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PN-EN 13201-2:2007

# Oświetlenie dróg

# Część 2: Wymagania eksploatacyjne

**Norma Europejska EN 13201-2:2015 *Road lighting - Part 2: Performance requirements* ma status Polskiej Normy**



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## Nota uznaniowa

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# Road lighting - Part 2: Performance requirements

Eclairage public - Partie 2: Exigences de performance

Straßenbeleuchtung - Teil 2: Gütemerkmale

This European Standard was approved by CEN on 6 June 2015.

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## European foreword

This document (EN 13201-2:2015) 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of an identical text or by endorsement, at the latest by June 2016 and conflicting national standards shall be withdrawn at the latest by June 2016.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 13201-2:2003.

In comparison with EN 13201-2:2003, the following significant changes have been made:

— restructuring of the document;

— addition of an introduction including background information;

— updating of terms and definitions;

— combination of several classes;

— replacement of the abbreviation TI with the symbol $f_{TI}$;

— change of several class designations;

— change of the designations of the luminous intensity classes;

— addition of a new informative Annex C on evaluation of disability glare for C and P classes.

This document EN 13201-2 has been worked out by the Joint Working Group of CEN/TC 169 “Light and lighting” with 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* [present document]*;*

— *Part 3: Calculation of performance;*

— *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

A lighting class is defined by a set of photometric requirements aiming at the visual needs of certain road users in certain types of road areas and environment. The needs can vary at different periods during the night and also in different seasons of the year, thus the recommendations may vary during these periods.

The purpose of introducing lighting classes is to make it easier to develop and use road lighting products and services in CEN member countries. The lighting classes have been defined with consideration of road lighting standards in these countries and the lighting classes defined in CIE 115:2010 (2nd Edition) aiming at harmonization of requirements where possible. However, specific circumstances concerned with the road layout, use and national approaches based on traditional, climatic or other conditions could require different values of the uniformities. Not all the classes describe in this standard should be applied in a given country.

The M classes are intended for drivers of motorized vehicles for use on traffic routes, and in some countries also residential roads, allowing medium to high driving speeds.

The main lighting criteria of these classes are based on the road surface luminance of the carriageway and include the average luminance, the overall uniformity and the longitudinal uniformity for the dry road surface condition. Additional criteria relate to disability glare quantified by the Threshold Increment TI and the lighting of the surrounding areas quantified by the Edge Illuminance Ratio EIR. An additional criterion, used in some countries, is the overall uniformity of luminance in a wet condition.

The C classes are also intended for drivers of motorized vehicles, but for use on conflict areas such as shopping streets, road intersections of some complexity, roundabouts and queuing areas, where the conventions for road surface luminance calculations do not apply or are impracticable. The lighting criteria are based on the horizontal illuminance and are expressed by the average and the overall uniformity. These classes have applications also for pedestrians and pedal cyclists.

The P classes or the HS classes are intended for pedestrians and pedal cyclists on footways, cycleways, emergency lanes and other road areas lying separately or along the carriageway of a traffic route, and for residential roads, pedestrian streets, parking places, schoolyards, etc.

The lighting criteria of the P classes are based on the horizontal illuminance on the road area and are expressed by the average and the minimum illuminance.

The lighting criteria of the HS classes are based on the hemispherical illuminance of the road area and are expressed by the average hemispherical illuminance and the overall uniformity of this illuminance.

The SC classes are intended as an additional class in situations where public lighting is necessary for the identification of persons and objects and in road areas with a higher than normal crime risk.

The EV classes are intended as an additional class in situations where vertical surfaces need to be seen in such road areas as toll stations, interchange areas, etc.

The requirements of the lighting classes reflect the category of road user in question or the type of road area. Thus the M classes are based on the road surface luminance, while the C, P and HS classes are based on the illuminance of the road area. The SC classes are based on semi-cylindrical illuminance, while the EV classes are based on the vertical plane illuminance.

Each series of lighting classes presents decreasing requirements in their order and form steps of lighting level.

The specified lighting levels are maintained levels which are defined as the design levels reduced by a maintenance factor to allow for depreciation (refer to 3.10). The required maintenance factor, or a maintenance regime that allows deduction of the maintenance factor, should be included in tender specifications.

It should be taken into account that the light output of some light sources is sensitive to temperature. As photometric data are generally published considering a reference temperature of 25 °C, a correction factor should be considered for these light sources, if ambient temperatures are different.

Environmental aspects of road lighting are considered in Clause 7 in terms of day time appearance, night time appearance and light emitted in directions, where it is neither necessary nor desirable. The purpose is to highlight criteria that can be included in tender specifications or similar, where relevant.

Installed luminous intensity classes for the restriction of disability glare and control of obtrusive light G*1, G*2, G*3, G*4, G*5 and G*6 are introduced in the informative Annex A. The use of G* classes is mentioned in Clause 5 for conflict areas and in Clause 7 on appearance and environmental aspects.

Installed glare index classes for the restriction of discomfort glare D0, D1, D2, D3, D4, D5 and D6 are introduced in the informative Annex A as well. These classes are intended mainly for road areas lighted for the benefit of pedestrians and pedal cyclists.

Additional items considered in the Annex A are the use of installed luminous intensity classes and obtrusive lighting.

Local lighting of pedestrian crossings is considered in the informative Annex B. The intention of local lighting is to attract the attention of drivers of motorized vehicles to the presence of the pedestrian crossing and to illuminate pedestrians in or at the crossing area.

For the C and P classes, disability glare conditions considering the TI are described in the informative Annex C.

All photometric quantities are based on photopic photometry.

From an energy efficiency and environmental perspective a lighting installation should have a lighting level that matches the minimum required value of the relevant lighting class, and should meet all other relevant requirements, for instance uniformity, lighting of surrounding areas or additional classes (SC or EV). In that sense, the lighting levels specified in the tables are target values for minimum maintained levels.

Maximum lighting levels may be provided in tender specifications or national regulations.

When designing new road lighting installations, all the lighting requirements specified in Clauses 4, 5 and 6 are relevant, and also requirements on environmental aspects as considered in Clause 7, should be complied with.

When modifying the optical components or the geometry of existing lighting installations (for instance by changing the luminaires), it should be attempted to comply with all requirements. However, this may be highly impractical or expensive in some cases, while deviations from one or more of the requirements may lead to more practicable and less expensive solutions. In such cases, decisions should only be taken after careful consideration of all the aspects.

# 1 Scope

This part of this European Standard defines *performance requirements which are specified as* lighting classes for road lighting aiming at the visual needs of road users, and it considers environmental aspects of road lighting.

NOTE Installed luminous intensity classes for the restriction of disability glare and control of obtrusive light and installed glare index classes for the restriction of discomfort glare are defined in the informative Annex A. Lighting of pedestrian crossings is discussed in the informative Annex B. Disability glare evaluation for conflict areas (C classes) and pedestrian and pedal cyclists (P classes) is discussed in the informative Annex C.

# 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 13201-3, *Road lighting — Part 3: Calculation of performance*

EN 13201-4, *Road lighting — Part 4: Methods of measuring lighting performance*

# 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**average road surface luminance (of a carriageway of a road)**
$\overline{L}$
luminance of the road surface averaged over the carriageway

Note 1 to entry: Unit is candelas per square metre ($cd \cdot m^2$).

**3.2**
**longitudinal uniformity (of road surface luminance of a carriageway)**
$U_l$
lowest of the ratios determined for each driving lane of the carriageway as the ratio of the lowest to the highest road surface luminance found in a line in the centre along the driving lane

**3.3**
**threshold increment TI (of an object at the road surface)**
$f_{TI}$
percentage increase of contrast of an object that is needed to make it stay at threshold visibility in presence of disability glare generated by luminaires of a road lighting installation.

Note 1 to entry: TI is a measure of the effect of disability glare, described as an equivalent veiling luminance caused by scattering of light in the human eye. TI values are calculated in accordance with EN 13201-3 by means of an equation for the equivalent veiling luminance which represents a young person. When setting requirements for the limitation of the TI, or when evaluating calculated TI values, it should be taken into account that the scattering in the eye tends to increase with the age of the person. The increase is individual and may be low for some, by a factor of two for others and can be high for persons suffering from untreated cataract conditions.

**3.4**
**edge illuminance ratio EIR (of illumination of a strip adjacent to the carriageway of a road)**
$R_{EI}$
average horizontal illuminance on a strip just outside the edge of a carriageway in proportion to the average horizontal illuminance on a strip inside the edge, where the strips have the width of one driving lane of the carriageway

Note 1 to entry: Separate values apply for each of the two sides of a carriageway, and for each of the two sides of both carriageways of a dual carriageway. When a minimum requirement is made for the EIR of a lighting installation, each of the separate values shall meet the requirement.

**3.5**
**average illuminance (on a road area)**
$\bar{E}$
horizontal illuminance averaged over a road area

Note 1 to entry: Unit is lux (lx).

**3.6**
**minimum illuminance (on a road area)**
$E_{min}$
lowest illuminance on a road area

Note 1 to entry: Unit is lux (lx).

**3.7**
**hemispherical illuminance (at a point on a road area)**
$E_{hs}$
luminous flux on a small hemisphere with a horizontal base divided by the surface area of the hemisphere

Note 1 to entry: Unit is lux (lx).

**3.8**
**average hemispherical illuminance (on a road area)**
$\bar{E}_{hs}$
hemispherical illuminance averaged over a road area

Note 1 to entry: Unit is lux (lx).

**3.9**
**overall uniformity (of road surface luminance, illuminance on a road area or hemispherical illuminance)**
$U_o$
ratio of the lowest to the average value

**3.10**
**maintained level (of average road surface luminance, average or minimum illuminance on road area, average hemispherical illuminance, minimum semi-cylindrical illuminance or minimum vertical plane illuminance)**
design level reduced by a maintenance factor to allow for depreciation

**3.11**
**semi-cylindrical illuminance (at a point)**
$E_{sc}$
total luminous flux falling on the curved surface of a very small semi cylinder divided by the curved surface area of the semi cylinder

Note 1 to entry: The axis of the semi cylinder is to be vertical and the direction of the normal to the flat face inside the semi cylinder is to be the direction of orientation of the semi cylinder.

Note 2 to entry: Unit is lux (lx).

**3.12**
**minimum semi-cylindrical illuminance (on a plane above a road area)**
$E_{sc,min}$
lowest semi-cylindrical illuminance on a plane at a specified height above a road area

Note 1 to entry: Unit is lux (lx).

**3.13**
**vertical plane illuminance (at a point)**
$E_{v}$
illuminance at a point on a vertical plane

Note 1 to entry: Unit is lux (lx).

**3.14**
**minimum vertical plane illuminance (on a plane above a road area)**
$E_{v,min}$
lowest vertical plane illuminance on a plane at a specified height above the road area

Note 1 to entry: Unit is lux (lx).

## 4 Requirements for motorized traffic

The M classes in Table 1 are intended for drivers of motorized vehicles on traffic routes of medium to high driving speeds.

NOTE 1 Guidance on the application of these classes is given in CEN/TR 13201-1.

The average road surface luminance ($\bar{L}$), the overall uniformity of the luminance ($U_o$), the longitudinal uniformity of the luminance ($U_l$), the threshold increment ($f_{TI}$) and the edge illuminance ratio ($R_{EI}$) are to be calculated and measured in accordance with EN 13201-3 and EN 13201-4.

**Table 1 — M lighting classes**

| Class | Luminance of the road surface of the carriageway for the dry and wet road surface condition | | | | Disability glare | Lighting of surroundings |
|---|---|---|---|---|---|---|
| | Dry conditions | | | Wet | Dry conditions | Dry conditions |
| | $\overline{L}$ [minimum maintained] cd·m$^2$ | $U_o$ [minimum] | $U_l$ [a] [minimum] | $U_{ow}$ [b] [minimum] | $f_{TI}$ [c] [maximum] % | $R_{EI}$ [d] [minimum] |
| M1 | 2,00 | 0,40 | 0,70 | 0,15 | 10 | 0,35 |
| M2 | 1,50 | 0,40 | 0,70 | 0,15 | 10 | 0,35 |
| M3 | 1,00 | 0,40 | 0,60 | 0,15 | 15 | 0,30 |
| M4 | 0,75 | 0,40 | 0,60 | 0,15 | 15 | 0,30 |
| M5 | 0,50 | 0,35 | 0,40 | 0,15 | 15 | 0,30 |
| M6 | 0,30 | 0,35 | 0,40 | 0,15 | 20 | 0,30 |

[a] Longitudinal uniformity (Ul) provides a measure of the conspicuity of the repeated pattern of bright and dark patches on the road surface and as such is only relevant to visual conditions on long uninterrupted sections of road and should therefore only be applied in such circumstances. The values stated in the column are the minimum recommended for the specific lighting class, however, they may be amended where specific circumstances appertaining to the road layout or use are determined by analysis or where specific national requirements appertain.

[b] This is the only criterion for wet road conditions. It may be applied in addition to criteria for the dry condition in accordance with specific national requirements. The values stated in the column may be amended where specific national requirements appertain.

[c] The values stated in the column $f_{TI}$ are the maximum recommended for the specific lighting class, however, they may be amended where specific national requirements appertain.

[d] This criterion shall be applied only where there are no traffic areas with their own lighting requirements adjacent to the carriageway. The values shown are tentative and may be amended where specific national or individual scheme requirements are specified. Such values may be higher or lower than the values shown, however care should be taken to ensure adequate illumination of the areas is provided.

NOTE 2 The road surface luminance is the result of the illumination of the road surface, the reflection properties of the road surface and the geometrical conditions of observation. Conventions are given in EN 13201-3 and EN 13201-4, aiming at driving along stretches of road with viewing distances of between 60 m and 160 m.

NOTE 3 The average luminance ($\overline{L}$) reflects the general luminance level at which the driver performs. At the low level of lighting used for road lighting, performance improves with luminance in terms of increasing contrast sensitivity, increasing visual acuity and amelioration of glare.

NOTE 4 The overall uniformity ($U_o$) measures in a general way the variation of luminances and indicates how well the road surface serves as a background for road markings, objects and other road users.

NOTE 5 The longitudinal uniformity ($U_l$) provides a measure of the conspicuity of the repeated pattern of bright and dark patches on the road. It relates to visual conditions on long uninterrupted sections of road.

NOTE 6 The threshold increment ($f_{TI}$) indicates that although road lighting improves visual conditions it also causes disability glare to a degree depending on the type of luminaires, lamps and geometric situation. The calculated $f_{TI}$ values represent a young driver. The underlying cause of glare is scattering in the human eye which tends to increase with the age of the person. The increase is individual and may be low for some, by a factor of two for others and can be high for persons suffering from untreated cataract conditions.

NOTE 7 Lighting confined to the carriageway is inadequate for revealing the immediate surrounds of the road and revealing road users at the kerb.

NOTE 8 In some countries, the road surface is damp or wet for a significant part of the hours of darkness. For a selected wet condition, an additional requirement to the overall uniformity ($U_0$) can be made to avoid a serious downgrading of the performance for some of the damp periods.

## 5 Requirements for conflict areas

The C classes in Table 2 are intended for drivers of motorized vehicles, and other road users, on conflict areas such as shopping streets, road intersections of some complexity, roundabouts, queuing areas, etc.

NOTE 1 Guidance on the application of these classes is given in CEN/TR 13201-1.

C classes can also be applied to areas used by pedestrians and pedal cyclists, e.g. underpasses.

The average illuminance ($\bar{E}$) and the overall uniformity of the illuminance ($U_o$) are to be calculated and measured in accordance with EN 13201-3 and EN 13201-4.

The road area for which the requirements of Table 2 apply can include the carriageway only, when applying separate requirements for the adequate lighting of other road areas for pedestrian and cyclists, or it can include also other road areas.

NOTE 2 Limitation of disability glare can be demonstrated by evaluating $f_{TI}$ values for all relevant combinations of observation directions and observer positions (see Annex C) or achieved by the selection of luminaires according to the classes G*1, G*2, G*3, G*4, G*5 or G*6 (see A.1).

**Table 2 — C lighting classes based on road surface illuminance**

| **Class** | **Horizontal illuminance** | |
|---|---|---|
| | $\bar{E}$ **[minimum maintained]** lx | $U_o$ **[minimum]** |
| C0 | 50 | 0,40 |
| C1 | 30 | 0,40 |
| C2 | 20,0 | 0,40 |
| C3 | 15,0 | 0,40 |
| C4 | 10,0 | 0,40 |
| C5 | 7,50 | 0,40 |

NOTE 3 The C classes are mainly intended for use when the conventions for road surface luminance calculations do not apply or are impracticable. This can occur when the viewing distances are less than 60 m and when several observer positions are relevant. The C classes are simultaneously intended for other road users on the conflict area. The C classes have further application for pedestrian and pedal cyclists in such cases, where P and HS classes defined in 6.1 are not adequate.

# 6 Requirements for pedestrians and pedal cyclists

## 6.1 General requirements

The P classes in Table 3 or the HS classes in Table 4 are intended for pedestrians and pedal cyclists on footways, cycleways, emergency lanes and other road areas lying separately or along the carriageway of a traffic route, and for residential roads, pedestrian streets, parking places, schoolyards, etc.

NOTE 1 Guidance on the application of the above-mentioned classes is given CEN/TR 13201-1.

The average illuminance ($\bar{E}$), the minimum illuminance ($E_{min}$), the average hemispherical illuminance ($\bar{E}_{hs}$) and the overall uniformity of the hemispherical illuminance ($U_o$) are to be calculated and measured according to EN 13201-3 and EN 13201-4.

The road area for which the requirements of Tables 3 and 4 apply can include all the road area such as carriageways on residential roads and reserves between carriageways, footways and cycleways.

NOTE 2 Limitation of disability glare can be demonstrated by evaluating $f_{TI}$ values for all relevant combinations of observation directions and observer positions (see Annex C) or achieved by the selection of luminaires according to the classes G*1, G*2, G*3, G*4, G*5 or G*6 (see A.1).

NOTE 3 Limitation of discomfort glare can be achieved by the selection of luminaires according to the classes D1, D2, D3, D4, D5 or D6 of Annex A (see A.2). For the HS classes of Table 4, only the classes D5 or D6 are relevant.

**Table 3 — P lighting classes**

| **Class** | **Horizontal illuminance** | | **Additional requirement if facial recognition is necessary** | |
|---|---|---|---|---|
| | $\bar{E}$ [a] **[minimum maintained]** lx | $E_{min}$ **[maintained]** lx | $E_{v,min}$ **[maintained]** lx | $E_{sc,min}$ **[maintained]** lx |
| P1 | 15,0 | 3,00 | 5,0 | 5,0 |
| P2 | 10,0 | 2,00 | 3,0 | 2,0 |
| P3 | 7,50 | 1,50 | 2,5 | 1,5 |
| P4 | 5,00 | 1,00 | 1,5 | 1,0 |
| P5 | 3,00 | 0,60 | 1,0 | 0,6 |
| P6 | 2,00 | 0,40 | 0,6 | 0,2 |
| P7 | performance not determined | performance not determined | | |

[a] To provide for uniformity, the actual value of the maintained average illuminance shall not exceed 1,5 times the minimum $\bar{E}$ value indicated for the class.

NOTE 4 A high colour rendering contributes to a better facial recognition.

**Table 4 — HS lighting classes**

| Class | Hemispherical illuminance | |
|---|---|---|
| | $\bar{E}_{hs}$ **[minimum maintained]** lx | $U_o$ **[minimum]** |
| HS1 | 5,00 | 0,15 |
| HS2 | 2,50 | 0,15 |
| HS3 | 1,00 | 0,15 |
| HS4 | performance not determined | performance not determined |

## 6.2 Additional requirements

The SC classes in Table 5 are intended as an additional class for pedestrian areas for the purposes of improving facial recognition and increasing the feeling of safety. The $E_{sc,min}$ shall be evaluated on a plane 1,5 m above the road area.

The EV classes in Table 6 are intended as an additional class in situations where vertical surfaces need to be seen, e.g. interchange areas.

The minimum semi-cylindrical illuminance ($E_{sc,min}$) and the minimum vertical plane illuminance ($E_{v,min}$) are to be calculated and measured according to EN 13201-3 and EN 13201-4.

The road area for which the requirements of Tables 5 and 6 apply can include all the road area such as carriageways on residential roads and reserves between carriageways, footways and cycleways.

**Table 5 — SC lighting classes**

| Semi-cylindrical illuminance | |
|---|---|
| **Class** | $E_{sc,min}$ **[maintained]** lx |
| SC1 | 10,0 |
| SC2 | 7,50 |
| SC3 | 5,00 |
| SC4 | 3,00 |
| SC5 | 2,00 |
| SC6 | 1,50 |
| SC7 | 1,00 |
| SC8 | 0,75 |
| SC9 | 0,50 |

**Table 6 — EV lighting classes**

| Vertical plane illuminance | |
|---|---|
| **Class** | $E_{v,min}$ **[maintained]** lx |
| EV1 | 50 |
| EV2 | 30 |
| EV3 | 10,0 |
| EV4 | 7,50 |
| EV5 | 5,00 |
| EV6 | 0,50 |

# 7 Appearance and environmental aspects

The design and siting of road lighting installations and equipment can make a great difference to the appearance of the road and the road environment, by day and by night. This applies not only to the road user, but also to the observer viewing the installation from some distance off the road.

Consideration shall be given to the following matters related to:

Day time appearance:

a) choice of supporting method, for example columns with or without brackets, suspension wires, or direct mounting on buildings;

b) design and colour of lighting columns;

c) scale and height of lighting columns or other suspension elements in relation to the height of adjacent buildings, trees and other salient objects in the field of view;

d) location of lighting columns in relation to views of scenic value;

e) design, length and tilt of brackets on columns;

f) tilt of luminaire;

g) choice of luminaire.

NOTE 1 Day time appearance is both a matter of taste, partly related to culture, and of matching the lighting installation to the surrounds and/or creating particular expressions.

Night time appearance and comfort:

h) colour appearance of the light;

i) colour rendering of the light;

j) mounting height of the luminaire;

k) lit appearance of the luminaire;

l) lit appearance of the complete installation;

m) lit appearance of urban built-up environment;

n) optical guidance by direct light from the luminaire;

o) reduction of light levels at certain times.

NOTE 2 The elements to be considered for night time appearance and comfort have a strong impact on the mood, the performance and the aesthetic impression provided by the lighting installation. Night time appearance is both a matter of taste, partly related to culture, and of matching the lighting installation to the surrounds and/or creating particular expressions in the area to be lit – although with different means.

Minimizing light emitted in directions where it is neither necessary nor desirable:

p) in rural or suburban conditions, the obtrusive view of road lighting installations seen at a distance across open country. The use of full cut-off luminaires of luminous intensity classes G*4, G*5 and G*6 can help to reduce obtrusive light;

q) nuisance by light intruding into properties. Some reduction of intrusive light can be obtained by selecting an appropriate optical system or accessory to reduce the light in the direction of properties and/or by reducing source power;

r) light above the horizontal which when scattered in the atmosphere obscures the natural sight of the stars and impairs astronomical observation;

s) light can increase luminance levels in natural area which could affect ecological functions.

NOTE 3 Reduction of light levels in periods can help to minimize light emitted in directions where it is neither necessary nor desirable during those periods.

NOTE 4 When these aspects are important an adequate design of the lighting installation can minimize unwanted light and optimize energy and/or operational cost. At least the following parameters may be of influence: luminous intensity distribution and upper light output ratio of luminaires, environmental constrains, lighted surface reflection properties and installation layout,

# Annex A
(informative)

# Installed classes for glare restriction and control of obtrusive light

## A.1 Luminous intensity classes

In some situations it may be necessary to restrict disability glare from installations where the threshold increment ($f_{TI}$) cannot be calculated, refer to A.3.

It can also be decided to control obtrusive light after consideration of the aspects listed in Clause 7.

Table A.1 gives installed luminous intensity classes G*1, G*2, G*3, G*4, G*5 and G*6 from which a class can be chosen to meet appropriate requirements for restriction of disability glare and/or the control of obtrusive light.

Requirements for maximum luminous intensity in cd/klm as provided in Table A.1 shall be checked for the actual tilt of the luminaire as installed.

Other requirements regarding luminous intensities to be zero above 95° for classes G*4 and G*5, and above 90° for class G*6, as provided in Table A.1 shall be checked for the actual tilt of the luminaire unless it is evident from the construction of the luminaire that no light is emitted above the relevant angle; for instance when luminous apertures are not visible above the relevant angle.

**Table A.1 — Luminous intensity classes**

| Class | Maximum luminous[a] intensity in directions below the horizontal in cd/klm of the output flux of the luminaire. | | | Other requirements |
|---|---|---|---|---|
| | at 70° and above[b] | at 80° and above[b] | at 90° and above[b] | |
| G*1 | | 200 | 50 | None |
| G*2 | | 150 | 30 | None |
| G*3 | | 100 | 20 | None |
| G*4 | 500 | 100 | 10 | Luminous intensities above 95° [b] to be zero[c] |
| G*5 | 350 | 100 | 10 | Luminous intensities above 95° [b] to be zero[c] |
| G*6 | 350 | 100 | 0[c] | Luminous intensities above 90° [b] to be zero[c] |

[a] Luminous intensities are given for any direction forming the specified angle from the downward vertical with the luminaire installed for use.

[b] Any direction forming the specified angle from the downward vertical, with the luminaire installed for use.

[c] Luminous intensities up to 1 cd/klm can be regarded as being zero.

NOTE 1 For luminaires equipped with lamps of higher luminous fluxes it may be necessary to limit also the absolute luminous intensities.

NOTE 2 G*1, G*2 and G*3 correspond to "semi cut-off" and "cut-off" concepts of traditional use, with requirements, however, modified to suit the prevailing use of light sources and luminaires. G*4, G*5 and G*6 correspond to full cut-off.

## A.2 Glare index classes

Table A.2 gives glare index classes D0, D1, D2, D3, D4, D5 and D6 from which a class can be chosen to meet appropriate requirements for restriction of discomfort glare. These classes are intended mainly for road areas lit for the benefit of pedestrians and pedal cyclists. Useful restrictions of discomfort glare are provided mainly by the classes D4, D5 and D6.

The glare index is $I \times A^{-0,5}$, unit cd/m, where:

*I* is the maximum value of the luminous intensity (cd) in any direction forming an angle of 85° from the downward vertical;

*A* is the apparent area ($m^2$) of the luminous parts of the luminaire on a plane perpendicular to the direction of *I*. If in the direction of *I*, parts of the light source are visible, either directly or as images, the area *A* shall include only these parts.

NOTE 1 The apparent area *A*, as determined in a horizontal direction, can be sufficiently accurate.

NOTE 2 When a light distribution table for the luminaire in the conditions of operation is available, intensity (*I*) can be derived from the table.

**Table A.2 — Glare index classes**

| Class | D0 | D1 | D2 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|---|
| Glare index maximum | – | 7 000 | 5 500 | 4 000 | 2 000 | 1 000 | 500 |

EXAMPLE 1 A luminous sphere has a diameter of 0,6 m and an intensity of 60 cd per 1 000 lm bare lamp output in any direction. The apparent area is $\pi \times 0,6^2/4\ m^2 = 0,28\ m^2$ and the glare index value is $60 \times 0,28^{-0,5} = 113$ per 1 000 lm lamp output. With current lamp output values, the use of 50 W or 70 W high pressure sodium lamps for this particular luminaire results in classes D6 or D5 respectively.

EXAMPLE 2 A luminaire has a suspended bowl, shaped like a box of height 0,1 m, length 0,3 m and width 0,2 m. The maximum value of $I \times A^{-0,5}$ at 85° to the downward vertical is found in the plane perpendicular to the longitudinal direction of the bowl, where:

*I* is 50 cd per 1 000 lm lamp output;

*A* is $0,3 \times 0,2 \times \cos 85° + 0,3 \times 0,1 \times \cos (90° - 85°)\ m^2 = 0,035\ m^2$, so that the glare index value is $50 \times 0,035^{-0,5} = 267$ per 1 000 lm lamp output.

## A.3 Use of installed luminous intensity classes

### A.3.1 Traffic routes

At a crest, it may be necessary to limit glare from luminaires beyond the crest as these luminaires may be viewed at angles where the intensity is high, and the more distant luminaires can appear low in the scene. At such situations, luminaires that conform to installed luminous intensity classes G*4, G*5 or G*6 could be used.

### A.3.2 Lighting of bridges

When lighting bridges similar considerations to the lighting of crests may apply. There may be a reduced luminous foreground or confusing forward scene, either of which can reduce the forward view of the driver. Drivers approaching the crest of a bridge can experience glare from lights on and beyond the crest and have a reduced length of visible lit road before them. Beyond the crest, their forward view

can be confused by the presence of road, vehicle and building lights occurring in the near and/or distant fields of view. An appropriate installed luminous intensity class G*4, G*5 or G*6 could be selected in order to mitigate such problems.

### A.3.3 Residential roads

Direct glare from luminaires in subsidiary roads and associated areas, footpaths and cycle ways tracks could be controlled. Where luminaires have clear bowls or refractors, these could conform to class G*1 or a higher installed luminous intensity class to provide adequate control of glare.

### A.3.4 Conflict areas

Conflict areas increase the visual demands on the driver, therefore glare in such areas could, as a minimum, be as well controlled as on the approach roads.

Where the luminance design approach of the main through-route can be applied to simple conflict areas, the threshold increment (TI) of the lighting is determined by the selected lighting class. For glare control, it is normally sufficient to use the same luminaires within the conflict area, but if different luminaires are to be used, an appropriate installed luminous intensity class G*1, G*2, G*3, G*4, G*5 or G*6 could be selected.

Where luminance design is not appropriate, and an illuminance class has been selected from Table 2, it is likely that there will be multiple viewing directions of luminaires at varying angles of azimuth, and thus TI cannot be calculated. In order to limit glare, an appropriate installed luminous intensity class G*1, G*2, G*3, G*4, G*5 or G*6 could be selected.

NOTE Classes G*4, G*5 or G*6 are normally appropriate.

## A.4 Obtrusive light

Obtrusive light is light that has undesirable visual effects on the night scenery for residents locally or over large areas.

NOTE Additional information can be found in CIE 126:1997: Guidelines for minimizing sky glow and CIE 150:2003: Guide on the limitation of the effects of obtrusive light from outdoor lighting installations.

All forms of exterior lighting may be sources of obtrusive light. These include road lighting, flood lighting (buildings, monuments, bridges, etc.), illumination of road signs (exterior illumination or transillumination), road signals, lamps on vehicles (headlamps and signal lamps), advertising (illuminated or luminous signs), etc. Even interior lighting may be a source of obtrusive light by light escaping from buildings.

Undesirable effects include:

a) intrusion of light into rooms, gardens or other property;

b) domination of the night scenery by luminaires, luminous signs, light signals, illuminated facades and surfaces, etc.;

c) sky glow.

These effects are considered for road lighting in the following.

Intrusion of light is sometimes considered as a benefit by some residents, for instance when an entrance or a driveway is well illuminated. However, it is generally beneficial to reduce intrusion of light. Methods of reducing intrusive light include the use of luminaires with little spill of light, for instance by selecting luminaires of an appropriate installed luminous intensity class G*1, G*2, G*3, G*4, G*5 or G*6, and to avoid that luminaires are mounted higher than buildings and vegetation along the road.

Domination of the night scenery by road lighting installations can also be avoided by installing luminaires of an appropriate installed luminous intensity class. The luminaires in a road lighting installation in an open area, may be visible over long distances unless they are of a high installed luminous intensity class. Additionally, the utilisation of light, and light falling outside of areas to be illuminated can be considered.

Sky glow is caused by light that is emitted or reflected in an upwards direction towards the sky and then partly reflected back.

The proportion of light that is reflected back is high, when the sky is clouded. In city areas this may cause a significant apparent luminance of the sky and a significant background level of illumination at the ground.

However, sky glow refers mainly to the situation when the sky is clear. The proportion of light that is reflected back is low, depending on atmospheric conditions such as humidity or pollution (smog), but nevertheless high enough to cause an artificial luminance of the sky that reduces visibility of celestial bodies.

One means of reducing sky glow is to use luminaires with little or no emission of upwards light, such as of those with a high installed luminous intensity class G*4, G*5 or G*6. This does not entirely prevent a contribution to sky glow as a proportion of the light emitted from the luminaire is reflected from the road area and its surroundings.

Reduction of light levels in periods of the night may be considered as a mean of energy saving, but has the additional effect of reducing obtrusive light during those periods.

When considering the provision of road lighting, the effects of intrusive light on surroundings should be considered in particular for roads in rural areas as road lighting can rarely be avoided on roads in urban areas.

# Annex B
(informative)

# Lighting of pedestrian crossings

Pedestrian crossings may require special consideration. In some countries national standards exist which give further guidance relative to national practices.

When a sufficiently high road surface luminance level can be provided, it may be possible to position the normal road lighting luminaires so as to provide good negative contrast with the pedestrian visible as a dark silhouette against a bright background.

Where local lighting provided by additional luminaires is considered for the illumination of pedestrian crossings the intention should be to directly illuminate pedestrians on or at the crossing and to draw the attention of drivers of motorized vehicles to the presence of the crossing.

The type of the additional luminaires and their positions and orientations relative to the crossing area should be considered so as to achieve positive contrast, and not cause undue glare to drivers. One solution is to mount luminaires a short distance before the crossing in the direction of approaching motorized traffic, and direct the light onto the side of pedestrians facing the drivers of this traffic. For a two way road, a luminaire is mounted before the crossing in each direction of the traffic flow on the side of the road on which traffic drives. Luminaires with asymmetric light output are suitable, causing less glare to drivers.

Local lighting can be arranged to provide sufficient illumination of the pedestrian on the side facing the traffic at all locations of the road crossing area. The illuminance, when measured on a vertical plane, should be significantly higher than the horizontal illuminance produced by road lighting on the carriageway of the road. Zones at either end of the road crossing, where pedestrians wait to enter the crossing, should receive adequate illumination. Lighting confined to a narrow band around the crossing area produces a dramatic affect assisting in raising attention.

# Annex C
(informative)

# Evaluation of disability glare for C and P classes

For lighting installations of the C and P Classes, limitation of disability glare can be demonstrated by evaluating $f_{TI}$ values in accordance with the methods of EN 13201-3 for all relevant combinations of observation directions and observer positions.

These $f_{TI}$ values should not exceed the maximum $f_{TI}$ values specified for the different C classes in Table C.1 and P classes in Table C.2.

**Table C.1 — Maximum $f_{TI}$ values for C classes**

| Class | $f_{TI}$ [maximum] % |
|---|---|
| C0 | 15 |
| C1 | 15 |
| C2 | 15 |
| C3 | 20 |
| C4 | 20 |
| C5 | 20 |

**Table C.2 — Maximum $f_{TI}$ values for P classes**

| Class | $f_{TI}$ [maximum] % |
|---|---|
| P1 | 20 |
| P2 | 25 |
| P3 | 25 |
| P4 | 30 |
| P5 | 30 |
| P6 | 35 |
| P7 | performance not determined |

# Bibliography

[1] CEN/TR 13201-1, *Road lighting - Part 1: Guidelines on selection of lighting classes*

[2] IEC 60050-845, *International Electrotechnical Vocabulary (IEV) - Chapter 845: Lighting*

[3] EN 12665:2011, *Light and lighting - Basic terms and criteria for specifying lighting requirements*

[4] CIE Publication 115: 2010, *Lighting of roads for motor and pedestrian traffic*

[5] CIE Publication 126:1997, *Guidelines for minimizing sky glow*

[6] CIE Publication 150:2003, *Guide on the limitation of the effects of obtrusive light from outdoor lighting installations*