Chapter Fifty-six

HIGHWAY LIGHTING

BUREAU OF DESIGN AND ENVIRONMENT MANUAL

Chapter Fifty-six
HIGHWAY LIGHTING

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Chapter Fifty-six

HIGHWAY LIGHTING

56-1 GENERAL

The general purpose of roadway lighting is to provide improved safety, security, and aesthetics for the various users of the roadway and associated facilities. Lighting enables the driver to recognize the geometry and condition of the roadway at extended distances, thereby simplifying the driving task at night. This, in turn, increases driver visual comfort and reduces driver fatigue, which contributes measurably to highway safety.

Due to the large and diverse volume of highway lighting information, it would be impractical for this Chapter to present a complete design guide. Instead, the intent is to provide the user with a synopsis of the highway lighting design process and to present IDOT's criteria, policies, and procedures on this issue. Use the references listed in Section 56-1.01 as guidance for highway lighting design.

56-1.01 References

For information applicable to IDOT highway lighting design projects, see the following publications:

1. *American National Standard Practice for Roadway Lighting*, (ANSI/IESNA RP-8), American National Standards Institute/Illuminating Engineering Society of North America;
2. *Roadway Lighting Design Guide*, American Association of State Highway and Transportation Officials;
3. *National Electrical Code*, National Fire Protection Association;
4. *National Electrical Safety Code*, American National Standards Institute/Institute of Electrical and Electronics Engineers;
5. *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, American Association of State Highway and Transportation Officials;
6. *Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, National Cooperative Highway Research Program Report No. 411, Transportation Research Board;
7. *A Guide to Standardized Highway Lighting Pole Hardware*, American Association of State Highway and Transportation Officials;

8. *Roadside Design Guide*, American Association of State Highway and Transportation Officials;

9. *Standard Specifications for Road and Bridge Construction*, Illinois Department of Transportation;

10. Supplemental Specifications and Recurring Special Provisions, Illinois Department of Transportation;

11. *Highway Standards*, Illinois Department of Transportation;

12. *Electrical Detail Sheets*, Illinois Department of Transportation;

13. *Warrants for Highway Lighting*, National Cooperative Highway Research Program Report No. 152, Transportation Research Board;

14. *Partial Lighting of Interchanges*, National Cooperative Highway Research Program Report No. 256, Transportation Research Board;

15. *Illinois Manual on Uniform Traffic Control Devices (ILMUTCD)*, IDOT;

16. *American National Standard Practice for Tunnel Lighting*, ANSI/IESNA RP-22, American National Standards Institute/Illuminating Engineering Society of North America;

17. *IESNA Recommended Practice for Roadway Sign Lighting*, IESNA RP-19, Illuminating Engineering Society of North America;

18. *Design Guide for Roundabout Lighting*, IESNA DG-19, Illuminating Engineering Society of North America;

19. *Luminaire Classification System for Outdoor Luminaires*, IESNA TM-15, Illuminating Engineering Society of North America;

20. US Coast Guard Bridge Administration Manual COMDTINST M16590.5, *Bridge Lighting and Other Signals;*

21. FAA Advisory Circular AC 70/74602J *Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace*; and

22. *Recommended Lighting for Walkways and Class 1 Bikeways*, IESNA DG-5, Illuminating Engineering Society of North America.

56-1.02 Responsibilities

Each district is responsible for the highway lighting projects within their respective jurisdictions (e.g., information gathering, plan preparation). See Chapter 63 for additional information on plan preparation. The district is also responsible for the coordination of Electrical and Mechanical Unit in the Central Office or consultant designs and plan submittals.

The district will contact the Electrical and Mechanical Unit in the Central Office to design the project lighting or to have it designed by a consultant. If it is decided to have it designed by a consultant, a pre-design discussion will be held with the consultant to outline the lighting design parameters for the project.

The consultant lighting design must be submitted and approved by the Electrical and Mechanical Unit before lighting plans are submitted. The district will submit all consultant preliminary and final lighting plans to the Central Office for review and approval by the Electrical and Mechanical Unit.

Lighting plans for all types of lighting installations will be reviewed and approved by the Electrical and Mechanical Unit in the Central Office. See Chapter 11 for additional information on the local agency highway lighting improvement projects that must be submitted for review.

District 1 is responsible for highway lighting projects within their jurisdiction. This includes both lighting design and plan review for approval.

56-1.03 Definitions

The following definitions are for a common understanding of terms for non-practitioners in the lighting field; consult listed references for detailed definitions:

1. Average Initial Illuminance. The average level of horizontal illuminance on the pavement area of a traveled way at the time the lighting system is installed, when lamps are new and luminaries are clean; expressed in average footcandles (lux) for the pavement area. See definition of Illuminance.

2. Average Maintained Illuminance (E_h). The average level of horizontal illuminance on the roadway pavement when the output of the lamp and luminaire is diminished by the maintenance factor (MF); expressed in average footcandles (lux) for the pavement area. See definition for Maintenance Factor.

3. Ballast. An electrical device used with high-intensity discharge lamps to regulate electric current through the lamp and provide the necessary voltage to start and operate the lamp.

4. Candela (cd). A measure of the luminous intensity of a light source as seen by the eye (a.k.a., “candle”). For example, because the eye is less sensitive to blue light than to green light, a blue light source must radiate more power in watts (W) than a green light source if the two are to have the same luminous intensity. Most light sources have different luminous intensities when viewed from different directions and so the luminous intensity for a light source may vary with the angle at which it is viewed (1 cd = 1 cp).

5. Candela per Square Meter (cd/m^2). The metric unit of luminance (photometric brightness) that is equal to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square meter (lm/m^2) or the average luminance of any surface emitting or reflecting light at that rate (1 cd/m^2 = 0.2919 fl).

6. Candlepower (cp). The luminous intensity in a specific direction; expressed in candelas (cd). It is no indication of the total light output (1 cp = 1 cd).

7. Coefficient of Utilization (CU). The ratio of the luminous flux (lm) from a luminaire received on the pavement surface to the rated lumens emitted by the luminaire.

8. Disability Glare. Glare resulting in reduced visual performance and visibility. It often is accompanied by discomfort. See definitions for Discomfort Glare and Glare.

9. Discomfort Glare. Glare producing discomfort. It does not necessarily interfere with visual performance or visibility. See definition for Glare.

10. Footcandle (fc). The US Customary unit of measurement for illuminance on a surface one square foot (ft^2) in area where there is uniformly distributed a light flux of one lumen (lm) (1 fc = 10.76 lx).

11. Footlambert (fl). The US Customary unit of luminance (photometric brightness) equal to the uniform luminance of a perfectly diffusing surface emitting or reflecting light at the rate of one lumen per square foot (lm/ft^2) or the average luminance of any surface emitting or reflecting light at that rate (1 fl = 3.426 cd/m^2).

12. Glare. The optical sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted and causes annoyance, discomfort, or loss in visual performance and visibility. See definitions for Disability Glare and Discomfort Glare.

13. House Side. The horizontal direction away from the roadway or behind the nadir of the luminaire. See definitions for Street Side and Nadir.

14. Isolux Diagram. A diagram plotted on any appropriate set of coordinates to show all points on a surface where the illuminance is the same, represented by a series of isolux line curves.

15. Illuminance. The density of the luminous incident on a surface. It is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated.

16. Lamp Lumen Depreciation Factor (LLD). A depreciation factor that indicates the decrease in a lamp's initial lumen output over time. For design calculations, the initial lamp lumen value is reduced by LLD to compensate for the anticipated lumen reduction. See definition for Maintenance Factor.

17. Light Standard (Pole). A pole provided with the necessary internal attachments for wiring and the external attachments for the bracket and luminaire.

18. Longitudinal Roadway Line (LRL). A line along the roadway parallel to the curb or shoulder line. See definition for Transverse Roadway Line.

19. Lumen (lm). The unit of luminous flux. It is equal to the flux through a unit solid angle (steradian), from a uniform point source of one candela (cd), or to the flux on a unit surface, all points of which are at unit distance from a uniform point source of one candela.

20. Luminaire. A complete lighting unit consisting of a lamp or lamps and ballast together with accessories (reflector and/or refractor) designed to distribute the light to its intended target area.

21. Luminaire Dirt Depreciation Factor (LDD). A depreciation factor that indicates the expected reduction of a lamp's initial lumen output due to the accumulation of dirt on or within the luminaire over time. See definition for Maintenance Factor.

22. Luminance. The luminous intensity of any surface in a given direction per unit of projected area of the surface as viewed from that direction.

23. Luminous Efficacy (lm/W). The quotient of the luminous flux (lm) emitted by the total lamp power input. It is expressed in terms of lumens per watt (lm/W).

24. Luminous Efficiency (%). The ratio of the total luminous flux emitted by a luminaire to that emitted by the bare lamp.

25. Luminous Intensity. See definition of Candela.

26. Lux (lx). The metric unit of illuminance on a surface one square meter (m^2) in area on which there is uniformly distributed light flux of one lumen (lm), or the illuminance produced on a surface where all points are at a distance of one meter (m) from a uniform point source of one candela (cd) ($1 \text{ lx} = 1 \text{ lm/m}^2 = 0.0929 \text{ fc}$).

27. Maintenance Factor (MF). A combination of light loss factors (LLD, LDD, EF) used to denote the reduction of the illumination for a given area after a period of time compared to the initial illumination on the same area (MF = Luminaire Lumen Depreciation (LLD) • Luminaire Dirt Depreciation (LDD) • Equipment Factor (EF)).

28. Mounting Height. The vertical distance between the roadway surface and the center of the light source in the luminaire.

29. Nadir. The vertical axis that passes through the center of the luminaire light source.

30. Overhang. The horizontal distance between a vertical line through the nadir of a luminaire and the edge of traveled way or edge of the area to be illuminated.

31. Setback. The horizontal distance between the face of a light pole and the edge of traveled way.

32. Spacing. The distance in meters between successive light poles.

33. Street Side. The horizontal direction toward the roadway from the nadir of the luminaire. See definition of House Side.

34. Transverse Roadway Line (TRL). Any line across the roadway that is perpendicular to the curb or shoulder line. See definition of Longitudinal Roadway Line.

35. Uniformity Ratio (E_h/E_{min}). The ratio of average maintained horizontal illuminance (E_h) to the maintained horizontal illuminance at the point of minimum illumination (E_{min}) on the pavement. A uniformity ratio of 3:1 means that E_h - footcandles (lux) is three times the E_{min} - footcandles (lux) at the point of least illuminance on the pavement.

36. Utilization Curve. A plot of the quantity of light falling on the horizontal surface both in front (street side) and behind (house side) the luminaire. It shows only the percent of bare lamp lumens that fall on the horizontal surface and is plotted as a ratio of width of area to mounting height of luminaire.

56-2 GUIDELINES FOR JUSTIFYING HIGHWAY LIGHTING

Providing lighting for all highway facilities is neither practical nor cost effective. It is generally IDOT's practice only to provide highway lighting where justified based on sound engineering judgment and on the criteria, recommendations, and principles presented in the AASHTO publication *Roadway Lighting Design Guide* and NCHRP Report No. 152 *Warrants for Highway Lighting*.

The Department will assess the economic feasibility of lighting on roadway projects and prioritize potential lighting projects. A location that appears to justify lighting does not necessarily obligate the Department to provide funding. Local agencies may provide lighting within their respective jurisdictions provided they find sufficient benefit in the forms of convenience, safety, policing, community promotion, public relations, etc., to participate in an appreciable percentage of the cost of, or wholly finance, the installation, maintenance, operation, and energy needs of the lighting facilities; see Chapter 5.

For a highway lighting facility to be considered for funding by IDOT, the lighting system must be both economically feasible and justified based on the applicable criteria presented in the following sections. The impacts of local conditions (e.g., frequent fog, ice, snow, roadway geometry, ambient lighting, sight distance, signing) should also be considered when analyzing highway lighting needs.

56-2.01 Analyzing Highway Lighting Needs

The AASHTO publication *Roadway Lighting Design Guide* presents an empirical approach to analyzing highway lighting needs with primary application to freeway-type facilities. The principal considerations are vehicular traffic volume, interchange spacing (i.e., an indicator of the relative frequency of vehicular traffic maneuvers), land development and artificial lighting conditions in the area surrounding the freeway, and the night-to-day crash ratio. The affect of these factors on driver visibility should be considered in the lighting needs analysis.

A supplemental approach to analyzing highway lighting needs, based primarily on an analytical evaluation of driver information, is published in NCHRP Report No. 152 *Warrants for Highway Lighting*. This publication has application to both urban-type facilities (e.g., streets, arterials, intersections) and freeway-type facilities (e.g., Interstates). In urban areas where the analyst may find difficulty in applying the AASHTO empirical approach, Report No. 152 offers an alternative approach for analyzing highway lighting needs. Additional information for analyzing partial interchange lighting is available in NCHRP Report No. 256.

56-2.02 Freeways

Use the criteria presented in the following sections when analyzing the lighting needs for State-maintained freeway facilities.

56-2.02(a) Continuous Freeway Lighting

Continuous lighting consists of all mainline and direct connections, and provides for complete lighting of all associated interchanges. Lighting may be provided through high-mast facilities, conventional, or both. Continuous freeway lighting (CFL) should be considered under the following conditions:

1. Freeway Volume. On those freeway sections in and near cities where the current ADT is 30,000 or more, CFL should be considered.
2. Interchange Spacing. CFL should be considered where three or more successive interchanges are located with an average spacing of 1.5 miles (2.5 km) or less, and adjacent areas outside the right-of-way are substantially urban in character.
3. Land Development/Lighting Conditions. Consider CFL where, for a length of 2 miles (3 km) or more, the freeway passes through a substantially developed suburban or urban area where one or more of the following conditions exist:
   - local traffic operates on a complete street grid having some form of street lighting, parts of which are visible from the freeway;
   - the freeway passes through a series of developments (e.g., residential, commercial, industrial areas, civic areas, colleges, parks, terminals), which include facilities (e.g., roads, streets, parking areas, yards) that are lighted;
   - separate cross streets, with and without connecting ramps, occur with an average spacing of 0.5 miles (1 km) or less, some of which are lighted as part of the local street system; or
   - freeway cross-section elements (e.g., median, shoulders) are substantially reduced in width below desirable criteria in relatively open country.
4. Night-To-Day Crash Ratio. CFL should be considered where the night-to-day ratio of crash rates is at least 2.0 or higher than the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. The number of nighttime crashes should also be evaluated.
5. Local Agency Needs. CFL should be considered where the local agency finds sufficient benefit in the forms of convenience, safety, policing, community promotion, public relations, etc., to pay an appreciable percentage of the cost of, or wholly finance, the installation, maintenance and operation of the lighting facilities. See Chapter 5 for additional information on local agencies’ lighting responsibilities.
6. Local Conditions. CFL should be considered where local conditions (e.g., frequent fog, ice, snow, roadway geometry, ambient lighting, sight distances, or frequent advertising signing) could justify lighting.

56-2.02(b) Complete Interchange Lighting

Complete interchange lighting (CIL) consists primarily of lighting the freeway's through traffic lanes within the interchange area, the traffic lanes of all ramps, the acceleration and deceleration lanes, all ramp terminals, and the crossroad between the outermost ramp terminals. Consider CIL at interchanges under the following conditions:

1. Ramp Volume. CIL should be considered where the total current ADT ramp traffic entering and exiting the freeway within the interchange area exceeds 10,000 for urban conditions, 8000 for suburban conditions, or 5000 for rural conditions.
2. Crossroad Volume. Consider CIL where the current ADT on the crossroad exceeds 10,000 for urban conditions, 8000 for suburban conditions, or 5000 for rural conditions.
3. Land Development/Lighting Conditions. Consider CIL at locations on unlighted freeways where existing substantial commercial or industrial development, which is lighted during hours of darkness, is located in the immediate vicinity of the interchange, or where the crossroad approach legs are lighted for 0.5 miles (1 km) or more on each side of the interchange.
4. Night-to-Day Crash Ratio. CIL should be considered where the night-to-day ratio of crash rates within the interchange area is at least 1.5 or higher than the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. The number of nighttime crashes should also be evaluated.
5. Local Agency Needs. CIL should be considered where the local agency finds sufficient benefit in the forms of convenience, safety, policing, community promotion, public relations, etc., to pay an appreciable percentage of the cost of, or wholly finance, the installation, maintenance, and operation of the lighting facilities. See Chapter 5 for additional information on lighting responsibilities of local agencies.
6. Continuous Freeway Lighting. Provide CIL at interchanges where continuous freeway lighting is provided. See Section 56-2.02(a).

56-2.02(c) Partial Interchange Lighting

Partial interchange lighting (PIL) generally is a lighting configuration that defines lighting for the decision-making areas. It consists of a few luminaires located in the vicinity of all ramp terminals. The usual practice is to light those general areas where the exit and entrance ramps connect with the through traffic lanes of the freeway and generally those areas where the ramps intersect the crossroad. Consider PIL at interchanges under the following conditions:

1. Ramp Volume. Consider PIL where the total current ADT ramp traffic entering and exiting the freeway within the interchange area exceeds 5000 for urban conditions, 3000 for suburban conditions, or 1000 for rural conditions.

2. Freeway Volume. Consider PIL where the current ADT on the freeway through traffic lanes exceeds 25,000 for urban conditions, 20,000 for suburban conditions, or 10,000 for rural conditions.

3. Night-to-Day Crash Ratio. PIL should be considered where the night-to-day ratio of crash rates within the interchange area is at least 1.25 or higher than the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. The number of nighttime crashes should also be evaluated.

4. Local Agency Needs. PIL should be considered where the local agency finds sufficient benefit in the forms of convenience, safety, policing, community promotion, public relations, etc., to pay an appreciable percentage of the cost of, or wholly finance, the installation, maintenance, and operation of the lighting facilities. See Chapter 5 for additional information on local agencies' lighting responsibilities.

5. Continuous Freeway Lighting. Consider PIL where continuous freeway lighting is justified, but not initially installed. See Section 56-2.02(a). The freeway section should be in or near a city where the current ADT is 30,000 or more, or the interchange should be among three or more successive interchanges located with an average spacing of 1.5 miles (2.5 km) or less with adjacent areas outside the right-of-way being substantially urban in character.

6. Complete Interchange Lighting. Where complete interchange lighting is justified, but not initially fully installed, a partial lighting system, which exceeds the normal partial installation in number of lighting units, is considered to be justified. See Section 56-2.02(b).

NCHRP Report No. 256 *Partial Lighting of Interchanges* provides additional information on analyzing the need for partial interchange lighting.

56-2.02(d) Crossroad Ramp Terminal Lighting

Lighting of the crossroad ramp terminal should be considered regardless of traffic volume where the crossroad ramp terminal design of freeway interchanges incorporates raised channelizing or divisional islands, where there is poor sight distance, or roadway alignment constitutes curvature or severe slopes.

56-2.03 Streets and Highways Other Than Freeways

Urban and rural conditions, traffic volumes (both vehicular and pedestrian), intersections, turning movements, signalization, channelization, and varying geometrics are factors that should be considered when determining the lighting needs of streets and highways other than freeways. Consider the following when assessing the lighting needs of such State-maintained facilities. NCHRP Report No. 152 *Warrants for Highway Lighting* provides additional information analyzing the need for lighting.

1. Facilities with Raised Medians. Consider highway lighting along sections of State-maintained facilities that have raised medians.

2. Major Urban Arterials. Consider highway lighting along all major arterials that are located in urban areas.

3. Intersections. Consider intersection lighting at rural intersections that meet any one of the following conditions:

    - there are 2.4 or more crashes per million vehicles in each of three consecutive years;
    - there are 2.0 or more crashes per million vehicles per year and 4.0 or more crashes per year in each of three consecutive years;
    - there are 3.0 or more crashes per million vehicles per year and 7.0 or more crashes per year in each of two consecutive years;
    - the intersection is signalized and in the past year the day-to-night crash ratio is at least 1.25 or higher than the Statewide average for similar signalized intersections;
    - substantial nighttime pedestrian volume exists;
    - less than desirable alignment exists on any of the intersection approaches;
    - intersection approach roadway leg has less than the required Safe Sight Stopping Distance (SSSD) at the intersection;
    - the intersection is an unusual type requiring complex turning maneuvers;
    - commercial development exists in the vicinity, which causes high nighttime traffic peaks;
    - distracting illumination exists from adjacent land development; and/or
    - there exists recurrent fog or industrial smog in the area.

    Isolated intersections located within the fringe of corporate limits that are suburban or rural in character may be illuminated at the State's expense provided they meet the above criteria. Every effort should be made to have the local agency accept ownership of the system after installation and assume all operational and maintenance costs. See Chapter 5 for additional information on lighting responsibilities of local agencies.

4. High-Conflict Locations. Consider lighting along roadway sections with high vehicle-to-vehicle interactions (e.g., sections with numerous driveways, where driveway separation is less than one SSSD, significant commercial or residential development, driveways with larger percentage of turning traffic, large complex intersection with more than one turning lane in one direction, intersection with raised medians, high percentage of trucks). Lighting generally improves traffic safety and efficiency at such locations.

5. Complex Roadway Geometry. Consider lighting at spot locations in rural areas where the driver is required to pass through a roadway section with complex or substandard geometry.

6. Night-to-Day Crash Ratio. Lighting should be considered at locations or sections of streets and highways where the night-to-day ratio of crash rates is higher than the statewide average for similar locations, and a study indicates that lighting may be expected to significantly reduce the night crash rate.

7. Local Agency Needs. Lighting should be considered where the local agency finds sufficient benefit in the forms of convenience, safety, policing, community promotion, public relations, etc., to pay an appreciable percentage of the cost of, or wholly finance, the installation, maintenance, and operation of the lighting facilities. See Chapter 5 for additional information on lighting responsibilities of local agencies.

8. Pedestrian Sidewalk. Consider lighting the sidewalk along the roadway section. Properly designed highway lighting may provide adequate roadway and sidewalk lighting without the need for supplemental or separate sidewalk lighting.

56-2.04 Rest Areas

Provide lighting at rest areas that offer complete rest facilities (e.g., comfort station, information kiosk, picnic areas). Illuminate all areas within the facility that have pedestrian activities (e.g., parking areas, immediate area of building). Provide lighting at rest area ramps, gore areas, other decision points, and traffic conflict areas.

56-2.05 Weigh Stations

Provide lighting and overheight detectors at all permanent truck weigh stations. Illuminate the weighing area, parking areas, speed change lanes, ramps, and gore areas.

56-2.06 Bridge Structures and Underpasses

Because of their typical configuration and length-to-height ratio, underpasses generally have good daylight penetration and do not require supplemental daytime lighting. Underpass lighting generally is installed to enhance driver visibility after daylight hours. When the underpass length-to-height ratio exceeds approximately 10:1, it usually is necessary to analyze specific geometry and roadway conditions, including vehicular and pedestrian activity, to determine the need for supplemental daytime lighting. See ANSI/IESNA *American National Standard Practice for Tunnel Lighting* for more information on daytime lighting.

On highways that are not continuously lighted, consider providing underpass lighting where frequent nighttime pedestrian traffic exists through the underpass or where unusual or critical geometry exists within or on an approach to the underpass.

Provide underpass lighting on all highways that are continuously lighted. Favorable positioning of conventional highway luminaires adjacent to a relatively short underpass often can provide adequate illumination within the underpass without a need to provide supplemental lighting. If this action is considered, ensure that shadows cast by the conventional luminaires do not become a visibility problem within the underpass.

56-2.07 Tunnels

Provide lighting for tunnels to create adequate roadway visibility necessary for safe and efficient traffic operation. Daytime tunnel lighting is recommended when driver visibility requirements are not satisfied without the use of a daytime lighting system to supplement natural daylight. Visibility requirements vary considerably with such items as:

- portal to portal tunnel length (i.e., short or long);
- tunnel portal design;
- geometry of tunnel and its approaches;
- vehicular and pedestrian traffic characteristics;
- treatment of pavement, portal, interior, and environmental reflective surfaces;
- climate and orientation of tunnel; and
- visibility objectives to provide for safe and efficient tunnel operation.

The AASHTO publication *Roadway Lighting Design Guide* provides tunnel lighting guidelines. For additional tunnel lighting requirements, consult the American *National Standard Practice for Tunnel Lighting*.

56-2.08 Roundabouts

Consider lighting at roundabouts as recommended by the AASHTO publication *Roadway Lighting Design Guide*. Additional lighting requirements are outlined in the *Design Guide for Roundabout Lighting*, IESNA DG-19. Provide pedestrian lighting as applicable, in addition to lighting in the roundabout, at crosswalks and on the approach legs.

56-2.09 Other Locations

Provide lighting for pedestrian crosswalks and all pedestrian underpass and pedestrian tunnel facilities. In addition, lighting for the following facilities will be considered on a case-by-case basis:

- commuter park-and-ride lots,
- bike paths,
- pedestrian walkways, and
- pedestrian overpasses.

56-2.10 Highway Sign Illumination

Overhead highway signs fitted with long-lasting, highly reflective sheeting may be adequately illuminated by vehicular headlights. Internally or externally illuminate signs with non-reflective, lower grade sheeting, by a direct light source. Roadway lighting does not meet the requirements for external sign illumination.

Provide sign illumination where background (roadway and/or non-roadway) lighting obscures the legend of the sign or the sign is not adequately visible by vehicular headlights. In urban areas with high-ambient lighting, the external illumination of overhead sign panels generally is warranted.

External lighting for all other overhead sign panels along lighted highway facilities will be illuminated on a case-by-case basis. See the *IESNA Recommended Practice for Roadway Sign Lighting* for additional information on when to light signs. Also, apply the requirements of this publication when designing lighting for sign panels.

56-2.11 Navigation and Obstruction Lighting

Highway structures over navigable waterways require waterway obstruction warning luminaires in accordance with US Coast Guard requirements. The district or Electrical and Mechanical Unit in the Central Office will coordinate with the Coast Guard. Design navigable waterway obstruction lighting in accordance with the US Coast Guard Bridge Administration Manual, *Bridge Lighting and Other Signals*.

Any need for aviation obstruction warning luminaires on highway structures will be coordinated with the Federal Aviation Administration by the district or Electrical and Mechanical Unit in the Central Office. For information on lighting for navigable airspace obstructions, consult the FAA Advisory Circular AC 70/74602J *Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace*.

56-2.12 Transition Lighting

Consider step-down transition lighting, or similar visibility measures, for traffic lanes emerging from a lighted area with very high lighting levels. For additional information, consult the *ANSI/IESNA RP-8*.

56-2.13 Roadway Reconstruction

Existing highway lighting shall be evaluated for upgrade to meet current Department highway lighting criteria on roadway reconstruction projects. Contact the Electrical and Mechanical Unit in the Central Office for additional information.

56-2.14 Municipal and Residential Lighting

IDOT will not participate in highway lighting on facilities located within an incorporated area except as described in Sections 56-2.02, 56-2.03, and Chapter 5.

56-2.15 Ornamental Lighting

At the request of a local agency, ornamental lighting may be permitted by the Department on a State-maintained facility if the' minimum requirements of the Department and ANSI/IESNA RP-8 are met and the local agency is 100% responsible for construction funding, ownership, electrical energy, and maintenance of such lighting both during and after construction. Special lighting requirements regarding light trespass and glare must also be satisfied. Contact the Electrical and Mechanical Unit in the Central Office for additional information on ornamental lighting requirements.

56-2.16 Lighting for Nighttime Construction

Ensure lighting for nighttime construction activities, either mobile or stationary, is provided and included in all plans. Ensure the lighting design does not impair motorist visibility and meets RP-8 glare and light trespass requirements. This should be done to help provide for the overall on-site safety of the workers and by making them more visible to motorists where construction is adjacent to traffic. Nighttime lighting also benefits the quality of the construction work.

56-2.17 Temporary Lighting

Consider temporary highway lighting in construction zones requiring complex traffic maneuvers (e.g., crossovers) and where existing lighting will be removed, relocated, or altered by construction operations. Temporary roadway lighting shall meet ANSI/IENSNA RP-8 requirements for lighting, glare, and light trespass. Also, ensure the temporary roadway lighting is designed to meet roadside safety issues (e.g., clear zone setback) in accordance with Chapter 38.

56-2.18 Replacement Lighting

Consider a new roadway lighting design where existing lighting facilities are being replaced on a complete lighting circuit basis or in its entirety. With the exception of spot replacements, large portions of lighting facilities replaced through maintenance or construction operations shall be reevaluated from a lighting design standpoint to ensure lighting facilities are upgraded to meet current Department lighting criteria, including ANSI/IENSNA RP-8 requirements.

This is especially important with older facilities that were installed with a different light source than is currently used, wiring methods, etc. Contact the Electrical and Mechanical Unit in the Central Office for additional information on the replacement of existing lighting facilities.

56-3 MATERIALS AND EQUIPMENT

Because luminaires, electrical devices, and support structures change rapidly with new developments, this section presents an overview rather than an absolute requirement for lighting equipment and materials. The *Standard Specifications, Highway Standards*, and the IDOT electric detail sheets provide additional details on lighting equipment and materials that are required for IDOT projects. Section 56-5 provides specific design guidance for luminaires, electrical devices, and support structures used by IDOT. Figure 56-3.A illustrates the various components of a typical highway lighting structure.

56-3.01 Foundations and Mounting

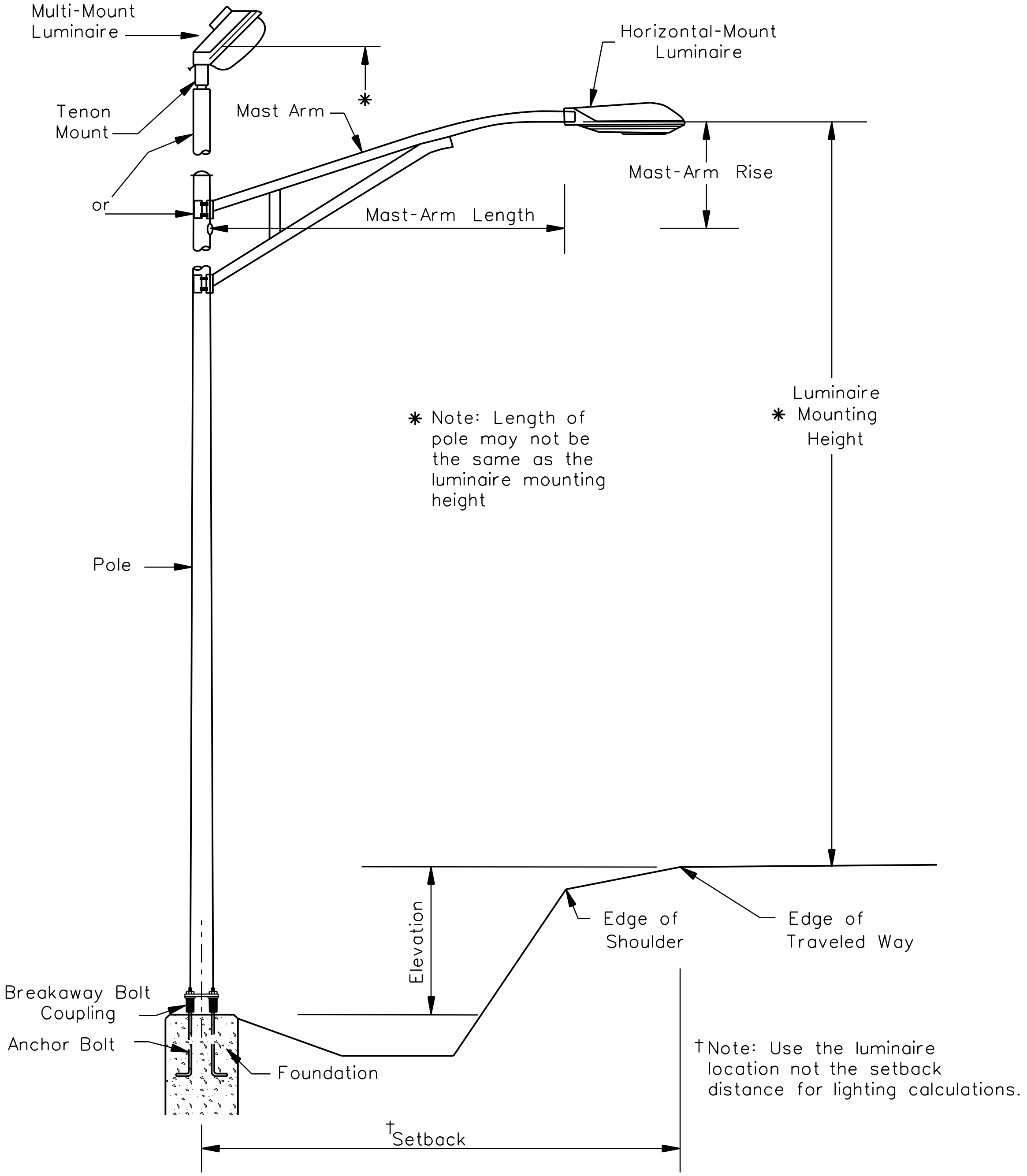
In conventional highway lighting applications, luminaire assemblies generally are attached to davit or mast-arm poles mounted along the roadway either on ground foundations or atop bridge parapets or barriers. Supports for conventional light poles may be either reinforced concrete or steel helix foundations and are constructed from typical designs. However, concrete foundations for light towers in high-mast lighting applications require special designs and soil analyses to determine adequate foundation depth. Depending on factors such as roadside location, most conventional light poles will be mounted on breakaway devices. Attach light poles that are mounted atop parapets and barriers or behind guardrail to foundations with high-strength, non-breakaway bolts. Use special vibration isolating materials to mount light poles on bridges. Where feasible at signalized intersections, a roadway luminaire may be mounted on a combination mast-arm assembly and pole using approved combination structures.

Luminaires mounted in underpasses and tunnels are either attached directly to the wall adjacent to or hung from vibration-dampening pendants at the edge of the travel lanes. Light sources that are used to externally illuminate overhead sign panels typically are fastened to the truss or cantilever support structure.

Waterway and aviation obstruction warning luminaires are attached directly to the structures representing the hazard. Ensure the location and installation of warning luminaires for waterway and aviation also meet the requirements of Section 56-2.10.

56-3.02 Pole Bases

Light poles may be attached to one of several types of bases (e.g., stainless steel flair base, transformer base, breakaway coupling base, anchor base, butt base). Selection is governed by project need and material suitability. A very important distinguishing characteristic of the pole base is whether it is classified by AASHTO and FHWA as an acceptable breakaway device. If the pole represents a roadside hazard, it will be mounted on a breakaway device (see Chapter 38 for additional guidance). Section 56-5.05 provides some design guidance on this issue. The following briefly describes typical pole configurations used by the Department:



Note: Single mast-arm/multi-mount luminaire shown for illustrative purposes. For other luminaire mounting types, see the IDOT Electric Detail Sheets, Highway Standards, and Standard Specifications.

TYPICAL HIGHWAY LIGHTING STRUCTURE

Figure 56-3.A

1. Breakaway Coupling. Breakaway couplings are connectors or sleeves that are designed to shear when the pole is hit by an errant vehicle. The bottom of each coupling (device) is threaded onto a foundation anchor bolt, and the pole is attached to the top of the coupling. Four couplings are used with each pole. All wiring at the pole base will have simultaneous quick disconnect splices.

2. Frangible Transformer Base. The frangible transformer base consists of a cast aluminum apron between the foundation and the base of the pole. It is designed to deform and break away when hit by an errant vehicle. All wiring inside the base will have quick disconnect splices.

3. Anchor Base. The anchor base consists primarily of a metal plate that is welded to the bottom of the pole. The plate allows the pole to be bolted directly to the foundation using anchor bolts without an intermediate breakaway connection. The anchor bolts and anchor base is not classified by the Department as a breakaway device.

56-3.03 Poles

Light poles for conventional highway lighting applications support luminaire mounting heights ranging from approximately 30 ft to 50 ft (9.1 m to 15.2 m). Light towers for high-mast lighting applications generally range from 80 ft to 160 ft (24.4 m to 48.8 m) and are designed in multiple sections. Weathering steel is a common material choice for light towers. Ornamental light poles used for local streets generally range in height for 8 ft to 15 ft (2.4 m to 4.5 m).

56-3.04 Arms

Depending on the particular application, luminaires may be mounted on single and/or double mast arms or davit arms at the top of the pole. The use of an arm places the light source closer to the traveled way while allowing the pole to be located further from the edge of the traveled way. Arms longer than 15 ft (4.5 m) require special approval.

56-3.05 Luminaires

Luminaire housing consists of a lamp or lamps and electrical components to start and regulate the lamps and distribute the light. The following sections provide some general information on the basic components of the luminaire.

56-3.05(a) Light Sources

There are numerous light sources for highway lighting applications. However, there are only a few practical choices when considering availability, size, power requirements, and cost effectiveness. It is rare that a light source other than the high-intensity discharge (HID) type is used in highway lighting applications.

Use high-pressure sodium for roadway lighting unless permission is obtained from the Department for a different light source. The local agency requests this permission from the district in writing and ensures the request demonstrates the ability of the alternative light source to light the roadway to the requirements of this Chapter without additional luminaires and increased cost.

Fluorescent lamps have been used to illuminate signs. Recently, light emitting diodes (LED's) have become a popular light source due to their long life and low electrical energy usage, but they have not yet become effective for most roadway applications. The following provides information on some of the HID light sources used in highway applications:

1. High-Pressure Sodium (HPS). HPS lamps have excellent luminous efficiency, power usage, and long life. The HPS lamp produces a soft, pinkish-yellow light by passing an electric current through a combination of sodium and mercury vapors.

2. Low-Pressure Sodium (LPS). LPS lamps are considered one of the most efficient light sources on the market. However, the LPS lamp is very long and produces a very pronounced monochromatic yellow light. Light is produced by passing an electrical current through a sodium vapor.

3. Mercury Vapor (MV). Prior to the introduction of HPS lamps, MV was the most commonly used light source in highway applications. The MV lamp produces a bluish-white light and is not as efficient as the HPS lamp. This light source is not longer used.

4. Metal Halide (MH). MH lamps produce better color at higher efficiency than MV lamps. However, life expectancy for MH lamps is shorter than for HPS or MV lamps. They also are more sensitive to lamp mountings and orientation (i.e., horizontal vs. vertical) than other light sources. MH lamps produce good color rendition. Light is produced by passing a current through a combination of metallic vapors. New technology is advancing pulse start and ceramic halide.

56-3.05(b) Optical System

The optical system of the luminaire consists of a light source, a reflector, and usually a refractor. The following provides a general discussion on the optical system components:

1. Light Source. See Section 56-3.05(a) for information on the high-intensity discharge lamps used in highway applications.

2. Reflector. The reflector is used to redirect the light rays emitted by the lamp. Its primary purpose is to redirect that portion of light emitted by the lamp that would otherwise be lost or poorly utilized. Reflectors are designed to function alone or, more commonly, with a refractor to redirect the poorly utilized portion of light to a more desirable distribution pattern. Reflectors are classified as either specular or diffused. Specular reflectors are made from a glossy material that provides a mirror-like surface. Diffuse reflectors are used where there is a need to spread light over a wider area.

3. Refractor. The refractor is another means of optical control to change the direction of the light. Refractors are made of a transparent, clear material, usually high-strength glass or plastic. The refractor, through its prismatic construction, controls and redirects both the light emitted by the lamp and the light redirected by the reflector. It also can be used to control the brightness of the lamp source.

56-3.05(c) Ballasts

All luminaires used in highway lighting applications have a built-in ballast. Ballasts are used to regulate the voltage and current to the lamp and to ensure that the lamp is operating within its design parameters. It also provides the proper open circuit voltage for starting the lamp.

56-3.05(d) Housing

The housing integrates the lamp, reflector, refractor, and ballast into a self-contained unit. The housing is designed to seal the unit against the entry of dust, moisture, and insects. Air entering the housing for thermal breathing will typically pass through a filter to eliminate contaminates. Housings are designed to accommodate access for lamp maintenance and adjustment (i.e., light direction and distribution). The housing is generally cast aluminum or stainless steel.

56-3.06 Other Materials and Equipment

There are numerous other materials and equipment that are used in a highway lighting system (e.g., quick disconnect fuseholders, controllers, photocells, surge arresters, raceways, ground rods, cabling, transformers, conduit, hand holes, pull boxes). The use and specification of These ancillary items will depend on the particular highway lighting application and will vary on a project-by-project basis.

56-3.07 Electric Service

Electric service must be a low voltage (0-600V) grounded system. Have the service delivered to the roadway right-of-way. Ground the service and equipment in accordance with the NEC. Specify the service transformer by the electric utility to typically deliver secondary voltages of single-phase 120/240V or 240/480V and 3-phase voltages of 120/208V or 277/480V.

56-4 LIGHTING PROJECTS (New)

The following is a brief overview of the development of a typical highway lighting design project requested by the district, except District 1, and designed by the Electrical and Mechanical Unit in the Central Office.

56-4.01 Determine Classifications and Justify Need

Determine the roadway classification, pedestrian area classification, pavement classification, and environmental conditions. A mutual determination will be made between the district and the Electrical and Mechanical Unit in the Central Office regarding the classification of any interchange or freeways as urban, suburban, or rural. The district will initiate a lighting project by submitting the warrants and all supporting data to the Central Office for review. Highway lighting projects that are justified may be incorporated into the annual improvements program.

56-4.02 Assemble Information

The district assembles all necessary information needed for a lighting design and forwards it to the Electrical and Mechanical Unit in the Central Office or the lighting design consultant. This may include:

- identifying current lighting design policies, preferences, and procedures;
- gathering all necessary roadway and bridge plan and profile sheets and any special detail sheets (e.g., as-built plans for existing lighting, as applicable);
- determining existing and proposed utility locations;
- discussing special considerations with the highway or bridge designer;
- determining existing and proposed roadway cross-sections, plan and profile, construction staging, and right-of-way lines;
- conducting field reviews with photographic inventory;
- establishing the need for temporary lighting, as applicable;
- contacting local officials for local projects;
- contacting local electrical utility for electric service;
- determining existing and proposed signalized intersections with detailed information on any combination traffic signal and lighting structures;
- noting areas of high ambient lighting or areas especially sensitive to trespass lighting;

- determining the location of advance warning beacons, changeable message boards, or other devices that may be impacted by roadway lighting;
- contacting the FAA for any possible height restrictions on lighting facilities due to airports in the vicinity;
- identifying the need for other lighting needs (e.g., aviation and/or waterway navigation warning luminaires, overhead sign lighting, bike paths); and
- noting any other special considerations that may affect the lighting design (i.e., location of light poles due to drainage).

56-4.03 Prepare Preliminary Plans

The district will submit to the Electrical and Mechanical Unit in the Central Office or the lighting design consultant the plan sheets showing the overall project with roadway and area classifications including significant other information to justify chosen classification and criteria. Ensure that the plans include:

- information gathered in Section 56-4.02 as appropriate;
- stationing at appropriate 100 ft (30 m) intervals and stationing of noses and tangent points of ramps which are formed by the roadway proper and not by the shoulder;
- pavement, shoulder, and median widths at frequent intervals;
- all roadway features which may affect the stationing or setback of poles (e.g., guardrail, barrier median, barrier curb, signs exceeding 50 ft^2 (4.5 m^2), driveways, culverts, railroads, pipelines);
- the approximate height of any power and telephone lines along and over the roadway;
- the location of power poles from which service may be obtained;
- if combination signals and lighting are present or proposed, the stationing and offset of the traffic signal poles, the arm length and mounting height of luminaires, the type and wattage of luminaire, and the location of the power pole and control cabinet; and
- lighting calculations in an electronic format with all the supporting data.

Electronic plans are preferred over paper copies. Show existing and proposed roadway geometry and basic plan information as noted above. Also, furnish as-built plans of existing lighting facilities, as applicable. In addition, copies of any available sample calculations, plans, notes, schedules, and pay quantities may provide further clarification for the lighting designer.

56-4.04 Electrical and Mechanical Unit Central Office Review

The district will communicate the project scope, configuration details, and timeframe for a lighting design to the Electrical and Mechanical Unit in the Central Office. Upon receipt of the request from the district, the Electrical and Mechanical Unit will design the lighting for the project and send the design package to the district. The design package will include the location of poles and luminaires, the electrical distribution and control system design, and associated specifications. The Electrical and Mechanical Unit also will furnish wiring diagrams and drawings of equipment, foundations, and electrical details, as applicable. The plans and specifications will be returned to the district for CADD drafting and completion as final contract documents.

When a consultant is used by the district to complete the design, the preliminary and final plans will be submitted to the Electrical and Mechanical Unit in the Central Office for review and approval. Prior to plan preparation, submit the consultant's lighting design to the Electrical and Mechanical Unit in the Central Office for review and approval.

56-4.05 Field Review

Prior to finalizing plans, the district or the lighting design consultant will conduct a field review to determine if pole and luminaire locations will interfere with existing or proposed underground, at-grade, and aerial utilities and/or roadway structures. The district will notify the Electrical and Mechanical Unit in the Central Office of any conflict that would cause modification to the design. For high-mast lighting designs, ensure that borings are taken for soil analyses to ascertain the correct foundation depth at each tower location.

56-4.06 Final Plan Preparation/Contract Award

The district and/or the lighting design consultant will prepare the final plans, specifications, and estimates and submit them to the BDE for processing and contract award. See Chapter 63 for information on plan preparation and Chapter 66 for information on contract processing. Upon award of the contract, the contractor will submit for approval a list of manufacturers for all major electrical equipment to be used on the project (e.g., poles, towers, luminaires, controllers, unit duct, cable), a complete set of manufacturer's product data, and detailed shop drawings for any fabricated equipment.

Submit the complete package of project shop drawings for lighting to the Electrical and Mechanical Unit in the Central Office for review and approval.

56-4.07 Final Inspection

The completed project will be inspected by the Electrical and Mechanical Unit in the Central Office in accordance with the *Standard Specifications*. If the installation is satisfactory, it will be accepted.

56-5 LIGHTING DESIGN

When designing a highway lighting system, there are numerous factors to consider. This Section presents design considerations commonly encountered in highway lighting designs and presents IDOT's criteria, policies, and procedures on these issues. Figure 56-5.A presents typical highway lighting design parameters used by the Department.

TYPICAL IDOT HIGHWAY LIGHTING DESIGN PARAMETERS	
Maintenance Factor (i.e., LLD • LDD)	0.50 to 0.70
Percent of Voltage Drop Allowed	3% to 5% maximum *
Typical Parameters for Conventional Lighting (Interstate)	Aluminum or Steel Pole, Single- or Twin-Arm Mounting; 45 ft to 55 ft (13.7 m to 16.8 m) Mounting Height; 250 W or 400 W HPS Horizontal Mount Luminaire; Breakaway Base where Justified.
Typical Parameters for Conventional Lighting (Expressway)	Aluminum Pole, Davit or Mast-Arm Mounting; 40 ft to 50 ft (12.2 m to 15.2 m) Mounting Height; 250 W or 400 W HPS Horizontal-Mount Luminaire; Breakaway Base where Justified.
Typical Pavement Classification	Class R3
Typical IES Luminaire Classification For Conventional Highway Lighting	Cutoff (C) or Full Cutoff (F).
Typical Luminaire Pole Arrangement	Staggered, Opposite, or Median Mounted.

* *Never exceed the equipment limits.*

Ensure all lighting designs conform to current recommended values in ANSI/IESNA/RP-8 for the selected roadway and pedestrian conflict areas.

TYPICAL IDOT HIGHWAY LIGHTING DESIGN PARAMETERS

Figure 56-5.A

56-5.01 Methodologies

There are at least two lighting design methodologies available for use in highway lighting design – illuminance or luminance. The Illuminating Engineering Society (IES) of North America has been a leader in developing these methodologies (see the publication, ANSI/IESNA RP-8). The levels defined in ANSI/IESNA RP-8 are minimum acceptable levels and the design approach shall achieve, but not significantly exceed these levels. Ensure calculated lighting levels do not exceed the levels for the next higher roadway and pedestrian classification.

It is a good practice, and will be required in consultant submittals, to consider both illuminance and a luminance design. Select the design that produces the most conservative results. Both of these methodologies require the designer to consider veiling luminance and limit the ratio to the values listed in Figures 56-5.B and 56-5.C. The following sections briefly describe each of the available design methodologies.

56-5.01(a) Illuminance

The illuminance methodology is the oldest and simplest method to employ. Illuminance is defined as the density of the luminous flux, lumen (lm), incident on a surface area, ft^2 (m^2), and is measured in footcandles (lux). Footcandle (fc) and lux (lx) are units of illuminance expressed in lumens (lm) per square foot (ft^2) and lumens per square meter (m^2), respectively. The illuminance methodology is used to determine the combined amount of luminous flux reaching critical pavement locations from contributing luminaires (i.e., a measure of light quantity) and to calculate how uniformly the luminaires' combined luminous flux is horizontally distributed over the pavement surface (i.e., a measure of light quality). The brightest spot normally will occur directly under the luminaire and diminishes as the driver travels away from the source.

An inherent disadvantage of the illuminance methodology was that it only accounts for incident light and does not assess the effect on visibility due to reflected light from an object or surface. This sensation is known as "brightness." Objects are distinguished by contrast from their difference in brightness. To address some visibility concerns, a new metric called "Veiling Luminance Ratio" was added to the illuminance methodology. Illuminance designs consider the average maintained horizontal illumination (E_h), or quantity of light, and the uniformity ratio, or quality of light. See Section 56-1.03 for the definition of uniformity ratio (E_h/E_{min}).

56-5.01(b) Luminance

Luminance is defined as the luminous intensity, candela (cd), of any surface in a given direction per unit of projected area, ft^2 (m^2), of the surface as viewed from that direction. It is measured in footlamberts (candelas per square meter). The luminance methodology is used to simulate driver visibility by assessing the quantity and quality of light reflected by the pavement surface to the motorist's eye from contributing luminaires. Assumptions are made regarding the spatial positioning of the driver's eye, and luminance values are calculated at grid points over

Roadway Facility Classification④	Area Classification	Pedestrian Conflict Area ③	Average Maintained①⑤ Horizontal Illuminance (E_h) Footcandle (Lux)			Uniformity Ratio (Ave./Min.)	Veiling Luminance Ratio L_{vmax}/L_{avg}
			Pavement Classification ④				
			R1	R2 & R3	R4		
Freeway ②	Class A		0.6 (6)	0.9 (9)	0.8 (8)	3:1	0.3
	Class B		0.4 (4)	0.6 (6)	0.5 (5)		
Expressway ②	Commercial	High	1.0 (10)	1.4 (14)	1.3 (13)		
	Intermediate	Medium	0.8 (8)	1.2 (12)	1.0 (10)		
	Residential	Low	0.6 (6)	0.9 (9)	0.8 (8)		
Major	Commercial	High	1.2 (12)	1.7 (17)	1.5 (15)		
	Intermediate	Medium	0.9 (9)	1.3 (13)	1.1 (11)		
	Residential	Low	0.6 (6)	0.9 (9)	0.8 (8)		
Collector	Commercial	High	0.8 (8)	1.2 (12)	1.0 (10)	4:1	0.4
	Intermediate	Medium	0.6 (6)	0.9 (9)	0.8 (8)		
	Residential	Low	0.4 (4)	0.6 (6)	0.5 (5)		
Local	Commercial	High	0.6 (6)	0.9 (9)	0.8 (8)	6:1	
	Intermediate	Medium	0.5 (5)	0.7 (7)	0.6 (6)		
	Residential	Low	0.3 (3)	0.4 (4)	0.4 (4)		
Alleys	Commercial		0.4 (4)	0.6 (6)	0.5 (5)		
	Intermediate		0.3 (3)	0.4 (4)	0.4 (4)		
	Residential		0.2 (2)	0.3 (3)	0.3 (3)		
Walkways/ Bikeways and Intersections ③	See ANSI/IESNA RP-8 for recommended criteria and specific treatments. See IESNA DG-5 for Walkways/Bikeways separated from the roadways.						
Rest Areas And Weigh Stations							
Ramp Gores & Interior Roadways	All		0.4 (4)	0.6 (6)	--	3:1 to 4:1	0.4
Parking & Major Activity Areas	All		0.8 (8)	1.1 (11)	--		
Minor Activity Areas	All		0.4 (4)	0.5 (5)	--	6:1	

Notes:

1. *Average illuminance on the traveled way.*
2. *Both mainline and ramps.*
3. *Facilities adjacent to a vehicular roadway should use the illuminance levels and uniformity ratios for that roadway as recommended in IESNA RP-8.*
4. *See Section 56-5.04 for definitions of roadway facility, area, and pavement classifications. Use either Column 2 or Column 3 in the tables to best describe the location to be lighted.*
5. *The illuminance values in Figure 56-5.B are minimum maintained averages. Higher levels than shown in the tables may be justified, consult the* AASHTO Roadway Lighting Design Guide *for details.*

IDOT ILLUMINANCE DESIGN CRITERIA

Figure 56-5.B

Road and Area Classification			Average Luminance L_{avg} (cd/m^2)	Uniformity Ratio L_{avg}/L_{min} (Maximum Allowed)	Uniformity Ratio L_{max}/L_{min} (Maximum Allowed)	Veiling Luminance Ratio L_{Vmax}/L_{avg} (Maximum Allowed)
Roadway	**Area Classification**	**Conflict Classification**				
Freeway Class A	N/A		0.6	3.5	6.0	0.3
Freeway Class B	N/A		0.4	3.5	6.0	0.3
Expressway	Commercial	High	1.0	3.0	5.0	0.3
	Intermediate	Medium	0.8	3.0	5.0	0.3
	Residential	Low	0.6	3.5	6.0	0.3
Major	Commercial	High	1.2	3.0	5.0	0.3
	Intermediate	Medium	0.9	3.0	5.0	0.3
	Residential	Low	0.6	3.5	6.0	0.3
Collector	Commercial	High	0.8	3.0	5.0	0.4
	Intermediate	Medium	0.6	3.5	6.0	0.4
	Residential	Low	0.4	4.0	8.0	0.4
Local	Commercial	High	0.6	6.0	10.0	0.4
	Intermediate	Medium	0.5	6.0	10.0	0.4
	Residential	Low	0.3	6.0	10.0	0.4

IDOT LUMINANCE DESIGN CRITERIA

Figure 56-5.C

the pavement surface. In theory, luminance is a good measure of visibility; however, the results of using the luminance methodology in highway lighting applications are greatly affected by ’the reflectance characteristics of the pavement surface, both now and in the future. Factors affecting pavement reflectivity include initial surface type, pavement deterioration, resurfacing material type, assumptions regarding weather conditions, etc. It is difficult to predict or control these factors. Luminance design parameters include average maintained luminance (L_{avg}), minimum luminance (L_{min}), maximum luminance (L_{max}), maximum veiling luminance (L_v), and ratios of L_{avg} to L_{min}, L_{max} to L_{min}, and L_v to L_{avg}.

56-5.01(c) Small-Target-Visibility (STV)

Many lighting practitioners no longer support the STV method discussed in ANSI/IESNA RP-8-00.

56-5.02 Computerized Design

The highway lighting design process is an iterative process that is quite effectively implemented by computer. If criteria are not initially satisfied, it will be necessary to change design parameters (e.g., pole spacing, mounting height, luminaire wattage, luminaire distribution) until an acceptable alternative is found. This process will be repeated until the design is optimized to meet the selected criteria.

For computerized designs prepared by outside consultants, the consultant will provide the program’s name and version and the input data and output reports in both printed and electronic format. Ensure the software program selected meets all necessary provisions, including ANSI/IESNA RP-8 calculation requirements. Contact the Electrical and Mechanical Unit in the Central Office for approved software programs.

56-5.03 Design Process

The following briefly describes the processes used in any highway lighting design:

1. Select Lighting Equipment. Select the lighting equipment and associated design parameters that will be used for the project. This will include items such as luminaire mounting height, pole setback, light source, lamp wattage, etc. It will be necessary to make some initial assumptions during preliminary design. Design parameters then may be iteratively changed to meet the highway lighting criteria.

2. Select Luminaire Arrangement. Select an appropriate luminaire arrangement for the project. This will depend on local site conditions and engineering judgment. Alternative arrangements may need to be considered. Computer programs will create the required output based on the input criteria.

3. Luminaire Spacing. Typically, luminaire spacing will be determined by computer software.

4. Check Uniformity. Once luminaire spacing has been determined, check the uniformity of light distribution and compare this value to the lighting criteria selected in Step #1. Adjust design parameters and recalculate as necessary to meet criteria.

5. Select Optimum Design. Because computerized design is relatively quick and easy, modify key design parameters (e.g., luminaire photometry, location, mounting height) to develop and test several alternative designs. It generally is not good engineering practice to consider only one design, even if found to satisfy the lighting criteria. There often are several alternatives that will work. Optimize and select the most cost-effective and minimum maintenance design.

Typically, do not terminate a lighting project just before an intersection. Consider motorist decision points and potential pedestrian interaction when evaluating how far to extend the limits of lighting.

56-5.04 Design Considerations

When selecting design criteria for a lighting project, it is necessary to determine classifications for the roadway facility, the area the roadway traverses, and the pavement type that best fit the descriptions contained in ANSI/IESNA RP-8 and AASHTO. Do not use the classifications of other publications. The following sections discuss these classifications for the purpose of highway lighting design only.

56-5.04(a) Roadway Classification

Use the following definitions to classify roadway facilities for IDOT highway lighting projects:

1. Freeway. A divided major highway with full control of access and with no crossings at grade.

2. Expressway. A divided major arterial highway for through traffic with full or partial control of access and generally with interchanges at major crossroads. Expressways for non-commercial traffic within parks and park-like areas generally are known as parkways.

3. Major. The part of the roadway system that serves as the principle network for through traffic flow. The routes connect areas of principle traffic generation and important rural highways entering the city.

4. Collector. The distributor and collector roadways serving traffic between major and local roadways. These are roadways used mainly for traffic movements within residential, commercial, and industrial areas.

5. Local. Roadways used primarily for direct access to residential, commercial, industrial, or other abutting property. They do not include roadways carrying through traffic. Long

local roadways generally will be divided into short sections by the collector roadway system.

6. Alley. A narrow public way within a block, generally used for vehicular access to the rear of abutting properties.

7. Sidewalk. Paved or otherwise improved areas for pedestrian use, located within public street right-of-way, which also contains roadways for vehicular traffic.

8. Pedestrian Way. Public sidewalks for pedestrian traffic generally not within rights-of-way for vehicular traffic roadways. Included are skywalks (pedestrian overpasses), subwalks (pedestrian tunnels), walkways giving access to park or block interiors, and crossings near centers of long blocks.

9. Bicycle Lane. Any facility that explicitly provides for bicycle travel.

56-5.04(b) Area Classification

For IDOT lighting projects, use the following definitions to classify the area in which the roadway traverses. These definitions match the AASHTO *Roadway Lighting Design Guide*. These definitions do not match the ANSI/IESNA RP-8 IESNA classifications, which are based on pedestrian/vehicular conflicts.

1. Commercial. That portion of a municipality in a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic or a sustained high pedestrian volume and a continuously heavy demand for off-street parking space during business hours. This definition applies to densely developed business areas outside of, as well as those that are within, the central part of a municipality.

2. Intermediate. That portion of a municipality that is outside of a downtown area but generally within the zone of influence of a business or industrial development, often characterized by a moderately heavy nighttime pedestrian volume and a somewhat lower parking turnover than is found in a commercial area. This definition includes densely developed apartment areas, hospitals, public libraries, and neighborhood recreational centers.

3. Residential. A residential development or mixture of residential and commercial establishments, characterized by few pedestrians and a low parking demand or turnover at night. This definition includes areas with single-family homes, townhouses, and/or small apartments. Regional parks, cemeteries, and vacant lands are also included.

56-5.04(c) Pedestrian Conflict Area Classification

The magnitude of pedestrian flow is nearly always related to the abutting land use. Three classifications of pedestrian night activity levels and the types of land use with which they are typically associated are given below. These definitions match the ANSI/IESNA RP-8 classifications, which are based on pedestrian/vehicular conflicts not the AASHTO *Roadway Lighting Design Guide*:

1. High. Areas with significant numbers of pedestrians expected to be on the sidewalks or crossing the streets during darkness. Examples are downtown retail areas, near theatres, concert halls, stadiums, and transit terminals.

2. Medium. Areas where lesser numbers of pedestrians utilize the streets at night. Typical areas are downtown office areas, blocks with libraries, apartments, neighborhood shopping, industrial, older city areas, and streets with transit lines.

3. Low. Areas with very low volumes of night pedestrian usage. These can occur in any of the cited roadway classifications, but may be typified by suburban single-family streets, very low density residential developments, and rural or semi-rural areas.

Consult ANSI/IESNA RP-8 for the method used in taking pedestrian counts and the associated pedestrian count that corresponds with these conflict areas.

56-5.04(d) Pavement Classification

For IDOT lighting projects, use the following definitions to classify the pavement type of the roadway facility. These pavement classifications have mean luminance coefficient Q_0:

1. Class R1 and (Q_0 = 0.10). Class R1 pavement has a mostly diffuse mode of reflectance. R1 pavements include portland cement concrete road surfaces and asphalt road surfaces with a minimum of 12% of the aggregates composed of artificial brightener (e.g., Synopal) aggregates (e.g., labradorite, quartzite).

2. Class R2 and (Q_0 = 0.07). Class R2 pavement has a mixed diffuse and specular mode of reflectance. R2 pavements include asphalt road surfaces with an aggregate composed of a minimum of 60% gravel with a size greater than 0.40 in (12 mm).

3. Class R3 and (Q_0 = 0.07). Class R3 has a slightly specular mode of reflectance. R3 pavements include asphalt road surfaces, both regular and carpet seal coats, with dark aggregates (e.g., trap rock, blast furnace slag) and exhibit a rough texture after some months of use. Class R3 pavement represents typical asphalt highways and is used on most highway lighting projects.

4. Class R4 and (Q_0 = 0.08). Class R4 pavement has a mostly specular mode of reflectance. R4 includes asphalt road surfaces with a very smooth texture.

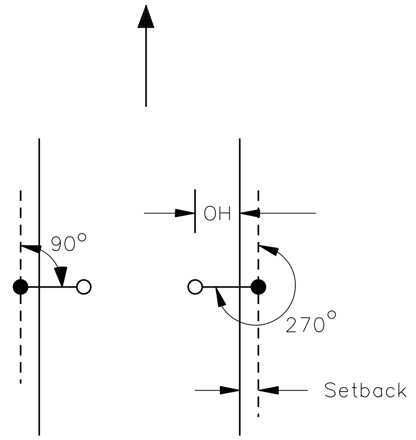
56-5.04(e) Illuminance and Luminance Design Levels

Design criteria for highway lighting projects vary according to the roadway, area, and pavement classification. Figures 56-5.B and 56-5.C present the illuminance and luminance design criteria used by the Department. In addition to these figures, consider the following:

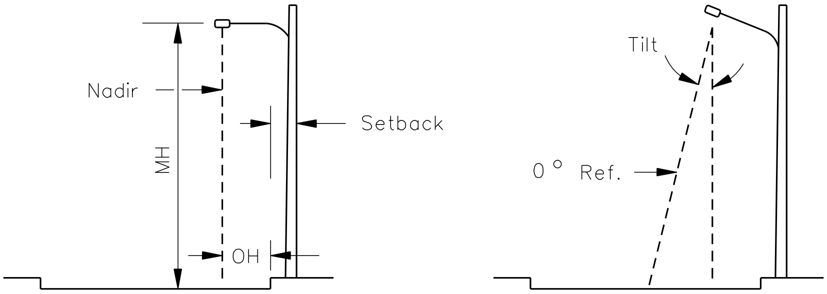
1. Crossroads at Interchanges. Lighting levels on crossroad approaches should not be reduced through an interchange area. If existing crossroad lighting currently is deemed inadequate, consider upgrading the lighting to current criteria to ensure safe and efficient traffic operation.
2. Partial Interchange Lighting. Where partial interchange lighting is provided, luminaires should be located to best light the through lanes and speed change lanes at diverging and merging locations. The design controls of basic level of lighting and uniformity should be subordinated to overall lighting of the roadway area at these locations.
3. Bridge Structures and Underpasses. Underpass lighting level and uniformity ratios should duplicate, to the extent practical, the lighting levels on the adjacent facility. On continuously lighted freeways and lighted interchanges, the lighting of bridges and overpasses should be at the same level as the adjacent roadway.
4. Transition Lighting. Transition lighting is a technique intended to provide the driver with a gradual reduction in lighting levels and glare when leaving an illuminated area. The designer should consider transition lighting if a study of the specific conditions at a location indicates a need. The designer may also want to consider extending delineation beyond the last luminaire for traffic lanes emerging from a lighted area. This will provide an additional measure of effectiveness. Visual adaptation occurs more quickly when approaching a lighted area and therefore no transition lighting is typically required.
5. Navigation and Obstruction Lighting. The lighting criteria and locations for waterway and aviation obstruction luminaires will be based on the requirements of the US Coast Guard and the Federal Aviation Administration, respectively.
6. Other Locations. Where lighting is justified for other facilities not covered under this section, consult the references in 56-1.01 and contact the Electrical and Mechanical Unit in the Central Office for additional information on lighting criteria.

56-5.04(f) Luminaire Characteristics

Figure 56-5.D illustrates the common terms used in defining and mounting luminaires (e.g., mounting height, overhang). The following sections discuss design issues related to luminaires.

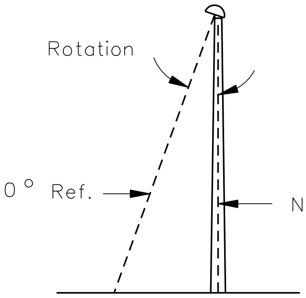


Orientation Angle
Overhang (OH)
(Plan)



Mounting Height (MH)
(Profile)

Tilt Angle
(Profile)



Rotation Angle
(Front)

LUMINAIRE GEOMETRY

Figure 56-5.D

56-5.04(f.1) Light Distribution

Light distribution is a major factor in highway lighting design. It affects the selection of luminaire mounting height, placement, and arrangement. Specific photometric data and light distribution sheets are available from each luminaire manufacturer. Manufacturers typically classify their luminaire products based on the IES luminaire classification system. This system uses a three part approach to define luminaire distribution — the lateral beam width, vertical angle of maximum candlepower, and the degree of glare control.

The following briefly describes the IES classification system:

1. Vertical Light Distribution. There are various classifications of vertical light distribution. The selection of a particular vertical light distribution is dependent upon the luminaire mounting height and application. The following defines each type:

   a. Short Distribution (S). The maximum candlepower strikes the roadway surface between 1 and 2.25 mounting heights from the luminaire. The theoretical maximum luminaire spacing, using the short distribution, is 4.5 mounting heights.

   b. Medium Distribution (M). The maximum candlepower is between 2.25 and 3.75 mounting heights from the luminaire. The theoretical maximum luminaire spacing is 7.5 mounting heights. Medium distribution is commonly used in highway applications.

   c. Long Distribution (L). The maximum candlepower is between 3.75 and 6.0 mounting heights from the luminaire. The theoretical maximum luminaire spacing is 12 mounting heights.

   From a practical standpoint, the medium distribution is predominantly used in highway practice, and the spacing of luminaires normally does not exceed five to six mounting heights. Short distributions are not used extensively for reasons of economy, because extremely short spacing is required. At the other extreme, the long distribution is not used to any great extent because the high beam angle of maximum candlepower often produces excessive glare.

2. Lateral Light Distribution. There are seven classifications for lateral light distribution. The following provides application guidelines for each luminaire type:

   a. Type I. The Type I luminaire is placed in the center of the roadway or area where lighting is required. It produces a long, narrow, oval-shaped lighted area. Some types of high-mast lighting are considered a modified form of Type I.

   b. Type I - 4-Way. This luminaire type is located over the center of the intersection and distributes the lighting along the four legs of the intersection.

   c. Type II. The Type II luminaire is placed on the side of the roadway or edge of the area to be lighted. It produces a long, narrow, oval-shaped lighted area, which is usually applicable to narrower roadways.

d. Type II - 4-Way. This luminaire type is placed at one corner of the intersection and distributes the light along the four legs of the intersection.

e. Type III. The Type III luminaire is placed on the side of the roadway or edge of the area to be lighted. It produces an oval-shaped lighted area and is usually applicable to medium width roadways.

A Type III distribution is where the street side segment of the half-maximum-intensity isointensity trace within the longitudinal range where the point of maximum intensity falls (S, M, or L), lies partly or entirely beyond the 1.75 MH street side LRL, but does not cross the 2.75 MH street side LRL; see Figure 56-5.E.

f. Type IV. The Type IV luminaire is placed on the side of the roadway or the edge of area to be lighted. It produces a wider, oval-shaped lighted area and is usually applicable to wide roadways.

g. Type V. The Type V luminaire is located over the center of the roadway, intersection, or area to be lighted. It produces a circular, lighted area. Type V often is used in high-mast lighting applications.

3. Control of Distribution. As the vertical light angle increases, disability and discomfort glare also increase. To distinguish the glare effects on the driver created by the light source, IES has defined the vertical control of light distribution as follows:

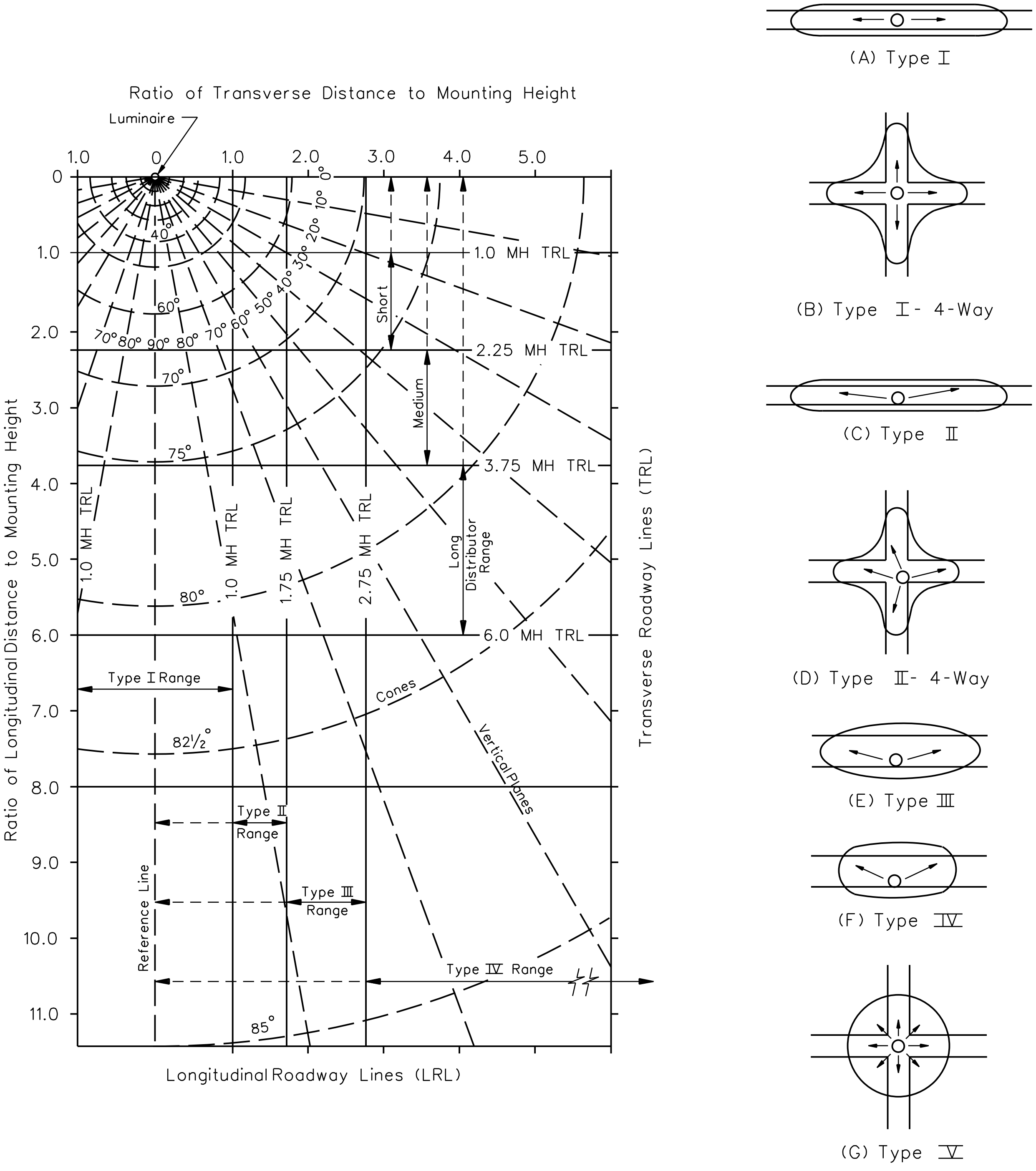
a. Full-Cutoff (F). A luminaire light distribution is designated as full cutoff (F) when zero candela intensity occurs at or above an angle of 90° above nadir. Additionally, the candela per 1000 lamp lumens does not numerically exceed 100 (10%) at or above a vertical angle of 80° above nadir. This applies to any lateral angle around the luminaire.

b. Cutoff (C). A luminaire light distribution is designated as cutoff (C) when the candela per 1000 lamp lumens does not numerically exceed 25 (2.5%) at or above an angle of 90° above nadir, and 100 (10%) at or above a vertical angle of 80° above nadir. This applies to any lateral angle around the luminaire.

c. Semi-Cutoff (S). A luminaire light distribution is designated as semi-cutoff (S) when the candela per 1000 lamp lumens does not numerically exceed 50 (5%) at or above an angle of 90° above nadir, and 200 (20%) at or above a vertical angle of 80° above nadir. This applies to any lateral angle around the luminaire.

d. Non-Cutoff (N). This classification is where there is no limitation on the zone above the maximum candela intensity.

A plan view of the theoretical light distribution (i.e., theoretical roadway coverage) and schematics of the intended application of each type of IES luminaire are illustrated in Figure 56-5.E.



PLAN VIEW OF ROADWAY COVERAGE FROM LUMINAIRES

Figure 56-5.E

Recently a system of backlight, uplight, and glare (BUG) ratings have been derived from the IES Luminaire Classification System (LCS). For additional information on the LCS and BUG ratings, consult the *Luminaire Classification System for Outdoor Ligh*ting. Use only the photometric data with the proper shield, if the project requires luminaire shielding. Do not use the photometric data without the appropriate shield for projects with shields.

56-5.04(f.2) Mounting Heights

Higher mounting heights used in conjunction with higher wattage luminaires enhances lighting uniformity and typically reduces the number of light poles needed to produce the same illumination level. In general, higher mounting heights tend to produce a more cost-effective design. For practical and aesthetic reasons, the mounting height should remain constant throughout the system. The manufacturer's photometric data is required to determine an appropriate mounting height. Typical mounting heights used by the Department for conventional highway lighting purposes range from 35 ft to 55 ft (10.7 m to 16.8 m). Mounting heights for light towers are typically 80 ft (24 m) or greater.

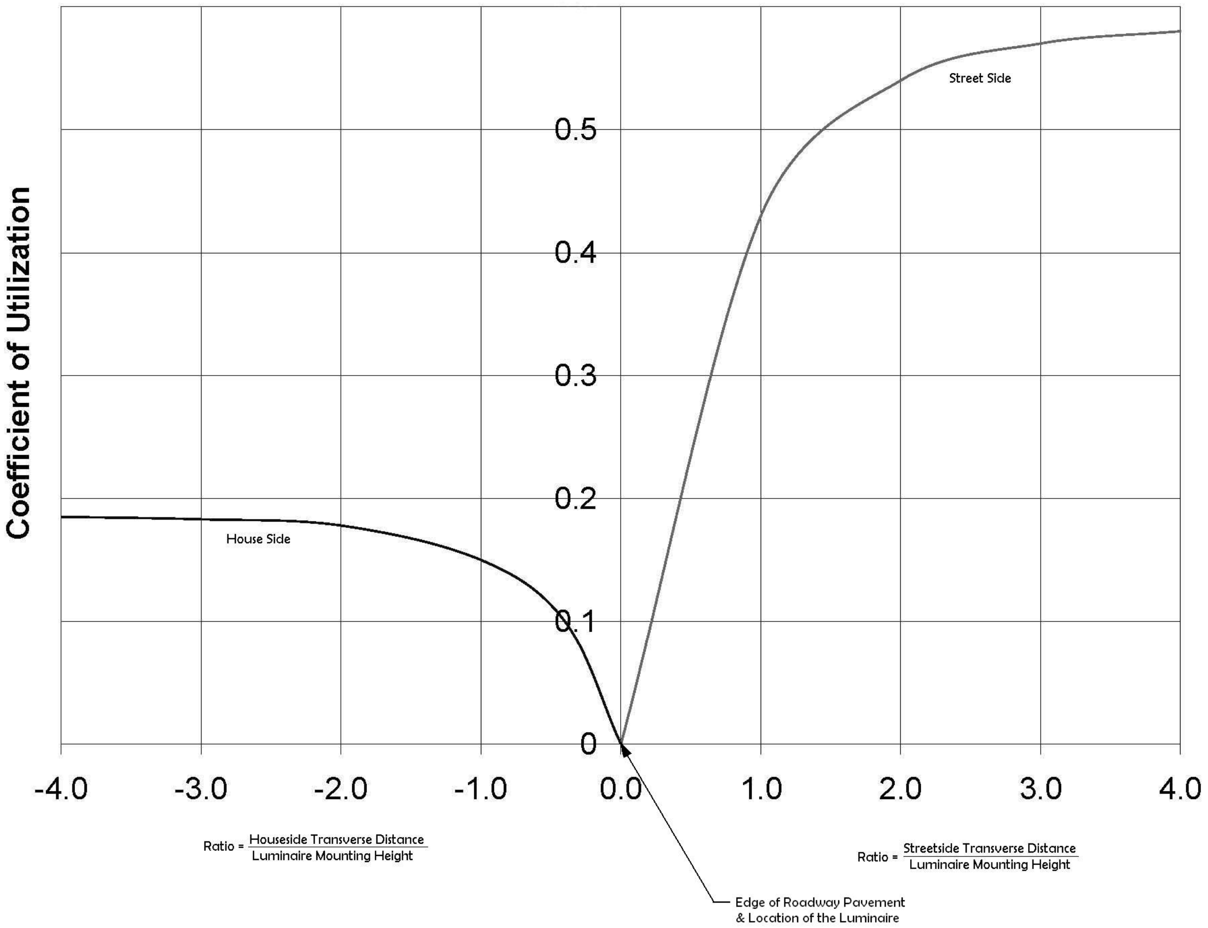
56-5.04(f.3) Coefficient of Utilization

A utilization curve is used to obtain a luminaire's coefficient of utilization (CU). Manufacturers typically provide utilization curves and isolux diagrams with each of their respective luminaire products. Figure 56-5.F illustrates a sample utilization curve. The utilization curve relates to the luminaire rather than to the light source. The ratio of transverse distance over luminaire mounting height provides the percentage of bare lamp lumens that are utilized. If the luminaire is placed over the traveled way (i.e., over the pavement), the total lumen utilization is determined by adding the percentages from the street side and curbside (i.e., house-side) light from the coefficient of utilization curve (furnished by the luminaire manufacturer). In essence, the utilization curve defines how much of the total lumen output reaches the area being lighted.

56-5.04(f.4) Light Loss Factors

The efficiency of a luminaire decreases over time. The designer must estimate this decrease to properly estimate the light available at the end of the luminaire's serviceable life. The following briefly discusses these factors:

1. Lamp Lumen Depreciation Factor (LLD). As the lamp progresses through its serviceable life, the lumen output of the lamp decreases. This is an inherent characteristic of all lamps. The initial lamp lumen value is adjusted by a lumen depreciation factor to compensate for the anticipated lumen reduction. This assures that a minimum level of illumination will be available at the end of the assumed lamp life (i.e., after the lamp lumen depreciation has occurred).

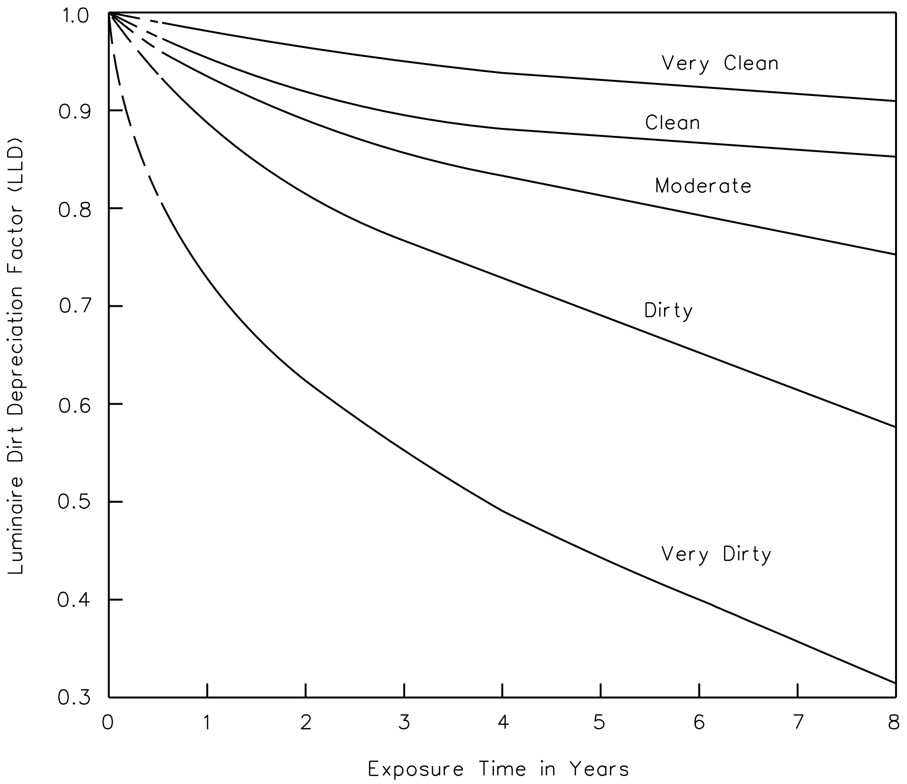


Note: The utilization curve will vary with each manufacturer and luminaire type.

SAMPLE UTILIZATION CURVE

Figure 56-5.F

2. Luminaire Dirt Depreciation Factor (LDD). Dirt on the exterior and interior of the luminaire, and to some extent on the lamp itself, reduces the amount of light reaching the pavement. Various degrees of dirt accumulation may occur depending upon the area where the luminaire is located. Industrial areas, automobile exhaust, diesel trucks, dust and other environs all affect the dirt accumulation on the luminaire. Higher mounting heights, however, tend to reduce the vehicle-related dirt accumulation. The relationship between the ambient environment and the expected level of dirt depreciation over time is shown in Figure 56-5.G.



Notes:

1. *VERY CLEAN - No nearby smoke or dust-generating activities and a low ambient contaminant level. Light traffic. Generally limited to residential or rural areas. The ambient particulate level is not more than 150 micrograms per cubic meter.*

2. *CLEAN - No nearby smoke or dust-generating activities. Moderate to heavy traffic. The ambient particulate level is not more than 300 micrograms per cubic meter.*

3. *MODERATE - Moderate smoke or dust-generating activities nearby. The ambient particulate level is not more than 600 micrograms per cubic meter.*

4. *DIRTY - Smoke or dust plumes generated by nearby activities may occasionally envelope the luminaires.*

5. *VERY DIRTY - As above, but the luminaires are commonly enveloped by smoke or dust plumes.*

ROADWAY LUMINAIRE DIRT DEPRECIATION CURVE

Figure 56-5.G

3. <u>Equipment Factor (EF)</u>. Allows for variations inherent in the manufacture and operation of the equipment (i.e., luminaire, system voltage, voltage drop). It is generally assumed to be 95%.

4. <u>Maintenance Factor (MF)</u>. The maintenance factor is the combination of light loss factors used to denote the reduction of the illumination for a given area after a period of time compared to the initial illumination on the same area. It is the product of the lamp lumen depreciation factor, the luminaire dirt depreciation factor, and the equipment factor (i.e., MF = LLD • LDD • EF). Consult the manufacturer's data and the Electrical and Mechanical Unit in the Central Office for the appropriate factors to use.

56-5.04(f.5) Luminaire Arrangement

Figure 56-5.H illustrates typical luminaire arrangements for conventional highway lighting designs. Use the calculation points provided in Figure A4 of ANSI/IESNA RP-8-00 publication.

56-5.04(g) Voltage Drop Determination

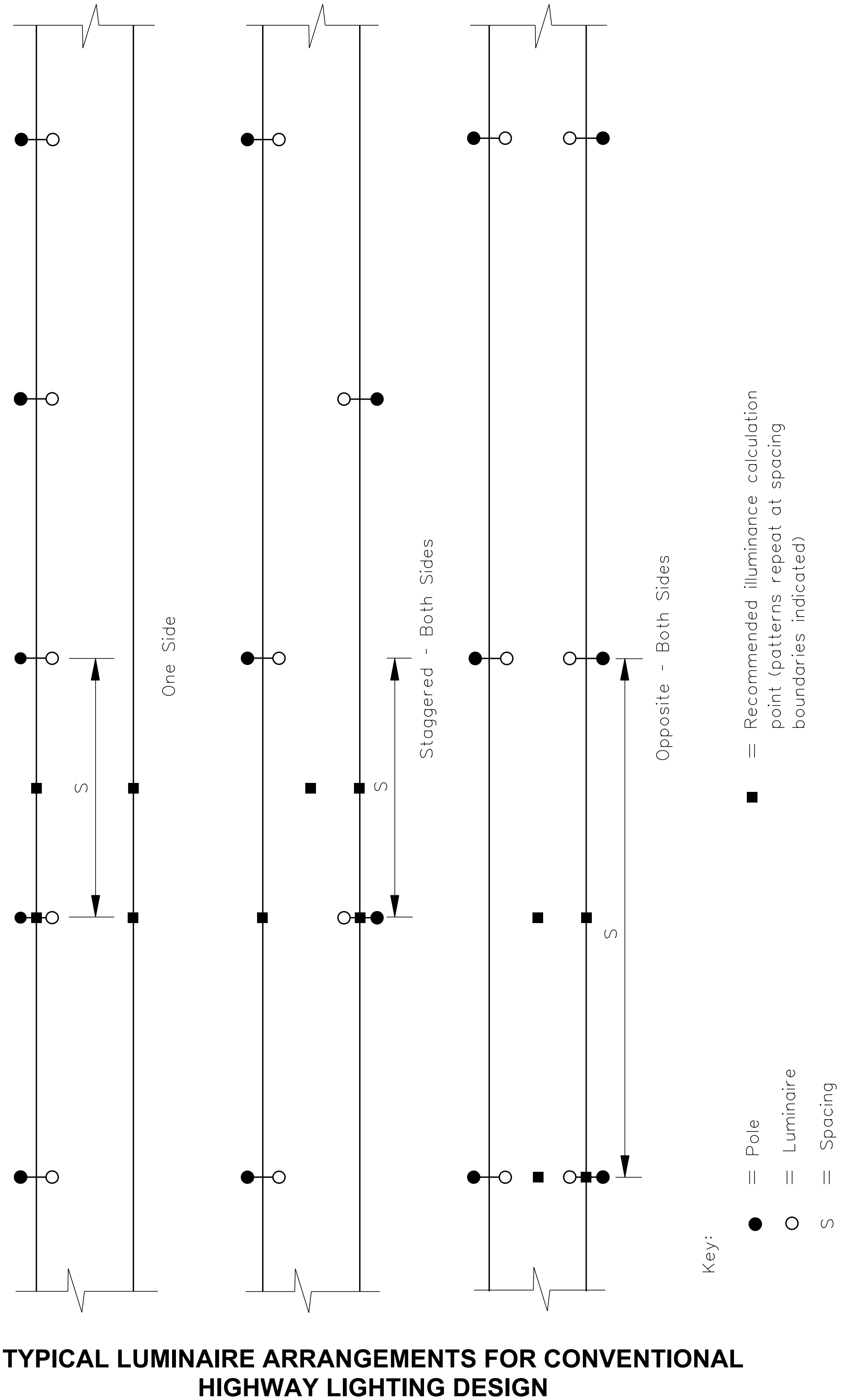
The typical power supply circuit to the highway lighting controller is 120/240 V or 240/480 V, single-phase, four-wire, 60-cycle alternating current. The branch lighting circuit consists of two conductors and an insulated ground wire. The lights are connected on both sides of the circuit to obtain 240V or 480V across the luminaire's ballast. Use Figure 56-5.I to determine the voltage drop between two adjacent luminaires.

56-5.05 <u>Other Design Considerations</u>

56-5.05(a) Roadside Safety Considerations

Light poles should be installed so that they will not present a roadside hazard to the motoring public. However, the physical roadside conditions often dictate their placement. It is important to recognize this limitation. Overpasses, sign structures, guardrail, roadway curvature, right-of-way, gore clearances, proximity to roadside obstacles, and lighting equipment limitations are all physical factors that can limit the placement of light poles. The designer also must consider factors such as roadway and area classification, design speed, posted speed, safety, aesthetics, economics, and environmental impacts. In addition, there should be adequate right-of-way, driveway control, and utility clearance. Consider the following when determining the location of light poles:

1. <u>Clear Zone</u>. Where practical, place light poles outside the roadside clear zone. See Chapter 38 for additional information on roadside clear zone.



TYPICAL LUMINAIRE ARRANGEMENTS FOR CONVENTIONAL HIGHWAY LIGHTING DESIGN

Figure 56-5.H

AMPS① (HPS Mag Reg Ballast)		
Watts	**240 Volts**	**480 Volts**
250 WATTS	1.4	0.7
400 WATTS	2.1	1.1

Wire Size AWG	Circuit Resistance ohms/100 ft (ohms/100 m)	Wire Size AWG	Circuit Resistance ohms/100 ft (ohms/100 m)
14	0.0032614 (1.0700)	2	0.0002009 (0.0659)
12	0.0020498 (0.6725)	1	0.0001600 (0.0525)
10	0.0012899 (0.4232)	1/0	0.0001271 (0.0417)
8	0.0008089 (0.2654)	2/0	0.0001009 (0.0331)
6	0.0005099 (0.1673)	3/0	0.0000796 (0.0261)
4	0.0003210 (0.1053)	4/0	0.0000625 (0.0205)

Notes:

1. *Consult manufacturer's data for specific ballasts being considered.*

2. *Voltage drop is determined using the following equation:*

   $V_d = 2 \cdot D \cdot I \cdot R$ *(For single-phase circuits with minimal impedance.)*

   where:

   V_d = *voltage drop (volts)*

   D = *distance in hundreds of ft (m). See Note 3.*

   I = *current (amperes). Use nominal, full-load current – published by the ballast manufacturer*

   R = *resistance in ohms/100 ft (ohms/100 m). See Note 4.*

3. *Distance is the circuit length from controller-to-pole or from pole-to-pole for the segment of circuit being analyzed, measured in hundreds of feet (meters).*

4. *DC resistances listed in table above are based upon stranded copper conductor at 167°F (75°C) operating temperature with an insulated covering and located in conduit. Reference source: Table 8 "Conductor Properties," Chapter 9 of the National Electrical Code.*

VOLTAGE DROP BETWEEN LUMINAIRES

Figure 56-5.I

2. Breakaway Supports. Unless located behind a roadside barrier, guardrail or crash cushion, which is necessary for other safety-related reasons, conventional light poles placed within the roadside clear zone will be mounted on FHWA-approved breakaway supports. Poles outside the clear zone also should be mounted on breakaway supports where there is a possibility of them being struck by errant vehicles. Be aware that falling poles and mast arms may endanger bystanders (e.g., pedestrians, bicyclist, motorists). Consider the following during design:

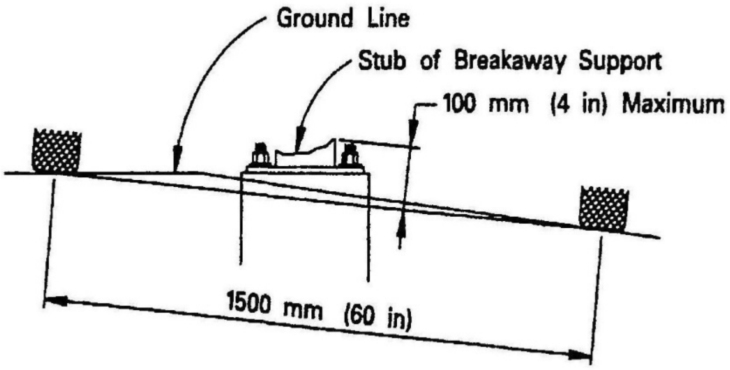
   a. Pedestrians. In areas where pedestrians, bicyclists, or building structures and windows may be struck by falling poles or mast arms after a crash, evaluate the relative risks of mounting the light pole on a breakaway support. Examples of locations where the hazard potential to pedestrian traffic would be greater include:

      - transportation terminals,
      - sports stadiums and associated parking areas,
      - tourist attractions,
      - school zones, or
      - central business districts and local residential neighborhoods where the posted speed limit is 30 mph (50 km/h) or less.

      In these locations, Use non-breakaway supports. Other locations that require the use of non-breakaway bases, regardless of the pedestrian traffic volume, are rest areas and weigh station parking lots and combination traffic signal/light poles.

   b. Breakaway Bases. All breakaway devices will comply with the latest applicable AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* requirements for breakaway supports.

   c. Breakaway Support Stub. Substantial remains of breakaway supports shall not project more than 4 in (100 mm) above a line between the straddling wheels of a vehicle on 60 in (1.5 m) centers. The line connects any point on the ground surface on one side of the support to a point on the ground surface on the other side, and it is aligned radially or perpendicular to the centerline of the roadway. Breakaway supports, including those placed on roadside slopes, must not allow impacting vehicles to snag on either the foundation or any substantial remains of the support. Surrounding terrain may need to be graded in order to permit vehicles to pass over any non-breakaway portion of the installation that remains in the ground or rigidly attached to the foundation. The specified limit on the maximum stub height lessens the possibility of snagging the undercarriage of a vehicle after a support has broken away from its base, and minimizes vehicle instability if a wheel hits the stub. The necessity of this requirement is based on field observations. Application of the clearance requirement is illustrated in Figure 56-5.J.



STUB HEIGHT REQUIREMENTS

Figure 56-5.J

d. Wiring. All light poles that require breakaway supports will be served by underground wiring and designed with simultaneous quick disconnect splices.

e. Light Towers. Light Towers used in high-mast lighting applications will not be mounted on breakaway supports. Also, towers will not be located within the roadside clear zone unless protected by guardrail, barriers, or crash cushions; see Chapter 38.

f. Bridge Parapets and Concrete Barriers. Where poles are mounted atop bridge parapets and concrete barriers, they will be mounted on non-breakaway supports.

3. Gore Areas. Where practical, locate light poles outside the gore areas of exit and entrance ramps. Generally, lighting support should not be placed within the clear zone of the gore area.

4. Horizontal Curves. Place light poles on the inside of sharp curves and loops. Where poles are located on the inside radius of superelevated roadways, provide sufficient lateral clearance to avoid being struck by trucks.

5. Maintenance. When determining pole and luminaire locations, consider the hazards that will be encountered while performing maintenance on the lighting equipment.

6. Barriers. Use the criteria provided in Chapter 38 to design and place light poles in conjunction with roadside barriers. Consider the following additional guidelines:

   a. Placement. Where a roadside barrier is provided, place all light poles behind the barrier.

   b. Deflection. Light poles placed behind a roadside barrier should be offset by at least the deflection distance of the barrier; see Chapter 38. This will allow the barrier rail to deflect without hitting the pole. If this clearance distance is not available, such as in extreme side slope conditions, designate the stiffening of the barrier rail for reduced deflection.

   c. Concrete Barriers. Light poles that are mounted atop barriers or protected by a rigid or non-yielding barrier do not require a breakaway support.

   d. Impact Attenuators. Do not locate light poles within the functional operation of any impact attenuator or other safety device.

7. Protection Features. Do not use protection features (e.g., barriers) for the primary purpose of protecting a light pole.

8. Longitudinal Adjustments. Locate light poles to balance both safety and lighting needs. Adjustments on the order of 2% average of the longitudinal spacing is permissible in the field to accommodate utilities or drainage facilities provided the new location does not constitute a roadside hazard. Larger adjustments need to be brought to the attention of the lighting designer for evaluation and approval.

56-5.05(b) Foundation, Pole Mounting, and Structural Considerations

The *Standard Specifications*, *Highway Standards* and the electrical detail sheets provide pole mounting details and details for foundation materials, depth, width, reinforcing, etc. When designing lighting systems, also consider the following:

1. Foundation Height Relative to Final Grade. For other than light towers, ensure pole foundations are no more than 0.5 in (13 mm) higher than the high edge of the surrounding final grade and in compliance with Figure 56-5.J. This permits proper drainage around the foundation and reduces the likelihood of the foundation intensifying a collision. The foundation also is less likely to be destroyed during a collision. When located within the clear zone, ensure that the foundation and fractured breakaway device does not protrude more than 4 in (100 mm) above the finished grade within a 5 ft (1.5 m) chord. See Chapter 38 for additional information on clear zones.

2. Steel Foundations. The steel (i.e., helix screw-in type) foundation is one that is commonly used by the Department for conventional light poles. This foundation is placed in undisturbed earth using a clockwise rotation similar to a common screw. The steel tube is typically 8 in (200 mm) in diameter and 6 ft to 8 ft (1.8 m to 2.4 m) long. Shorter lengths may be appropriate for foundations in areas with shallow bedrock. The steel foundation will accommodate poles with 11.5 in and 15 in (292 mm and 381 mm) bolt circles for luminaire mounting heights up to 50 ft (15.2 m).

3. Light Tower Foundations. Foundations for light towers used in high-mast lighting applications typically require specialized designs and soil surveys to ensure adequate support. A 4-ft (1.2-m) diameter reinforced concrete foundation, to a depth as required by the soils analysis, usually is adequate for towers accommodating 80 ft to 110 ft (24.4 m to 33.5 m) luminaire mounting heights. The top 18 in (450 mm) of the foundation is

formed. Below this depth, ensure that the foundation is poured monolithically against the undisturbed earth of the bored hole. Specify the foundation depth on the lighting plans. Additionally, include a level concrete work pad at the base of the tower..

4. Foundations for Temporary Lighting. Foundations for temporary lighting will be determined on a case-by-case basis. This may include direct embedment of wood poles to a depth of from 5.5 ft (1.7 m) for 30 ft (9.1 m) poles, to 12 ft (3.6 m) for 65 ft (19.8 m) poles. The use of butt base anchors also may be considered. However, locate these supports outside the clear zone; see Section 56-5.05(b) for more details.

5. Pole Mounting on Parapets. Poles for bridge lighting typically are mounted on specially designed concrete parapet sections. Mounting design includes the necessary non-breakaway, high-strength bolts, leveling plate, and vibration isolation pad and washers.

6. Structural Design. Poles will be designed and fabricated to meet or exceed AASHTO requirements as documented in *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and NCHRP Report 411. See the *IDOT Standard Specifications* for the appropriate design criteria (e.g., wind loading, gust factor, luminaire mass, and effective area).

56-5.05(c) Other Considerations

In addition to the items discussed in the previous sections, consider the following when designing the highway lighting system:

1. Signs. Place light poles to minimize interference with the driver's view of the roadway and any highway signs. Luminaire locations should not seriously detract from the legibility of signs at night.

2. Structures. Place light poles sufficiently away, generally at least one mounting height, from overhead bridges and sign structures to minimize glare and distracting shadows on the roadway surface.

3. Trees. Insufficiently pruned trees can cause shadows on the roadway surface and reduce the luminaire's effectiveness. Design the pole/luminaire with a height and mast-arm length to negate such adverse effects.

4. Criteria. Consult the authority having jurisdiction of the lighting for design criteria and standards prior to design.

5. Navigable Airspace. Where lighting projects are being considered in close proximity to an active airfield or airport, consider the impact the height of the light pole has on navigable airspace during and after construction. For additional information, consult the FAA Advisory Circular AC 70/7460-2J *Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace*.

6. Luminaire Shielding. Avoid external shielding of luminaires. If external shielding is used, ensure the shields have been tested to achieve the necessary light control and designed to prevent rotation and misalignment. The lighting design must incorporate the correct photometry that accurately depicts the luminaire with the shields in place.

7. Combination Traffic Signal/Light Pole. The use of combination traffic signal structures that have a roadway luminaire top attachment generally improve roadside safety. They should be used, where practical, to eliminate a light pole adjacent to a traffic signal structure. Place combination poles beyond the pedestrian crosswalk to allow pedestrian visibility in silhouette.

56-6 HIGH-MAST LIGHTING DESIGN

In general, the design of high-mast lighting systems follows the same design procedures as discussed in Section 56-5. In addition, consider the following:

1. Light Source. IDOT-owned and maintained lighting systems typically use either 400W, or 750W HPS lamps. The number of luminaires required will be determined by the area to be lighted. As a general starting point, it can be assumed that 400W luminaires will be used and the number per pole will be six luminaires.
2. Mounting Heights. Mounting heights in high-mast lighting applications range from 80 ft to 160 ft (24.3 m to 48.8 m). In general, heights of 100 ft to 150 ft (30.5 m to 45.7 m) have exhibited the most practical designs. Greater mounting heights require more luminaires to maintain illumination levels. However, greater heights allow for fewer poles and provide better light uniformity. As a general starting point, it can be assumed that mounting heights of 80 ft to 100 ft (24.3 m to 30.5 m) will be used.
3. Location. In determining the location of light towers, review the plan and profile view of the area to determine the critical areas requiring lighting. In selecting tower locations, consider the following:
    a. Critical Areas. Locate light towers so that the highest localized levels of illumination fall within the critical traffic areas (e.g., freeway/ramp junctions, ramp terminals, merge points).
    b. Roadside Safety. Locate light towers outside the roadside clear zone and a sufficient distance from the roadway so that the probability of a collision is virtually eliminated; see Chapter 38. Do not place light towers on the end of long tangents.
    c. Signs. Locate light towers so that they are not within the driver's direct line of sight to highway signs.
4. Design. Use point-by-point calculations to evaluate luminance, illuminance, and veiling luminance levels. Calculation grids must be placed at appropriate locations to analyze these levels. Consult the Electrical and Mechanical Unit in the Central Office for assistance to make these determinations.

    Adjust luminaires, pole locations, and other variables, as needed, to ensure that the minimum-maintained illumination is provided and the uniformity ratio has been satisfied. Give consideration to adjacent land use during the analysis. Ensure the design minimizes glare and maintains light control on adjoining property.
5. Navigable Airspace. Where lighting projects are being considered in close proximity to an active airfield or airport, consider the impact the height of the light tower has on navigable airspace during and after construction.