PURCHASE SPECIFICATION
LIGHT EMITTING DIODE (LED) LUMINAIRE
(Mast Arm Mounted)

This specification is for the purchase of light emitting diode (LED) highway lighting luminaires (herein referred to as luminaires) mast-arm applications. This includes general roadway lighting luminaires for intersection and freeways as well as luminaires for underpasses, bridges, and parking lots.

All devices shall meet the general specifications of the Transportation Electrical Equipment Specifications (TEES), Chapter 1--General Specifications, Section 86 of the Standard Specifications as well as the following specification. Incase of conflict, this specification shall govern over the TEES, Chapter 1.

1 Glossary

Wherever the following terms or abbreviations are used, the intent and meaning shall be interpreted as follows:

CALiPER	Commercially Available LED Product Evaluation and Reporting A US DOE program for the testing and monitoring of commercially available LED luminaires and lights.
CCT	correlated color temperature. A visible light characteristic of comparing a light source to a theoretical, heated black body radiator. Measured in Kelvin.
Cd	Candela. Unit of measurement of light intensity.
Chromaticity	The property of color of light
fc	foot-candle. Unit of illuminance
IP	International Protection rating, sometimes referred to as ingress protection, that delineates the level at which foreign objects and water can intrude inside a device.
junction temperature	The temperature of the electronic junction of the LED device. The junction temperature is critical in determining photometric performance, estimating operational life, and preventing catastrophic failure of the LED.
L70	The extrapolated life in hours of the luminaire when the luminous output depreciates 30 percent from initial values.
LED	Light Emitting Diode.
LM-79:	A test method from the Illumination Engineering Society of North America (IESNA) specifying test conditions, measurements and report format for testing solid state lighting devices including LED luminaires.
LM-80:	A test method from the Illumination Engineering Society of North America (IESNA) specifying test conditions, measurements and report format for testing and estimating the long term performance of LEDs for general lighting purposes.
METS	Material Engineering and Testing Services of the Translab.
NEMA	National Electrical Manufacturers Association
NVLAP	National Voluntary Laboratory Accreditation Program. A program under the US DOE to accredit independent testing laboratories to qualify
Power factor	The ratio of the real power component to the total (complex) power component.
Rated power	The power consumption that the luminaire was designed and tested for at ambient temperature (70°F or 21°C)
SPD	Surge Protection Device. A subsystem or component(s) that can protect the unit against short duration voltage and current surges.
TEES	Transportation Electrical Equipment Specifications. A package of standard specifications for transportation related electrical equipment to be used on State Highways. This document is compiled by Caltrans Traffic Operations Program.

THD	Total Harmonic Distortion. The amount of higher frequency power on the power line

2 General Requirements

2.1 Each luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply).

2.2 Each luminaire shall be rated for a minimum operational life of 63,000 hours.

2.2.1 Each luminaire will operate at an average operating time of 11.5 hours per night.

2.2.2 Each luminaire is expected to have a minimum operational life of 180 months (15 years).

2.3 Each luminaire shall be designed to operate at an average nighttime operating temperature of 70°F.

2.3.1 The operating temperature range shall be -40°F to +130°F.

2.3.2 Each luminaire is expected to operate above 100°F, but not expected to comply with photometric requirements.

2.3.3 Some parameters and tests (such as LM-79 and LM-80) shall be conducted at different ambient temperatures.

2.4 Each luminaire shall meet all parameter of this specification throughout the minimum operational life when operated at the average nighttime operating temperature.

2.5 Each luminaire shall be defined by the application (additional applications may be added as needed)

Application	Typically Replaces
Roadway 1	200 Watt HPS mounted at 34 ft
Roadway 2	310 Watt HPS mounted at 40 ft.
Roadway 3	310 Watt HPS mounted at 40 ft. with house/back side control
Roadway 4	400 Watt HPS mounted at 40 ft.

2.6 The individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.

2.7 Each luminaire shall be listed with Underwriters Laboratory, Inc. under UL 1598 for luminaires in wet locations, or an equivalent standard from a recognized testing laboratory.

3 Technical Requirements

3.1 Electrical

3.1.1 Power Consumption

Maximum power consumption allowed for the luminaire shall be (by application).

Application	Max Wattage
Roadway 1	165
Roadway 2	235
Roadway 3	235
Roadway 4	300

3.1.2 Operation Voltage

3.1.2.1 The luminaire shall operate from a 60 HZ ±3 HZ AC power source. The fluctuations of line voltage shall have no visible effect on the luminous output.

3.1.2.2 The operating voltage may range from 120 VAC to 480 VAC. The luminaire may operate over the entire voltage range or the voltage range may be selected from the two following options.

3.1.2.3 The luminaire shall operate over a minimum voltage range of 95 VAC to 277 VAC. The typical operating voltages for this option are 120 VAC, 240 VAC.

3.1.2.4 The luminaire shall operate over a minimum voltage range of 347 VAC to 480 VAC. The typical operating voltage for this option is 480 VAC.

3.1.3 Power Factor

The luminaire shall have a power factor of 0.90 or greater.

3.1.4 THD

Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20 percent.

3.1.5 Surge Suppression

The luminaire on-board circuitry shall include surge protection devices (SPD) to withstand high repetition noise transients as a result of utility line switching, nearby lightning strikes, and other interference.

3.1.5.1 The SPD shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41.2 (Tables 1 and 4) for Location Category C-High.

3.1.5.2 SPD shall conform to UL 1449, or UL 1283, depending of the components used in the design.

3.1.5.3 SPD performance shall be tested per the procedures in ANSI/IEEE C62.45 based on ANSI/IEEE C62.41.2 definitions for standard and optional waveforms for Location Category C-High.

3.1.6 Operational Performance

The LED circuitry shall prevent perceptible flicker to the unaided eye over the voltage range specified above.

3.1.7 Compatibility

The luminaire shall be operationally compatible with currently used lighting

control systems and photoelectric controls as detail in Standard Specification 86-6.07 (2006 Version).

3.1.8 RF Interference

The luminaires and associated on-board circuitry shall meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.

3.2 Photometric Requirements

3.2.1 Illuminance

3.2.1.1 The minimum maintained illuminance shall be as required in the table below, and be measured as a point.

Application	Mounting Height (ft)	Minimum Maintained Illuminance (fc)	Light Pattern Figure (isofootcandle curve)
Roadway 1	34	0.15	1
Roadway 2	40	0.2	1
Roadway 3	40	0.2	2
Roadway 4	40	0.2	3

3.2.1.2 The L70 of the luminaire shall be at least the minimum number of hours as specified in Section 2.2 or greater.

3.2.1.3 The measurements shall be calibrated to standard photopic calibrations.

3.2.2 Light Color/Quality.

3.2.2.1 The luminaire shall have a correlated color temperature (CCT) range of 3,500K to 6,500K.

3.2.2.2 The color rendition index (CRI) shall be 65 or greater.

3.2.3 Cut-Off Requirements

3.2.3.1 The luminaire shall not allow more than 10 percent of the rated lumens to project above 80 degrees from vertical.

3.2.3.2 The luminaire shall not allow more than 2.5 percent of the rated lumens to project above 90 degrees from vertical.

3.3 Thermal Management

3.3.1 The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to assure proper operation of the luminaire over the minimum operational life (section 2.2).

3.3.1.1 The LED manufacturer's maximum junction temperature for the minimum operational life (Section 2.2) shall not be exceeded.

3.3.1.2 The designed maximum junction temperature shall not exceed 221°F (105°C)

3.3.1.3 The junction-to-ambient thermal resistance shall be 58°F/Watt or less.

3.3.2 Thermal management shall be passive by design.

3.3.2.1 The use of fans or other mechanical devices shall not be allowed.

3.3.2.2 The heat sink material shall be aluminum or other material of equal or lower thermal resistance.

3.3.3 The luminaire may contain circuitry that will automatically reduce the power to the LEDs to a level that will insure that the maximum junction temperature is not exceeded, when the ambient, outside air temperature is 100°F or greater.

3.4 Physical and Mechanical Requirements

3.4.1 The luminaire shall be a single, self-contained device, not requiring on-site assembly for installation. The power supply for the luminaire shall be integral to the unit.

3.4.2 The maximum weight of the luminaire shall be 35 lbs.

3.4.3 The maximum effective projected area (when viewed from either side or either end) shall be 1.4 sq ft.

3.4.4 The housing shall be a light to medium gray color within the Federal Standard 595B ranges of 26250 to 26500 for semi-gloss sheen, or 36250 to 36500 for flat sheen.

3.4.5 Each housing shall be provided with a slip-fitter capable of mounting on a 2 inch pipe tenon.

3.4.5.1 This slip-fitter shall fit on mast-arms from 1-5/8 to 2-3/8 in (O.D.)

3.4.5.2 The slip-fitter shall be capable of being adjusted a minimum of ±5 degrees from the axis of the tenon in a minimum of five steps (+5, +2.5, 0, -2.5, -5).

3.4.5.3 The clamping brackets of the slip-fitter shall not bottom out on the housing bosses when adjusted within the designed angular range.

3.4.5.4 No part of the slip-fitter mounting brackets on the luminaires shall develop a permanent set in excess of 1/32 in. when the two or four 3/8 in. diameter cap screws used for mounting are tightened to 10 ft-lb.

3.4.5.5 Two sets of cap screws may be supplied to allow for the slip-fitter to be mounted on any pipe tenon in the acceptable range without the cap screws bottoming out in the threaded holes.

3.4.5.6 The cap screws and the clamping bracket(s) shall be made of corrosion resistant materials and be compatible with the luminaire housing and the mast-arm, or treated to prevent galvanic reactions.

3.4.6 The assembly and manufacturing process for the LED luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration from high winds and other sources.

3.4.7 Luminaires to be mounted on horizontal mast arms, when tested in conformance with California Test 611 (as modified below), shall be capable of withstanding cyclic loading in (G = Acceleration of Gravity):

3.4.7.1 a vertical plane at a minimum peak acceleration level of 3.0 G peak-to-peak sinusoidal loading (same as 1.5 G peak) with the power supply installed, for a minimum of 2 million cycles without failure of any luminaire parts, and

3.4.7.2 a horizontal plane perpendicular to the direction of the mast arm at a minimum peak acceleration level of 1.5 G peak-to-peak sinusoidal loading (same as 0.75-G peak) with the power supply installed, for a minimum of 2 million cycles without failure of any luminaire parts.

3.4.8 The housing shall be designed to prevent the buildup of water on the top of the housing.

3.4.8.1 Exposed heat sink fins shall be oriented so that water can freely run off the luminaire, and carry dust and other accumulated debris away from the unit.

3.4.9 The optical assembly of the luminaire shall be protected against dust and moisture intrusion per the requirements of IP-66 (minimum).

3.4.10 The electronics/power supply enclosure shall be protected per the requirements of IP-43 (minimum).

3.4.11 Each luminaire shall be furnished with an ANSI C136.10 compliant, locking type, photocontrolreceptacle. A rain tight shorting cap must be provided and installed. The receptacle must conform to the requirements of Standard Specification 86-6.07B(1).

3.4.11.1 When available, an ANSI C136.41 compliant, locking type photocontrol receptacle with dimming connections shall be furnished in place of the ANSI C136.10 compliant receptacle.

3.4.12 When the components are mounted on a down opening door, the door shall be hinged and secured to the luminaire housing separately from the refractor or lens frame. The door shall be secured to the housing in a manner to prevent its accidental opening. A safety cable shall mechanically connect the door to the housing.

3.4.13 Field wires connected to the luminaire shall terminate on a barrier type terminal block secured to the housing. The terminal screws shall be captive and equipped with wire grips for conductors up to No. 6. Each terminal position shall be clearly identified.

3.4.14 The power supply shall be contained inside the luminaire.

3.4.14.1 The power supply shall be rated for outdoor operation. The power supply must have a minimum IP rating of IP65.

3.4.14.2 The power supply shall be rated for a minimum life expectancy equal to or greater than the minimum operation life (Section 2.2) of the luminaire.

3.4.14.3 The power supply case temperature shall have a self rise of 45° F or less above ambient temperature in free air with no additional heat sinks.

3.4.14.4 The power supply shall have two leads to accept standard 0-10V Dimming control. (compatible with IEC 60929 Annex E)

3.4.14.5 If the control leads are open or the analog control signal is lost, the driver will default to 100% power.

3.5 Materials

3.5.1 Housings shall be fabricated from materials that are designed to withstand a 3000-hour salt spray test as specified in ASTM Designation: B117.

3.5.2 Each refractor or lens shall be made from UV inhibited high impact plastic (such as acrylic or polycarbonate) or heat and impact resistant glass, and be resistant to scratching.

3.5.3 All aluminum used in housings and brackets shall be a marine grade alloy with less than 0.2% copper. All exposed aluminum shall be anodized.

3.5.4 Polymeric materials (if used) of enclosures containing either the power supply or electronic components of the luminaire shall be made of UL94VO flame retardant materials. The len(s) of the luminaire are excluded from this requirement.

3.5.5 Paint or powder coating of the housing shall conform to the requirements of the Caltrans Standard Specifications and the Caltrans Standard Special Provisions.

3.6 Luminaire Identification

3.6.1 Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked inside the each unit and the outside of each packaging box.

3.6.2 The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in Watts and Volt-Ampere.

4 Quality Assurance

4.1 The luminaires shall be manufactured in accordance with a manufacturer quality assurance (QA) program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of the modules built to meet this specification, and a documented process of how problems are to be resolved.

4.2 QA process and test results documentation shall be kept on file for a minimum period of seven years.

4.3 LED luminaire designs not satisfying design qualification testing and the production quality assurance testing performance requirements described below shall not be labeled, advertised, or sold as conforming to this specification.

4.4 Design Qualification Testing

4.4.1 Design Qualification Testing shall be performed by the manufacturer or an independent testing lab hired by the manufacturer on new luminaire designs, and when a major design change has been implemented on an existing design.
A major design change is defined as a design change (electrical or physical) which changes any of the performance characteristics of the luminaire, results in a different circuit configuration for the power supply, or changes the layout of the individual LED's in the module.

4.4.2 A quantity of two units for each design shall be submitted for Design Qualification Testing.

4.4.2.1 Test units shall be submitted to Caltrans after the manufacturer's testing is complete.

4.4.2.2 Manufacturer's testing data shall be submitted with test units for Caltrans verification of Design Qualification Testing data.

4.4.2.3 Product submittals shall be accompanied by product specification sheets or other documentation that includes the designed parameters as detailed in this specification. These parameters include (but not limited to):

- 4.4.2.3.1 Maximum power in Watts
- 4.4.2.3.2 Maximum Designed Junction Temperature
- 4.4.2.3.3 Heat sink area in square inches.
- 4.4.2.3.4 Designed junction to ambient thermal resistance calculation with thermal resistance components clearly defined.
- 4.4.2.3.5 L70 in hours, when extrapolated for the average nighttime operating temperature (section 2.3)

4.4.2.4 Product submittals shall be accompanied by IES LM-79 and IES LM-80 compliant test reports from a CALiPER qualified or NVLAP approved testing laboratory for the specific model being submitted.

4.4.2.5 Product submittals shall be accompanied by a IES LM63 compliant photometric file (IES) based on the LM-79 test report.

4.4.2.6 Product submittals shall be accompanied by initial and depreciated isofootcandle charts showing the specified minimum illuminance curve for that particular application.

- 4.4.2.6.1 The charts shall be calibrated to feet and show a 40 by 40 foot grid.
- 4.4.2.6.2 The charts shall be calibrated to the mounting height specified for that particular application.
- 4.4.2.6.3 The depreciated isofootcandle curve shall be calculated at the minimum operational life.

4.4.2.7 Product submittals shall be accompanied by a test report showing SPD performance as tested per the definitions and procedures in ANSI/IEEE C62.41.2 and ANSI/IEEE C62.45.

4.4.2.8 Product submittals shall be accompanied by a test report detailing the results of California Test 611 (or equal), the mechanical vibration requirements.

4.4.2.9 One test unit shall be fitted with temperature sensors

- 4.4.2.9.1 Temperature sensors shall be thermistor or thermocouple type
- 4.4.2.9.2 Thermocouples will be either Type K or Type C.
- 4.4.2.9.3 Thermistors shall be negative temperature coefficient (NTC) type with a nominal resistance of 20k ohm.
- 4.4.2.9.4 Temperature sensors shall be mounted on the LED solder pads as close to the LED as possible.
- 4.4.2.9.5 One temperature sensor shall be mounted on the power supply (driver) case.
- 4.4.2.9.6 Light bar or modular systems shall have one sensor for each module, mounted as close to the center of the module.
- 4.4.2.9.7 Other configurations shall have at least 5 sensors per luminaire. (Contact Caltrans for advice on sensor location.)
- 4.4.2.9.8 The appropriate thermocouple wire shall be used. The leads shall be a minimum of 6 ft.
- 4.4.2.9.9 Documentation shall accompany the test unit that details the type of sensor used.

4.4.3 Burn In.

The sample luminaires shall be energized for a minimum of 24 hours, at 100

percent on-time duty cycle, at a temperature of +70°F (+21°C) before performing any design qualification testing.

4.4.4 Any failure of the luminaire, which renders the unit non-compliant with the specification after burn-in, shall be cause for rejection.

4.4.5 The luminaire shall be tested according to California Test No. 678, and as described herein.

4.4.5.1 Luminaire performance shall be judged against the specified minimum illuminance in the specified pattern for a particular application.

4.4.5.2 The luminaire lighting performance shall be adjusted (depreciated) for the minimum life expectancy (Section 2.2).

4.4.5.2.1 The performance shall be adjusted (depreciated) by using the LED manufacturer's data or the data from the LM-80 test report, which ever one results in a higher level of lumen depreciation.

4.5 Caltrans Quality Assurance Testing (random sample testing)

4.5.1.1 Caltrans may perform random sample testing on all shipments.

4.5.1.2 Testing shall be completed within than 30 days after delivery to the Transportation Laboratory.

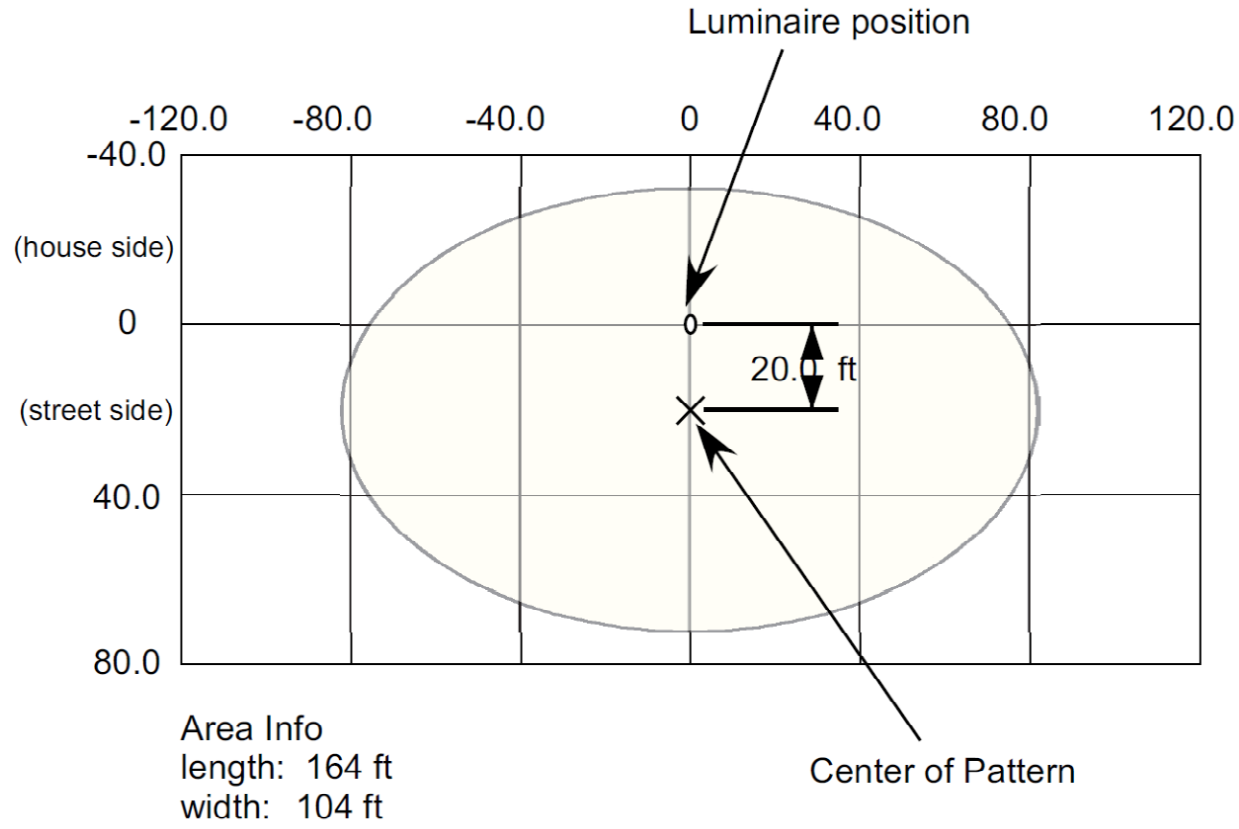
4.5.1.3 Luminaires shall be tested according to California Test No. 678, and as described herein.

4.5.1.4 All parameters of the specification may be tested on the shipment sample.

5 Warranty

The manufacturer shall provide a warranty against loss of performance and defects in materials and workmanship for the luminaires for a period of 84 months after acceptance of the luminaires. Replacement luminaires shall be provided promptly after receipt of luminaires that have failed at no cost to the State. All warranty documentation shall be given to the Translab prior to random sample testing.

Figure 1

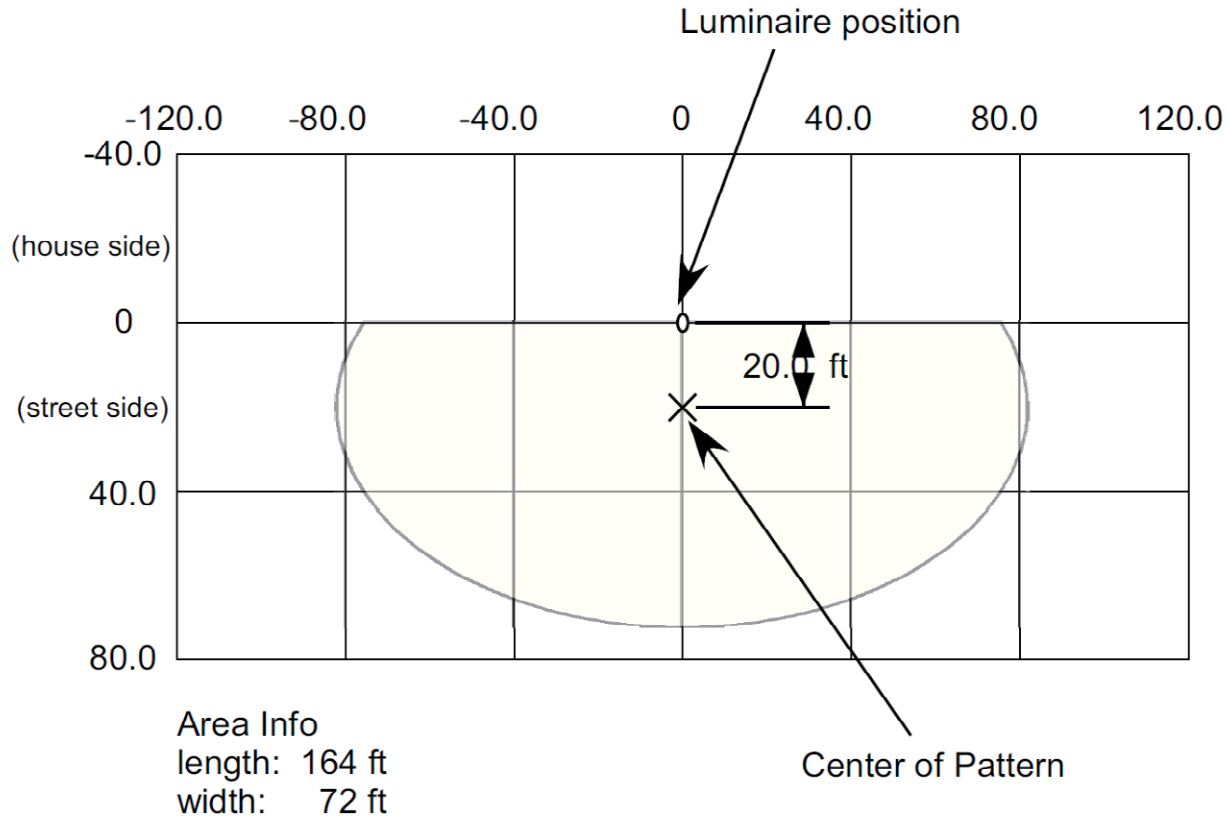


Pattern defined by ellipse with equation:

$$\frac{x^2}{(82)^2} + \frac{(y-20)^2}{(52)^2} = 1$$

x direction is longitudinal to the roadway,
y direction is transverse to roadway,
luminaire is offset from center of pattern by 20 feet to the "house side" of pattern.

Figure 2



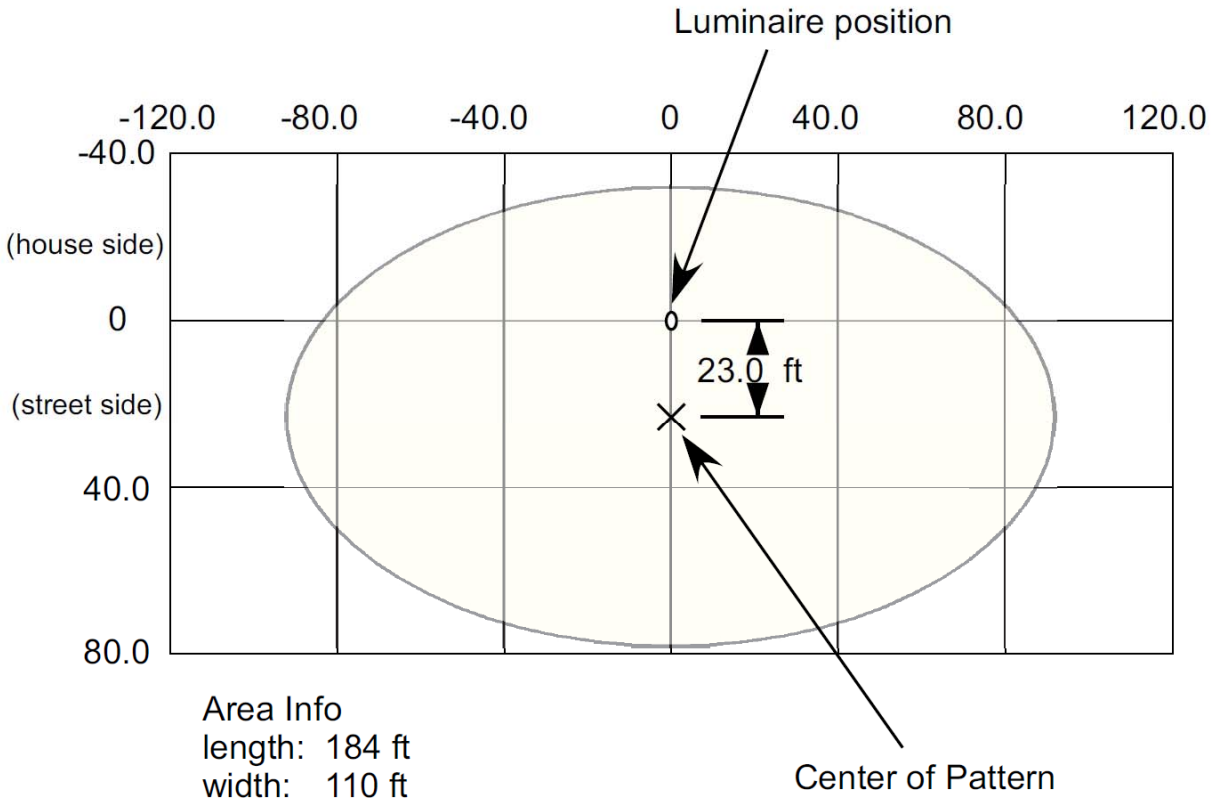
Pattern defined by ellipse with equation:

$$\frac{x^2}{(82)^2} + \frac{(y-20)^2}{(52)^2} = 1$$

for y ≥ 0 (street side only)

x direction is longitudinal to the roadway,
y direction is transverse to roadway,
luminaire is offset from center of pattern by 20 feet to the "house side" of pattern.

Figure 3



Pattern defined by ellipse with equation:

$$\frac{x^2}{(92)^2} + \frac{(y-23)^2}{(55)^2} = 1$$

x direction is longitudinal to the roadway,
y direction is transverse to roadway,
luminaire is offset from center of pattern by 23 feet to the "house side" of pattern.