Solid State Lighting Annex: Interlaboratory Comparison Test Method

VERSION 1.0

Efficient Electrical End-Use Equipment (4E)
International Energy Agency

SSL Annex Task 2

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The IEA Implementing Agreement on Efficient Electrical End-Use Equipment (4E)

4E is an International Energy Agency (IEA) Implementing Agreement established in 2008 to support governments to formulate effective policies that increase production and trade in efficient electrical end-use equipment.

Globally, electrical equipment is one of the largest and most rapidly expanding areas of energy consumption which poses considerable challenges in terms of economic development, environmental protection and energy security. As the international trade in appliances grows, many of the reputable multilateral organisations (for example the G8, APEC, IEA and IPEEC2) have highlighted the role of international cooperation and the exchange of information on energy efficiency as crucial in providing cost-effective solutions to climate change.

Thirteen countries have joined together to form 4E as a forum to cooperate on a mixture of technical and policy issues focused on increasing the efficiency of electrical equipment. But 4E is more than a forum for sharing information – it initiates projects designed to meet the policy needs of participants.

Participants find that pooling of resources is not only an efficient use of available funds, but results in outcomes which are far more comprehensive and authoritative. The main collaborative research and development activities under 4E are undertaken within a series of Annexes, each of which has a particular project focus and agreed work plan. These currently comprise:

- Mapping and Benchmarking
- Electric Motor Systems (EMSA)
- Standby Power
- Solid State Lighting (SSL)

Current members of 4E are: Australia, Austria, Canada, Denmark, France, Japan, Republic of Korea, The Netherlands, Switzerland, Sweden, UK and USA. Information on the 4E Implementing Agreement is available from: www.iea-4e.org

Current members of the 4E SSL Annex are: Australia, China, Denmark, France, Japan, The Netherlands, Republic of Korea, Sweden, UK and USA. China works as an expert member of the 4E SSL Annex.

This test method has been prepared by the Team working on Task 2 of SSL Annex, with primary contribution by Yoshi Ohno of the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, USA.

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Disclaimer

The Authors have made their best endeavours to ensure the accuracy and reliability of the data used herein, however neither they nor the IEA 4E Implementing Agreement make warranties as to the accuracy of data herein nor accept any liability for any action taken or decision made based on the contents of this report.
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1 Introduction

This document is prepared as the test method for LED lamps and LED luminaires (referred to as "Solid State Lighting (SSL) products" or simply "products" in this document) to be used in the 2013 Interlaboratory Comparison performed by International Energy Agency (IEA) 4E SSL Annex. This document covers test methods for many of the performance characteristics specified in the IEA 4E “Performance Tiers” [1]. This test method is written so in such a way that the measurement requirements encompass those in IES LM-79-08 [2], EN 13032-4 (Draf) prepared by CEN TC169 WG7 and CIE TC2-71 [3] (excluding the method based on corrections to the standard conditions with no tolerances and the parts on LED modules), the test methods drafts included in the Annexes of IEC performance standards (drafts) on LED lamps and LED luminaires [4], the test methods covering LED lamps and LED luminaires in the Japanese standards: JIS C 7801:2009, JIS C 8105-5:2011, and JIS C 7801 Amendment 1: 2012 [5], and the test methods covered in the Chinese standards: GB standards Drafts for self-ballasted LED reflector lamps, and CQC3127-2010, CQC3128-2010, CQC3129-2010, CQC3130-2011 [6]. By complying with this IEA Interlaboratory Comparison Test Method, all the measurement requirements for LED lamps and LED luminaires in the above listed test methods are considered to be satisfied. This document is to be revised when the referred test method standards drafts have been published.

2 Scope

This document covers test methods for measurements of electrical, photometric, and colorimetric quantities of LED lamps and LED luminaires that are covered in IEA 4E SSL Annex Interlaboratory Comparisons, which deal only with complete SSL products (LED lamps and LED luminaires) that require AC mains power or a DC voltage power in branch circuit to operate. Non-integrated LED lamps (including tubular LED lamp) and luminaires with a separate LED driver (physically separate from the lamp or the luminaire) are also covered in this document if its driver is sold together or clearly specified by the product specification. LED light engines, LED modules and LED packages are not covered in this document. Testing of the lifetime of the products is not covered.

The performance characteristics of SSL products include: voltage (unit: volt), current (unit: ampere), power (unit: Watt), power factor, total harmonic distortion of current, total luminous flux (unit: lumen), luminous efficacy (unit: lumen/Watt), luminous intensity distribution, chromaticity coordinates, correlated colour temperature (CCT), colour rendering index (CRI), and spatial uniformity of chromaticity.

3 Terminology

The terms used in this document follow definitions in CIE S017 (ILV) [7], IEC 62504 [8], IEC 60050 (International Electrotechnical Vocabulary) [9], and LM-79 [2]. Some important terms in these standards are repeated below, and other important terms used as defined in the document are included below.

3.1 Aging (seasoning) [8].

preconditioning period of the LED light source before initial values are taken
3.2 Stabilization [2]
operation of SSL products under test for a sufficient period of time such that the electrical and the photometric, and temperature values become stable

3.3 Ambient temperature [8]
average temperature of air or another medium in the vicinity of the product under test

3.4 LED luminaire [8]
luminaire designed to incorporate one or more LED light source(s)

3.5 Photometer head [2]
unit containing a detector, a V(\(\lambda\))-correction filter, and any additional components (aperture, diffuser, amplifier, etc.) within the unit as a whole

3.6 Colorimeter head
unit containing filtered detectors to measure the CIE tristimulus values (X, Y, Z), and any additional components (aperture, diffuser, amplifier, etc.) within the unit as a whole

*Note:* The Y-channel of a colorimeter head works as a photometer head.

3.7 Sphere-photometer
integrating sphere employing a photometer head as the detector

3.8 Sphere-spectroradiometer
Integrating sphere employing a spectroradiometer as the detector.

3.9 Goniophotometer [7]
Photometer for measuring the directional light distribution characteristics of sources, luminaires, media or surfaces

*Note:* In this document, “goniophotometer” includes goni-colorimeter and goni-spectroradiometer.

3.10 Goni-colorimeter
goniophotometer equipped with a tristimulus colorimeter head as the detector.

*Note:* A tristimulus colorimeter is an instrument incorporating three or four filtered detectors matching their relative spectral responsivity to the CIE colour matching functions \(X(\lambda), Y(\lambda), Z(\lambda)\). For the details, see Ref. 10.

3.11 Goni-spectroradiometer
goniophotometer equipped with a spectroradiometer as the detector.

3.12 Absolute photometry (with a goniophotometer)
configuration of a goniophotometer to measure absolute luminous intensity distribution (cd), from which total luminous flux (lm) can be obtained
3.13 Relative photometry (with a goniophotometer) configuration of a goniophotometer to measure relative luminous intensity distribution, normally in cd per 1000 lm of the light source used in the luminaire

3.14 Traceability [11] 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: The 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 note 7 of metrological traceability [11]).

3.15 National Metrology Institute (NMI) national laboratory that maintains the SI units for the country and authorized to disseminate the units and calibration standards for measurements

4 Environmental Conditions

4.1 Ambient temperature

4.1.1 The ambient temperature during the measurement of the product shall be maintained at (25 ± 1) °C.

If a laboratory does not meet this requirement, outside the range (25 ± 1) °C and within 21°C to 27°C is allowed only if the results are corrected to the values for 25°C, using the ambient-temperature dependence data for the particular device under test for particular measurement quantities. In this case, the actual measured ambient temperature, method (formula) of correction, and temperature dependence data of the device shall be reported.

4.1.2 The temperature sensor shall be placed at the same height and within 1 m from LED lamp or luminaire under test.

4.1.3 The temperature sensor shall be shielded from direct optical radiation from the SSL product and from any other light source. Environment of the temperature sensor and the lamp or luminaire should not be isolated.

4.1.4 The thermometer shall have resolution of 0.1 °C or less.
Note: It is recommended that the thermometer has a calibration uncertainty\(^1\) of 0.2°C or less.

4.2 Air movement

4.2.1 Air flow around the SSL product being tested should be such that normal convective air flow induced by device under test is not affected. The air flow shall be less than 0.2 m/s.

*Note 1:* Air flow in an integrating sphere (without forced air cooling system) when closed is considered to be satisfying this requirement.

*Note 2:* Portable anemometers are commercially available with measurement uncertainty of 0.05 m/s.

*Note 3:* In case the light source is moved on the goniophotometer during measurements, the moving speed should be chosen adequately to meet the requirement in 4.2.1.

4.3 Laboratory humidity

4.3.1 Relative humidity of the laboratory should be 65 % or less.\(^2\)

5 Mounting Conditions

5.1 Operating position

5.1.1 The operating position of the artefacts used for the Interlaboratory Comparison are specified in the Test Protocol. Measurement shall be made with the artefact operated accordingly.

5.2 Supporting objects

5.2.1 SSL products with a screw base or bayonet shall be supported only by the socket.

5.2.2 LED luminaires shall be mounted to the measuring instrument (integrating sphere or goniophotometer) so that heat conduction through supporting objects causes negligible temperature effects. (The product may be suspended in air by wire or held by support materials that have low heat conductivity, e.g., Teflon).

5.2.3 If the SSL product under test is provided with a support structure that is designated to be used as a component of the luminaire thermal management system, the product shall be tested with the support structure attached.

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\(^1\) All uncertainty values stated in this document are expanded uncertainty with a 95 % confidence interval, normally with a coverage factor \(k=2\), as prescribed in [12].

6 Electrical conditions and measurement

6.1 Operation of SSL product

6.1.1 The SSL product under test shall be operated at the rated voltage (AC or DC) and frequency (for AC operation, normally 50 Hz or 60 Hz) according to the specification of the product under test for its normal use.

*Note:* Operating voltage and frequency of each SSL product will be provided in the Interlaboratory Comparison Test Protocol prepared by IEA 4E SSL Annex.

6.1.2 The tolerance of the test voltage for AC-input products is ±0.2 % of the rated value and the tolerance of frequency is ±0.2 %. The tolerance of test voltage for DC-input products is ±0.1 % of the rated value.

6.1.3 The voltage shall be measured at the socket (for screw-base or bayonet-base lamps), or at the power input line as close to the product as possible. The measurement position (length from the socket or the power input line) shall be reported.

*Note:* This is critical especially for low-voltage lamps. For screw base lamps, 4-pole socket is commercially available, which allows measurement of voltage directly across the cap with no effect of contact resistance.

6.1.4 If the product has dimming capability, measurements shall be performed at the maximum input power condition, which should be identified in the Interlaboratory Comparison Test Protocol for each region, if applicable.

6.1.5 Care should be taken when applying the power to the product under test.

*Note 1:* When applying a constant DC voltage, the voltage should be ramped up slowly to protect the device. Large frame power supplies can apply a surge before recovering to an appropriate DC power.

*Note 2:* When applying AC voltage, the power supply should be set to come on at a zero degree phase. A few LED drivers that involve capacitors may have a large in-rush current if the AC voltage is applied at a non-zero degree phase.

6.1.6 The voltage (V), current (A), power (W) (RMS for AC operation), and power factor for AC operation, shall be measured at the time photometric measurements are taken.

6.1.7 For AC-input products, if required, the total harmonic distortion of the current waveforms during the operation of the product under test should also be measured. This can be measured with some digital AC power meter or a power analyser.

*Note:* Measuring total harmonic distortion of voltage waveform may also be useful to reveal the mains impedance effects.
6.2 Electrical instrumentation

6.2.1 The voltage of an AC power supply or DC power supply applied to the product under test shall be regulated to within ±0.2 % (AC) or ±0.1 % (DC) under load.

6.2.2 AC voltage ripple of the DC power supply shall be 0.5 % or less.

6.2.3 The AC power supply shall have a sinusoidal voltage waveshape at the prescribed frequency with the total harmonic distortion not exceeding 3 % under a resistive load.

6.2.4 For AC-input SSL products, an AC power meter shall be connected between the AC power supply and the SSL product under test, and AC power as well as input voltage and current shall be measured.

6.2.5 The AC power meter shall have the capability of measuring power factor. If required by the Interlaboratory Comparison Test Protocol, the AC power meter should also have capability of measuring total harmonic distortion of current (and voltage).

6.2.6 The AC power meter shall have a sampling rate that is capable of resolving the current wave for the SSL product. Many LED drivers based on capacitors and diode bridges have very sharp current waves requiring a high sampling rate. Analogue AC power meters will not measure properly.

Note: IEC 61000-3-2 [13] states that the electrical characteristics of lighting products should be analysed in a frequency range covering the fundamental (50 Hz or 60 Hz) and up the 40th order (2 kHz or 2.4 kHz). IEC 61000-4-7 [14] indicates that power measurement equipment should be able to analyse components up to 9 kHz.

6.2.7 The calibration uncertainties (see the Note below) of the instruments for AC voltage and AC current shall be ≤ 0.2 %. The calibration uncertainty of the AC power meter shall be ≤ 0.5 % and that for DC voltage and current shall be ≤ 0.1 %.

Note: Uncertainty here, and throughout this document, refers to relative expanded uncertainty with a 95 % confidence interval, normally with a coverage factor $k=2$, as prescribed in ISO Guide for expression of uncertainties in measurement [12].

6.2.8 For DC-input SSL products, a DC voltmeter and a DC ammeter shall be connected between the DC power supply and the SSL product under test. The voltmeter is connected across the electrical power inputs of the SSL product (separate from the power supply contacts).

Note: The product of the measured DC voltage and the DC current gives the input electrical power (wattage) of the DC powered SSL products.
7 **Seasoning**

The Interlaboratory Comparison artefacts shall not be seasoned or pre-burned by the participants. If any pre-burning is required, it will be specified in Interlaboratory Comparison Test Protocol.

8 **Stabilization**

Prior to taking measurements, the product under test shall be operated at the rated condition to stabilize so that the changes of electrical power and total luminous flux (for integrating sphere) or luminous intensity (for a goniophotometer setup) in a fixed direction are less than 0.5 % over a 30 minute window by monitoring the signal every minute. The actual stabilization time shall be reported for each SSL product tested.

9 **Photometric and colorimetric measurement**

The following instruments are used for the measurement quantities needed:

- Sphere-spectroradiometer (for total luminous flux, colour quantities, CRI)
- Sphere-photometer (for total luminous flux)
- Goniophotometer with a photometer head (luminous intensity distribution, total luminous flux (if configured for absolute photometry)).
- Goni-spectroradiometer (luminous intensity distribution, total luminous flux, colour quantities, CRI, chromaticity spatial uniformity)
- Gonio-colorimeter (luminous intensity distribution, total luminous flux, chromaticity spatial uniformity)

9.1 **Total luminous flux**

9.1.1 Total luminous flux of an SSL product shall be measured using an integrating sphere system (a sphere-spectroradiometer and/or a sphere-photometer) or a goniophotometer (configured for absolute photometry).

**Integrating sphere systems**

9.1.2 A sphere-spectroradiometer shall be calibrated with a total spectral radiant flux standard traceable to an NMI.

*Note 1:* If total spectral radiant flux standard lamps are not available from the local NMI, the standard may be derived by the user from spectral irradiance standard lamp(s) and total luminous flux standard lamp(s), both shall be traceable to an NMI. In this case, the derivation methods and related data (e.g., angular uniformity of spectrum or CCT of the standard lamp) shall be reported.

*Note 2:* It would not be acceptable if the spectroradiometer used with the integrating sphere is calibrated for spectral irradiance only without considering the relative spectral throughput of the integrating sphere. The integrating sphere and
the spectroradiometer together shall be calibrated as one system for total spectral radiant flux.

9.1.3 The spectroradiometer used for the sphere-spectroradiometer system shall cover the wavelength range of at least 380 nm to 780 nm, and the bandwidth (full width half maximum) and scanning interval to be no greater than 5 nm. Wavelength scale uncertainty shall be within 0.3 nm.

9.1.4 A sphere-photometer system or sphere-spectroradiometer system shall be equipped with an auxiliary lamp and self-absorption measurement shall be carried out and correction made for each product under test.

9.1.5 A sphere-photometer shall be calibrated with a total luminous flux standard traceable to an NMI.

9.1.6 A sphere-photometer shall have a total relative spectral responsivity (sphere plus photometer head) that meets the $f'_s$ value [15] of 2% or less. If $f'_s$ of the sphere-photometer exceeds 2%, then $f'_s$ no greater than 6% is acceptable if spectral mismatch correction is applied to each product tested. For this correction, the relative spectral distribution of the product and the relative spectral responsivity of the sphere-photometer is necessary. In this case, the correction factor and data for spectral mismatch correction shall be reported.

*Note 1:* If $f'_s$ value of the total sphere system is not available from the manufacturer, guidance on how to measure the relative spectral responsivity of a sphere-photometer system is available in [16].

*Note 2:* The formula for $f'_s$ and spectral mismatch correction are available in [2], [16].

9.1.7 A combination of a photometer head and a spectroradiometer may also be used, with the photometer head used for luminous flux measurement and the spectroradiometer used for spectral mismatch correction determinations and for measurement of colour quantities.

*Note:* In this case, the spectroradiometer measures only the relative total spectral radiant flux and needs to be calibrated only for relative total spectral radiant flux scale.

9.1.8 The photometer head of a sphere-photometer and the spectroradiometer input optics at integrating sphere detector port (normally equipped with a diffuser) shall have approximate cosine correction, with the $f_z$ value [15] of 15% or less.

9.1.9 Further guidance on construction and use of a sphere-spectroradiometer and a sphere-photometer for measurement of SSL products are available in [2].

**Goniophotometer**

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3 This is the requirement of the EN 13032-4 (draft). $f'_s \leq 3\%$ qualifies for LM-79 and other test methods. See Annex A for the details.
9.1.10 The goniophotometer to be used shall be the type, in which the operating position of the SSL product under test with respect to gravity is not changed (known as Type C in USA [17])⁴.

Note: Type C goniophotometers include the moving detector type for relatively short photometric distances (for smaller SSL products) and the moving mirror type for larger photometric distances (larger SSL products or having a narrow beam angle).

9.1.11 For goniophotometers employing a photometer head, the relative spectral responsivity of the photometer head (plus mirror if used) shall have an \( f_{\lambda'} \) value \([15]\) of 1.5 % or less. If the \( f_{\lambda'} \) of the photometer head (or the Y channel of a colorimeter head) of a goniophotometer exceeds 1.5 % (but < 6 %), the spectral mismatch correction shall be applied to each product under test. For this correction, the relative spectral distribution of the product is necessary.

Note: Guidance for spectral mismatch correction is available in [2], [16].

9.1.12 Scanning resolution fine enough to accurately define the test sample shall be used. For typical wide-angle, smooth intensity distributions, a 22.5° lateral (horizontal) and 5° longitudinal (vertical) grid may be acceptable. For reflector lamps, the longitudinal angle increments shall be 1/10 or less of the beam angle (diameter of the angular cone emitting more than 1/2 of the peak intensity) but not larger than 5°. Finer angle resolution (smaller test increments) shall be used where the luminous intensity from the SSL product is changing rapidly or is erratic, such as in beam forming sources.

Note: For SSL products having rapidly changing intensity distribution, measurements may be repeated with another randomly selected vertical reference plane to ensure that results are within laboratory's uncertainty budget for the test.

9.1.13 The goniophotometer used for total luminous flux measurement shall be calibrated for luminous intensity standard or illuminance standard traceable to an NMI, and measured total luminous flux value (lm) shall be verified by measuring a total luminous flux standard traceable to an NMI. Alternately, the goniophotometer system may be calibrated against a total luminous flux standard traceable to an NMI, if the dead angle of the Goniophotometer does not affect the measurement of the total luminous flux standard lamp.

Note 1: For mirror type goniophotometers, a luminous intensity standard lamp is normally used to calibrate the photometer head, in which case, the photometric distance and the reflectance of mirror are automatically included in the calibration.

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⁴ Type C is required in IES LM-79. Other types of goniophotometer, if corrections are applied appropriately for the effect of changes of operating position of the SSL product, may qualify for other test methods.

⁵ \( f_{\lambda'} \leq 1.5 \% \) is required in the EN 13032-4 (draft). \( f_{\lambda'} \leq 3 \% \) qualifies for LM-79 and other test methods. See Annex A for the details
9.3.14 Goniophotometers shall have an angular scan range covering the entire solid angle to which the SSL product emits light.

Note: Goniophotometers in general have some angular region (called dead angle) where emission from a light source is blocked by its mechanism, e.g., an arm to hold the light source. Goniophotometers having a large dead angle (exceeding ±10°) should not be used to measure total luminous flux of omnidirectional lamps or luminaires unless appropriate correction procedures are implemented.

9.1.15 Care should be taken to minimize stray light errors.

Note 1: The goniophotometers should be installed in a dark room with low reflectance wall surfaces, and should preferably be equipped with a light trap or light absorbing surface on the opposite side of the mirror or detector on the rotating arm, so that the errors due to reflections and stray light from surrounding surfaces are minimized.

Note 2: The photometer head or spectroradiometer input should be equipped with a hood or aperture screens to receive the light only from the effective angle range of the SSL product under test.

9.2 Luminous intensity distribution

9.2.1 Luminous intensity distribution of an SSL product shall be measured with a goniophotometer that fulfils requirements in 9.1, except the need for verification with total luminous flux standard in 9.1.13. The results are normally expressed in absolute luminous intensity in candela. For relative luminous intensity distribution, there is no need to calibrate the goniophotometer against absolute luminous intensity or illuminance standard.

9.2.2 The coordinate system and geometry for mounting SSL products should follow the general practice used in traditional luminaire testing [17], [18].

9.2.3 A sufficient photometric distance should be used – generally, more than five times of the largest dimension of the test SSL product having broad angular distributions. A longer distance may be needed for narrow beam sources.

9.3 Centre-beam luminous intensity

9.3.1 The centre-beam luminous intensity is the luminous intensity along the centre axis of the SSL product. The centre axis is the axis defined by the SSL product mounting base and the intended direction of the light determined by the optical components built into the SSL product. For further details of measurement conditions, see [23].
9.4 Luminous efficacy

9.4.1 The electrical input power $P_{\text{TEST}}$ (W) of the SSL product under test shall be measured according to section 6.

9.4.2 The luminous flux $\Phi_{\text{TEST}}$ (lm) shall be measured according to section 9.1.

9.4.3 The luminous efficacy $\eta_v$ (lm/W) of the product under test shall be determined by

$$\eta_v = \frac{\Phi_{\text{TEST}}}{P_{\text{TEST}}} \quad (1)$$

9.5 Colour quantities

9.5.1 Colour quantities to be measured for SSL products include chromaticity coordinates $(x, y)$ and/or $(u', v')$, correlated colour temperature (CCT), and general Colour Rendering Index (CRI $R_i$) [21]. Duv [20] and the special CRI ($R_s$) [21] are optional and to be reported if required in the Interlaboratory Comparison Test Protocol. Colour quantities are calculated from the measured relative spectral power distribution of the SSL product according to the definitions given in [19]-[21].

9.5.2 The colour quantities of SSL products shall be measured as spatially averaged values, with its value at each point weighted by the intensity and the solid angle, over the angular range where light is intentionally emitted from the SSL product.

Note 1: A sphere-spectroradiometer automatically measures the spatially averaged spectral power distribution, from which spatially averaged colour quantities can be calculated. The sphere-spectroradiometer to be used shall meet the requirements in section 9.1.

Note 2: Spatially averaged colour quantities can also be measured with a goniom-spectroradiometer or a goniocolorimeter. In this case, the angular scan shall be made for at least two vertical planes at 90° apart ($\phi$ angle), and at 10° increments for a vertical angle scan ($\theta$ angle) in each vertical plane. For reflector lamps, the $\theta$ angle increments shall be 1/10 or less of the beam angle (diameter of the angular cone emitting more than 1/2 of the peak intensity) but no larger than 10°. The colour quantities and (relative) luminous intensity at each goniometer angle shall be recorded over the angle range where the luminous intensity is more than 10% of the peak intensity, which are used for the calculation of spatially averaged colour quantities. The colour quantity values are weighted by the solid angle (represented by the $\theta$ angle) and the luminous intensity of the point. An example of calculation formulae is available in section 12 of [2].

9.5.3 If a goniocolorimeter is used, the chromaticity at one of the angular points shall be measured with a spectroradiometer to calibrate the colorimeter head, and all
measured results by the colorimeter shall be corrected based on the spectroradiometer reading.

9.5.4 If necessary, chromaticity spatial uniformity can be measured using a gonio-spectroradiometer or gonio-colorimeter. First, the spatially averaged chromaticity \((u'_v, v'_s)\) is calculated according to 9.5.1 to 9.5.3. The spatial uniformity of chromaticity, \(\Delta u'v'\), is determined as the maximum differences in chromaticity \((u', v')\) between the average chromaticity \((u'_v, v'_s)\) and the measured chromaticity coordinates at all angle points measured.

9.6 Lag start time

The lag time is the time needed after switching on for the SSL product to start fully and remain lighted. If measurement is required, the following procedures should be taken.

9.6.1 Lag start time is measured using a fast photometer head (having time constant of less than 10 ms) measuring the relative luminous intensity in one direction near the centre of the beam or relative total luminous flux in an integrating sphere.

9.6.2 The SSL product is thermally stabilized at \((25 \pm 1) \, ^\circ C\) without electrical power supplied.

9.6.3 For AC powered products, the AC power supply should start at zero degree phase.

9.6.4 The electrical power is applied with a trigger that simultaneously triggers an oscilloscope that receives the output signal from the photometer head and the voltage signal from the power supply.

9.6.5 The lag time is determined from subtracting the time where the power is initially applied from the time where the photometer signal indicates that the SSL product has started fully.

10 Measurement Uncertainty

The uncertainties should be reported for all measurement results.\(^6\) In reporting uncertainties, the international recommendation [12] should be followed to evaluate and express uncertainties of measurement. For all measurements covered in this document, a coverage factor of \(k=2\) (generally corresponding to a confidence interval of 95 %) shall be used. Guidance on evaluation of uncertainty in photometry is available in [22].

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\(^6\) Statement of uncertainty is required in the EN 13032-4 (draft) [3] but not required in other test methods (LM-79, etc.) listed in section 1. See Annex A for the details.
11 References

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   GB/T draft: Self-ballasted LED reflector lamps – Performance requirements.
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8. IEC 62504/TS: General lighting – LEDs and LED modules – Terms and definitions (CD draft).
13. IEC 61000-3-2:2005 Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).
17. IESNA LM-75-01, Goniophotometer Types and Photometric Coordinates.


23. IEC TR61341:2010 Method of measurement of centre beam intensity and beam angle(s) of reflector lamps.
### Annex A: SSL Test Methods Comparison Table

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#### Thermal Conditions

<table>
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<tr>
<th><strong>Ambient Temperature</strong></th>
<th>25 ±1 °C (4.1.1)</th>
<th>25 ±1 °C (2.2)</th>
<th>25 ±1 °C</th>
<th>25 ±1 °C (A1)</th>
<th>Room temperature is within 2 deg. In the range of 21 to 27 °C (5.2) ambient temperature of a lamp is based on a standard or the conditions which were specified. (4.2)</th>
<th>20 to 30 °C (Incandescent lamp, HID lamp, Low-pressure sodium lamp) 23 to 27 °C (Other lamps (include LED))</th>
<th>Not specified</th>
</tr>
</thead>
</table>

| **Outside the specified temperature range** | outside the range (21 to 27 °C) is allowed only if all measured results are corrected to the value at 25 °C using the ambient-temperature dependence data of the device for all quantities (total luminous flux, chromaticity, CRI, etc.), which must be tested for the particular device under test. In this case, the measured temperature, method (formula) of correction, and temperature dependence data of the device shall be reported. (4.1.1) | Not specified | LM79 but considers CEN and JIS | Not allowed (in Option 1) | Not specified | Not specified |
|---------------------------------------------|-------------------------------------------------|-----------------------------|----------------|----------------|---------------------------------|-----------------------------|-----------------------------|

<table>
<thead>
<tr>
<th><strong>Products with feedback control</strong></th>
<th>Not specified.</th>
<th>Not specified</th>
<th>LM79</th>
<th>Not specified</th>
<th>Not specified</th>
<th>Not specified</th>
<th>Not specified</th>
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</thead>
</table>

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<thead>
<tr>
<th><strong>Measurement point</strong></th>
<th>Not more than 1 m from device.</th>
<th>not more than 1 m from device and at the same height</th>
<th>Shall be measured at horizontal distance maximum 1.5 m</th>
<th>Not specified</th>
<th>at a distance of 0.5 m to 2 m from the end of a luminaire and the temperature sensor of a thermometer shall not be directly subjected to light irradiation of the luminaire.</th>
<th>Not specified</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>For products specified for ambient temperature other than 25 °C</strong></th>
<th>Not included in RR.</th>
<th>Not specified.</th>
<th>When manufacturer specifies ambient temp other than 25 °C, &quot;service factor&quot; shall be measured and reported.</th>
<th>a correction factor will need to be established to correct the measured luminous flux value at 25 °C to the luminous flux value at the declared ambient. This shall be done using relative photometry in a temperature controlled cabinet. (A.1)</th>
<th>Not specified</th>
<th>Not specified</th>
</tr>
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</table>

GB: For the lamps with declared applicable ambient temperature range more wide, tests under Tmax±2°C and Tmin±2°C should also be performed.
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<tr>
<td>Temperature measurement resolution</td>
<td>Resolution within 0.1 °C (4.1.4)</td>
<td>CEN</td>
<td>Not specified</td>
<td>Resolution within 0.1 °C</td>
<td>Not specified</td>
<td>Not specified</td>
<td>0.1 °C</td>
<td></td>
<td></td>
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<tr>
<td>Temperature measurement uncertainty</td>
<td>Uncertainty ≤ 0.2 °C (guidance) (4.1.4)</td>
<td>CEN</td>
<td>Not specified</td>
<td>Uncertainty ≤ 0.2 °C (guidance)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
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<tr>
<td>Relative humidity</td>
<td>Less than 65 % (4.3.1)</td>
<td>IEC, China</td>
<td>Not specified</td>
<td>Not specified</td>
<td>less than 65 % (A.1 of IEC 62717)</td>
<td>less than 65 % (A.1)</td>
<td>less than 65 %</td>
<td></td>
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</tr>
<tr>
<td>Mounting method</td>
<td>Supporting objects shall not cause cooling effect (5.2.1)</td>
<td>LM-79</td>
<td>Supporting objects shall not cause cooling effect (2.3)</td>
<td>Operated in free air</td>
<td>Only guidance with no number requirement (5.2)</td>
<td>Only guidance with no number requirement (7.2)</td>
<td>Not specified</td>
<td>Not specified</td>
<td></td>
</tr>
<tr>
<td>Air flow / Air movement</td>
<td>Air movement shall not exceed 0.2 m/s. (4.2.1)</td>
<td>CEN</td>
<td>Only guidance with no number requirement (2.4)</td>
<td>Air movement shall not exceed 0.2 m/s.</td>
<td>Air movement shall not exceed 0.2 m/s.</td>
<td>Only guidance with no number requirement (5.2)</td>
<td>Not specified</td>
<td>Not specified</td>
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<tr>
<td>Air velocity measurement uncertainty</td>
<td>≤ 0.05 m/s (recommendation) (4.2.1)</td>
<td>CEN</td>
<td>not required</td>
<td>≤ 0.05 m/s (recommendation)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
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<tr>
<td>Electrical Conditions</td>
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<tr>
<td>Test voltage (AC and DC)</td>
<td>tolerance of within 0.2 % for AC, 0.1% for DC products. (6.1.2)</td>
<td>CEN, IEC</td>
<td>Rated voltage (AC or DC) of the product (7.6) – no tolerance</td>
<td>Rated voltage of within 0.2 % for AC, 0.1% for DC products. (A.2.1 of IEC 62717)</td>
<td>Rated voltage, current, or power with tolerance 0.2 % (A.3.1)</td>
<td>Rated electric condition (Volt, Current, power) of the product (4.2) – no tolerance</td>
<td>Rated electric condition (Volt, Current, power) of the product, or user specified condition (8.2.1) – no tolerance</td>
<td>AC220V50Hz. For the lamps declaring large voltage range, also Vmax and Vmin</td>
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<tr>
<td>AC power supply THD</td>
<td>≤ 3 % (6.2.3)</td>
<td>All</td>
<td>≤ 3 % (3.1)</td>
<td>≤ 3 % (A.1 of IEC 62717)</td>
<td>≤ 3 % (A.1)</td>
<td>≤ 3 % (table.1 informative)</td>
<td>≤ 3 % (table.3)</td>
<td>≤ 3 %</td>
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<tr>
<td>AC power supply voltage regulation</td>
<td>≤ 0.2 % (6.2.1)</td>
<td>≤ 0.2 % (3.2)</td>
<td>≤ 0.2 % (A.1 of IEC 62717)</td>
<td>≤ 0.2 % (A.1)</td>
<td>≤ 0.2% (table.1 informative)</td>
<td>≤ 0.2% (table.3)</td>
<td>≤ 0.2%</td>
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<tr>
<td>DC power supply voltage regulation</td>
<td>≤ 0.1 % (6.2.1)</td>
<td>≤ 0.1 % (3.2)</td>
<td>≤ 0.1 % (A.1 of IEC 62717)</td>
<td>≤ 0.2 % (A.1)</td>
<td>≤ 0.1% (table.1 informative)</td>
<td>≤ 0.1% (table.3)</td>
<td>NA</td>
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<tr>
<td>AC power supply frequency uncertainty</td>
<td>≤ 0.2 % (6.1.2)</td>
<td>CEN, JIS</td>
<td>Not specified</td>
<td>≤ 0.2 %</td>
<td>≤ 0.2% (table.1 informative)</td>
<td>≤ 0.5% (table.4)</td>
<td>Not specified</td>
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<tr>
<td>DC power supply voltage AC ripple</td>
<td>≤ 0.5 % (6.2.2)</td>
<td>CEN</td>
<td>Not specified</td>
<td>≤ 0.5 %</td>
<td>≤ 0.5% (table.3)</td>
<td>Not specified</td>
<td>NA</td>
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<tr>
<td>AC voltmmeter and ammimeter uncertainty</td>
<td>≤ 0.2% (6.2.7)</td>
<td>≤ 0.2% (8.2)</td>
<td>≤ 0.2%</td>
<td>≤ 0.2% (table.1 informative)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
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**Notes:**
- Specifications below are subject to change.
- Draft versions are marked with “Draft” and publication dates.
- Goniophotometric LED luminaire testing lamp is scoped (includes LED lamp).
- AC220V50Hz. For the lamps declaring large voltage range, also Vmax and Vmin. 
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<td>AC power measurement uncertainty</td>
<td>≤ 0.5% (6.2.7)</td>
<td>≤ 0.5% (8.2)</td>
<td>≤ 0.5%</td>
<td>≤ 0.5%</td>
<td>≤ 0.2% (table.1 informative)</td>
<td>Not specified</td>
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<td>DC voltage and current measurement Uncertainty</td>
<td>≤ 0.1 % (6.2.7)</td>
<td>≤ 0.1 % (8.2)</td>
<td>≤ 0.2% (table.1 informative)</td>
<td>≤ 0.2% (table.1 informative)</td>
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<td>Four-wire contacts socket</td>
<td>recommended (6.1.3)</td>
<td>CEN</td>
<td>Not specified.</td>
<td>recommended</td>
<td>Not specified.</td>
<td>Not specified.</td>
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<tr>
<td>Ageing / Seasoning</td>
<td>No aging. If any pre-burning is required, it will be specified in Round Robin Protocol. (7.)</td>
<td>No aging (4.6)</td>
<td>according to appropriate LED device standard</td>
<td>Not required (but manufacturer can define aging period) (A.2.2 of IEC 62717)</td>
<td>Not required (but manufacturer can define aging period up to 500 h) (A.2.2)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>1000hrs</td>
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<tr>
<td>Stabilization of test device</td>
<td>within 0.5 % in 30 min (8.)</td>
<td>LM79 (Chinese requirement for change of direction is not considered)</td>
<td>within 0.5 % in 30 min (5.0)</td>
<td>light output within 0.5 % in 15 min and V, A, W within 1 %. (A.1 of IEC 62717)</td>
<td>light output within 0.5 % in 15 min and power within 1 %. (A.1)</td>
<td>secure the time until optical power is sufficiently stabilized(7.3)</td>
<td>Warm up the luminaire and goniophotometer sufficiently, and after confirming that they become stabilized, perform the measurement. (8.2.1)</td>
<td>within 0.5% in 30min, and should not be change in the same direction</td>
<td></td>
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<tr>
<td>Monitoring stabilization</td>
<td>monitor light output and electrical power every 1 min. (8.)</td>
<td>IEC, CEN, LM79</td>
<td>monitor light output and electrical power at every 15 min or less apart (5.0)</td>
<td>monitor light output every 1 minute (Power will be added.)</td>
<td>monitor light output every 1 min.</td>
<td>monitor light output every 1 min.</td>
<td>not specified</td>
<td>monitor the light output and power every 5min</td>
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<tr>
<td>If it takes very long time</td>
<td>not specified</td>
<td>LM79</td>
<td>not specified</td>
<td>Max 45 min for module, lamp Max 150 min for luminaire but declare observed fluctuations</td>
<td>Max 45 min for module, lamp Max 150 min for luminaire (A.1 of IEC 62717)</td>
<td>Max 45 min (A.1)</td>
<td>Not specified</td>
<td>not specified</td>
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<tr>
<td>Operating orientation/operating position</td>
<td>Specified by the RR protocol (5.1.1). (cap up for LED lamps)</td>
<td>Use the operating position recommended by the manufacturer (6.0)</td>
<td>LED lamp: cap up unless otherwise specified by the manufacturer</td>
<td>vertical position, cap-up, unless otherwise specified by the manufacturer or responsible vendor.</td>
<td>Not specified</td>
<td>Not specified</td>
<td>not specified</td>
<td>base up, if others, should make correction</td>
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<tr>
<td>Different position than specified by the manufacturer (or protocol)</td>
<td>Not specified. (Not allowed)</td>
<td>Not allowed.</td>
<td>Not allowed (in Option 1)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td>not specified</td>
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<tr>
<td>If a number of same type of products are measured</td>
<td>Not applicable for RR.</td>
<td>pre-aging is allowed.</td>
<td>shorter time allowed with 1.05 method (A.1 of IEC 62717)</td>
<td>shorter time allowed with 1.05 method. (A.1)</td>
<td>Not specified</td>
<td>Not specified</td>
<td>not specified</td>
<td></td>
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<tr>
<td>LED device with dimming control</td>
<td>Specified by the RR protocol, if such a device is included in RR.</td>
<td>Maximum setting (7.3)</td>
<td>Maximum setting</td>
<td>Maximum setting</td>
<td>Not specified</td>
<td>Not specified</td>
<td>maximum power setting</td>
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<tr>
<td>LED device with multiple/variable colour/CCT</td>
<td>Specified by the RR protocol, if such a device is included in RR.</td>
<td>measurement may be made at different modes of operation (and CCTs) if necessary, and such setting conditions shall be clearly reported (7.2)</td>
<td>each defined settings or indicated by the manufacturer</td>
<td>each defined settings or indicated by the manufacturer</td>
<td>Not specified</td>
<td>Not specified</td>
<td>test under each condition</td>
<td></td>
</tr>
<tr>
<td>Integrating Sphere</td>
<td>Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required (9.1.2, 9.1.5)</td>
<td>LM-79 but consider the fact that total spectral radiant flux standards are not available only in NMI other than NIST.</td>
<td>Required, NMI traceable.</td>
<td>Required, NMI traceable.</td>
<td>Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required (5.1)</td>
<td>Out of scope</td>
<td>not specified</td>
<td></td>
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<tr>
<td>Self-absorption measurement for sphere system</td>
<td>Required (9.1.4)</td>
<td>Required (9.1)</td>
<td>Required</td>
<td>Required</td>
<td>if needed (7.3, 7.4)</td>
<td>Out of scope</td>
<td>required</td>
<td></td>
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<tr>
<td>f1 of sphere photometer</td>
<td>≤ 2 % (9.1.6)</td>
<td>≤ 3 %</td>
<td>≤ 2 % or 3 % still under discussion</td>
<td>≤ 2 % or 3 % still under discussion</td>
<td>≤ 6 %</td>
<td>Out of scope</td>
<td>&lt;3.5%</td>
<td></td>
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<tr>
<td>f2 of photometer head of sphere system</td>
<td>≤ 15% (9.1.7)</td>
<td>≤ 15%</td>
<td>≤ 15%</td>
<td>≤ 15%</td>
<td>Not specified</td>
<td>Out of scope</td>
<td>not specified</td>
<td></td>
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### Goniophotometer

**Operating position of LED device for goniophotometer**

- **Type C**: Burning position shall not change on goniophotometer (9.1.9)
- **China (but the requirement “spatial position of the lamp should not change” is not considered, as it is covered by the limit of the drafts.)**
- **Type C**: Burning position shall not change on goniophotometer (9.3.1)
- ** Shall not change (in Option 1)**
- **Out of scope**
- **Not specified.**
- **Type c: burning position and spatial position of the lamps should not change**

**Other than Type C**

- **Not allowed.**
- **LM79**
- **Not allowed.**
- **Not allowed (in Option 1)**
- **Out of scope**
- **specified(7.6).**
- **For reflector lamps: 1° ver; 5°hor (for lamp with irregular distribution)**

**Scanning angle resolution**

- **Scanning resolution fine enough to accurately define the test sample shall be used. (9.1.11)**
- **Maybe Chinese, but specification is not clear. LM79 language is used.**
- **22.5° hor. 5° ver. (only guidance)**
- **as specified in application standard**
- **Out of scope**
- **specified(7.6).**
- **For reflector lamps: 1° ver; 5°hor (for lamp with irregular distribution)**

**Angle coverage (for luminous flux)**

- **Cover entire range of emission from device. For omnidirectional lamp, dead angle <±10° (interpolation correction is only guidance)**
- **Cover entire range of emission. Dead angle ±10° allowed but correction needed (only guidance)**
- **Cover entire range of emission.**
- **Cover entire range of emission. dead angle ≤ ±10° allowed but correction needed (only guidance)**
- **Out of scope**
- **Not specified.**
- **not specified**

**F' of photometer head of the goniophotometer (including mirror)**

- **≤ 1.5 %, (9.1.10)**
- **≤ 3 %, (9.3.6)**
- **≤ 1.5 %**
- **≤ 6 %**
- **≤ 3.5%**

**Calibration of goniophotometer for luminous flux measurement**

- **Luminous. Intensity or illuminance standards traceable to NMI, plus verification with total luminous flux standard is required. (9.1.12)**
- **Luminous. Intensity or illuminance standards traceable to NMI, plus check with total luminous flux standard is required. (9.3.7)**
- **Required, NMI traceable.**
- **Required, NMI traceable.**
- **Out of scope**
- **Calibration by specified standards traceable to NMI is required (6 annex A)**
- **not specified**

**Luminous flux by goniophotometer**

- **Absolute photometry required. (9.1.1)**
- **Absolute photometry required.**
- **Absolute photometry required.**
- **Out of scope**
- **Calibration by luminous flux standards traceable to NMI is required (annex A)**
- **not specified**
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<td>2009 (published), 2012 supplement 1 will be published. Self ballasted LED lamp is in the scope of this document.</td>
<td>2011 (published), Goniophotometric LED luminaire testing lamp is scoped (includes LED lamp).</td>
<td>FGBHZ/CQC: 2010 GB: Draft, waiting for publication</td>
</tr>
<tr>
<td>Photometric center of luminaire (for goniophotometry)</td>
<td>Specified in RR protocol if necessary.</td>
<td>Not specified.</td>
<td>Center of luminous surface</td>
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<tr>
<td>Coordinate system for goniophotometer (data format)</td>
<td>Follow the general practice used in traditional luminaire testing, referring to CIE 121 and LM-63 (9.2.2)</td>
<td>LM-63 format required. (10.0)</td>
<td>CIE C, y (CIE 121)</td>
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<tr>
<td>Photometric distance of Goniophotometer for intensity distribution</td>
<td>more than five times of the largest dimension of the test product is recommended (9.2.3)</td>
<td>longer than five times of the longest dimension of the source (only guidance) (10.0)</td>
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<tr>
<td>Intensity distribution of LED luminaire with interchangeable LED lamps</td>
<td>Not covered in the current RR.</td>
<td>Not specified (not allowed)</td>
<td>Relative goniophotometry may also apply for LED luminaire with interchangeable LED lamps</td>
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<tr>
<td>Peak intensity</td>
<td>Not covered in the current RR.</td>
<td></td>
<td>measured in accordance with IEC/TR 61341 (A.3.4)</td>
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<tr>
<td>Beam angle</td>
<td>Not covered in the current RR.</td>
<td></td>
<td>measured in accordance with IEC/TR 61341. (A.3.5)</td>
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<tr>
<td>Colour measurement</td>
<td>Colour quantities shall be spatially averaged (with some exceptions). (9.5.2)</td>
<td>LM79 JIS</td>
<td>Colour quantities shall be spatially averaged (with some exceptions). (12.0)</td>
<td>spatially average by default except if request is made for directional</td>
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<tr>
<td>with a gonio-spectroradiometer or gonio-colorimeter</td>
<td>Every 10 deg. vertical and 2 horizontal planes 90 deg. apart at minimum. (9.5.2)</td>
<td>LM79</td>
<td>Every 10 deg. vertical and 2 horizontal planes 90 deg. apart at minimum. (12.2)</td>
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<tr>
<td>Gonio-colorimeter (calibration)</td>
<td>shall be calibrated against spectroradiometer (at one point for that device under test) (9.5.3)</td>
<td>LM79</td>
<td>shall be calibrated against spectroradiometer (at one point for that device under test) (12.2)</td>
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**Note:** Specifications below are subject to change.
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<tbody>
<tr>
<td><strong>Version</strong></td>
<td>Draft 1.0 (2012-10-15)</td>
<td>2008 (published)</td>
<td>Draft 2012-9-16. Entries below are for Option 1 (section 4.2.1) only. Specifications below are subject to change.</td>
<td>&quot;Manuscript for CD&quot; 2011-9-9 Specifications below are subject to change.</td>
<td>CDV 2011-10-28. Specifications below are subject to change.</td>
<td>2009 (published), 2012 (supplement 1 will be published). Self ballasted LED lamp is in the scope of this document.</td>
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</tr>
<tr>
<td><strong>Spatial colour uniformity</strong></td>
<td>Every 10 deg. Vertical and 2 horizontal planes 90 deg. Apart at minimum. Maximum deviation from spatial average. (recommendation only) (9.5.4)</td>
<td>LM79</td>
<td>LM79</td>
<td>Similar to LM-79.</td>
<td>Not specified.</td>
<td>Out of scope</td>
<td>Out of scope</td>
<td>Out of scope</td>
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<tr>
<td><strong>Spectroradiometer requirement</strong></td>
<td>380 to 780 nm, 5 nm or less bandwidth and interval. Wavelength scale uncertainty ≤ 0.3 nm (9.1.3)</td>
<td>JIS</td>
<td>380 to 780 nm, 5 nm or less bandwidth and interval</td>
<td>380 to 780 nm, 5 nm or less bandwidth and interval</td>
<td>380(380) to 830(780) nm, 5 nm or less bandwidth and interval, wavelength scale is within 0.3nm(9.2)</td>
<td>Out of scope</td>
<td>Out of scope</td>
<td>Out of scope</td>
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<tr>
<td><strong>Measurement uncertainty</strong></td>
<td>Uncertainty is required. (but not required for accreditation using test methods other than EN13032-4)</td>
<td>CEN</td>
<td>Uncertainty statement is required. Use of default uncertainties is allowed in Option.</td>
<td>Specified, but not required.</td>
<td>Not specified.</td>
<td>Specified, but not required.</td>
<td>Not specified.</td>
<td>Specified, but not required.</td>
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