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Cestna razsvetljava - 3. del: Izračun lastnosti

Road lighting - Part 3: Calculation of performance

Straßenbeleuchtung - Teil 3: Berechnung der Gütemerkmale

Eclairage public - Partie 3: Calcul des performances

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English Version

Road lighting - Part 3: Calculation of performance

Eclairage public - Partie 3: Calcul des performances

Straßenbeleuchtung - Teil 3: Berechnung der Gütemerkmale

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 13201-3:2015) has been prepared by Technical Committee CEN/TC 169 “Light and lighting”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2016 and conflicting national standards shall be withdrawn at the latest by June 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13201-3:2003.

In comparison with EN 13201-3:2003, three significant changes were made:

— in the veiling luminance calculation, L_v, there is no more test about the contribution of at least 2 % of the next luminaire in the row to end the calculation before reaching a distance of 500 m (this is to avoid ambiguous interpretations that can produce different results from different software);

— the default option is about 500 m, but there is an alternative to retain only the luminaires of a shorter installation. This last case should be clearly mentioned in the lighting design by the number of luminaires involved in calculation of f_{TI};

— there is a new formula for calculating veiling luminance L_v, for a wider range of θ values. Thus the case where luminaires could be very near to the axis of vision of the observer: 0,1°< θ < 1,5° can be evaluated with Formula (38).

NOTE for programmers: Calculation of threshold increment f_{TI}, (*new symbol for TI designation*) has changed in the revision of EN 13201-3:2003.

This European Standard was worked out by the Joint Working Group of CEN/TC 169 “Light and lighting” and CEN/TC 226 “Road Equipment”, the secretariat of which is held by AFNOR.

EN 13201, *Road lighting* is a series of documents that consists of the following parts:

— *Part 1: Guidelines on selection of lighting classes* [Technical Report]*;*

— *Part 2: Performance requirements;*

— *Part 3: Calculation of performance* [present document]*;*

— *Part 4: Methods of measuring lighting performance;*

— *Part 5: Energy performance indicators.*

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The calculation methods described in this part of EN 13201 enable road lighting quality characteristics to be calculated by agreed procedures so that results obtained from different designers will have a uniform basis.

1 Scope

This European Standard specifies the conventions and mathematical procedures to be adopted in calculating the photometric performance of road lighting installations designed in accordance with the parameters described in EN 13201-2 to ensure that every lighting calculation is based on the same mathematical principles.

The design procedure of a lighting installation also requires the knowledge of the parameters involved in the described model, their tolerances and variability. These aspects are not considered in this part of EN 13201 but a procedure to analyse their contribution in the expected results is suggested in EN 13201-4 and it can also be used in the design phase.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13032-1, *Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 1: Measurement and file format*

EN 13201-2, *Road lighting — Part 2: Performance requirements*

EN 12665:2011, *Light and lighting — Basic terms and criteria for specifying lighting requirements*

3 Terminology

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12665:2011 and the following apply.

3.1.1
vertical photometric angle
γ
angle between the light path and the downward vertical axis both passing through the luminaire photometric centre

Note 1 to entry: Unit ° (degree).

Note 2 to entry: The direction $\gamma = 0$ is therefore oriented to the nadir.

Note 3 to entry: See Figure 1.

3.1.2
azimuth
C
angle between the vertical half plane passing through the light path and the reference half plane

Note 1 to entry: I.e. the vertical half plane passing through the second axis of a luminaire, when the luminaire is at its tilt during measurement.

Note 2 to entry: Unit ° (degree).

Note 3 to entry: See Figure 1.

3.1.3
angle of incidence
ε
angle between the light path at a point on a surface and the normal to the surface

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 4, Figure 12 and Figure 13.

3.1.4
angle of deviation
β
angle between the oriented vertical planes through the observer to the point of observation and from the point of observation through the luminaire (with respect to luminance coefficient)

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 4.

3.1.5
luminance coefficient
q
quotient of the luminance of a surface element in a given direction by the illuminance on the surface element

Note 1 to entry: Unit sr^{-1}.

Note 2 to entry:

$$q = \frac{L}{E} \tag{1}$$

where

q is the luminance coefficient, in reciprocal steradians (sr^{-1});

L is the luminance, in candelas per square metre ($cd{\cdot}m^{-2}$);

E is the illuminance, in lux (lx).

3.1.6
reduced luminance coefficient
r
luminance coefficient of a surface element multiplied by the cube of the cosine of the angle of incidence of the light on the surface element

Note 1 to entry: Unit sr^{-1}.

Note 2 to entry: This can be expressed by the formula: $r = q \cos^3 \varepsilon$ (refer to CIE 66) (2)

where

q is the luminance coefficient, in reciprocal steradians;

ε is the angle of incidence, in degree.

Note 3 to entry: The angle of observation, α in Figure 4, affects the value of r. In accordance with the requirements specified in EN 13201-2, consider this angle fixed at 1° and this value is adopted for the calculation described in this standard, r is reasonably constant for values of α between 0,5° and 1,5°.

3.1.7
tilt during measurement
$\boldsymbol{\theta_m}$
angle between a defined datum axis on a luminaire and the horizontal when the luminaire is mounted for photometric measurement

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 7.

Note 3 to entry: The defined datum axis can be any feature of the luminaire, but generally for a side-mounted luminaire it lies in the mouth of the luminaire canopy, in line with the spigot axis. Another commonly used feature is the spigot entry axis.

3.1.8
tilt for calculation
$\boldsymbol{\delta}$
difference in angle between the tilt in application and the tilt during measurement of a luminaire

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 7.

3.1.9
tilt in application
$\boldsymbol{\theta_f}$

angle between a defined datum axis on a luminaire and the horizontal when the luminaire is mounted for field use

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 7.

Note 3 to entry: The defined datum axis can be any feature of the luminaire but generally for a side-mounted luminaire it lies in the mouth of the luminaire canopy, in line with the spigot axis. Another commonly used feature is the spigot entry axis.

3.1.10
orientation
$\boldsymbol{\nu}$
angle a chosen reference direction makes with the C = 0°, γ = 90° measurement direction of a luminaire when the first photometric axis of the luminaire is vertical

Note 1 to entry: Unit ° (degree).

Note 2 to entry: When the road is straight the reference direction is longitudinal.

Note 3 to entry: See Figure 6, which illustrates the sign conventions.

3.1.11
rotation
ψ
angle the first photometric axis of a luminaire makes with the nadir of the luminaire in the plane C = 0°, C = 180°, when the tilt during measurement is zero

Note 1 to entry: Unit ° (degree).

Note 2 to entry: See Figure 6, which illustrates the sign conventions.

3.1.12
first photometric axis (of a luminaire when measured in the (C, γ) coordinate system)
axis through the photometric centre of a luminaire and perpendicular to the plane which is representative of the main light emitting area

Note 1 to entry: The polar axis of the (C, γ) coordinate system does not necessarily coincide with the first axis of the luminaire if the luminaire is tilted during measurement.

3.1.13
longitudinal direction
direction parallel to the axis of the road

3.1.14
transverse direction
direction at right angles to the axis of the road

Note 1 to entry: On a curved road the transverse direction is that of the radius of curvature at the point of interest on the road.

3.1.15
installation azimuth
φ
angle a chosen reference direction (which is longitudinal for a straight road) makes with the vertical plane through a given point on the road surface and the photometric centre of a luminaire, when the luminaire is at its tilt during measurement

Note 1 to entry: Unit (degree).

Note 2 to entry: See Figure 4.

3.2 List of symbols and abbreviations

The symbols and abbreviations used in this standard are listed in Table 1.

Table 1 — Symbols and abbreviations

Quantity		
Symbol	**Name or description**	**Unit**
A_y	Age of observer	y
C	Photometric azimuth angle (Figure 1)	°(degree)
D	Spacing between calculation points in the longitudinal direction (see Figure 9 and Figure 14)	m

Quantity		
Symbol	**Name or description**	**Unit**
d	Spacing between calculation points in the transverse direction (see Figure 9 and Figure 14)	m
$\overline{E}$	Generic symbol used for average illuminance	lx
$\overline{E}_{hi}$	Initial average horizontal illuminance of the lit surface (see 8.5.3)	lx
E_h	Horizontal illuminance at a point	lx
E_{hs}	Hemispherical illuminance at a point	lx
E_{sc}	Semi-cylindrical illuminance at a point	lx
E_v	Vertical illuminance at a point	lx
f_M	Overall maintenance factor	–
f_{TI}	Threshold increment	%
H	Mounting height of a luminaire	m
$I(C, y)$	Luminous intensity table in the C, y system. Also named I-table	cd
j, m	Integers indicating the row or column of a table	–
$\overline{L}$	Generic symbol used for average luminance	cd·m^{-2}
$\overline{L}_i$	Initial average horizontal luminance of the lit surface (see 8.5.3)	cd·m^{-2}
L_v	Equivalent veiling luminance	cd·m^{-2}
L	Luminance at a point	cd·m^{-2}
N	Number of calculation points in the longitudinal direction of a grid (see Figure 9 and Figure 14)	–
n	Number of calculation points in the transverse direction of a grid (see Figure 9 and Figure 14)	–
n_{lu}	Number of luminaires considered in the calculation	–
q	Luminance coefficient	sr^{-1}
Q_0	Average luminance coefficient	sr^{-1}
r	Reduced luminance coefficient	sr^{-1}
$r(\tan \varepsilon, \beta)$	Reduced luminance coefficient table. Also named r-table	sr^{-1}
R_{EI}	Edge illuminance ratio	–
S	Spacing between luminaires	m
W_L	Width of driving lane	m
W_r	Width of relevant area or of carriageway	m
W_S	Width of strip	m
x	Abscissa in (x, y) coordinate system (Figure 5)	m
y	Ordinate in (x, y) coordinate system (Figure 5)	m
α	Angle of observation of road surface (Figure 4)	°(degree)

Quantity		
Symbol	**Name or description**	**Unit**
α_k	angle between the normal to the flat surface of the semicylinder and the vertical plane containing the light path (Figure 12) or angle between the normal to the selected vertical plane and the vertical plane containing the light path (Figure 13)	°(degree)
β	Angle of deviation (Figure 4)	°(degree)
ρ	Average diffuse reflection factor of a surface (See 8.5.3)	–
γ	Photometric elevation angle (Figure 1)	°(degree)
δ	Luminaire tilt for calculation (Figure 6 and Figure 7)	°(degree)
ε	Angle of incidence (Figure 4)	°(degree)
ε_k	Angle of incidence for semicylindrical and vertical illuminance (Figure 12 and Figure 13)	°(degree)
θ_1	Luminaire tilt in application (Figure 7)	°(degree)
θ_m	Luminaire tilt during measurement (Figure 7)	°(degree)
θ_κ	Angle between the line of sight and the centre of the k^{th} luminaire (See 8.5 in the formulae)	
ν	Orientation of luminaire (Figure 6)	°(degree)
φ	Installation azimuth (Figure 4)	°(degree)
ψ	Rotation of luminaire (Figure 6)	°(degree)

4 Mathematical conventions

4.1 General

The basic conventions made in the mathematical procedures described in this standard are:

a) the luminaire is regarded as a point source;

b) light reflected from the surrounds and inter-reflected light is disregarded;

c) obstruction to the light from luminaires by trees and other objects is disregarded;

d) the atmospheric absorption is zero;

e) the road surface is flat and level and has uniform reflecting properties over the area considered;

f) the evaluation in *I*-tables and *r*-tables shall be obtained by linear interpolation.

In case of continuous lines of luminaires, generally at low mounting height, it is advisable to check whether the distance between the optical centre of each luminaire to the nearest point of the grid of calculation is greater than or equal to five times the length of the luminous area of a single luminaire. If this is not the case it might be necessary to simulate near-field photometry by fragmenting the luminaire into virtual point light sources of the same light distribution as the entire luminaire. The luminous flux of each virtual light source is an equal proportion of the total luminous flux for the luminaire.

4.2 Decimal places of the requirements

The calculation results shall be presented in the form and with at least the number of digits given in the tables of requirements of EN 13201-2, shown in Table 2.

Table 2 — Number of decimal digits of the lighting requirements

	$\overline{L}$	U_o	U_l	f_{TI}	R_{EI}	$\overline{E}$ <10 lx	10 lx ≤ $\overline{E}$ ≤ 20 lx	$\overline{E}$ > 20 lx
Number of decimal places	**2**	**2**	**2**	**0**	**2**	**2**	**1**	**0**

5 Photometric data

5.1 General

Photometric data for the light distribution of the luminaires used in the lighting installation are needed for calculating the lighting quality characteristics in this standard. These data are in the form of an intensity table (*I*-table) which gives the distribution of luminous intensity emitted by the luminaire in all relevant directions. When luminance calculations are to be made, photometric data for the light reflecting properties of the road surface are required in the form of an *r*-table.

Interpolation is needed in using both these tables to enable values to be estimated for directions between the tabulated angles.

5.2 The *I*-table

5.2.1 System of coordinates and advised angular intervals of the *I*-table

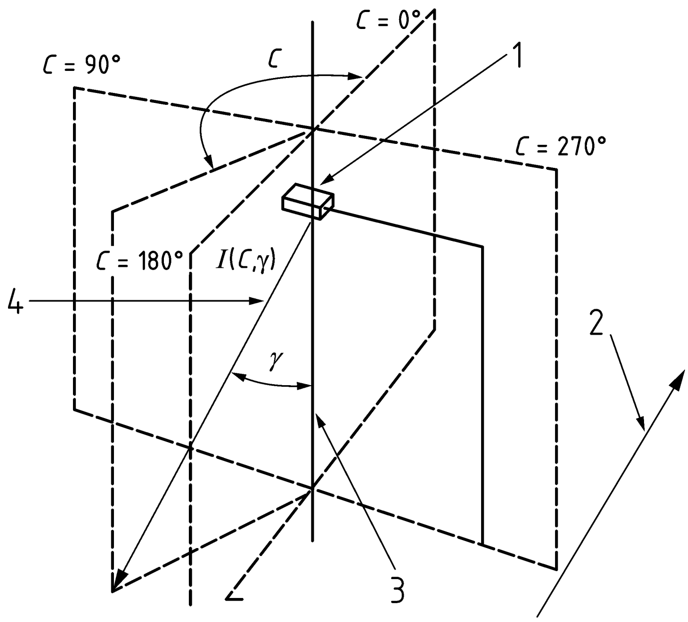
For calculations made in accordance with this standard, an intensity table (*I*-table) that describes the behaviour of the luminaire with the required accuracy by the aim of calculation shall be used. This *I*-table shall be prepared in accordance with EN 13032-1. The coordinate system used for road lighting luminaires is the *C*-planes system, shown in Figure 1. For floodlight installations, the intensity distribution measured in the *B*-planes system may be accepted if the calculation program can transfer the intensity values in the *C*-planes system. In Figure 1, the luminaire is shown at its tilt during measurement.

Luminous intensity shall be expressed in candelas.

The luminous flux used in calculation shall be declared in the calculation report.

Unless specific conditions are mentioned in the calculation report, the luminous flux used shall be that of the light source mentioned in the data sheet of the luminaire.

If the luminous intensity table is given in candelas per kilolumen ($cd \cdot klm^{-1}$), its values shall be converted in candelas, considering the luminous flux of all the light sources in the luminaire.



Key

1 luminaire at tilt during measurement

2 longitudinal direction

3 vertical direction

4 direction of luminous intensity

Figure 1 — Orientation of *C*, *γ* coordinate system in relation to longitudinal direction of carriageway

Maximum angular intervals stipulated in this standard have been selected to give acceptable levels of interpolation accuracy.

In the (C, γ) system of coordinates, luminous intensities shall be provided at the angular intervals stated below.

For all luminaires the angular intervals in vertical planes (γ) shall at most be 2,5° from 0° to 180°. In azimuth the intervals shall be varied according to the symmetry of the light distribution from the luminaire as follows:

a) luminaires with no symmetry: the intervals shall at most be 5°, starting at 0°, when the luminaire is at its tilt during measurement, and ending at 355°;

b) luminaires with nominal symmetry about the C = 270° – 90° plane: the intervals shall at most be 5°, starting at 270°, when the luminaire is at its tilt during measurement, and ending at 90°;

c) luminaires with nominal symmetry about the C = 270° – 90° and C = 0°– 180° planes: the intervals shall at most be 5°, starting at 0°, when the luminaire is at its tilt during measurement, and ending at 90°;

d) luminaires with nominally the same light distribution in all C-planes: only one representative set of measurements in a vertical (C-plane) is needed.