

# WSDOT Photometric Evaluation Criteria for Light Emitting Diode (LED) Roadway Luminaires

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## 1. Introduction

To ensure interchangeability between High Pressure Sodium (HPS) and Light Emitting Diode (LED) luminaires, and between future iterations of LED luminaires, the Washington State Department of Transportation (WSDOT) classifies LED luminaires based on their equivalency to a standard HPS wattage luminaire. WSDOT uses AGI32 software to conduct these evaluations.

*The current version of this document, and sample grids for any types and classes of luminaires listed in this document, are available from the WSDOT Approved LED Luminaires for Roadway Lighting web page, at <https://www.wsdot.wa.gov/Design/Traffic/ledluminaires.htm>. Contact information is provided at the bottom of the web page.*

## 2. Basic Luminaire Specifications

WSDOT has established maximum acceptable power limits (in Watts) for each type and class of luminaire. These power limits are listed in WSDOT Standard Specification 9-29.10(1)B, and are reproduced here in Table 2-1 Below.

**Table 2-1; Operational Power Limits for LED Luminaires**

Type	Class	Power Limit (W)	Power Reduction
Cobra-Head	200W	115	54%
Cobra-Head	250W	145	54%
Cobra-Head	310W	180	53%
Cobra-Head	400W	270	44%
Wall	70W	50	48%
Wall	100W	75	41%
Wall	150W	105	44%

Luminaires with power use greater than these limits will not be considered for evaluation. As LED technology continues to improve, these power limits will periodically decrease.

### 2.1 Basic Test Grids

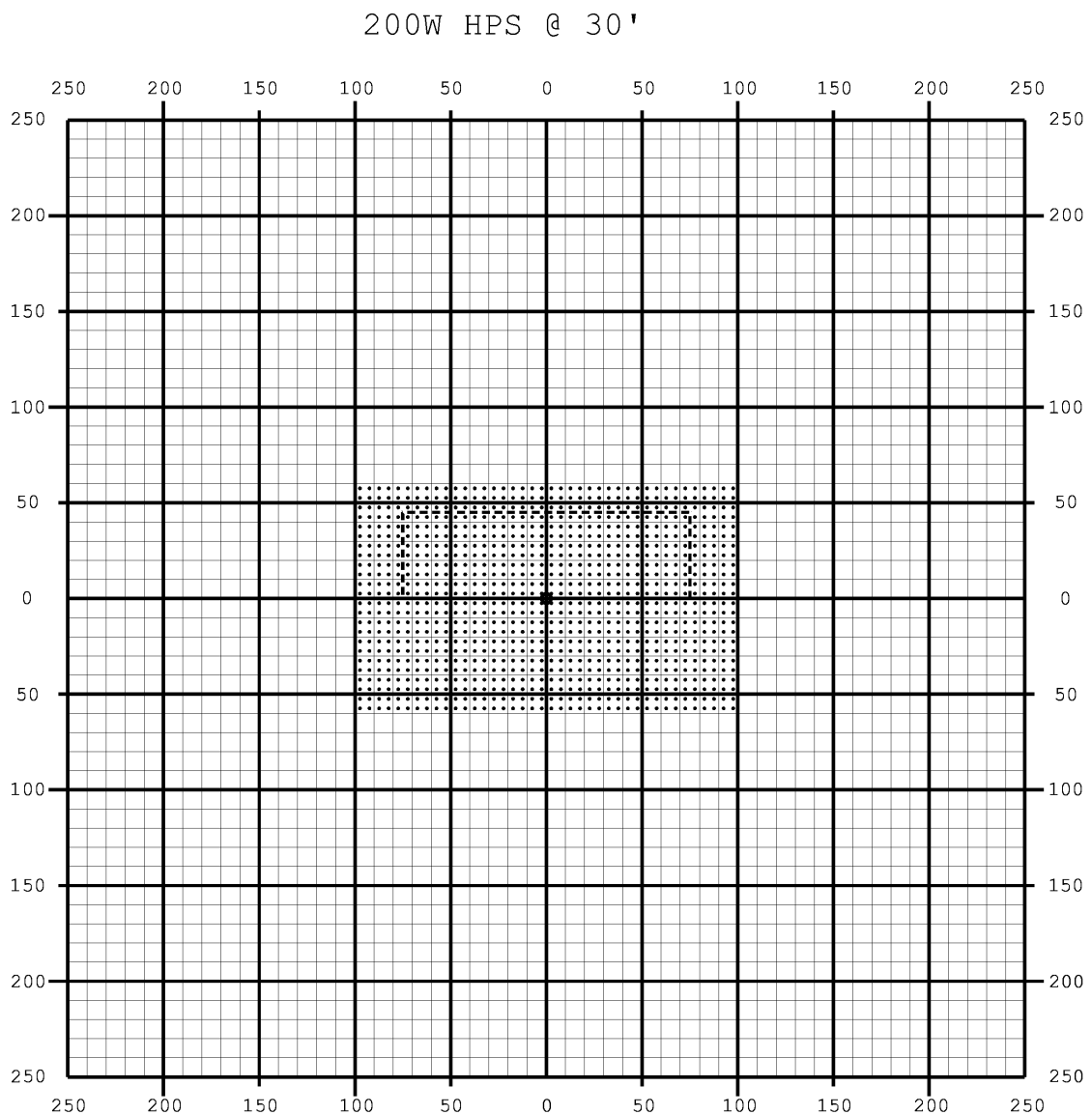
LED luminaires are evaluated using two different types of test grids. The first type is a single unit test grid, where one luminaire is evaluated independently for minimum average output (in foot-candles; fc), minimum output (in fc), and uniformity (as a ratio of average fc to minimum fc).

The second type is a set of roadway grids, which evaluates minimum average output, minimum output, uniformity, and disability glare (ratio of maximum veiling luminance to average luminance).

### 2.1.1 Single Unit Test Grids

Single unit test grids are rectangular, using calculation points at 5 foot by 5 foot spacing. The luminaire being evaluated is centered on one of the long sides of the grid. The size of the grid and the mounting height of the luminaire depend on the type and wattage class of the luminaire being evaluated. These values are provided in the individual sections of this document for each type of luminaire. An example grid for a 200W class cobra-head type luminaire is shown in Exhibit 2-1.

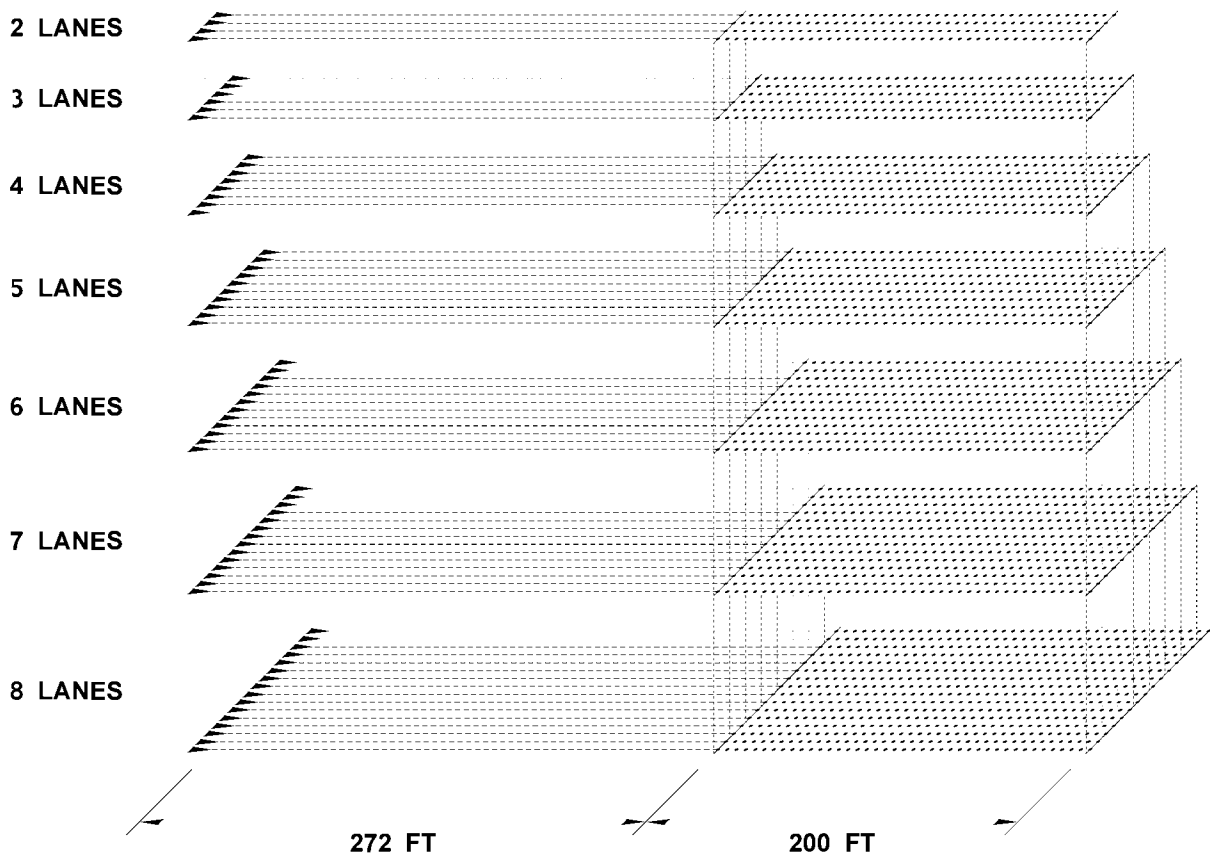
Exhibit 2-1; Example Single Unit Test Grid



## 2.1.2 Roadway Test Grids

Roadway test grids are made up of multiple overlapping roadway grids. To ensure that requirements are met over multiple lane configurations, separate grids are constructed for a certain number of lanes – from two to eight. All grids are set up for left to right traffic, with the lighting arrangement simulating right shoulder installation. Which lane configurations are used depends on the type and wattage class of the luminaire being evaluated. Exhibit 2-2 shows an expanded view of the individual grids; when evaluated, all grids are superimposed at an elevation of 0.00.

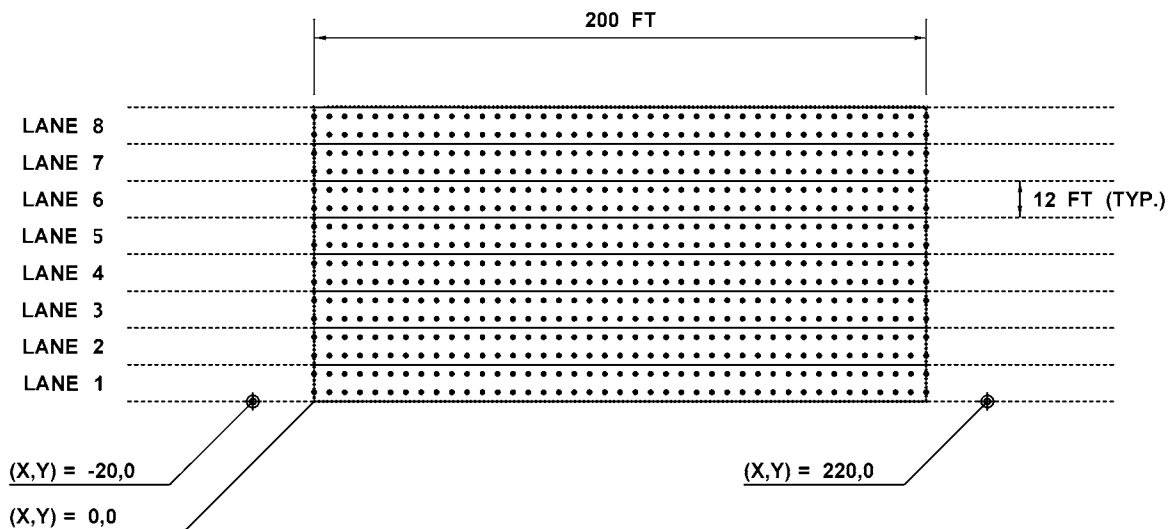
Exhibit 2-2; Roadway Test Grid Array



Each grid is 200 feet long, with the associated 272-foot advance observation area for veiling luminance ( $L_v$ ). The total width of each grid is 12 feet multiplied by the number of lanes (Ex: 4 lanes = 48 feet total width), separated into 12 foot lanes. Calculation points are spaced at 5-foot intervals. Calculations in AGI32 use the IES RP-8-14 Standard, with 5 foot point spacing, and the R2 (Diffuse and Specular) roadway surface R-Table.

Each test uses multiple luminaires so that glare can be illuminated, and the spacing and setback of the luminaires depends on the type and class of luminaire being evaluated. Luminaires are spaced evenly and relative to the center of the grid, along what would be the right side of the roadway. Exhibit 2-3 shows an example of luminaire placement for a 400W class cobra-head type luminaire.

Exhibit 2-3; Luminaire Placement Example – 400W Cobra-Head Type Luminaire



The right side of lane one, at the beginning of the grid, is defined as (X, Y) coordinate 0, 0. In the example shown in Exhibit 2-3, the spacing for a 400W class cobra-head luminaire is 240 feet and a setback of 0 feet, resulting in luminaires centered at -20,0 and 220,0. The mounting height is also dependent on the type and wattage class of the luminaire being evaluated. These values are also provided in the individual sections of this document for each type of luminaire.

### 3. Luminaire Evaluation Criteria

#### 3.1 Cobra-Head Type Luminaires

Cobra-Head Type luminaires are the most common and frequently used type of roadway luminaire. All roadway luminaires are evaluated using a Lamp Lumen Depreciation (LLD) of 0.85 and a Luminaire Dirt Depreciation (LDD) Factor of 0.90, for a total Light Loss Factor (LLF) of 0.765.

##### 3.1.1 Single Unit Test Criteria

All cobra-head type luminaires are evaluated to meet the following basic criteria over the specified test grid area:

1. Average Illuminance: Measured in foot-candles (fc), must be greater than or equal to 0.6 fc.
2. Minimum Illuminance: Measured in fc, must be greater than or equal to 0.2 fc.
3. Uniformity Ratio: Defined as the ratio of the average illuminance to the minimum illuminance, must be less than or equal to 4.0.

The specified test grid and mounting height for each class of cobra-head luminaire is provided in Table 3.1-1.

**Table 3.1-1; Single Unit Test Grid Parameters for Cobra-Head Type Luminaires**

Class	Grid Length (ft)	Grid Width (ft)	Mounting Height (ft)
200W	150	45	30
250W	170	55	40
310W	200	60	40
400W	230	75	50

##### 3.1.2 Roadway Test Criteria

Each roadway test grid array has different criteria for each grid associated with a specific number of lanes. Tables 3.1-2 through 3.1-5 list these criteria for each wattage class of luminaire. The evaluated luminaire must meet or exceed the required values for average and minimum fc, and must not exceed the required values for uniformity and glare.

**Table 3.1-2; Rodway Grid Criteria for 200W Class Cobra-Head Type Luminaires**

Class	Roadway Grid	Average fc	Minimum fc	Uniformity	Glare
200W	2 Lane	0.6	0.2	4	0.3
200W	3 Lane	0.6	0.2	4	0.3
200W	4 Lane	0.6	0.2	4	0.3
200W	5 Lane	0.6	0.1	6.5	0.45

**Table 3.1-3; Rodway Grid Criteria for 250W Class Cobra-Head Type Luminaires**

Class	Roadway Grid	Average fc	Minimum fc	Uniformity	Glare
250W	2 Lane	0.6	0.2	4	0.3
250W	3 Lane	0.6	0.2	4	0.3
250W	4 Lane	0.6	0.2	4	0.3
250W	5 Lane	0.6	0.2	4	0.35
250W	6 Lane	0.5	0.2	4	0.4

**Table 3.1-4; Rodway Grid Criteria for 310W Class Cobra-Head Type Luminaires**

Class	Roadway Grid	Average fc	Minimum fc	Uniformity	Glare
310W	2 Lane	0.6	0.2	4	0.3
310W	3 Lane	0.6	0.2	4	0.3
310W	4 Lane	0.6	0.2	4	0.3
310W	5 Lane	0.6	0.2	4	0.3
310W	6 Lane	0.6	0.2	4	0.4

**Table 3.1-5; Rodway Grid Criteria for 400W Class Cobra-Head Type Luminaires**

Class	Roadway Grid	Average fc	Minimum fc	Uniformity	Glare
400W	2 Lane	0.6	0.2	4	0.3
400W	3 Lane	0.6	0.2	4	0.3
400W	4 Lane	0.6	0.2	4	0.3
400W	5 Lane	0.6	0.2	4	0.3
400W	6 Lane	0.6	0.2	4	0.4
400W	7 Lane	0.6	0.2	4	0.3
400W	8 Lane	0.55	0.1	6	0.4

Cobra-head type luminaires shall be placed using the spacing, mounting heights, and coordinates shown in Table 3.1-6.

**Table 3.1-6; Rodway Grid Parameters for Cobra-Head Type Luminaires**

Class	Mounting Height (ft)	Spacing (ft)	X Position, Luminaire 1	X Position, Luminaire 2
200W	30	180	10	190
250W	40	200	0	200
310W	40	218	-9	209
400W	50	240	-20	220

The Y position for all cobra-head type luminaires is 0 (over the right lane edge line).

## 4. Reporting

Test reports should be provided in the basic format shown in Table 4-1.

**Table 4-1; Sample Test Report Format**

Mfr.	Model	IES Filename	Wattage Class	Actual Watts	Single Avg fc	Single Min fc	Single Unif	2-Lane Avg fc	2-Lane Min fc	2-Lane Unif.	2-Lane LvR
Brand X	XYZ	XYZ_001.ies	200	87	0.68	0.23	3.65	0.84	0.32	2.89	0.28

WSDOT will provide a similar test report, but will also include lines with the criteria and the benchmark luminaire for reference. A sample of this format is provided in Table 4-2.

**Table 4-2; Sample WSDOT Test Report Format**

Mfr.	Model	IES Filename	Wattage Class	Actual Watts	Single Avg fc	Single Min fc	Single Unif	2-Lane Avg fc	2-Lane Min fc	2-Lane Unif.	2-Lane LvR
N/A	Criteria	N/A	200	N/A	0.6	0.2	4	0.6	0.2	4	0.3
Benchmark	HPS	GE451002.ies	200	248	0.75	0.21	3.57	0.97	0.3	3.23	0.26
Brand X	XYZ	XYZ_001.ies	200	87	0.68	0.23	3.65	0.84	0.32	2.89	0.28

Any values that do not meet the criteria limits will be highlighted in red.

## 5. References

The following references are used in the development of this chapter:

[Design Manual](#), M 22-01, WSDOT

[Standard Specifications for Road, Bridge, and Municipal Construction](#) (Standard Specifications), M 41-10, WSDOT

AGi32 Software, a product of Lighting Analysts, Inc.; <https://lightinganalysts.com/>

**NOTE:** WSDOT cannot accept or review AGI files from versions newer than 18.X (any sub-version of 18) at this time, due to back compatibility problems with version 19 and newer.