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Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

CIE S 025/E:2015

International Standard

Test Method for LED Lamps, LED Luminaires and LED Modules

Méthode d'essai pour lampes à LED, luminaires à LED et modules à LED

Testmethode für LED-Lampen, LED-Leuchten und LED-Module

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Foreword

International Standards produced by the Commission Internationale de l'Eclairage are concise documents on aspects of light and lighting that require a unique definition. They are a primary source of internationally accepted and agreed data which can be taken, essentially unaltered, into universal standard systems.

This CIE International Standard has been prepared by Technical Committee TC 2-71 of Division 2 "Physical Measurement of Light and Radiation" of the Commission Internationale de l'Eclairage.

This standard was developed in collaboration with CEN/TC 169/WG 7, which developed EN 13032-4, to produce two technically-harmonized standards at CIE and CEN level.

The collaboration of CEN/TC 169 is acknowledged.

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Test Method for LED Lamps, LED Luminaires and LED Modules

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 "Lamps and related equipment".

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 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. This standard does not cover LED packages and products based on OLEDs (organic LEDs).

2 Normative References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application.¹ For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE S 017/E:2011. *ILV: International Lighting Vocabulary*

CIE DIS 024/E:2015. *Light Emitting Diodes (LEDs) and LED Assemblies – Terms and Definitions*

CIE 13.3:1995. *Method of Measuring and Specifying Colour Rendering of Light Sources*

CIE 15:2004. *Colorimetry, 3rd edition*

CIE 84-1989. *Measurement of Luminous Flux*

CIE 121-1996. *The Photometry and Goniophotometry of Luminaires*

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

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

¹ The referenced IEC/PAS documents are under process to become IEC standards. As soon as published, they will replace the IEC/PAS documents for the purpose of this standard.

ISO 11664-1:2007(E)/CIE S 014-1/E:2007. *Colorimetry — Part 1: CIE Standard Colorimetric Observers*

ISO 11664-2:2007(E)/CIE S 014-2/E:2006. *Colorimetry — Part 2: CIE Standard Illuminants*

ISO 11664-3:2012(E)/CIE S 014-3/E:2011. *Colorimetry — Part 3: CIE Tristimulus Values*

ISO/CIE 19476:2014(E). *Characterization of the Performance of Illuminance Meters and Luminance Meters*

ISO 23539:2005(E)/CIE S 010/E:2004. *Photometry – The CIE System of Physical Photometry*

IEC/TR 60725:2012 ed3.0 *Consideration of reference impedances and public supply network impedances for use in determining the disturbance characteristics of electrical equipment having a rated current ≤ 75 A per phase*

IEC/TR 61341 ed.2 (2010). *Method of measurement of centre beam intensity and beam angle(s) of reflector lamps*

IEC 62504 ed.1 (2014) *General lighting – Light emitting diode products and related equipment – Terms and definitions*

IEC 62612. *Self-ballasted LED-lamps for general lighting services — Performance requirements*

IEC/PAS 62717 ed1.0 (2011). *LED Modules for General Lighting – Performance requirements*

IEC/PAS 62722-1 ed1.0 (2011). *Luminaire performance – Part 1: General requirements*

IEC/PAS 62722-2-1 ed1.0 (2011). *Luminaire performance – Part 2-1: Particular requirements for LED luminaires*

ISO/IEC Guide 98-3:2008. *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*, also JCGM 100:2008

ISO/IEC Guide 98-4: 2012. *Uncertainty of measurement- Part 4: Role of measurement uncertainty in conformity assessment*, also JCGM 106:2012

ISO/IEC Guide 99:2007. *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*, also JCGM 200:2008

ILAC P10:01/2013. *ILAC Policy on the Traceability of Measurement Results*

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in CIE S 017/E:2011, CIE DIS 024/E:2015 (partly repeated in this document) and the following apply.

3.1

electric light source

primary light source that transforms electrical energy into optical radiation

[SOURCE: CIE DIS 024/E:2015, 3.3]

3.2

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: The optical emission may be in the ultraviolet, visible, or infrared wavelength regions.

Note 2 to entry: “LED” normally represents the LED die (or chip) or LED package. It is also used as a generic term representing the technology.

[SOURCE: CIE DIS 024/E:2015, 3.14]

3.3

LED package

single discrete component encapsulating one or more LED die(s), possibly with optical elements and thermal, mechanical, and electrical interfaces

Note 1 to entry: The LED package is the most basic practical form of an LED device that, analogous to transistor or IC components, integrates one or more semiconductor die(s) in a single package and includes electrical, mechanical and thermal interfaces and possibly additional optical elements and/or a light converter (phosphor).

Note 2 to entry: The generic term “LED” typically refers to a packaged LED.

[SOURCE: CIE DIS 024/E:2015, 3.13]

3.4

LED light source

electric light source based on LED technology

Note 1 to entry: An LED light source may take the form of an LED package, LED module, LED light engine or LED lamp.

[SOURCE: CIE DIS 024/E:2015, 3.10]

3.5

LED lamp

LED light source incorporating one or more LED package(s) or LED module(s) and provided with one or more cap(s)

Note 1 to entry: An LED lamp may include other optical, thermal, mechanical and electrical components.

Note 2 to entry: An LED lamp may be integrated (LEDi lamp) or semi-integrated (LEDsi lamp) or non-integrated (LEDni lamp).

Note 3 to entry: Single- and double-capped lamps are included.

Note 4 to entry: An LED lamp is designed to be replaced by a layman.

Note 5 to entry: The term is defined differently in IEC 62504 Ed. 1:2014 (3.15), but the definitions are consistent.

[SOURCE: CIE DIS 024/E:2015, 3.8]

3.6

integrated LED lamp

LEDi lamp

LED lamp, incorporating LED 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 as equivalent term.

[SOURCE: IEC 62504:2014, 3.15.1, modified — “controlgear” is changed to “LED control gear”, Note 1 to entry added.]

3.7

semi-integrated LED lamp

LEDsi lamp

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

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

[SOURCE: IEC 62504:2014, 3.15.4, modified — “controlgear” is changed to “LED control gear”, Note 1 to entry added.]

3.8

non-integrated LED lamp

LEDni lamp

LED lamp which needs a separate LED control gear to operate

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

[SOURCE: IEC 62504:2014, 3.15.2, modified — “controlgear” is changed to “LED control gear”, Note 1 to entry added.]

3.9

LED module

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

Note 1 to entry: An 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 an LED lamp or LED luminaire.

[SOURCE: CIE DIS 024/E:2015, 3.12, modified — Note 1 to entry and Note 2 to entry added.]

3.10

integrated LED module

LEDi module

LED module, incorporating LED 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 used as equivalent term.

[SOURCE: IEC 62504:2014, 3.19.4, modified — “controlgear” changed to “LED control gear”, Note 1 to entry modified.]

3.11

semi-integrated LED module

LEDsi module

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

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

[SOURCE: IEC 62504:2014, 3.19.6, modified — “controlgear” is changed to “LED control gear”, Note 1 to entry modified.]

3.12

non-integrated LED module

LEDni module

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

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

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

[SOURCE: IEC 62504:2014, 3.19.5, modified — “controlgear” is changed to “LED control gear”, Note 1 to entry modified.]

3.13

LED control gear

unit inserted between the electrical supply system and one or more LED packages or LED modules which serves to supply the LED package(s) or LED module(s) with its (their) rated voltage or rated current

Note 1 to entry: The unit may consist of one or more separate component(s) and may include means for dimming, correcting the power factor and suppressing radio interference, and further control functions.

Note 2 to entry: An LED control gear consists of a power supply and a control unit and may be partly or totally integrated in the LED module or LED lamp.

Note 3 to entry: The term “controlgear for LED module” is used in IEC documents with a similar definition.

Note 4 to entry: The term “LED driver” is not recognized as an international term to designate a “LED control gear”.

[SOURCE: CIE DIS 024/E:2015, 3.5]

3.14

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: An LED light engine typically shall have defined electrical, mechanical, thermal and control interfaces, and specific photometric properties.

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

[SOURCE: CIE DIS 024/E:2015, 3.9]

3.15

LED luminaire

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

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

[SOURCE: CIE DIS 024/E:2015, 3.11]

3.16

LED device

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

3.17

beam angle

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: IEC 62504:2014, 3.4, modified — “two imaginary lines” changed to “two lines”, “, where the centre beam intensity is the value of luminous intensity measured on the optical beam axis” added, Note 3 to entry added.]

3.18

type test

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

[SOURCE: IEC 62504:2014, 3.41]

3.19

applicant

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.

3.20

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.

3.21

supply voltage <for an LED device>

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

[SOURCE: IEC 62504:2014, 3.37, modified — “<for an LED device>” added to specify the field of application of the term.]

3.22

rated value

value of a quantity used for specification purposes, established 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: IEC 62504:2014, 3.33]

3.23

ageing <for an LED source>

preconditioning period of the LED light source before initial values are taken

Note 1 to entry: In some documents the term “seasoning” is used as equivalent term.

Note 2 to entry: Initial values are the photometric and electrical characteristics measured at the end of the ageing period and stabilization time.

[SOURCE: IEC 62504:2014, 3.1, modified — “<for an LED source>” added to specify the field of application of the term, Notes 1 and 2 to entry added.]

3.24

stabilisation time <for an LED device>

stabilization time

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

[SOURCE: IEC 62504:2014, 3.35, modified — term “stabilization time” added, “<for an LED device>” added to specify the field of application of the term.]

3.25

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: IEC 62504:2014, 3.38.1, modified — “product” changed to “device”, Note 2 to entry omitted.]

3.26

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 LED 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: IEC 62504:2014, 3.38.9, modified — “<of a component>” added to specify the field of application of the term, “controlgear” is changed to “LED control gear”.]

3.27

performance temperature <of an 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: The performance temperature is measured at the designated t_{p} -point.

[SOURCE: IEC 62504:2014, 3.38.6, modified — “<of an LED module>” added to specify the field of application of the term.]

3.28

t_{p} -point

designated location of the point on the surface of the LED module where the performance temperatures t_{p} are measured

Note 1 to entry: The location of the performance temperature t_{p} and the rated maximum temperature t_{c} can be different.

[SOURCE: IEC/PAS 62717:2011, 3.16, modified — Note 1 to entry added.]

3.29

rated maximum performance temperature <of an LED module>

$t_{\text{p}, \text{n}}$

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 rated maximum performance temperature $t_{p,n}$ is a fixed value, not a variable, where n , the number in the subscript, indicates the related lifetime claim in kilohours. Example: $t_{p,60}$ where $n = 60$ represents 60 000 h lifetime claim.

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

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

[SOURCE: IEC 62504:2014, 3.38.8, modified — “<of an LED module>” added to specify the field of application of the term, symbol changed from $t_{p, nm}$ to $t_{p,n}$, Notes 2 and 3 to entry modified and Note 4 to entry added.]

3.30

rated maximum performance ambient temperature <of a luminaire>

$t_{q,n}$

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 lifetime, the rated maximum performance ambient temperature $t_{q,n}$ is a fixed value, not a variable, where n , the number in the subscript, indicates the related lifetime claim in kilohours. Example: $t_{q,60}$ where $n = 60$ represents 60 000 h lifetime claim.

Note 3 to entry: There can be more than one rated maximum performance ambient temperature $t_{q,n}$, depending on the lifetime claim.

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

[SOURCE: IEC 62504:2014, 3.38.7, modified — “<of a luminaire>” added to specify the field of application of the term, symbol changed from $t_{q, nm}$ to $t_{q,n}$, Notes 2 and 3 to entry modified and Note 4 to entry added.]

3.31

light output ratio <of a luminaire>

LOR

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

Note 1 to entry: Equivalent term used in the US: “luminaire efficiency”.

Note 2 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: CIE S 017/E:2011 ILV, 17-668, IEV 845-09-39, modified — Note 2 to entry added.]

3.32

total spectral radiant flux <of a light source>

spectral concentration of the geometrically-total (4π sr) 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 ($\text{W} \cdot \text{nm}^{-1}$).

3.33**partial luminous flux** <of a light source, within a specified cone angle>

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:

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

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 the observed optical beam axis of the light source, the axis about which the luminous intensity is substantially symmetrical.

3.34**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 (see 3.35). Luminous intensity distribution is measured and reported in absolute values in candela.

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

3.35**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.

3.36**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.

3.37**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]

3.38

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]

3.39

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 for Tests

4.1 General

4.1.1 Standard Test Conditions

Measurements of the photometric, colorimetric and electrical characteristics of an 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.

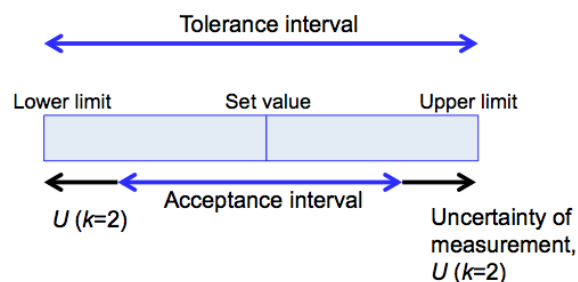


Figure 1 – Illustration of the tolerance interval and acceptance interval

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: $\pm 2,5$ °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 °C, the acceptance interval will be $\pm 2,0$ °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 °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 °C in some cases.