



ROADWAY LIGHTING GUIDELINES



Department of Energy

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Department of Energy (DOE), Philippines

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MESSAGE

Much of our roadway lighting systems today are lamentably poorly designed. Excessively illuminated places, improperly installed lighting fixtures, inefficiently used lamps, and the absence of lighting, when necessary, are the perennial cause of social problems such as unpaid electric bills by the local government units, increased crime rate, and vehicular accidents, due to the improperly lighted roadways.

The social cost of inefficient roadway lighting will produce environmental cost. Inefficient lighting will waste energy. When energy is inefficiently used, we simply add greenhouse gas emissions (GHGs) to the atmosphere. GHGs are pinpointed to be the main culprit for climate change. It is high time for us to be conscious of our environment, and I laud our professionals for recognizing this phenomenon.

The purpose of this guideline is to provide strategies for the proper design of roadway lighting systems. We aim not only for road visibility and safety, but also energy efficiency.

Angelo T. Reyes
Secretary

Preface

This document, Roadway Lighting Guidelines, addresses the need to provide guidelines to design, construct and manage safe and energy-efficient road lighting systems in the Philippines.

These Guidelines form part of the efforts of the Department of Energy (DOE) through the Philippine Efficient Lighting Market Transformation Project (PELMATP), as supported by the United Nations Development Programme - Global Environmental Facility (UNDP-GEF), to address the barriers to the widespread use of energy-efficient lighting systems in the Philippines.

These Guidelines were developed thru a consensus development process facilitated by the Institute of Integrated Electrical Engineers of the Phils., Inc. (IIEE), Philippine Lighting Industry Association (PLIA) and the Energy Management Association of the Philippines (ENMAP) together with various experts, professionals and stakeholders.

Though conscientious efforts have been exerted to make the contents of these guidelines as technically sound as possible, it is advised that it be applied by duly qualified and competent professionals. Any concern or issue as to its applicability, accuracy or completeness of this document shall be addressed to the Department of Energy for further validation and interpretation.

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Section 1. Purpose

These guidelines are aimed at providing policies and strategies for designing, operating and maintaining road lighting for use by administrators, contractors, designers, engineers and others involved in similar activities, with the view of achieving energy efficiency and savings while ensuring road visibility and safety.

Section 2. Scope and Applicability

2.1 These guidelines cover lighting systems used to illuminate expressways, major roads, collector roads, minor roads and rural highways, classified as follows:

- a. Expressways.** These are roads reserved for motor traffic which are accessible only from interchanges and with no crossings at grade.
- b. Major Roads.** These are roads which are part of a roadway system that serves as the principal network for through traffic flows. The routes connect areas of principal traffic generation from different cities or municipalities.
- c. Collector Road.** These are distribution and collector roadways servicing traffic between major and minor roadways. They are used mainly for traffic movements within residential, commercial, and industrial center in the urban areas.
- d. Minor Roads.** These roads include subdivision roads and local roadways that are used primarily as an access road to residential areas, commercial buildings and industrial plants and where there is minimal through traffic most of the time.
- e. Rural Highways.** These are provincial roads which serve as the principal network for through traffic in the rural areas.

2.2 These guidelines does not cover special categories such as landscape lighting (structure, hardscape and softscape), walkway and bikeway lighting, plaza and park lighting, outdoor lighting (sports, retail, etc.) and specialty area lighting.

2.3 All new national, local or barangay road lighting shall be constructed in accordance with these guidelines.

SECTION 2. SCOPE AND APPLICABILITY

2.4 All roadway lighting being modified, extended, expanded or added to the existing roadway installations shall conform to these guidelines.

Section 3. Lighting Luminaire

3.1 For Roadway Lighting, Type III Medium Semi Cutoff* High Pressure Sodium (HPS) luminaire**, or its equivalent, shall be used.

3.2 All roadway lighting in private, residential, commercial, industrial, municipal, recreational or institutional property shall be aimed, located and designed in such a way that it will not produce high discomfort glare to motorists and pedestrians.

3.3 For special applications where there would be regular maintenance on the lighting facility to be installed, the following shall apply:

- a.** For narrow barangay roads measuring one to three (1-3) meters and pedestrian walkways in provincial areas and for urban alleys, the use of outdoor type of luminaire with high efficiency linear or compact fluorescent lamps may be allowed provided that the lighting requirements in Table 6.5.1 are met.
- b.** Aesthetic lighting may be additionally installed provided that the basic requirements of roadway lighting based on Table 6.5.1 are first met.

* *Based on the IESNA outdoor luminaire classifications*

** *Other types of luminaire may be used provided that it can be proven through the testing of the Department of Energy (DOE) and Department of Trade and Industry (DTI) that it would result to a more efficient, economical, and better light distribution compared to those on Table 6.5.1.*

Section 4. Electrical System

4.1 Lamps and Ballasts

- 4.1.1** Ballast and lamp to be used shall be designed and manufactured according to the requirements in Section 9 and Section 10.
- 4.1.2** They shall operate within the range of voltage-current characteristic parameters that are compatible with each other.
- 4.1.3** Retrofit control gear shall have a power factor of 0.90 and above, and a Total Harmonic Distortion (THD) of 15% and below.

4.2 Grounding

- 4.2.1** Equipment shall be grounded in accordance with the latest edition of the Philippine Electrical Code Part 2 (PEC 2), including the installation of an equipment-grounding conductor.
- 4.2.2** All metal parts of the raceway should be connected to the grounding conductor, these includes the metal ground box lids, exposed metal conduit, metal poles, and supplemental ground rods at pole foundations (and other locations).

4.3 Voltage Drop

- 4.3.1** The roadway lighting shall be designed so that the farthest luminaire in the branch circuit shall still operate within the tolerable voltage supply level.

SECTION 4. ELECTRICAL SYSTEM

4.3.2 Corollary to the preceding requirement, typical computations showing the voltage profile of the lighting circuit shall be shown in the design plan and shall be approved by a duly licensed electrical engineer/s.

4.4 Controls. Roadway lighting system shall be provided with the means of controlling lighting facilities efficiently. Provisions 4.4.1 through 4.4.3 shall apply.

4.4.1 Roadway lighting should be provided with reliable photoelectric controls to keep lights turned ON/OFF automatically when needed even during adverse weather conditions.

4.4.2 Group controlled lighting systems shall be provided with NEMA Type 3R service cabinet, Philippine National Standard (PNS) compliant control breakers, and phototransistor or photodiode type fail-off electronic photoelectric control*.

4.4.3 Individually controlled lighting system shall make use of phototransistor or photodiode type electronic photoelectric control with the appropriate receptacle*.

4.5 Metering. Meter and meter-socket shall be provided for lighting systems not owned by the Distribution Utility (DU)/Electric Cooperative (EC) and shall be installed in accordance with the standards set by the DU/EC having franchise ownership over that area. Nevertheless, the end user may request for the installation of a meter and meter-socket if the lighting system is owned by the DU/EC.

* *Note: for detailed requirement of photoelectric control, refer to Section 11.*

SECTION 4. ELECTRICAL SYSTEM

4.6 Electrical Works and Materials

- 4.6.1** All electrical works and materials shall comply with the latest edition of the Philippine Electrical Code Part 1 and PEC 2.
- 4.6.2** All materials (equipment and devices) to be installed by the contractor shall be new and shall bear the Certification Mark (Philippine Standard Quality Mark or Import Commodity Clearance) issued by the Department of Trade and Industry-Bureau of Product Standards (DTI-BPS) for specific purposes.

Section 5. Structural System

5.1 General. The components of the structural system shall be compatible with each other including that of the luminaires and the accessories to be used.

5.2 Poles

5.2.1 Pole Height. The pole height specified shall result to the following:

- a. Adequate illumination intensity & uniform brightness of area covered. Refer to Table 6.5.2 for height and illumination requirement.
- b. Reduced glare. Refer to Table 6.5.2 for height and illumination requirement.

The maximum height of lighting poles to be installed near an airport or flight path shall be coordinated with the airport authority.

5.2.2 Pole Placement. Pole placement shall be based on the geometry, character of the roadway, physical features, environment, maintenance policy, economics, aesthetics, and overall lighting objectives. For proper configuration, refer to Section 8.

5.2.3 Type of Pole. The distribution pole that is usually used in conjunction with roadway lighting by Distribution Utilities shall be concrete, wood, aluminum or steel poles.

5.2.4 Material and Finish.

- a. Independent lighting poles shall have a minimum thickness of 4.5 mm and shall be hot-dipped galvanized in

SECTION 5. STRUCTURAL SYSTEM

accordance with Material and Finish. Generally, pole shaft shall be made in accordance with ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

- b. All lighting poles, made of steel, shall be hot-dip galvanized based on ASTM A123/A123M Standard Specification for Zinc (hot-dip galvanized) Coating on Iron and Steel Products.
- c. The zinc coating shall be relatively smooth and reasonably uniform in thickness. The parts shall be free from uncoated areas, blisters, flux deposits, block spots, dross inclusions, and other defects not consistent with good galvanizing practice.
- d. Pole surface shall be matte or dull finished to prevent glare.

5.2.5 Strength requirement. Pole shall be so designed to adequately bear the additional load imposed by the lighting equipment/facilities on the distribution poles and shall meet the strength requirements specified in the latest edition of PEC 2.

5.3 Mast Arm (Mounting Bracket). The mast arm which is the same as horizontal bracket that is used to support the luminaire shall have a length that is coordinated with the proper photometric distribution.

5.3.1 Material and Finish.

5.3.1.1 The mast arm shall be fabricated using Black Iron (BI) pipe that are manufactured in accordance with PNS 26 Steel – Black and hot-dipped zinc coated (galvanized) longitudinally welded steel pipes (for ordinary use) – Specification.

5.3.1.2 It shall be provided with mounting plate and stiffener to supplement its load bearing capacity.

SECTION 5. STRUCTURAL SYSTEM

5.3.1.3 It shall be designed in accordance with the strength requirements of PEC 2.

5.4 Foundations and Pads. The foundations and pads shall be designed to adequately support the luminaire and pole structure as well as resist wind blows and vibrations inherent in the area where the poles are going to be located.

Section 6. Lighting Parameters

6.1 Lighting Arrangement.

- 6.1.1** Single Sided arrangement, in which all luminaires are located on one side of the road, shall be used when the road width is less than or equal to the mounting height.

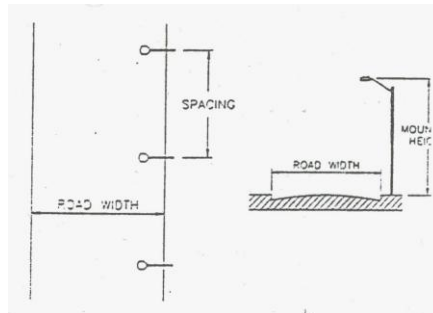


Figure 6.1 Single Sided Lighting Arrangement

- 6.1.2** Staggered arrangement, in which the luminaires are placed alternately on each side of the road in a “zig-zag” or staggered fashion shall be used when the Road Width is equal to 1 to 1.5 times the Mounting Height.

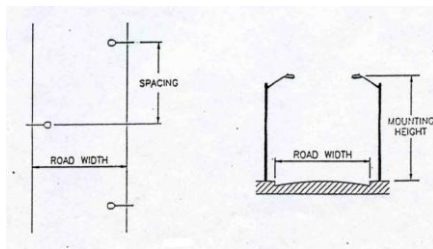


Figure 6.2 Staggered Lighting Arrangement

SECTION 6. LIGHTING PARAMETERS

- 6.1.3** Opposite arrangement, in which the luminaires are placed directly opposite and facing each other along the road, shall be used when the Road Width is more than 1.5 times the Mounting Height.

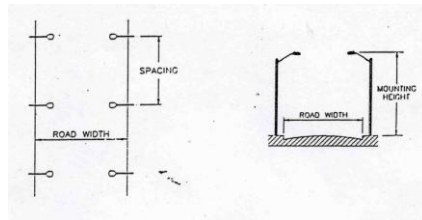


Figure 6.3 Opposite Lighting Arrangement

- 6.1.4** Twin Central arrangement, in which the luminaires are mounted on a T-shaped like masts in the middle of the center island of the road, shall be used when the road width is less than or equal to the mounting height.

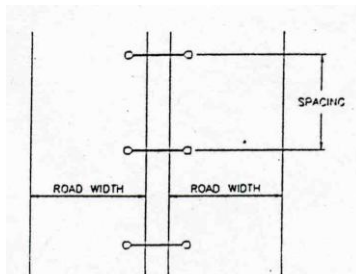


Figure 6.4 Twin Central Lighting Arrangement

6.2 Mounting Height.

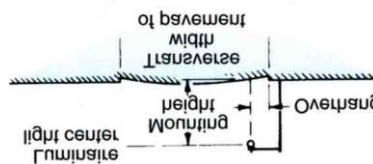


Figure 6.4 Mounting Height

SECTION 6. LIGHTING PARAMETERS

- 6.2.1** The mounting height shall be the perpendicular distance from the center of the lamp to the ground surface.
- 6.2.2** All roadway lighting shall have a mounting height in accordance with Table 6.5.2.
- 6.2.3** Where the luminaire overhangs the road surface, the minimum mounting height shall be generally 8.0 meters. However, a luminaire that does not overhang the roadway may have a minimum mounting height of 3.0 m provided that the installed luminaire used would not result into disability glare to the motorist and the pole is installed in accordance with the latest edition of PEC 2.

6.3 Spacing.

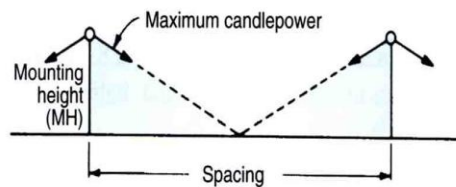


Figure 6.5 Spacing

- 6.3.1** Spacing shall be defined as the horizontal distance between poles supporting the luminaire.
- 6.3.2** The minimum and maximum allowable spacing shall be in accordance with the values set in Table 6.5.2.
- 6.3.3** The spacing of luminaires shall be closer for a curve than for a similar stretch of a straight road. A curved road that has a radius of 1000 m and above may be treated as a straight road.

6.4 Overhang.

- 6.4.1** The luminaire overhang shall be defined as the projected horizontal distance from the luminaire to the road curb.

SECTION 6. LIGHTING PARAMETERS

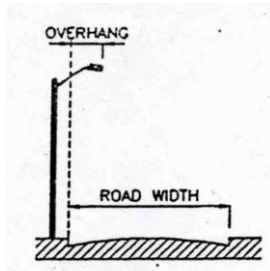


Figure 6.6 Overhang

6.4.2 Where the luminaire does not overhang the road curb, the new road width to be used in conjunction with Table 6.5.2 shall be computed in the following manner:

- a. For single sided and central roadway lighting arrangements, the new road width (R_n) to be considered shall be computed as follows:

$$R_n = R_a + (Ps - 1)$$

where:

R_n = new road width
 R_a = actual road width
 Ps = pole setback

- b. For opposite side and staggered roadway lighting arrangements, the new road width (R_n) to be considered shall be computed as follows:

$$R_n = R_a + (Ps_1 + Ps_2 - 2)$$

where:

R_n = new road width
 R_a = actual road width
 Ps_1 = pole setback of one side of the street
 Ps_2 = pole setback of the other side of the street

SECTION 6. LIGHTING PARAMETERS

Values for R_n may be rounded off to the nearest fives and tens when practical.

6.5 Design Consideration.

6.5.1 All roadway lighting design shall conform to the set criteria as prescribed in Table 6.5.1.

Table 6.5.1 Minimum Values for Roadway Lighting Parameters

Road Classification	Luminance	Uniformity Ratios		Glare Restrictions	
	Average Road Surface, Cd/m^2	Overall Uniformity Ratio	Longitudinal Uniformity Ratio	Glare Control Mark	Threshold Increment
Expressway	2.0	0.40	0.60	5.0	6.70
Major	1.0	0.40	0.50	5.0	10.00
Collector	1.0	0.40	0.40	5.0	13.00
Rural Highway	1.0	0.40	0.35	5.0	13.00
Minor	0.5	0.40	0.30	5.0	13.00

6.5.2 The following table shall be used for specifying Roadway Lighting Parameters:

Table 6.5.2 Specification Guide for Roadway Lighting

Road Classification	Road Width, meters	Arrangement	Lamp Wattage, watts	Luminaire Spacing, meters	Mounting Height, meters	Mast Arm Length, meters
Express	10	Twin Central	250	25-35	12	1.5
	15		250	20-35	12	3.0
	20	Opposite	250	20-45	12	1.5
	25		250	20-40	12	1.5
	30		250	20-30	12	1.5
	36		250	20-25	12	1.5
	40		250	20-22	12	1.5
Major	10	One-side	250	10-40	10	1.5
	15		250	10-45	12	3.0
	10	Twin Central	150	20-37	10	1.5
	15		250	20-43	12	3.0
	20	Opposite	150	20-40	10	3.0
	25		250	20-45	10	1.5
	30		250	20-45	10	1.5
	36		250	20-45	12	3.0
	40		250	20-45	12	3.0
Collector	10	One-side	150	10-40	10	1.5
	15		250	10-50	12	3.0
	10	Twin Central	150	20-40	10	1.5
	15		150	20-37	12	3.0

Table 6.5.2 (Continued)

Road Classification	Road Width, meters	Arrangement	Lamp Wattage, watts	Luminaire Spacing, meters	Mounting Height, meters	Mast Arm Length, meters
Collector	20	Opposite	150	20-47	10	1.5
	25		250	20-48	10	1.5
Rural Highway	8	One-side	150	10-38	8	1.5
	10		150	10-37	8	3.0
	15		150	15-38	10	3.0
	10	Twin Central	150	20-45	10	3.0
	15		150	20-39	12	3.0
	20	Opposite	150	20-45	8	1.5
Minor	4	One-side	70	10-40	8	1.5
	6		70	10-40	8	1.5
	8		70	10-40	8	1.5
	10		70	10-39	8	1.5
	10	Twin Central	70	20-35	8	1.5
	15	Staggered	70	10-20	8	1.5
	15	Opposite	70	20-40	8	1.5

Notes:

1. Assumed setback of pole from street curb is 1.0 m. In case where the pole setback is more than 1.0 m, a new road width shall be computed using the formula in Section 6.4. This computed new road width shall be the one that will be used in referring to Table 6.5.2.

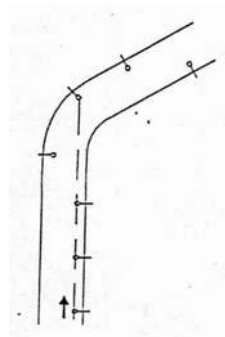
2. Luminaire spacing for curved roads shall be reduced by 25% to 50% of that indicated in the table.

Section 7. Lighting Configuration

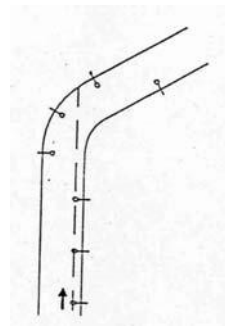
7.1 The lighting configuration shall set up as to provide the following:

7.1.1 Visual Alertness and Guidance. The roadway lighting configuration shall be able to provide visual alertness towards an approaching road junction and visual guidance at the junction itself and on curves (see Fig. 7.1). To meet the objective, the roadway lighting configuration shall possess at least one of the following:

- a. Difference in lighting arrangement
- b. Difference in luminaire height
- c. Use of different types of lamp
- d. Increased luminance at road junction



(a)
Improper installation



(b)
Proper installation

Figure 7.1 Illustrative guide on the proper and improper way of locating luminaires in curved roads.

SECTION 7. LIGHTING CONFIGURATION

7.1.1.1 The relative positions of the luminaires at the junction shall not be closer than the minimum distance given in Table 6.5.2.

7.1.1.2 For curved roads, visual guidance is enhanced by reducing the luminaire spacing by 25% to 50% of that normally applied for straight roads. Curves with a radius of 1000 m or more may be treated as straight roads.

7.1.1.3 For inclined roads, the roadway lights shall be so located such that the driver of a vehicle going uphill would not experience excessive glare discomfort.

7.1.2 Safety Clearance. The roadway lighting facilities shall conform to the latest edition of the PEC 2.

Section 8. Luminaire Requirements

8.1 Luminaire. For purposes of this section on the "luminaire" requirements, the term luminaire shall be defined as a complete lighting apparatus consisting of the housing and all integral parts necessary for its mounting, optical assembly, control gears and wiring assembly. Lamps are excluded in the luminaire specification. The requirements for lamp are listed in a separate section.

8.2 Standards. All luminaires shall meet applicable design and testing requirements of the latest edition of the PNS. If other equivalent internationally accepted standards are used, these standards and other supplementary standards, if applicable, shall be explicitly stated in the design proposal.

8.3 Design and Construction Features.

8.3.1 The housing of the luminaire shall be made of heat-treated, die-cast aluminum or aluminum alloy and shall be painted with an electro-coated gray paint finish.

8.3.2 Hardware such as hinges, latches, springs, nuts, screws, washers, pins, etc. shall be made of materials compatible to the housing material and shall be inherently corrosion-proof or have been protected by finishes approved for corrosion resistance. However, those exposed to the elements shall be made of high-grade stainless steel.

8.3.3 The luminaire shall be used for horizontal mounting on a mast arm. The mounting shall be designed using a clamping plate with at least two (2)-9.5 mm minimum diameter hexagonal head clamping bolts to mechanically clamp the luminaire to a 32-50 mm (1.25-2 inches) nominal diameter metal pipe end of the mast arm and adjust it to the required

SECTION 8. LUMINAIRE REQUIREMENTS

position. All clamps, hinges, and latches shall withstand high vibrations and wind pressure of up to 1244 Pa.

- 8.3.4** A shoulder or stop shall be provided to limit the insertion of the pipe end of the mast arm during installation. The open area surrounding the insertion shall be guarded against entry of birds or other wildlife.
- 8.3.5** The luminaire housing shall bear a nameplate or other type of indelible marking that shall identify it as to type, rating, manufacturer, date manufactured, catalog number, etc.
- 8.3.6** A wattage marking in accordance with the latest edition of the PNS shall be provided on the underside of the housing using black-colored numerals 50.8 mm minimum height with yellow gold-colored square background 76.2 mm minimum dimension on the side. The marking shall be visible from an observer on the ground and shall be designed to endure the life of the luminaire.
- 8.3.7** The luminaire housing shall be provided with a receptacle for a three-prong, twist-lock type photoelectric control, unless otherwise specified in the inquiry or purchase order.
- 8.3.8** The luminaire surfaces, joints, and rim shall be smooth and free of burrs and sharp edges that could cause injury to the workman.
- 8.3.9** The luminaires shall have a special protective lens to minimize UV radiation in the event that the outer glass bulb is broken.

8.4 Electrical Rating

- 8.4.1** The luminaire shall be designed to operate at 230 volts A.C., 60 hertz, single-phase.
- 8.4.2** The standard wattage rating could either be for 70 watts, 150 watts, or 250 watts.

SECTION 8. LUMINAIRE REQUIREMENTS

8.5 Optical Assembly

- 8.5.1 The reflector shall be made from approved material and shall be capable of efficiently directing the light in the required directions while reducing it in directions where it might cause glare discomfort.
- 8.5.2 The refractor shall be prismatic type made from heat/impact-resistant glass. It shall be held in place in such a manner as to allow for its expansion and contraction.
- 8.5.3 The design of the optical system shall be based on the use of a clear, tubular or ovoid/elliptical lamp.
- 8.5.4 The lamp socket shall be designed for high-pressure sodium lamp with E27 base for 70-watt or E39/40 base for 150-watt and 250-watt applications. It shall be of 600-volt classification, made from glazed porcelain with one-piece rolled threads and stationery socket lead connectors that will not move during lamp insertion and removal. The screw shell shall be constructed of nickel-plated brass material or any materials made in accordance with PNS. The center contact inside the socket shall be spring-loaded to provide lamp-gripping action.
- 8.5.5 The refractor-housing and socket-reflector junctions shall be adequately sealed against entry of moisture, rainwater, dust or insects, with provisions for thermal breathing and air filtering.
- 8.5.6 The luminaire light distribution shall be IES Type III, medium distribution, semi-cutoff classification or equivalent. The manufacturer shall submit photometric data consisting of the isolux and horizontal illumination diagrams showing the projection of maximum candlepower and half maximum candlepower isocandela trace on the roadway for various mounting heights (i.e., 6, 7, 8, 9, 10 & 12 meters), utilization data.

SECTION 8. LUMINAIRE REQUIREMENTS

8.6 Control Gears and Wirings

8.6.1 The ballast shall be high power factor (power factor $\geq 90\%$), reactor type. The manufacturer shall determine the correct rating of the capacitor to be installed to achieve the desired power factor. The ballast shall be designed to have an expected minimum average life of 10 years under the condition of a maximum permissible winding temperature of 130°C.

8.6.2 The ballast shall be designed to operate a high-pressure sodium vapor lamps with the following ratings whichever may be specified:

Lamp wattage, watts	Nominal lamp voltage, volts	Nominal lamp current, amperes
70	90	1.0
150	100	1.8
250	100	3.0

8.6.3 The ballast shall be corrosion and moisture-resistant and shall satisfy the design and testing requirements of the PNS.

8.6.4 All ballasts shall be complete with electrically matched starter/ignitor component.

8.6.5 The starter/ignitor component shall be a solid-state device capable of withstanding temperature of 100°C. It shall provide timed pulsing with sufficient follow through current to completely ionize and start all lamps that meet published ANSI or IEC standards. The starter/ignitor circuit board shall be treated in an approved manner to provide moisture resistant coating.

SECTION 8. LUMINAIRE REQUIREMENTS

- 8.6.6** The ballast and starting component shall be designed to protect itself against normal lamp failure modes. Ballasts shall be capable of operation with the lamps in the open circuit or closed circuit failure condition for at least six months without significant loss of life.
- 8.6.7** The ballast, starter/ignitor and capacitor shall be field replaceable with no adjustment necessary for proper operation and ease of maintenance.
- 8.6.8** The starting circuit-ballast combination shall be designed to consistently provide the following parameters:
- a.** Lamp wattage must be maintained with the trapezoid recommended by lamp manufacturers within the full rated input voltage range.
 - b.** Pulse characteristics shall conform to ANSI or IEC specifications.
- 8.6.9** The ballast, starter/ignitor and capacitor shall each bear a nameplate or other type of indelible marking complete with information the same as those specified for the luminaire housing in Subsection 9.3(e).
- 8.6.10** The photoelectric control receptacle, when provided, shall conform to ANSI C136.10, latest revision or equivalent.
- 8.6.11** All components shall be securely fastened to the housing gear compartment and completely pre-wired using a terminal block. A wiring diagram shall be provided, legible and permanently affixed inside the luminaire. The diagram shall indicate the ballast, capacitor, lamp socket, photoelectric control receptacle, starter/ignitor circuit, and coded terminal block connections.
- 8.6.12** All circuitry wirings shall be insulated to a minimum temperature rating of 125°C. Electrical terminations and connections shall have provisions that ensure good electrical and mechanical integrity and ease of replacement. Terminals

SECTION 8. LUMINAIRE REQUIREMENTS

of supply conductor shall be connected to the terminal block by means of screw-on type connections.

8.7 Tests and Inspection. All tests on the luminaire and its components shall be performed in accordance with applicable testing procedures and acceptance criteria of applicable PNS. Certified test reports for all types of test conducted shall be submitted prior to shipment of the luminaires.

Section 9. High Pressure Sodium Lamps Requirements

9.1 Standards. All lamps furnished under this specification shall meet applicable design and testing requirements of the latest edition of the PNS. If other equivalent internationally accepted standards are used, these standards and other supplementary standards, if applicable shall be explicitly stated in the proposal.

9.2 Design and Construction and Features

- 9.2.1** Lamps shall have clear, ovoid/elliptical glass envelopes.
- 9.2.2** Lamp dimensions shall conform to the requirements of the latest edition of the ANSI or IEC standard.
- 9.2.3** Screw caps (bases) shall be E27 for 70-watt and E40 for 150-watt and 250-watt high-pressure sodium lamps.
- 9.2.4** All lamps shall be externally ignited and designed to operate in a universal burning position.
- 9.2.5** The following information shall be distinctly and durably marked on each lamp:
 - a.** Mark of origin in the form of trademark or the manufacturer's mark.
 - b.** Rated wattage and voltage

9.3 Electrical Rating. Lamps shall be designed based on the following ratings:

SECTION 9. HIGH PRESSURE SODIUM LAMPS REQUIREMENTS

Lamp wattage, watts	Nominal lamp voltage, volts	Nominal lamp current, amperes	Mean lumen output, lumens
70	90	1.0	5400
150	100	1.8	13500
250	100	3.0	24750

9.4 Tests and Inspection. All tests on lamps shall be performed in accordance with applicable testing procedures and acceptance criteria of the latest edition of the PNS.

Section 10. Photoelectric Controls Requirements

This specification covers requirements for photoelectric controls rated 230 volts AC, 60 hertz used primarily for switching high pressure mercury vapor and high pressure sodium vapor lamps in road way lighting applications.

10.1 Standards. All photoelectric controls shall meet the design and testing requirements of the latest applicable ANSI standards. If equivalent internationally accepted standards are used, these standards and other supplementary standards, if applicable, shall be explicitly stated in the proposal.

10.2 Service Conditions

10.2.1 Physical Conditions. The photoelectric control shall provide reliable switching of high-pressure mercury vapor and high-pressure sodium vapor lamps under the following environmental conditions:

Ambient temperature range, °C	10°C - 50°C
Moisture level	90% relative humidity at 40°C
Specific corrosive contaminants at site	Salt water, excessive dust, fumes and/or soot

10.2.2 Operating Conditions

10.2.2.1 The photoelectric control shall turn on at a nominal light level setting of 10.76 lux (1.0 footcandle)

SECTION 10. PHOTOELECTRIC CONTROLS REQUIREMENTS

which is within the limits of 5.38 to 21.52 lux (0.5 to 2.0 footcandles) at rated voltage of 230 V AC, 60 Hz. It shall be adaptable for calibration up to 107.64 lux (10 footcandles).

10.2.2.2 The ratio of the turn-off to the turn-on light level shall not exceed 3.

10.2.2.3 The photoelectric control shall be designed with a fail-off failure mode.

10.3 Electrical Features

10.3.1 Rated Voltage. The photoelectric control shall be rated at 230 volts AC, 60 Hz.

10.3.2 Rated Load. The photoelectric control shall have a minimum load rating of both 1000 watts incandescent lamp load and 1800 volt-amperes load. The volt-ampere load consists of lamp wattage, ballast losses, and a reactive volt-amperes with power factor of $\geq 50\%$.

10.3.3 Dielectric Withstand. The electrical insulation of the photoelectric control shall withstand for one minute a 60-Hz Dielectric Withstand Test of 2.5 kV r.m.s. minimum (dry) between current-carrying components and any metallic portion of the enclosure or receptacle with its mounting.

10.3.4 Surge Protection. The photoelectric control shall be provided with a Metal Oxide Varistor (MOV) arrester capable of at least 160 joules energy dissipation and a clamping voltage of not greater than 1,000 volts.

10.3.5 Power Consumption. The power consumption of the photoelectric control shall not exceed 3 VA.

Section 11. Tunnels / Underpasses

11.1 All roadways below the normal thoroughfare level, whether classified as tunnel or underpass shall be adequately and efficiently lighted.

11.2 For Tunnel Lighting, asymmetrical type of High Pressure Sodium luminaire shall be used.

11.3 Photoelectric controls shall be strategically designed and located along tunnel / underpass to activate roadway lights as necessary especially during nighttime and during adverse weather condition.

11.4 The entrance, interior, and exit portion of the tunnel shall be provided with separate control system.

11.5 Ceiling and wall surfaces shall be of a light color, easily maintained finish and highly reflective with an initial reflectance of 50%.

11.6 Uniformity of roadway lighting is critical to visibility and safe adaptation in tunnel lighting. A tunnel lighting layout should be designed based on luminance values to insure the average to minimum uniformity ratio do not exceed 2 to 1 and a maximum to minimum ratio of 2.5 to 1.

11.7 Construction material to be used shall be of the type that would reduce the luminance contrast between the outside and the inside of the tunnel, which in turn reduce entrance zone luminance and illuminance requirements.

11.8 The luminance level shall be designed to provide direct illumination ranging from the adaptable daylight brightness to minimum nighttime lighting requirement with minimal or no glare.

SECTION 11. TUNNELS/UNDERPASSES

11.9 Warrants for Tunnel Lighting.

- 11.9.1** The design of tunnel lighting shall take into consideration the physiological limitation of the human eye to adapt from a bright environment to a relatively darker environment to avoid the “black hole effect”.
- 11.9.2** Lighting shall be extended up to the level where the motorist could distinguish lane markings. Lane markings should be easily recognized in order to provide safe driving condition.
- 11.9.3** Prior to establishment of a lighting design, an evaluation of brightness conditions (pavement, adjacent landscape, sky, and others) must be made for the actual roadway and tunnel.
- 11.9.4** The optimization conditions of the tunnel lights shall produce an adequate visibility level of not less than 3cd/m^2 .
- 11.9.5** Tunnel lighting control systems shall be designed to have the least probability of a total tunnel outage in the event of a circuit failure or other breakdown.

