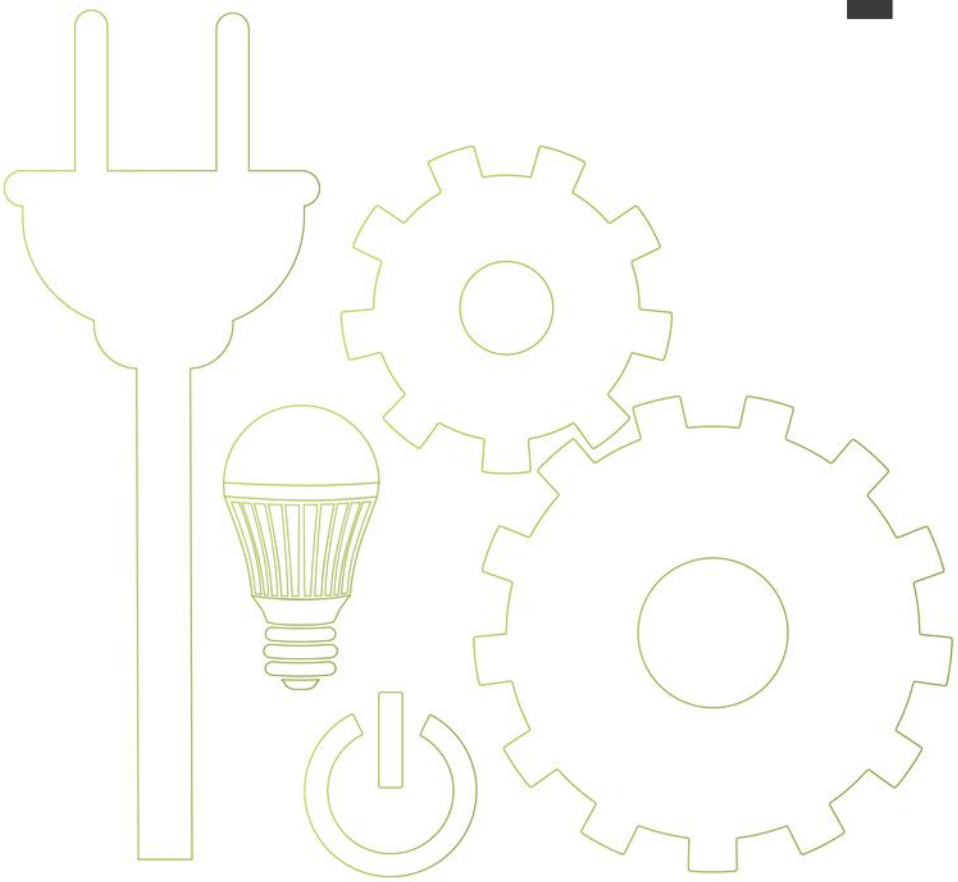
Energy Efficient End-use Equipment
International Energy Agency



Solid State Lighting Annex:
Task 1: Application Study of CIE S 025/E:2015

Supporting Document for IC 2017

Energy Efficient End-use Equipment (4E)
International Energy Agency

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iea Energy Technology Network

IEA 4E Solid State Lighting Annex
Task 1: Application Study of CIE S 025/E:2015

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About the IEA 4E Solid State Lighting Annex: The SSL Annex was established in 2010 under the framework of the International Energy Agency's Energy Efficient End-use Equipment (4E) Implementing Agreement to provide advice to its member countries seeking to implement quality assurance programmes for SSL lighting. This international collaboration was established by the governments of Australia, Denmark, France, Japan, The Netherlands, the Republic of Korea, Sweden, United Kingdom and the United States of America. Further information on the 4E SSL Annex is available from: http://ssl.iea-4e.org/

About the IEA Implementing Agreement on Energy Efficient End-Use Equipment (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 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. Twelve 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 include:

- The Electric Motor Systems Annex (EMSA)
- The Mapping and Benchmarking Annex
- The Solid State Lighting Annex (SSL)
- The Electronic Devices and Networks Annex (EDNA)

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

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Acronyms and Abbreviations

4E	Energy Efficient End-use Equipment
A	ampere
AC	alternating current
CCT	correlated colour temperature
CEN	European Committee for Standardisation
CIE	Commission Internationale de l´Eclairage (International Commission on Illumination)
CRI	Colour Rendering Index
D	photometric distance (e.g., of a goniophotometer)
Duv	distance from the Planckian locus
DUT	device under test
DC	direct current
GB	(*Guobiao,* Chinese national testing standard)
IEA	International Energy Agency
IES	Illuminating Engineering Society (of North America)
ILMD	imaging luminance measurement device
JIS	Japanese Industrial Standard
KS	Korean National Testing Standard
LED	light emitting diode
lm	lumen
ms	millisecond
NIST	National Institute of Standards and Testing (US Department of Commerce)
nm	nanometre
OLED	organic light emitting diodes
RoHS	Regulation of Hazardous Substances (Directive)
SSL	solid state lighting
TC	technical committee (of a standardisation body)
UK	United Kingdom
UNEP	United Nations Environment Programme
USA	United States of America
UV	ultraviolet
W	watt

1 Objective of Task 1

The objective of this task is to promote the use of the Commission Internationale de l'Eclairage (CIE) International Standard CIE S 025/E:2015 for light emitting diode (LED) based lighting products, also called Solid State Lighting (SSL) products. Given the title, "Test Method for LED Lamps, LED Luminaires and LED Modules", this standard was developed to be used by regulators and accreditation bodies around the world to harmonise the testing and accreditation of LED products.

2 Workplan of Task 1

Task 1, the Application Study of CIE S 025/E:2015, is divided into three subtasks:

Subtask 1: Technical Coverage of CIE S 025/E:2015

- Study which products and properties are covered by this standard.

Subtask 2: Inform Regulatory Agencies

- Develop a letter informing regulatory entities about CIE S 025/E:2015 and encourage these agencies to consider using it as the basis of test methods for regulations;
- Develop a table comparing CIE S 025/E:2015 to certain national test and measurement standards and attach it to the letter developed for regulatory entities; and
- Send the letter and attachment to both regulatory entities and accreditation bodies that are involved in or interested in SSL.

Subtask 3: Give Feedback to CIE

- Prepare recommendation(s) to CIE on future improvements to CIE S 025/E:2015 to support SSL regulations.

In addition to the work above, the SSL Annex will conduct outreach activities to manufacturers and the general public about CIE S 025/E:2015, via this report, through speaking engagements and by providing information on our website.

3 Subtask 1: Technical Coverage of CIE S 025/E:2015

The technical coverage of CIE S 025/E:2015 was investigated in preparation for subtask 2.

3.1 CIE S 025/E:2015 Scope

CIE S 025/E:2015 - Test method for LED Lamps, LED luminaires and LED modules was published in March 2015. A harmonised European standard with identical technical content to CIE S 025/E:2015 was published by the European Committee for Standardisation (CEN) in June 2015: *EN 13032 Lighting Applications — Measurement and presentation of photometric data of lamps and luminaires — Part 4: LED lamps, modules and luminaires.*

The scope of coverage for CIE S 025/E:2015 and EN 13032-4:2015(E) as reported in the respective standards are the same:

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).

Figure 1. Scope of Coverage of CIE S 025/E:2015

1 Scope

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

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

Figure 2. Scope of Coverage of EN 13032-4:2015 (E)

3.2 Coverage of Products

Table 1 presents a summary of which products are covered (*i.e.*, within scope) by CIE S 025/E:2015 and which are not covered (*i.e.*, out of scope).

Table 1. Summary of Product Coverage by CIE S 025/E:2015

Products covered	Products not covered
• LED lamps (integrated, non-integrated) • LED luminaires • LED modules (including LED light engines) • Covers AC and DC powered products	• OLED products • LED packages

Concerning the two products not covered by CIE S 025/E:2015, in March 2016, a new technical committee (TC) was formed in CIE Division 2 with the objective of preparing an amendment to CIE S 025/E:2015 that would extend the coverage to include OLED products. For LED packages, the Illuminating Engineering Society of North America (IES) published a standard in 2014 called: LM-85-14 *Approved Method for the Electrical and Photometric Measurements of High-Power LEDs*. LM-85-14 covers and sets measurement methods for LED packages. At the time of this report, there is no CIE standard that is similar to LM-85-14, but CIE plans to start this work.

3.3 Measurement Quantities Covered by CIE S 025/E:2015

On the following page, Table 2 lists the product quantities that are covered and the product quantities that are not covered by CIE S 025/E:2015.

Table 2. Coverage of Measurement Quantities in CIE S 025/E:2015

Quantities covered	Quantities not covered**
Photometric • Total luminous flux • Partial luminous flux (cone of lumens) • Luminous efficacy • Luminous intensity distribution • Luminance • Centre beam luminous intensity • Beam angle **Electrical** • Active power • Current (AC, DC) • Voltage (AC, DC) • Power factor (PF) **Colour** • Chromaticity coordinates (x, y), (u', v') • Correlated colour temperature (CCT) • Distance from Planckian locus (Duv) • Colour Rendering Index (CRI) • Angular colour uniformity ($\Delta_{u', v'}$)	• Long-term maintenance test of luminous flux (life test), etc. • Optical waveform (flicker) • Start-up time • Test methods for specific illumination applications • Standby power • Harmonic distortion

** Note: Some of these quantities are covered in other standards, such as those published by the IEC.

On the following page, Table 3 lists the technical parameters and product quantities that are included in the IEA 4E SSL Annex Quality and Performance Tiers[1]. This table indicates whether those same parameters and quantities are covered by the new international standard CIE S 025/E:2015.

[1] The IEA-4E SSL Annex has prepared voluntary quality and performance tiers to address product attributes such as colour, lifetime, power, and efficacy for common SSL applications. These product performance tiers are a limited number of proposed performance levels, agreed upon by IEA SSL Annex members, that could be utilised by government, non-profit and donor agencies when designing programmes and policies. The objective is to provide a limited number of levels that can be utilised by programme designers to reduce costs of writing specifications and to facilitate economic advantages for industry/trade. Further, they help minimise compliance costs with SSL programmes and policies. Member countries are not obligated to use the tiers, and they are not international standards. To view the SSL Annex quality and performance Tiers, please visit: http://ssl.iea-4e.org/product-performance

Table 3. Technical Parameters from Task 6 (Performance Tiers) and CIE S 025/E:2015

Technical Parameters in IEA 4E SSL Annex Quality and Performance Tiers (Task 6)	Covered in CIE S 025/E:2015
Total luminous flux (lm)	Yes
Active power (W)	Yes
Luminous efficacy (lm/W)	Yes
Correlated colour temperature (K)	Yes
Chromaticity coordinates and tolerance	Yes
Colour Rendering Index (CRI) (Ra)	Yes
Power factor (PF)	(Yes)
Centre beam luminous intensity	Yes
Angular colour uniformity	Yes
Harmonic distortion	Yes
Luminous intensity distribution 0—180°	Yes
Luminance (cd/m^2)	Yes
Standby power (W)	No
Dominant light modulation frequency (f) Modulation percent at this frequency (Mod%) (includes Flicker effects)	No
Photobiological risk group (blue light and UV hazard)	No
Luminous flux maintenance life (L70)	No
Rated lamp lifetime (F50)	No
Colour maintenance (Δu'v' at 6,000h)	No
Endurance test, cycle on-off time	No
Harmonic distortion	No
Dimmer compatibility	-
Safety	-
Warranty (duration)	-
RoHS compliance	-
Recyclable content (%)	-

3.4 Measurement instruments covered

The following list of lighting laboratory measurement instruments are covered by CIE S 025/E:2015:

- Sphere-photometer
- Sphere-spectroradiometer
- Goniophotometer
- Gonio-spectroradiometer
- Luminance meter

The following lighting laboratory measurement instruments are also accepted for use with CIE S 025/E:2015 as long as equivalent results are demonstrated. In other words, these measurement instruments are acceptable if they are demonstrated to produce results equivalent to those of a conventional integrating sphere system or conventional (*i.e.*, far-field) goniophotometer system:

- Integrating hemisphere
- Near-field goniophotometer
- Imaging luminance measurement device (ILMD)

Please note that "equivalent results" are not defined in CIE S 025/E:2015, and thus when using one of the above three instruments in accreditation testing, the judgement of equivalency is left to the accreditation body (AB) assessors. Some work is in progress to address this issue in CIE Division 2, such as, Direct Reportership DR2-70 *Guide for the Field Photometric Measurements for the Verification of Lighting Systems* and TC 2-59: *Characterisation of Imaging Luminance Measurement Devices*.

3.5 Standard Test Conditions

Standard test conditions for measurements made using CIE S 025/E:2015 include:

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

These tolerance ranges already include the uncertainty of measurement of the parameters. Therefore, laboratories are required to know the uncertainties of measurement of these parameters. To address this, the following new concepts are introduced and discussed in CIE S 025/E:2015:

- Tolerance interval: interval of permissible values of a property; and
- Acceptance interval: interval of permissible measured quantity values.

3.6 Requirements for Electrical Measurement Instruments

Tolerances and/or requirements of equipment used for electrical measurements in CIE S 025/E:2015 include:

- Calibration uncertainty of AC voltmeters and ammeters: ≤ 0.2 % for AC, and ≤ 0.1 % for DC;
- 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: ≤ 1.5% (≤ 3 % for PF > 0.9) at DUT terminal;
- AC power supply frequency uncertainty: ≤ 0.2 %;
- DC power supply voltage AC ripple: ≤ 0.5 %;
- Stabilisation time: ≥ 30 min, and, variation in light output and power: ≤ 0.5 % in 15 min (LED lamp, LED luminaire); and
- Variation in set t_p: ≤ ±1 °C in 15 min (LED module).

3.7 Requirements for Photometric Measurement Instruments

Tolerances and/or requirements of equipment used for photometric measurements in CIE S 025/E:2015 include:

- f1' of the photometer system (goniophotometer, sphere): ≤ 3 %;
- f2 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: ≤ 0.5 nm;
- Angle uncertainty of goniophotometers: ≤ 0.5°; and
- Photometric distance of goniophotometers:
  - Near cosine (beam angle ≥ 90°): ≥5 × D;
  - Broad distribution (beam angle ≥60°): ≥10 × D;
  - Narrower distribution: ≥15 × D.

  Note: D is the largest dimension of the luminous area of the DUT.

3.8 Requirements for Measurement Uncertainty

The uncertainties of measurements made with CIE S 025/E:2015 shall be evaluated according to ISO/IEC Guide 98-3 and its supplements. Guidance on measurement uncertainty is also available from CIE 198, "Determination of Measurement Uncertainties in Photometry"[2]. For all measured quantities, the expanded uncertainty shall be given and expressed for a confidence level of 95 %.

[2] CIE 198:2011: Determination of Measurement Uncertainties in Photometry. See: http://www.cie.co.at/index.php?i_ca_id=824

For the purposes of testing, if all tolerance conditions are met without any corrections, each test report may show uncertainty values for a typical product of the similar type, with a statement that indicates so in the test report. In this case, labs shall have a detailed uncertainty budget for a typical product of the same type as the device under test (DUT); e.g., phosphor white LED type or RGB type, omnidirectional or directional (of similar beam angle), at CCTs close to that of the DUT (e.g., 3000 K, 4000 K, 6500 K). Furthermore, laboratories must consider the following:

- NOTE 1: In this context, products could be considered of similar type if the following properties are the same as the DUT: phosphor type or RGB(A) type; compact or tubular type; similar intensity distributions; omnidirectional or directional (beam angle between +50 % and -25 % of the value of the DUT); CCT within ±15 % of the CCT value of the DUT.
- NOTE 2: An example statement in the test report: “The uncertainty values stated in this test report are those for a similar type of product: phosphor type LED lamp (compact), directional (beam angle 60°), CCT 3500 K.” If the type of DUT does not match the type categories listed in NOTE 1, the product type should be described specifically.
- NOTE 3: When corrections are applied to the results, the correction must always use the characteristics of the DUT (or product of the same model).

4 Subtask 2: Inform Regulatory Agencies

A letter that informs regulatory agencies and relevant organisations about CIE S 025/E:2015 and the IEA 4E SSL Annex's encouragement for consideration of its use in regulations was prepared (Appendix 1). A test method comparison table also was developed as an attachment to the letter (Appendix 2). This table offers brief notes on important items explaining the differences between the respective existing national test standards and CIE S 025/E:2015. Test method comparisons were made with these standards and/or specifications from China, Japan, Korea and the USA. Europe adopted a harmonised standard with identical technical content to CIE S 025/E:2015 by CEN in 2015: EN 13032 Lighting Applications — Measurement and presentation of photometric data of lamps and luminaires — Part 4: LED lamps, modules and luminaires. China is in the process of adopting CIE S 025/E:2015 as its national standard test method for SSL products.

The IEA 4E SSL Annex is sending letters with the test method comparison tables to the regulatory agencies, accreditation bodies and standards developing organisations listed in Table 4.

Table 4. Regulatory Agencies and Accreditation Bodies Receiving Letters from SSL Annex

Country	Organisations
Australia	• Greenhouse Energy Minimum Standards (GEMS) Regulator, Department of the Environment and Energy http://www.energyrating.gov.au/suppliers/legislation • National Association of Testing Authorities (NATA) http://www.nata.com.au/nata/ • National Measurement Institute (NMI) http://www.measurement.gov.au/Services/calibrationtesting/Pages/PhotometryandRadiometry.aspx • Standards Australia (SA) http://sdpp.standards.org.au/Committee.aspx?sector=Electrotechnology%20and%20Energy • NSW Gov - Energy Savings Scheme (IPART - ESS) http://www.ess.nsw.gov.au/Home • ACT Gov - Energy Efficiency Improvement Scheme (EPD - EEIS) http://www.environment.act.gov.au/energy/smarter-use-of-energy/energy_efficiency_improvement_scheme_eeis • SA – Retailer Energy Efficiency Scheme (ESC - REES) http://www.escosa.sa.gov.au/industry/rees/overview/rees-overview • Vic Gov – Victorian Energy Efficiency Target (ESC - VEET) https://www.veet.vic.gov.au • Illuminating Engineering Society of Australia and New Zealand (IES ANZ) http://www.iesanz.org/

Country	Organisations
Belgium	• Belgian Accreditation Council (BELAC); Federal Public Service Economy - Division Accreditation (http://economie.fgov.be/en/entreprises/life_enterprise/quality_policy/Accreditation/)
Brazil	• National Institute of Metrology, Quality and Technology (INMETRO) (http://www.inmetro.gov.br/english/)
Canada	• Canadian Association for Laboratory Accreditation, Inc. (CALA) (http://www.cala.ca/) • Canadian Standards Association (CSA) (http://www.csagroup.org/) • Natural Resources Canada (NRCan) (http://www.nrcan.gc.ca/home)
China	• China National Accreditation Service for Conformity Assessment (CNAS) (https://www.cnas.org.cn/english/) • General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (http://www.aqsiq.gov.cn/) • Standardisation Administration of the People's Republic of China (http://www.sac.gov.cn/) • China National Institute of Standardisation (CNIS) (http://en.cnis.gov.cn/) • Ministry of Science and Technology of the People's Republic of China (MOST) (http://www.most.gov.cn/eng/)
Denmark	• Danish Accreditation (DANAK) (http://english.danak.dk/) • Ministry of Business and Growth, Denmark (http://www.evm.dk/english) • Danish Ministry of Energy, Utilities and Climate (http://www.efkm.dk/en) • Danish Energy Agency (Energistyrelsen) (https://ens.dk/en) • DFM Danish National Metrology Institute www.dfm.dtu.dk/index.php?id=113&L=title%3DCentre • Danish Standards (DS) (http://www.ds.dk/en) • Danish Secretariat for Ecodesign and Energy Labelling of Products
Europe	• DG Energy • DG Internal Market, Industry, Entrepreneurship and SME • European Accreditation (EA)
Finland	• Finnish Accreditation Service (FINAS)

Country	Organisations
France	• Comité Français d'Accréditation (COFRAC) (http://www.cofrac.fr/)
Germany	• Deutsche Akkreditierungsstelle GmbH (DAkkS) (http://www.dakks.de/en/startseite)
Hong Kong	• Hong Kong Accreditation Service (HKAS) (http://www.itc.gov.hk/en/quality/hkas/about.htm#)
Republic of Korea	• KOLAS – Korea Laboratory Accreditation Scheme (KOLAS)
The Netherlands	• Raad voor Accreditatie (RVA) / Dutch Accreditation Council (https://www.rva.nl/en)
New Zealand	• International Accreditation New Zealand (IANZ) (http://www.ianz.govt.nz/) • New Zealand Energy Efficiency and Conservation Authority (EECA) https://www.eeca.govt.nz
Russia	• Federal Accreditation Service (FAS), The Russian Government (http://government.ru/en/department/233/)
Sweden	• Swedish Board for Accreditation and Conformity Assessment (SWEDAC) (https://www.swedac.se/?lang=en) • SEK Svensk Elstandard (www.elstandard.se) • SIS Swedish Standards Institute (www.sis.se) • Belysningsbranschen (Swedish association of lighting companies) (www.belysningsbranschen.se)
Taiwan	• Taiwan Accreditation Foundation (TAF) (http://www.taftw.org.tw/wSite/mp?mp=2)
United Kingdom	• United Kingdom Accreditation Service (UKAS) (https://www.ukas.com/)
United States of America	• National Voluntary Laboratory Accreditation Program (NVLAP) (http://www.nist.gov/nvlap/) • Perry Johnson Laboratories Accreditation (PJLA) (http://www.pjlabs.com/) • Accreditation Services Bureau (A-S-B) (http://l-a-b.com/about-lab/) • International Accreditation Service, Inc. (IAS) (http://www.iasonline.org/) • American Association for Laboratory Accreditation (A2LA) (https://www.a2la.org/) • ANSI-ASQ National Accreditation Board (ANAB) (http://anab.org/)

Country	Organisations
Multinational	• UN Environment - United for Efficiency (U4E) (http://united4efficiency.org/) • UN Development Program (request that email is forwarded to all regional Technical Advisors for dissemination to their lighting projects) • Asia Pacific Laboratory Accreditation Cooperation (APLAC) https://www.aplac.org • International Association of Lighting Designers (IALD) https://www.iald.org/ • International Laboratory Accreditation Cooperation (ILAC) (request that email is included in newsletter and information disseminated to members of ILAC, including APLAC, EA, etc.) • International Association of Lighting Designers (IALD) https://www.iald.org/ • Global Lighting Association (GLA) http://www.globallightingassociation.org • International Solid State Lighting Alliance http://isa-world.org • Commission internationale de l'éclairage (CIE) http://www.cie.co.at • International Electrotechnical Commission (IEC) http://www.iec.ch • The Illuminating Engineering Society (IES) https://www.ies.org • The ASEAN Centre for Energy (ASEAN-ACE) http://www.aseanenergy.org • ASEAN SHINE http://www.aseanshine.org

5 Subtask 3: Give Feedback to CIE

This Task 1 report will be placed in the public domain and shared with CIE Division 2. The following points have been identified by the SSL Annex Task 1 for possible areas of improvement to CIE S 025/E:2015 or areas where CIE may consider developing additional documentation to provide supplemental guidance on these important topics:

- **Uncertainty evaluation**: CIE S 025/E:2015 requires reporting the uncertainty of all measurement results, though not for every product tested. The SSL Annex IC 2013[3] found that many laboratories have difficulty in evaluating uncertainties, especially quantities calculated from spectral data. Some of the uncertainty values (e.g., chromaticity x, y) reported by some laboratories were unreasonable. In CIE S 025/E:2015, Section 8 and Annex D provide some information and examples, but these do not necessarily meet the needs of all the laboratories. More detail and very clear step-by-step guidance is needed.

- **Near-field goniophotometer accreditation**: many laboratories are using near-field goniophotometers. Some of these laboratories are seeking testing accreditation, e.g., for ENERGY STAR measurements. However there is currently no guidance on test methods and acceptance criteria for near-field goniophotometers. It would be helpful therefore if CIE were to publish recommendations on this topic through DR2-69, *Technical note on the validation of a near-field goniophotometer*.

- **AC power measurements**: the SSL Annex's IC 2013 identified larger than expected variations in AC electrical measurements. Other studies reported that such variations may be caused by differences in power supply impedance. It would be helpful therefore if CIE were to publish recommendations on a method to stabilise the impedance effect (used with a power supply).

- **Centre beam luminous intensity**: the measurement of centre beam luminous intensity is determined based on "observed beam axis (the axis about which the luminous intensity distribution is substantially symmetrical)," according to a Note in section 6.6 of CIE S 025/E:2015. However, this definition of centre beam luminous intensity is ambiguous. Some laboratories may have difficulty following the guidance. A clearer definition using a formula would be helpful for laboratory experts conducting such measurements.

[3] The SSL Annex conducted an Interlaboratory Comparison 2013 (IC 2013) between October 2012 and August 2013 which involved 110 laboratories comparing measurements of photometric, colorimetric, and electrical quantities of several different types of SSL products. For information about IC 2013 and to download a copy of the final report, please visit: http://ssl.iea-4e.org/news/2013-ic-final-report

- **Definition of 'beam angle'**: in CIE S 025/E:2015, beam angle in a plane is defined but beam angle of a lamp is not defined. A definition or test procedure to determine beam angle of a lamp may be needed. For example, section 4.5.3 of CIE S 025/E:2015 specifies a photometric distance depending on the beam angle of DUT. There is a question of how to determine the correct photometric distance if the beam profile is not rotationally symmetric.

In addition to these possible areas of improvement to CIE S 025/E:2015 or areas where CIE may consider developing additional documentation to provide clarification, the SSL Annex is going to be conducting its Interlaboratory Comparison 2017 (IC 2017) of Goniophotometer Measurements. If any additional issues are identified through the work with laboratories, these issues will also be written up in the Final Report of IC 2017 and provided to the CIE.

6 Outreach Activities

The following are a sample of some of the outreach activities conducted by the SSL Annex to raise awareness about CIE S 025/E:2015 and the value of having a global, harmonised test method for LED lamps, luminaires and modules:

- News item and final report for IC 2013 published, "Worldwide comparison of 110 LED testing laboratories: Results Presented" by IEA 4E SSL Annex on 10 September 2014. http://ssl.iea-4e.org/news/2013-ic-final-report

- Article published, "110 labs in world's largest interlaboratory comparison of LED test labs – improving testing competency to support market transformation," in: eceee 2015 Summer Study on Energy Efficiency proceedings, June 2015. https://www.nist.gov/node/796401

- SSL Annex Expert, Dr. Yoshi Ohno, lectured in Beijing on "*Photometric Measurement Based on CIE S 025*" at an Industry Workshop on April 21, 2015 and at the UNEP-lites.asia Laboratory Training Workshop, April 22-24, 2015 in Beijing, China[4].

- SSL Annex Expert, Steve Coyne, provided training for the UN Environment's en.lighten initiative in conjunction with lites.asia on CIE S 025/E:2015 in Jakarta, Indonesia, August 2014. http://www.lites.asia/downloads/in-country-training

- SSL Annex Expert, Dr. Yoshi Ohno, assisted CIE Australia President, Tony Bergen (AU), for UNEP's webinar on CIE S 025, for approximately 100 participants.

- CIE Division 2 organized the CIE Tutorial and Expert Symposium *on CIE LED measurement standard S 025*" in Braunschweig, Germany, November 25-26, 2015. Ohno lectured on integrating sphere measurements: http://div2.cie.co.at/?i_ca_id=974

- The 2nd CIE Tutorial and Expert Symposium on CIE S 025/E:2015 held in Braunschweig, Germany in November, 2015.

- SSL Annex Expert, Dr. Yoshi Ohno presented a talk entitled "Light quality – international standards" on test methods and light quality of SSL products at the "Nordic Light Quality - International standards" conference at the Technical University of Denmark, (DTU) Roskilde, Denmark in November 7, 2016.

[4] Dr. Ohno's slides from the 24-25 April 2015 UNEP-lites.asia Laboratory Training Workshop in Beijing, see: http://www.lites.asia/files/otherfiles/0000/0412/Session_1_Photometric_measrement_based_on_CIE_S_025.pdf

- SSL Annex Expert, Dr. Yoshi Ohno presented a talk at the CIE Division 2 meeting, Tutorial and Practical Workshop on LED Lamp and Luminaire Testing to CIE S 025 on 8-11 May 2017, METAS Bern-Wabern, Switzerland.

7 Evidence of Use of CIE S 025/E:2015 Around the World

This section provides a few examples of organisations and programmes that are applying CIE S 025/E:2015 into their activities. This list is by no means comprehensive, however it provides an indication of the global adoption and harmonisation of this measurement standard.

- IEA 4E SSL – Interlaboratory Comparison 2017
    - Participant labs: Yet to be advertised
    - Nucleus labs: KILT (Korea); LNE (France); NIST (USA, reference); NLTC (China)
- IEA 4E SSL – Task 6 Quality and Performance Tiers
- IEA 4E SSL – member country LED product benchmarking for Australia, Denmark and Sweden
- European – EN 13032-4:2015 is harmonised with CIE S 025, and is therefore referenced for use by the European ecodesign directive, regulating LED products in Europe.
- UNDP Ukraine – Inter-laboratory Comparison 2016/2017 – five Ukraine government laboratories and NLTC (China) nucleus lab
- UNEP ASEAN SHINE – regional LED lamp benchmarking programme; participant countries are: Cambodia, Indonesia, Laos PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. The test lab for this project is LEDlab, Australia.
- Australia & New Zealand Energy Efficient Lighting Regulation – CIE S 025:E/2015 is being considered as the test method for proposed MEPS for LED products
- Clean Energy Ministerial's Super-efficient Equipment and Appliance Deployment (SEAD) Global Efficiency Awards – basis for competition quality requirements

Appendices

Appendix 1. Letter to Regulatory Agencies and Accreditation Bodies

Appendix 2. Test Method Comparison with the national standards for China, Japan, Korea and the USA

- Comparison for China (CIE S 025/E:2015 and China standards and specifications)
- Comparison for Japan (CIE S 025/E:2015 and JIS C7801 & C8105-5)
- Comparison for Korea (CIE S 025/E:2015 and KS C 7653 & C 7651)
- Comparison for the USA (CIE S 025/E:2015 and IES LM-79-08)

Appendix 1. Letter to Regulatory Agencies and Accreditation Bodies

XX July 2017

TO: xxxx (Representatives of government regulatory agencies dealing with SSL)
xxxx (Representatives of accreditation bodies dealing with SSL)

Re: Recommendation on the use of CIE Test Method Standard CIE S 025/E:2015 in regulatory programmes and accreditation programmes

Dear xxxx,

The Solid-State Lighting (SSL) Annex was established in 2010 under the framework of the International Energy Agency's (IEA) Energy Efficient End-use Equipment (4E) Implementing Agreement to provide advice to its member countries seeking to implement quality assurance programmes for SSL lighting. This international collaboration works to assist governments of member countries in promoting SSL as a means to reduce energy consumption worldwide.[5]

Regulations and government programmes are needed to accelerate wide-spread market adoption of SSL products, and, to promote energy-efficient, quality products while removing poor-performing products from the market. Regulations and programmes are already in place or are being developed in different regions of the world. To support these regulations, various test standards have been developed, in many cases at national or a regional level. National and regional programmes need testing accreditation programmes to support such regulations and government programmes. In today's market, different test standards used in regulations in different countries or regions are creating a trade barrier because an international test standard was lacking.

To address this problem, the International Commission on Illumination (CIE) developed and published an international test method for LED lighting products, CIE S 025/E:2015 ("*Test Method for LED lamps, LED luminaires, and LED modules*"). This international test standard is available for purchase[6]. It was developed by a CIE technical committee comprised of many expert members from around the world including Asia, Europe, North America and Oceania.

[5] The SSL Annex works internationally to support efforts at a national and regional level by addressing critical challenges with SSL technologies. The Annex member countries believe that there are significant advantages in engaging in an international collaboration in order to develop a consensus on harmonised approaches to SSL performance and quality. The SSL Annex was established by the governments of Australia, Denmark, France, Japan, The Netherlands, the Republic of Korea, Sweden, United Kingdom and the United States of America. China works as an expert member of the 4E SSL Annex. The work of the SSL Annex spans a wide range of initiatives which can be found on the Annex's website: http://ssl.iea-4e.org/, including guidance for policy makers, quality and performance tiers and support for laboratory accreditation.
[6] To purchase a copy of CIE S 025/E: 2015, visit http://www.techstreet.com/cie/standards/cie-s-025-e-2015?product_id=1893005

In the drafting of this international standard, the needs and situations of various regions around the world were considered and are reflected. Regional test method standards were investigated and many of the requirements in CIE S 025/E:2015 were made compatible, while some new concepts and requirements were introduced to enable global agreement in measurement results. If you are establishing or updating regulations or programmes that relate to the performance of LED products, the IEA 4E SSL Annex recommends that you consider using CIE S 025/E:2015 as the test standard for product performance measurements, which would also avoid the duplication of efforts to develop LED test methods in your country.

LED lighting product test reports issued in some countries are not accepted by programmes in other countries or regions because the regional test methods used are inconsistent and not compatible. If one international test method (i.e., CIE S 025/E:2015) is used in regulations across all regions, then testing accreditation programmes can be based on the same test method, and results can be mutually recognised so that test reports from one region are accepted in other regions.

Proficiency testing of LED products can also be shared if an accreditation body that has no proficiency test capability for these products wishes to establish an LED testing accreditation programme in their country. For example, in the United States, the National Institute of Standards and Technology (NIST) provides proficiency test services on IES LM-79 for several accreditation bodies that do not have an LED proficiency test but provide LED testing accreditation for the ENERGY STAR programme. A similar system could be established internationally by using CIE S 025/E:2015 as the reference test method, enabling LED test accreditation programmes to be mutually recognised globally, and test reports to be accepted universally. This would reduce manufacturers' costs, facilitate international trade and further accelerate the adoption of SSL products globally.

The SSL Annex requests cooperation from your country in this global endeavour. We would appreciate it if you, as an administrator of government regulations, testing accreditation programmes, voluntary programmes, or performance standards for LED products would consider using the international test method, CIE S 025/E:2015, in your future programmes.

The SSL Annex has several technical experts who are familiar with the CIE standard. We are willing to assist with any questions you may have. For your information and assistance, we prepared a detailed Test Method Comparison Table (see attached) which compares the testing requirements in China, Korea, Japan and the USA with those of CIE S 025/E:2015. This comparison includes notes explaining the differences for each item.

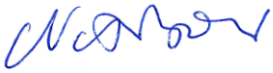
We would be pleased to support your decision to use the international test method in place of a regional or national test method. Please feel free to contact us with any questions you may have.

We thank you in advance for your consideration of this request.

Sincerely,

Peter Bennich, PhD
Management Committee Chair,
SSL Annex;
Energy Efficiency Department,
Swedish Energy Agency

Dr. Yoshi Ohno
Task 1 Leader, SSL Annex;
National Institute of
Standards and Technology,
US Department of Commerce



Nils Borg
Operating Agent,
SSL Annex

Attachment: Table of comparison between CIE S 025/E:2015 and national standards for China, Japan, Korea and the USA.

Appendix 2. Test Method Comparison Table

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
	Published 2015-3 (entries updated 2015-5)	2008 (published)	Comparison notes (red: S025 is stricter)	2009 (published), 2012 (supplement 1 will be published). Self ballasted LED lamp is in the scope of this document.	**2014 update**	**2014 update**		**2016 update**	2016 updated	2014 updated	Comparison notes (red: S025 is stricter)	Published 2015-3 (entries updated 2015-5)
	Thermal Conditions											
1	**Ambient Temperature**	25 ± 1.2 °C (4.2.2) (Uncertainty must be subtracted.)	25 ±1 °C (2.2)	The tolerances are similar. If the uncertainty is 0.2° (k=2), the LM-79 tolerance (±1°C) is the same as S025.	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)	20 to 30 °C (Incandescent lamp, HID lamp, Low-pressure sodium lamp) 23 to 27 °C (Other lamps (include LED))	JIS temperature ranges are very large compared to S025 or LM-79. Errors for some products can cause significant errors for the large tolerance.	25 ±1 °C		(25±3) °C	(25±3) °C	Major differene. S025 condition is stricter. Other specifictions are typically ±1 °.
2	**Outside the specified temperature range**	Allowed if correction is applied.	Not specified (not allowed)	S025 provides an option for labs that have difficulty.	Not specified	Not specified	S025 provides an option for labs that have difficulty.	Allowed if correction is applied	S025 provides an option for labs that have difficulty.	Not specified	Not specified	Korean range is allowed under this option in S025.
3	**Products with feedback control**	Tested the same way as normal products.	Not specified	This is only for special products.	Not specified	Not specified	This is only for special products.	Not specified	This is only for special products.	Not specified	Not specified	
4	**Measurement point of ambient temperature**	at points representative of the near surrounding of the DUT. (4.2.2)	not more than 1 m from device and at the same height	LM-79 is more specific.	fully away from the light source and the integrating sphere wall, at the same height, and the temperature sensor of a thermometer shall not be directly subjected to light irradiation of the light source	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.	JIS is more specific.	Not more than 1m from device at the same height, without direct irradiation		Not specified	Not specified	Specified in S025
5	**For products specified for ambient temperature other than 25 °C**	unless measurement is made at that temperature, measurement results at 25,0 °C are first reported, then a service conversion factor shall be established (4.2.2)	Not specified.	This is only for special products.	Not specified	Not specified	This is only for special products.	For the lamps with declared applicable ambient temperature range more wide, tests under Tmax±2°C and Tmin±2°C should also be performed.		Not specified	Not specified	

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
6	**Temperature measurement resolution**	Not specified, but need to be known (as a part of uncertainty of temperature measurement)	Not specified	In S025, this is inclusive in 7.	Not specified	Not specified	In S025, this is inclusive in 7.	0.1℃ (informative)	In S025, this is inclusive in 7.	Not specified	Not specified	
7	**Temperature measurement uncertainty**	Not specified, but uncertainty of thermometer need to be known (used to determine acceptance interval of ambient temperature	Not specified	In S025, labs need to know the uncertainty of thermomoeter. (It is a problem in LM-79 that the uncertainty of this parameter was ignored.)	Not specified	Not specified	In S025, labs need to know the uncertainty of thermomoeter. (It is a problem in LM-79 that the uncertainty of this parameter was ignored.)	Not specified	In S025, labs need to know the uncertainty of thermomoeter. (It is a problem in LM-79 that the uncertainty of this parameter was ignored.)	Not specified	Not specified	Required in S025
8	**Relative humidity**	Not specified	Not specified	Same	less than 75%	less than 75%	Same	less than 65%		equal or less than 65 %	equal or less than 65 %	S025 does not specify this
9	**Mounting method**	The test device shall be mounted so that any thermal conduction through supporting elements holding the device causes negligible unintended cooling effects (5.3.1)	Supporting objects shall not cause cooling effect (2.3)	Same requirements.	Not specified	Not specified	This is additional consideration for some cases.	heat insulation material shall be used		LED luminaire shall be mounted according to actual use, unless otherwise specified by manufacturer.	LED lamp shall be mounted and operated in the condition on base-up, unless otherwise specified by manufacturer.	<- operating position.
10	**Air flow / Air movement**	Tolerance interval: 0 m/s to 0,25 m/s (uncertainty must be subtracted)	Only guidance with no number requirement (2.4)	In S025, air flow must be measured.	Only guidance with no number requirement (5.2)	Only guidance with no number requirement (7.2)	In S025, air flow must be measured.	only guidance without number requirement for normal test. For test under Tmax/Tmin±2℃, shall be ≤0.2m/s	In S025, air flow must be measured.	draught-free	draught-free	S025 requires to measure air flow with uncertainty.
11	**Uncertainty of air velocity measurement**	Not specified but uncertainty of anemometer need to be known (used to determine acceptance interval of air velocity)	not required	In S025, labs need to know the uncertainty of anemometer.	Not specified	Not specified	In S025, labs need to know the uncertainty of anemometer.	Not specified	In S025, labs need to know the uncertainty of anemometer.	Not specified	Not specified	
	Electrical Conditions											
12	**Test voltage (AC and DC)**	±0,4 % for AC; ±0,2 % for DC (uncertainty must be subtracted)	Rated voltage (AC or DC) of the product (7.0) -- no tolerance	Tolerance specified in S025. (It was a problem in LM-79 that a tolerance was not specified. This is the important parameter.)	Rated electric condition (Volt, Current, power) of the product (4.2) -- no tolerance	Rated electric condition (Volt, Current, power) of the product, or user specified condition (8.2.1) -- no tolerance	Tolerance is specified in S025. This is an important parameter. No tolerance is a problem.	AC220V50Hz. For the lamps declaring large voltage range, also Vmax and Vmin	Tolerance is specified in S025. This is an important parameter. No tolerance is a problem.	Rated Voltage shall be stabilized within ±0.5% during the stabilization period.	Rated Voltage shall be stabilized within ±0.5% during the stabilization period.	S025 is stricter.
13	**AC power supply THD**	≤ 1.5 % if PF≤ 0.9 ≤ 3 % if PF> 0.9 (4.3.3.2)	≤ 3% (3.1)	S025 is stricter.	≤ 3% (table.1 informative)	≤ 3% (table.3)	S025 is stricter.	≤ 3%	S025 is stricter.	≤ 3%	≤ 3%	S025 is stricter.
14	**AC power supply voltage regulation**	Within acceptance interval of test voltage	≤ 0.2 % (3.2)	This is not specified in S025 but inclusive in 12 in S025.	≤ 0.2% (table.1 informative)	≤ 0.2% (table.3)	This is not specified in S025 but inclusive in 12 in S025.	≤ 0.2%	This is not specified in S025 but inclusive in 12 in S025.	≤ 0.2%	≤ 0.2%	In S025, this is inclusive in AC Test voltage requirement in 12.
15	**DC power supply voltage regulation**	Within acceptance interval of test voltage	≤ 0.2 % (3.2)	This is not specified in S025 but inclusive in 12 in S025.	≤ 0.1% (table.1 informative)	≤ 0.1% (table.3)	This is not specified in S025 but inclusive in 12 in S025.	≤ 0.1% (informative)	This is not specified in S025 but inclusive in 12 in S025.	N/A	N/A	So, Korean test methods do not cover DC-driven products?

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
16	**AC power supply frequency**	≤ 0.2 % (4.3.3.2)	Not specified	Specified in S025. Most of recent AC power meters and analyzers show frequency.	≤ 0.2% (table.1 informative)	≤ 0.2% (table 3)	Same or similar.	≤ 5% (informative)	Specified in S025. Most of recent AC power meters and analyzers show frequency.	Not specified	Not specified	Specified in S025. Most of recent AC power meters and analyzers show frequency.
17	**DC power supply voltage AC ripple**	≤ 0.5 % of Dc voltage (4.3.3.3)	Not specified	Specified in S025. This is for DC-powered products.	Not specified	≤ 5% (table.3)	S025 much more strict.	NA	Specified in S025	N/A	N/A	Specified in S025
18	**AC voltmeter and ammeter uncertainty**	≤ 0.2% (4.3.2)	≤ 0.2% (8.2)	Same	≤ 0.2% (table.1 informative)	≤ 0.5% (table.4)	Same	Not specified		Not specified	Not specified	Required in S025. This is critical.
19	**DC voltmeter, ammeter Uncertainty**	≤ 0.1 % (4.3.2)	≤ 0.1 % (8.2)	Same	≤ 0.2% (table.1 informative)	≤ 0.5% (table.4)	S025 is more strict.	NA	Specified in S025	N/A	N/A	Specified in S025
20	**AC power meter uncertainty**	≤ 0.5% (4.3.2)	≤ 0.5% (8.2)	Same	≤ 0.2% (table.1 informative)	≤ 0.5% (table.4)	JIS is more strict.	Not specified	Specified in S025	Not specified	Not specified	Specified in S025. This is critical.
21	**AC power meter bandwidth**	≥ 100 kHz (4.3.2) A lower bandwidth may be accepted (5 kHz or 30 kHz) if the absence of significant high frequency components (respectively above 5 kHz or 30 kHz) is demonstrated	Not specified	Specified in S025. This factor is critical.	Not specified.	Not specified.	Specified in S025. This factor is critical.		Specified in S025. This factor is critical.	Not specified	Not specified	Specified in S025. This factor is critical.
22	**Voltage measurement point**	The set value is the rated supply voltage of the DUT, measured at the supply terminals of the DUT (4.3.1)	Not specified.	Specified in S025. This factor is critical.	Not specified.	Not specified.	Specified in S025. This factor is critical.	Not specified	Specified in S025. This factor is critical.	Not specified	Not specified	Specified in S025. This factor is critical.
	Test Procedures											
23	**Ageing / Seasoning**	according to the appropriate LED product performance standard (5.1) (typically no aging)	No aging (4.0)	This may be different in some cases. IEC standards should be referred.	Not specified	Not specified	S025 provides the condition. This condition should be specified.	1000 hrs or 0 hrs	Different. IEC standards should be referred.	100 hrs on steady-state	100 hrs on steady-state	Different. IEC standards should be referred.
24	**Stabilization of test device**	At least 30 min then within 0.5 % (light output and electrical power) in last 15 min (4.4.1) If pre-burned, "min 30 min" is not required.	light output and electrical power within 0.5 % in 30 min (5.0)	These requirements are very similar. LM-79 is slightly stricter.	secure the time until optical power is sufficiently stabilized(7.3)	Warm up the luminaire and goniophotometer sufficiently, and after confirming that they become stabilized, perform the measurement. (8.2.1)	JIS conditions are ambiguous. S025 provides clear procedure.	within 0.5% in 30min, and should not be change in the same direction	These requirements are very similar. S025 is slightly stricter.	Not specified	Not specified	Required in S025, this specification is critical.
25	**Monitoring stabilization**	monitor light output and electrical power every 1 minute (4.4)	monitor light output and electrical power at every 15 min or less apart.(5.0)	S025 is stricter but minor difference.	Not specified	for example, measures such as the measurement of luminous intensity performed at intervals of five minutes should be taken.(8.2.1)	S025 is stricter but minor difference.	monitor the light output and power every 5min	S025 is stricter but minor difference.	Not specified	Not specified	As in 24.

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
26	**If it takes very long time**	In case of large fluctuations, 45 min of operation for LED lamps or 150 min for LED luminaires. In case of slow decrease, 4.4.1 above will apply.	not specified	S025 provides a solution for special cases.	Not specified	Not specified	S025 provides a solution for special cases.	not specified	S025 provides a solution for special cases.	Not specified	Not specified	S025 provides a solution for special cases.
27	**Operating orientation/operating position**	The DUT shall remain in its designed operating condition throughout the stabilisation and testing period.(4.2.5) LED lamp: vertical base-up position, unless other operating orientation is specified by the applicant (5.3.1)	Use the operating position recommended by the manufacturer (6.0)	same. S025 has additional recommendation for LED lamp.	Based on a lamp standard	Not specified	S025 has requirement. This is critical.	Same with the design intention and normal operation, if no information, then base up, if others, should make correction	similar	LED luminaire shall be mounted according to actual use, unless otherwise specified by manufacturer.	LED lamp shall be mounted and operated in the condition on base-up, unless otherwise specified by manufacturer.	similar.
28	**Different position than specified by the manufacturer (or protocol)**	Allowed if correction applied. "If this requirement is not met, the measurements shall be corrected to the performance in the designed operating position." (4.2.5)	Not allowed.	S025 provides option for some labs that have difficulty.	Not specified	Not specified	S025 provides option for some labs that have difficulty.	not specified	S025 provides option for some labs that have difficulty.	Not specified	Not specified	S025 provides option for some labs that have difficulty.
29	**If a number of same type of products are measured**	Pre-burning is allowed. "measurement time may be reduced if it has been demonstrated that the pre-burning method produces the same stabilized condition as when using the normal procedure." (4.4.1)	pre-aging is allowed.	Same	Not specified	Not specified	S025 addresses the need in labs measuring many lamps.	Always require a number of same type of products measurement, pre-burning is allowed and commonly applied, but not written down in standards / specifications (from quality control aspect, requirements on stabilisation checking is sufficient).	S025 addresses the need in labs measuring many lamps.	Not specified	Not specified	S025 addresses the need in labs measuring many lamps.
30	**LED device with dimming control**	maximum light output for all tests or to pre-defined levels if instructed by the applicant. (5.4.1)	Maximum setting (7.0)	Same	Not specified	Not specified	S025 provides guidance for such products.	maximum power setting	Same	Not specified	Not specified	S025 provides guidance for such products.
31	**LED device with multiple/variable colour/CCT**	LED devices with adjustable colour points shall be adjusted or set to the defined settings as indicated by the manufacturer or applicant. (5.4.1)	measurement may be made at different modes of operation (and CCTs) if necessary, and such setting conditions shall be clearly reported (7.0)	similar.	Not specified	Not specified	S025 provides guidance for such products.	test under each condition	similar	Not specified	Not specified	S025 provides guidance for such products.

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
	Integrating Sphere											
32	**Calibration of int. sphere for luminous flux**	A sphere-spectroradiometer system shall be calibrated with or verified against a total spectral radiant flux standard traceable to the SI. (4.5.2.1) If total spectral radiant flux standard lamps are not available, the standard may be derived by the user from spectral irradiance standard lamp(s) and total luminous flux standard lamp(s), both traceable to the SI. A sphere-photometer shall be calibrated with a total luminous flux standard traceable to the SI (4.5.2.2)	Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required (9.1.6)	similar. S025 allows wider options for labs that have difficulty.	Calibration by total luminous flux or total luminous flux standards traceable to NMI is required (5.1)	Out of scope	similar. S025 allows wider options for labs that have difficulty.	Spectral radiant flux standard or total luminous flux standard		shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	similar. S025 allows wider options for labs that have difficulty.
33	**Self-absorption measurement for sphere system**	A self-absorption correction factor shall be applied by use of the auxiliary lamp method (CIE 84-1989) unless … (6.2)	Required (9.1)		if need(7.3,7.4)	Out of scope		required		Not specified	Not specified	Required in S025. This is critical.
34	**f1' of sphere photometer**	≤ 3% (for sphere system or goniophotomter) (4.5.1) (4.5.2.2)	≤ 3 %	Same	≤ 6 %	Out of scope	S025 tolerance is smaller, but this can be solved by an option for correction in S025.	＜3.5% (informative)	S025 tolerance is smaller, but this can be solved by an option for correction in S025.	Not specified	Not specified	Required in S025. This is critical.
35	**f2 of photometer head of sphere system**	≤ 15% (4.5.2)	≤ 15%	Same	Not specified.	Out of scope	S025 (and LM-79) makes this requirement only to avoid wrongly-desinged detector for the sphere.	not specified	S025 (and LM-79) makes this requirement only to avoid wrongly-desinged detector for the sphere.	Not specified	Not specified	S025 (and LM-79) makes this requirement only to avoid wrongly-desinged detector for the sphere.
	Goniophotometer											
36	**Operating position of LED device for goniophotometer**	The DUT shall remain in its designed operating condition throughout the stabilisation and testing period.(4.2.5)	Type C. Burning position shall not change on goniophotometer (9.3.1)	Same	Out of scope	Not specified.	This requirement is critical, as some products are affected by operating position.	type c. burning position and spatial position of the lamps should not change	Same			This requirement is critical, as some products are affected by operating position.

Item #	Document	CIE S 025: 2015 (EN 13032-4:2015)	IES LM-79-08	Remarks	JIS C7801 (Japan) for LED lamps	JISC8105-5 (Japan) for LED luminaire/lamp gonio	Remarks	China standards and specifications for LED lamps, luminaires	Remarks	KS C 7653 Recessed and fixed LED luminaires - Safety and Performance	KS C 7651 Self-ballasted LED lamps - Safety and Performance	Remarks
37	**Other than Type C**	Other position is allowed if correction is applied. "If this requirement is not met, the measurements shall be corrected to the performance in the designed operating position." (4.2.5)	Not allowed.	S025 provides an option for labs that have difficulty.	Out of scope		S025 provides an option for labs that have difficulty.	near-field goniophotometer may also applicable	S025 provides an option for labs that have difficulty.	Not specified	Not specified	S025 provides an option for labs that have difficulty.
38	**Scanning angle intervals**	No recommendation except for colour uniformity (see 52).	22.5° hor. 5 ° ver. (only guidance) (9.3.3)	LM-79 provides only guidance, not requirement.	Out of scope	specified(7.6).		No uniform requirement depending on the specific product characteristic.)		Not specified	Not specified	
39	**Uncertainty of angle setting**	≤ 0.5° (4.5.3) Resolution ≤ 0.1° (4.5.3)		Required in S025. This is critical for narrow-beam products.	Out of scope	Not specified	Required in S025.		Required in S025.	Not specified	Not specified	Required in S025.
40	**Angle coverage (for luminous flux)**	Goniophotometers having a large dead angle exceeding a solid angle of 0,1 sr (corresponding to a cone angle of approximately 10° radius) should not be used to measure total luminous flux of omnidirectional lamps or such luminaires unless appropriate correction procedures are implemented. (4.5.3)	Cover entire range of emission. dead angle ≤ ±10° allowed but correction needed (only guidance) (9.3.4)	Basically the same.	Out of scope	Not specified	Specified in S025 and LM-29. This is important for measuring total luminous flux of ombini-directional lamp.	not specified	Specified in S025 and LM-29. This is important for measuring total luminous flux of ombini-directional lamp.	Not specified	Not specified	Specified in S025 and LM-29. This is important for measuring total luminous flux of ombini-directional lamp.
41	**f1' of photometer head of the goniophotometer (including mirror)**	≤ 3% (4.5.1) (4.5.3.1)	≤ 3 %. (9.3.6)	Same	Out of scope	≤ 6 %	S025 tolerance is smaller, but this can be solved by an option for correction in S025.	≤ 3.5%	S025 tolerance is smaller, but this can be solved by an option for correction in S025.	Not specified	Not specified	Specified in CIE. This is critical.
42	**Calibration of goniophotometer for luminous flux measurement**	Goniophotometers shall be calibrated against a luminous intensity standard or illuminance standard traceable to the SI. Alternatively, calibrated against a total luminous flux standard traceable to the SI. (4.5.3.1)	luminous. Intensity or illuminance standards traceable to NMI, plus check with total luminous flux standard is required. (9.3.7)	Same	Out of scope	Calibration by specified standards traceable to NMI is required (6,annex A)	S025 is more specific.	Luminous intensity standard or total luminous flux standard	Specified in S025. This should be a requirement.	shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	In S025, goniophotometers are basically calibrated with a luminous intensity or illuminance standard. Luminous flux is verified with lluminous flux standard lamp.

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43	**Calibration of gonio-spectroradiometer for luminous flux measurement**	Gonio-spectroradiometers shall be calibrated against spectral irradiance or spectral radiant intensity standard traceable to the SI. Alternatively, calibrated against a total spectral radiant flux standard traceable to the SI, (4.5.3.2) If total spectral radiant flux is also measured, the values (expressed in W/nm) shall also be verified by measuring a total spectral radiant flux standard lamp traceable to the SI. (4.5.3.2)	The spectroradiometer used in this measurement (described in section 12.2) shall be calibrated against spectral irradiance or spectral radiance standards traceable to a national metrology institute. (12.2)	Same	Out of scope	Not specified	S025 is more specific.		Specified in S025. This should be a requirement.	shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	shall have the accuracy guaranteed -> it means that Calibration by total luminous flux or total spectral radiant flux standards traceable to NMI is required	Same as above except spectral.
44	**Luminous intensity distribution by goniophotometer**	Absolute photometry required. (6.1) (6.5.2)	Absolute photometry required.	Same	Out of scope	Calibration by luminous flux standards traceable to NMI is required (annex A)	S025 clarifies that relative photometry is not suitable for LED products.	Absolute photometry required	S025 clarifies that relative photometry is not suitable for LED products.	Not specified	Not specified	S025 clarifies that relative photometry is not suitable for LED products.
45	**Photometric centre of luminaire (for goniophotometry)**	the centre of the solid figure bounded in outline by the luminous surfaces. (5.3.3)	Not specified.	S025 provides clear instruction.	Out of scope	specified(7.4).	S025 provides clear instruction.		S025 provides clear instruction.	Not specified	Not specified	S025 provides clear instruction.
46	**Coordinate system for goniophotometer (data format)**	CIE C, γ (CIE 121) (6.5)	LM-63 format required. (10.0)	Basically the same	Out of scope	Specified (Annex D)--compatible to LM-63	Basically the same			Not specified	Not specified	
47	**Photometric distance of Goniophotometer for intensity distribution**	≥ 5 × D for beam angle ≥ 90° ≥ 10 × D for beam angle ≥ 60° ≥ 15 × D for steep gradients in the luminous intensity distribution or critical glare control ≥ 15 × (D+S) for large non-luminous spaces between the luminous areas	longer than five times of the longest dimension of the source (only guidance) (10.0)	Similar but S025 is more strict. This is important to reduce errors for narrow-beam products.	Out of scope	longer than five times of the longest dimension of the source (only guidance) (7.5)	Similar but S025 is more strict. This is important to reduce errors for narrow-beam products.	5m for reflector lamp	S025 is more strict. This is important to reduce errors for narrow-beam products.	Not specified	Not specified	Specified in S025. This is critical.
48	**Intensity distribution of LED luminaire with interchangeable LED lamps**	LOR may be determined for LED luminaires using interchangeable sources (e.g. LED lamps) in some cases. (3.31)	Not specified (not allowed)	S025 allows this for special cases.	Out of scope	Not specified.	S025 allows this for special cases.	not specified	S025 allows this for special cases.	Not specified	Out of scope	S025 allows this for special cases.

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49	**Beam angle**	Covered in 3.17 and 6.6		S025 provides a guidance.	Out of scope	specified(8.2.3), JIS is applying a beam spread, instead of a beam angle.	S025 provides a guidance.	IEC/TR 61341	S025 provides a guidance.	Out of scope	covered in annex F	S025 provides a guidance.
50	**Colour measurement**	Spatially averaged colour quantities are used for all LED lamps, light engines, and LED luminaires except otherwise specified by the manufacturer or applicant. (7.1)	Colour quantities shall be spatially averaged (with some exceptions). (12.0)	Same	Colour quantities shall be spatially averaged (when related with total luminous flux measurement). (9.2)	Out of scope	Same		Spetial average in S025. This is critical.	Not specified	Not specified	Spetial average in S025. This is critical.
51	**Angular steps for Spatial colour uniformity**	vertical angle interval of 10° or less (2,5° is recommended) and a horizontal angle interval of 90° or less (22,5° is recommended). For reflector lamps, the angle increments shall be 1/10 or less of the beam angle but no larger than 10°. (7.1.4)	Every 10 deg. Vertical and 2 horizontal planes 90 deg. Apart at minimum. Maximum deviation from spatial average. (12.5)	Similar. S025 is more strict for narrower beam products. The calculation formula for color uniformity are slightly different from those in CIE S 025. This may create minor differences in results.	Not specified.	Out of scope	S025 provides requirement		S025 provides requirement	Not specified	Not specified	S025 provides requirement
52	**Angle steps for a gonio-spectroradiometer or gonio-colorimeter for colour**	Same as above.	Every 10 deg. vertical and 2 horizontal planes 90 deg. apart at minimum. (12.2)	Similar. S025 is more strict for narrower beam products.	Not specified.	Out of scope				Not specified	Not specified	
53	**Gonio-colorimeter (calibration)**	may be used only for colour difference measurement (4.5.3.3)	shall be calibrated against spectroradiometer (at one point for that device under test) (12.2)	Same requirement.	Not specified.	Out of scope	Specified in S025 and LM-79		Specified in S025 and LM-79	Out of scope	Out of scope	Specified in S025 and LM-79
54	**Spectroradiometer requirement**	380 to 780 nm, 5 nm or less bandwidth and interval (4.5.2.1 sphere) (4.5.3.2 gonio)	380 to 780 nm, 5 nm or less bandwidth and interval	same	360(380) to 830(780) nm, 5 nm or less bandwidth and interval, wavelength scale is within 0.3nm(9.2)	Out of scope	Similar.		Specified in S025 and LM-79	Not specified	Not specified	Specified in S025 and LM-79
55	**Measurement uncertainty**	Uncertainty statement is required, but uncertainties of similar typical products can be reported in test reports. (8.)	Not required but some guidance given with references. (13.0)	Major difference. S025 requires it, though not every product tested.	specified, but not required.	Specified, but not required.	Major difference. S025 requires it.		Major difference. S025 requires it.	Not specified	Not specified	Major difference. Required in S025.