CHAPTER 5

LIGHTING

5.0 INTRODUCTION

The design criteria in this Chapter are not intended to be a textbook. The information herein is written for qualified lighting engineers and to assist them in preparing a uniform and standard lighting design of highway lighting systems.

The criteria included in this Chapter apply to Freeway Interchanges, except as specifically designated. Roadway areas not covered in this Chapter should be based on the criteria listed in the AASHTO *Roadway Lighting Design Guide* and as specified at the predesign meeting.

The designer's engineering judgment in the application of the criteria is subject to review and concurrence by the Central Office. It is suggested that the designer obtain prior approval from the Central Office on matters of design which raise questions in the application of these criteria to a specific condition.

Present the design report in the format shown by the sample design reports in Section 5.12.

Sources of reference in addition to this Manual are:

- AASHTO-Current *Roadway Lighting Design Guide*.
- AASHTO-*Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*.
- Publication 408, *Specifications,* and associated changes, Pennsylvania Department of Transportation.
- Current Publication 72M, *Roadway Construction Standards*, Highway Lighting Drawings, RC-80M, RC-81M, RC-82M, RC-83M and RC-84M.
- Current Publication 219M, *Standards for Bridge Construction*, BC-721M and BC-722M.
- Publication 10, Design Manual, Part 1, *Transportation Program Development and Project Delivery Process.*
- Publication 10C, Design Manual, Part 1C, *Transportation Engineering Procedures.*
- Publication 10X, Design Manual, Part 1X, *Appendices to Design Manuals 1, 1A, 1B, and 1C.*
- Publication 14M, Design Manual, Part 3, *Plans Presentation.*
- Publication 15M, Design Manual, Part 4, *Structures*.

5.1 SITE INSPECTION

The designer shall familiarize himself with existing overhead and underground facilities which may interfere with lighting facilities. Facilities which are to be installed, such as underground drains, guide rail, utility structures and/or appurtenances and overhead signs, require coordination with proposed lighting facilities and should be coordinated prior to the start of design.

To avoid conflict with any proposed utility facility relocations and to obtain, at an early date, an available source of electrical service, the lighting designer is to proceed as follows:

1. Invite the District Utility Relocation Supervisor to attend the scheduled field meeting with the lighting designer and the utility to review the preliminary design requirements for sign or highway lighting, and to determine the available source of energy and the location of the service terminal.

2. Prepare and forward a summary of the field review meeting to the utility with a request for confirming in writing the location of the service terminal and the location of the available source of energy.

3. Furnish a copy of the letter of confirmation received from the utility to the District Utility Relocation Unit for current investigation of any conflict with interim relocation plans being furnished.

4. Have any conflicts observed by the District Utility Relocation Unit brought to the attention of the lighting designer and the utility for further investigation and coordination of any necessary adjustments.

Existing lighting facilities to be removed, relocated or coordinated with are part of the total scope of work of the proposed lighting system under design.

Include facilities other than lighting facilities which are to be moved or relocated in the scope of work for the roadway construction or alterations.

5.2 PRELIMINARY DESIGN

A. Conventional Lighting:

1. Design Criteria. Design all roadway surfaces based on the current AASHTO *Roadway Lighting Design Guide*.

2. Pole Spacing. Determine pole spacing using the following formula. However, the use of computer programs is encouraged, especially for the glare ratio computation:

$$S = \frac{L \times LLD \times UF \times MF}{LX \times W}$$

where:

S = Spacing is the distance in meters (feet) between luminaires. In curved sections of roadways, use the baseline distance as basis of spacing.

L = The initial lumen value is obtained from manufacturers' lamp data. Use horizontal lumens if the lamp is burned in a horizontal position and vertical lumens if the lamp is burned in a vertical position. Confirm values obtained with Central Office's latest data before the start of design.

UF = The utilization factor is from the luminaire photometric data sheet.

MF = The maintenance or dirt factor assumes the luminaire output at the end of rated life if the lamp is reduced because of dirt on the reflector and the refractor.

LX (FC) = The average maintained horizontal lux (footcandles) on the roadway at the end of rated life of the lamp with maintenance factor.

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W = Width of the roadway as associated with the spacing to define the illuminated area. Use the following widths: (1) curb to curb for bridges and curbed roadways, (2) wall to wall or barrier to barrier when the distance from edge of pavement to wall or barrier is less than 3.0 m (10 ft) and (3) Edge of Pavements for all open roadways.

LLD = Lamp lumen depreciation factor. Use 0.8 for HPS lamps. For MV or MH lamps, consult the Central Office Lighting Unit.

3. Uniformity Ratio. Refer to the current AASHTO *Roadway Lighting Design Guide*. The uniformity ratio is the ratio of the average maintained horizontal lux (footcandles) to the darkest spot lux (footcandles) at the end of rated life (ERL) of the lamp, including the maintenance factor (MF). Compute the uniformity ratio using the following formula:

METRIC:

$$UR = \frac{LX}{CF \times lx}$$

where:

LX = Average maintained horizontal lux (same value used in the pole spacing formula)

lx = Darkest point lux from the isolux diagram.

CF = Correction factor to convert the diagram value (lx) to the end of rated life value. Photometric data gives lamp lumen output on which the isolux plot was based. Hence,

$$CF = \frac{L \times 0.8ERL \times 0.8MF}{\text{Photo - Data - Test Lumens}}$$

where:

ERL = End of rated life

ENGLISH:

$$UR = \frac{FC}{CF \times fc}$$

where:

FC = Average maintained horizontal footcandles (same value used in the pole spacing formula)

fc = Darkest point footcandles from the isofootcandle diagram.

CF = Correction factor to convert the diagram value (fc) to the end of rated life value. Photometric data gives lamp lumen output on which the isofootcandle plot was based. Hence,

$$CF = \frac{L \times 0.8ERL \times 0.8MF}{\text{Photo - Data - Test Lumens}}$$

where:

ERL = End of rated life

Apply a second correction factor for the darkest spot lux (footcandles) when the mounting height is other than for which the data was plotted. Refer to the photometric data sheet for this correction factor.

4. Illumination Level. Illumination levels greater than recommended by AASHTO criteria, or the level on which the design is based, are justified under the following conditions:

a. To obtain acceptable uniformity ratio.
b. Spacing is the result of fixed or control points on the roadway.
c. Full spacing not available at specific locations because of control or fixed points.

5. Overhang. Base the overhang of the luminaire from edge of pavement, either positive or negative, upon the following considerations:

a. System efficiency.
b. Driver comfort.
c. Pole setback and arm length required. (Only standard arm lengths are to be specified.)
d. Illumination level and uniformity.

6. Mounting Height. The mounting height is the height of the luminaire above the edge of pavement. Pole shaft lengths must necessarily vary to compensate for the difference in elevations between the pole foundation or anchorage and the roadway surface. Publication 72M, *Roadway Construction Standards*, gives this adjustment to the pole shaft length by the C-dimension.

B. High Mast Lighting:

1. Design Criteria. All roadway surfaces are typically designed for illumination of 6 to 10 average maintained horizontal lux (0.6 to 0.9 average maintained horizontal footcandle) at the end of rated life of the lamp. Provide the minimum lux (footcandle) level at any point on the roadway as 2 lx (0.2 fc) maintained. Do not exceed uniformity ratio of 4:1.

Use the 400 W High Pressure Sodium (HPS) lamp with the required number of luminaires necessary to achieve the proper lux (footcandle) level and uniformity ratio period. Mount on high mast poles at a nominal mounting height of 30.5 m (100 ft) above the road surface. Do not exceed a pole length of 36.6 m (120 ft).

At the time of the pre-design meeting, the Department will furnish the consultant with the required candela (candlepower) and lux (footcandle) data necessary to accomplish the lighting design. Do not consider light at angles greater than 75°.

2. Design Procedures. Determine the average maintained lux (footcandle) level on the roadway in the following manner:

a. Locate points at 30 m (100 ft) intervals on the centerline of the mainline in each direction, all ramps and the crossroad.

b. Determine the end of rated life maintained horizontal lux (footcandle) level at each of these points, considering the usable contribution from all poles in the vicinity of each point.

c. Calculate the lux (footcandle) level at each point by a computerized program. With prior approval, the Central Office, Bureau of Maintenance and Operations may accept manual computations for specific projects. Use the lux (footcandle) data previously supplied by the Central Office, Bureau of Maintenance and Operations.

d. Divide the interchange area into sections of the mainline in each direction, each ramp and the crossroad.

e. Determine the average maintained lux (footcandle) level in each section by adding all lux (footcandle) points in that section and dividing by the number of points in the section. Obtain a result between 6 and 10 lx (0.6 and 0.9 fc).

f. Determine the uniformity ratio of each road section by dividing the average maintained lux (footcandle) level in that section by the minimum lux (footcandle) level at any point in the section. Obtain a result equal to or less than 4.0. Tabulate all design results as shown in Section 5.12.

5.3 PRELIMINARY DESIGN REPORT

Prepare the preliminary design report for present lighting by including the following:

1. All information developed in the design shown on a 1:500 or 1:1000 (1" = 50' or 1" = 100') standard size drawing as prescribed in Publication 10C, Design Manual, Part 1C, *Transportation Engineering Procedures*, Chapter 4, Section 4.4.C.

2. Guide rail, type, location and distance from edge of pavement (also include for final review).

3. Boundary lines of political subdivisions.

4. Light pole locations by stations. (Include high mast pole foundation ground elevations on both the preliminary and the final plans.)

5. Complete calculations and tabulation of results, as shown in Section 5.12, for each different road width and situation, including calculations for coefficient of utilization, uniformity ratio, etc.

6. Bridge and underpass lighting provisions.

7. ADT of roadway at the time facility is opened to traffic.

8. Legend of symbols used, scale of plans and date.

9. Right-of-way lines.

10. Shoulder and curb lines.

11. Location and parameters of existing lights.

12. Overhead and underground electrical utilities (for locating power supplies).

13. Electronic copy of the .ies file from an accredited Testing Laboratory.

5.4 LUMINAIRES

A. Conventional Lighting. Install conventional roadway luminaires at nominal mounting heights of 9.1 m to 15.2 m (30 ft to 50 ft) using HPS lamps. Have the design agency determine the best wattages, distribution types and mounting heights for specific roadways.

B. High Mast Lighting. For a high mast roadway lighting system with 30.5 m (100 ft) nominal mounting heights, employ area type luminaires with symmetrical (Type V) light distributions. Employ 400 W HPS luminaires for the lighting system. If "run-out" lighting is required, use HPS lamps as detailed above for conventional lighting.

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5.5 POLES

A. Conventional Lighting:

1. Know what restrictions are upon light pole locations when designing a highway lighting system. The restrictions are based upon vehicular safety, driver comfort, ease of maintenance, protection of facilities and aesthetic considerations and are as follows:

a. Locate poles on driver's right, whenever possible.

b. Locate poles on the inside of curves when required for safety. Do not place guide rail solely for light pole protection.

c. Use pole arm lengths not exceeding 9.1 m (30 ft).

d. Do not locate poles in the median strip except under special conditions and with specific approval.

e. Locate poles at exit ramp gores on interchanges at 45 m ± 3 m (150 ft ± 10 ft) minimum from the actual shoulder nose.

f. Locate poles at entrance ramp gores on interchanges at 30 m ± 3 m (100 ft ± 10 ft) minimum from the actual shoulder nose.

g. Provide minimum pole clearance from overhead sign structures and bridges as follows:

MOUNTING HEIGHT (MH) FOR POLE	MINIMUM POLE CLEARANCE FROM OVERHEAD SIGN STRUCTURES AND BRIDGES
9.1 m (30 ft)	15.2 m ± 3.0 m (50 ft ± 10 ft)
10.7 m (35 ft)	18.3 m ± 3.0 m (60 ft ± 10 ft)
12.2 m (40 ft)	21.3 m ± 3.0 m (70 ft ± 10 ft)
13.7 m (45 ft)	24.4 m ± 3.0 m (80 ft ± 10 ft)
15.2 m (50 ft)	27.4 m ± 3.0 m (90 ft ± 10 ft)

h. Locate poles on the high barrier of bridges when the superelevation is greater than 6.0%.

i. Set back all unprotected or exposed poles as far as possible from the roadway, consistent with available approved equipment.

Where poles are considered to be exposed to traffic, design them to have a suitable breakaway or yielding feature. For the breakaway or yielding feature, comply with all applicable AASHTO requirements for structural supports. Poles provided with breakaway or yielding features are described as Type S Poles available with arm lengths up to and including 6.1 m (20 ft). In general, locate Type S poles on a 6:1 slope or less. Use Modified Foundations when the slope is greater than 6:1 and less than or equal to 4:1.

j. Do not place poles in front of guide rail.

k. Do not locate poles less than 4.6 m (15 ft) from the edge of pavement and 1.5 m (5 ft) from the edge of paved shoulder, except when the poles are placed behind barrier, guide rail, walls or other approved protection.

l. Install pole foundations as shown in Publication 72M, *Roadway Construction Standards*.

m. Locate poles on bridges on the side least likely to be disturbed if there are plans to widen the bridge in the future. Locate poles at pier locations if feasible.

n. Provide poles on bridges with arms not exceeding 2.5 m (8 ft). Provide bridge mounted poles with vibration dampers.

o. Determine minimum arm lengths for poles by the following formula:

Arm Length = Setback - 0.6 m (2 ft) + Overhang. Use only standard arm lengths. Overhang resulting from actual setback can vary ± 0.5 m (± 2 ft) from overhang used in the design.

p. Determine minimum pole setback in guide rail areas by the following formulas:

(1) Strong Post Guide Rail (Type 2-S)*
SB = d + 1.1 m (3.5 ft)
= Arm Length + 0.6 m (2 ft) - Overhang.

*Refer to Chapter 12.

(2) Weak Post Guide Rail (Type 2-W)*
SB = d + 2.6 m (8.5 ft)
= Arm Length + 0.6 m (2 ft) - Overhang.
d = Distance from edge of pavement to back of post. Overhang resulting from actual setback can vary ± 0.6 m (± 2 ft) from design. Use only standard arm lengths. (See Figure 5.1)

2. Pole Types:

Specify lighting poles as follows:

a. Normally specify steel or aluminum poles.

b. Specify aluminum poles only or steel poles only when justified and approved for the project.

c. Specify steel poles with single member arms and aluminum poles with truss arms. (Bracket type unless approved otherwise).

d. Specify pole arm rise compatible for each length specified. Refer to Publication 72M, *Roadway Construction Standards*.

e. Specify poles and arms compatible with adjacent existing installations.

f. Provide anchor base, Type A Poles, when:

(1) Pole is mounted on a bridge barrier or wall.
(2) Pole is located behind guide rail.
(3) Pole is considered protected by natural roadside considerations.
(4) Poles in or near pedestrian areas.

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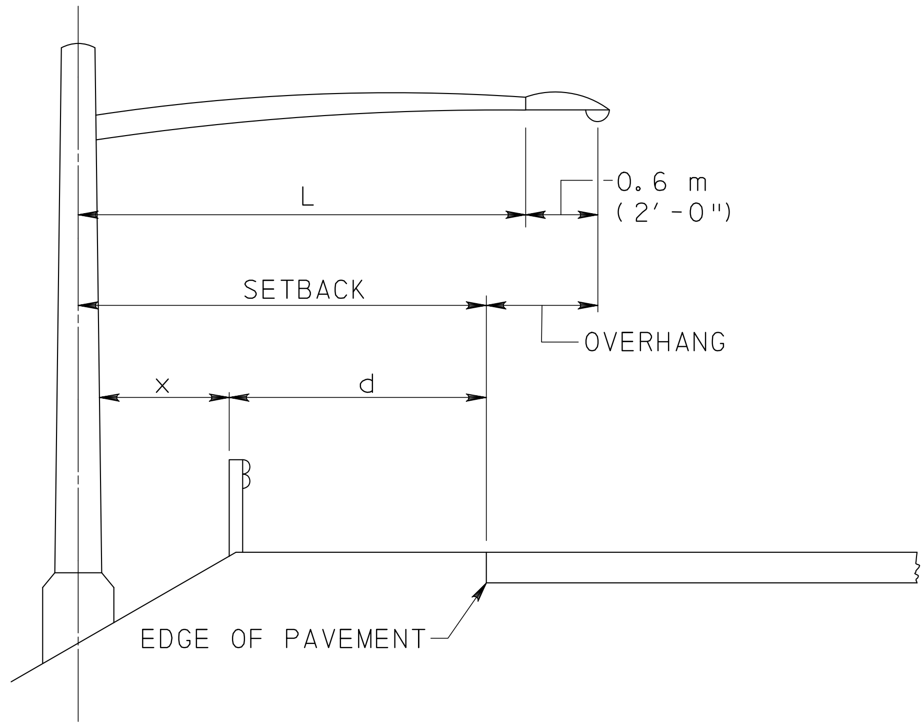

FIGURE 5.1
LIGHTING POLE SETBACK IN
GUIDE RAIL AREAS

* REFER TO CHAPTER 12.

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3. Pole Setback:

x = 1.1 m (3.5 ft) min for Strong Post Guide Rail (Type 2-S)*
x = 2.4 m (8.5 ft) min for Weak Post Guide Rail (Type 2-W)*
Set Back = x + d + 0.15 m (0.5 ft) = L + 0.6 m (2 ft) - OH

Note: 0.15 m (0.5 ft) from centerline to face of pole.
L (min) = x + d + OH - 0.6 m (2 ft) + 0.15 m (0.5 ft)

4. Example (METRIC):

Design OH = 0.9 m d = 5.5 m
Strong Post Guide Rail (Type 2-S)
L (min) = 1.1 m + 5.5 m + 0.9 m - 0.6 m = 6.9 m
NEAREST STANDARD LENGTH GREATER IS 7.6 m. Now solve for
SB = L + 0.6 m - OH

SB = 7.6 m + 0.6 m - 0.9 m = 7.3 m
x = 7.3 m - 5.5 m = 1.8 m

Table 12.3 requires 0.9 m clearance for Type 2-S guide rail, therefore SB is OK.

Example (ENGLISH):

Design OH = 3.0 ft d = 18.0 ft
Strong Post Guide Rail (Type 2-S)
L (min) = 3.5 ft + 18.0 ft + 3.0 ft - 2.0 ft = 22.5 ft
NEAREST STANDARD LENGTH GREATER IS 25.0 ft. Now solve for
SB = L + 2.0 ft - OH

SB = 25.0 ft + 2.0 ft - 3.0 ft = 24.0 ft
x = 24.0 ft - 18.0 ft = 6.0 ft

Table 12.3 requires 3.0 ft clearance for Type 2-S guide rail, therefore SB is OK.

B. High Mast Lighting:

1. Pole Locations. Locate poles on tangent sections and on the inside of curves a minimum of 15 m (50 ft) from the edge of pavement wherever practical. Locate poles on the outside of curves either a minimum of 15 m (50 ft) from the edge of pavement or as determined by the required clear zone width criteria in Chapter 12 (use highest value). Shield poles that are located closer than 15 m (50 ft) from the edge of pavement by placement either behind guide rail or on natural earth mounds.

2. Pole Types. Construct poles in accordance with Publication 408, *Specifications,* and Publication 72M, *Roadway Construction Standards*.

5.6 UNDERPASS LIGHTING

Illuminate underpasses at the same level of illumination as the outside roadway. Supplemental lighting may be needed when the pole mounted luminaires do not sufficiently penetrate the underpass. Daytime and nighttime lighting may be needed when pedestrian safety is involved.

5.7 TUNNEL LIGHTING

Tunnels may need daytime and/or nighttime lighting. Base design of tunnel lighting on the AASHTO *Roadway Lighting Design Guide* or on the Illuminating Engineering Society (IES) of North America Publication, *IES Lighting Handbook*. Contact the Central Office Lighting Unit for proper design parameters on each tunnel lighting project.

5.8 SAFETY REST AREAS, WELCOME CENTERS AND PERMANENT TRUCK WEIGH STATIONS

Light the ramps leading in, around and out of these areas to 6 average maintained lux (0.6 average maintained footcandle) and a maximum uniformity ratio of 4:1 with HPS lamps.

Light the car parking lot area to 11 average maintained lux (1.0 average maintained footcandle) and the truck parking lot area to 9 average maintained lux (0.8 average maintained footcandle) with a maximum uniformity ratio of 4:1 using HPS lamps.

Light the sidewalks leading from the parking lot to and around the safety rest building with 100 W HPS post-top mounted luminaires at a mounting height of 4.6 m (15 ft), placed approximately 1.0 m to 1.5 m (3 ft to 5 ft) from the edge of the sidewalk with a spacing between luminaires of approximately 12 m (40 ft). The use of high mast lighting poles may delete the need for post-top mounted luminaires.

5.9 FINAL DESIGN

Final design entails the development of information needed to prepare the lighting construction plans based upon the preliminary design previously approved. The information involves the following:

1. Routing of Lighting Circuits (8.37 mm^2 (#8 AWG) cu-minimum for distribution).

2. Base wire size calculations upon 3% voltage drop maximum for reactor type ballasts and 5% voltage drop maximum for auto-regulator or regulator-type ballasts.

3. Determination of pole arm lengths and pole setbacks.

4. Determination of the "C" dimensions for all pole locations as shown in Publication 72M, *Roadway Construction Standards*. Show this dimension to the nearest 0.05 m (0.1 ft) alongside the setback distance on the tabulation of quantities sheet. Refer to Publication 14M, Design Manual, Part 3, *Plans Presentation*.

5. Size or rating of power supply components. Size breakers to 75% of rating.

6. Size lighting loads to include sign loads when signs are to be energized from the roadway lighting circuits.

7. Determination of type of poles required: S-Base or A-Base.

8. Power Supply service voltage and location. Supply voltage shall be either 120/240 V or 240/480 V, single phase, 3-wire system. Other voltages require specific approval from the Central Office, Bureau of Maintenance and Operations. Include confirmation letter from the power company as applicable.

9. Determination of pole foundation required as detailed in Publication 72M, *Roadway Construction Standards*.

10. Necessary details of location required as detailed in Publication 72M, *Roadway Construction Standards*.

11. Include guide rail type, location and distance from edge of pavement.

12. Standard and special notes and special provisions.

5.10 POWER SUPPLY

The electric utility company typically delivers 3 wire, single phase 120/240 V service or a 240/480 V service to the Department service pole as indicated in Publication 72M, *Roadway Construction Standards*. Provide a service location, service disconnect equipment and the meter installation acceptable to the local electric utility company.

Design the sizes of equipment to meet the needs of each project. Simplified diagrams are shown in Publication 72M, *Roadway Construction Standards*.

A step up transformer may be required on larger systems that use a 120/240 V supply. Provide transformers where they can be justified in wire size savings.

Specify a metered service for all projects except where a Department approved unmetered energy only rate is available.

5.11 MULTIPLE DISTRIBUTION SYSTEM

Use and install direct burial cable in PVC conduit as shown in Publication 72M, *Roadway Construction Standards*. Balance the luminaires alternately on each side of the 3-wire, single phase distribution system connected line to neutral. Protect each side or phase leg of the distribution system with a breaker of suitable size but not less than 20 A. Provide an interchange with as many circuits as are needed to obtain economical wire sizes within limits of voltage drop and number of power supplies available. If overhead lighted signs are also involved, specify wire sizes and protective devices of sufficient size to provide for the sign loads as well as for the highway lighting loads.

5.12 SAMPLE DESIGN REPORTS

Present the design reports for conventional highway lighting and high mast highway lighting using the formats as shown on the following pages.

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SAMPLE

CONVENTIONAL

HIGHWAY LIGHTING

DESIGN REPORT

______________________ County

SR ____________, Section ___________

Interchange with SR _________________

Pre-Design Conference _______________
Date

1. Energy and maintenance letter of intent from county dated _________________ included.
2. This project is to be programmed for Federal-aid.
3. Justification for this lighting is AASHTO case _______________, ADT shown on plan.

Consultant ______________________

Designed by ______________________

Checked by ______________________

Date ______________________

Rev ______________________

DESIGN CRITERIA (METRIC)
(Sheet 1 of 2)

I. MOUNTING HEIGHT
SR _____... 15.2 m
SR _____... 13.7 m
Ramps .... 10.7 m
Underpass.. 4.6 m

II. LUMINAIRES
SR _____... 400 W, HPS
SR _____... 250 W, HPS
Ramps .... 150 W, HPS
Underpass.. 100 W, HPS

III. LAMPS (LLD = 0.80)
SR _____... 400 W, 40 000 lm, ERL
SR _____... 250 W, 22 000 lm, ERL
Ramps .... 150 W, 12 800 lm, ERL
Underpass.. 100 W, 7600 lm, ERL

IV. PHOTO-METRIC DATA
GE 35-17XXXX .... 400 W, HPS, M-SC-III
GE 35-17XXXX .... 250 W, HPS, M-SC-II
GE 35-17XXXX .... 150 W, HPS, M-SC-II
GE 35-17XXXX .... 100 W, HPS, M-SC-IV

V. OVERHANG
SR _____ Roadway...........0 m...Structures............2.7 m
SR _____ Roadway...........0 m...Structures............none
Ramps.............Roadway............Radius > 75 m = 1.5 m
Radius < 75 m = 3.0 m
Structures...........................1.8 m
Underpass.........Ramp...........0 m
SR______ 1.5 m

VI. DESIGN PARAMETERS
Average maintained lux at ERL........... 6 lx
Dirt Factor... 0.80
Uniformity Ratio.................................. 4:1 maximum
Glare Ratio... 0.3:1 maximum

DESIGN CRITERIA (METRIC)
(Sheet 2 of 2)

VII. CORRECTION FACTORS

A. 400 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(9)^2}{(15)^2} = 0.36$

Curve Factor $\frac{40\ 000}{1000} = 40$ (data per 1000 lm)

CF Total....................................... $0.36 \times 0.80 \times 40 = 11.52$

B. 250 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(9)^2}{(13.5)^2} = 0.44$

Curve Factor $\frac{22\ 000}{1000} = 22$ (data per 1000 lm)

CF Total....................................... $0.44 \times 0.80 \times 22 = 7.74$

C. 150 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(9)^2}{(10.5)^2} = 0.74$

Curve Factor $\frac{12\ 800}{1000} = 12.8$ (data per 1000 lm)

CF Total....................................... $0.74 \times 0.80 \times 12.8 = 7.58$

D. 100 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(9)^2}{(4.5)^2} = 4$

Curve Factor $\frac{7600}{1000} = 7.6$ (data per 1000 lm)

CF Total....................................... $4 \times 0.80 \times 7.6 = 24.32$

DESIGN CRITERIA (ENGLISH)
(Sheet 1 of 2)

I. MOUNTING HEIGHT

SR _____ .... 50 ft
SR _____ .... 45 ft
Ramps .... 35 ft
Underpass... 15 ft

II. LUMINAIRES

SR _____ .... 400 W, HPS
SR _____ .... 250 W, HPS
Ramps .... 150 W, HPS
Underpass... 100 W, HPS

III. LAMPS (LLD = 0.80)

SR _____ .... 400 W, 40,000 lm, ERL
SR _____ .... 250 W, 22,000 lm, ERL
Ramps .... 150 W, 12,800 lm, ERL
Underpass... 100 W, 7,600 lm, ERL

IV. PHOTO-METRIC DATA

GE 35-17XXXX .... 400 W, HPS, M-SC-III
GE 35-17XXXX .... 250 W, HPS, M-SC-II
GE 35-17XXXX .... 150 W, HPS, M-SC-II
GE 35-17XXXX .... 100 W, HPS, M-SC-IV

V. OVERHANG

SR _____ Roadway.......0 ft.......Structures.......9 ft
SR _____ Roadway.......0 ft.......Structures.......none
Ramps..............Roadway...........Radius > 250 ft = 5 ft
Radius < 250 ft = 10 ft
Structures................................6 ft
Underpass.........Ramp............0 m
SR ________ 5 ft

VI. DESIGN PARAMETERS

Average maintained footcandle at ERL ....0.60 fc
Dirt...0.80
Uniformity Ratio ....4:1 maximum
Glare Ratio..0.3:1 maximum

DESIGN CRITERIA (ENGLISH)
(Sheet 2 of 2)

VII. CORRECTION FACTORS

A. 400 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(30)^2}{(50)^2} = 0.36$

Curve Factor $\frac{40{,}000}{1000} = 40$ (data per 1000 lm)

CF Total....................................... $0.36 \times 0.80 \times 40 = 11.52$

B. 250 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(30)^2}{(45)^2} = 0.44$

Curve Factor $\frac{22{,}000}{1000} = 22$ (data per 1000 lm)

CF Total....................................... $0.44 \times 0.80 \times 22 = 7.74$

C. 150 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(30)^2}{(35)^2} = 0.74$

Curve Factor $\frac{12{,}800}{1000} = 12.8$ (data per 1000 lm)

CF Total....................................... $0.74 \times 0.80 \times 12.8 = 7.58$

D. 100 W Luminaire, HPS — Dirt Factor = 0.80

Mounting Height Factor $\frac{(30)^2}{(15)^2} = 4$

Curve Factor $\frac{7{,}600}{1000} = 7.6$ (data per 1000 lm)

CF Total....................................... $4 \times 0.80 \times 7.6 = 24.32$

TABULATION OF DESIGN COMPUTATIONS (METRIC)
(Sheet 1 of 1)

ROADWAY	STATION	OVER-HANG	WATTS DISTR	MOUNTING HEIGHT	SPACING	AVG MAINT LUX	UNIFORMITY RATIO	GLARE RATIO	COMP SHEET
SR ____	23+100 LT	0	400 W M-SC-III	15.2 m					
					75 m	6.6	3.5	0.18	7
	23+175 RT	0	400 W M-SC-III	15.2 m					
					75 m	6.6	3.5	0.18	8
	23+250 LT	0	400 W M-SC-III	15.2 m					
					72 m	6.8	3.2	0.19	9
	23+322 RT	0	400 W M-SC-III	15.2 m					
SR ____	48+800 RT	0	250 W M-SC-II	13.7 m					
					78 m	6.7	3.7	0.19	18
	48+878 LT	0	250 W M-SC-II	13.7 m					
SR ____ Seg ____	16+200 LT	-1.5 m	150 W M-SC-II	10.7 m					
					60 m	7.1	3.9	0.15	22
	16+260 LT	-1.5 m	150 W M-SC-II	10.7 m					
					45 m	7.5	3.8	0.13	23
	16+305 LT	-4.5 m Wallpack	150 W S-NC-IV	4.6 m					

TABULATION OF DESIGN COMPUTATIONS (ENGLISH)
(Sheet 1 of 1)

ROADWAY	STATION	OVER-HANG	WATTS DISTR	MOUNTING HEIGHT	SPACING	AVG MAINT FOOT-CANDLE	UNIFORMITY RATIO	GLARE RATIO	COMP SHEET
SR ______	23+10 LT	0	400 W M-SC-III	50 ft					
					250 ft	0.61	3.5	0.18	7
	25+60 RT	0	400 W M-SC-III	50 ft					
					250 ft	0.61	3.5	0.18	8
	28+10 LT	0	400 W M-SC-III	50 ft					
					240 ft	0.63	3.2	0.19	9
	30+60 RT	0	400 W M-SC-III	50 ft					
SR ______	48+80 RT	0	250 W M-SC-II	45 ft					
					260 ft	0.62	3.7	0.19	18
	51+30 LT	0	250 W M-SC-II	45 ft					
SR ______ Seg ______	16+20 LT	-5 ft	150 W M-SC-II	35 ft					
					200 ft	0.66	3.9	0.15	22
	17+70 LT	-5 ft	150 W M-SC-II	35 ft					
					150 ft	0.70	3.8	0.13	23
	19+70 LT	-15 ft Wallpack	150 W S-NC-IV	15 ft					

COMPUTATIONS (METRIC)
(Sheet 8 of ___)

Station 0 + 770 to 0 + 845 (400 W) (It is encouraged to substitute computer calculations for manual calculations. Computer analysis is required to determine the glare ratio.)

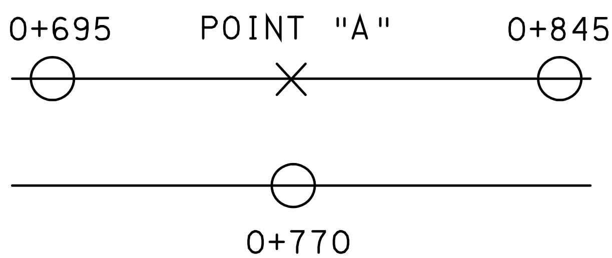
$W_1 = 15.0$, $W_2 = 18.0$ $\quad W_A = (15.0 + 18.0) \div 2 = 16.5$

$CU_1 = \frac{15.0}{15.0} = 1.0$ $\quad CU_2 = \frac{18.0}{15.0} = 1.2$

$UF_1 = 25\%$ $\quad UF_2 = 27\%$ $\quad UF_A = 26\%$

$$S = \frac{(40\ 000)(0.26)(0.8)}{(16.5)(6)} = 84$$

USED S = 75 m $\quad LX = \frac{84}{75} \times 6 = 6.7$ lx



Point "A" Illumination

(0 + 770) LR $\frac{0}{15.0} = 0$ $\quad$ (0 + 845) LR $\frac{75}{15.0} = 5.0$

TR $\frac{15}{15} = 1.0$ $\quad$ TR $\frac{0}{15} = 0$

lx = 0.18* $\quad$ lx = Nil

$$UR = \frac{LX\ (Avg)}{LX\ (Min)} = \frac{6.7}{0.18 \times 11.52} = 3.2:1$$

NOTE: It may be necessary to consider other points to determine lowest illumination.

*LX values obtained by interpolation of tabulated manufacturers data or read direct from isolux data. Apply values with curve factor based on ERL lamp lumens.

LR = Longitudinal Ratio of Distance
TR = Transerve Ratio of Distance
CU = Coefficient of Utilization
UF = Utilization Factor
S = Spacing
UR = Uniformity Ratio
W = Road Width

COMPUTATIONS (ENGLISH)
(Sheet 8 of ___)

Station 25 + 60 to 28 + 10 (400 W) (It is encouraged to substitute computer calculations for manual calculations. Computer analysis is required to determine the glare ratio.)

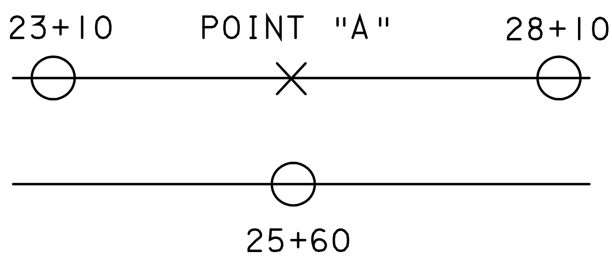
$W_1 = 15.0$, $W_2 = 18.0$ $W_A = (15.0 + 18.0) \div 2 = 16.5$

$CU_1 = \frac{50}{50} = 1.0$ $CU_2 = \frac{60}{50} = 1.2$

$UF_1 = 25\%$ $UF_2 = 27\%$ $UF_A = 26\%$

$$S = \frac{(40\,000)(0.26)(0.8)}{(55)(0.6)} = 253$$

USED S = 250 ft $FC = \frac{253}{250} \times 0.6 = 0.61$



Point "A" Illumination

$(25 + 60)\ LR\ \frac{0}{50} = 0$ $(28 + 10)\ LR\ \frac{250}{50} = 5.0$

$TR\ \frac{50}{50} = 1.0$ $TR = \frac{0}{50} = 0$

fc = 0.018* Fc = Nil

$$UR = \frac{FC\ (Avg)}{FC\ (Min)} = \frac{0.61}{0.018 \times 11.52} = 2.9{:}1$$

NOTE: It may be necessary to consider other points to determine lowest illumination.

*FC values obtained by interpolation of tabulated manufacturers data or read direct from isofootcandle data. Apply values with curve factor based on ERL lamp lumens.

LR = Longitudinal Ratio of Distance
TR = Transerve Ratio of Distance
CU = Coefficient of Utilization
UF = Utilization Factor
S = Spacing
UR = Uniformity Ratio
W = Road Width

SAMPLE

HIGH MAST

HIGHWAY LIGHTING

DESIGN REPORT

_______________________ County

SR ____________, Section ___________

Interchange with SR _________________

Pre-Design Conference _______________
Date

1. Energy and maintenance letter of intent from county dated _________________ included.
2. This project is to be programmed for Federal-aid.
3. Justification for this lighting is AASHTO case _______________, ADT shown on plan.

Consultant ______________________

Designed by ______________________

Checked by ______________________

Date ______________________

Rev ______________________

DESIGN CRITERIA (METRIC)

1.	Nominal Mounting Height	--	30.5 m
2.	Luminaires	--	400 W
3.	Photometric Data	--	Holophane Test 24400 Fixture 1138-Sym
4.	Design Values	--	Avg Maintained 6 lx Min Point 2 lx Dirt Factor 0.80 Uniformity Ratio 4:1 maximum
5.	Lamp Data	--	Initial output 50 000 lm End of Life 40 000 lm Rated Life 24 000 h

6. Luminaire Specifications (General)
   a. Max Candela angle = 60°
   b. Projected area = 0.33 m^2
7. Basis of tabulated values:

$$\text{Initial LX} = \frac{I(\cos\theta)^3}{MH^2} \qquad I = \text{Candelas at } \theta$$

$$\text{End Life LX} = \text{Initial LX} \times \frac{\text{Lamp end of life lumens}}{\text{Test lamp lumens}} \times 0.8$$

$$= \text{Initial LX} \times \frac{40\,000}{50\,000} \times 0.8$$

Dirt Factor = 0.8

TABULATION OF HIGH MAST POLES (METRIC)

POLE ID NO.	NO. OF LUMINAIRES	ROADWAY	STATION	GROUND ELEVATION	POLE HEIGHT	SETBACK
1	8	SR 8000 SEG 10	0 + 466 RT	330 m	33.5 m	18.0 m
2	8	SR 8000 SEG 20	0 + 523 LT	333 m	36.6 m	30.0 m
3	6	SR 793 NB	8 + 530 RT	329 m	36.6 m	18.9 m
4	8	SR 793 NB	8 + 364 LT	327 m	36.6 m	15.0 m
5	7	SR 793 SB	8 + 244 LT	335 m	33.5 m	9.0 m
6	8	SR 793 SB	8 + 060 LT	331 m	30.5 m	17.4 m

SUMMARY OF ROADWAY ILLUMINATION (METRIC)

ROADWAY	AVERAGE ILLUMINATION	UNIFORMITY RATIO
SR 793 NB	8.21	2.54
SR 793 SB	7.85	2.80
SR 820	7.44	3.45
SR 8000 SEG 10	6.92	2.30
SR 8000	7.32	2.52
ENTIRE	7.36	3.09

TABULATION OF ROADWAY POINT ILLUMINATION (METRIC)

SR 8000, SEG 10

STATION	ELEVATION	TOTAL LUX	CONTRIBUTING SOURCES (Pole No. and Contribution)
0 + 490	331 m	4.56	#5-4.12 #10-0.44
0 + 460	332 m	3.57	#5-1.79 #10-1.78
0 + 400	332 m	5.35	#3-1.15 #12-4.20
0 + 370	329 m	5.98	#3-0.37 #12-5.47 #6-0.14

No of Points 16, Average Lux 6.92, Uniformity Ratio 2.30

DESIGN CRITERIA (ENGLISH)

1. Nominal Mounting Height -- 100 ft
2. Luminaires -- 400 W
3. Photometric Data -- Holophane Test 24400 Fixture 1138-Sym
4. Design Values -- Avg Maintained 0.60 footcandle
   Min Point 0.20 footcandle
   Dirt Factor 0.80
   Uniformity Ratio 4:1 maximum
5. Lamp Data -- Initial output 50,000 lm
   End of Life 40,000 lm
   Rated Life 24,000 h
6. Luminaire Specifications (General)
   a. Max Candela angle = 60°
   b. Projected area = 3.5 ft^2
7. Basis of tabulated values:

$$\text{Initial FC} = \frac{I(\cos\theta)^3}{MH^2} \qquad I = \text{Candelas at } \theta$$

$$\text{End Life FC} = \text{Initial FC} \times \frac{\text{Lamp end of life lumens}}{\text{Test lamp lumens}} \times 0.8$$

$$= \text{Initial FC} \times \frac{40{,}000}{50{,}000} \times 0.8 \qquad \text{Dirt Factor} = 0.8$$

TABULATION OF HIGH MAST POLES (ENGLISH)

POLE ID NO.	NO. OF LUMINAIRES	ROADWAY	STATION	GROUND ELEVATION	POLE HEIGHT	SETBACK
1	8	SR 8000 SEG 10	15 + 30 RT	1083 ft	110 ft	60 ft
2	8	SR 8000 SEG 20	17 + 17 LT	1091 ft	120 ft	100 ft
3	6	SR 793 NB	279 + 84 RT	1081 ft	120 ft	63 ft
4	8	SR 793 NB	274 + 40 LT	1073 ft	110 ft	50 ft
5	7	SR 793 SB	270 + 47 RT	1099 ft	100 ft	30 ft
6	8	SR 793 SB	264 + 42 LT	1085 ft	100 ft	58 ft

SUMMARY OF ROADWAY ILLUMINATION (ENGLISH)

ROADWAY	AVERAGE ILLUMINATION	UNIFORMITY RATIO
SR 793 NB	0.763	2.54
SR 793 SB	0.729	2.80
SR 820	0.691	3.45
SR 8000 SEG 10	0.643	2.30
SR 8000	0.680	2.52
ENTIRE	0.684	3.09

TABULATION OF ROADWAY POINT ILLUMINATION (ENGLISH)

SR 8000, SEG 10

STATION	ELEVATION	TOTAL FOOTCANDLES	CONTRIBUTING SOURCES (Pole No. and Contribution)
16 + 00	1085 ft	0.424	#5-0.383 #10-0.041
15 + 00	1090 ft	0.332	#5-0.166 #10-0.166
13 + 00	1088 ft	0.497	#3-0.106 #12-0.390
12 + 00	1080 ft	0.555	#3-0.34 #12-0.508 #6-0.013

No of Points 16, Average Footcandles 6.43, Uniformity Ratio 2.30

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