fixtures with 40–120 LEDs
8. Control by others
9. Please consult factory for availability
10. Not available with TL, TL2, or TL3 options when UH voltage is selected
11. Sensor not included
12. Refer to multi-level spec sheet for more information
13. Must specify voltage other than UL or UH
14. Not available with TL2 or TL3 options
15. Not available with HL or TL options when UH voltage is selected
16. Available on fixtures with 40–100 LEDs
17. Not available when UH voltage is selected

LED PERFORMANCE SPECS

# of LEDs	Initial Delivered Lumens – Type V Short @ 6000K	B	U	G	Initial Delivered Lumens – Type V Short @ 4300K	B	U	G	System Watts 120–277V	Total Current @ 120V	Total Current @ 230V	Total Current @ 277V	System Watts 347–480V*	Total Current @ 347V	Total Current @ 480V	L_{70} Hours** @ 25° C (77° F)
		Rating***				Rating***										
350mA (Standard) Fixture Operating at 25° C (77° F)																
40[5]	3,833 (04)	2	0	0	3,362 (04)	2	0	0	49	0.41	0.23	0.20	55	0.16	0.16	105,000
60[4]	5,750 (06)	2	0	1	5,043 (06)	2	0	1	71	0.60	0.32	0.28	77	0.22	0.20	105,000
80	7,667(08)	3	0	1	6,725 (08)	2	0	1	93	0.78	0.41	0.35	99	0.29	0.23	105,000
100	9,583 (10)	3	0	1	8,406 (10)	3	0	1	116	0.98	0.52	0.43	123	0.35	0.28	105,000
120	11,500 (12)	3	0	1	10,087 (12)	3	0	1	139	1.17	0.61	0.52	146	0.42	0.33	105,000
140	13,417 (14)	3	1	2	11,768 (14)	3	0	1	164	1.39	0.74	0.63	172	0.50	0.37	105,000
160	15,333 (16)	3	1	2	13,449 (16)	3	1	2	186	1.58	0.83	0.71	195	0.56	0.41	105,000
180	17,250 (18)	4	1	2	15,130 (18)	3	1	2	211	1.77	0.93	0.79	220	0.63	0.47	105,000
200	19,167 (20)	4	1	2	16,812 (20)	4	1	2	233	1.97	1.03	0.87	243	0.70	0.51	105,000
220	21,083 (22)	4	1	2	18,493 (22)	4	1	2	256	2.16	1.13	0.95	267	0.77	0.56	105,000
240	23,000 (24)	4	1	2	20,174 (24)	4	1	2	279	2.35	1.23	1.03	291	0.84	0.61	105,000
525mA Fixture Operating at 25° C (77° F)																
40[5]	4,983 (04)	2	0	1	4,371 (04)	2	0	0	69	0.58	0.31	0.27	75	0.22	0.19	61,000
60[4]	7,475 (06)	3	0	1	6,556 (06)	2	0	1	110	0.92	0.49	0.41	116	0.33	0.27	61,000
80	9,967 (08)	3	0	1	8,742 (08)	3	0	1	138	1.16	0.62	0.54	145	0.42	0.32	61,000
100	12,458 (10)	3	0	2	10,927 (10)	3	0	1	177	1.49	0.79	0.68	186	0.53	0.40	61,000
120	14,950 (12)	3	1	2	13,113 (12)	3	1	2	217	1.82	0.96	0.81	226	0.65	0.48	61,000

* Utilizes magnetic step-down transformer

** For recommended lumen depreciation data see TD-13

*** For more information on the IES BUG (Backlight-Uplight-Glare) Rating visit www.iesna.org/PDF/Erratas/TM-15-07BugRatingsAddendum.pdf

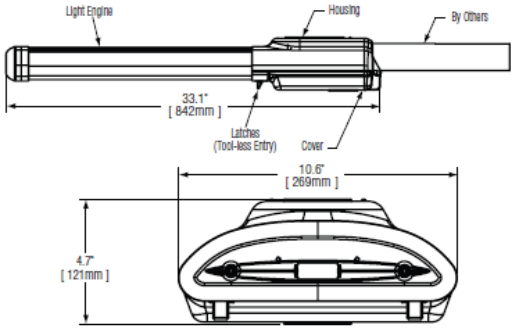
Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

STR-LWY-1S-HT LEDway® Streetlight – Type I Short

Rev. Date: 4/19/11

BetaLED Catalog #: STR - LWY - 1S - HT - - D - - - - IP - DIM7 -

Reset



Notes:

Product	Family	Optic	Mounting	# of LEDs (x 10)	LED Series	Voltage	Color Options	Drive Current
STR	LWY	1S[1]	HT[2]	☐ 07 ☐ 08 ☐ 09	D	☐ UL Universal 120–277V ☐ UH Universal 347–480V	☐ SV Silver[3] ☐ BK Black[3] ☐ BZ Bronze[3] ☐ PB Platinum Bronze[3] ☐ WH White[3]	☐ 700 700mA (Standard) ☐ 525 525mA ☐ 350 350mA

Factory-Installed Options

Please type additional options in manually on the lines provided above.

- ☐ IP IP66 Classification
- ☐ 43K 4300K Color Temperature[4]
- ☐ DIM 0–10V Dimming[5,6,7]
- ☐ F Fuse[8,9]
- ☐ HL Hi/Low (175/350/525, dual circuit input)[10]
- ☐ N No Quick Disconnect Harness or Leveling Bubble[11]
- ☐ PD Power Door[12]
- ☐ R NEMA Photocell Receptacle[8]
- ☐ SC Door Safety Tether[13]
- ☐ TL 2-Level (175/525 w/ integrated sensor control)[10]
- ☐ TL1 2-Level (350/700 w/ integrated sensor control)[10]
- ☐ TL2 2-Level (0/350 w/ integrated sensor control)[10]
- ☐ TL3 2-Level (0/525 w/ integrated sensor control)[10]
- ☐ TL4 2-Level (0/700 w/ integrated sensor control)[10]
- ☐ UTL Utility[14]

Footnotes

1. IESNA Type I Short distribution
2. Horizontal tenon mount
3. Light engine portion of extrusion is not painted and will remain natural aluminum regardless of color selection
4. Color temperature per fixture; minimum 70 CRI
5. Control by others
6. Refer to dimming spec sheet for availability and additional information
7. Can't exceed the specified drive current. Consult factory if exceeding the drive current is necessary.
8. Not available with all multi-level options. Refer to multi-level spec sheet for more availability and additional information
9. When code dictates fusing use time delay fuse
10. Refer to multi level spec sheet for availability and additional information
11. Standard product features unless N option is specified
12. All connections between door and fixture are shipped unconnected from the factory; door release spring included to open door automatically when the latches are released
13. Stainless steel aircraft cable
14. Includes exterior wattage label that reflect watts for the specified drive current selected. The ability to exceed drive current will be disabled.

LED PERFORMANCE SPECS

# of LEDs	Initial Delivered Lumens – Type I Short @ 6000K	B	U	G	Initial Delivered Lumens – Type I Short @ 4300K	B	U	G	System Watts @ 120V	Total Current @ 240V	Total Current @ 277V	System Watts 347–480V	Total Current @347V	Total Current # 480V	L_{70} Hours* @ 25° C (77° F)	50K Hours Lumen Maintenance Factor*
		Rating**				Rating**										
350mA Fixture Operating at 25° C (77° F)																
70	7,963 (07)	3	0	1	7,339 (07)	3	0	1	80	0.67	0.35	83	0.25	0.20	> 150,000	94%
80	9,048 (08)	3	0	1	8,339 (08)	3	0	1	91	0.77	0.39	94	0.28	0.22	> 150,000	
90	10,104 (09)	3	0	1	9,312 (09)	3	0	1	100	0.84	0.42	104	0.31	0.24	> 150,000	
525mA Fixture Operating at 25° C (77° F)																
70	11,148 (07)	3	0	1	10,274 (07)	3	0	1	119	0.99	0.47	127	0.37	0.29	140,000	93%
80	12,668 (08)	3	0	1	11,675 (08)	3	0	1	135	1.13	0.53	144	0.42	0.32	136,000	
90	14,145 (09)	3	0	1	13,037 (09)	3	0	1	149	1.27	0.58	160	0.47	0.35	132,000	
700mA (Standard) Fixture Operating at 25° C (77° F)																
70	13,934 (07)	3	0	1	12,843 (07)	3	0	1	161	1.35	0.61	166	0.49	0.36	115,000	91%
80	15,835 (08)	4	0	1	14,594 (08)	4	0	1	183	1.55	0.69	190	0.56	0.45	110,000	
90	17,682 (09)	4	0	1	16,296 (09)	4	0	1	200	1.69	0.76	211	0.62	0.41	107,000	

* For recommended lumen maintenance data see TD-13

** For more information on the IES BUG (Backlight-Uplight-Glare) Rating visit www.iesna.org/PDF/Erratas/TM-15-07BugRatingsAddendum.pdf

NOTE: All data subject to change without notice.

 • 1200 92nd Street • Sturtevant, WI 53177 • 800-236-6800 • www.betaLED.com

Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

IES ROAD REPORT
PHOTOMETRIC FILENAME : ARE-EDG-_1S-__-12-D-UL-525-43K.IES

DESCRIPTIVE INFORMATION (From Photometric File)

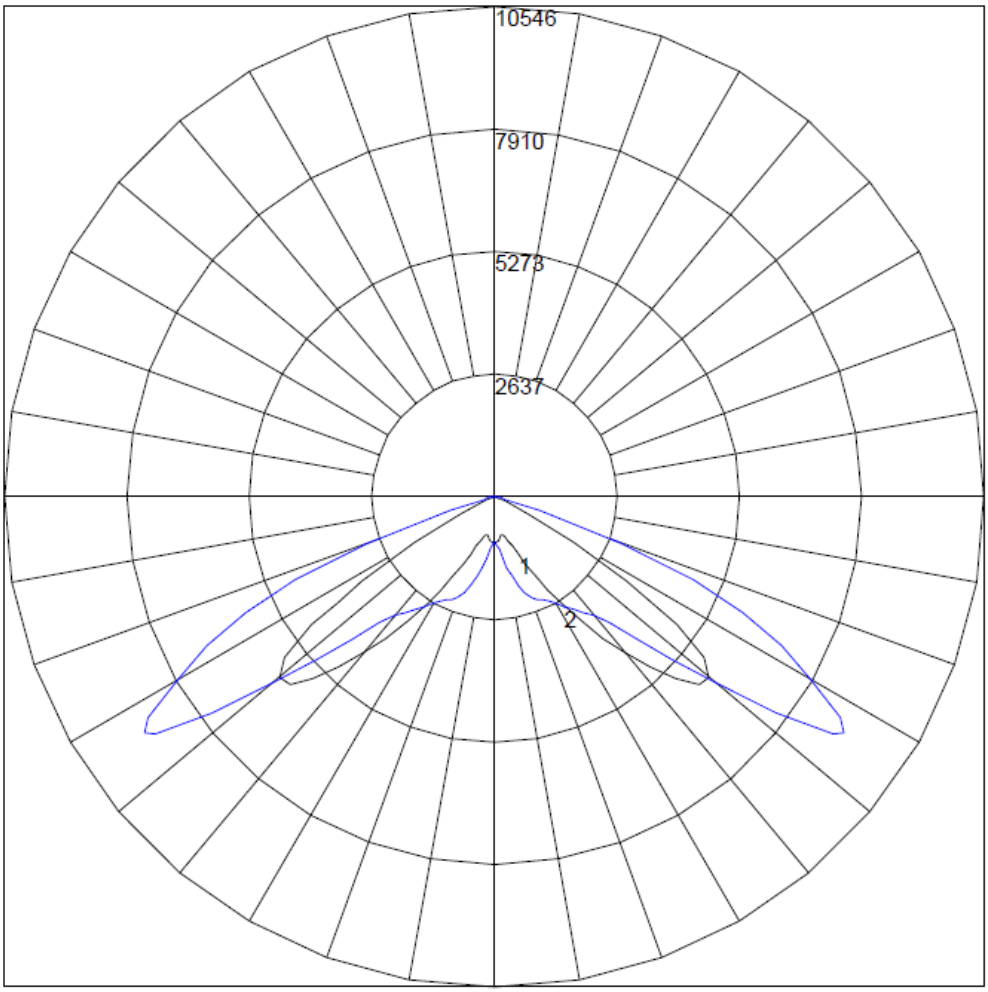
IESNA:LM-63-2002
[TEST]ITL68091
[TESTLAB]INDEPENDENT TESTING LABORATORIES, INC.
[ISSUEDATE]04/01/11
[MANUFAC]BETALED, A DIVISION OF RUUD LIGHTING
[LUMCAT]ARE-EDG-1S-**-12-D-UL-525-43K or BXAL1T12D-UC7 (525mA)
[LUMINAIRE]120 LED TYPE I SHORT 525mA EDGE AREA
[LAMP]ONE HUNDRED TWENTY WHITE LIGHT EMITTING DIODES (LEDS),
[MORE]VERTICAL BASE-UP POSITION.
[OTHER]TOTAL INPUT WATTS = 190.8 AT 240.0 VOLTS
[_LEDDRIVER]TWO BETALED CE366X03, BETALED CE138X SURGE PROTECTOR
[_NOTE]DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT
[MORE]VOLTAGE (240VAC, 60Hz) TO THE SURGE PROTECTOR. CLIENT STATES
[MORE]LEDS HAVE BEEN SEASONED FOR A MINIMUM OF 100 HOURS.
[OTHER]TEST PROCEDURE: IESNA LM-79-08
[OTHER]TEST DISTANCE = 25.25 FEET
[_ABSOLUTELUMENS]17295

CHARACTERISTICS

IES Classification	Type II
Longitudinal Classification	Short
Cutoff Classification (deprecated)	Full Cutoff
Lumens Per Lamp	N.A. (absolute)
Total Lamp Lumens	N.A. (absolute)
Luminaire Lumens	17295
Total Luminaire Efficiency	N.A.
Downward Total Efficiency	N.A.
Upward Waste Light Ratio	0.00
Maximum Candela	10546
Maximum Candela Angle	65H 55V
Maximum Candela (<90 Degrees Vertical)	10546
Maximum Candela Angle (<90 Degrees Vertical)	65H 55V
Maximum Candela At 90 Degrees Vertical	0 (0.0% Luminaire Lumens)
Maximum Candela from 80 to <90 Degrees Vertical	114 (0.7% Luminaire Lumens)
Total Luminaire Watts	190.8
Ballast Factor	1.00

IES ROAD REPORT
PHOTOMETRIC FILENAME : ARE-EDG-_1S-__-12-D-UL-525-43K.IES

POLAR GRAPH



Maximum Candela = 10546 Located At Horizontal Angle = 65, Vertical Angle = 55
1 - Vertical Plane Through Horizontal Angles (0 - 180)
2 - Vertical Plane Through Horizontal Angles (90 - 270)

Appendix D

Luminaire Data – Additional LED Products Considered

mfr/series	IP rating		max lm		notes
Affineon CA	65	.	1750	.	
Albeo S (sealed)	56	.		.	
Beacon Aurora	66	x	10620	.	IP-65 Endura is 7100 lm
Bega 6922LED	65	.	5370	.	
BetaLED EDG-CAN	66	x	24000	x	Gen D source, Type I optic (available in LEDway)
Day-Brite HBL	65	.	22500	x	
Dialight HB7C4M	66	x	10430	.	
Emco ELG	65	.	7500	.	
Everlight-Zenaro Caveled	65	.	3050	.	
Gardco SFC	65	.	9571	.	DF7 is lower output
GELS EGMS	65	.	8100	.	IP-66 asymmetric is 5400 lm
Holophane PLED	66	x	10418	.	14" height
Hydrel 8200	67	x	12900	.	8100 and Rhythm are lower output
IntenCity GL50	66	x	7000	.	
Kim PGL7	66	x	4200	.	offers asymmetric (left/right) optics
Lightwild Lusio	65	.	14000	.	
Lithonia ALX2	67	x	29734	x	not for ceiling mounting; IP-65 VAP is 8170 lm
LSGC FLB	66	x	10280	.	
LSII XPG3	67	x	8300	.	IP-67 XHB-series is 12,000 lm
Lumenpulse LumenbeamXL		.	7271	.	Lumenfacade is lower output
Lumisave LSFL390	65	.	9295	.	
McGraw CNC/VPL	66	x	7500	.	
On-Q	65	.	10000	.	
ReLume PSHO	65	.	11900	.	
Sportlite GR-52		.	5200	.	
Tersen TLRPG15		.	8500	.	
Traxon WWS-XB-CW	66	x	2583	.	
Visionaire ELE-3	65	.	24000	x	Can be ceiling mounted
Wide-Lite VZ	65	.	7230	.	floodlight requires external power supply

application

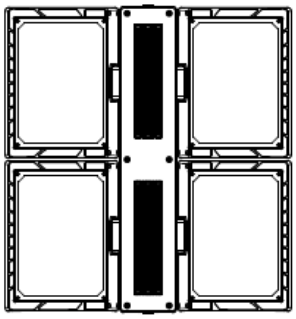
- This luminaire can be used to illuminate manufacturing, warehousing, gymnasiums, arenas and many other large indoor spaces with control and precision.

construction & features

- Die cast aluminum driver housing.
- Die cast aluminum heat sinks for light engines provide excellent thermal transfer to extend component life.
- Tempered glass lens with molded silicone rubber gasket, seals the optical compartment.
- Polyester powder finish on all die cast parts for excellent impact, corrosion and UV resistance.
- LED light engines and drivers are field replaceable.
- 5 Year Limited Warranty
- Components are RoHS compliant.

electrical

- Listed by ETL to meet UL 1598 standards for damp location and 45° C ambient.
- Dimming drivers are standard. Control is 0-10V DC. (See wiring notes below)
- Furnished with surge protector.

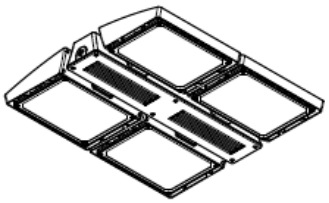


HB-20020

High Bay

HBL

300 Watt LED



Specifier's Reference
Project
Type
Model No.
Comments

Green Choice: HBL128GL70NW-UNV-MC-WT

HBL – ___ – ___ – ___

Family
HBL

No. of LEDs
128GL
192GL

Driver Current
35 – 350 mA
53 – 530 mA
70 – 700 mA

CCT
WW – 3000K
NW – 4000K
CW – 5700K

Voltage
UNV – 120-277
120 – 120
208 – 208
240 – 240
277 – 277
HRV – 347-480
347 – 347
480 – 480

Optics
N – Narrow
M – Medium
W – Wide
A – Aisle

Mounting
C – Cable
P – Pendant stem or hook
S – Surface Mount
(Requires OB or OBD - Order Separately)

Paint Colors
BZ – Dark Bronze
WT – White
BK – Black
AL – Silver Aluminum
(Consult factory for other colors)

Options
WHP6 – Wired Hook, 6' Cord & Plug[#6,1,2]
WP6 – 6' Wired Cord & Plug[#6,1,2]
WC6 – 6' Wired Cord[1]
MD360 – 360 Motion Detector[#6,1,2,3]
MD180 – 180 Motion Detector[#6,1,2,3]
WL – Wet location
IP65 – IP65 (Cable mount version Only)
EM – Emergency Lampholder (Lamp by others)[1]
IND – Indirect[1,2]
WSF – Wired Single Fuse[#6]
WDF – Wired Double Fuse[#5]
SL – Solite Lens

Accessories (Order Separately)

CH – Cover Half for Power Hook (use with PB)
PB – Power Box for Power Hook (use with CH)
HMR – Suspension Hook Male
LMR – Suspension Loop Male
HP12 – Hook-Cord-Plug Assembly 120V (P mounting only)
HP25 – Hook-Cord-Plug Assembly 208-240V (P mounting only)
HP27 – Hook-Cord-Plug Assembly 277V (P mounting only)
HP48 – Hook-Cord-Plug Assembly 480V (P mounting only)
SCB3 – Ballast Retainer Chain 3'
OB – Thru-wire outlet box
OBD – Thru-wire outlet box with disconnect
OBD4 – Thru-wire outlet box with 4 wire disconnect
OBD5 – Thru-wire outlet box with 5 wire disconnect
(Refer to Section 18000 for additional accessories.)

Wiring Notes

Standard cords or cord and plug assemblies have 3 wires.
Consult factory for cord or cord and plug options for dimming.

General Notes

All options factory installed.
All accessories are field installed.
Ambient is 40°C for surface mount or for unit hung 12" or less from the ceiling.

Predicted L_{70} Lifetime

25°C Ambient - > 100,000 hours
45°C Ambient - = 100,000 hours
(based upon LED manufacturer's supplied LM-80 data and in-situ laboratory testing)

Footnotes

[1]Not available with IP65 option.
[2]Not available with WL option.
[3]Motion detector is on/off only.
[#5]Use with 208, 240 and 480 volt.
[#6]Use with 120, 277 and 347 volt.
[#]Must specify voltage.

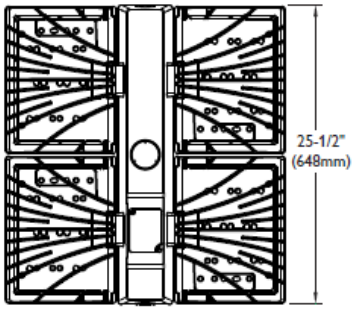
Weight = 36 lbs. (max.)

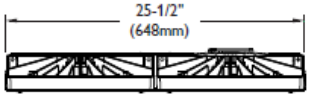
PHILIPS
Day-Brite

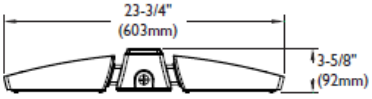
HB-20020

HBL LED High Bay

dimensions







photometry

LEDs: 4x32 Cree XPG — Distribution – Medium — CCT: NW

Catalog No.	HBL128GL70NW-UNV-W
Test No.	29362
S/MH	1.4
Current	700mA
Input Watts	287
Lumens	22,234
Efficacy	77.5 lm/W

The photometric results were obtained in the Philips Day-Brite laboratory which is NVLAP accredited by the National Institute of Standards and Technology.

Photometric data based on tests performed in compliance with LM-79

Candlepower

Angle	Avg. Candela
0	10479
5	10405
10	10241
15	10239
20	10596
25	11308
30	10790
35	9817
40	8000
45	4926
50	1882
55	769
60	538
65	390
70	264
75	144
80	59
85	10

Light Distribution

Degrees	Lumens	% Lamp	% Luminaire
0-30	9070	40.8	40.8
0-40	15502	69.7	69.7
0-60	21523	96.8	96.8
0-90	22234	100.0	100.0

Average Luminance

Angle	End	45°	Cross
45	27805	19966	20149
55	4923	3989	3732
65	3483	2675	2552
75	2293	1648	1353
85	688	224	172

Coefficients of Utilization

EFFECTIVE FLOOR CAVITY REFLECTANCE 20 PER (pfc=0.20)

Ceil	80				70				50			30			10		
Wall	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10
RCR																	
0	119	119	119	119	116	116	116	116	111	111	111	106	106	106	102	102	102
1	113	109	107	104	110	107	105	102	103	101	99	99	98	96	96	95	93
2	106	101	96	92	104	99	95	91	96	92	89	93	90	87	90	88	86
3	100	92	87	82	98	91	86	82	88	84	80	86	82	79	84	81	78
4	94	85	79	74	92	84	78	74	82	77	73	80	75	72	78	74	71
5	88	78	71	67	86	77	71	66	75	70	66	74	69	65	72	68	64
6	82	72	65	60	80	71	64	60	69	64	59	68	63	59	66	62	58
7	76	65	58	54	75	65	58	53	63	57	53	62	57	53	61	56	52
8	71	60	53	48	70	59	52	48	58	52	48	57	51	47	56	51	47
9	66	55	47	42	65	54	47	42	53	47	42	52	46	42	51	46	42
10	61	50	42	38	60	49	42	38	48	42	38	47	41	37	46	41	3

LEDs: 4x32 Cree XPG — Distribution – Wide — CCT: NW

Catalog No.	HBL128GL70NW-UNV-W
Test No.	29363
S/MH	2.7
Current	700mA
Input Watts	287
Current	22,435
Efficacy	78.2 lm/W

The photometric results were obtained in the Philips Day-Brite laboratory which is NVLAP accredited by the National Institute of Standards and Technology.

Photometric data based on tests performed in compliance with LM-79

Candlepower

Angle	Avg. Candela
0	3277
5	3378
10	3581
15	3841
20	4201
25	4700
30	5300
35	5973
40	6698
45	7510
50	8043
55	7584
60	4679
65	789
70	298
75	158
80	67
85	18

Light Distribution

Degrees	Lumens	% Lamp	% Luminaire
0-30	3624	16.1	16.1
0-40	7366	32.8	32.8
0-60	19747	88.0	88.0
0-90	22435	100.0	100.0

Average Luminance

Angle	End	45°	Cross
45	31294	31931	32268
55	40895	40678	38128
65	9094	5222	4046
75	2131	1905	1512
85	825	555	600

Coefficients of Utilization

EFFECTIVE FLOOR CAVITY REFLECTANCE 20 PER (pfc=0.20)

Ceil	80				70				50			30			10		
Wall	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10
RCR																	
0	119	119	119	119	116	116	116	116	111	111	111	106	106	106	102	102	102
1	110	106	102	99	108	104	100	97	100	97	94	96	94	91	92	90	89
2	101	94	88	83	99	92	86	82	88	84	80	85	82	78	82	79	76
3	92	82	75	68	90	81	74	68	78	72	67	75	70	66	73	68	64
4	84	72	64	57	82	71	63	57	68	62	56	66	60	55	64	59	55
5	76	63	54	47	74	62	53	47	60	52	47	58	51	46	56	50	46
6	68	55	45	39	66	54	45	38	52	44	38	50	43	38	48	42	37
7	61	47	38	31	60	46	37	31	44	36	31	43	36	30	42	35	30
8	56	41	32	26	54	40	32	26	39	31	26	38	31	25	36	30	25
9	51	36	27	21	49	36	27	21	34	27	21	33	26	21	32	26	21
10	46	32	23	18	45	31	23	18	30	23	18	29	22	17	29	22	17

776 South Green Street • Tupelo, MS 38804
p. 800.234.1890 • f. 662.841.5501
Canadian Division
189 Bullock Drive • Markham, Ontario L3P 1W4
p. 905.294.9570 • f. 905.294.9811

Contact Factory for Additional Configurations.
Specifications are subject to change without notice.

LITHONIA LIGHTING®

Catalog Number	
Notes	
Type	

ALX
LED Luminaires

Area Luminaire

ALX2 LED

LED

NIGHTTIME FRIENDLY™
Consistent with LEED® goals & Green Globes™ criteria for light pollution reduction

FEATURES & SPECIFICATIONS

INTENDED USE — This softly contoured luminaire seamlessly blends into all forms of architecture. Highly efficient and long-lasting, it is ideal for streets, walkways, parking lots, and surrounding areas.

CONSTRUCTION — Sturdy low-copper aluminum, single-piece die cast housing. Unique flow-through design allows for optimized thermal management through convective cooling. A metallic screen covers the top of the housing, preventing debris build-up while allowing air-flow and natural cleaning of the light engine heat sink. Modular design allows for ease of maintenance and future light engine upgrades. The LED driver and electronics are thermally isolated from the heat-generating light engine ensuring long life. Housing is completely sealed against moisture and environmental contaminants. Low profile design minimizes wind-loading.

Finish: Exterior parts are protected by a zinc-infused Super Durable TGIC thermoset powder coat finish (available in both textured and non-textured) that provides superior resistance to corrosion and weathering. A tightly controlled multi-stage process ensures a minimum 3 mm thickness for a finish that can withstand extreme climate changes without cracking or peeling. Standard Super Durable colors include dark bronze, black, natural aluminum and white.

OPTICS — Individual precision-molded acrylic lenses provide optimal luminaire spacing and improved uniformity. Lenses are indexed to the circuit board to ensure consistent optical alignment on each module and mechanically set in a proprietary material, delivering repeatable photometric performance. Choice of three optimized distributions: Type III, Type IV, and Type V. The optical system controls light above 90 degrees, eliminating wasteful up light.

ELECTRICAL — High-efficiency 5100K, 70 CRI LEDs mounted to a metal-core circuit board and aluminum heat sink, ensuring optimal thermal management and long life (L70 50,000 hrs, 40°C ambient). Standard and dimming drivers are available in 120-277V and 347-480V; 50/60 Hz. Drivers have power factor >90% and THD <20%. Thermal isolation results in expected driver life of over 60,000 hours. Integral surge protection in accordance with IEEE/ANSI C62.41.2 Category C Low is standard.

INSTALLATION — Integral arm provides easy installation to a pole and ensured alignment and leveling. Rugged, secure connection built to withstand up to 1.5 G vibration load per ANSI C136.31. ALX pole-mounted luminaires utilize the AERIS™ series pole drilling pattern.

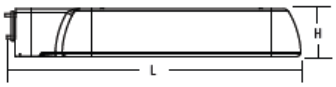
LISTINGS — CSA certified to U.S. and Canadian standards for 40°C (104°F) ambient. Downward installation only. Light engine is IP67 rated. Luminaire is IP65 rated. **U.S. Patent No. D632830.**

WARRANTY — Five-year limited warranty.

Note: Specifications subject to change without notice.

Specifications

EPA: 1.2 ft²
Length: 35-3/8 (89.7)
Width: 18-1/2 (46.9)
Height: 5-7/8 (14.9)
Weight (3 light engines): 74 lbs (33.6 kg)
*Weight (4 light engines): 87 lbs (39.4 kg)
*Weight as configured in example below.



All dimensions are inches (centimeters) unless otherwise noted.

ORDERING INFORMATION

Lead times will vary depending on options selected. Consult with your sales representative.

Example: ALX2 LED 4 30A350/51K SR5 MVOLT SPA DDBXD

ALX2 LED		30A350/51K					
Series	**Number of light engines**	**Performance package**	**Distribution**	**Voltage**	**Mounting**	**Options**	**Finish[10]**
ALX2 LED	3 4	30A350/51K	SR3 Type III SR4 Type IV SR5 Type V	MVOLT[1] 120 208 240 277 347 480	SPA Square pole mounting RPA Round pole mountinig	Shipped installed in fixture PER NEMA twist-lock receptacle only (no photocontrol)[2] DCR Dimming control - ROAM (PER required)[2] HS Houseside shield (SR3, SR4)[3,4] SF Single fuse (120, 277, 347V) DF Double fuse (208, 240, 480V) DMG Dimming option[5] WTB Utility terminal block DS Dual switching[6] Shipped separately[3] DSS124N 1.5 TJJE J12 Solid-state twist-lock photocell[7] SC U Shorting cap[8] VG Vandal guard[9] BS Bird-deterrant spikes[9]	DDBXD Dark bronze DBLXD Black DNAXD Natural aluminum DWHXD White DDBTXD Dark bronze textured DBLBXD Black textured DNATXD Natural aluminum textured DWHGXD White textured

Note: ALX shares a unique drilling pattern with the AERIS™ and OMERO™ families. This pattern should be used when specifying poles. See example below.

Example: SSA 20 4C DM19AS DDBXD

Aeris Drilling Pattern

DM19AS	1 at 90 degrees
DM28AS	2 at 180 degrees
DM29AS	2 at 90 degrees
DM39AS	3 at 90 degrees
DM49AS	4 at 90 degrees
DM32AS	3 at 120 degrees (round poles only)

Accessories: Tenon Mounting Slipfitter
Order as separate catalog number. Must be used with pole mounting (RPA).

Tenon O.D.	One	Two@180°	Two@90°	Three@120°	Three@90°	Four@90°
2-3/8"	AST20-190	AST20-280	AST20-290	AST20-320	AST20-390	AST20-490
2-7/8"	AST25-190	AST25-280	AST25-290	AST25-320	AST25-390	AST25-490
4"	AST35-190	AST35-280	AST35-290	AST35-320	AST35-390	AST35-490

Notes
1. Optional multi-volt driver capable of operating on any line voltage from 120V-277V.
2. ROAM enabled fixture. Additional hardware and services required for ROAM deployment must be purchased separately. Call 1-800-442-6745 or email: sales@roamservices.net.
3. May be ordered as an accessory.
4. Prefix with ALX when ordering as an accessory (for "HS" option, order quantity 1 per light engine).
5. Not available with 347 or 480v.
6. Available with 4 light engines only. Wired with half the LEDs to each branch of the circuit. N/A with PER, DCR, DMG or WTB.
7. Must order PER option. Not available 347v. Consult factory for 480v photocontrol option. Must be ordered as a separate line item from Acuity Brands Controls in multiples of 12.
8. Must be ordered on separate line.
9. For accessory, order as ALX2BS U.
10. Must specify finish.

PERFORMANCE DATA

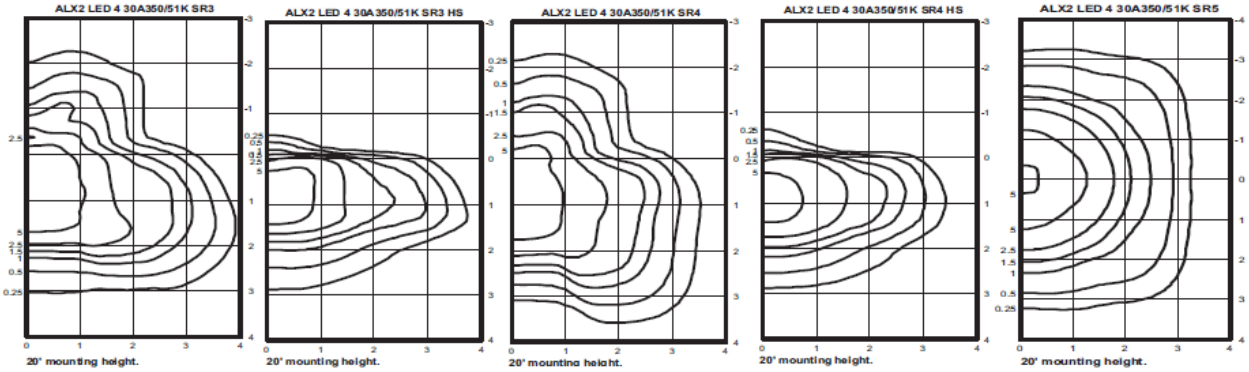
Number of light engines	Performance package	Distribution	Option	Lumens	B	U	G	System watts[1]	LPW
3	30A350/51K	SR3		21,694	3	3	3	336	65
3	30A350/51K	SR4		21,125	3	3	4	336	63
3	30A350/51K	SR5		22,380	4	2	2	336	67
3	30A350/51K	SR3	HS	11,785	1	2	2	336	35
3	30A350/51K	SR4	HS	10,262	0	3	2	336	31
4	30A350/51K	SR3		28,863	3	3	4	448	64
4	30A350/51K	SR4		27,944	3	3	4	448	62
4	30A350/51K	SR5		29,734	5	2	5	448	66
4	30A350/51K	SR3	HS	15,530	1	3	3	448	35
4	30A350/51K	SR4	HS	14,022	1	3	3	448	31

		Current (A)					
Light Engines	Power (W)	120	208	240	277	347	480
3	336	2.80	1.62	1.40	1.21	0.97	0.70
4	448	3.73	2.15	1.87	1.62	1.29	0.93

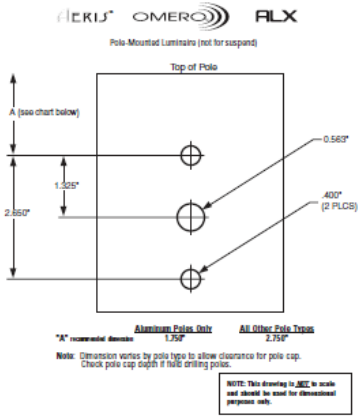
Notes

1 At 277V.

PHOTOMETRICS



DRILLING TEMPLATE # 8



Notes

1 Photometric data for other distributions can be accessed from the Lithonia Lighting web site (www.lithonia.com).

2 For electrical characteristics consult outdoor technical data specification sheets on www.lithonia.com.

3 Various operating factors can cause differences between laboratory and actual field measurements. Dimensions and specifications are based on the most current data and are subject to change. **Tested to IESNA LM-79-08 standards.**

Mounting Height Correction Factor

(Multiply the fc level by the correction factor)

10 ft. = 4

15 ft. = 1.78

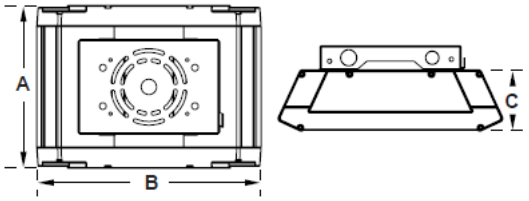
30 ft. = 0.44

$$\frac{\text{Existing Mounting Height}^2}{\text{New Mounting Height}^2} = \text{Correction Factor}$$

Element - Garage/Canopy
LED

Project Name	Type
Catalog Number	

Dimensional Drawings



Fixture	A	B	C	Max. LEDs	Lbs
ELE-1	12⅞"	14½"	4"	96	28½

The **Element - Garage/Canopy** masters heat dissipation via its thermal convection air management system, which lowers the LED junction temperature, resulting in longer LED life and superior lumen maintenance; perfect for warm environments that must operate around the clock. Additionally, the **Element's** optics have been specifically designed for typical low-mounting-height garage applications.

Housing: The **Element - Garage/Canopy** utilizes a heavy-duty, extruded aluminum body, with heat radiating fins for cutting edge thermal management; cast aluminum end caps, and a protective, perforated top cover that directs constant air flow for maximum cooling. Galvanized steel ceiling mount bracket can be secured directly to recessed junction box or to the ceiling. The housing hanger allows fixture to be suspended from ceiling bracket while making wiring connection.

Finish: Durable Quali-Guard® textured thermoset polyester powder coat, oven-baked at a temperature of 400 °F to promote maximum adherence and finish hardness. Finish is guaranteed for five (5) years.

Optics: Offered in Type III and Type V optics, the **Element - Garage/Canopy** qualifies as an IES full cutoff fixture; and is Dark-Sky certified to restrict light trespass, glare and light pollution. Optional High-Low system available.

LEDs: High lumen output VisionBar™ LEDs are utilized, offering a minimum estimated life of 70,000 hours, and a maximum estimated life of 200,000 hours; in the desirable light color temperature of 4,000 Kelvin.

Ballast: A high-performance LED driver operates at 120 thru 277 volts, 50 to 60 Hz, with a 90% power factor; and is rated for -40 °C operation.

Model	Optics	Source	Milliamps	Kelvin	Voltage	Mounting	Finish	Options
ELE-1	Type III (T3)	# of LEDs	mA	4000K (4K)	120-277 *Universal voltage (UNV)	Ceiling Mount (CM)	White (WH)	Fusing *Specify voltage Single in-line fuse (SF120) (SF277)
	Type V (T5)	24 (24L)	350 (3)			Pendant Mount *Specify pendant length (PM)	Bronze (BZ)	Double Inline Fuse (DF208) (DF240)
		48 (48L)	530 (5)				Black (BK)	Dual Circuit (DC)
		72 (72L)	700 (7)				Grey (GY)	Cutoff Louver System (CLS)
		96 (96L)					Silver Metallic (SL)	Motion Sensor (MS)
							Custom Color (CC)	High-Low System (HL)

Pair with:

Element
Area fixture.

LED - Light Emitting Diode

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www.visionairelighting.com

Element - Garage/Canopy
LED

Housing
• The fixture housing is heavy-duty, extruded aluminum, with heat radiating fins and cast aluminum end caps. Extruded aluminum side covers provide complete protection for the electronic driver. A perforated aluminum top cover protects the heat radiating fins from contaminants and directs constant air flow over them for maximum cooling.

Thermal Management
• The **Element - Garage/Canopy** provides excellent overall thermal management by maximizing the efficiency of the heat sink in the fixture. This enables the **Element - Garage/Canopy** to withstand higher ambient temperatures and higher drive currents without degrading LED life. The **Element - Garage/Canopy** has a low thermal resistance rating. The heat radiating fins and perforated fixture components (see Air Flow Path illustration below) create superior thermal management results.
• The L_{70} test determines the point in an LED's life when it reaches 70 percent of its initial output. **Element** series LEDs have been determined to last 200,000 hours in 40 °C environments when driven at 350 mA. See chart below for additional test results.

Optical System
• The highest lumen output LEDs available are utilized in the **Element** series. IES Types III and V distributions are standard. The LED VisionBar™ light assemblies are field replaceable. Available in nominal wattages from 25 to 200 watts. The optical system qualifies as IES full cutoff; and is Dark-Sky certified to restrict light trespass, glare and light pollution.

Quali-Guard® Finish
• A Quali-Guard® thermoset polyester powder coat painted finish is standard, and offered in a variety of colors.

Mounting
• Galvanized steel ceiling mount bracket can be secured directly to recessed junction box, or to the ceiling. The housing hanger bracket allows fixture to be suspended from ceiling bracket while making wiring connection. The housing bracket then attaches to the ceiling bracket via a tool-less latch. A tamper-proof screw can then secure the bracket.

Electrical Assembly
• The **Element - Garage/Canopy** is supplied with a choice of 350, 530 or 700 mA high-performance LED drivers that accept 120 V thru 277 V, 50 Hz to 60 Hz, input. Power factor of 90%. Rated for -40 °C operations.

Warranty
• Five (5) year limited warranty on entire system, including finish. For full warranty information, please visit VisionaireLighting.com.

Options
• Dual circuit
• Cutoff louver system
• Motion sensor
• High-low system

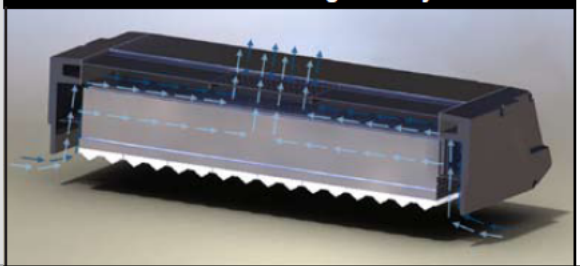
Please consult factory for custom options and available upgrades

Listings
• c UL us LISTED listed for wet locations.
• LM79 • LM80
• RoHS Compliant • IP65 • Patent Pending
• Dark-Sky Friendly®, full cutoff certified by the International Dark-Sky Association
• Powder Coated Tough™

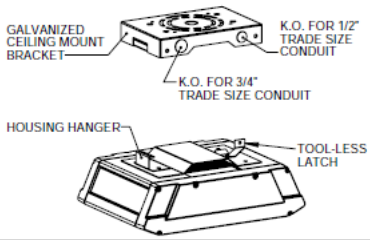
LED Data Chart

# LEDs	Output mA	Nominal Watts	Initial Lumens T3	Initial Lumens T5	System Watts 120-277	L_{70} Hours @ 40° C
24	350	25	1,771	1,946	28	200,000
	530	35	2,439	2,680	39	120,000
	700	50	2,962	3,255	55	70,000
48	350	50	3,504	3,850	56	200,000
	530	70	4,540	4,989	78	120,000
	700	100	5,667	6,228	110	70,000
72	350	75	5,185	5,698	84	200,000
	530	105	6,928	7,613	117	120,000
	700	150	8,057	8,854	165	70,000
96	350	100	6,916	7,600	112	200,000
	530	140	8,911	9,792	156	120,000
	700	200	10,072	11,068	220	70,000

Thermal Convection Air Management System

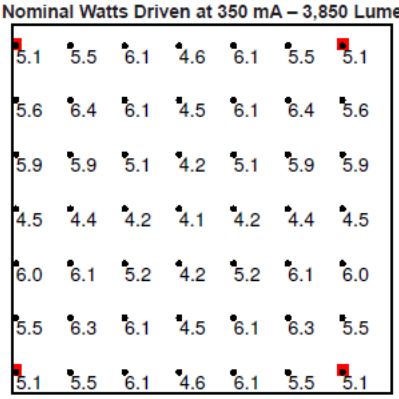


Ceiling Mount Detail



Parking Garage Typical - Open Ceiling

50 Nominal Watts Driven at 350 mA – 3,850 Lumens



Mounting Height: 10 feet
30' Spacing - Center to Center

Average FC: 5.39
Max FC: 6.4
Min FC: 4.1
Max/Min: 1.56

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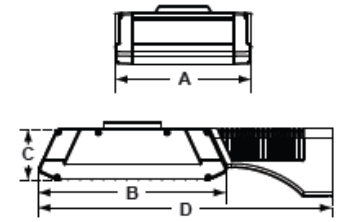
Area

Element
LED

Project Name	Type
Catalog Number	

Dimensional Drawings



Fixture	A	B	C	D	Max. LEDs	Lbs
ELE-1	12⅞"	14½"	4"	21½"	96	28½
ELE-2	22⅞"	14½"	4"	21½"	168	37
ELE-3	32⅞"	14½"	4"	21½"	240	44½

The **Element** is a modularly-designed area luminaire that maximizes the latest in LED technology. It is available in three sizes, offering from 25 to 350 nominal watts of LED lighting. The **Element** masters the art of efficient heat dissipation, electronic driver protection, maximization of optics control; and features a wide array of energy and security options for optimal efficiency and safety.

The range of housing sizes is accomplished by utilizing a heavy-duty, extruded aluminum body, with heat radiating fins for cutting edge thermal management.

Cast aluminum end caps, and a shielded, perforated top cover, beneath a protective debris guard, complete the construction of this innovative, long-life LED luminaire. The standard finish on the **Element** is a thermoset polyester powder coat painted finish in standard and custom colors.

The **Element** utilizes a high-performance LED light engine; and the highest lumen output VisionBar™ LEDs; with built-in optical control; to provide IES Types I, II, III, IV and V distribution patterns. It qualifies as an IES full cutoff fixture; and is Dark-Sky certified to restrict light trespass, glare and light pollution for neighborhood-friendly lighting.

The **Element** boasts an excellent thermal management rating that results in increased lumen output and an LED minimum life estimated from 60,000 to 200,000 hours. Control systems may extend the life of all the **Element** and further reduce maintenance costs. See LED Data Chart for more information.

Model	Optics	Source	Milliamps	Kelvin	Voltage	Mounting	Finish	Options
ELE-1	Type I (T1)	# of LEDs	mA	4000K (4K)	120-277 *Universal voltage (UNV)	Bolt-On Arm (BOA)	White (WH)	Button Type Photocell *Specify voltage (PC120) (PC208) (PC240) (PC277)
	Type II (T2)	24 (24L)	350 (3)		Solar 12 VDC (12VDC)	Wall Mount *Includes Cast Wall Plate (WM)	Bronze (BZ)	Dual Circuit (DC)
	Type III (T3)	48 (48L)	530 (5)			Knuckle Mount (KM)	Black (BK)	Cutoff Louver System (CLS)
	Type IV (T4)	72 (72L)	700 (7)			Mast Arm Fitter (MAF)	Grey (GY)	Motion Sensor (MS)
ELE-2	Type V (T5)	96 (96L)					Silver Metallic (SL)	High-Low System (HL)
		120 (120L)					Custom Color (CC)	Round Pole Plate Adaptor For 4"Ø Pole (RPP4) For 5"Ø Pole (RPP5)
		144 (144L)						
		168 (168L)						
ELE-3		192 (192L)						
		216 (216L)						
		240 *Not available in 700 mA (240L)			Consult factory for 347-480V	Round Pole Plate Adaptors (RPP) are to be ordered separately.		

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Element
LED

Housing
• The fixture housing is heavy-duty, extruded aluminum, with heat radiating fins. A perforated aluminum top cover protects the heat radiating fins from contaminants and directs constant air flow over them for maximum cooling.

Thermal Management
• The **Element** provides excellent overall thermal management by maximizing the fixture's heat sink efficiency. This enables the **Element** to withstand higher ambient temperatures and drive currents without degrading LED life. The **Element** has a low thermal resistance rating. The heat radiating fins and perforated fixture components (see Thermal Convection Heat Management System cutaway below) create superior thermal management results.
• **The** L_{70} test determines the point in an LEDs life when it reaches 70 percent of its initial output. **Element** series LEDs have been determined to last 200,000+ hours in 40 ºC environments when driven at 350 mA. See LED Data Chart for additional test results.

Optical System
• The highest lumen output LEDs available are utilized in the **Element** series. IES distribution Types I, II, III, IV and V are available. The LED VisionBar™ light assemblies come in multiples of 24 (minimum 24 to maximum 240 LEDs) and are field replaceable. The optical system qualifies as IES full cutoff; and is Dark-Sky certified to restrict light trespass, glare and light pollution.

Quali-Guard® Finish
• A Quali-Guard® thermoset polyester powder coat painted finish is available in white and custom colors.

Mounting
• The **Element** is provided with a pre-mounted, cast aluminum bolt-on arm (BOA) and Quick Mount pole adaptor that is shipped installed on a Visionaire pole. Installation is as simple as hooking the bolt-on arm onto the pole adaptor and tightening one set screw (see Quick Mount Arm detail). A Round Pole Plate adaptor (RPP) is required for mounting to 3"-5" round poles.

Electrical Assembly
• The **Element** is supplied with a choice of 350, 530 or 700 mA high-performance LED drivers that accept 120v thru 277v, 50 Hz to 60 Hz, input. Power factor of 90%. Rated for -40 ºC operations.

Solar Vision Pole™ Option
• The **Element** LED is compatible for use with Visionaire Lighting's Solar Vision Pole™. Power up to 50 watts (SMR-1 wrap) or 100 watts (SMR-2 rigid panel) off-the-grid in any locale.

Warranty
• Five (5) year Limited Warranty on entire system, including finish. For full warranty information, please visit VisionaireLighting.com.

Options
• Button type photocell
• Dual circuit
• Cutoff louver system
• Motion sensor
• High-low system
• Round pole plate adaptor

Please consult factory for custom options and available upgrades.

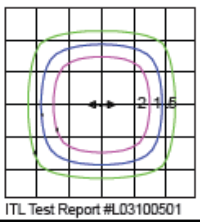
Listings
• **Element** is listed, suitable for wet locations.
• LM79 and LM80.
• RoHS compliant.
• Dark-Sky Friendly®, full cutoff certified by the International Dark-Sky Association.
• Meets ANSI 2GC136.31-2001 Vibration Standards when ordered with the MAF mounting option.
• IP65 Pending.
• Powder Coated Tough™

LED Data Chart

# Bars	# LEDs	Output mA	Nominal Watts	Initial Lumens T8	Initial Lumens T5	System Watts 120-277	L_{70} Hours @ 40° C
1 ELE-1	24	350	25	1,774	1,946	28	200,000
		530	35	2,439	2,680	39	120,000
		700	50	2,962	3,255	55	70,000
2 ELE-1	48	350	50	3,504	3,850	56	200,000
		530	70	4,540	4,989	78	120,000
		700	100	5,667	6,228	110	70,000
3 ELE-1	72	350	75	5,185	5,698	84	200,000
		530	105	6,928	7,613	117	120,000
		700	150	8,057	8,854	165	70,000
4 ELE-1	96	350	100	6,916	7,600	112	200,000
		530	140	8,911	9,792	156	120,000
		700	200	10,072	11,068	220	70,000
6 ELE-2	120	350	125	8,175	9,164	130	200,000
		530	175	10,637	11,928	199	80,000
		700	250	12,457	13,968	268	60,000
8 ELE-2	144	350	150	9,810	10,997	156	200,000
		530	210	12,681	14,224	237	80,000
		700	300	14,752	16,547	319	60,000
7 ELE-2	168	350	175	11,444	12,830	182	200,000
		530	245	14,716	16,488	274	80,000
		700	350	17,005	19,053	368	60,000
8 ELE-3	192	350	200	13,073	14,663	208	200,000
		530	280	16,702	18,558	312	140,000
		700	400	19,167	21,483	418	60,000
9 ELE-3	216	350	225	14,539	16,635	238	200,000
		530	315	18,735	21,427	354	140,000
		700	450	21,704	24,823	475	60,000
10 ELE-3	240	350	250	16,162	18,483	264	200,000
		530	350	20,731	23,689	391	140,000
		700	N/A	N/A	N/A	N/A	N/A

Visit www.VisionaireLighting.com for up-to-the-minute chart information, including Types not listed here.

Isolux Curve

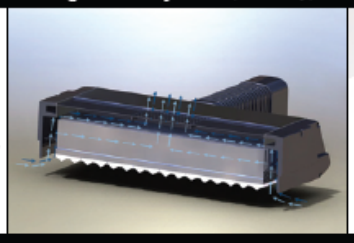


ELEMENT-3
TYPE V
LED OPTICS
240 LEDs @ 350 mA

Scale: 1 Square = 30 ft
Initial Light Loss Factor = 1.00
Total Lumens Per Luminaire = 18,483
Mounting Height = 33 ft
Arrangement: Twin (back-to-back)

ITL Test Report #L03100501

Thermal Convection Heat Management System (Cutaway)



Quick Mount Arm Detail

EPA Data

Fixture with Arm						
ELE-1	.6	.9	1.3	1.4	1.4	1.4
ELE-2	.7	n/a	1.3	n/a	1.5	n/a
ELE-3	1.0	n/a	1.3	n/a	n/a	n/a

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Appendix E

Notes Received from NPS on March 9, 2010

1) FIRST 200 FT OF TUNNEL IS CALLED THE THRESHOLD ZONE. (54) Luminare bulbs 3.7 Feet apart.
(44) 400W & (10) 100W HPS.
EVERY 4TH LUMINAIRE IS 100 WATT (5TH)?

2) SECOND 250 FT OF TUNNEL IS CALLED THE TRANSITION ZONE. (14) 250W AND (13) 100W 9.25 FEET APART

3) The middle section is called the Interior ZONE. (75) 100 WATT 19.5 FEET APART 1462

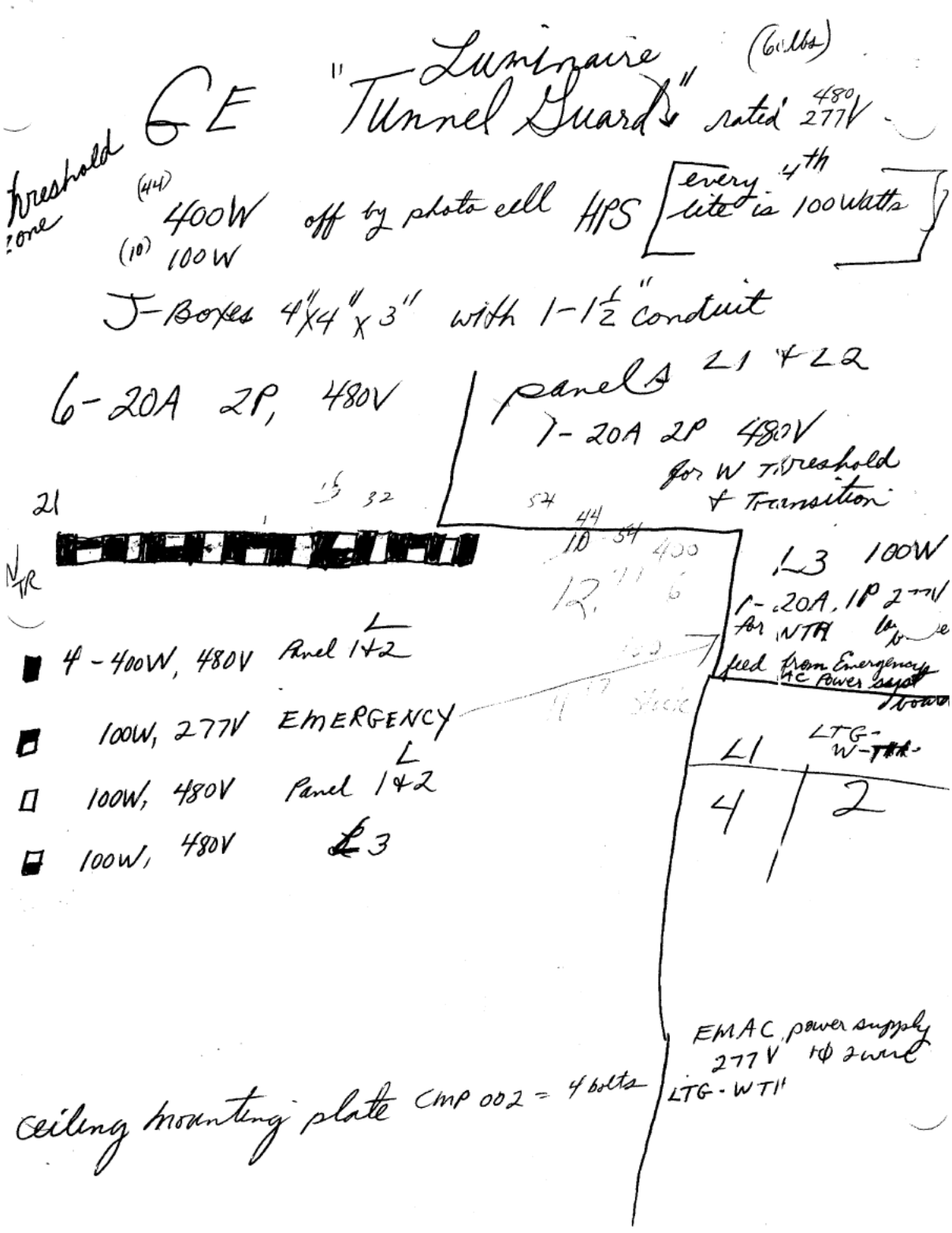
EMERGENCY LIGHT Bulb# (5) Bulb# (25) Bulb# (45)

(44) 400W (14) 250W (14) 250W (44) 400W
(10) 100W (13) 100W (75) 100W (13) 100W (10) 100W

(88) 400W Bulbs
(28) 250W Bulbs
(121) 100W Bulbs

237 BULBS IN ALL

TUNNEL IS just UNDER 1/2 mile


GE "Luminaire" "Tunnel Guard" rated 480 277V
(6 lbs)
threshold zone
(44) 400W
(10) 100W
off by photo cell HPS
every 4th lite is 100 watts
J-Boxes 4"x4"x3" with 1-1/2" conduit
6-20A 2P, 480V
panels L1 & L2
1-20A 2P 480V
for W. threshold & Transition
21
15
32
54
44
10
54
400
12
6
L3 100W
1-20A, 1P 277V
for NTR
feed from Emergency AC Power
L1
LTG-W
4
2
NTR
4-400W, 480V Panel 1&2
100W, 277V EMERGENCY L
100W, 480V Panel 1&2
100W, 480V L3
EMAC power supply 277V 1Φ 2 wire
LTG-WTH
ceiling mounting plate CMP 002 = 4 bolts

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