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Cestna razsvetljava - 4. del: Metode za merjenje lastnosti razsvetljave

Road lighting - Part 4: Methods of measuring lighting performance

Straßenbeleuchtung - Teil 4: Methoden zur Messung der Gütemerkmale von Straßenbeleuchtungsanlagen

Eclairage public - Partie 4: Méthodes de mesure de performances photométriques

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93.080.40	Cestna razsvetljava in pripadajoča oprema	Street lighting and related equipment

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English Version

Road lighting - Part 4: Methods of measuring lighting performance

Éclairage public - Partie 4 : Méthodes de mesure des performances photométriques

Straßenbeleuchtung - Teil 4: Methoden zur Messung der Gütemerkmale von Straßenbeleuchtungsanlagen

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

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 13201-4:2015) 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of an identical text or by endorsement, at the latest by June 2016 and conflicting national standards shall be withdrawn at the latest by June 2016.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 13201-4:2003.

The main technical changes in this version are:

— The definition of different aims of measurement with peculiar requirements in order to optimize the instrument characteristics, measurement cost and time;

— A deeper comparison between static and dynamic measurement requirements;

— Addition of specific requirements for ILMD (Image Luminance Measuring Device) when used as luminance meter;

— Evaluation of measurement uncertainty;

— Comparison with requirements or design expectation carried out considering the expanded measurement uncertainty of the measure;

— Addition of guidelines for the measurement of Threshold Increment and of Edge Illuminance Ratio;

— Suggestion for an algorithm for the evaluation of tolerances in road lighting installation design;

— Description of the concept of particular parameters in order to consider measurements carried out in condition different from the normative ones;

— Description of an improved convention for symbols of photometric quality parameters in order to avoid confusion between values of the same parameter but with different meanings;

— Measurement systems for adaptive road lighting are considered;

— Guidelines for the measurement uncertainty evaluation are given.

This document EN 13201-4 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;*

— *Part 3: Calculation of performance;*

— *Part 4: Methods of measuring lighting performance* [present document]*;*

— *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 purpose of Part 4 of this European Standard is to:

a) establish conventions and procedures for the characterization based on measurements of road lighting installations considering the photometric quality parameters, i.e. the set of quantities that characterize a lighting class, specified in Part 2;

b) give advice on the use and selection of luminance meters and illuminance meters for this particular application;

c) specify measurement requirements according to the aims of the measurement and expected accuracy;

d) establish conventions for evaluating the measurement uncertainty of involved parameters;

e) give information on the application of tolerance analysis in the design of the lighting installation.

A non-exhaustive list of possible measurement aims is:

f) verification of compliance with standard requirements;

g) verification of compliance with design expectations;

h) road lighting installation monitoring, e.g. for maintenance purposes;

i) road lighting installation control, e.g. for optimizing energy saving;

j) investigation of discrepancies between real lighting conditions and design expectations.

The conventions for observer position and location of measurement points are those adopted in EN 13201-3. However, relaxation from these is permitted especially where the measurements are used for monitoring the performance of a road lighting installation, to control its performances or other purposes or when different conditions are specified in the road lighting installation design.

Conditions, which can lead to inaccuracies, are identified and precautions are given to minimize and quantify these.

This standard should be used to write measurement procedures for the characterization of road lighting installations.

Criteria for deciding when measurements should be done, on the purpose of measurements and on how the measurement results shall be used fall outside the scope of this standard.

1 Scope

This European Standard specifies measurement conditions and procedures for measuring the photometric quality parameters of road lighting installations, i.e. the quantities that quantify their performances in accordance with EN 13201-2 lighting classes.

Parameters used for quantifying the energy performance of road lighting installations are not considered.

A methodology to evaluate the road lighting performances considering tolerances in the design parameters is described in the informative Annex A.

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

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 13201-3:2015, *Road lighting — Part 3: Calculation of performance*

3 Terms and definitions

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

3.1
automatic measuring system for control purpose
automatic system used to generate a control signal, correlated to one or more measured photometric parameters that can influence the operating conditions of a road lighting installation

Note 1 to entry: Metrological parameters, such as measurement repeatability and stability, generally are the main characteristic of the system.

3.2
dynamic measurement system
measurement system that moves along the road surface to carry out the measurement

3.3
static measurement system
measurement system that does not move when in service

3.4
parameter (normative)
quantity defined in EN 13201-2 following calculation rules of EN 13201-3

Note 1 to entry: The value of the parameter can:

a) give standard requirements;

b) give values effectively required by the road authority (design expectations). These values can differ from values given in EN 13201-2;

c) be evaluated using the appropriate algorithm (based on a physical model of light propagation in the environment) as specified by EN 13201-3;

d) be measured following conditions that fit those specified in EN 13201-3 for the points of the grid and, if necessary, for the position of the observer and verifying if the influence of the metrological characteristics of the measuring instrument is compatible with the physical definition of the parameter.

3.5
particular parameter
quantity calculated, measured or evaluated in accordance with given and well-defined conditions, but different to those specified in EN 13201-3

Note 1 to entry: The set of conditions shall be described with the measurement results.

3.6
luminance (normative)
L
luminance of an elementary surface centred at a given point when viewed from the standard observation position according to EN 13201-3

Note 1 to entry: The luminance is expressed in candela per square metre.

3.7
luminance (particular)
***L*$_p$**
luminance of a surface centred at a given point when viewed from a specified observation position and/or specified conditions highlighted using the subscript p

Note 1 to entry: The luminance (particular) is expressed in candela per square metre.

3.8
extended uniformity
a particular parameter introduced to mathematically analyse the influence of non-homogeneity of the environment or of the road surface

Note 1 to entry: This is particularly useful when dynamic measurement systems are used and the presence of non- homogeneity cannot be evaluated before the measurement.

Note 2 to entry: Extended uniformity is discussed in the informative Annex B.

3.9
set measurement
measurement carried out in an installation to determine the values of parameters used by an automatic measuring system for control purpose

3.10
image luminance measuring device
ILMD
digital electronic device, equipped with a lens, an adequate photometric matching filter, a sensor made by a matrix of detector (pixel), and calibrated for measuring the luminance distributions of the framed scene

Note 1 to entry: Every pixel is calibrated to determine the luminance values of the space imaged on its surface by the lens system.

Note 2 to entry: The matrix of pixel is generally realized with CCD (charge coupled device) or CMOS (complementary metal oxide semiconductor) sensors.

Note 3 to entry: In literature different terms may be found to describe ILMD such as multi-channel luminance meter, luminance mapper, array (or matrix) luminance meter, video photometer, photo luminance meter, CCD luminance meter, luminance camera, multidirectional luminance meter, spatial luminance profile device.

3.11
split detector system
a method of measuring horizontal illuminance using couple/s of detectors, the first detector of every couple measures light from the hemisphere in the forward direction, the second one measures light from the hemisphere in the rearward direction

Note 1 to entry: This method is usually applied in dynamic measurement system where one detector is mounted on the front of the vehicle and the other on the rear of the vehicle.

Note 2 to entry: The point illuminance value is obtained by summing the readings of the two detectors at the same spatial point.

3.12
adaptive lighting
temporal controlled changes in luminance or illuminance in relation to traffic volume, time, weather or other parameters

4 Symbols and abbreviations

EN 13201-3 lists the normative photometric quality parameters of a road lighting installation.

For particular measurement purposes, in addition of normative parameters, a set of particular parameters is described in the informative Annex B. In accordance with the measurement aims and measurement procedures, the person responsible for the measurement decides if it is necessary to use these parameters.

When necessary, to clearly specify with a symbol the meaning or the measurement conditions linked to a parameter the conventions described in the normative Annex C shall be adopted.

5 Preliminary information of road lighting system measurement

5.1 Aims of measurements

At least four different aims require the measurement of the photometric quality parameters of a road lighting system:

Measurements at the final testing phase: measurements carried out during the final testing/commissioning phase of the road lighting installation, to verify the compliance with standard requirements and/or with design expectations. These results can be used for the road lighting installations formal approval.

Measurements during the road lighting lifetime: measurements carried out at pre-determined intervals during the road lighting lifetime, to quantify the degradation of the lighting performance and to define the need for maintenance or to verify the compliance of the road lighting installation with the standard requirements or design expectations, generally based on maintained values.

Measurements for adaptive road lighting: measurements carried out continuously or at pre-determined intervals to control the luminous flux of luminaires in adaptive road lighting, where the installations performance is kept at the given value within a given tolerance.

Measurements for investigation of discrepancies: measurements carried out as and when required to investigate discrepancies between measures and design expectations or environment influence.

For every aim different measurement procedures, requirements and metrological characteristics of instruments shall be considered.

The main part of the standard considers requirements for measurement at the final testing phase and during the road lighting lifetime. Peculiarities or additional requirements for measurements for adaptive road lighting are given in the normative Annex D and for investigation of discrepancies in the informative Annex E.

The set measurement (see 3.9) is considered as a peculiar measurement that shall follow requirements for measurement at the final testing phase.

Except for the set measurement, when measurement results need to be compared they shall be carried out considering the same set of measurement points and, if required, observer position.

Measurements shall be carried out following a detailed operating procedure that shall consider the standard requirements or design expectations, describes the evaluation of measurement uncertainty (see informative guidelines in Annex F), specifies the conditions of its applicability and considers practical aspects (see informative guidelines in Annex G).

The objectives of the measurement shall be written in the test report (see Clause 9 and the informative Annex H).

NOTE An existing installation can have its design documentation missing. In this case measurement can be done according to tender specifications.

5.2 Measurement procedures and selection of photometric instruments

5.2.1 Static versus Dynamic measurements

Measurements can be done with either static or dynamic measurement systems. For a given measurement aim (see 5.1), the selection of the adopted system shall be done considering the required accuracy of the results and other constrains that can rise from safety reasons, local and temporary conditions and/or tender requirements.

A dynamic measurement system can measure the total length (or surface) of a road lighting installation in a more reasonable time than a static measurement system. This peculiarity can be useful when the homogeneity of performances of the road lighting installation shall be investigated or when an entire road network has to be evaluated at a given instant.

NOTE Guidance on design and use of dynamic measurement systems is given in CIE 194:2011.

5.2.2 General requirements on measurement procedures and on measurement devices

The measurement procedures adopted shall be suited to the purpose of the measurements.

For a given measurement aim, the maximum acceptable value of the expanded measurements uncertainty shall be defined considering national or tender requirements and upon the evaluation of the influence this uncertainty can have on the decision taken using the measurement results or on the power consumption of the road lighting installation or any other parameters defined in EN 13201-5.

All instruments shall be calibrated in the ranges used to assure their metrological traceability.

NOTE 1 Calibration performed by an EN ISO/IEC 17025 accredited calibration laboratory guaranties this requirement.

The metrological characteristics of the instruments used shall be suited to the purpose of the measurements. Luminance shall be measured with a luminance meter which has a performance suitable for the purpose of the measurements. Illuminance shall be measured with an illuminance meter which has a performance suitable for the purpose of the measurements:

— for the measurement of horizontal and vertical illuminance a photometer head for the measurement of planar illuminance is required;

— for semicylindrical or hemispherical illuminance a photometer head designed for this purpose is required.

The instruments metrological performances shall be evaluated for the specific conditions of the application.

Therefore if needed, the calibration and photometric characteristics of the detector used shall be corrected taking account of the ambient temperature and humidity conditions during measurements and the spectra emitted in the visible region by the luminaires.

Instruments used for measurement of photometric parameters shall be characterized in accordance with EN 13032-1 for all the relevant parameters and their influence shall be considered in the uncertainty evaluation model.

NOTE 2 Guidance on the performance of illuminance and luminance meters is given in CIE S 023/E:2013.

5.2.3 Specific requirements for luminance meter

For every type of luminance meters the influence of light sources external to the framed field shall be considered.

For every type of luminance meter, in every case of grind point measurement the angular subtense of the measured road surface shall be not be greater than 2 min of arc in the vertical plane and not greater than 20 min of arc in the horizontal plane. The minimum angular subtense shall be no lower of 1 min of arc.

NOTE 1 The field of calculation specified in EN 13201-3 commences 60 m from the observer. This means that to prevent overlap of the measurement areas as seen through a luminance meter set at this distance, the maximum value of angle of the measurement cone has the value indicated above.

NOTE 2 The minimum value of the angular subtense consider a conventional visual acuity of 1 min of arc.

If the measurement is carried out at a closer distance respect to the nominal positions of the observer given in EN 13201-3 (see 7.2.1) it is recommended that the measurement cone of the luminance meter should not exceed 30 min of arc, and the size of the measurement area on the road should not be greater than 0,5 m transversely and 2,5 m longitudinally.

5.2.4 Additional requirements for ILMD

For ILMDs the influence of shutter repeatability, pixel saturation and ghost images shall also be considered.

If an ILMD is used the luminance for each grid point may be determined by averaging the reading of adjacent pixels. In every case the conditions on the angular subtense of the measured surfaces shall comply with requirements given in 5.2.3.

5.3 Measurement uncertainty evaluation

The measurement uncertainty can be considered as having three groups of components:

a) Those concerning the metrological characteristics of the measurement system and the influence of measurement procedures;

b) Those concerning the influence of the nominal characteristics and layout of the road lighting installation being measured;

c) Those concerning the influence of the instantaneous characteristics of the road lighting installation being measured, and of the weather and environmental conditions.

These three groups shall be separated because the last one can change significantly from one measurement to another, while the influence of the measurement system can remain substantially constant.

The various sources of measurement uncertainty can be classified as:

a) accuracy of measurement instruments;

b) accuracy of the coordinate reference of the measured point or area (if relevant);

c) influence of the measurement procedure;

d) influence of data elaboration methods;

e) road lighting installation characteristics and stability of the photometric parameter's during measurement;

f) electrical power supply conditions;

g) weather conditions (temperature, relative humidity, wind velocity, etc.);

h) environmental conditions (presence of trees, shielding objects, disturbing light sources, other lighting installations, etc.).

For practical reasons this European Standard does not require the evaluation of the uncertainty contribution of the last three, but only a description in the test report of their conditions, because:

i) they are not usually under the control of the measurement team;

j) their evaluation or measurement can be difficult or expensive;

k) the road lighting installation should normally be evaluated in real working conditions that do not need to be quantitatively known in detail;

l) the influence of these matters on the measured illuminance or luminance value is generally not known and it is likely to be impossible to determine without a laborious and expensive set of measurements.

If point values or uniformities are given in the test report, the influence of the detector misalignment (e.g. the detector surface is not in the nominal position with respect to grid points) for illuminance measurements or position and dimensions of the framed surface for luminance measurements shall be considered when evaluating measurement uncertainties. This correlation is a characteristic of the road lighting installation (spatial variation of illuminance or luminance near the point due to non-uniform light distribution) and not of the measurement system or measurement procedures.

This contribution to the measurement uncertainties need not be considered for average values.

Guidelines for the evaluation of measurement uncertainty in road lighting installation characterization are given in the informative Annex F.

NOTE Guidance on the calculation of measurement uncertainty is given in ISO/IEC Guide 98-1:2009 and ISO/IEC Guide 98-3:2008.

5.4 Measured zones

The measurements shall consider the entire length of the road lighting installation and all its operating conditions (lighting classes).

If the road lighting installation characteristics are designed as constant for the total length of the installation, it is possible to select a relevant number of zones and to carry out measurements only in these zones (measured zones). In this case a description of the reasons, justifications and consequences of this choice shall be written in the test report.

NOTE One of the most common reasons for the selection of particular measured zones is the supply voltage drop in the power supply electrical line.

5.5 Measured parameters

The road geometrical parameters in the measured zone (column spacing, carriage and lane width) shall be measured or known to allow for defining the reference for point coordinates and the nominal values of point coordinates.

The position, inclination and orientation of the sensitive surface of the illuminance meter (for illuminance measurement) or of the position of measured surface (for luminance measurement) with respect to the nominal grid points shall be recorded in the test report.

For illuminance measurement the z coordinate (height of the light sensitive surface of the detector with respect to the road surface) shall also be specified.

NOTE These parameters are specified using their nominal value and tolerances, or the measured values with uncertainty.

Measurement *for the verification of compliance with standard requirements* shall consider all the photometric quality parameters for the pertinent lighting class/classes.

A reduced set of parameters may be adopted if agreed with the purchaser or operator and if this choice is described in the road installation design.

Measurement *for the verification of compliance with design expectation* shall consider a congruent set of parameters as specified and evaluated in the road lighting installation design.

EXAMPLE This set can specify the measurement of illuminance in grid points instead of the road surface average luminance and the calculation of uniformities considering these values.

The following additional points shall be described in the test report:

a) electrical power supply conditions,

b) weather and environmental conditions,

and shall be measured if requested as part of a tender specification or required as part of a pertinent standard (see Clause 8).

If tender specification or pertinent standard require the measurement of illuminance, as a preliminary verification step for M lighting classes, point illuminances at the same points of the grid used for luminance calculation shall be calculated for M lighting classes and illuminance measured at the same points.