Overview of Lighting Standards

Steve Coyne
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International Standards Bodies: Relevant to Lighting

International Organisation for Standardisation

International Commission on Illumination

International Electrotechnical Commission

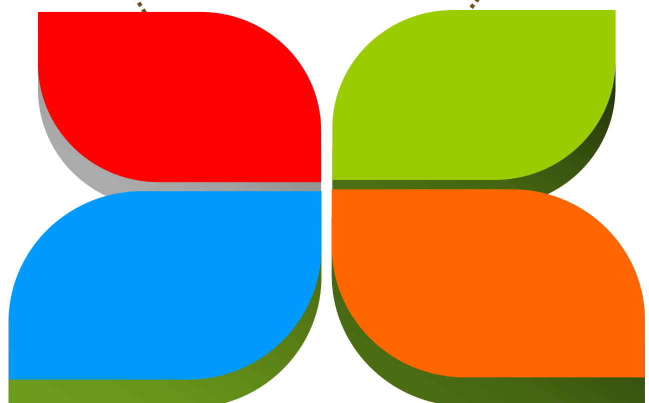
General classification of lighting standards and relevant standards bodies for lighting products

Product safety standard

IEC

Test method standard

CIE



Technical performance requirements

IEC

Energy efficiency regulation

Gov't

U4E United for Efficiency

Other Regional Bodies:
Relevant to Lighting Standards

Regional Organisations

Institute of Electrical and Electronics Engineers

European Commission

Illuminating Engineering Society of North America

Lighting Standards Types and relevant standards bodies

Product and connector form and dimensions….

Product safety requirements

- Electrical…………………………………………………
- Mechanical……………………………………………….
- Photobiological………………………………………
- Flicker & stroboscopic effects……

Lighting Standards Types

Product performance requirements

- Photometric.. IEC
- Electrical .... IEC
- Lifetime .... IEC
- Emissions .... IEC
- Energy Efficiency ....Gov't

U4E UN environment United for Efficiency

Lighting Standards Types

Product Test methods ....

Lighting application design requirements...

Lighting design methods...........................

Lighting audit methodologies....................

Questions

8

Overview of Two Specific Standards

Functional Performance Standard

IEC 62612 - Self-ballasted LED lamps for general lighting services with supply voltages > 50 V – Performance requirements

Test Procedure Standard

CIE S 025 - Test Method for LED Lamps, LED Luminaires and LED Modules

IEC 62612 - Self-ballasted LED lamps for general lighting services with supply voltages > 50 V – Performance requirements

General Requirements of self-ballasted LED lamps:

- Comply with safety standard IEC 62560
- Operate satisfactorily at:
    - voltages between 92 % and 106 % of rated supply voltage
    - Ambient air temperature between –20 °C and 40 °C

Measurements shall be made in a draught-free room at a temperature of 25 °C with a tolerance of ±1 °C, a relative humidity of 65 % maximum and steady state operation of the LED lamp.

Performance Requirements – Lamp Input

Lamp Power

The initial power consumed by each individual LED lamp in the measured sample shall not exceed the *rated power* by more than 10 %.

The average of initial power consumed by the LED lamps in the measured sample shall not exceed the *rated power* by more than 7.5 %.

Displacement factor

The measured displacement factor for each individual lamp of the sample shall not be less than the *marked value* by more than 0.05.

Performance Requirements – Light Output

Luminous Flux

For directional lamps the luminous flux (known as useful luminous flux) shall be measured in a solid angle of 90° (0,6 π sr or where the beam angle is greater than 90°, be measured in a solid angle of 120° (π sr).

Directional lamp is defined as having at least 80 % luminous flux within a solid angle of π sr (corresponding to a cone with angle of 120°)

The initial luminous flux of each individual LED lamp shall not be less than the *rated luminous flux* by more than 10 %.

The average initial luminous flux of the LED lamps shall not be less than the *rated luminous flux* by more than 7.5 %.

Measurement method references CIE 84, IES LM 79 (CIE S 025 published later)

Efficacy

The LED lamp efficacy shall not be less than 80 % of the *rated LED lamp efficacy* as declared by the manufacturer or responsible vendor

Performance Requirements – Light Output

Luminous intensity distribution

Shall be in accordance with that declared by the manufacturer. (no compliance test)

Measured in accordance with CIE 121 and IEC/TR 61341

Peak intensity value

(Where provided) The initial peak intensity of each individual LED lamp shall not be less than 75 % of the *rated intensity*

Measured in accordance with IEC/TR 61341

Beam angle value

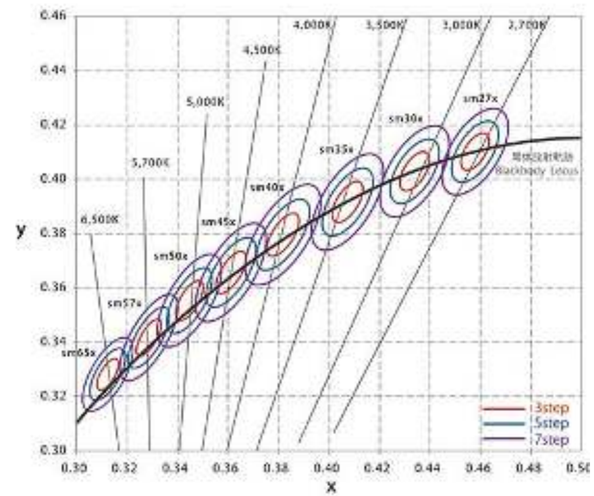
(Where provided) the initial beam angle value of each individual LED shall not deviate by more than 25 % of the *rated value*

Measured in accordance with IEC/TR 61341

Performance Requirements – Colour nomenclature, variation and rendering

Colour variation categories

The measured chromaticity co-ordinate values of an LED lamp (the initial value and maintained value) shall not move beyond the chromaticity coordinate tolerance category (3, 5, 7, >7 step MacAdam ellipse) as indicated by the manufacturer or responsible vendor



Colour rendering index (CRI)

For each individual LED lamp the measured CRI values shall not decrease by more than:

- 3 points from the *rated CRI* value (see Table 1) for initial CRI values, and
- 5 points from the *rated CRI* value (see Table 1) for maintained CRI values.

Measured and determined in accordance to CIE 13.3 and CIE 177

Performance Requirements – Lamp Life

Lumen maintenance

The measured luminous flux value at 25 % of rated life (with a maximum duration of 6 000 h) shall never be less than the luminous flux pertaining to the maximum lumen maintenance value related to the rated life as defined and provided by the manufacturer or responsible vendor.

The calculated lumen maintenance shall correspond with the lumen maintenance code as defined and provided by the manufacturer or vendor.

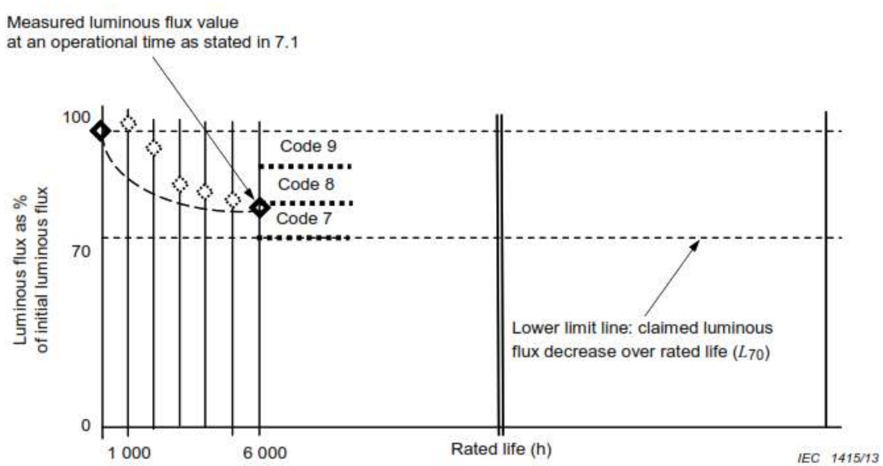


Figure 1 – Luminous flux depreciation over test time

Lumen maintenance (%)	Code
≥ 90	9
≥ 80	8
≥ 70	7

Performance Requirements – Lamp Life

Endurance tests

Temperature cycling test

Test chamber temperature is varied from –10 °C to +40 °C over a 4 h period and for a test duration of 250 periods (1 000 h).

At the end of the test all the LED lamps shall operate and have a luminous flux which stays within the claimed lumen maintenance code for a period of at least 15 min and show no physical effects of temperature cycling such as cracks or delaminating of the label.

Performance Requirements – Lamp Life

Endurance tests

Supply switching test

At test voltage, the lamp shall be switched on and off for 30 s each. The cycling shall be repeated for a number equal to half the rated life in hours (example: 10 k cycles if rated life is 20 000 h.).

At the end of the test all the LED lamps shall operate and have a luminous flux which stays within the claimed lumen maintenance code for a period of at least 15 min.

Performance Requirements – Lamp Life

Endurance tests

Accelerated operational life test

The LED lamp shall be operated continuously without switching at a test voltage and at a temperature corresponding to 10 K above the maximum specified operating temperature, if declared by the manufacturer (otherwise: 50 °C) and over an operational time of 1 000 h.

At the end of this test, and after cooling down to room temperature and being stabilised, all the lamps shall have an allowed decrease of light output of maximum 20 % compared to the initial value for at least 15 min.

Questions

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19

CIE S 025 - Test Method for LED Lamps, LED Luminaires and LED Modules

What it Covers

Products covered:

- LED lamps
- LED luminaires
- LED modules

Products not covered:

- LED packages
- OLED products

21

Measurements it Covers

- Total luminous flux
- Partial luminous flux (useful lumens)
- Centre beam and beam angles
- Electrical measurements
- Luminous efficacy (efficiency)
- Luminous intensity distribution
- Chromaticity coordinates
- Correlated colour temperature
- Distance from Planckian locus
- Colour rendering indices
- Angular colour uniformity

22

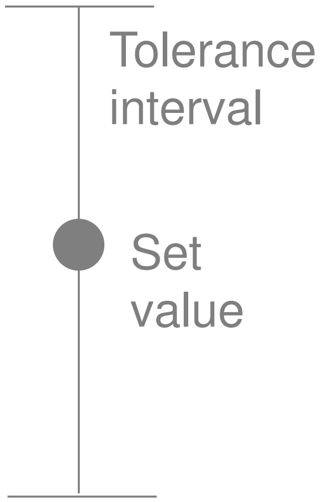
Standard test conditions and tolerance interval

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 (Device Under Test). A standard test condition includes a ***set value*** and a ***tolerance interval***.

Measurement results are expressed for the set value of the standard test conditions.



23

Standard Test Conditions

(For operation of DUT)

- Ambient temperature (LED lamps, luminaires): 25 °C ± 1.2 °C
- Surface temperature (LED module): specified t_p ± 2.5 °C
- Air movement: 0 to 0.25 m/s
- Test voltage: rated supply voltage ± 0.4 %

Set value ± tolerance interval

24

Need to Consider

What is the uncertainty of your instrument (eg: thermometer, anemometer)?

How does the uncertainty affect the tolerance interval?

4.1.2 Tolerance Interval

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.

25

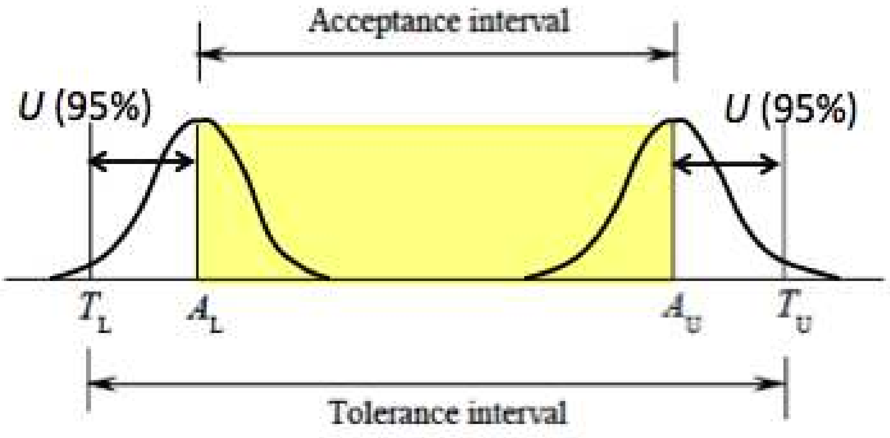
Tolerance Interval and Acceptance Interval

Annex A

Tolerance Interval

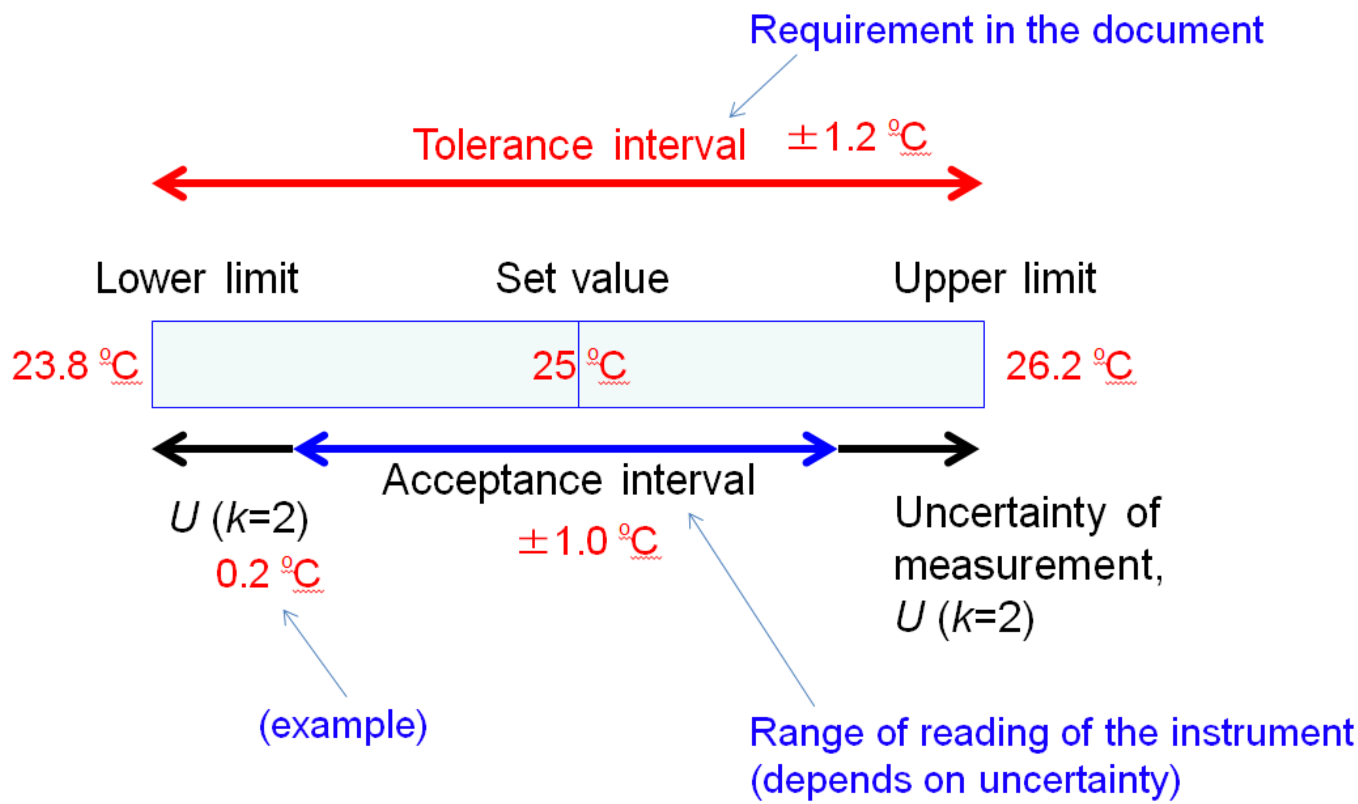
"*tolerance interval*" defined in ISO/IEC Guide 98-4 Role of measurement uncertainty in conformity assessment.

Tolerance interval is an acceptable range of the true value of the parameter (not the range of readings of instrument). Therefore, to ensure this requirement is fulfilled, measurement uncertainty of the parameter needs to be taken into account.



Tolerance Interval and Acceptance Interval

Example: Ambient temperature 25 ℃ ±1.2 ℃



27

Examples of Acceptance Intervals

(example values only)

	Tolerance Interval	Instrument uncertainty (k=2)	Acceptance interval
Ambient temperature	± 1.2 °C	0.2 °C 0.5 °C	± 1.0 °C ± 0.7 °C
Surface temperature (LED module)	± 2.5 °C	0.5 °C	± 2.0 °C
Air movement speed	± 0.25 m/s	0.05 m/s	± 0.20 m/s
Supply voltage (AC)	± 0.4 %	0.2 %	± 0.2 %
(DC)	± 0.2 %	0.1 %	± 0.1 %

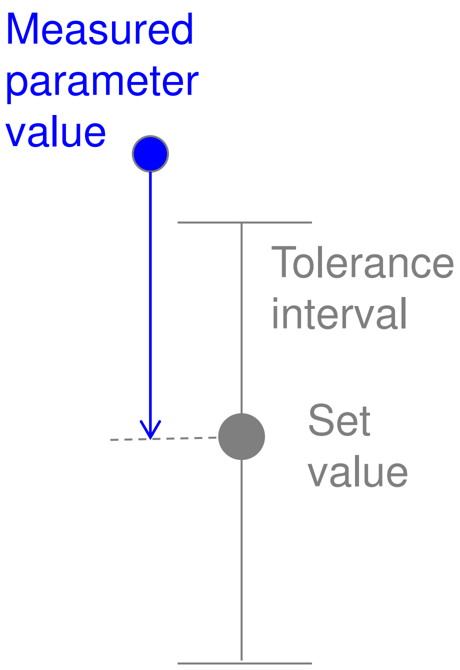
- There are no requirements for the instrument uncertainties
- The larger the uncertainty, the smaller the acceptance interval

28

Outside the Tolerance Interval

4.1 General
4.1.1 Standard Test Conditions

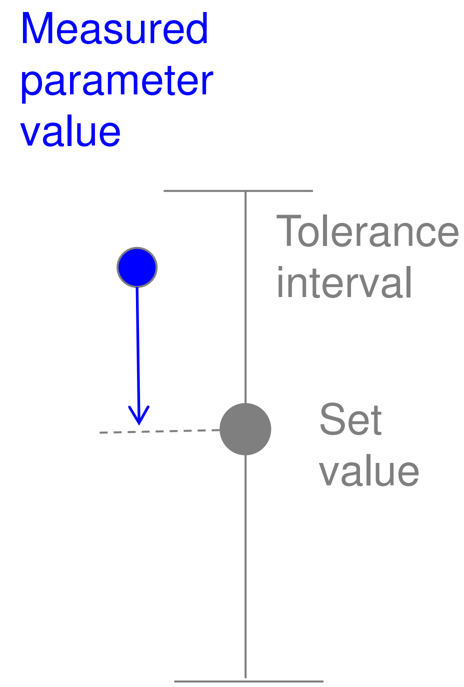
In case where some of the standard test conditions or requirements cannot be fulfilled, deviations outside the tolerance intervals or requirements are permitted if the related measurements are corrected to the standard test conditions. In such cases, the specific uncertainty component for the corrected 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.



Correction to the Standard Condition

4.1 General
4.1.1 Standard Test Conditions

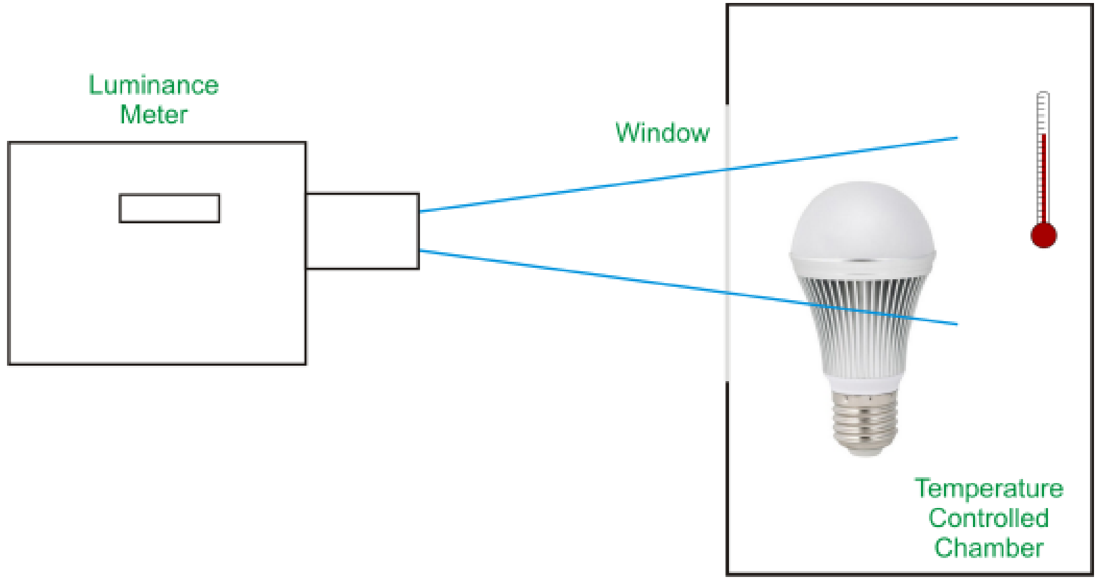
(Even if the tolerance is met) To further reduce the uncertainty of measurements, the results may be corrected for the deviation within the tolerance interval, to conditions at the set value of the standard test condition. The set value is normally the centre value of the tolerance interval, though not always so.



Direct Correction of the Measurement Result

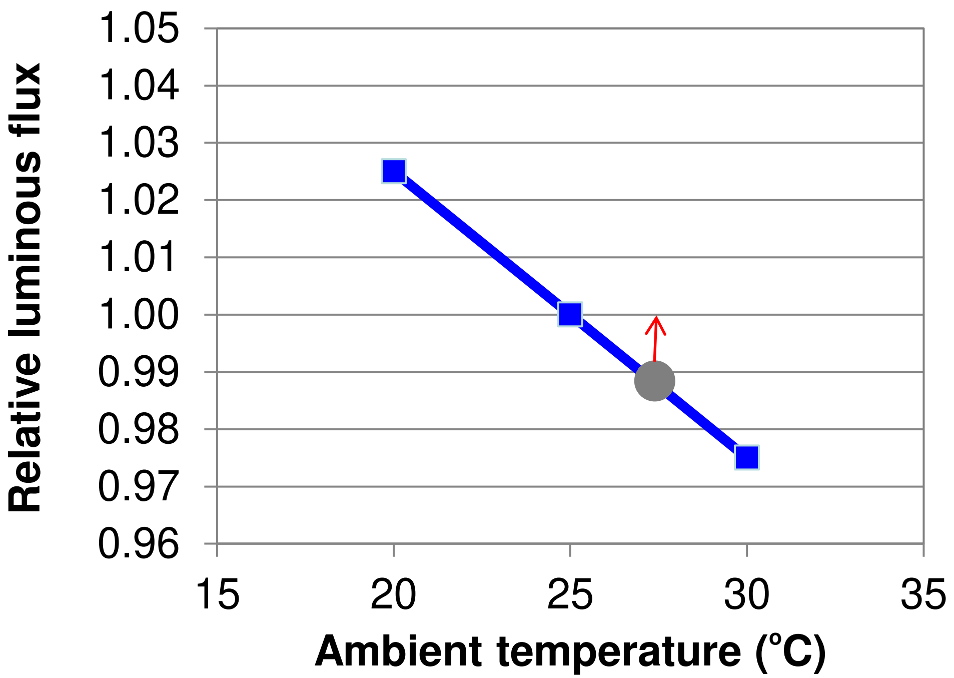
Example: In a goniophotometric measurement, room temperature = 27.3 ^{o}C

Use a temperature controlled chamber and a luminance meter to make a correction factor to correct the measured result to what it would be at 25.0 ^{o}C



31

Correction Using Sensitivity Coefficient



Slope of graph is the Sensitivity coefficient
= -0.5% / °C

T_A Set value = 25.0 °C

T_A Measured value = 27.3 °C

Measured luminous flux, Φ (27.3 °C) = 1243 lm

Corrected luminous flux: Φ (25.0 °C) = 1257 lm $= \frac{1243\ lm}{\left[\frac{(1-0.005)}{°C} \times -2.3°C\right]}$

32

Operating conditions for device under test

Temperature Conditions for Operation of DUT
LED lamps are measured in standard test conditions and data shall be reported for t_{amb} = 25 °C.

Air Movement
Measurements shall be made in still air. (Set value: air velocity is zero). Tolerance interval: 0 m/s to 0.25 m/s

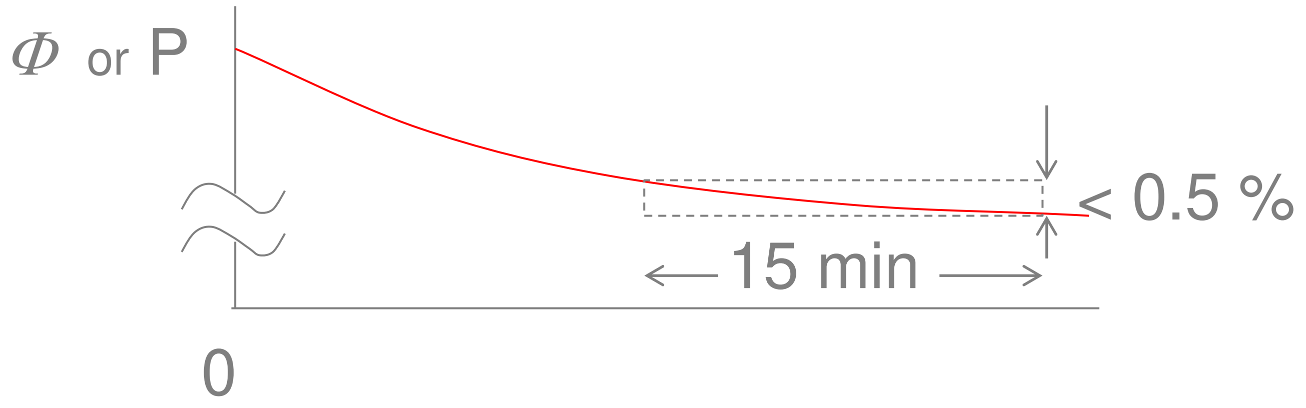
Operating Position
Specific requirement: The DUT shall remain in its designed operating condition (with respect to gravity direction) throughout the stabilization and testing period.

33

Stabilization of Device Under Test (DUT)

LED Lamps and LED Luminaires

The DUT shall be operated (at ambient temperature 25 °C) for at least 30 min and it is considered as stable if the relative difference of maximum and minimum readings of light output and electrical power observed over the last 15 minutes is less than 0.5 % of the minimum reading.



Laboratory Requirements for Tests

All measurements shall be traceable to the SI* when instruments are used to measure absolute values of a quantity relevant to the measurement.

3.37
traceability
property of a measurement result whereby the result can be related to a reference (usually NMI's calibration) through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

* Note: SI is an abbreviation for Système International d'Unités (International System of Units) is defined by the CGPM (General Conference of Weights and Measure) and includes the units used internationally today.

35

Electrical Test Conditions and Electrical Equipment

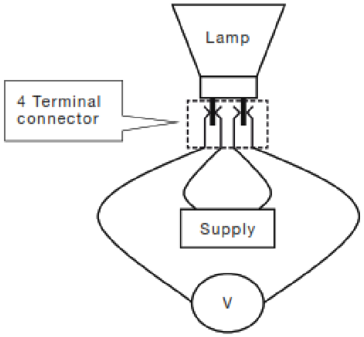
Specific requirements (summary)

- *Calibration uncertainty of AC Voltmeters and ammeters*
  - for AC: ≤ 0.2 %
  - for DC: ≤ 0.1 %
- *Calibration uncertainty of AC power meter:* ≤ 0.5 %
- *Bandwidth of AC power meter:* *≥ 100 kHz.*
- *Internal impedance of the voltage measurement:* ≥ 1 MΩ
- AC power supply THD at DUT terminal: ≤ 1.5%
  - for PF > 0.9: ≤ 3 %
- AC power supply frequency uncertainty: ≤ 0.2 %
- DC power supply voltage AC ripple: ≤ 0.5 %

U4E UN environment United for Efficiency

Electrical Test Conditions and Electrical Equipment

The voltage of the AC power supply shall be regulated (tested) at the supply terminals of the DUT. (not at the output terminal of power supply. Cables included).



Specific requirement: Any drift or fluctuation of the supply voltage during measurement of a DUT shall be within the acceptance interval of the test voltage.

37

Luminous Flux Measurement - 2 methods

Goniometer

- Expensive
- Slow
- Suitable for directional and non directional lamps

Integrating Sphere

- Inexpensive
- Fast
- Suitable mainly for non directional lamps

Detector forms:

- Photometer
- Colorimeter
- Spectroradiometer

Photometric and Colorimetric Measurement Instruments

Specific requirements (summary)

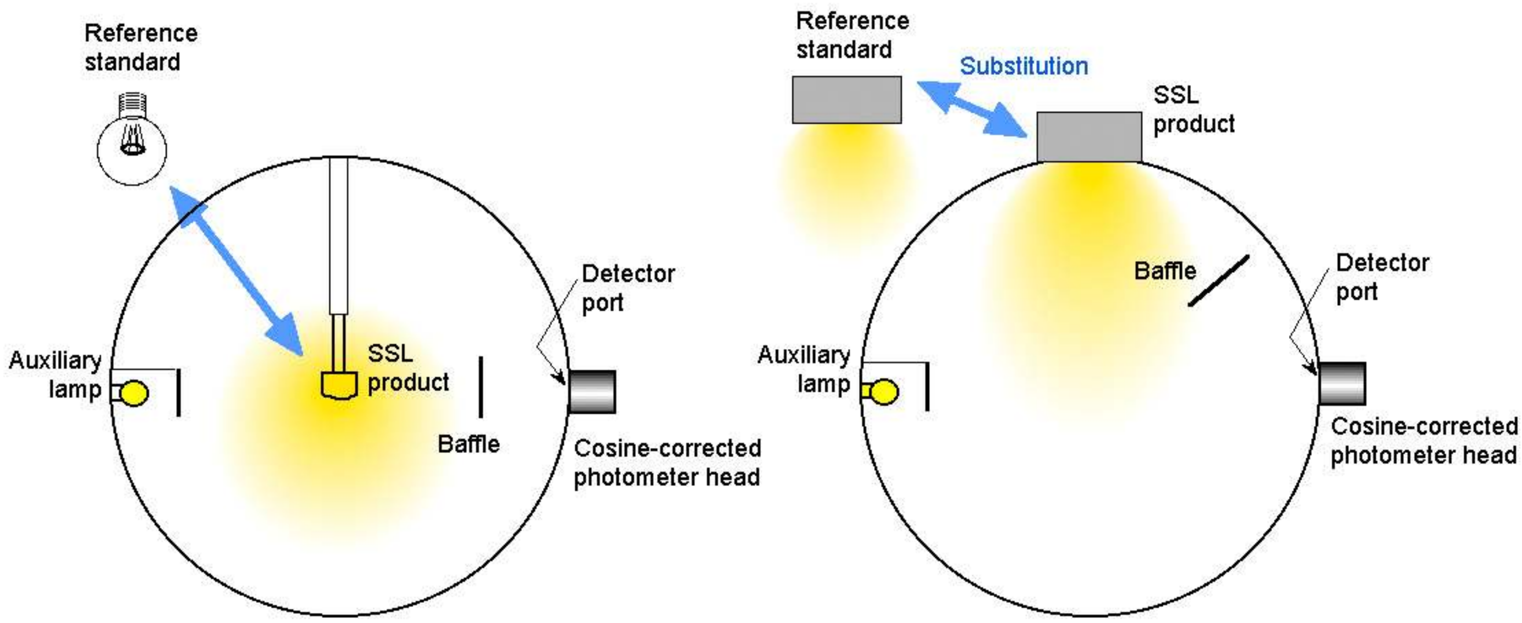
▪ f_1’ or V(λ) mismatch, of the photometer system (gonio, sphere):	≤ 3 %
▪ f_2 or cosine response, of the detector head of sphere system:	≤ 15 %
▪ Repeatability of sphere (open/close):	≤ 0.5 %
▪ Stability of the sphere between recalibrations:	≤ 0.5 %
▪ Spectroradiometer bandwidth and interval:	≤ 5 nm
▪ Spectroradiometer wavelength uncertainty:	≤ 0.5nm
▪ Angle uncertainty of goniophotometers:	≤ 0.5 °

See ISO/CIE 19476:2014 “Characterization of the performance of illuminance meters and luminance meters” for more details

39

Integrating Sphere Measurements

Covers both 4π and 2π integrating sphere systems



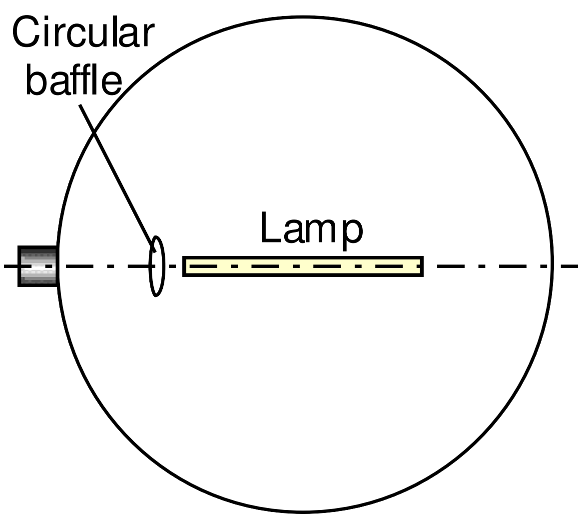
<4 π geometry> <2 π geometry>

Source: IES LM-79

40

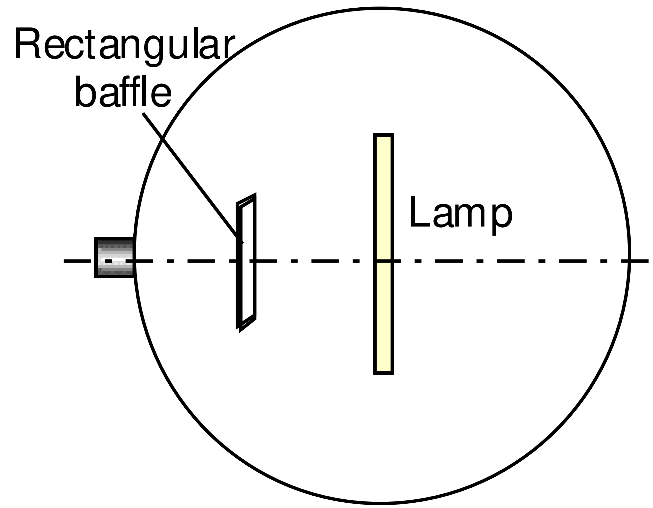
Mounting a tubular lamp in a sphere

When a linear shaped DUT is mounted in the centre of the sphere (4π geometry), its long axis should coincide with the line between the detector head and the centre of the sphere so that the size of the baffle can be minimized.



(a) Coaxial arrangement

Recommended



(b) Perpendicular arrangement

Not preferred

Sphere coating reflectance

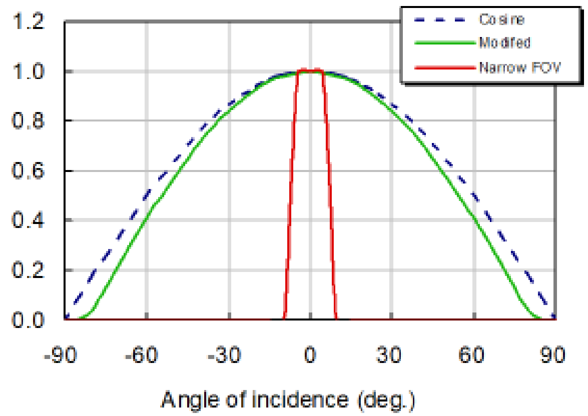
The internal coating of the integrating sphere shall be diffuse, high-reflectance, non-spectrally selective and should not show fluorescence. Coating reflectances > 90 % are recommended for sphere-spectroradiometer systems.

The light source holder and auxiliary equipment in the sphere should have the smallest dimensions possible. All baffles inside the sphere as well as supporting structures for the DUT are coated with the coating having highest diffuse reflectance possible.

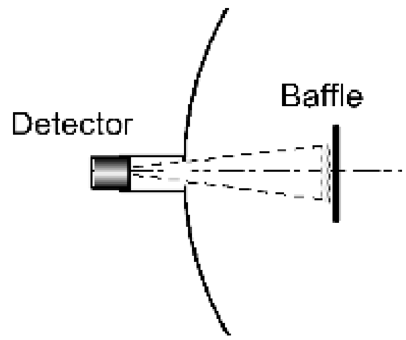
Cosine-correction for sphere detector

The detector port's entrance optics shall be cosine corrected. It is normally achieved by using a diffuser or a satellite integrating sphere at the entrance port.

Specific requirement: The photometer head or the spectroradiometer entrance port of an integrating sphere shall have a cosine correction with a value f_2 of 15 % or less.



Modified angular responsivity

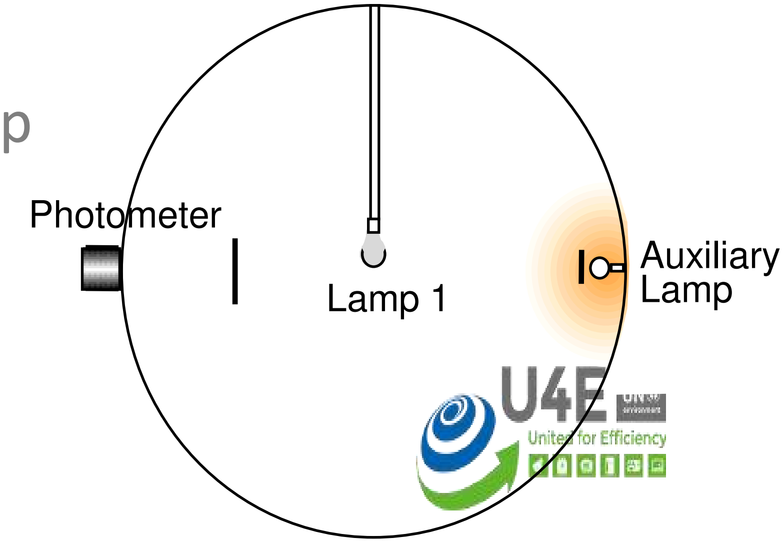


Repeatability of open/close of integrating sphere

The integrating sphere system shall have sufficient mechanical repeatability so that the sphere responsivity is kept constant when DUT measurements are conducted with opening and closing of the sphere.

Specific requirement: The repeatability of the sphere for opening and closing shall be within ±0,5 % and taken into account in the uncertainty budget.

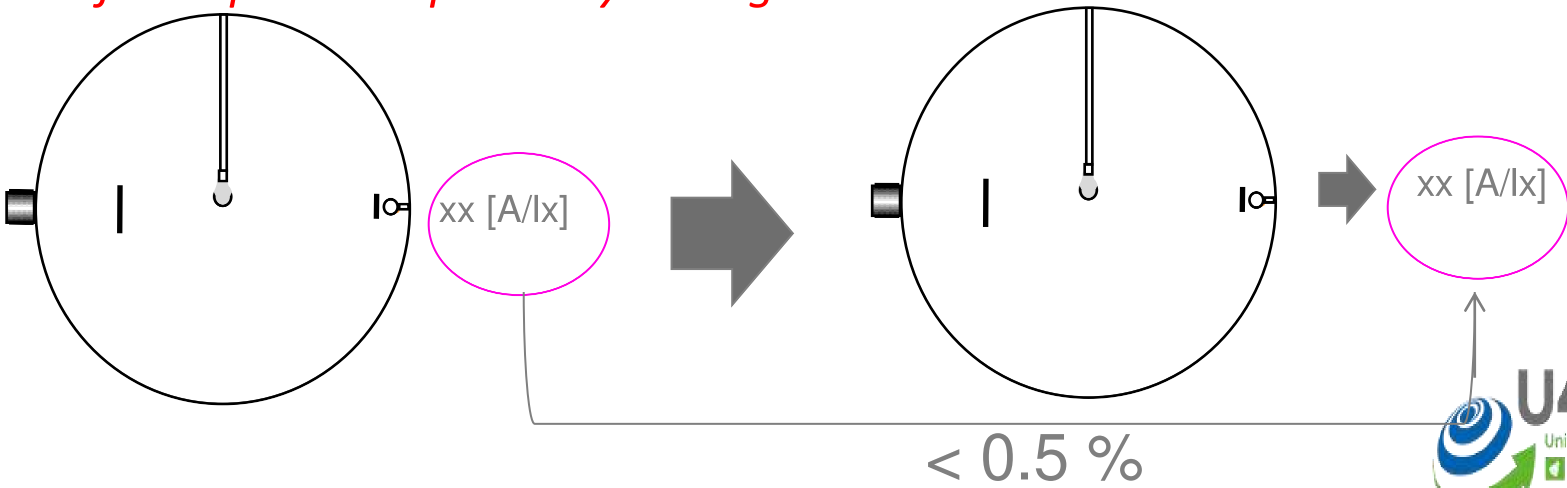
This can be checked by measuring sphere output for a stable test lamp (or the auxiliary lamp) operated in the sphere while sphere is opened and closed repeatedly.



Periodic calibration of integrating sphere

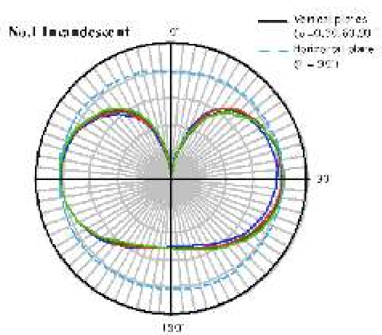
The integrating sphere system (including measurement device) shall have sufficient stability of responsivity between recalibrations. The stability of the sphere system should be checked by first measuring a stable lamp immediately after calibration and then measuring the same lamp periodically to determine the drift or variation of the sphere responsivity.

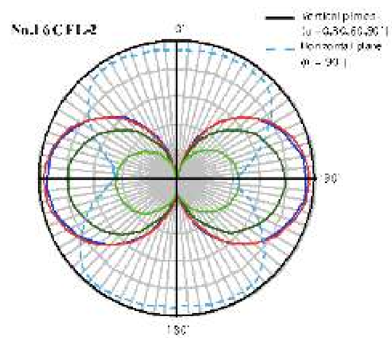
Specific requirement: Unless the sphere is calibrated immediately before each use, the sphere shall be re-calibrated at appropriate intervals so that the drift of the sphere responsivity during the interval is less than 0.5 %.

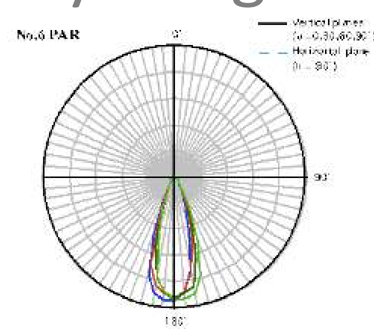


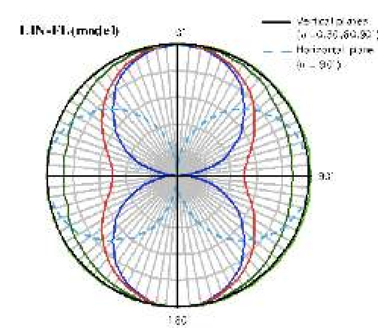
Angular intensity distribution of the standard lamp

The integrating sphere should be calibrated with reference standards having a similar intensity distribution to the DUT (e.g. omnidirectional or directional). Differences in intensity distribution between reference standards and the DUT should be considered in the uncertainty budget.









Sphere-Spectroradiometer

A sphere-spectroradiometer system shall be calibrated with **a total spectral radiant flux standard** traceable to the SI.

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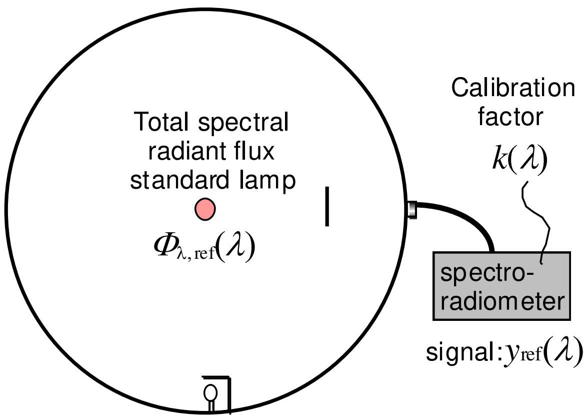

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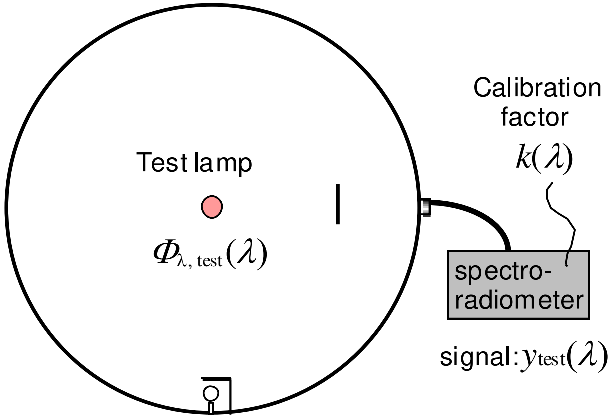


Calibration factor:

$$k(\lambda)=\frac{\Phi_{\lambda,\mathrm{ref}}(\lambda)}{y_{\mathrm{ref}}(\lambda)}$$

Total spectral radiant flux (W/nm):

$$\Phi_{\lambda,\mathrm{test}}(\lambda)=k(\lambda)\cdot y_{\mathrm{test}}(\lambda)/\alpha(\lambda)$$

$\alpha(\lambda)$: self-absorption factor

Total luminous flux (lm):

$$\Phi_{\mathrm{test}}=K_{\mathrm{m}}\int_{\lambda}\Phi_{\lambda,\mathrm{test}}(\lambda)V(\lambda)\,\mathrm{d}\lambda$$

K_{m}: 683 lm/W

Color quantities also calculated.

Sphere-Photometer

A sphere-photometer shall be calibrated with a total luminous flux standard traceable to the SI. It is desirable that the standard lamp has spectral distribution similar to that of the DUT, if such standard lamps are available.

A sphere-photometer shall have a total relative spectral responsivity (sphere plus photometer head) that matches the spectral luminous efficiency function for photopic vision $V(\lambda)$. The general $V(\lambda)$ mismatch index of the sphere-photometer system shall meet the requirements in 4.5.1.

Spectral mismatch

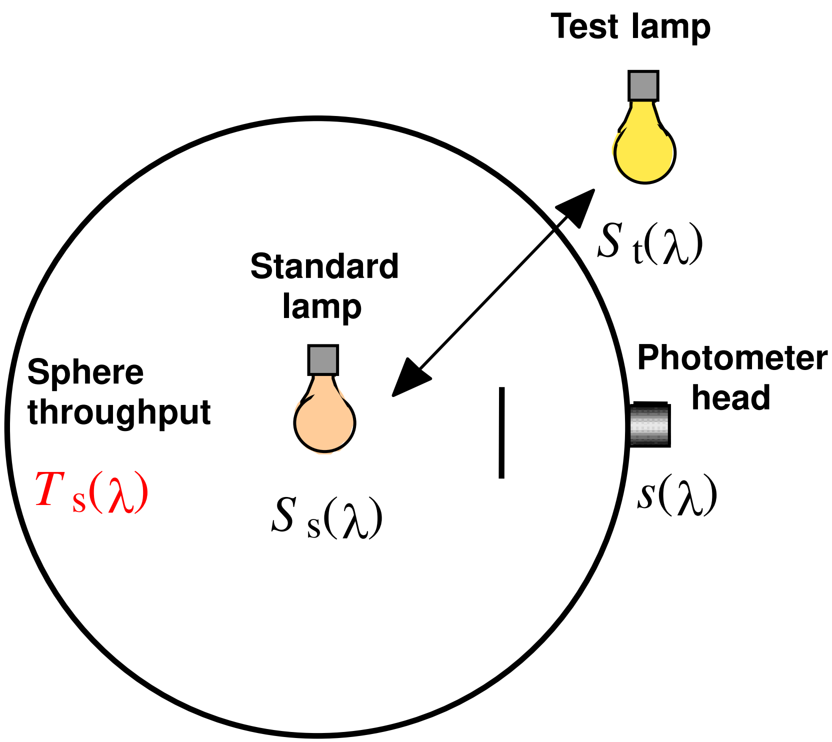
For instruments using $V(\lambda)$-corrected detectors (sphere-photometer, goniophotometer, luminance meter), the following requirements shall be fulfilled.

Specific requirement: The general $V(\lambda)$ mismatch index (f_1') of the total relative spectral responsivity (sphere plus photometer head) shall be 3 % or less.

If this requirement is fulfilled, spectral mismatch correction is not required for measurement of white light LED devices, although highly recommended. Spectral mismatch correction is required for LED devices that emit coloured light (e.g. red, green or blue single colour LED modules).

If the above requirement for is not fulfilled, it can be permitted if spectral mismatch correction is applied for each DUT measured. In this case, the actual value of the system and the fact that the correction is applied shall be reported (see also 4.1.1).

Spectral mismatch correction for an integrating sphere photometer



Spectral mismatch correction factor:

$$F(S_t, S_s) = \frac{\int_\lambda S_s(\lambda)\, R_s(\lambda)\, d\lambda \int_\lambda S_t(\lambda)\, V(\lambda)\, d\lambda}{\int_\lambda S_s(\lambda)\, V(\lambda)\, d\lambda \int_\lambda S_t(\lambda)\, R_s(\lambda)\, d\lambda}$$

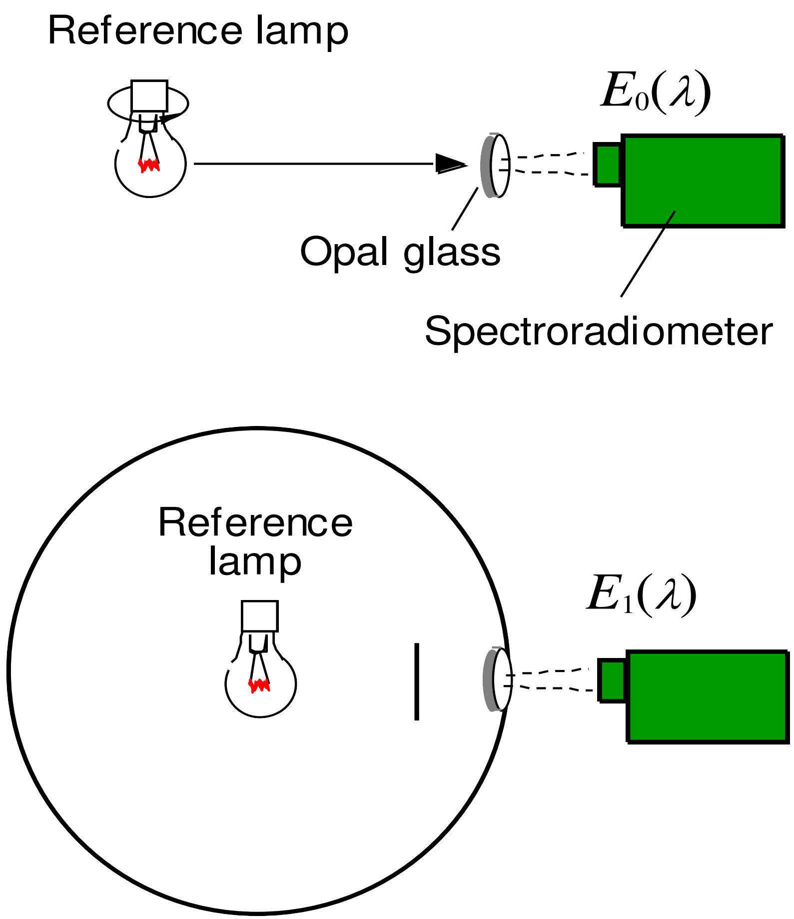
Where, Rs(λ) is the spectral responsivity of the total system

$$R_s(\lambda) = s(\lambda)\, T_s(\lambda)$$

$T_s(\lambda)$: Spectral throughput of the sphere

How to measure spectral throughput of a sphere

Measurement of the spectral throughput of the integrating sphere



Relative spectral throughput of the sphere :

$$T_S(\lambda) = c\, E_1(\lambda) \,/\, E_0(\lambda)$$

(c : normalization factor)

Goniophotometer Measurements

Gives guidance for:

- Angular scan range and dead angle
- Angular aiming and accuracy
- Stray light
- Spectral responsivity (including mirror reflectance)
- Test distance for far-field measurements (see next slide)

52

Distance requirements for goniophotometers

Luminous intensity measurements according to the inverse square law require a sufficient photometric distance.

Specific requirements for test distance in far-field photometry:

- *For DUT having near cosine (Lambertian) distribution (beam angle ≥ 90°) in all C-planes: ≥ 5 × D*
- *For DUT having a broad angular distribution different from a cosine distribution (beam angle ≥ 60°) in some of the C-planes: ≥ 10 × D*
- *For DUT with narrower angular distributions , steep gradients in the luminous intensity distribution or critical glare control: ≥ 15 × D*
- *For DUT where there are large non-luminous spaces between the luminous areas: ≥ 15 × (D+S)*
  where D is the maximal luminous dimension of the DUT and S is the largest distance between two adjacent luminous areas.

Reporting of Measurement Uncertainties

It is a simple fact of life that no measurement is ever perfect

For each measurement there is an uncertainty of measurement, which is like an estimate of the possible error that could be associated with the measurement result

CIE S 025 requires that all measurement reports **shall include a statement of uncertainties of measurement**

54

Reporting of Measurement Uncertainties

A statement of uncertainties consists of a magnitude and an associated probability

Magnitude

May be relative (eg: 5%)
May be absolute (eg: 14 lm)

Probability

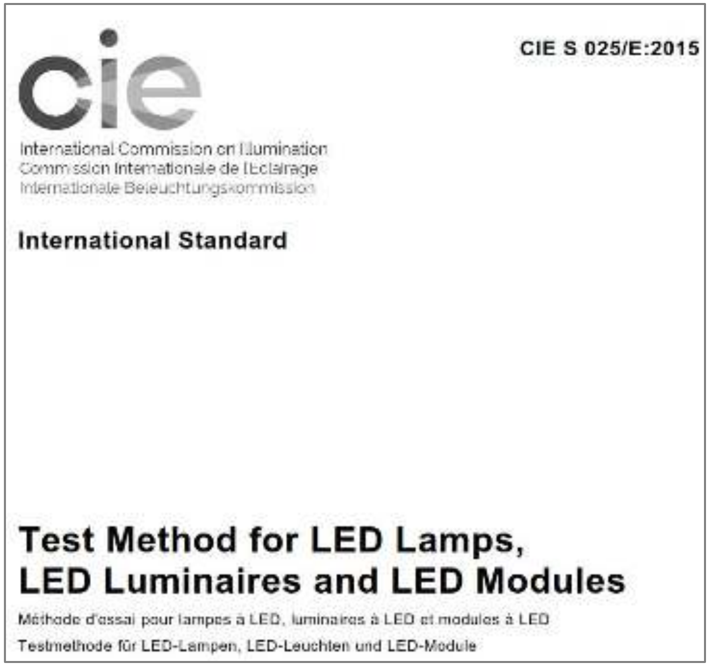
May be a coverage probability, eg: 95%
May be a coverage factor, eg: k = 2

"The measured luminous flux is 783 lm ± 4.2% with a coverage factor k = 2"

"The correlated colour temperature is 3012 K ± 55 K with a confidence interval of 95%"

U4E UN environment United for Efficiency

55



CIE S 025/E:2015

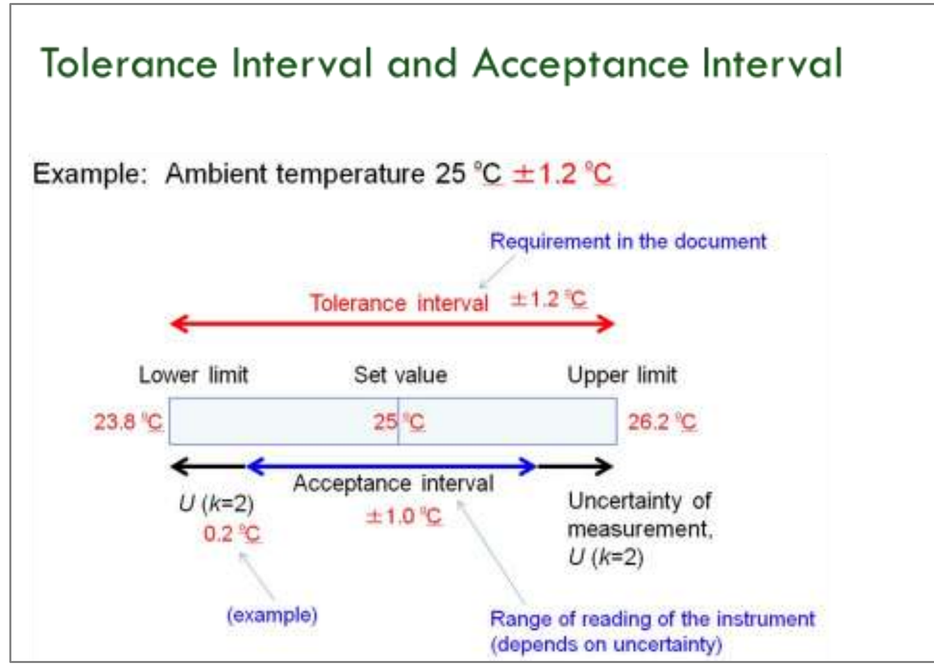
International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

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



Questions

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57