

Australian/New Zealand Standard™

Lighting for roads and public spaces

Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting



AS/NZS 1158.2:2020

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This Standard was issued in draft form for comment as DR AS/NZS 1158.2:2017.

Australian/New Zealand Standard™

Lighting for roads and public spaces

Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting

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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 1158.2:2005.

The objective of this Standard is to specify the computer-based design procedures applicable to Category V and Category P lighting for the calculation of light technical parameters (LTPs), as required, for the design or evaluation of road lighting in accordance with the requirements of AS/NZS 1158.1.1 and AS/NZS 1158.3.1.

This Standard forms Part 2 of the AS/NZS 1158 series, which covers lighting schemes for the generality of roads and outdoor public areas.

The AS/NZS 1158 series consists of the following:

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 installation design requirements
- 1158.1.2 Part 1.2: Vehicular traffic (Category V) lighting—Guide to design, installation, operation and maintenance
- 1158.2 Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting (this Standard)
- 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

SA/SNZ TS

- 1158.6 Part 6: Luminaires—Performance

The following document also relates to road and street lighting:

AS/NZS 60598.2.3, *Luminaires, Part 2.3: Particular requirements — Luminaires for road and street lighting (IEC 60598-2-3. Ed.3.1 (2011) MOD)*.

For each lighting subcategory described in this series of Standards the light technical parameters (LTPs) and their prescribed values are both necessary and sufficient for the particular application. Conformance with the relevant Standard will be achieved by meeting all the required values of the LTPs for the designated subcategory. A higher quality of lighting scheme can be achieved within a subcategory by, for example, increasing the minimum level of uniformity or reducing the glare allowable, or both.

The significant technical changes that have been made in this Standard in relation to the previous publication include the following:

- (a) Appendix B revised to include test calculations for LED luminaires.
- (b) Appendix C rewritten to provide guidance and requirements for software vendors.
- (c) Appendix D revised to show road surface reflectance tables for both Australia and New Zealand.
- (d) Corrections to formulae.
- (e) For New Zealand users, the previous NZN4 and NZR2 r-tables (both with $Q_0 = 0.09$) have been replaced by a single r-table R2 with a $Q_0 = 0.07$. This change uses the results of recent research to better align the r-table with road surfaces in use in New Zealand today.

The source code (SAA STAN) and shell program (STANSHELL) are available to purchasers of this Standard. Purchasers are not limited to the accompanying SAA STANSHELL software when applying this Standard. Alternative shell programs, using the SAA STAN source code, may be used to achieve conformance with the requirements of this Standard.

The source code and shell program are available to purchasers of this Standard in downloadable zipped format. Delivery methods of the product containing the source code and related program may change over time.

The source code and shell program in the accompanying product are only permitted to be used, reproduced or modified by an authorized user in a way that meets the requirements of this Standard. They are not to be used for any other purposes.

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

Statements expressed in mandatory terms in notes to figures are deemed to be requirements of this Standard.

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Australian/New Zealand Standard
Lighting for roads and public spaces

**Part 2: Computer procedures for the calculation of light technical parameters
for Category V and Category P lighting**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the computer-based design procedures applicable to Category V and Category P lighting for the calculation of light technical parameters (LTPs), as required, for the design or evaluation of road lighting in accordance with the requirements of AS/NZS 1158.1.1 and AS/NZS 1158.3.1.

It gives the basic formulae for the LTPs and the associated grid of points (i.e. the calculation field) over which the calculation is to be made. The source code of one computer program, designated SAA STAN, together with a shell program designated STANSHELL, is given for the calculation of the LTPs for Category V lighting on straight sections of road.

This Standard also includes the general requirements for computer programs used to calculate LTPs for other road and public space elements in both Category V and Category P lighting, luminaire light distribution and road surface reflection input data and computer program test data.

NOTES:

- 1 Refer to AS/NZS 1158.1.1 and AS/NZS 1158.3.1 for information on the types of road for which Category V and Category P lighting, respectively, are appropriate.
- 2 It is expected that persons using this Standard will have some expertise in lighting design and be familiar with the nature of computer-generated data.
- 3 The requirements regarding the use of the program SAA STAN are described in Section 4 and other relevant information is given in Appendices A, B and C.

1.2 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

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
1158.3.1	Part 3.1: Pedestrian area (Category P) lighting—Performance and design requirements
3827	Lighting system performance—Accuracies and tolerances
3827.1	Part 1: Overview and general recommendations

CIE*

- | | |
|-----|--|
| 31 | Glare and uniformity in road lighting installations |
| 140 | Road lighting calculations |
| 144 | Road surface and road marking reflection characteristics |

1.3 TERMS AND DEFINITIONS

For the purpose of this Standard, the definitions given in AS/NZS 1158.0 and CIE 144 apply.

1.4 SYMBOLS AND ABBREVIATIONS

For the purpose of this Standard the symbols and abbreviations given in AS/NZS 1158.0 apply.

* International Commission on Illumination, Vienna.

SECTION 2 LIGHTING PERFORMANCE CRITERIA, THEIR LTPs AND BASIC FORMULAE

2.1 CATEGORY V LIGHTING SCHEME DESIGNS

2.1.1 Evaluation of performance

Conformance with AS/NZS 1158.1.1 is based on a lighting scheme achieving prescribed values of quantities known as LTPs (light technical parameters). These LTPs and the values required for conformance are given in AS/NZS 1158.1.1. The list of LTPs is reproduced in Table 2.1 below and defined in Clauses 2.1.2 to 2.1.6.

The luminance and illuminance-based LTPs are each derived, directly or indirectly, from the luminance and illuminance distribution over a designated field of interest. This area is known as the calculation field, which is represented by a finite grid of calculation points. The relevant calculation fields are described in Section 3.

Since the required conformance values are maintained values, those LTPs that are expressed in absolute terms, that is $\bar{L}$ and E_{Ph} , shall be calculated using a maintenance factor.

TABLE 2.1
LTP SYMBOL AND BASIS—
FOR CATEGORY V LIGHTING

LTP	Symbol	Basis
Average carriageway luminance	$\bar{L}$	Luminance
Overall uniformity	U_0	Luminance
Longitudinal uniformity	U_L	Luminance
Surround (verge) illuminance	E_s	Illuminance
Point horizontal illuminance	E_{Ph}	Illuminance
Illuminance uniformity Category V	U_{E1}	Illuminance
Threshold increment	TI	Glare
Upward waste light ratio	$UWLR$	Light flux

2.1.2 Basis of conformance

The LTPs set out in Table 2.1 shall be calculated using the methods described in Section 4.

2.1.3 Luminance-based LTPs

The luminance-based LTPs ($\bar{L}$, U_0 and U_L) apply to the straight and curve elements of the roadway and are derived from the calculation fields described in Clause 3.2.1(a).

Calculation of any of these LTPs requires the calculation of L at various points. The maintained luminance at each point shall be calculated, in cd/m^2 , as follows:

$$L = \frac{\sum r(\beta, \gamma) \times I(C, \gamma)}{H^2} \times MF \times 10^{-4} \quad \dots 2.1(1)$$

where

$r(\beta, \gamma)$ = reduced luminance (reflection) coefficient of the surface at the calculation point

NOTE: Tabulations of $r \times 10^4$ for standard road surfaces are referred to in Appendix C.

$I(C, \gamma)$ = luminous intensity from a luminaire directed to the point, in candelas

MF = ratio of the light flux emitted from a luminaire at a given time to that emitted initially

NOTE: Refer to AS/NZS 1158.1.2:2010 Table 14.4 for IP5X luminaires and to AS/NZS 1158.3.1:2020 Table 3.2 for IP6X luminaires to determine the LDD.

H = mounting height of the luminaire

Σ indicates that the luminance contributions of all the luminaires involved in the calculation are summed

NOTE: The meaning and relationship of the angles C , γ and β to the calculation point are shown in Figure 3.1.

The luminance-based LTPs are defined as follows (see Note):

(a) The average carriageway luminance ($\bar{L}$):

$$\bar{L} = \frac{\Sigma L}{N} \quad \dots 2.1(2)$$

where

N = total number of calculation points

ΣL = sum of the N calculated luminances

(b) Overall luminance uniformity (U_0):

$$U_0 = \frac{L_{\min}}{\bar{L}} \quad \dots 2.1(3)$$

where

$L_{\min}$ = minimum of all the calculated luminances of the calculation points

$\bar{L}$ = as per Equation 2.1(2)

(c) Longitudinal luminance uniformity (U_L):

$$U_L = \frac{L_{\min}}{L_{\max}} \quad \dots 2.1(4)$$

where

$L_{\min}$ and $L_{\max}$ = minimum and maximum calculated luminance value, respectively, of only those calculation points lying on the longitudinal carriageway line containing the observer position

NOTE: In Australia, there will be only one value of these LTPs, corresponding with a single observer position. In New Zealand, there will be a value for each traffic lane under consideration

2.1.4 Illuminance-based LTPs

Of the illuminance-based LTPs (E_S , E_{Ph} and U_{E1}), E_S applies to the straight, curve, bend and intersection elements of the roadway and is derived from the calculation fields described in Clause 3.2.1(b). E_{Ph} and U_{E1} apply to sharp bend, changes in alignment and intersection elements of the roadway and are derived from the calculation fields described in Clauses 3.2.3 and 3.2.4.

All of the illuminance requirements for Category V lighting shall be referenced to a horizontal plane at ground level.

The illuminance-based LTPs shall be calculated as follows:

(a) The maintained horizontal illuminance at a point (E_{Ph}), in lux:

$$E_{Ph} = \frac{\Sigma I(C, \gamma) \times \cos^3 \theta}{H^2} \times MF \quad \dots 2.1(5)$$

where

$I(C, \gamma)$ = luminous intensity from a luminaire directed to the point, in candelas

MF = ratio of the light flux emitted from a luminaire at a given time to that emitted initially

NOTE: Refer to AS/NZS 1158.1.2:2010 Table 14.4 for IP5X luminaires and to AS/NZS 1158.3.1:2020 Table 3.2 for IP6X luminaires to determine the LDD.

H = mounting height of the luminaire

Σ indicates that the luminance contributions of all the luminaires involved in the calculation are summed

θ = angle of incidence of the incoming ray at the point

NOTE: The meaning and relationship of the angles C and γ and the point is shown in Figure 3.2.

(b) Surround (verge) illuminance ratio (E_s):

$$E_s = \frac{\Sigma E_{\text{verge}}}{\Sigma E_{\text{carriageway}}} \quad \dots 2.1(6)$$

where

ΣE_{verge} and $\Sigma E_{\text{carriageway}}$ = sum of the calculated illuminances of all the calculation points of the verge and the carriageway halves of the calculation field, respectively

(c) The illuminance (horizontal) uniformity for Category V lighting:

$$U_{E1} = \frac{E_{\text{max}}}{E_{\text{min}}} \quad \dots 2.1(7)$$

where

E_{max} and E_{min} = minimum and maximum calculated illuminance value, respectively, of the calculation points

2.1.5 Glare-based LTP

Threshold increment (TI) (see Note) measures the disabling effect of glare and is expressed as the threshold increment in the contrast of a standard object required for that object to remain at threshold visibility in the presence of glare, expressed as a percentage. It shall be calculated according to CIE 31 as follows:

$$TI = \frac{65 \times L_{veil}}{(\bar{L}_{init})^{0.8}} \quad \dots 2.1(8)$$

where

$\bar{L}_{init}$ = as per Equation 2.1(2) where $\bar{L}$ is calculated with $MF = 1$

L_{veil} = veiling luminance, in candelas per square metre, defined as

$$L_{veil} = \Sigma 3 \times 10^{-3} \frac{E}{\Omega^2}$$

E = illuminance at the observer's eye on a plane normal to the observer's line of sight from the luminaire with $MF = 1$, in lux

Ω = angular displacement of the luminaire from the observer's line of sight, in radians

Σ indicates that the veiling luminance contribution from each of the required luminaires are summed

NOTE: In Australia, for TI , there will be only one value of this LTP, corresponding with a single observer position. In New Zealand, there will be a value for each traffic lane under consideration.

C2.1.5 In the SAA STAN program, the L_{veil} luminance is calculated by summing the veiling luminance contribution row by row for each longitudinal luminaire row (up to 4 rows) from the following luminaires:

In each row (beginning with the luminaire Row 1—the closest to the left side of the Observer's carriageway and progressing row by row from left to right if more than one row), the first contributing luminaire is that intersecting the 20° inclined shielding plane above the horizontal through the Observer's eye (this defines the Observer's luminaire longitudinal setback position for the calculation). The additional veiling luminance contribution from each n^{th} luminaire in that row in front of the Observer is further calculated and summed progressively for that row.

For each row, summation is ended and the n^{th} veiling luminance contribution is not included in the sum if the horizontal distance of n^{th} luminaire from the Observer's eye is greater than 500 m.

For each row, summation is also ended with the contribution included if the n^{th} veiling luminance contribution of the luminaire was less than 2% of the current veiling luminance sum for that row.

The total veiling luminance summed from all rows is the value of L_{veil} used in the calculation of TI .

If a staggered arrangement is being evaluated then two veiling luminance summation calculations are made:

1. The veiling luminance summation for all rows of luminaires is calculated first with the longitudinal Observer position setback from the first luminaire in Row 1 (the primary staggered row).
2. The veiling luminance summation is calculated again for all rows of luminaires with the longitudinal Observer position setback from the first luminaire in Row 2 (the primary non-staggered row).

The greater of these two veiling luminance summations is the value of L_{veil} used in the calculation of TI .

2.1.6 Flux-based LTP

The upward waste light ratio $UWLR$ shall be evaluated for the tilt angle at which the luminaire is mounted, using the following formula:

$$UWLR = \frac{\Phi_A}{\Phi_T} \quad \dots 2.1(9)$$

where

Φ_A = flux emitted by the luminaire above the horizontal

Φ_T = total flux emitted by the luminaire

2.2 CATEGORY P LIGHTING SCHEME DESIGNS

2.2.1 Evaluation of performance

Conformance with AS/NZS 1158.3.1 is based on a lighting scheme achieving prescribed values of LTPs. These LTPs and the values required for conformance are given in AS/NZS 1158.3.1. The LTPs are reproduced in Table 2.2 and defined in Clauses 2.2.3 and 2.2.4.

The illuminance-based LTPs are each derived, directly or indirectly, from the illuminance distribution over a designated field of interest. This area, the calculation field, is represented by a finite grid of calculation points. The relevant calculation fields for the applicable road reserves, pathways and spaces are described in Section 3.

The illuminance requirements of Category P lighting are referenced either to a horizontal plane at ground level or a vertical plane.

The glare control characteristics required of luminaires are given in AS/NZS 1158.3.1.

Since the required conformance values are maintained values, it is essential that those LTPs that are expressed in absolute terms, that is $\bar{E}_h$, E_{Ph} and E_{Pv} are calculated using a maintenance factor. Where E_{Pv} is used for obtrusive light calculations the maintenance factor shall be 1.0.

TABLE 2.2
LTP SYMBOL AND BASIS—
FOR CATEGORY P LIGHTING

LTP	Symbol	Basis
Average space horizontal illuminance	$\bar{E}_h$	Illuminance
Point horizontal illuminance	E_{Ph}	Illuminance
Point vertical illuminance	E_{Pv}	Illuminance
Illuminance uniformity Category P	U_{E2}	Illuminance
Obtrusive light	E_{Pv}	Illuminance
Upward waste light ratio	$UWLR$	Light flux

2.2.2 Basis of conformance

The LTPs in Table 2.2 shall be calculated using the methods described in Section 4.

2.2.3 Illuminance-based LTPs

The illuminance-based LTPs ($\bar{E}_h$, E_{Ph} , E_{Pv} , U_{E2}) apply to all Category P areas, including straight and curve roadway elements, intersections and public spaces. They shall be derived from calculation fields described in Clauses 3.3.1 to 3.3.9.

Calculation of any of these LTPs requires the calculation at various points of E_h and E_v . The maintained illuminance at each point shall be calculated, in lux, as follows:

- (a) The maintained horizontal illuminance at a point (E_{ph}), in lux, as calculated by Equation 2.1(5).
- (b) The maintained vertical illuminance at a point (E_{pv}), in lux:

$$E_{pv} = \frac{\sum I(C, \gamma) \times \cos^2 \gamma \times \cos \theta}{(H - 1.5)^2} \times MF \quad \dots 2.2(1)$$

where

$I(C, \gamma)$ = luminous intensity from a luminaire directed to the point, in candelas

θ = angle of incidence of the incoming ray at the point

MF = ratio of the light flux emitted from a luminaire at a given time to that emitted initially

NOTE: Refer to AS/NZS 1158.1.2:2010 Table 14.4 for IP5X luminaires and to AS/NZS 1158.3.1:2020 Table 3.2 for IP6X luminaires to determine the LDD.

H = mounting height of the luminaire

Σ indicates that the luminance contributions of all of the luminaires involved in the calculation are summed

NOTES:

- 1 The number 1.5 is the height, in metres, of the calculation plane for Category P areas. For pedestrian crossings this value will be different.
- 2 The meaning and relationship of the angles C , γ and θ and the point are shown in Figure 3.3.

The illuminance-based LTPs are defined as follows:

- (i) The average space horizontal illuminance ($\overline{E}_h$):

$$\overline{E}_h = \frac{\sum E_{ph}}{N} \quad \dots 2.2(2)$$

where

N = total number of calculation points

$\sum E_{ph}$ = sum of the N calculated illuminances

- (ii) The point horizontal illuminance (E_{ph}), as defined in Equation 2.1(5).
- (iii) The point vertical illuminance (E_{pv}), as defined in Equation 2.2(1).
- (iv) The illuminance uniformity for Category V lighting ratio (U_{E2}):

$$U_{E2} = \frac{E_{hmax}}{\overline{E}_h} \quad \dots 2.2(3)$$

where

E_{hmax} = maximum calculated horizontal illuminance value, from all of the calculation points

2.2.4 Flux-based LTP

The upward waste light ratio ($UWLR$) shall be evaluated for the tilt angle at which the luminaire is mounted using Equation 2.1(9). (See Clause 2.1.6.)

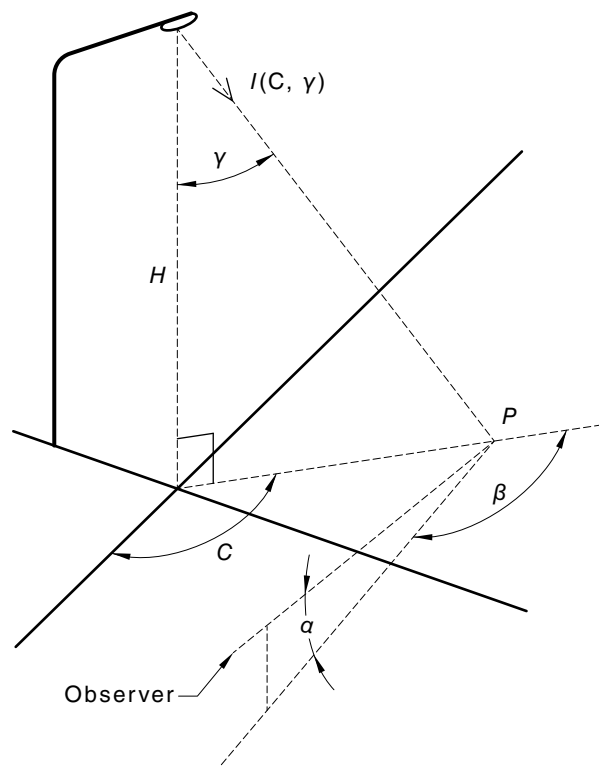
SECTION 3 DESIGNATED CALCULATION FIELDS

3.1 GENERAL

This Section sets out the calculation fields and the associated grids of calculation points for the determination of the values of the LTPs for Categories V and P lighting given in Section 2.

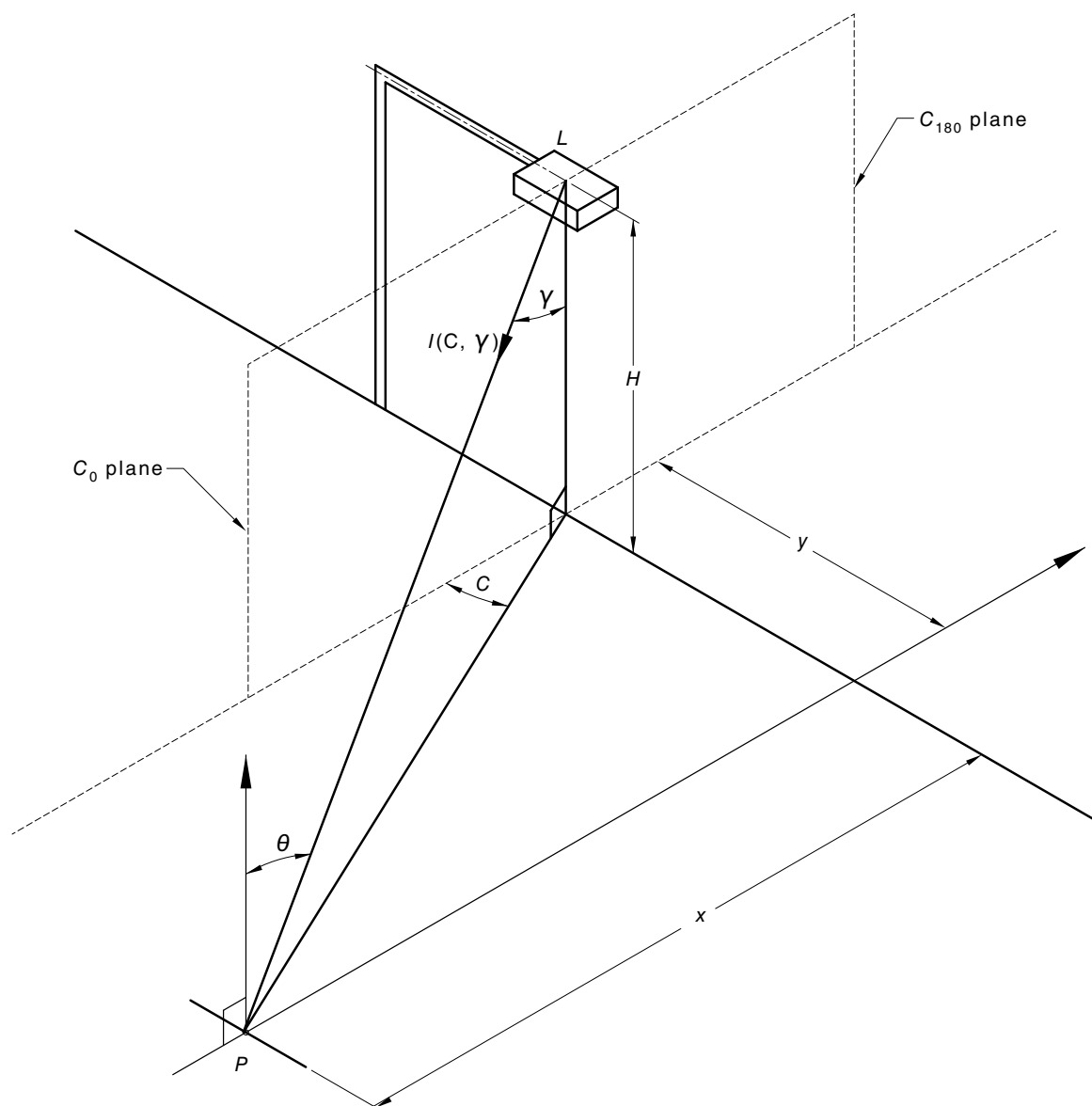
It also shows:

- For Category V luminance-based LTPs, the relationship between a calculation point on the horizontal surface and the observer and luminaire. (See Figure 3.1.)
- For Categories V and P illuminance-based LTPs, the relationship between a calculation point on the horizontal or vertical surface and luminaire. (See Figures 3.2 and 3.3.)



NOTE: The luminance (reflection) coefficient at P depends on α , β and γ , however the range of α involved is small and is taken as a constant ($\alpha = 1^\circ$).

FIGURE 3.1 ANGULAR RELATIONSHIP BETWEEN THE OBSERVER, CALCULATION POINT P AND LUMINAIRE



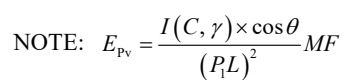
NOTE: Fundamentally, $E_{ph} = \frac{I(C, \gamma) \times \cos \theta}{(PL)^2} \times MF$

In this (i.e. horizontal) case:

θ (the angle of incidence) = γ

so $E_{ph} = \frac{I(C, \gamma) \times \cos^3 \theta}{H^2} \times MF$

FIGURE 3.2 ILLUSTRATION OF SITUATION ASSUMED IN CLAUSE 3.1 FOR THE CALCULATION OF HORIZONTAL ILLUMINANCE



(ii) Throughout this Standard, the length PP_1 is 1.5 m, therefore $H_1 = H - 1.5$.

$$\text{so } E_{pv} = \frac{I(C, \gamma) \times \cos^2 \gamma \times \cos \theta}{(H - 1.5)^2} \times MF$$

FIGURE 3.3 ILLUSTRATION OF SITUATION ASSUMED IN CLAUSE 3.1 FOR THE CALCULATION OF VERTICAL ILLUMINANCE