



BSI Standards Publication

Light and lighting - Measurement and presentation of photometric data of lamps and luminaires

Part 4: LED lamps, modules and luminaires

National foreword

This British Standard is the UK implementation of EN 13032-4:2015+A1:2019. It supersedes BS EN 13032-4:2015, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

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lamps, modules and luminaires

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données photométriques des lampes et des luminaires
- Partie 4 : Lampes, modules et luminaires LED

Licht und Beleuchtung - Messung und Darstellung
photometrischer Daten von Lampen und Leuchten -
Teil 4: LED-Lampen, -Module und -Leuchten

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COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 13032-4:2015+A1:2019) 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of an identical text or by endorsement, at the latest by December 2019, and conflicting national standards shall be withdrawn at the latest by December 2019.

A1 This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (M/495 and M/519), and supports essential requirements of EU Directive(s): No 244/2009, No 874/2012, No 1194/2012 and No 2015/1428 amending 244/2009.

For relationship with EU Directive(s), see informative Annexes ZA, ZB and ZC, which is an integral part of this document. **A1**

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

This document includes Amendment 1 approved by CEN on 21 March 2019.

This document supersedes EN 13032-4:2015.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1** .

This standard was developed in collaboration with CIE TC2.71, which developed CIE S 025, to produce two technically-harmonized standards at CEN and CIE level.

Acknowledgement is given to CIE for their support in the preparation of this standard.

According to the CEN-CENELEC Internal Regulations, the national standards organisations 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, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This standard provides requirements to perform reproducible photometric and colorimetric measurements on LED lamps, LED modules and LED luminaires (LED devices). It also provides advice for the reporting of the data.

The availability of reliable and accurate photometric data for LED devices is a basic requirement for designing good lighting systems and evaluating performance of products. By obtaining these data through measurements in specific normalized measuring conditions the consistency of the data should be ensured between different laboratories (within the limits of the declared measurement uncertainty) and comparison of different products on the same basis is possible.

This standard aims in particular to cover measurement methods for testing the compliance of LED devices with the photometric and colorimetric requirements of LED performance standards (see Clause 2) issued by IEC/TC 34/CLC/TC 34 “Lamps and related equipment” and/or relevant European regulations.

LED devices offer a large variety of configurations in respect to geometry and/or colour. For each configuration the photometric and colorimetric performances are considered individually.

1 Scope

This European Standard specifies the requirements for measurement of electrical, photometric, and colorimetric quantities of LED lamps, LED modules and LED luminaires, for operation with AC or DC supply voltages, possibly with associated LED control gear. LED light engines are assimilated to LED modules and handled accordingly. Photometric and colorimetric quantities covered in this standard include total luminous flux, luminous efficacy, partial luminous flux, luminous intensity distribution, centre-beam intensity, luminance and luminance distribution, chromaticity coordinates, correlated colour temperature (CCT), colour rendering index (CRI), and angular colour uniformity.

A1 This document does not cover LED packages. Described measurement methods for LED lamp or luminaires may apply as measurement methods for OLEDs products. **A1**

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 ISO 11664-1:2011, *Colorimetry — Part 1: CIE standard colorimetric observers (ISO 11664-1:2007)*

EN ISO 11664-2:2011, *Colorimetry — Part 2: CIE standard illuminants (ISO 11664-2:2007)*

EN ISO 11664-3:2013, *Colorimetry — Part 3: CIE tristimulus values (ISO 11664-3:2012)*

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

EN 13032-1:2004+A1:2012, *Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 1: Measurement and file format*

EN 61341:2011, *Method of measurement of centre beam intensity and beam angle(s) of reflector lamps (IEC/TR 61341:2010)*

EN 62504:2014, *General lighting — Light emitting diode products and related equipment— Terms and definitions (IEC 62504:2014)*

A1 EN 62717:2017, *LED modules for general lighting — Performance requirements (IEC 62717:2014, modified + A1:2015, modified)* **A1**

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 98-4:2012, *Uncertainty of measurement — Part 4: Role of measurement uncertainty in conformity assessment*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

CIE/DIS 024/E:2013, *Light Emitting Diodes (LEDs) and LED Assemblies — Terms and Definitions*

CIE 13.3, *Method of Measuring and Specifying Colour Rendering of Light Sources*

CIE 15, *Colorimetry*

CIE 84:1989, *Measurement of Luminous Flux*

CIE 198:2011, *Determination of Measurement Uncertainties in Photometry*

CIE 198:2011-SP1, *Determination of Measurement Uncertainties in Photometry – Supplement 1: Modules and Examples for the Determination of Measurement Uncertainties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12665, EN 13032-1 and the following apply.

3.1

electric light source

primary light source that transforms electrical energy into optical radiation

[SOURCE: CIE/DIS 024/E:2013, 3.3]

3.2

directional light source

electric light source having at least 80 % luminous flux within a solid angle of π sr

Note 1 to entry: A cone with angle of 120° is usually considered for the solid angle of π sr. Other shape of solid angle may apply for non-circular shaped beams e.g. elliptical or rectangular shaped beam. 

3.3

light-emitting diode

LED

solid state device embodying a p-n junction, emitting incoherent optical radiation when excited by an electric current

Note 1 to entry: This definition is independent from the existence of enclosure(s) and of terminals.

Note 2 to entry: The output is a function of its physical construction, material used and exciting current. The optical emission may be in the ultraviolet, visible, or infrared wavelength regions.

Note 3 to entry: “LED” term represents the LED die (or chip) or LED package. It is also used as a generic term representing the technology.

Note 4 to entry: “LED” term should not be used for reporting product performance (like luminous flux, colour rendering, lifetime...) instead use for example “luminous flux of the LED module”.

[SOURCE: EN 62504:2014, 3.24]

3.4

LED package

single electrical component encapsulating principally one or more LED dies, possibly including optical elements and thermal, mechanical, and electrical interfaces

Note 1 to entry: The component does not include the control unit of the control gear, does not include a cap, and is not connected directly to the supply voltage.

Note 2 to entry: A LED package is a discrete component and part of the LED module or LED lamp.

[SOURCE: EN 62504:2014, 3.20]

3.5**LED light source**

electric light source based on LED technology

Note 1 to entry: A luminaire may include LED light sources but is not considered itself as a light source.

Note 2 to entry: LED light source(s) for a LED luminaire represent(s) one or more LED lamp(s) or LED module(s).

[SOURCE: EN 62504:2014, 3.16]

3.6**LED lamp**

LED light source provided with (a) cap(s) incorporating one or more LED module(s) and possibly including one or more of the following: electrical, optical, mechanical, and thermal components, interfaces and control gear

Note 1 to entry: A LED lamp may be integrated (LEDi lamp) or semi-integrated (LEDsi lamp) or non-integrated (LEDni lamp).

Note 2 to entry: Single and double-capped lamps are included.

Note 3 to entry: A LED lamp is designed so that it can be replaced by an ordinary person (as defined in IEC 60050-18-03, 826)

[SOURCE: EN 62504:2014, 3.15]

3.7**integrated LED lamp (LEDi lamp)**

LED lamp, incorporating control gear, and any additional elements necessary for stable operation of the light source, designed for direct connection to the supply voltage

Note 1 to entry: In some documents the term self-ballasted LED lamp is still used.

[SOURCE: EN 62504:2014, 3.15.1 modified by note1, added]

3.8**semi-integrated LED lamp (LEDsi lamp)**

LED lamp which carries the control unit of the control gear, and is operated by the separated power supply of the control gear

Note 1 to entry: In some documents the term semi-self-ballasted LED lamp is still used.

[SOURCE: EN 62504:2014, 3.15.4 modified by note 1, added]

3.9**non-integrated LED lamp (LEDni lamp)**

LED lamp which needs a separate control gear to operate

Note 1 to entry: In some documents the term non-self-ballasted LED lamp is still used.

[SOURCE: EN 62504:2014, 3.15.2 modified by note1, added]

3.10

retrofit LED lamp

LED lamp, intended as a replacement of a non-LED lamp without requiring any internal modification of the luminaire

[SOURCE: EN 62504:2014, 3.15.3]

3.11

LED module

LED light source having no cap, incorporating one or more LED package(s) on a printed circuit board, and possibly including one or more of the following: electrical, optical, mechanical, and thermal components, interfaces and control gear

Note 1 to entry: A LED module may be integrated (LEDi module) or semi-integrated (LEDsi module) or non-integrated (LEDni module).

Note 2 to entry: The LED module is usually designed to be part of a LED lamp or LED luminaire.

[SOURCE: EN 62504:2014, 3.19]

3.12

integrated LED module (LEDi module)

LED module, incorporating control gear and any additional elements necessary for stable operation of the light source, designed for direct connection to the supply voltage

Note 1 to entry: In some documents the term self-ballasted LED module is still used.

[SOURCE: EN 62504:2014, 3.19.4 modified by note 1, added]

3.13

semi-integrated LED module (LEDsi module)

LED module which carries the control unit of the control gear, and is operated by the separated power supply of the control gear

Note 1 to entry: In some documents the term semi-self-ballasted LED module is used.

[SOURCE: EN 62504:2014, 3.19.6 modified by note 1 added]

3.14

non-integrated LED module (LEDni module)

LED module which needs a separate control circuitry or control gear to operate

Note 1 to entry: In some documents the term non-self-ballasted LED module is used.

Note 2 to entry: One or more LED packages on a printed circuit board or substrate in a geometric structure are regarded as LED array. No further components are included like electrical, optical, mechanical and thermal components.

[SOURCE: EN 62504:2014, 3.19.5 modified by note 1, added]

3.15

integral LED module

LED module, generally designed to form a non-replaceable part of a luminaire

[SOURCE: EN 62504:2014, 3.19.3]

3.16**control gear for LED module****LED control gear**

unit inserted between the electrical supply and one or more LED modules which serves to supply the LED module(s) with its (their) rated voltage or rated current. The unit may consist of one or more separate components and may include means for dimming, correcting the power factor and suppressing radio interference, and further control functions

Note 1 to entry: The control gear consists of a power supply and a control unit.

Note 2 to entry: The control gear may be partly or totally integrated in the LED module.

Note 3 to entry: When no confusion is expected like used in a LED standard, “control gear” may also be used.

Note 4 to entry: Both terms “controlgear” or “control gear” are acceptable.

[SOURCE: EN 62504:2014, 3.6.1, modified, Note 4 to entry added]

3.17**LED light engine**

integrated assembly or set consisting of LED module(s) and LED control gear for direct connection to the electrical supply system

Note 1 to entry: A LED light engine typically shall have defined electrical, mechanical, thermal and control interfaces, and specific photometric properties.

Note 2 to entry: A LED light engine may incorporate a heat sink or not.

[SOURCE: CIE/DIS 024/E:2013, 3.13]

3.18**LED luminaire**

luminaire designed to incorporate one or more LED light source(s)

Note 1 to entry: The LED light sources(s) may be an integral part of a LED luminaire

[SOURCE: EN 62504:2014, 3.17 modified by note1, added]

3.19**LED device**

generic term to designate LED lamps, LED modules, LED light engines or LED luminaires for the purpose of this standard

3.20**beam angle**

the angle between two lines in a plane through the optical beam axis, such that these lines pass through the centre of the front face of the device and through points at which the luminous intensity is 50 % of the centre beam intensity, where the centre beam intensity is the value of luminous intensity measured on the optical beam axis

Note 1 to entry: Beam angle is expressed in degrees (°)

Note 2 to entry: This angle is a full angle measure, not a half angle measure.

Note 3 to entry: The optical beam axis is the axis about which the luminous intensity distribution is substantially symmetrical.

[SOURCE: EN 62504:2014, 3.4 modified by note 3, added]

3.21

tuneable LED devices

device with independent channels where the spectra of the emitted light can be deliberately modified

Note 1 to entry: This means chromaticity coordinates are changeable.

Note 2 to entry: For devices with independent channels and changeable chromaticity coordinates the colorimetric figures are usually determined for the gamut corners, for changeable correlated colour temperature devices the minimum and maximum correlated colour temperature and for any additional setup (defined by applicant).

3.22

type test

conformity test on one or more LED product(s) representative of the production

[SOURCE: EN 62504:2014, 3.41]

3.23

type test sample

one or more LED product(s) submitted by the manufacturer or responsible vendor for the purpose of the type test

[SOURCE: EN 62504:2014, 3.42]

3.24

applicant

the responsible person who commissions a test

Note 1 to entry: The applicant can be for example a manufacturer, responsible vendor, customer or regulator.

Note 2 to entry: The applicant will normally provide all information required to correctly perform the test.

3.25

device under test

DUT

LED device submitted for testing

Note 1 to entry: A DUT (device under test) is not a type test sample unless it is declared so.

3.26

supply voltage (for a LED device)

voltage applied to the complete unit of LED light source or LED luminaire

[SOURCE: EN 62504:2014, 3.37]

3.27

supply power (for a LED device)

electrical power consumed by the light source(s), control gear and any control circuit in the device which includes any parasitic power when the light source is turned on

3.28**rated value**

value of a quantity used for specification purposes under standard test conditions as declared by the manufacturer or responsible vendor

Note 1 to entry: The standard test conditions are given in the relevant standard.

[SOURCE: EN 62504:2014, 3.33]

3.29**initial values**

photometric and electrical characteristics measured at the end of the ageing period and stabilisation time

Note 1 to entry: Ageing period can be specified as zero.

[SOURCE: A_1 EN 62717:2017, 3.3 A_1]

3.30**ageing (for a LED source)**

preconditioning period of LED light source before initial values are taken

Note 1 to entry: In some documents the term seasoning is used.

[SOURCE: EN 62504:2014, 3.1 modified by note 1, added]

3.31**stabilisation time (for a LED device)**

time that is required for the LED light source or LED luminaire to obtain stable photometric output and electric power with constant electrical input

[SOURCE: EN 62504:2014, 3.35]

3.32**ambient temperature**

t_{amb}

temperature of air or another medium in the vicinity of the device under test

Note 1 to entry: Ambient temperature is expressed in degrees Celsius (°C).

[SOURCE: EN 62504:2014, 3.38.1 modified]

3.33**ambient performance temperature**

ambient temperature related to the performance of the LED light source or LED luminaire

Note 1 to entry: Ambient performance temperature is expressed in degrees Celsius (°C).

[SOURCE: EN 62504:2014, 3.38.2]

3.34

rated maximum temperature (of a component)

t_c

highest permissible safety related temperature which may occur on the outer surface of the component (LED module or control gear) (at the indicated position, if marked) under normal operating conditions and at the rated voltage/current/power or the maximum of the rated voltage/current/power range

Note 1 to entry: Rated maximum temperature is expressed in degrees Celsius (°C).

[SOURCE: EN 62504:2014, 3.38.9]

3.35

performance temperature (of a LED module)

t_p

temperature related to performance of the LED module

Note 1 to entry: Performance temperature is expressed in degrees Celsius (°C).

Note 2 to entry: Temperature is measured at a designated t_p -point.

[SOURCE: EN 62504:2014, 3.38.6]

3.36

t_p -point

the designated location of the point where to measure the performance temperatures t_p at the surface of the LED module

Note 1 to entry: The location of t_p and t_c can be different.

[SOURCE:  EN 62717:2017, 3.15 , modified by introduction of a note]

3.37

rated maximum performance temperature (of a LED module)

$t_{p,nn}$

highest temperature at t_p -point, related to a rated performance of the LED module, both as declared by the manufacturer or responsible vendor

Note 1 to entry: Rated maximum performance temperature is expressed in degrees Celsius (°C).

Note 2 to entry: For a given performance, the $t_{p,nn}$ temperature is a fixed value, not a variable, where nn, the number in the suffix indicates the related lifetime claim in khours, example: $t_{p,60}$ where nn = 60 represent 60 000 h lifetime claim.

Note 3 to entry: There can be more than one $t_{p,nn}$, depending on the performance claim.

Note 4 to entry: In some documents the symbol $t_{p,n}$, $t_{p, rated}$ or $t_{p max}$ is used instead of $t_{p,nn}$

[SOURCE: EN 62504:2014, 3.38.8 modified by note 4, added and omission of note 2]

3.38

rated maximum ambient performance temperature (of a luminaire)

$t_{q,nn}$

highest ambient temperature around the luminaire related to a rated performance of the luminaire under normal operating conditions, both as declared by the manufacturer or responsible vendor

Note 1 to entry: Rated maximum performance ambient temperature is expressed in degrees Celsius (°C).

Note 2 to entry: For a given life time, the $t_{q,nn}$ temperature is a fixed value, not a variable, where nn, the number in the suffix indicates the related lifetime claim in khours, example; $t_{q,60}$ where nn = 60 represent 60 000 h lifetime claim.

Note 3 to entry: There can be more than one $t_{q,nn}$ temperature, depending on the life time claim.

Note 4 to entry: In some documents the symbol $t_{q,n}$ or t_q , is used instead of $t_{q,nn}$

[SOURCE: EN 62504:2014, 3.38.7 modified by note 4, added]

3.39

luminous efficacy (of a source)

η_v, η

quotient obtained when the emitted luminous flux is divided by the power consumed by the source

Note 1 to entry: Luminous efficacy is expressed in $\text{lm} \cdot \text{W}^{-1}$

Note 2 to entry: For LED applications, the source may be a LED package, module, lamp, luminaire etc.

[SOURCE: EN 62504:2014, 3.26]

3.40

light output ratio (of a luminaire)

LOR

ratio of the total flux of the luminaire, measured under specified practical conditions with its own light sources and equipment, to the sum of the individual luminous fluxes of the same light sources when operated outside the luminaire with the same equipment, under specified conditions

Note 1 to entry: LOR may be determined for LED luminaires using interchangeable sources (e.g. LED lamps) in some cases. The use of LOR is disregarded for LED luminaires with non-replaceable LED light sources. For LED luminaires with non-replaceable LED light sources, only the total flux of the luminaire can be measured, in which case, LOR is 100 % as a consequence and not significant.

[SOURCE: IEC 845-09-39, modified by note 1, added]

3.41

total spectral radiant flux (of a light source)

spectral concentration of the geometrically-total (4π steradian) radiant flux Φ of a light source:

$$\Phi_\lambda(\lambda) = \frac{d\Phi}{d\lambda} \quad (1)$$

Note 1 to entry: Total spectral radiant flux is expressed in Watt per nanometre ($\text{W} \cdot \text{nm}^{-1}$).

3.42

partial luminous flux (of a light source, within a specified cone angle)

total luminous flux emitted from a light source within a specified cone angle α , determined from the luminous intensity distribution $I(\theta, \varphi)$ of the source:

$$\Phi_\alpha = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\alpha/2} I(\theta, \phi) \sin \theta \, d\theta \, d\phi \quad (2)$$

Note 1 to entry: Partial luminous flux is expressed in lumen (lm)

Note 2 to entry: $(\theta, \varphi) = (0,0)$ is the direction of the cone axis

Note 3 to entry: The cone angle α is the full angle (diameter) of the cone

Note 4 to entry: "Cone luminous flux" is also used in some applications in the same meaning.

Note 5 to entry: "Useful luminous flux" is also used in a similar meaning, but is determined with the cone axis that is coincident with the observed optical beam axis of the light source, the axis about which the luminous intensity is substantially symmetrical.

A1 3.43

useful luminous flux (for a light source)

$\Phi_{u,\alpha}$

part of the luminous flux of a light source which contributes predominantly to the lighting task

Note 1 to entry: For non-directional light sources the useful luminous flux is the total luminous flux of the source.

Note 2 to entry: For directional light sources the useful luminous flux is the partial luminous flux in a defined open cone, the axis of the cone being the optical beam axis of the light source, the axis about which the luminous intensity is substantially symmetrical. In general, a cone is defined by its solid angle expressed in steradian. It may also be described by the full opening angle or cone angle, α , expressed in degrees or radian, if the cone has a circular shape or by 2 full plain angles (the two planes coinciding with the major and minor axes) if elliptical. The cone angle value(s) has to be specified as a subscript of the useful luminous flux symbol e.g. $\Phi_{u,\pi/2}$ or $\Phi_{u,90^\circ}$.

Note 3 to entry: For the calculation of energy efficiency of directional light sources, Annex III, point 1.1 of regulation (EU) No 1194/2012 specifies to consider useful flux in 90° or 120° cones depending the product characteristics stated in the regulation itself. Symbol used: Φ_{use} .

Note 4 to entry: The useful luminous flux is expressed in lumen (lm). A1

3.44

absolute photometry

process for measuring photometric quantities directly in SI units

Note 1 to entry: This term is often used in goniophotometry of luminaires, in contrast with relative photometry A1 (see 3.45) A1.

Note 2 to entry: Absolute measurements require instruments calibrated for the appropriate SI units.

3.45

relative photometry

measurement obtained as a quotient of two photometric quantities

Note 1 to entry: This term is often used in goniophotometry of luminaires, where luminous intensity distribution is measured as relative values normalized by total luminous flux of the lamps used, and reported in the unit [cd/klm]

Note 2 to entry: This method is not applicable to LED light sources and LED luminaires with integrated LED light sources.

3.46

photometer head

combination of a detector and facilities for the spectral weighting of the detected radiation

Note 1 to entry: It may also contain facilities for directional evaluation of the light, e.g. diffusing windows, lenses, and apertures.

Note 2 to entry: In this document, a photometer head refers to an illuminance measuring unit containing a detector, a $V(\lambda)$ -correction filter, and any additional components (aperture, diffuser, amplifier, etc.) within the unit.

3.47

traceability

property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

Note 1 to entry: The International Laboratory Accreditation Cooperation (ILAC) considers the elements for confirming metrological traceability to be an unbroken metrological traceability chain to an international measurement standard or a national measurement standard, a documented measurement uncertainty, a documented measurement procedure, accredited technical competence, metrological traceability to the SI, and calibration intervals (see ILAC P10:01/2013).

Note 2 to entry: The expression “traceability to the SI” means ‘metrological traceability to a measurement unit of the International System of Units’.

[SOURCE: ISO/IEC Guide 99:2007, 2.41, modified] also [JCGM 200, 2.41, modified]

3.48

tolerance interval

interval of permissible values of a property

Note 1 to entry: Unless otherwise stated in a specification, the tolerance limits belong to the tolerance interval.

Note 2 to entry: The term ‘tolerance interval’ as used in conformity assessment has a different meaning from the same term as it is used in statistics.

[SOURCE: ISO/IEC Guide 98-4, 3.3.5]

3.49

acceptance interval

interval of permissible measured quantity values

Note 1 to entry: Unless otherwise stated in the specification, the acceptance limits belong to the acceptance interval.

[SOURCE: ISO/IEC Guide 98-4, 3.3.9]

4 Laboratory requirements

4.1 General

4.1.1 Standard Test Conditions

Measurements of the photometric, colorimetric and electrical characteristics of a LED device shall be performed by means of appropriate equipment and procedures under defined *standard test conditions* for operation of the DUT. A standard test condition includes a *set value* and a *tolerance interval*. Ideally an operating condition parameter of a DUT (e.g. test voltage) is set exactly to the set value. In real situations, the set values cannot be set exactly and there are some deviations, and therefore a tolerance interval for each set value is specified in this test method. If necessary, a correction of results is made to adjust at the set value. Measurement results are expressed for the set value of the standard test

conditions. Furthermore, test equipment shall fulfil *specific requirements*, often specified with a maximum or minimum value (or a range of values) of a performance characteristic of the instrument. The tolerance intervals and specific requirements are shown in *Italic font* in 4.2, 4.3, 4.4 and 4.5.

All measurements shall be traceable to the SI when instruments are used to measure absolute values of a quantity relevant to the measurement. The measurement reports shall include a statement of uncertainties of measurement (see Clause 8 for further details). All uncertainty values of instruments in Clause 4 are expressed in expanded uncertainty with a confidence interval of 95 % (typically with a coverage factor $k = 2$).

The test shall be performed with all test conditions within the tolerance intervals and all instruments meeting the specific requirements in 4.2, 4.3, 4.4 and 4.5. In this case the measurements are considered as complying with the standard conditions. To further reduce the uncertainty of measurements, the results may be corrected for the deviation within the tolerance interval, to conditions at the set value of the standard test condition. The set value is normally the centre value of the tolerance interval, though not always so.

In cases where some of the standard test conditions or requirements cannot be fulfilled, deviations outside the tolerance intervals or requirements are permitted if the related measurements are corrected to the standard test conditions. In such cases, the specific uncertainty component for the corrected parameter shall be evaluated and incorporated into the final uncertainty budget. The actual measurement condition and the fact that correction is made to the standard test condition for the parameter shall be reported in the test report.

In order to apply a correction, the sensitivity coefficients of the DUT shall be determined. The correction shall be applied only if the DUT is in steady conditions with respect to all the quantities involved for the correction parameter.

NOTE If a number of products of the same model are measured, the sensitivity coefficients measured for a DUT of that model or equivalent models may be used for correction of the other DUTs.

For the uncertainty budget, the main properties (and related sensitivity coefficients) of the DUT should be analysed. However, in practice, a detailed evaluation of all the properties of the DUT is not always possible or practical. Therefore, if there is no detailed information available, the sensitivity values for the DUT performance from Annex C may be used for evaluation of the measurement uncertainty, but these sensitivity values shall not be used for correction purposes.

The model of evaluation as the basis of the uncertainty budget and details of all correction factors used and uncertainty component evaluations made shall be kept by the laboratory and made available on demand.

Measurement equipment designs and configurations other than those explicitly described in this standard are acceptable if they are demonstrated to produce equivalent results.

Further details and examples for accounting for practical laboratory conditions are given in Annex A and guides to determining uncertainty are given in Clause 8 and Annex D.

4.1.2 Tolerance Interval

For each standard test condition, a tolerance interval for the related parameter is given for setting the operating conditions of the DUT. The measurement uncertainty of the related parameter shall be taken into account to ensure that the parameter is within the tolerance interval. For this purpose, an acceptance interval is defined as the tolerance interval reduced by the expanded uncertainty (95 % confidence) of the measurement of the parameter on both limits of the tolerance. The result of measurement of a DUT parameter shall lie within the acceptance interval. This is illustrated in Figure 1. The measurement uncertainty of the parameter includes the calibration uncertainty of the measurement instrument and additional contributions from the measurement conditions. See Annex A

for additional information and some examples on tolerance interval and acceptance interval. Further information on the concept of acceptance interval is given in ISO/IEC Guide 98-4.

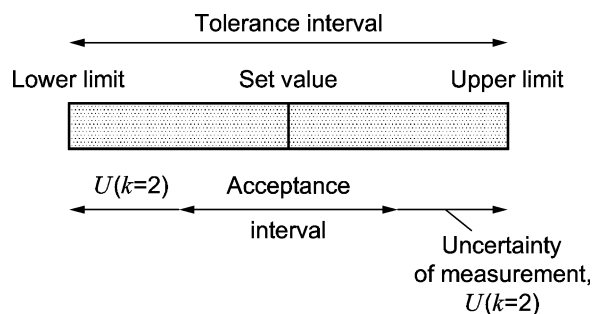


Figure 1 — Illustration of the tolerance interval and acceptance interval

4.2 Laboratory and Environmental Conditions

4.2.1 Test Room

Measurements shall be made in a room where environmental effects have negligible impacts on the measured quantities (e.g. smoke, dust, mist, vibrations).

Surroundings are arranged so that stray light is minimized and, if significant, the related error shall be corrected. More information is given in Annex B.

4.2.2 Ambient Temperature

The set ambient temperature t_{amb} shall be 25,0 °C for the measurements of LED lamps, LED light engines (designed for ambient temperature) and LED luminaires.

Tolerance interval: $\pm 1,2$ °C.

To fulfil this requirement, the result of the temperature measurement shall lie within the acceptance interval (see 4.1.2). For example, if the uncertainty of the temperature measurement is 0,2 °C, the acceptance interval will be $\pm 1,0$ °C. If the uncertainty is larger, the acceptance interval will be narrower.

The ambient temperature shall be measured at points representative of the near surrounding of the DUT. For an integrating sphere, the thermometer sensor should be inside the sphere and at the same height of the DUT, or at a close height (if the DUT is mounted at the top of the sphere in 2π geometry). The temperature measurement shall not be influenced by direct radiation from the DUT under test: the thermometer sensor shall be baffled to prevent the direct light reaching the sensor.

Room air conditioning and any heaters shall be arranged so that air flow and radiant heat does not directly hit either the DUT or the temperature sensor.

Care shall be taken to ensure that the thermometer and its housing do not interfere in the light measurement path.

NOTE Air temperature may be measured with a thermometer of any convenient and appropriate type (e.g. liquid-in-glass, thermocouple, and thermistor). Thermometers for this purpose are often enclosed in a metal housing polished on its outside surface so as to reflect radiation (but baffled, if necessary, to prevent reflected light reaching the detector).

Where a declared ambient air temperature other than 25,0 °C is specified for the DUT by the applicant (e.g. LED luminaire for a refrigerator show case), unless measurement is made at that temperature, measurement results at 25,0 °C are first reported, then a service conversion factor shall be established to allow converting the measured photometric value at 25,0 °C to that at the specified ambient temperature. This may be done by measuring the ratio of total luminous flux (or luminous intensity or

luminance in a fixed direction) of the device in a thermal chamber or a temperature-controlled measurement system (e.g. integrating sphere with air temperature control). This service conversion factor is reported separately.

4.2.3 Surface Temperature (t_p -Point Temperature)

For LED modules, except for light engines designed for ambient temperature, all measured quantities shall be reported for the rated performance temperature t_p .

Tolerance interval: $\pm 2,5\text{ }^{\circ}\text{C}$

To fulfil this requirement, the result of the temperature measurement shall lie within the acceptance interval (see 4.1.2). For example, if the uncertainty of the surface temperature measurement is $0,5\text{ }^{\circ}\text{C}$, the acceptance interval will be $\pm 2,0\text{ }^{\circ}\text{C}$. If the uncertainty is larger, the acceptance interval will be narrower.

NOTE 1 The calibration uncertainty of the thermometer may be quite small e.g. $0,2\text{ }^{\circ}\text{C}$, however the measurement of surface temperature adds additional components like thermal contact of the thermometer to the surface, resulting in measurement uncertainty up to $2,0\text{ }^{\circ}\text{C}$ in some cases.

NOTE 2 There can be more than one value of rated performance temperature t_p for a LED module depending on the associated rated lifetime claim.

Once the LED module is incorporated into a light engine or luminaire and its t_p -point is not accessible, the manufacturer or the applicant shall indicate a temperature monitoring point and the relationship between the temperature at this point and performance temperature (or deliver a special prepared DUT permitting access to t_p -point).

Care should be taken to ensure that the thermometer and its housing do not interfere in the light measurement path. Surface temperature measuring devices shall not influence the thermal behaviour of the DUT, while a good thermal contact between the DUT surface and thermometer is ensured.

4.2.4 Air Movement

Measurements shall be made in still air. (Set value: air velocity is zero.)

Tolerance interval: 0 m/s to $0,25\text{ m/s}$

To fulfil this requirement, the result of measurement shall lie within the acceptance interval (see 4.1.2). If the uncertainty of the air movement measurement is $0,05\text{ m/s}$, the acceptance interval will be 0 m/s to $0,20\text{ m/s}$. If the uncertainty is larger, the acceptance interval will be narrower.

NOTE 1 The movement of air around the DUT can change its effective operating temperature, and as a consequence the luminous flux value can also change. Such movement of air can be caused by draughts, air conditioning, motion of the device in the goniophotometer, or motion of the goniophotometer frame itself.

NOTE 2 The requirement above is considered satisfied in an integrating sphere when it is closed, unless the sphere has a fan-forced air temperature control in which case it will require characterization. However, closing an integrating sphere can cause a draught on a DUT, so it is sometimes necessary to wait a short time for the DUT to stabilize after closing a sphere.

NOTE 3 For LED devices highly sensitive to temperature variations a lower air velocity (e.g. less than $0,10\text{ m/s}$) may be necessary.

Air movement shall be measured in the vicinity of the device and shall ignore any effect of forced cooling or self-heating of the DUT.

In the case of a goniophotometer that moves the position of the light source during measurement, the movement speed shall be chosen adequately to meet the requirement stated above or an adequate correction shall be applied.

4.2.5 Operating Position

Specific requirement: The DUT shall remain in its designed operating condition throughout the stabilization and testing period.

NOTE This requirement is not applicable to LED modules whose temperature is set and maintained to performance temperature (see 5.3.1).

If this requirement is not met, the measurements shall be corrected to the performance in the designed operating position.

EXAMPLE: A photometric measurement can be corrected using an auxiliary photometer method that monitors the relative luminous intensity of the DUT in a fixed direction. In this method, the ratio of a reference value to the value measured by the auxiliary photometer during measurement in each different operating position serves as a measurement correction factor. The reference value is represented by the output of the auxiliary photometer measured after the stabilization procedure of the light source in the designed operating position. The relative position of the auxiliary photometer to the DUT is maintained constant during all measurements.

4.3 Electrical Test Conditions and Electrical Equipment

4.3.1 Test Voltage and Test Current

The set value is the rated supply voltage of the DUT, or rated supply current of the DUT (LED modules with DC current input), measured at the supply terminals of the DUT.

Tolerance interval: $\pm 0,4$ % for RMS (root mean square) AC voltage; $\pm 0,2$ % for DC voltage. For LED modules with DC current input, $\pm 0,2$ % for DC current.

To fulfil this requirement, the measurement result shall lie within the acceptance interval (see 4.1.2). If the uncertainty of the AC voltage measurement is 0,2 %, the acceptance interval will be $\pm 0,2$ %. Specific requirements on the calibration uncertainties of voltmeters and ammeters are specified in 4.3.2.

The test voltage shall be measured at the supply terminals of the DUT, not at the output terminals of power supply, to avoid errors due to voltage drop by the cables and connectors.

In case the rated supply voltage is specified in a range, the test voltage shall be chosen according to the appropriate IEC LED performance standard or regional specification.

NOTE The IEC LED performance standards generally relate to end-user devices which are connected to the mains power line or operated with constant voltage. For some LED modules, current control may apply instead.

4.3.2 Electrical Measurements

Measurements of AC/DC voltage, current and power shall be made with suitable measurement equipment.

Specific requirements: The calibration uncertainty of AC Voltmeters and ammeters shall be less than or equal to 0,2 %. The calibration uncertainty of DC Voltmeters and ammeters shall be less than or equal to 0,1 %.

Measurements of AC power shall be made with a suitable power meter or power analyser. The power meter shall have an appropriate bandwidth to cover the harmonic content of the electrical current.

Specific requirements: The calibration uncertainty of AC power meter or power analyser shall be less than or equal to 0,5 %. The bandwidth shall be at least 100 kHz. A lower bandwidth may be accepted (5 kHz or 30 kHz) if the absence of significant high frequency components (respectively above 5 kHz or 30 kHz) is demonstrated.

LED products may or may not show significant high frequencies components (>5 kHz) depending on the auxiliary apparatus (control gear, dimmer, etc.) used. For LED control gears generating significant high