



**INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS**

**PROCEDURE FOR EVALUATION AND APPROVAL
LIST REQUIREMENTS FOR SOLID STATE
BALLASTED LUMINAIRES
ITM No. 957-23**

1.0 SCOPE

- 1.1** This procedure establishes the method that a luminaire utilizing solid state technology for the control of current is evaluated and is placed, maintained, or removed from the approval list.
- 1.2** Luminaires submitted for evaluation will be considered for approval under one or more of the following sub-lists: High Mast, High Lumen Roadway, Low Lumen Roadway, Roadway and Underpass.
- 1.3** This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES

2.1 ANSI Standards

C136 Series	Standards for Roadway and Area Lighting Equipment
C62.41.2	Practice on Characterization of Surges in Low-voltage (1000 V and Less) AC Power Circuits
C78.377	Specifications for the Chromaticity of Solid-state Lighting Products C82.77 Harmonic Emission Limits-Related Power Quality Requirements for Lighting Equipment
1449	Safety, Transient Voltage Surge Suppressors, Third Edition (ANSI/UL)
1598	Luminaires (ANSI/UL)
8750	Light Emitting Diode (LED) Equipment for Use in Lighting Products (ANSI/UL)
60529	Degrees of Protection Provided by Enclosures (IP Code)

2.2 IES Standards

RP-8-14	Recommended Practice for Roadway Lighting
LM-79-08	Electrical and Photometric Measurements of Solid State Lighting Products
LM-80-15	Measuring Lumen Maintenance of LED Light Sources

- TM-15-11 Luminaire Classification System for Outdoor Luminaires
- TM-21-11 Projecting Long-Term Lumen Maintenance of LED Light Sources

2.3 INDOT Standards

INDOT Standard Specifications, Sections 807 & 920
Indiana Design Manual, Chapter 502-4

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with Indiana Design Manual as well as ANSI/IESNA RP-8-14, American National Standard Practice for Roadway Lighting.

3.1 High Lumen Roadway Luminaires. Models which are a suitable and cost effective alternative to a 400 watt High Pressure Sodium luminaire. These provide adequate light output so that INDOT design light levels are met in a system utilizing 40 ft mounting heights while operating at no more than 250 watts of power. They are capable of IESNA Type II and Type III light distributions.

3.2 High Mast Luminaires. Models which are a suitable and cost effective alternative to a 1000 watt High Pressure Sodium luminaire. These provide adequate light output so that INDOT design light levels are met in a system consisting of towers with mounting heights as great as 200 ft (typically 125 ft to 150 ft) while operating at no more than ~~600~~ 750 watts of power. They are capable of both symmetric and asymmetric light distributions, though models providing only symmetric distribution patterns may be allowed in applications where symmetric distribution patterns are acceptable.

3.3 Low Lumen Roadway Luminaires. Models which are a suitable and cost effective alternative to a 250 watt High Pressure Sodium luminaire. These provide adequate light output so that INDOT design light levels are met in a system utilizing 25, 30, 35, or 40 ft mounting heights while operating at no more than 150 watts of power. They are capable of IESNA Type II and Type III light distributions.

3.4 Underpass Luminaires. Models which are a suitable and cost effective alternative to a 150 watt High Pressure Sodium luminaire. These provide adequate light output so that AASHTO recommended light levels are met at the same or lower operating power.

4.0 SIGNIFICANCE AND USE. This ITM is used to evaluate, approve, maintain approval, and remove luminaires which are placed on the Department List of Luminaires. Each luminaire model will be evaluated separately.

5.0 SAMPLING.

- 5.1** High Mast Luminaires. Upon review and acceptance of the documentation required in Section 6.2 the manufacturer shall furnish, at no cost to the Department, 7 randomly selected production-run luminaires of each model to be evaluated for a test period of at least 3 months. The manufacturer shall deliver 6 of the luminaires to the location (typically INDOT district or sub-district) determined by the Department and one to the Purdue Energy Efficiency & Reliability Center, Schneider Ave Building, 2200 169th St, Hammond, IN 46323; attention: Dr. Robert Kramer (219-989-2147).
- 5.2** Roadway and Underpass Luminaires. Upon review and acceptance of the documentation required in Section 6.2 the manufacturer shall furnish, at no cost to the Department, 4 randomly selected production-run luminaires of each model to be evaluated for a test period of at least 3 months. The manufacturer shall deliver 3 of the luminaires to the location determined by the Department and one to the Purdue Energy Efficiency and Reliability Center.

6.0 SUBMITTAL

- 6.1** The manufacturer shall submit the Preliminary Product Evaluation Form for each model of luminaire to be considered for the Qualified Products List.
- 6.2** The following documentation regarding the proposed luminaire shall be submitted with the Evaluation Form. Certifications and test reports shall be provided by a laboratory that is either listed as a National Recognized Testing Laboratory or accredited by the National Voluntary Laboratory Accreditation Program (NVLAP).
- 6.2.1** Luminaire specifications and data sheets;
 - 6.2.2** Test report verifying UL 1598 compliance;
 - 6.2.3** Test report indicating compliance with ANSI C 136.31 2G or 3G requirements;
 - 6.2.4** Test reports in accordance with ANSI/IEC 60529 indicating the IP ratings for the optical assembly, power drivers, and surge protection devices;
 - 6.2.5** IESNA LM-79 test report;
 - 6.2.6** Test report indicating surge protection device survival in accordance with ANSI/IEEE C62.41.2;
 - 6.2.7** UL 1449 certification;
 - 6.2.8** Test report indicating Title 47 CFR Part 15, Class A compliance;

- 6.2.9 Power driver specifications and data sheets
- 6.2.10 Test reports in accordance with ANSI C82.77 for electronic power drivers indicating the total harmonic distortion and power factor
- 6.2.11 Mean time to failure prediction for the power driver in accordance with Telcordia SR 332, issue 3 or MIL-HDBK-217F;
- 6.2.12 Power driver lifetime report including curves showing predicted life time as a function of temperature and the associated test conditions used to obtain the data for these curves. The statistical range of predicted values for driver lifetime should be indicated as well as the basis for these calculations. Information and test details regarding the influence of power quality and specifically electrical transients on driver life time should also be included.
- 6.2.13 IESNA LM-80 test report if the proposed light source is LED;
- 6.2.14 IESNA TM-21 test report indicating the maximum LED junction temperature if the proposed light source is LED.
- 6.2.15 IESNA photometric distribution file in either Visual, developed by Acuity Brands Lighting, or AGi32 from Lighting Analysis, Inc. for the applicable distribution types (see section 7.2). The file shall be based on absolute (not relative) IES data (.ies extension).
- 6.2.16 For underpass luminaires salt spray test report in accordance with ASTM B117, 2000 hour time horizon.
- 6.2.17 Warranty documents.

The requestor is encouraged to submit any supporting documents and references as to the manufacturer's experience and performance history. This documentation should indicate experience in providing luminaires for public agency projects, show ability to honor warranties, and attest to long term stability of the manufacturer.

7.0 **EVALUATION.** The evaluation will consist of three steps: the first is a review of the required documentation, then simultaneously a physical inspection/lab testing and a field test of the model. The Department may waive the field test step if the model has already been satisfactorily demonstrated by the department.

7.1 **Submittal Documentation Review.** The documentation provided with the Evaluation Form will be reviewed by the Office of Traffic Administration and the Traffic Design Office for completeness and to determine that the required reports and certifications demonstrate the model meets or exceeds the requirements set

forth in INDOT's Standard Specifications. This review will verify the following for all light source types:

- 7.1.1** The photometric adequacy of the luminaire by applying the photometric file to a typical system(s). The photometric analysis must show that the applicable INDOT design levels for average maintained illumination and uniformity ratio (average to minimum illumination levels) are met.
- 7.1.2** The manufacturer's warranty is in compliance with section 8.0. The manufacturer's long term stability and ability to meet warranty requirements will also be considered.
- 7.1.3** BUG ratings as defined by I.E.S.N.A. should also be provided. The upright rating should be 0 and while INDOT has no specific requirements for backlight and glare ratings all three ratings may be considered when comparing models that otherwise perform equally- lower ratings being more desirable.
- 7.1.4** Luminaire will operate in temperatures from -40°F to +120°F.
- 7.1.5** Luminaire will operate with input voltage variations of ±10%.
- 7.1.6** Operating life is at least 50,000 hrs.
- 7.1.7** The Mean Time to Failure of the power driver is 1,000,000 hours or greater.
- 7.1.8** Luminaire Power Factor is 0.90 or greater.
- 7.1.9** Total harmonic distortion does not exceed 20%.
- 7.1.10** The Correlated Color Temperature is between 3500°K and 4500°K.
- 7.1.11** The Color Rendering Index is 70 or greater.
- 7.1.12** Housing is precision cast aluminum.
- 7.1.13** Gasketing is provided to protect the optical assembly at a rating IP 66 or higher.
- 7.1.14** Ingress protection rating of the power driver(s) and surge protection is IP 65 or higher.
- 7.1.15** The refractor or lens is of high impact, heat resistant, prismatic glass or UV inhibited, high impact plastic

7.1.15 Reflectors are specular aluminum

7.1.16 A three position terminal block shall be provided for power wiring. The contacts shall accommodate #14 - #6 AWG stranded or solid, copper or aluminum conductors.

7.1.17 Housing is grounded

For models utilizing LED light sources

7.1.18 LED light packages provide at least 85% of the initial lumens at 50,000 hours at 130°F.

For Light emitting plasma models:

7.1.19 The plasma emitter provides at least 70% of its initial lumens at 50,000 hours at 130°F

For metal halide models:

7.1.20 Metal Halide luminaires utilize a power driver

7.1.21 external capacitors and ignitors are not used

7.2 Physical Inspection/Laboratory Testing. Once all the required documentation is reviewed and found to be acceptable the following will be verified by INDOT or the Purdue Energy Efficiency and Reliability Center:

7.2.1 The unit requires no assembly, it is single and self-contained.

7.2.2 A four bolt slip-fitter is provided that is capable of mounting to a 2 inch mounting bracket with adjustments $\pm 5^\circ$ from level.

7.2.3 Housing is aluminum and is powder coat finished in light gray.

7.2.4 The weight of luminaire is no more than 66 lbs for high mast luminaires, 53 lbs for roadway luminaires and 23 lbs for underpass models.

7.2.5 The effective projected area is no more than 2.4 sq. ft. for high mast and for roadway luminaires

7.2.6 External and internal labels in accordance with ANSI C136.15 and ANSI C136.22 respectively are provided. The external sticker also provides the following information: light source type, manufacturer, model, wattage, date of manufacture, and warranty period

- 7.2.7** Fans or other mechanical cooling systems are not used for thermal management.
- 7.2.8** Access (door) to optical and electrical components is provided. Hinges and latches are made of stainless steel and remain closed during the operation. Latches are positive and on the street side.
- 7.2.9** Connectors are crimp type.
- 7.2.10** A three position terminal block shall be provided for power wiring. The contacts shall accommodate #14 - #6 AWG stranded or solid, copper or aluminum conductors.
- 7.2.11** The luminaire has a seven wire photocontrol receptacle in accordance with ANSI C136.41 for future installation of adaptive lighting control. A shorting cap shall be provided for the receptacle.
- 7.2.12** Power driver, LED arrays, surge protection and other primary components are as shown in documentation. A surge protection device external to the power driver is provided and contained within the luminaire housing.
- 7.2.13** Power driver operation is consistent and temperature is adequately controlled while performing within the luminaire.
- 7.2.14** The construction of the luminaire and arrangement of components do not hinder heat dissipation from the light source. Internal electronics shall be pre-wired and positioned for optimal heat dissipation through the housing heat sink. Temperatures at various points/components of the luminaire will be measured to check for even heat flow/points of heat build-up.
- 7.2.15** Loss of an LED does not result in loss of the entire luminaire or in flickering as perceived by the unaided eye. Loss of an LED does not increase operating temperature or reduce service life.
- 7.2.16** The unit meets spectral and power quality requirements as specified by INDOT and consistent with applicable industry standards.
- 7.2.17** An internal bubble level that is readily viewable is included to assist in alignment during installation.
- 7.3 Field Test.** Unless waived by the Department, a field test will be conducted on existing lighting poles/high mast towers in order to verify:
- Light Output
 - Chromaticity

- Power Consumption
- Power Quality
- Ease of Installation
- Reliability

Roadway luminaire units will be tested at the Indianapolis Subdistrict test bed. Underpass luminaires will be tested at the rear drive of INDOT's Research and Development Division building in West Lafayette. High Mast luminaires will be tested on an existing tower at one of the rest areas in the Greenfield district.

The testing period shall last at least 3 months or as determined by INDOT. The method for in-service illuminance performance will conform to the procedure below:

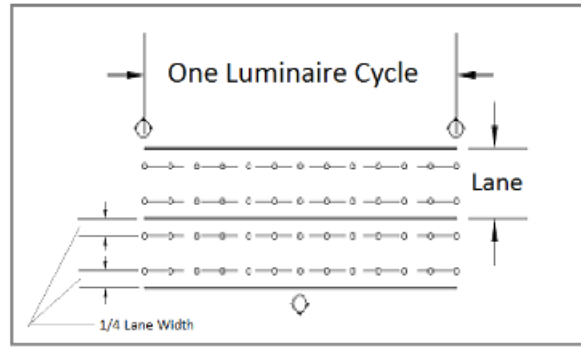
7.3.1 Light Output Measurement Procedure:

7.3.1.1 An illuminance or chroma meter will be used to obtain readings two times- the first proximate to the time of activation and the second towards the end of the test period.

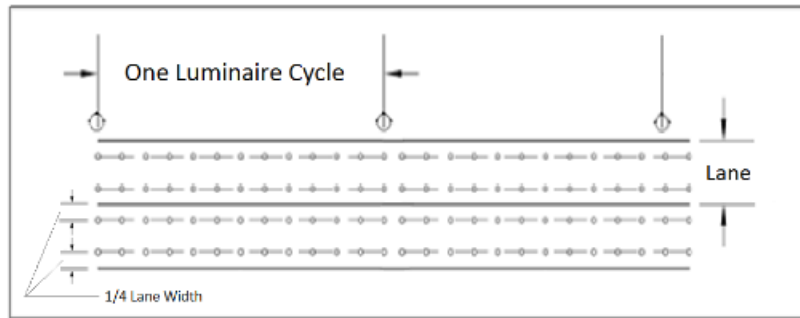
7.3.1.2 Measurement Locations:

a. Roadway and Underpass Luminaires:

- i. For staggered pole placements one luminaire cycle (3 Light Poles) will be tested and cover the distance of two adjacent poles.
- ii. For one sided pole placements two luminaire cycles (2 poles) will be tested and cover the distance between the two poles.
- iii. If the distance between two adjacent luminaires is large, the luminaire cycle will begin from the selected pole to its two sides at a distance where rapid changing illuminance readings are found.
- iv. Test points on straight roadway areas shall be determined as in the figure below. Test points shall be at the quarter-lane lines. From the selected pole, test points shall be marked and measured at a space no more than 16 ft.
- v. Determination of test points on junctions shall meet the criteria on straight roadway areas.
- vi. Once the illuminance data is collected for the test area, the maximum illuminance, average illuminance, minimum illuminance, and uniformity ratio will be determined and compared to the illuminance design criteria provided in Figure 502-4E of the Indiana Design Manual.



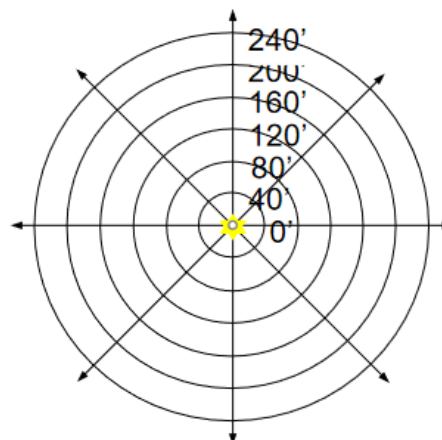
Staggered Pole Placement



One-Sided Pole Placement

b. High Mast Luminaires:

- i. For high mast luminaires one tower (100' or 125') with 4 or 6 luminaires will be tested for both symmetric and asymmetric patterns unless the requestor indicates that the model is for symmetric use only. Luminaire aiming capabilities at 360 degree angles.
- ii. Test points along 8 lines at 45° angles radiating from the tower will be determined as in the figure below. Test points shall be marked and measured at a space of 40 ft or as site conditions allow.



- iii. Determination of test points on junctions shall meet the criteria at an interchanges
- iv. Once the illuminance data is collected for the test area, the maximum illuminance, average illuminance, minimum illuminance, and uniformity ratio will be determined and compared to the illuminance design criteria provided in Figure 502-4E of the Indiana Design Manual.

7.3.2 Chromaticity Verification

7.3.2.1 An illuminance spectrophotometer or chroma meter will be used to obtain Color Temperature readings two times: the first proximate to the time of activation and the second towards the end of the test period.

7.3.2.2 Correlated Color Temperature readings will be taken at three locations for each luminaire and will be noted. For roadway and underpass the reading will be taken proximate to the luminaire and at the midpoints of the cycle. The readings towards the end of the test period will be taken at the same locations.

7.3.2.3 All values taken must be within the range specified in 7.1.9.

7.3.3 Power Consumption Check

7.3.3.1 A power meter or an ammeter will be used to measure current draw of each luminaire provided two times: the first, proximate to the time of activation, and the second towards the end of the test period.

7.3.3.2 Measured current will be converted to power by the following relationship:
Power (wattage) = Current Drawn (amps) x Electric Potential (voltage) x Power Factor

7.3.3.3 This calculated power will be compared to the documentation submitted. A value greater than the limit indicated in Section 1.2 will be grounds for rejection. A value that is significantly greater than that indicated by the submittal documentation may also be cause for rejection.

7.3.4 Power Quality. The power quality measurements will include consideration of voltage, current, power, wave form shape and distortion, flicker, harmonics, current and voltage transients, and variation of parameters over time. Power quality measurements, including total harmonic distortion, will be made with a Dranetz PowerXplorer PX5 meter. Data is further analyzed using the Dran-View

6 computer program. Measurements will be taken of the entire harmonic spectrum available from the instrument.

7.3.5 Ease of Installation. District personal that install will be asked if they had any problems with the installation and how the process compared to installing a traditional HPS luminaire.

7.3.6 Reliability. During the test period any performance issues will be noted. Luminaire failure, light source flickering, loss of light output, or color degradation will be cause for rejection.

8.0 WARRANTY. In accordance with INDOT Specifications, a non-prorated manufacturer's written warranty against loss of performance and defects in materials and workmanship for a period of ten years from date of shipping shall be provided covering all components of the luminaire including ballast, driver, and light source. The criteria defining the loss of performance includes more than 10% of the total number of original individual LEDs fail, LED junction temperature exceeds the specification limit under any circumstance, the luminaire is operating below the lumen maintenance curve, and the color temperature shifts more than 500K outside of the specified color temperature range. Warranty documents shall provide the manufacturer's name, contact person, telephone phone number, and email address. Warranty documents shall provide the estimated life cycle of the lamps, LEDs, or Plasma emitter, and power driver.

9.0 APPROVAL LIST

9.1 The luminaire unit(s) may be placed on the approval list when the following conditions are met:

- a) A potential net benefit to the Department is realized by inclusion of the item on the list.
- b) The physical review/lab test and field testing are completed with satisfactory results.
- c) The required documentation is submitted.
- d) Only minimal maintenance operations were necessary during the field testing.

9.2 The Indiana Department of Transportation reserves the right to perform random sample testing on all shipments at its own cost. Random sample testing will be completed as soon as possible after delivery. INDOT shall determine the sampling parameters to be used for random testing. If the units tested fail random testing the units will be removed from the INDOT product list for Solid State luminaires.

9.3 The Department reserves the right to remove models from the Qualified Products List as better performing models are submitted as determined by the procedure detailed in Section 7.0.

- 9.4** The Department may choose to limit the number of models on any of the sub lists to facilitate maintenance.