

**CITY OF BALTIMORE**  
**DEPARTMENT OF TRANSPORTATION**  
**SPECIFICATIONS**  
**FOR**  
**STREET LIGHTING & CONDUIT**

**Street Lighting and Photometric Design Guide**

To be read in conjunction with

**STREET LIGHTING & CONDUIT**  
**MATERIAL SPECIFICATIONS**

Reviewed and Approved by:

Bimal Devkota  
 Bimal Devkota, PE  
 TEC Division Chief  
 6/28/12 Date

Alvaro Lozano 6-15-12  
 Alvaro Lozano, PE  
 Highway Engineer  
 Date

Prepared by:

Micah W. Payne  
 Micah W. Payne  
 Street Lighting Engineer

6-15-12  
 Date

Adopted by:

Khalil A. Zaied  
 Khalil A. Zaied  
 Baltimore City  
 Director Department of Transportation

6/28/20  
 Date



## PREFACE

The City of Baltimore, Department of Transportation Specifications for Street Lighting & Conduit Street Lighting and Photometric Design Guide (henceforth referred to as the “Design Guide”) has been prepared by the Transportation, Engineering and Construction Division in cooperation with the Conduit and Maintenance Divisions of the Department of Transportation. This Design Guide has been coordinated with the 2006 Edition of the City of Baltimore Standard Plans and Specifications for Municipal Construction.

The Design Guide applies whenever any public or private construction is to be performed within the Rights-of-Way of the City of Baltimore including work performed by private parties at their own expense under authority granted by ordinance of the City Council or by permit from the Department of General Services. All matters relating to financing of such work shall be between the permittee and the Contractor, and the City shall not enter into such matters.

Despite considerable efforts to produce 1) a completely error-free document, and 2) a document consistent with our Standard Plans and Specifications some mistakes and inconsistencies seem to defy detection until after publication. If the reader of this Design Guide discovers errors or inconsistencies, please bring them to our attention by contacting the City’s Street Lighting Engineer.

My sincere thanks and appreciation to all the individuals who participated in the effort of producing this Design Guide and to the Department for agreeing to standardize street light illumination.

The hardcopy version of this document is available at the Baltimore City Department of Transportation located at 417 E. Fayette St 7<sup>th</sup> Floor.

This preface is for informational purposes only and is not to be used to interpret or affect the terms of any Contract between the City of Baltimore as the Contracting Agency and the Design Professionals or Contractors.

Micah W. Payne  
Street Lighting Engineer  
Department of Transportation  
Transportation, Construction and Engineering Division

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## 1. Street Lighting Design Requirements

### 1.1 Glossary:

- ANSI/IESNA RP-8-00: Illuminating Engineering Society of North America's American National Standard Practice for Roadway Lighting, issued June 27, 2000 and reaffirmed in 2005
- Luminance Design: A design based on the amount of light which is reflected from a surface and reaches the eye of the observer. It is based on the "light" the observer sees at a given point and is based on the reflectance of the surface and the angle and distance of the observer from the point observed. The International Standard unit of measure for luminance is candela per square meter ( $CD/m^2$ ). See RP-8-00, Annex G, page 57 for further information on luminance.
- Illuminance Design: A design based on the amount of light which is incident on a surface. Illuminance ignores the surface upon which the light falls. The International Standard unit of measure for illuminance is lumen per square meter, or lux ( $lm/m^2$ ). See RP-8-00, Annex G, page 56 for further information on Illuminance.
- Pedestrian Conflict Area Classification: Road classifications describe general conditions of vehicular traffic conflict in urban areas. A second type of conflict is the vehicular/pedestrian interaction. Pedestrian activity is nearly always related to the adjacent land use. There are three levels of pedestrian conflict used by RP-8-00, high, medium and low. For the purposes of this guide, the pedestrian conflict level is assumed to be low or medium (adjacent to schools only) unless otherwise determined by the City Highway Engineer. High Pedestrian Conflict (PC) Areas are areas with significant numbers of pedestrians on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas (Inner Harbor), areas near theatres (Hippodrome), concert halls, stadiums (M&T Bank Stadium and Camden Yards) and transit terminals (Light Rail and subway). Medium PC Areas are areas where fewer pedestrians use the streets at night. Examples are downtown office areas, areas with libraries (Enoch Pratt), apartments, neighborhood shopping and streets with transit lines. Low PC Areas are areas with low volumes of pedestrian traffic at night. Examples are suburban streets, low density developments and rural or semi-rural areas. See RP-8-00, pages 4 & 5 and 9 & 10 for further information of pedestrian conflict classifications.
- Pavement Classifications: Luminance calculations require information about the directional surface reflectance of the pavement. There are four general pavement classifications given in RP-8-00;
- R1: Which is concrete or old asphalt pavement,
- R2: Which is asphalt road surface with a relatively high level of gravel or

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- light colored aggregate,
- R3: Which is asphalt road surface with a normal aggregate mix and normal age and wear – this is the typical road classification for roads and the pavement classification to be used in Baltimore City unless otherwise directed by the City Highway Engineer, and
- R4: Which is asphalt road surface with a very smooth texture.
- Roadway Type: Roadways may fall in any of the following classifications:
- Expressway: A highway for high-speed traffic which has many or most characteristics of a freeway, including limited or no access to adjacent property, some degree of separation of opposing traffic flow, use of grade separated interchanges to some extent, prohibition of some modes of transport such as bicycles and very few or no intersecting cross-streets.
- Arterial: Provides the highest level of service at the greatest speed for the longest uninterrupted distance, with some degree of access control.
- Collector: Provides a less highly developed level of service at a lower speed for shorter distances by collecting traffic from local roads and connecting them with arterials.
- Local: Consists of all roads not defined as arterials or collectors; primarily provides access to land with little or no through movement.
- Uniformity Ratio: The ratio of the average foot-candles of illumination on the pavement area to the foot-candles at the point of minimum illuminance on the pavement. A uniformity ration of 3 to 1 means the average foot-candle value on the pavement is three times the foot-candle value at the point of least illuminance on the pavement.
- Footcandle (fc): The unit of illuminance when the foot is taken as the unit of length. It is the illuminance on a surface one square foot in area on which there is uniformly distributed flux of one lumen, or the illuminance is produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candela.
- Veiling Luminance: A luminance superimposed on the retinal image that reduces its contrast. It is the veiling effect produced by bright sources or areas in the visual field that results in decreased visual performance and visibility
- Light Trespass: Any form of artificial illuminance emanating from a light fixture that falls beyond the property it is intended to illuminate.
- Light Loss Factor: A depreciation factor which is applied to the calculated initial average luminance or illuminance to determine the value of depreciated average luminance or illuminance at a predetermined time in the operating cycle, usually just prior to re-lamping, and which reflect the decrease in effective light output

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of a lamp and luminaire during its life.

**1.2 General:**

Street lighting design in the City of Baltimore shall be generally based on ANSI/IESNA RP-8-00. Modifications to RP-8-00 have been made in certain areas to better conform to the City's requirements. This Design Guide shall be used together with RP-8 (latest revision).

Street lighting design in Baltimore must provide uniform lighting at a level that is adequate and comfortable for vehicular and pedestrian movement on the City's roads, bicycle lanes and sidewalks. All street lighting systems in the City of Baltimore shall be designed by a qualified lighting designer using the illuminance method as described in RP-8-00 (unless noted otherwise), as well as incorporating both the latest revision of City's Specifications for Materials, Highways, Bridges, Utilities and Incidental Structures (Green Book); Book of Standards; and the specifications provided herein. Street lighting design in Baltimore must take into consideration all of the approved luminaires of a given type in order to allow interchangeability of luminaires during maintenance operations.

Cross sections, road layouts and/or pedestrian conflict levels must be dealt with on an individual design basis. A specific lighting design and its associated calculations must be submitted to the City's Street Lighting Engineer for review.

It is the responsibility of the street lighting designer to ensure they have the latest revisions of the City of Baltimore's street lighting standards and specifications and a current list of approved suppliers prior to designing the street lighting system.

All federally funded street lighting design and construction projects carried is subject to SHA inspection and approval. All materials used for street lighting that are part of federally funded projects in the City of Baltimore must meet SHA specifications.

Decorative street lighting may be used in the City only with the City's permission and in accordance with the City's requirements and specifications.

**1.3 Replacement and Upgrade Policy:**

New installations shall be designed and constructed in accordance with the specifications and references contained in this guide wherever possible. Where the designer wishes to use materials or specifications not contained in this guide, he/she must first contact the City Street Lighting Engineer and/or his/her Designated Representative to obtain their approval.

It is the policy of the City that damaged or destroyed streetlight poles, luminaires, etc. shall be replaced with materials in accordance with the new standards.

**1.4 Lighting Policy:**

It is the policy of the City that all street and sidewalk lighting design shall be based on ANSI/IESNA RP-8-00 as referred to above.

All lighting designs for the downtown area must be submitted to the City Street Lighting Engineer for review with the necessary back-up material. Shop drawings, lighting design data, cross sections,

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etc. must be provided. Where the City’s standard cross sections are not applicable, the designer shall submit the appropriate road cross section(s) and the proposed road and pedestrian conflict classifications to both the City Street Lighting and Highway Engineer for review. No design shall proceed without the City’s approval of the road and pedestrian conflict classifications.

**2. IES Illuminance and Luminance Design Criteria**

The design requirements for luminance and illuminance given below in Tables 1 and 2 are taken from ANSI/IES RP-8-00. The values given for luminance shall govern; the values given for illuminance are for use in intersection and sidewalk designs. For the purposes of new lighting design in the City of Baltimore, where the improvement involves installation of new infrastructure and the replacement of existing street lights is not the main focus it will be required from a qualified lighting designer to prepare and submit a suitable design to the City for review.

All lighting installations shall be designed to minimize the usage of energy for the purposes of illumination. Use of advanced lighting technologies in combination with optically designed reflectors shall be considered in conjunction with lighting controls.

**Table 1: Luminance Design Criteria for Standard Roads**

Roadway Type <sup>3</sup>	Pedestrian Conflict Area <sup>1</sup>	Average Luminance	Luminance Uniformity <sup>2</sup>		Veiling Luminance Ratio (maximum) L <sub>vmax</sub> to L <sub>avg</sub>
		L <sub>avg</sub> (cd/m <sup>2</sup> )	L <sub>avg</sub> to L <sub>min</sub>	L <sub>max</sub> to L <sub>min</sub>	
Expressway	High	1.3	3 to 1	5 to 1	0.3 to 1
	Medium	1.0	3 to 1	5 to 1	
	Low	0.8	3.5 to 1	6 to 1	
Arterial	High	1.5	3 to 1	5 to 1	0.3 to 1
	Medium	1.1	3 to 1	5 to 1	
	Low	0.8	3.5 to 1	6 to 1	
Collector	High	1.0	3 to 1	5 to 1	0.4 to 1
	Medium	0.8	3.5 to 1	6 to 1	
	Low	0.5	4 to 1	8 to 1	
Local	High	0.8	6 to 1	10 to 1	0.4 to 1
	Medium	0.6	6 to 1	10 to 1	
	Low	0.4	6 to 1	10 to 1	

Note 1: Pedestrian Conflict Area Classification (PCC) as defined in ANSI/IES RP-8-00 in paragraph 2.2 on page 4. The only standard exception to the low PCC used in lighting calculations in the City is in school zones, where a medium PCC shall be used.

Note 2: The relationship between individual and respective luminance and illuminance values is derived from general conditions to dry paving and straight road sections. This relationship does not apply to averages.

Note 3: For divided highways, where the lighting on one roadway may differ from that on the other, calculations should be made on each roadway independently.

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**Table 2: Average Maintained Illuminance Values**

<b>Roadways - Average Maintained Illuminance Values (<math>E_{avg}</math>) in Foot-candles</b>						
<b>Roadway Type<sup>3</sup></b>	<b>Pedestrian Conflict Area<sup>1</sup></b>	<b>Pavement Classification<sup>4</sup></b>			<b>Illuminance Uniformity Ratio<sup>2</sup> (<math>E_{ave}</math> to <math>E_{min}</math>)</b>	<b>Veiling Luminance Ratio (<math>L_{Vmax}</math> to <math>L_{avg}</math>)</b>
		R1	R2 & R3	R4		
Expressway	High	1.3	1.8	1.6	3 to 1	0.3 to 1
	Medium	1	1.5	1.3		
	Low	0.8	1.1	1		
Arterial	High	1.5	2	1.9	3 to 1	0.3 to 1
	Medium	1.1	1.6	1.4		
	Low	0.8	1.1	1		
Collector	High	1	1.5	1.25	4 to 1	0.4 to 1
	Medium	0.8	1.1	1		
	Low	0.5	0.9	0.6		
Local	High	0.8	1.1	1	6 to 1	0.4 to 1
	Medium	0.6	0.9	0.8		
	Low	0.4	0.6	0.5		

- Note 1: Pedestrian Conflict Area Classification (PCC) as defined in ANSI/IES RP-8-00 in paragraph 2.2 on page 4. The only standard exception to the low PCC used in lighting calculations in the City is in school zones, where a medium PCC shall be used.
- Note 2: The relationship between individual and respective luminance and illuminance values is derived from general conditions to dry paving and straight road sections. This relationship does not apply to averages.
- Note 3: For divided highways, where the lighting on one roadway may differ from that on the other, calculations should be made on each roadway independently.
- Note 4: Pavement references are as follows: R1-Mostly Diffuse, R2-Semi Diffuse, R3-Semi Specular, R4-Specular

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**Table 3: Illuminance Design Criteria for Pedestrian Sidewalks and Bikeways**

<b>Average Maintained Illuminance Values (<math>E_{avg}</math>) in Foot-candles</b>			
<b>Walkway and Bikeway Classification</b>		<b>Minimum Average Horizontal Levels (<math>E_{avg}</math>)</b>	<b>Average Vertical Levels for Special Pedestrian Security (<math>E_{avg}</math>)<sup>1,2</sup></b>
Roadside Sidewalks and Bikeways	Commercial Areas	1.2	2.2
	Areas Intermediate	0.8	1.1
	Residential Areas	0.4	0.5
Walkways and Bikeways distant from roadways	Walkways, bikeways, and stairways	0.6	0.5
Pedestrian Tunnels		5.4	5.4

Note 1. Shall be calculated for areas where facial recognition is critical.

Note 2. Calculation to be performed 4.9-ft above sidewalk/bikeway in a bi-directional manner parallel to the main pedestrian flow.

**2.1 Required Calculations for Lighting Installations**

- a. Purpose: Each lighting installation shall be required to submit evidence that the intended design meets required values for lighting metrics defined under this guide.
- b. Illuminance (E)
  - 1) Illumination levels, in foot-candles (FC), shall be used as the defining metric for evaluating the overall lighting levels on surfaces.
  - 2) Required Calculations: The required levels for illuminance shall meet the listed values in Table 2 and 3. Calculations shall be performed by recognized lighting software listed for this purpose.
  - 3) Required Submission: The approved design shall clearly indicate on the submitted "Site Lighting Plan" illuminance levels measured in Foot-candles (FC). Refer to Section 9 for overall submission requirements.
- c. Luminance (L)
  - 1) Luminance Level, in candela per meter squared (CD/M2), shall be the defining metric for evaluating surface brightness on surfaces:

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- 2) Required Calculation: The required levels for Luminance shall meet the listed values in Tables 1, 2 and 3. Calculations shall be performed by recognized lighting software listed for this purpose.
- d. Minimum Values: The levels presented in the table are minimum values.
- Higher than Minimum Value Requests: Values higher than those listed may be required due to public safety concerns. Request to exceed values listed in this guide shall be detailed in a project specific Request for Proposal (RFP) issued by the City of Baltimore.

## **2.2 Recommended Spacing for Street Lighting on the City of Baltimore Standard Sections**

Variations in pavement width, luminaire offset and sidewalk width and offset must be dealt with on an individual design basis and a specific lighting design and its associated calculations must be submitted to the City for review.

## **2.3 Submission of Plans and Evidence of Compliance**

- a. Submission Contents: The applicant in connection with proposed work involving street lighting within the City of Baltimore shall submit (as part of the design process) evidence that the proposed work will comply with this guide. The submission shall contain but shall not necessarily be limited to the following, all or part of which may be part or in addition to the information required elsewhere in the City of Baltimore upon application for performance of the work:
- 1) Complete plans indicating the location of luminaires, and the type of illuminating devices, fixtures, supports, reflectors, and other devices, shall be clearly indicated.
  - 2) Description of the illuminating devices, fixtures, lamps, supports, reflectors, and other devices as summarized in a fixture schedule.
  - 3) Catalog cut sheets by manufacturers including photometric information.
- b. Additional Information: The above required submission contents are intended to enable the City Street Lighting Engineer to readily determine whether compliance with the requirements of this guide are met. If such plans, descriptions and data cannot enable this ready determination, by reason of the nature or configuration of the devices, fixtures, or lamps proposed, the applicant will provide additional information to substantiate compliance with this guide.
- 1) Lamp or fixture Substitution: Should any street light fixture or type of light source therein be changed after approval of plans has been issued, a change request must be submitted to design professional and City Street Lighting Engineer for his/her approval, together with adequate information to assure compliance with this guide, which must be received prior to substitution.

## **2.4 Lighting for Urban Intersections**

The luminance method is difficult to use with the design of lighting for intersections due to the basic assumptions inherent in luminance design and the methods used in its calculation. Therefore illuminance criteria and calculations are recommended for use in the design of intersections.

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Intersections should be illuminated to a level equal to the sum of the recommended average illumination levels for each of the intersecting roads. These levels are given in Table 2, above. The pedestrian conflict classification of “low” is included in the illumination levels given in table 2. No further adjustment of lighting levels is required due to pedestrian conflict classifications unless a higher classification is chosen.

Typical lighting layouts for intersections are given in ANSI/IES RP -8-00 in Annex “D”, Figure D3 on page 40.

## **2.5 Light Trespass**

To control light trespass onto adjacent properties or streets, the maximum vertical illumination, when measured at a 0.5-feet within the adjacent property line at a height of 5-feet and facing the light fixture(s), shall be no greater than .01 vertical foot candles.

## **2.6 Light Loss Factors**

Light loss factors are comprised of several variables and judgment must be exercised in arriving at a suitable factor. Typical variables to consider when determining the light loss factor are given in ANSI/IES RP -8-00 in Annex “A”, on page 26.

## **2.7 Curves and Hills**

When lighting curves and/or hills, designer shall refer to the procedures given in ANSI/IES RP-8-00 in Annex “D”, Figure D2 on page 39.

## **2.8 Cul-de-sac**

There are several design problems to be dealt with when designing lighting for the end (bulb) of cul-de-sac. These are:

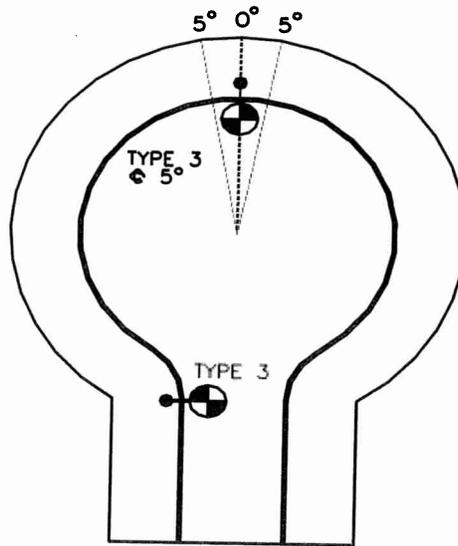
- a. the area to be lit is not readily adaptable to the standard luminaires used in Baltimore;
- b. the space available for the placement of the luminaires/poles is generally quite limited due to the convergence of driveways in the boulevard areas; and
- c. due to the basic assumptions inherent in luminance design and the methods used in its calculation, the use of luminance criteria at the ends of cul-de-sac (or any other “dead-end” arrangement) is not recommended. Illuminance criteria and calculations are recommended for use in the design of cul-de-sac, as specified in Table 3.

### **2.8.1 Lighting in Cul-de-sac**

It is suggested that lighting in cul-de-sac be arranged in accordance with the sketches provided below.

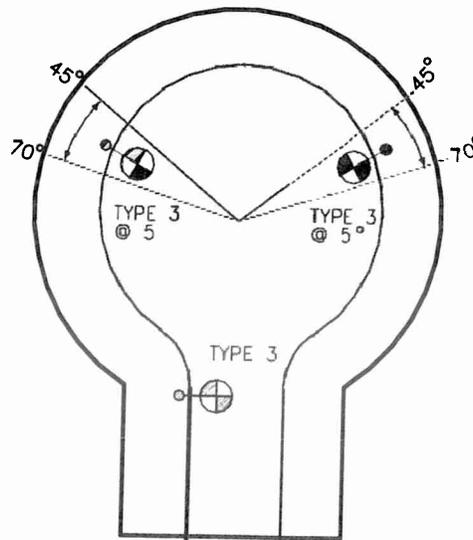
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**Figure 1: Cul-de-Sac Option A**



Option A consists of a street light placed as close as possible to neck of bulb and a street light tilted at 5° at the top of the bulb at an angle of 0° +/- 5° off the “north” line. The luminaire wattage and pole size are to match the luminaire/pole combination specified for the type of street. See Table 3 for appropriate illuminance levels.

**Figure 2: Cul-de-Sac Option B**



Option B consists of a street light placed as close as possible to neck of bulb and two street lights

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tilted at 5° at angles of 45° +/- to 70° +/- from the top centre of the bulb. The luminaire wattage and pole size are to match the luminaire/pole combination specified for the type of street. See Table 3 for appropriate illuminance levels.

Designs for street lights using arrangements other than the standard locations given above shall be accompanied by a full set of lighting calculations for review by the City Street Lighting Engineer.