

Australian/New Zealand Standard™

Lighting for roads and public spaces

Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance



AS/NZS 1158.1.2:2010

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The following are represented on Committee LG-002:

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Australian Industry Group
Australian Local Government Association
CIE Australia Inc.
Department of Transport and Main Roads, Queensland
Energy Networks Association
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Australian/New Zealand Standard™

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Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance

Originated as AS/NZS 1158.1.3:1997.
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee LG-002, Lighting for Roads and Public Spaces, to supersede AS/NZS 1158.1.3–1997 *Road Lighting Part 1.3: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance*, now designated as Part 1.2.

This Standard is part of the AS/NZS 1158 series, *Lighting for roads and public spaces*, which covers lighting schemes for most roads and public spaces.

The performance criteria for such lighting schemes may include any or all of the following:

- (a) Facilitation of safe movement.
- (b) The discouragement of illegal acts.
- (c) Contributing to the amenity of an area through increased aesthetic appeal.

The series has divided road lighting into the following two broad categories:

- (i) *Category V lighting* Lighting that is applicable to roads on which the visual requirements of motorists are dominant, e.g. traffic routes.
- (ii) *Category P lighting* Lighting that is applicable to roads on which the visual requirements of pedestrians are dominant, e.g. local roads and lighting that is applicable to outdoor public areas, other than roads, where the visual requirements of pedestrians are dominant, e.g. outdoor shopping precincts.

This Standard applies to Category V lighting.

Its objective is to provide guidance to those concerned with design, installation, operation and maintenance of such lighting, to facilitate compliance with the requirements of AS/NZS 1158.1.1.

The following Standards have been issued in the AS/NZS 1158 series:

AS/NZS

1158	Lighting for roads and public spaces
1158.0	Part 0: Introduction
1158.1.1	Part 1.1: Vehicular traffic (Category V) lighting—Performance and design requirements
1158.1.2	Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance (this Standard)
1158.2	Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting
1158.3.1	Part 3.1: Pedestrian area (Category P) lighting—Performance and installation design requirements
1158.4	Part 4: Lighting of pedestrian crossings
1158.5	Part 5: Tunnels and underpasses
1158.6	Part 6: Luminaires

Road lighting is acknowledged to be an effective crash counter-measure. The costs involved in providing road lighting can be demonstrated to provide significant financial and community benefits in terms of reductions in road crashes at night. Studies in Australia and New Zealand, and in other countries, have led to the conclusion that traffic route lighting is likely to reduce night time casualty crashes by about 30%, taken over the road network. A summary of the findings of lighting and crashes is given in Appendix C. (See also Ref. 9, 20 and 21 in Paragraph A2.)

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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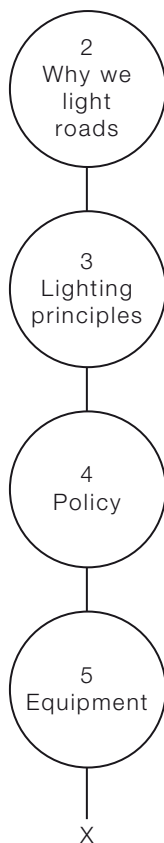
FOREWORD

The subject matter covered in this Standard is divided into three main elements, as follows:

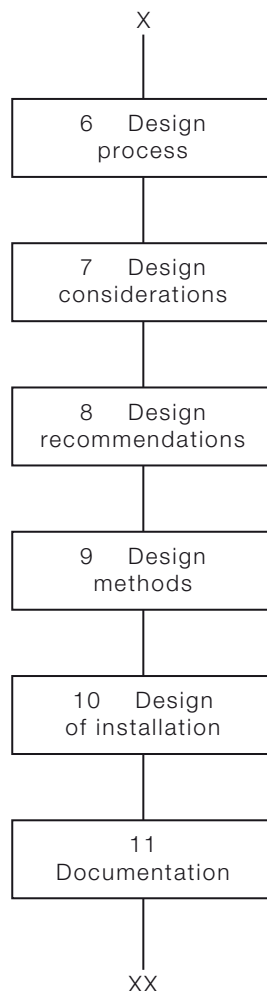
- (a) *Fundamentals* The information that must be known before engaging in a road lighting design.
- (b) *Design* The considerations and processes involved in the development of a design for a road lighting scheme.
- (c) *Application* Advice relating to the installation, operation and maintenance of a road lighting scheme.

These three broad subject areas are further divided into sections within this Standard as shown in the flow chart below.

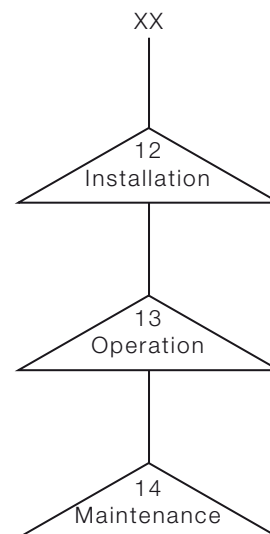
Fundamentals



Design



Application



STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Lighting for roads and public spaces

**Part 1.2: Vehicular traffic (Category V) lighting—Guide to design,
installation, operation and maintenance**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard sets out requirements, background information, guidelines and other relevant information for the design, installation, operation and maintenance of Category V lighting schemes intended to comply with AS/NZS 1158.1.1. It should be read in conjunction with that Standard. For the purpose of this Standard, the lighting categories set out in AS/NZS 1158.1.1 apply. Table 2.1 of that Standard describes typical applications for each of the lighting categories given.

The Standard does not purport to cover every possible means of ensuring compliance with AS/NZS 1158.1.1.

Much of this Standard is also applicable to lighting schemes intended to comply with AS/NZS 1158.3.1 and reading of it in conjunction with that Standard is recommended.

The appropriate lighting category for a particular road is a matter for determination in consultation with the road or traffic authority concerned.

1.2 REFERENCED DOCUMENTS

A list of the Standards and other documents referred to in this Standard is given in Appendix A. The Appendix also lists a number of additional documents that are considered useful sources of information on the subject of this Standard.

1.3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS/NZS 1158.0 apply.

NOTE: See Paragraph B3 of Appendix B for definitions of terms related to the use and placement of road lighting poles.

SECTION 2 WHY WE LIGHT ROADS

2.1 ROAD LIGHTING OBJECTIVES

The objective of road lighting is to provide an illuminated environment, which is conducive to the safe and comfortable movement of vehicular and pedestrian traffic at night, and the discouragement of illegal acts. To accomplish this, the lighting should reveal necessary visual information. This consists of the road itself, the course of the road ahead, kerbs, footpaths, property lines, road furniture and surface imperfections, together with the road users including pedestrians, cyclists and vehicles and their movements, and other animate and inanimate obstacles.

2.2 ROAD SAFETY

The primary purpose of road lighting is to protect people from injury and death on the roads at night. All efforts and technological developments harnessed to attain this goal will also help curb the economic toll that traffic crashes take on national resources. The lowering of crash costs alone will generally justify investment in optimized road lighting.

2.3 ROAD LIGHTING AS A CRASH COUNTERMEASURE

Road crashes at night are disproportionately higher in number and severity compared to daytime crashes. Individual factors such as increased alcohol usage, fatigue, and over-representation of young drivers in night traffic contribute to the problem. However, the major factor is darkness.

With the low light levels that prevail at night, visual capabilities such as acuity, distance judgement, speed of seeing, colour discrimination and glare tolerance are impaired. There will also be adverse interactions between impaired vision due to low light and other factors, such as inclement weather.

As a result of these conditions, visibility will be severely reduced at night. Thus, it can be expected that the provision of light through road lighting will be a crash countermeasure. However, the installation of the lighting cannot be expected to result in a reduction in crashes if there is a major traffic management or road design problem at any particular site.

The International Commission on Illumination (CIE) has conducted a review of research worldwide into the effectiveness of road lighting as a crash countermeasure. The findings are given in Ref. 4 in Paragraph A2 and in Appendix C.

2.4 SECURITY AND AMENITY

Further objectives of road lighting are to facilitate security and amenity. The provision of appropriate lighting can discourage crimes against both people and property, including parked vehicles. It may also enhance the environment for appropriate use by pedestrians and give rise to feelings/perceptions of safety and security.

SECTION 3 LIGHTING PRINCIPLES

3.1 VISUAL PROCESSES AND THE LIGHTING NEEDS OF ROAD USERS

Vehicle drivers require a readily discernible flow of visual information in order to safely, efficiently and comfortably carry out the task of driving. Some of this information is provided by traffic control signals, road signs or markings and by vehicle lighting, e.g. presence and brake lights and turn signals. However, much of the required information comes from the general road scene itself, e.g. from the run of the road ahead and its layout, the presence of vehicles and other road users, and their perceived speeds and manoeuvres.

Assimilation of this information is facilitated by the contrast of the objects of interest with their surrounds, by detail within the objects, and by colour and movement.

The capacity of the human visual system to assimilate information largely depends on the ambient light level. In daylight (unless dazzled by the sun) vision is optimal; contrast sensitivity, acuity, colour perception, motion perception and the speed of vision are all as good as is humanly possible.

In spite of the facility of the eye to adapt to changing light levels, optimum vision cannot be sustained at low light levels. The light level provided by a traffic route lighting installation should be sufficient to limit any deterioration of vision at night, so that the driver's vision is as near as practicable to the optimum. This is particularly important on traffic routes where an error in judgement could result in a severe crash. If the lighting is sufficient for drivers of vehicles, it will be more than adequate for other more slow-moving road users, such as pedestrians and cyclists.

The values of luminance and illuminance specified in Section 2 of AS/NZS 1158.1.1 are pitched so the human visual system is on the borderline between being light-adapted (photopic vision) and of starting to become dark-adapted (mesopic vision). The values specified are much greater than those pertaining to the completely dark-adapted eyes (scotopic vision). If completely dark-adapted, e.g. to a moonless night, the eye would only have the facility to detect very large moving shapes, without any colour or detail being discernible. However, the lighting levels specified for traffic route lighting, whilst maintaining vision at close to the optimum, are modest and will only be a fraction of those applying under daylight. Light levels experienced in daylight will generally be a thousand times higher, and even on dull days, a hundred times higher. Again, by comparison, office lighting will be more than 10 times the level implicit in traffic route lighting. The success of road lighting as a traffic crash counter measure indicates that this lighting level is both sufficient and necessary (see Clause 2.3 and Appendix C).

3.2 LIGHTING INSTALLATIONS AND LIGHT TECHNICAL PARAMETERS

3.2.1 Basis of road lighting

Once the general level of lighting that is required has been established, the purpose of the light, as well as the light technical parameters needed to achieve that purpose, should be considered.

The carriageway of the traffic route is particularly important, in that this is the area of most activity and of the fastest activity. Moreover, the carriageway will have a surface of reasonably predictable and stable reflection characteristics. This allows the lighting of the carriageway to be designed on the basis of the luminance of the road surface, which is appropriate, since it is the luminance (or 'brightness') of that surface that is seen and not the illuminance (or quantity of light) falling on it.

Making the road surface bright by exploiting its reflection characteristics has the effect of—

- (a) raising the adaption light level of the driver and, by so doing, maintaining general visual performance at near optimum;
- (b) emphasizing the condition and run of the road ahead;
- (c) providing an extended luminous background, which provides a frame of reference in judging (subconsciously) relative speed and movement; and
- (d) facilitating visibility of the presence and shape of objects on the carriageway by silhouette, i.e. dark object against bright surrounds.

In order to make the road surface bright, a luminaire emits light in a beam directed towards the oncoming driver. With this beam direction there is no light on the object surfaces facing the driver. Hence the possibility of viewing objects by silhouette as described in Item (d) above. The effect is most apparent when objects are some distance away (several spans of lighting ahead) and are thus, angularly, relatively small.

The luminaire will also have a trailing beam emitting light in the direction of travel. This light will directly illuminate objects to show up colour and detail. The effect is most apparent when the objects are close and are thus relatively large, in angular size.

Of course, for drivers travelling in the opposite direction, the two beams of light are in effect, reversed. The one luminaire thus serves both directions of travel.

3.2.2 Light technical parameters

Section 2 of AS/NZS 1158.1.1 specifies maintained (minimum) values for the average carriageway luminance ($\bar{L}$) which is the simple arithmetic mean of luminances within a span of lighting*. Maintained values for $\bar{L}$ are specified to ensure an adequate level of carriageway luminance on the initial installation of the lighting and to limit the subsequent deterioration in service to a tolerable level. Several lighting categories are given to cover the range of traffic routes with respect to the amount and type of activity on them (see Section 1 of AS/NZS 1158.1.1).

In specifying maintained values for $\bar{L}$, a limitation is placed on the uniformity of luminance to ensure the following:

- (a) That there are no dark areas within a span of lighting, which may conceal objects. The light technical parameter is U_O and is a ratio, i.e. $U_O = L_{\min} \div \bar{L}$. The specified value is the same for each lighting category since it effectively limits the minimum luminance ($L_{\min}$) anywhere within a span of lighting.
- (b) That there are no light and dark bars across the road, repeated through the length of the installation. This may arise, for example, if luminaires with excellent glare control are spaced excessively far apart. The light technical parameter is U_L and is a ratio, i.e. $U_L = L_{\min} \div L_{\max}$. The specified value applies along a designated longitudinal line within a span of lighting and, being a ratio, is the same for each lighting sub-category.

A traffic route will consist of a variety of elements other than the straight carriageway. For example, there are the intersections and the immediate surrounds to the carriageway edges, i.e. the verges. These areas do not lend themselves to a luminance-based lighting design.

For intersections, the carriageway may not be visible ahead when undertaking turning manoeuvres. It is therefore important to illuminate channelizations, road surface markings and vehicles within the general area of the intersection.

* The exact definitions of the light technical parameters are given in AS/NZS 1158.0.

For this purpose, a maintained (minimum) illuminance (E_{ph}) at any point within the designated area is specified. Maintained values of E_{ph} are given, together with different values for each lighting category reflecting the level and type of activity on the road. Thus E_{ph} sets the general level of lighting required. The uniformity of illuminance is controlled to ensure there are no excessively bright points within the designated design area. The light technical parameter is U_{EI} and is a ratio, i.e. $U_{EI} = E_{max} \div E_{ph}$. As the uniformity is a ratio, only one value is given for all the lighting sub categories.

For road verges, the surface will be indeterminate, i.e. shoulder, footpath, nature strip. Nevertheless such surfaces are important as a starting point for pedestrians to cross the carriageway. In these cases, the lighting design is based on the illuminance on the relevant surface. The illumination of the verges is ensured by specifying that the illuminance on the designated verge area be not less than a specified fraction of the value for U_{EI} that applies for the contiguous carriageway area. The light technical parameter is E_s .

Glare from the luminaires has the potential to inhibit vision. Glare is conventionally categorized into that which gives rise to an impairment in seeing (disability glare) and that which gives rise to visual discomfort (discomfort glare). In road lighting, attention is specifically given to the former on the basis that, if disability glare is suitably controlled, the discomfort glare will be controlled as well. The relevant light technical parameter is TI . One maximum value is given for all lighting categories.

It should be noted that glare control and the production of carriageway surface luminance are not independent of one another. The specified value of TI is a compromise between adequate glare control and economic spacing of the luminaires. Excellent glare control will necessitate the use of luminaires with a much lower value of TI ($\approx 10\%$). However, the resulting reduced angle of the beam of light from the luminaire downward vertical will require a concomitant closer spacing of the luminaires. The use of such luminaires will normally be restricted to situations where good glare control is necessary, e.g. on bridges where luminaires may be seen against dark backgrounds, around airports, and in other locations where a high degree of glare control is required. (See also Clause 5.3.)

The glare from vehicle headlights is controlled by specified limits in the relevant (motor vehicle) Australian Design Rules and in New Zealand the Land Transport Rule Vehicle Lighting 2004.

The environmental effects of installing road lighting also need to be considered. These are described in Clause 1.1. The upward waste light ratio ($UWLR$) is the only light technical parameter specified in Section 2 of AS/NZS 1158.1.1 and controls the amount of light that road lighting luminaires may release above the horizontal.

3.3 FACTORS AFFECTING PAVEMENT LUMINANCE

A road lighting luminaire mounted above the pavement produces a characteristic 'T' shaped bright patch on the road surface. It comprises a wide head stretching across the road, commencing a very short distance behind the luminaire, with a tail extending in the direction of the observer towards the image point (see Figure 3.1).

The actual shape will depend partly on the light distribution from the luminaire and partly on the type of road surface. A well-lit road is judged to be one that looks evenly bright, and to achieve this, the 'T' patches of brightness from each luminaire should interlock rather like the pattern of a jigsaw (see Figure 3.2).

The luminance of a point on the pavement is principally influenced by the amount of light incident at the point in question, the angles of incidence and of observation, and the reflecting characteristics of the pavement surface. The parameters involved are illustrated in Figure 3.3.

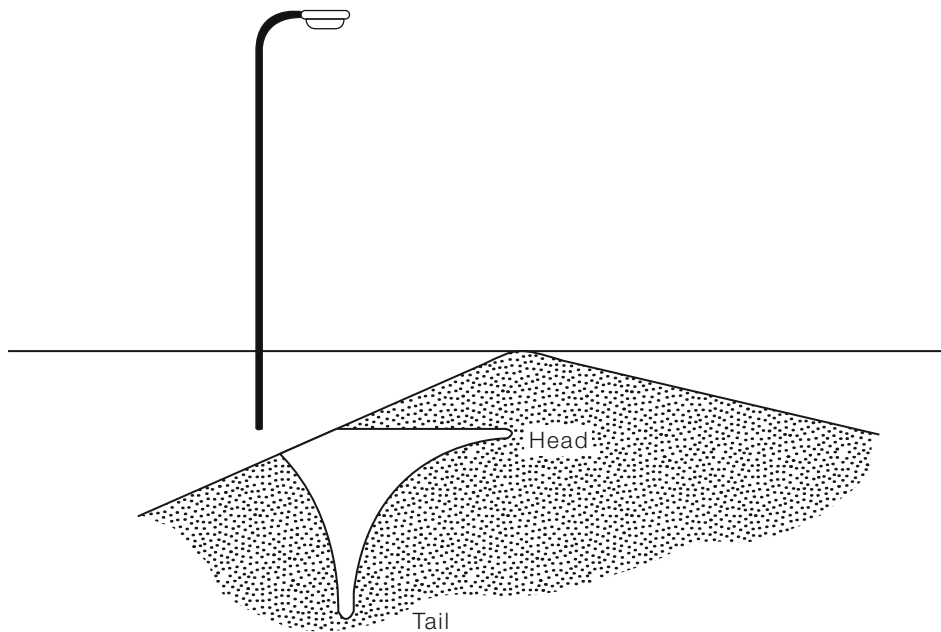
The illuminance (E), or the amount of light incident on the horizontal surface, in lux, at a given point (P) may be calculated from the following equation:

$$E = \frac{I \cos^3 \gamma}{H^2} \quad \dots 3.3(1)$$

Part of this light is reflected in the direction of the observers' eye and it is this component that creates the sense of brightness or luminance of the surface. The luminance (L), in candelas per square metre, in the direction of observation, is given by the following equation:

$$L = \frac{I q \cos^3 \gamma}{H^2} \quad \dots 3.3(2)$$

Where q is the luminance coefficient for the surface at the point, which varies with the angles alpha (α), beta (β) and gamma (γ) as defined in Figure 3.3 and with the surface characteristics as discussed in Clause 3.4 (see Ref. 20 in Paragraph A2).



NOTE: The tail of the light patch always extends towards the observer.

FIGURE 3.1 CHARACTERISTIC 'T' SHAPED LIGHT DISTRIBUTION FROM A SINGLE LUMINAIRE

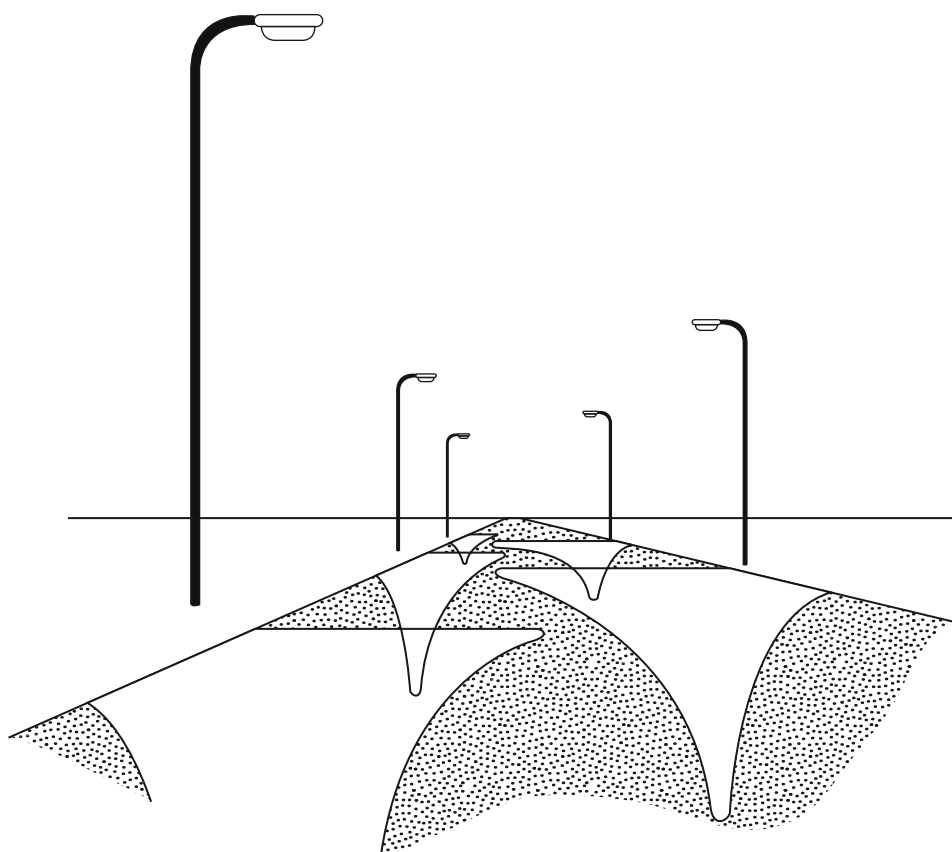
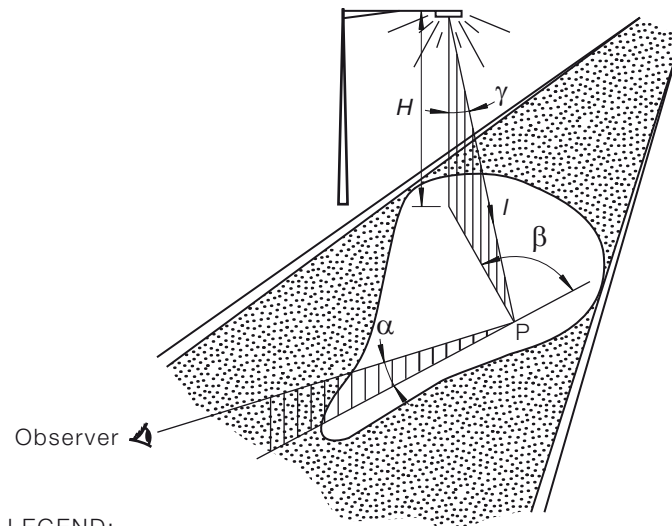


FIGURE 3.2 TYPICAL LIGHTING INSTALLATION WITH INTERLOCKING OF 'T' SHAPED LIGHT DISTRIBUTIONS



LEGEND:

- I = luminous intensity of the light source directed toward P, in cd/m^2
 α = angle of observation (usually taken as 1°)
 β = angle between the planes of the direction of illumination and the direction of observation at the point P
 γ = vertical angle of intensity
 H = mounting height of the light source, in metres

FIGURE 3.3 PARAMETERS AFFECTING PAVEMENT LUMINANCE

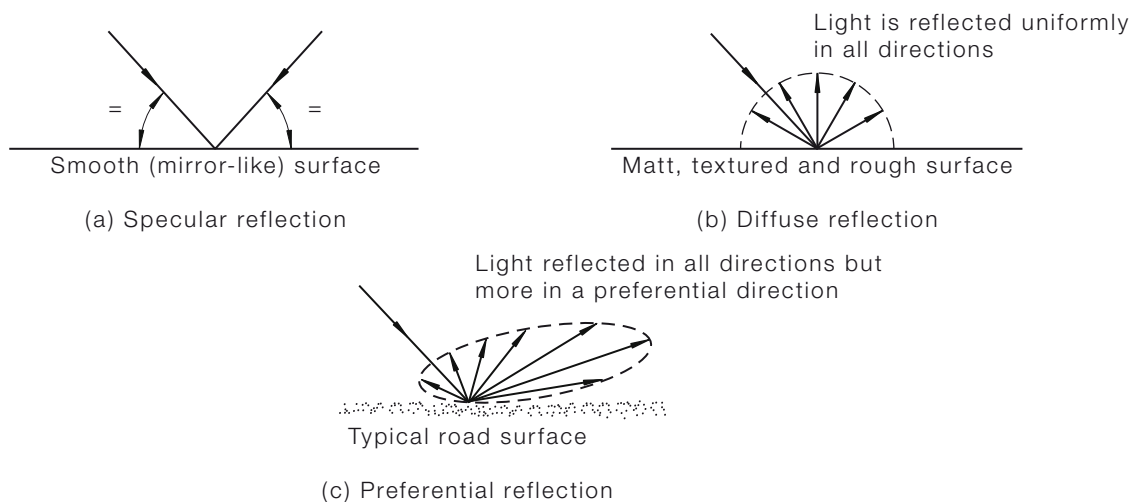
3.4 PAVEMENT REFLECTANCE

3.4.1 General

When light is beamed onto a surface, it is reflected as a specular reflection, if the surface is mirror-like, or as diffuse reflection, if the surface is completely matt, textured and rough. In practice, road surfaces exhibit both of these modes of reflection resulting in preferential reflection towards the eye of the vehicle driver. This is illustrated in simplified terms in Figure 3.4.

The reflecting properties of the road surface play an important part in the performance achieved by a road lighting installation. The reflecting characteristics of a road pavement surface, which influences the luminance coefficient (q), depends on the following:

- The macro and micro texture (i.e. whether it is rough or smooth, harsh or polished).
- The colour and lightness of the road material.
- The degree of dampness of the surface.



NOTES: A road pavement exhibits a combination of specular and diffuse reflection, resulting in preferential reflection towards the eye of the vehicle driver.

FIGURE 3.4 PAVEMENT REFLECTION

3.4.2 Surface texture

Surface texture is very important to road lighting performance, and also influences skid resistance and other traffic characteristics, such as noise. In respect to lighting, coarse-textured surfaces produce more diffuse reflection of light, which results in more rounded (i.e. shorter) light patches from individual luminaires. This requires a closer spacing of luminaires to achieve a given average luminance and uniformity (see Figure 3.5).

Polishing of the surface has the effect of reducing surface micro texture. This slightly increases the specular reflecting properties, thus increasing the light reflected in the preferential direction, resulting in longer light patches and possible improved uniformity of lighting on dry pavements.

3.4.3 Colour and lightness

While the actual colour of the surface plays only a minimal role, the lightness (especially where artificial brighteners are used) can significantly increase the luminance coefficient and thus the average luminance.

The variation of colour, lightness and surface texture are represented in several standard road surfaces defined in CIE Publication No. 30.2. The classification adopted in that publication is summarized in Table 3.1.

See Clause 7.6 for details of the standard road surfaces that are assumed in AS/NZS 1158.1.1 for calculations of the light technical parameters.

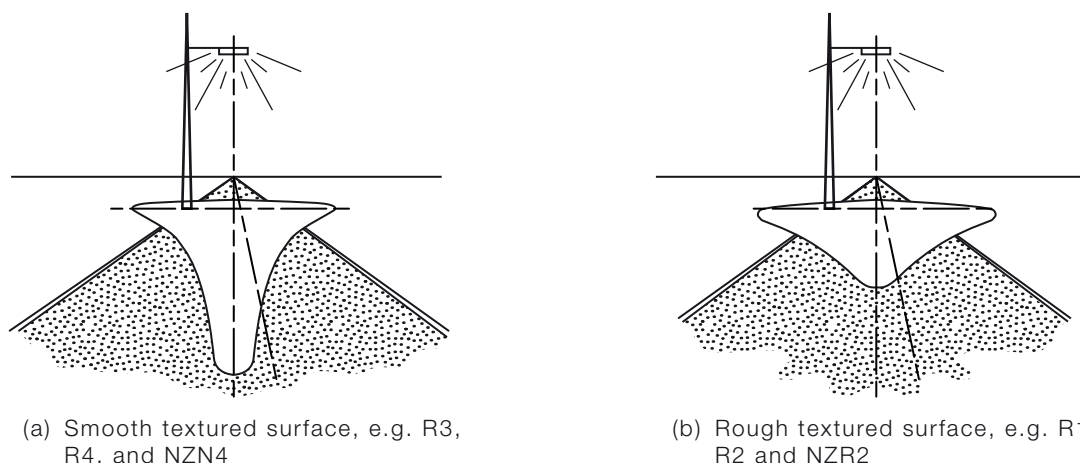


FIGURE 3.5 EFFECT OF SURFACE TEXTURE IN FIGURE 3.5(B) NZR2

TABLE 3.1

CLASSIFICATIONS OF ROAD SURFACES FOR LUMINANCE CALCULATIONS

Class	Description
R1*	(a) Asphaltic road surfaces with at least 15% of artificial brightener or with at least 30% of very bright anorthosites (arclite, labradorite or similar). (b) Surface dressings with chippings where over 80% of the road surface is covered and where chippings exist for a great many artificial brighteners or for 100% of very bright anorthosites. (c) Concrete road surfaces.
R2* and NZR2†	(a) Surface dressings with harsh texture and with normal aggregates (b) Asphaltic surface with 10% to 15% of artificial brighteners in the mixture (c) Coarse and harsh asphaltic concrete rich in gravel (>60%) and with gravel sizes up to or greater than 10 mm. (d) Mastic asphalt (Gussasphalt) after dressing in new condition
R3*	(a) Asphaltic concrete (cold, mastic asphalt) with gravel sizes up to 10 mm but with harsh texture (sandpaper). (b) Surface dressings with coarse texture but polished.
R4* and NZN4†	(a) Mastic asphalt (Gussasphalt) after some months of use. (b) Road surfaces with rather smooth or polished texture.

* Characteristics defined in CIE Publication No 30.2.

† Characteristics defined in Appendix D of AS/NZS 1158.2. Same as corresponding CIE surfaces but with a multiplication factor applied to the luminance coefficient (q).

3.4.4 Wet pavements

The degree of wetness or dryness of the pavement surface has a marked effect on the performance of road lighting. As a normal pavement changes progressively from a dry state to become damp, then wet and ultimately inundated, the reflecting characteristics change from diffuse reflection, becoming increasingly specular to the point where the surface of the water film reflects like a mirror. During this change, the size and shape of the light patches formed by the luminaires initially become larger (when the surface is just slightly damp) thereby improving both the level of luminance and uniformity. As further wetness develops, the light patches become narrower, elongated and brighter (as specular reflection increases), until ultimately the light from each luminaire is reflected as intense bands of light with the width and luminance approximately that of the actual luminaire (see Figure 3.6).

Increasing the coarseness or texture depth of a road pavement surface enhances the ability of the surface to maintain uniformity of lighting under damp to wet conditions. It may be noted that coarse textured pavements also improve skid resistance in wet conditions and reduce the amount of spray thrown up by tyres from a wet road. A classification of wet surfaces, including standard tabulations of reflection data for each surface, is given in CIE Publication No. 47.

The performance of a lighting installation under wet conditions depends largely on the characteristics of the road pavement over which the lighting designer has no control. No light technical parameters are therefore specified for wet road conditions but advice is given on measures that can be taken to enhance visibility (see Clause 7.5.2).

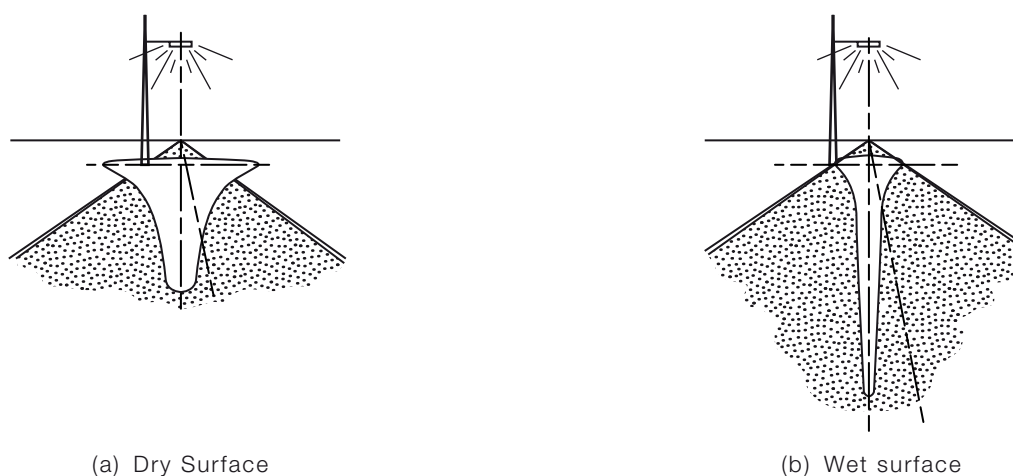


FIGURE 3.6 EFFECT OF PAVEMENT WETNESS

SECTION 4 POLICY CONSIDERATIONS

Generally the road controlling authority will be the owner/operator of the road that lighting is installed on. The responsibility of defining which road elements require lighting falls upon this body. While designers can offer advice on the level of lighting that may be required for Category V road lighting schemes as set out in AS/NZS 1158.1.1, Table 2.1, the warrants are set by the road authority.

Most road controlling authorities have their own policy and standards for road lighting that must be adhered to.

SECTION 5 EQUIPMENT

5.1 GENERAL

Road lighting equipment involves three main items, as follows:

- (a) *Lamps* The replaceable unit that is the source of the light.
- (b) *Luminaires* The apparatus housing the lamp and controlling the light distribution.
- (c) *Bracket arms and poles* The structural members that mount the luminaire(s) via a bracket arm to the vertical support structure.

Other equipment includes luminaire control gear, terminal panels, pole cages, pits, ducting, electrical cables and junction boxes. While these are important elements of lighting equipment, they will not be discussed in this Standard. Detailed information can be obtained from the relevant authority/agency.

5.2 LAMPS

The following high intensity discharge (HID) lamps shall be used for the provision of Category V lighting, as set out in AS/NZS 1158.1.1, Clause 2.8:

- (a) High pressure sodium vapour lamps with clear or diffusing outer envelopes.
- (b) Metal halide lamps with clear or diffusing outer envelopes.

A comparison of the main characteristics of the above lamps is given in Table 5.1.

5.3 ROAD LIGHTING LUMINAIRES

Luminaires may have either integral or remote control equipment. Requirements for road lighting luminaires are as specified in AS/NZS 1158.6.

Luminaires are available with either dished bowl or flat (aeroscreen) visors.

The dished bowl visor types are designed to allow a higher light output at angles nearer to horizontal than the flat (aeroscreen) visor types. The former provide substantially increased spacing compared with the flat (aeroscreen) visor types and consequently are the most commonly utilized luminaires. However, these luminaires exhibit higher glare than the flat (aeroscreen) visor types.

The flat (aeroscreen) visor types, whilst normally providing a higher quality installation, may only be justified where a greater degree of glare control is deemed necessary, since these luminaires generally require closer spacings than those for dished bowl luminaires. The following are typical examples of these installations:

- (a) To satisfy the requirements of the civil aviation authority, in areas surrounding airports.
- (b) To reduce spill light onto properties abutting roads that require Category V lighting, e.g. residential properties adjacent to freeways.
- (c) To reduce glare at locations where the background is intrinsically dark, e.g. bridges, flyovers, overpasses, isolated intersections.

TABLE 5.1
COMPARISON OF DISCHARGE LAMPS USED FOR CATEGORY V LIGHTING

1	2	3	4	5	6	7
Lamp type	Approx. average luminous efficacy (see Notes) (lm/W)	Typical average useful life (see Notes) (h)	Commonly used ratings (W)	Source appearance	Colour rendering	Comments
High Pressure Sodium Vapour	120	18 000	100 150 250 400	Golden yellow	Fair	Most cost-effective light source due to high efficiency, long life and high lumen maintenance. To be used for general Category V lighting.
Metal Halide Ceramic	105	8 000	100 150 250 400	White or warm white	Excellent	May be used for high prestige areas. Not favoured for general use on overall economic grounds. Offers better efficacy and lower early failure rate performance and life than Quartz lamps.
Metal Halide Quartz	80	8 000	100 150 250 400	White or warm white	Good	Not favoured for general use on overall economic grounds. Some variations in colour appearance may be observed between individual lamps.

NOTES:

- 1 The data given in Columns 2 and 3 are only indicative. See Appendix E for typical lamp mortality and lumen depreciation data, which should be considered in conjunction with the data of Columns 2 and 3. Significant variations in this data may apply for different lamp ratings and for lamps of the same rating produced by different manufacturers.
- 2 For design purposes, data applicable to the selected lamp type and rating should be obtained from the lamp supplier.

5.4 BRACKET ARMS AND POLES

5.4.1 Dimensions

Preferred dimensions of lighting poles and bracket arms used for the mounting of road lighting luminaires are given in AS 1798.

5.4.2 Pole types

Consideration should be given to the type of pole used and its installation requirements (see Clause 7.2) as follows:

- (a) *Material* The pole may be manufactured from a variety of materials including metal (generally galvanized steel), fibreglass, concrete or timber.
- (b) *Installation* The method of installation can be—
 - (i) direct-buried; or
 - (ii) baseplate-mounted.
- (c) *Power supply* The method of supply of power to a pole depends on the type of pole. Power supply for rigid poles may be aerial or underground but for frangible poles it is required to be underground. Slip base type frangible poles are required to be fitted with a special plug and socket connector located in the pole base. For the energy (impact) absorbing type refer to the relevant road lighting owner for connection arrangements.
- (d) *Maintenance* Account should be taken of necessary provision for access to lighting equipment for maintenance.

Sound traffic engineering and safety principles should be employed in the selection of the correct type of pole for the task at hand.

NOTE: See Appendix B for guidelines on the use and placement of rigid and frangible road lighting poles.

5.4.3 Combination traffic signal mast arm and joint-use road lighting poles

Combination mast arm and joint-use poles in accordance with AS 2979 should be used when lighting intersections and junctions at which traffic signals are proposed or installed. This will enable the road lighting luminaires to be accommodated on the proposed/existing road traffic signals hardware, resulting in a safer and more economical installation. In addition it may be easier to meet the lighting design requirements at larger intersections and junctions.

Conversely, when designing new traffic signal installations, it is important that current and known future requirements for road lighting be considered so that, where possible, road traffic signals and lighting can share the same pole.

SECTION 6 DESIGN PROCESS

6.1 GENERAL

Road lighting design requires more than just putting luminaires on poles. It involves a design process addressing sound traffic engineering principles and safety.

AS/NZS 1158, Part 1.1, Appendix C sets out the minimum technical information that should be provided to the designer of a Category V road lighting scheme. This Section amplifies this and fully details the design process. The design process commences with the provision of a detailed design brief from the client containing all the relevant design information. By necessity there will often be consultation between the client and the road lighting designer concerning design parameters and site conditions, for example, in the determination of the carriageway lighting design width. However, the final decisions are the responsibility of the client.

6.2 BASES OF ROAD LIGHTING PROCESS

The bases of the provision, design and operation of a road lighting scheme is as follows:

- (a) Background information (see Sections 2 and 3).
- (b) Authority (see Section 4).
- (c) Preliminary design information (see Sections 5 and 7).
- (d) Road lighting design (see Sections 8, 9 and 10).
- (e) Documentation (see Section 11).
- (f) Installation (see Section 12).
- (g) Operation (see Section 13).
- (h) Maintenance (see Section 14).

6.3 SIMPLIFIED LIGHTING DESIGN PROCESS

The following sets out the simplified steps in the lighting design process and also serves as a brief specifying requirements for the provision of a lighting design service, including a statement of the scope of work that the consultant/contractor is required to carry out:

- (a) Hold discussions with the client regarding their specific design parameters.
- (b) Obtain relevant cadastral and civil layout plans from the relevant authorities, if available.
- (c) Perform site inspections and surveys to mark/confirm all pole locations, luminaire types and lamp ratings, length of outreach brackets and mounting heights, overhead conductor clearances, road geometries and details of road channelization.
- (d) Undertake designs to comply with AS/NZS 1158.1.1 and other special requirements that apply.
- (e) Prepare the design using the relevant I-tables from the luminaire manufacturers.
- (f) Prepare plans and works schedules giving details of luminaires, their locations, mounting heights and details of brackets. Include details of additional poles to be installed and agreed alterations to the utility services to accommodate the lighting scheme.
- (g) Nominate luminaires that comply with AS/NZS 1158.6.

- (h) Submit design calculations complying with AS/NZS 1158.1.1, and proposed road lighting arrangement drawings.
- (i) Ensure the final designs have been signed as recommended and approved by persons with qualifications recognized by the client and satisfying any statutory requirements.
- (j) Submit completed documentation, including computer-generated drawings.
- (k) Liaise with construction staff, if requested, during the construction works scheduling or lighting installation stage.

6.4 FULL ROAD LIGHTING DESIGN PROCESS

6.4.1 Steps involved in process

The full road lighting design process will involve all or most of the steps illustrated in Appendix D, which are described here and in Sections 7 to 11.

6.4.2 Design brief checklist

The design brief should contain all the relevant information required for a specific project. This may include some or all of the following:

- (a) Brief description of work(s).
- (b) Lighting categories, including those of intersecting roads.
- (c) Overall site plan(s) showing a line view of the project, including features such as intersections, junctions, roundabouts, on/off ramps, bridges, overpasses at grade separation and road names.
- (d) Accurate base plan(s) to a nominated scale, preferably showing only the following:
 - (i) Road features, e.g. lanes, shoulders, medians.
 - (ii) Details of any traffic signals.
 - (iii) All radii of curvature of route lighting segments and on/off ramps.
 - (iv) Control lines with identifying names.
 - (v) Chainages.
 - (vi) Roadside features, e.g. cut, fill, trees, drainage.
 - (vii) Electricity authority details, e.g. poles, overhead power supplies and existing lighting.
 - (viii) Relevant underground ducting or services.
 - (ix) Clear start/cut-off points where plans overlap.
- (e) Extent of the road lighting required, including nominated chainages.
- (f) Cross-section plan(s).
- (g) Anticipated electricity authority lighting tariff(s).
- (h) Any special equipment requirements, e.g. aeroscreen luminaires.
- (i) Relevant road authority policies on equipment and pole placement.
- (j) Any regulatory limitations, e.g. civil aviation, marine and railway.
- (k) Identification of observatories.
- (l) Clear indication of areas where lighting structures are not permissible.
- (m) Identification of areas of civic, historical, or special significance.
- (n) AADT of major and minor roads.

- (o) Project engineer's name and contact number.
- (p) Name of local authority.
- (q) Name of electricity supply authority.
- (r) Project identification number.
- (s) Required by date.
- (t) Estimate costing type, e.g. unit rate.

6.4.3 Site inspection check list

A site inspection should be performed to verify the relevant site details that may influence the road lighting design, particularly pole positions, as follows:

- (a) Record location and type of existing road lighting poles and distribution poles and their pole numbers.
- (b) Location of proposed new road lighting pole(s).
- (c) Location of proposed new outreach arm(s).
- (d) Location of proposed new ducting and overhead catenary lines.
- (e) Clearance to obstacles, e.g. power lines and trees.

It is important that the road lighting allocation in the road reserve is identified as well as whether or not there is an alternative allocation that can be used, if necessary, so that poles can be positioned as far from the edge of the traffic lane(s) as possible, e.g. on the property line.

SECTION 7 DESIGN CONSIDERATIONS

7.1 GENERAL

To be effective, Category V road lighting should provide a level of visibility that enables the motorist to see quickly, distinctly and with a degree of certainty all significant detail, most notably the alignment of the road (its direction and its surrounds). Uniformity in relation to light levels and pole placement is essential so as not to cause indecision and confusion.

When designing Category V lighting, the lighting designer should call upon traffic engineering input to optimize lighting designs taking into account road lighting parameters, lighting poles, luminaires, road safety, site geometry, economics, maintenance and aesthetics.

7.2 ROAD SAFETY CONSIDERATIONS

7.2.1 General

Road lighting is provided, in addition to other traffic control devices, to improve road safety during hours of darkness. The designer should ensure the provision of road lighting does not detract from the existing level of road safety. Consideration should be given to the relevant road authority policies on lighting levels and the location and use of road lighting poles.

Where economically viable, consideration should be given to the use of existing structures, or new structures with combined functions, to support lighting equipment in order to reduce the number of roadside hazards. Typical examples are as follows:

- (a) Joint-use pole for the support of luminaires and traffic signals.
- (b) Combination traffic signal mast arm with lighting outreach arm assembly.
- (c) Joint-use pole for road lighting and electricity distribution, telecommunications or tramway services.
- (d) Other structures such as building walls or verandas.

7.2.2 Pole positions

Road safety will be enhanced by locating lighting poles in positions that are unlikely to cause a hazard to errant vehicles. If it is not possible to satisfy this objective, then consideration should be given to the use of frangible pole types. In determining the location and type of pole, consideration should be given to the following and Appendix B:

- (a) Speed zones.
- (b) Traffic volumes.
- (c) Traversable and non-traversable verges.
- (d) Clear zones, narrow, unprotected traffic islands and medians.
- (e) Obstructions on the side of the road, e.g. services, trees and road furniture.
- (f) Presence of crash barrier and clearance to them.
- (g) Locations where the fall of the pole may foul overhead electrical conductors.
- (h) Low-lying areas where drainage is poor.
- (i) Accessibility to luminaires for maintenance purposes, e.g. provision for service vehicle access, clearances from overhead conductors.

- (j) Parking or other low speed activity that may result in crash damage to the poles.
- (k) Level of pedestrian activity.

7.2.3 Pole setback and pole types

The early research by Fox, Good and Joubert (see Ref. 10 in Paragraph A2) into crashes on urban roads established that a factor affecting the likelihood of a vehicle that had left the carriageway colliding with a utility pole was the distance between the pole and the edge of the carriageway. For lighting poles this distance is known as the pole setback and the research shows that as the setback increases the likelihood of a crash decreases. Further crash data show that for rigid poles the severity of such crashes is disproportionately great. Therefore rigid lighting poles should be positioned with as great a set back as possible and be positioned against the property line in urban areas and for all other locations as far from the edge of the carriageway as is practicable. Increased pole setback can be accommodated by a corresponding increase in outreach to maintain lighting design requirements.

Since that research, frangible poles have been developed. These greatly reduce vehicle damage and the trauma to occupants by reducing violent deceleration on impact and do not require a very large pole setback (see Ref. 1 in Paragraph A2). These can be employed effectively on higher speed roads and where pedestrian traffic is low.

Selection of an appropriate pole type and setback commensurate with the traffic hazard will result in the safest possible lighting installation. Recommended minimum setbacks and pole exclusion zones from the kerb for various traffic conditions and pole type are set out in Appendix B.

7.2.4 Curves

Curves may be lit from poles positioned on the inside, the outside or in some combination of this, depending on (amongst other factors) the road width.

Locating poles on the outside of curves provides additional visual guidance through the curve, and fewer poles will be required to achieve the required lighting level. Locating poles on the inside of curves places the poles in a less vulnerable position and reduces the chances of their being struck by errant vehicles.

The decision of where to locate poles will be dependent on the pole type (see Appendix B) and the parameters of the lighting design.

7.2.5 Roundabouts

The satisfactory operation of a roundabout relies heavily on the ability of drivers to enter into and separate from a circulating traffic stream in a safe and efficient manner.

For details of the pole placement with respect to the size and layout of a roundabout see Clause 8.6 and Appendix B.

7.2.6 Delineation

Where possible, luminaires and poles should provide a clear and continuous line, delineating the course of the road ahead. At complicated locations care should be taken to position the luminaires so motorists are not presented with a misleading view.

NOTE: See Figure F14, Appendix F, for an example of a misleading array of luminaires.

7.2.7 Joint-use traffic signal mast arms and joint-use lighting poles

The use of joint-use traffic signal mast arms and joint-use lighting poles at signalized intersections and junctions will minimize the number of potential hazards placed adjacent to the roadway and may also provide the driver with a clearer view of the road situation, highlighting the location of traffic signals and the course of the road ahead (see Clause 5.4.3). Where the luminaire outreach is mounted at an angle to the carriageway, care should be taken to avoid presenting misleading visual information to the motorist (see Clause 7.2.6).

7.3 ENVIRONMENTAL CONSIDERATIONS

7.3.1 General

The effects a road lighting system may have upon the environment should be minimized at the design stage. This is increasingly important as the general public become aware and voice concerns and government policies are implemented to counteract adverse environmental impact. Particularly important is the minimization of energy use and consequent greenhouse gas emissions associated with road and public space lighting. Often minimizing environmental impact will lead to reduced direct costs of the lighting system.

7.3.2 Energy usage

Energy usage through the life cycle of the lighting system should be minimized by the following:

- (a) Selection of the lowest lighting sub-category appropriate for the particular road type and operating characteristics (see AS/NZS 1158.1, Table 2.1). Provision of adequate but not excessive illuminances and luminances to comply with the requirements of that specific lighting sub-category. The lighting levels set for each sub-category are adequate and not excessive for the particular application and should not be arbitrarily reduced. The efficient use of other road safety devices such as perimeter line marking (visual and audible) and retroreflective, wherever possible, to minimize the need for higher lighting levels or additional lighting.
- (b) Limiting the equipment used, such as luminaires, columns, cabling. For example, all other considerations being equal, a central median mounted system needs less initial equipment than an opposite arrangement. Cut-off luminaires need to be placed closer together than semi cut-off ones.
- (c) The use of energy-efficient lamps and equipment will minimize electricity use.
- (d) The use of a maintenance factor that is as high as possible for the road pollution category (see Section 14). The luminaire used should have an IP rating of 6X and the lamp as good as possible lumen maintenance in order to maximize the length of the maintenance cycle (see AS/NZS 1158.1, Clause 2.10, Section 14 and Appendix E).

7.3.3 Spill light

Light emitted beyond the bounds of the carriageway and upward is, in general, wasted light and energy and the following can have adverse environmental impacts:

- (a) Upward light is scattered in the atmosphere and results in artificial sky glow, which inhibits the clear view of the heavens for both astronomers and casual viewers. Upward light from luminaires is controlled by a specified maximum value of Upward Waste Light Ratio (UWLR) (see AS/NZS 1158.1, Clause 2.6). Many current semi cut-off luminaires have UWLR values of close to 1%. However some upward light may be beneficial on roads with an over-arching tree canopy (see Clause 8.8). The use of upcast of the luminaires, beyond the 5 degrees normally used for aesthetic purposes, should not be used to spread light across a wide road, instead adequate toe-in within the luminaire should be utilized. In particularly sensitive situations, such as in the vicinity of astronomical observatories and airports, cut-off luminaires should be used.
- (b) Sideways spill light into properties and the direct view of luminaires may become obtrusive to residents (see AS 4282). Category V lighting is generally exempt from the provisions of AS 4282 due to the high levels of lighting necessary and because the lighting provides the community at large with an effective night crash counter measure. In sensitive situations, various measures may alleviate spill light problems, e.g. placement of lighting points, use of shields in the house-side of the luminaire visor or the use of cut-off luminaires.

7.3.4 Glare

Besides the possibility of a direct view of luminaires by residents, there is the view of the luminaires by both motorists and pedestrians using the roadway. The disability aspect of glare is adequately controlled by the specification of a maximum permissible value of threshold increment (*TI*) (see AS/NZS 1158.1.1, Table 2.2 and AS/NZS 1158.2, Clause 2.1.5). However, where semi cut-off luminaires are specified by the installer to achieve the greatest spacing possible, the value of *TI* will be close to the permissible limit. Thus there is a risk that these luminaires may appear overly bright and somewhat discomforting over a lengthy lighting system.

7.3.5 Colour of light

With the advent of metal halide lamps emitting white light, of high efficacy and reasonable lumen maintenance and lamp life makes these lamps an attractive proposition. They may be used in city and suburban centres where the associated high colour rendering values will enhance the perceived colourfulness and brightness of these environments. However, high pressure sodium lamps, although emitting yellow light of poorer colour rendition, are preferred for the lighting of the generality of traffic routes since these lamps offer the higher reliability and efficacy and hence energy efficiency (see AS/NZS 1158.1, Clauses 2.7 and 2.8). High pressure mercury lamps shall not be used in Category V lighting systems.

7.4 TREE-LINED TRAFFIC ROUTES

Where trees are planted at the roadside or in the road shoulders and partially overhang the carriageway, the light output from conventionally placed luminaires may be obstructed. Where the trees are large, of spreading habit and very substantially or completely overhang the carriageway, conventional placement of luminaires is generally impracticable. Guidance for the lighting designer is given in Clause 8.8.

7.5 WEATHER CONDITIONS

7.5.1 Effects on visibility

7.5.1.1 *Wet conditions*

As a paved surface passes from the dry state through stages of being damp, wet and finally flooded, its reflecting characteristics change. When merely damp, the effectiveness of the lighting installation may be reduced very little, if at all. Thereafter, reflection changes from diffuse to specular, and visibility deteriorates. Bright patches contract into bright streaks leaving areas of comparative darkness between. The distorted specular image has a brightness and width comparable with that of the light source.

When wet, painted line markings, including those with retroreflecting beads, tend to lose their contrast with the road surface. Lane marking studs continue to be visible while retroreflecting signs and markers lose none of their effectiveness.

Road verges, particularly if dark in colour and rough in texture, appear darker, as do objects on them and contrast is thus diminished.

Visibility is further impaired in wet conditions because of the presence of water droplets and road dirt in the atmosphere and on vehicle windscreens, which deflect, absorb and reflect light.

7.5.1.2 *Foggy conditions*

The conditions described in Clause 7.5.1.1 will, in general, also apply when fog is present. Additionally, visibility is further affected as a consequence of light from a vehicle's headlights being reflected back from the densely packed water droplets in the direction of the driver's eyes. The scattering of light from the water droplets produces a luminous glow that inhibits visibility of distant objects.

7.5.2 Means of improving visibility

The use of reflective material such as white paint or retroreflective markers is of great value at all times and may be essential for safety in wet or foggy weather (see Clause 7.9).

The revealing of the road ahead, especially on bends and curves, is greatly assisted in bad weather by logical placement of luminaires as seen in perspective. Misleading placement may cause crashes (see Figure F14, Appendix F).

The most critical light technical parameter to be considered in designing for wet carriageway conditions is the overall luminance uniformity (U_0). This uniformity can be enhanced by one or more of the following:

- (a) Reducing the spacings of the luminaires.
- (b) Increasing the luminaire mounting height.
- (c) Selecting a luminaire with a greater toe-in.
- (d) Changing the overhang.

In fog-prone areas, the use of high pressure sodium vapour luminaires is recommended due to their ability to more efficiently penetrate the fog, due to lower atmospheric scattering compared to other current light sources.

Lighting above the minimum requirements of AS/NZS 1158.1.1 is especially advantageous in wet or foggy weather due to improved visibility and route guidance afforded by the higher illumination of objects.

7.6 REFLECTING PROPERTIES OF ROAD SURFACES

Because a primary objective of roadway lighting is to produce bright road surfaces, the reflecting characteristics of that surface are vital factors affecting both the luminaire design and planning of the luminaire layout. The light technical parameters specified in AS/NZS 1158.1.1 are based on the reflecting characteristics of the following standard road surfaces:

- (a) *In Australia* The light parameters are based on the reflecting characteristics of the CIE R3 road surface (see Table 3.1), which is an asphaltic concrete surface that is dry in a moderately worn condition. It has been shown, based on an analysis of the limited data available on the reflecting properties of Australian road surfaces, that the choice of the CIE R3 road surface is appropriate.

The CIE R3 road surface will also be applicable for surface-treated pavements that have reflecting characteristics that vary much more widely according to the state of wear, but have average characteristics that are, in general, not dissimilar to those of the dry asphaltic concrete surface.

Concrete surfaces have reflecting characteristics little different from those of bituminous pavements, but can exhibit high luminance values because of their better diffuse reflectance. Variation in texture and colour may improve visual conditions, but should not influence the lighting design.

- (b) *In New Zealand* NZR2 and NZN4 road surfaces apply for the purposes of calculating the light technical parameters. Compliance is to be achieved in calculations involving both of these surfaces. The NZR2 surface is typical of a new chip seal (diffuse) surface, and NZN4 of a polished asphaltic (glossy) surface. These represent the two extremes in reflection properties of New Zealand roads.

7.7 ROAD LAYOUT

In designing a road lighting installation, instances will occur where, for aesthetic or practical reasons, departures from the recommended geometry will be necessary. Also, locations may be encountered where visibility problems exist by day as well as by night, due primarily, or even in some cases entirely, to the road layout features.

In such cases special treatment will be required. As road lighting is an integral part of road design, the cooperation of road authorities and electricity supply authorities may be needed in arriving at a satisfactory solution. On occasions, potentially troublesome areas are not evident from roadway plans. The lighting designer should therefore undertake an inspection of the site at an early stage to establish the topography of the area and to locate existing features such as drains, trees, bridges, overhead conductors or other obstructions that may not be shown on the base drawings.

7.8 ROADWAY FEATURES

Visibility of roadway features (e.g. kerbs, islands) depends largely on brightness contrasts produced by diffuse reflections from the relevant surfaces (i.e. upon their 'lightness' and 'darkness'). It follows that the effectiveness of a lighting system will be greatly enhanced if contrasting colours or textures can be introduced into the roadway features.

These considerations are particularly important at channelizations and where medians with mountable kerbs are used.

7.9 SURROUNDING BACKGROUNDS TO ROAD

A specific requirement for the lighting of traffic routes is the provision of illumination on the immediate verges or footpaths to the carriageway (light technical parameter E_s). It follows therefore that a significant proportion of the luminous flux from the luminaires will be directed to that area and beyond. It is advantageous if this light falls on light coloured surfaces, particularly vertical surfaces facing the carriageway, because the surroundings as well as the carriageway surface itself, will appear relatively bright to road users. This will add to the effectiveness of the road lighting in further raising the general light adaptation level of the road users, so improving visibility and reducing glare.

It is not realistic to expect the surrounds to roads, such as building facades, walls and fences, to be always light in colour. However, when the opportunity arises, as in planning new, or refurbishing, land development and roads, it may be feasible to incorporate this principle in the design requirements. One example would be to deliberately use light-coloured surfaces on any noise barriers adjacent to the roadway.

A corollary is that the lighting installation itself should be as effective as possible where the surrounds to the road are dark. This will arise where there is extensive abutting foliage or where building facades are dark coloured or are distant from the roadway. In these cases consideration should be given to the provision of a somewhat higher level of road luminance and more restrictive glare control than is warranted by the lighting category otherwise applicable to the particular road type and operating characteristics.

7.10 VISIBILITY OF ROAD SIGNS

A road lighting installation should not be adjusted to light road signs but every effort should be made to avoid the installation obscuring or otherwise distracting from their visibility, including such influences as background glare.

Attention should also be given to the possibility of specular reflections from road lighting luminaires interfering with the legibility of signs. Usually there is some latitude for signs to be adjusted or moved within limits to fit in with the road lighting layout. Where this is not possible because of structural or other considerations, such as a critical location for a large sign, the position of the luminaire may need to be reviewed.

To ensure adequate visibility at night, the use of independently illuminated signs should be considered. However, care should be taken that these are not a source of glare to the motorist. Where the road lighting employs sources of predominantly monochromatic light (e.g. low pressure sodium vapour lamps), it is generally necessary to illuminate the signs independently to restore a reasonable colour appearance.

7.11 AESTHETICS

At all times consideration should be given to the aesthetic appearance of the lighting equipment used. While aesthetic evaluations rely largely on subjective assessment and often on personal preference, it is desirable to consider this aspect, particularly in sensitive areas, e.g. in the vicinity of cultural and civic centres.

The ability of the lighting layout to be in scale and to harmonize with its surroundings requires careful appraisal by appropriately skilled people.

SECTION 8 DESIGN RECOMMENDATIONS

8.1 INSTALLATION GEOMETRY

8.1.1 Required data

The geometric parameters of the installation should be determined in accordance with Clauses 8.1.2 to 8.1.4. These parameters are defined in AS/NZS 1158.0 and are illustrated in Figure 8.1 of this Standard.

8.1.2 Carriageway lighting design width (W_K)

The installation should be designed to adequately light the whole of the used portion of the road, whether or not it is sealed across the full width. In some cases there may be difficulty in deciding just what width of road should be used for design purposes. It is then necessary to exercise judgement in determining how much of the road is normally used by vehicles, either moving or stationary (taking into account breakdown lanes and parking lanes), and therefore needs to be lit, and to take the boundaries of this portion of the road as the carriageway edges.

The point at which pedestrians become vulnerable is a factor that may need to be taken into account. For example, a road might consist of a narrow, sealed pavement with very wide shoulders in which a row of trees is planted with spaces between the trees, that can be used for manoeuvring and parking vehicles. In this case, the installation will need to be designed to light the whole width between the tree trunks, and the line of tree trunks would then be taken as the carriageway edge.

8.1.3 Lighting arrangement (AAR) and mounting height (H)

The required lighting arrangement and mounting height will depend on the road cross-section and should be commensurate with the carriageway lighting design width. The following guidelines are given to establish a mounting height to serve as a starting point for design:

(a) *Single carriageway:*

ARR 1,2 (single side) for W_K around H

ARR 3 (staggered) for W_K around $1.5 H$ ($1.25 H$ for aeroscreen luminaires)

ARR 4 (opposite) for W_K around $2 H$

(b) *Dual carriageway:*

ARR 5 (opposite), 5S (staggered) for W_K around $1.25 H$

ARR 6 (central) for W_K around $1.25 H$

ARR 7 (twin staggered) for W_K around $1.75 H$

ARR 8 (twin opposite) for W_K around $2.5 H$

Consideration should be given to obstructions in the median that might preclude any light contribution from luminaires on the opposite carriageway (e.g. dense plantations of tall shrubs and trees as landscaping (see Clause 8.8), headlight shield, noise barrier and the effect of the width of the median (see Clause 8.4). However, the effect of median barriers may be ignored (see Clauses 8.3 and 8.4).

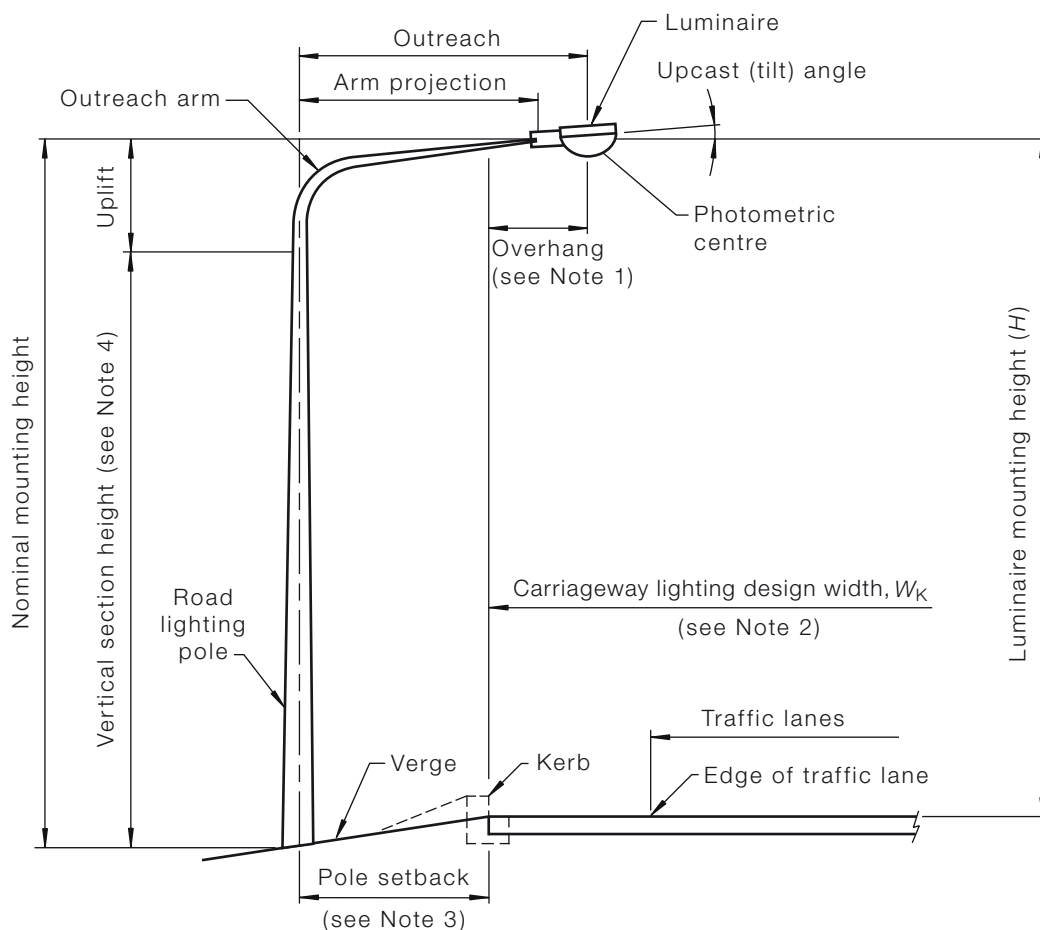
The mounting height should generally be not less than 9 m for Category V4 and V5 luminaires and not less than 10.5 m for Category V1, V2 and V3 luminaires unless special conditions exist, e.g. in the vicinity of airport runways or for bridge parapet lighting.

Where dedicated lighting poles are used, it is recommended that the luminaire mounting height (H) correspond to one of the preferred nominal mounting heights, e.g. 9 m, 10.5 m, 12 m, 13.5 m or 15 m (see AS 1798). Where existing electricity distribution poles are used, mounting heights other than the preferred values referred to above may need to be adopted.

NOTE: AS 1798 is an Australian only Standard.

In any one installation the mounting height should, as far as possible, be kept constant to preserve continuity of the line of luminaires.

Subject to attainment of the required values of luminance or illuminance, as applicable, the use of greater luminaire mounting heights will lead to improved uniformity of these parameters, fewer lighting poles and lower operating costs. However, account should be taken of economics (e.g. from the use of existing structures), aesthetics and maintenance (e.g. ability to access the luminaires). It should be noted that the adoption of greater mounting heights will necessitate the use of luminaires with a higher light output and may unnecessarily increase the light spilled into properties abutting the roadway.



NOTES:

- 1 Overhangs of between 0 and $H/4$ will generally achieve the best lighting designs.
- 2 W_K is the width of that part of the carriageway that is used for calculation or assessment of road lighting (see Clause 8.1.2).
- 3 Pole setback is the horizontal distance between the edge of the carriageway and the centre-line of the lighting pole, measured normal to the direction of traffic. Shoulders and breakdown lanes should be taken as part of the carriageway.
- 4 Vertical section height is only applicable where a detachable outreach arm is used.

FIGURE 8.1 ROAD LIGHTING DESIGN PARAMETERS