Product Categories

- Goniophotometer >
- Spectroradiometer >
- Integrating Sphere >
- LED Test Instruments >
- EMI and EMC Test Systems >
- Electrical Safety Tester >
- Environmental Test Chamber >
- AC and DC Power Supply >
- Object Color and Glossiness Test >
- Electronic Components Test >
- Test Finger, Test Probe, Test Pin >
- Plug, Switch and Cables Testing >
- Gauges for Plugs and Sockets >

LM-79 Moving Detector Goniophotometer (Mirror Type C)

Product No: LSG-6000

Leave a Message

Name*

Company*

Cell/WhatsApp

Email*

Message*

12 + 8 = Captcha*

Submit

Related Applications

HID Lamp Test Solutions

Description Video Download


CFL Lamp Test Solutions


LM-79 and LM-80 Test Solutions


LEDs and Luminaire Test Solutions

Related Standards


CIE S 025/E:2015 Test Method for LED Lamps, LED Luminaires and LED Modules and its supplement


IEC 62722-2-1:2023 Luminaire performance – Part 2-1: Particular requirements-LED luminaires

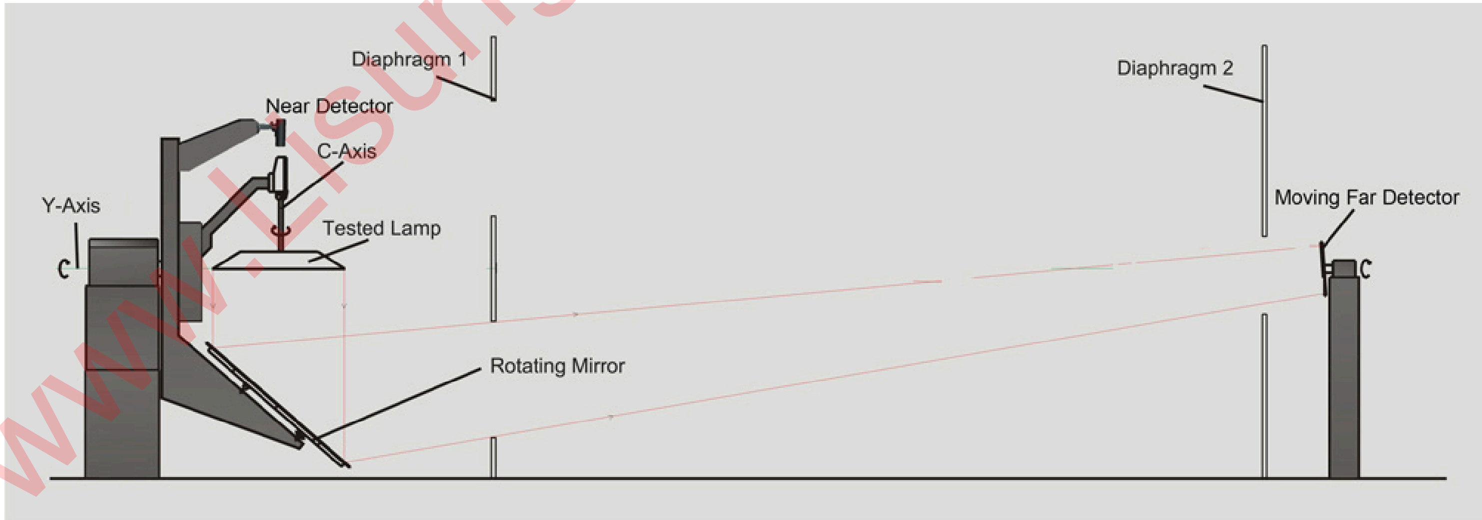

CIE 121:1996 The Photometry And Goniophotometry Of Luminaires


EN 13032-1: 2004 Light and Lighting – Measurement and Presentation of Photometric Data of Lamps and Luminaires – Part 1: Measurement and File Format

standard Clause 7.3.1. It’s an automatic light distribution intensity 3D curve testing system for measuring light. The darkroom can be designed according to the customer’s existing room size.

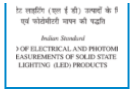
Standard:
LM-79-19 “Optical and Electrical Measurements of Solid State Lighting Products”
EN13032-1 “Light and lighting – Measurement and presentation of photometric data of lamps and luminaires – Part 1: Measurement and file format; German version EN 13032-1:2004+A1:2012”
CIE-121 ” The Photometry and Goniophotometry of Luminaires”
CIE S025 “Test Method for LED Lamps, LED Luminaires and LED Modules”

What is the use of goniophotometer?
The manufacturer of LSG-6000 gonio photometer is LISUN. It can measure all types of lighting sources, LED, Plant Lighting or HID luminaires such as indoor and outdoor luminaires, roadway luminaires, street lamps, flood lights and other kinds of luminaires.



LSG-6000 Moving Detector Goniophotometric Working Principle

Tags: LM-79 Moving Detector Goniophotometer , LSG-3000 , LSG-5000 , LSG-6000



Electrical and Photometric Measurements of Solid State Lighting (LED) Products

SASO 2870 Energy Efficiency, Functionality, and Labeling Requirements for General Light Sources

SASO 2927 Energy Efficiency Functionality and Labeling Requirements for Lighting Products – Part III: Street Lighting

SASO 2902 Energy Efficiency, Functionality and Labelling Requirements for Lighting Products Part 2

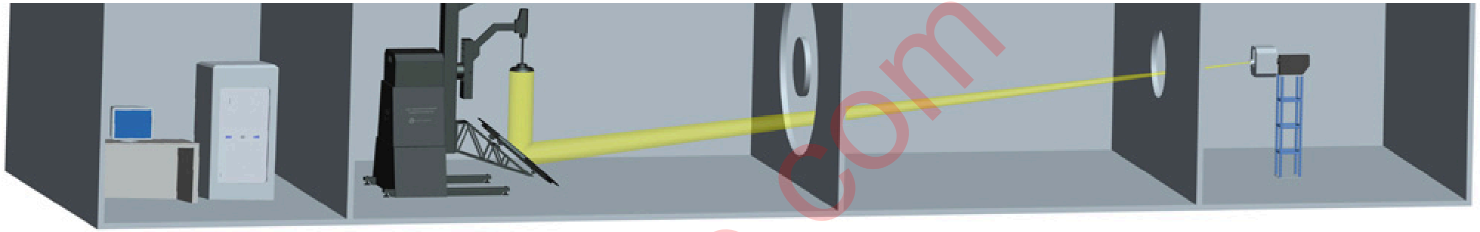
ANSI/IES LM-75 Approved method: guide to goniometer measurements and types, and photometric coordinate systems

Related Technical Articles

What is Light Intensity: Understanding Through the LISUN LSG-6000 LM-79 Moving Detector Goniophotometer

Comparative Testing of Bulb Lights, PAR Lamps, and LED Tubes Using the LISUN LSG-6000 LM-79 Moving Detector Goniophotometer (Mirror Type C)

Understanding How Light Intensity is Measured in Full-Space Distribution Photometers Using



LSG-6000 Moving Detector Goniophotometric Dark Room

Measurement:
Luminous Intensity Data, Photometric Data, Luminous Intensity Distribution, Zonal Luminous Flux, Luminaries Efficiency, Luminance Distribution(Option), Coefficient Of Utilization, Luminance Limitation Curves Glare, Maximum Ratio of Distance to Height, Equal Illuminance Diagrams, Curves of Luminaires VS Lighting Area, Isocandela Diagrams, Efficient Luminescence Angle, EEI, UGR, etc.

Feature:
- The near field detector moves together with the big mirror in a line. The big mirror and the far field detector move synchronously.
- The burning position of the lumainares will be kept without moving at all, and the detector will always sense the light directly from the luminares.
- The rotary motor is from Japan MITSUBISHI MOTORS and the angle decode system is from Germany. They help the goniophotometer rotating smoothly with high accuracy. It is very stable when start and stop.
- The working principles are according to IESNA and CIE. The LSG-6000 completely meet the LM-79, LM-75, GB, EN and CIE121-1996 standards.
- Special collimation device with cross laser line help you installing the position of the luminaires under test conveniently and accurately.

Specification:
- The mirror and detector rotates around the luminaire under test with an angle of (γ) vertical axis ±180° (or 0-360°) and the luminaire rotates around itself with an angle of (C) horizontal axis ±180° (or 0-360°).
- The accuracy of angle: 0.05°, Resolution of angle: 0.001°
- Accuracy of Goniophotometry detector: Constant temperature photo detector DIN5032-6/CIE pub1. No. 69 Class L
- LISUN goniophotometer software can export CIE, IES, LDT and other format files. These kinds of format files can be used via other illumination and luminaire design software such as DiaLux.

LISUN Model	**Testing Lamp Size (Diameter E* Depth F)**	**Measure Power (W)**	**Minimum dark room height**
LSG-6000/LSG-6000CCD (Standard Size)	max Φ1600*600mm, 50kg	max 600V/10A, AC/DC	4.1m
LSG-6000L/LSG-6000LCCD (Super Big Size)	max Φ2000*900mm, 80kg	max 600V/10A, AC/DC	5.2m
LSG-6000B/LSG-6000BCCD (Big Size)	max Φ1800*800mm, 60kg	max 600V/10A, AC/DC	4.7m
LSG-6000S/LSG-6000SCCD (Small Size)	max Φ1200*500mm, 40kg	max 600V/10A, AC/DC	3.0m

The following Photo Detectors are optional to test UV light:

LISUN Model	PHOTO-UVA-A	PHOTO-UVB-A	PHOTO-UVC-A
Wavelength Range	UVA: 320~400nm	UVB: 275~320nm	UVC: 200~275nm
UV Photometric Test Report Sample	UVA Photometric Report	UVB Photometric Report	UVC Photometric Report
Photo Detector Accuracy	Class A (Made by LISUN)		

How does Mirror Goniophotometer work?

Goniophotometer adopts the measuring principle of fixed detector and rotating lamp method. The measuring lamp is installed on a two-dimensional rotating worktable, and the luminous center of the lamp coincides with the rotating center of the rotating worktable through the laser beam of the laser sight.

LISUN LSG-6000CCD LM-79 Moving Detector Goniospectroradiometer (Mirror Type C) – After-sales Frequently Asked Questions (FAQ).

LISUN LSG-6000CCD LM-79 Moving Detector Goniospectroradiometer (Mirror Type C) were in the market for more than 10 years, LISUN engineers service team already summary the most of the After Sales Questions and Answers in the above link. Please read it carefuly, you

- Understanding LED Light Testers: Key Features and Applications
- LISUN LSG-6000: A High-Precision Luminous Intensity Distribution Measurement Solution for Ensuring Lighting Product Quality
- Distributed Photometer: Principle and Applications
- Exploring the Use of Photometric Testing and Luminance Measurement for Enhanced Visibility
- How to use a Type-C Goniophotometer for Road Lighting Testing
- The Importance and Methods of Illumination Distribution Measurement and LED Luminaire Flux Testing

Related Successful Case

- India – Achieving ISO 17025 and NABL Certification with LISUN LSG-6000CCD Goniospectroradiometer
- India – LISUN engineer guide customer successfully installed and operated LSG-6000 LM-79 Moving Detector Goniophotometer (Mirror Type C)
- Turkey- LISUN engineer free installation and training LSG-6000 LM-79 Moving Detector Goniophotometer and SG61000-5 10KV lightning surge generator
- EPYPT – Customer set LED lab purchased LISUN LSG-6000CCD LM-79 Moving Detector

operate LISUN LSG-6000S LM-79 Moving Detector Goniophotometer by watching the operation video

Malaysia-Customers successfully installed by watching video of LSG-3000B LM-79 Moving Detector Goniophotometer (Mirror Type C)

India– Free installation and training for LSG-1700B goniophotometer & LSG-3000B Type C goniophotometer

Mexico – Installation and training for LSG-5000SCCD Type C Goniophotometer

India- Free Installation and training for LSG-3000 Moving Mirror Type C Goniophotometer

2019-12-26

We have the LSG-1800BCCD gonio photometer. LISUN is professional and the photometer is nice. LISUN engineer came and installed for us. Now everything is functional. We are glad to cooperate with LISUN.

Related Products

DC3005 Digital CC and CV DC Power Supply (High Precision)

LSP-500VARC Pure Sine Wave AC Power Source (High Precision)

LS2010 Digital Power Meter (Harmonic Analyzer Model)

CASE-19IN 19-inch Standard Instrument Cabinet

ANSI/IES LM-79-24

Illuminating
ENGINEERING SOCIETY

APPROVED METHOD: OPTICAL AND ELECTRICAL MEASUREMENTS OF SOLID-STATE LIGHTING PRODUCTS

AN AMERICAN NATIONAL STANDARD

Approved American National Standard
ANSI

www.ies.org

ANSI/IES LM-79-24

APPROVED METHOD: OPTICAL AND ELECTRICAL MEASUREMENTS OF SOLID-STATE LIGHTING PRODUCTS

AN AMERICAN NATIONAL STANDARD

Publication of this document
has been approved by the IES.

Suggestions for revision
should be directed to the IES.

Prepared by the
IES Testing Procedures Committee

Approved by the IES Standards Committee April 1, 2024, as a Transaction of the Illuminating Engineering Society.

Approved October 22, 2024, by the American National Standards Institute.

Published by the Illuminating Engineering Society, 85 Broad Street, New York, New York 10004.

IES Standards are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to the IES Director of Standards, at standards@ies.org or the above address, for verification and correction. The IES welcomes and urges feedback and comments.

ISBN 978-0-87995-483-3

Printed in the United States of America

DISCLAIMER

IES publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IES administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IES disclaims liability for any injury to persons or property or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document

In issuing and making this document available, the IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IES and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Prepared by the IES Testing Procedures Committee.

KC Fletcher, *Chair*
Andrew Jackson, *Vice Chair*
David N. Randolph, *Secretary*

Members

Carl K. Andersen
Randall P. Bergin
Rolf S. Bergman
Eric Bretschneider
Aaron A. Feldman
Michael L. Grather
Jeff N. Hulett
Po-Chieh Hung
Jianzhong Jiao
Mihaly Kotrebai
James E. Leland
Kurt M. Liepmann
Jeff Lockner
Greg McKee
Saori Mitsuhashi
Michael Piscitelli
Emil Radkov
Mark B. Sapcoe
Jacki S. Swiernik
Jonathan C. Vollers
Yuqin Zong

Advisory Members

Lawrence M. Ayers
Alex Baker
Carl A. Bloomfield
Fred Carpenter
Pei-Ting Chou
Troy E. Cowan
Patxi Cruz
Lynn Davis
Francisco De Caso
Jeff J. Demirjian
Mark E. Duffy
Elijah W. Dunn
Victor Eberhard
James Grandusky
Kyle J. Hemmi
Robert E. Higley
Gareth John
Jozsef Juhasz
Ryan Kelley
Jessica D. Kramer
Becky Kuebler
Kelly C. Lerbs
Steven Longo
Philip McCarthy
Greg McKee
C. Cameron Miller
Yoshihiro Ohno
Erik Page
Doosung Park
Eric S. Perkins
David P. Ramer
Timothy W. Rasinski
Daniel Rogers
Michael P. Royer
Marvin Ruffin
Markus Schneider
Tobias Schneider
Anthony W. Serres
Pratibha Sharma
Ryan W. Siddon
Daniel Spicer
Gary A. Steinberg
Matthew Stevenson
Lane Swainston
Anders Thorseth
Jason R. Tuenge

Please refer to the IES Bookstore for possible Errata: www.ies.org.

CONTENTS

Preface

This document is a revision of *ANSI/IES LM-79-19, Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products*. Changes have been made to update information and provide better guidance based on information gathered from proficiency testing associated with laboratory accreditation and independent research. The updated requirements in this test method are intended to reduce the variation of measurement results across testing laboratories, while minimizing the burden on the testing laboratories. The method is based on absolute photometry addressing the requirements for optical and electrical measurement of solid-state lighting products.

1.0 Introduction and Scope

1.1 Introduction

Solid-state lighting (SSL) products as defined in this document utilize light-emitting diodes, including inorganic LEDs (simply called LEDs) and organic LEDs (OLEDs), as optical radiation sources to generate light for illumination purposes. An overview of LEDs and lighting is available in ANSI/IES LP-4-20. Although constant current control is typical for individual LEDs, this document addresses integrated SSL products incorporating semiconductor device-level current control; thus, the electrical parameters of interest are the SSL product's input electrical parameters.

For special purposes, it may be useful to determine the characteristics of SSL products when they are operated at other than the standard conditions described in this approved method. Where this is done, such results are meaningful only for the conditions under which they were obtained, and these conditions shall be stated in the test report.

The photometric information typically required for SSL products includes total luminous flux (lumens), luminous efficacy (lm/W), luminous intensity (candelas) in one or more directions, chromaticity coordinates, correlated color temperature (CCT), and color rendering index (CRI). In addition, special lighting applications of SSL products may need data such as radiant intensity, photon intensity, radiant flux, photon flux, radiant efficacy, and photon efficacy. For this approved method, the determination of all these parameters will be considered *optical measurements*.

The electrical characteristics measured for AC-powered SSL products include RMS* AC voltage, RMS AC current, AC active power, power factor, total harmonic current distortion, and voltage frequency. For DC-powered SSL products, measured electrical characteristics include DC voltage, DC current, and power. For this Approved Method, the determination of these parameters will be considered *electrical measurements*.

1.2 Scope

This Approved Method describes the procedures to be followed and precautions to be observed in performing reproducible accurate measurements of total luminous, radiant, or photon flux; electrical power; luminous, radiant, or photon intensity distribution; and the spectrum of solid-state lighting (SSL) products used for illumination purposes; as well as derived quantities of system efficacy and color quantities, under standard conditions. This Approved Method covers LED luminaires, OLED luminaires, integrated LED lamps, integrated OLED lamps, non-integrated LED lamps operated with a driver designated by a manufacturer's identification number or by a defined [ANSI] reference circuit, and LED light engines, all of which will be referred to as *SSL product* or *device under test* (DUT). SSL products, an excluding non-integrated LED lamps, are intended to directly connect to AC mains power or to a DC voltage power supply to operate.

This document does not cover SSL products that require external heat sinks, nor does it cover components of SSL products, such as LED packages or LED arrays. This

---

* "RMS" stands for *root-mean-square* and is a way of expressing an AC quantity of voltage or current in terms functional equivalence to DC. For example, 10 V AC RMS is the amount of voltage that would produce the same amount of heat dissipation across a resistor of given value as 10 V DC. RMS voltage is also referred to as the "equivalent" or "DC equivalent" value of an AC voltage or current. For a sine wave, the RMS value is approximately 0.707 of its peak value. Source: All About Circuits. Online: www.allaboutcircuits.com/textbook/alternating-current/chpt-1/measurements-ac-magnitude/. (Accessed 2024 Nov 18).

document does not cover housings or luminaires sold without a light source (for which relative photometry would typically be used). This document describes test methods for individual SSL products and does not cover the determination of the performance rating of products, in which individual variations among the products should be considered.

2.0 Normative References

2.1 ANSI/IES LS-1-22

Lighting Science: Nomenclature and Definitions for Illuminating Engineering. New York: Illuminating Engineering Society; 2022. Free viewing online: https://www.ies.org/standards/definitions/. (Accessed 2024 Nov 18).

2.2 ANSI/IES LM-78-20

Approved Method: Total Luminous Flux Measurement of Lamps Using an Integrating Sphere Photometer. New York: Illuminating Engineering Society; 2020.

For measurements using an integrating sphere system, the laboratory shall meet the requirements stated therein.

2.3 ANSI/IES LM-75-19

Approved Method: Guide to Goniometer Measurements and Types, and Photometric Coordinate Systems. New York: Illuminating Engineering Society; 2019.

For measurements using a goniometer system, the laboratory shall meet the requirements stated therein.

3.0 Definitions

Note: For definitions not provided here, refer to ANSI/IES LS-1-22 (see **Section 2.1**) and CIE S 017:2020, *ILV: International Lighting Vocabulary*, 2nd edition.

3.1 acceptance interval

Interval of permissible measured quantity values. (See **Annex B** in this document, and ISO/IEC Guide 98-4, Section 3.3.9.)

The acceptable results of a measurement lie within an acceptance interval, defined as the tolerance interval reduced by the expanded uncertainty ($k = 2$) of the measurement on both limits of the tolerance interval.

3.2 current crest factor

The ratio of the absolute value of the peak AC current divided by the AC RMS current.

3.3 photometric center

The point in a light source from which the inverse-square law operates most closely in the direction of maximum intensity. (See ANSI/IES LM-75-19, Section 3.28.)

3.4 tolerance interval

Interval of permissible values of a property. (See **Annex B** in this document, and ISO/IEC Guide 98-4, Section 3.3.5.)

Note 1: In this document, stated conditions include a tolerance interval.

Note 2: The term *tolerance interval* as used in conformity assessment has a different meaning from the same term as used in statistics.

4.0 Physical and Environmental Test Conditions

4.1 General

Due to the thermal characteristics of LEDs, photometric values, optical measurements, and electrical characteristics of SSL products are sensitive to changes in ambient temperature or air movement.

4.2 Temperature

4.2.1 Ambient Temperature. The ambient temperature in which measurements are taken shall be maintained at 25 °C with a tolerance interval of ±1.2 °C, measured at a point not more than 1.5 m from the SSL product and at the same height as the SSL product. (See **Annex B**.)

For example, if the expanded uncertainty ($k = 2$) of the thermometer is 0.2 °C, the reading of the thermometer shall be ±1.0 °C.

The temperature sensor shall be shielded from direct optical radiation from the SSL product and direct optical radiation from any other source, such as an auxiliary lamp. Measurements performed at temperatures other than this recommended temperature constitute a non-standard condition and shall be noted in the test report.

4.2.2 Measurement of Light Engine Temperature. For the measurement of light engines, all components of the light engine shall be subject to the same environmental conditions, even though the elements of the assembly may not be mechanically connected (e.g., the driver, though electrically connected, is mechanically separated from the LED engine) (refer to ANSI/IES LM-82-20). The temperature of the light engine at the temperature monitoring point shall be recorded during testing. The temperature monitoring point shall be identified by the party requesting that the test be conducted or the LED engine manufacturer. The requesting party shall identify and diagram an LED engine temperature monitoring point, T , and a driver temperature monitoring point, T , if applicable (refer to ANSI/IES LM-82-20).

A variety of temperature transducers, such as thermocouples or thermistors (temperature sensitive resistors), may be used. If thermistors are used, they shall be calibrated against a standard traceable to the International System of Units (SI). The temperature transducer shall be chosen such that it does not conduct a significant amount of thermal energy away from the LED engine. The temperature transducer shall also be shielded from ambient light. The temperature shall be measured with a tolerance interval of ±2.0 °C. (See **Annex B**.) The temperature transducer(s) shall be thermally and mechanically attached to the test point(s) throughout the duration of the tests, as defined by the requesting party or manufacturer.

Note: The light engine temperature monitoring point measurement described above applies to light engines that are not mounted in a complete luminaire system. This measurement does not replace the in-situ temperature measurement test.

4.3 Airflow

The incidence of air movements on the surface of an SSL product under test may substantially alter electrical and photometric values. Airflow around the SSL product under test should be such that normal convective airflow induced by the device under test is not affected.

For goniometer measurements that require movement of the device under test, the instantaneous tangential velocity of any point on the DUT shall be less than an upper tolerance limit of 0.20 m/s.

4.4 Thermal Conditions for Mounting SSL Products

The method of mounting can be the primary path for heat flow away from the device and can therefore affect measurement results significantly. The SSL product under test shall be mounted to the measuring instrument (e.g., integrating sphere, goniometer) so that heat conduction through supporting objects results in minimizing cooling effects. For example, when a ceiling-mounted product is measured by mounting at a sphere wall, the product should be suspended in open air rather than directly mounted in close thermal contact with the sphere wall. Alternatively, the product may be held by support materials that have low heat conductivity (e.g., polytetrafluoroethylene). A mount may be verified by comparing the performance of a DUT mounted directly to the measuring instrument to the performance of the same DUT mounted to the measuring instrument using two wires to connect the DUT to the socket.

Any deviation from this requirement should be evaluated for impact on measurement results. Also, care should be taken that supporting objects do not disturb airflow around the product. 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. Any such support structure included in the measurement shall be reported.

4.5 Vibration

No specific requirements are stated, but good laboratory practice suggests SSL products should not be subjected to excessive vibration or shock during stabilization, transportation, mounting, or testing.

4.6 Stray Light

For goniometer measurements, stray light should be suppressed in the test environment, through the adequate use of low-reflectance finishes on surfaces, shielding, and baffling. In addition, stray light may be measured and subtracted from the SSL product measurement. (Refer to ANSI/IES LM-75-19 for more detailed information and requirements; see **Section 2.3**.) Stray light is not usually a concern for integrating sphere measurements; however, care should be taken for minimizing external light from entering the sphere—for example, around SSL products mounted in a 2π configuration (refer to ANSI/IES LM-78-20; see **Section 2.2**).

4.7 Humidity

Relative humidity values greater than approximately 65% can lead to corrosion effects in some instruments, and values below approximately 10% can lead to electrostatic effects. Therefore, laboratory humidity should be monitored and maintained between 10% and 65%.

5.0 Electrical Test Conditions

5.1 Power Supply Requirements

5.1.1 Voltage Waveform and Frequency. During operation of the SSL product, the AC power supply shall have a sinusoidal voltage waveform at the prescribed frequency (typically 60 Hz or 50 Hz) such that the total harmonic distortion or RMS summation of the harmonic components (as discussed in **Section 5.3.4**) shall not exceed 3% of the fundamental frequency during operation of the DUT. The supplied frequency shall have a tolerance interval of ±2 Hz from the prescribed frequency.

Note: The internal or dynamic response of the AC power supply should be kept as low (i.e., as fast) as possible. One measure of this is the output voltage response time, which typically is 50 µs or faster.

5.1.2 AC Voltage Regulation. The voltage of an AC power supply (RMS voltage) applied to the DUT shall be regulated to within ±0.2% under load. The AC power supply shall have a current crest factor capability greater than required by the DUT. If the current crest factor of the waveform required by the DUT is unknown, the power supply shall have a current crest factor capability of at least 10.

Note: For devices requiring a voltage threshold greater than 220 V, the current crest factor capability is not required.

5.1.3 DC Voltage Regulation. The voltage of a DC power supply (instantaneous voltage) applied to the DUT shall be regulated to within ± 0.2 % under load. The AC voltage component or ripple factor of the DC regulated voltage shall be less than 0.5% (RMS) of the DC regulated voltage.

Note: Ripple factor = [AC RMS Voltage (or "ripple")]/(DC Voltage), expressed as a percentage.

5.2 Test and Reference Circuit Requirements

5.2.1 Test Circuit Requirements (4-Pole Socket). To avoid effects of voltage drops in cables or sockets, voltage measurements shall use separate sense leads connected at the point where the supply leads attach to the DUT. For an Edison-type base, a 4-terminal connection (i.e., 4-pole socket or Kelvin socket) is required. **Figure 5-1** shows a schematic of the required connection.

For SSL products operated with DC voltage, a DC ammeter shall be connected between the low voltage side (relative to ground) of the DUT and the DC power supply. The input electrical power (wattage) is calculated as the product of the measured voltage and current applied to the DUT.

For SSL products operated with AC voltage, an AC power analyzer shall be connected between the low voltage side (relative to ground) of the DUT and the AC power supply.

5.2.1.1 Maximum Test Circuit Resistance. Because a large resistance may alter the operation of SSL products operated with AC voltage, the resistance of the test circuit, not including the power supply, shall be less than 0.5 ohms (Ω).

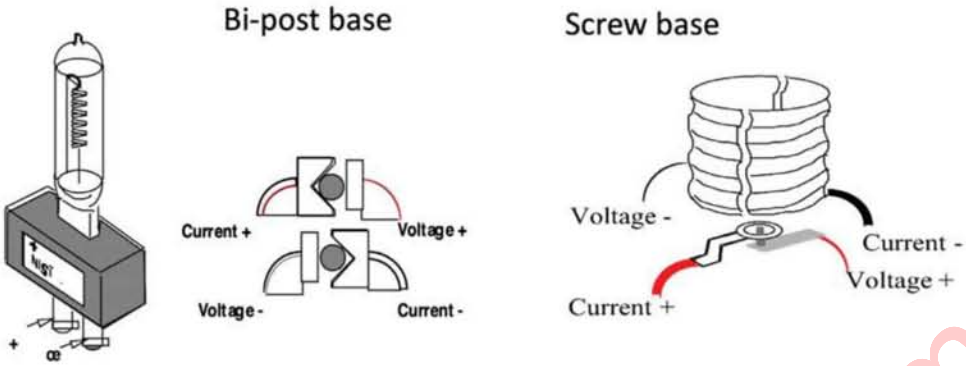


Figure 5-1. A schematic of the required 4-pole socket for bi-post base and screw base sockets.

Note: The resistance of the test circuit need only be verified during installation of equipment or when changes are made to the wiring of the system.

5.2.1.2 Maximum Test Circuit Capacitance. The capacitance of the test circuit, not including the power supply, shall be less than 2.0 nanofarads (nF). The test circuit capacitance shall be determined by measuring the capacitance across the wires intended to be connected to the AC power supply terminals.

Note 1: The capacitance of the test circuit need only be verified during installation of equipment or when changes are made to the wiring of the system.

Note 2: Certain SSL products have been shown to create a high-frequency current component (which can be greater than 30 kHz) when operated with AC power supplies that rely on a digital wave synthesizer to create the AC waveform. Test circuits may be sensitive to high frequency current due to capacitance in the system, which may result from wires running in parallel that are not separated by an appreciable distance. A discussion of this topic is presented in **Annex A**.

5.2.2 Reference Circuit Test. No reference circuit is required for testing SSL products. A small number of SSL products are significantly sensitive to the impedance of the measurement system and the dynamic impedance of the AC power supply. Errors associated with such sensitivity might be ameliorated using a reference circuit to bridge laboratory AC power supplies to typical wall AC characteristics. At present, no such reference circuit has been developed.

5.3 Electrical Measurement Instrument Calibration

All electrical measurement equipment shall be calibrated and traceable to the International System of Units (SI).

5.3.1 Voltage Circuit Internal Impedance. To avoid error due to leakage currents, the internal impedance of voltage measurement circuits (which includes the power analyzer) shall be at least 1 MΩ as measured by disconnecting the power supply and measuring the resistance at the test lamp socket or the wire connection to the luminaire connector.

5.3.2 AC Power Analyzer Accuracy. The AC power analyzer shall be operated with all line filters off and all frequency filters off.

For the measurement of RMS AC voltage, the analyzer shall have an expanded uncertainty ($k = 2$) of 0.4% or less for measurement of a 60-Hz sinusoidal waveform.

Note: Most AC power analyzers on the market provide specifications in terms of accuracy. A discussion of the relationship between accuracy and measurement uncertainty is presented in **Annex B**.

For the measurement of RMS AC current, the analyzer shall have an expanded uncertainty ($k = 2$) of 0.6% or less for measurement frequencies ranging from 0.5 Hz to 1 kHz. The analyzer shall have an expanded uncertainty ($k = 2$) of 2.0% or less for measurement frequencies ranging from 1 kHz to 100 kHz. The laboratory is not required to calibrate the power analyzer for current frequencies greater than 1 kHz.

Note: A discussion of the justification for the use of an AC power analyzer capable of measuring frequencies larger than 100 kHz is presented in **Annex A**.

For the measurement of active AC power, the analyzer shall have an expanded uncertainty (k =2) of 1.0% or less for measurement frequencies ranging from 0.5 Hz to 1 kHz. The analyzer shall have an expanded uncertainty (k = 2) of 2.0% or less for measurement frequencies ranging from 1 kHz to 100 kHz. The Laboratory is not required to calibrate the power analyzer for power frequencies greater than 1 kHz.

5.3.3 AC Power Analyzer Frequency Range. The AC power analyzer shall have a frequency range from DC to at least 100 kHz to cover the harmonic content of the electrical current.

Note: Due to power supply interactions (as discussed in **Annex A**), some SSL products generate high-frequency components above the bandwidth of an average AC power analyzer. For these products, an AC power analyzer with a bandwidth frequency range from DC (0 Hz) to at least 1 MHz is recommended.

5.3.4 Total Harmonic Distortion Measurements. Total harmonic distortion (THD) shall be calculated as the RMS summation of the harmonic components (orders of magnitude of 2 to 50, as a minimum) divided by the fundamental frequency during operation of the DUT.

5.3.5 DC Voltage Measurement. The DC voltage measurement shall have an expanded uncertainty (k = 2) of 0.1% or less.

5.3.6 DC Current Measurement. The DC current measurement shall have an expanded uncertainty (k = 2) of 0.1% or less.

5.4 Electrical Settings

The DUT shall be operated at the rated RMS AC voltage, rated DC voltage, or rated DC current per the specification of the SSL product for its normal use. The set value measurement shall fall within a tolerance interval of ±0.5% for AC RMS voltage, ±0.2% for DC voltage, and ±0.2% for DC current.

Note: Within the United States market, integrated LED lamps or luminaires with multiple rated voltages including 120 volts, should be operated at 120 volts. If an integrated LED lamp or luminaire with multiple rated voltages is not rated for 120 volts, the lamp should be operated at the highest rated input voltage. Typical operating voltages vary for other economic markets.

Some SSL products suffer from large inrush currents when AC power is applied at a phase of 90°. To protect sensitive instruments from such inrush current, it is recommended to set the AC power supply to begin applying current at zero-phase. If the AC power supply is not capable of ensuring a zero-phase start, the AC voltage should be ramped up starting from 0 volts. The AC voltage may be ramped up over a few seconds.

Note: Certain AC-powered SSL products will not turn on if ramped up from 0 volts and have to be turned on with a non-zero voltage applied. This voltage can vary from product to product. This can be especially true for products that attempt to operate the LEDs at constant power and may try to draw excessive current at low input voltages. Should the DUT not turn on when attempting to ramp up from 0 volts, the DUT shall be started by applying rated input voltage to the DUT.

Some DC-powered SSL products require inrush current to start the operation, which is much larger than the rated current; thus, for some products, the current limit needs to be set much higher than the rated current.

Pulsed input electrical power, and measurements synchronized with reduced duty cycle input power intended to reduce p-n junction temperatures below those reached with continuous input electrical power, shall not be used for SSL product testing.

If the DUT has dimming capability, measurements shall be performed at the maximum input power condition as a standard condition. If the product has multiple modes of operation, including variable correlated color temperature (CCT), measurement may be made at power levels for the different modes of operation (and CCTs). Such setting conditions shall be clearly reported.

For low voltage AC or DC devices, the voltage may be limited by the resolution of the power supply. In this case, measurements may be taken with a combination of a voltage greater than the set value and a voltage lower than the set value. The required measurement data is then determined by interpolating the results of these two measurements. For typical AC power supplies that have a resolution of 0.1 V, linear interpolation should be used for all data measurements over an interval of 0.1 V when the tolerance interval of ±0.5% for AC RMS voltage cannot be met.

6.0 Test Preparation

6.1 DUT Identification

If the DUT is not marked or clearly identified, it shall be marked or clearly identified as the DUT.

6.2 DUT Handling

While SSL products are not as sensitive to movement as incandescent lamps, vibrations and mechanical shocks should be minimized. Devices to be tested should not be stored under temperature extremes or at high-humidity conditions.

6.3 Seasoning

SSL products shall be tested with no seasoning.

Note: Many, but not all, LED sources are known to increase their light output slightly during the first 1,000 hours of operation. If the SSL product is meant to be a check standard or a device for inter-laboratory comparison, the SSL product should be operated for at least 1,000 hours before being put into service.

6.4 Pre-burn and Stabilization

Before measurements are taken, the DUT shall be operated long enough to reach photometric and electrical stabilization and temperature steady-state. The time required for stabilization depends on the type of SSL product. The stabilization time typically ranges from 30 minutes for small integrated LED lamps to two or more hours for large SSL luminaires. During stabilization, the SSL product shall be operated in ambient temperature as specified in **Section 4.2.1**, and in the operating orientation as specified in **Section 6.5**. Stability shall be achieved when the variation (maximum to minimum) of at least three readings of the light output and electrical power consumption, taken at a maximum of 10-minute intervals over a period of 20 minutes and divided by the last of these measurements chronologically, is less than 0.5%. Readings should be taken at regular intervals.

For subsequent measurements of the same SSL product (which has reached initial stabilization) at a different color or intensity control setting, an alternate method of determining stability is the point at which the variation in lumen output and electrical power is projected via linear regression to be less than 0.5% over 20 minutes; the linear regression shall be based on at least three measurements taken at least one minute apart. The stabilization time used for each measurement shall be recorded.

SSL products may be pre-burned for several hours to decrease the stabilization time required and the magnitude of change in light output and power consumption during the stabilization period. For the case in which the intended use requires only a limited lifetime (on the order of 1,000 hours or less), DUTs should not be pre-burned prior to performing measurements.

6.5 Operating Position and Orientation

The DUT shall be tested in the operating position with respect to gravity recommended by the manufacturer for an intended use of the SSL product. Stabilization and photometric and optical measurements of the DUT shall be performed in the same operating position. The position and orientation with respect to the goniometric system of the DUT as mounted for measurement shall be reported.

Note: While the light emission of an LED itself is not affected by its position, the position of an SSL product can cause changes in the thermal conditions of the LEDs used in the product, and thus the light output may be affected by SSL product position.

6.6 Optical and Electrical Waveforms

The time-dependent optical and electrical waveforms of SSL products are varied and often undocumented. The laboratory should analyze the optical and electrical waveforms to ensure that the measurement equipment used is appropriate. A discussion of the benefits of optical and electrical waveform measurement is provided in **Annex C**.

7.0 Total Luminous Flux and Integrated Optical Measurements

7.1 General

The total luminous flux (lumens) and/or spectral and/or angular integrated optical measurements (including chromaticity, and radiant and photon flux) of the DUT shall be measured with an integrating sphere system or a goniophotometer (goniospectroradiometer) system. The method may be chosen depending on what other parameters (e.g., intensity distribution) need to be measured, the size of SSL products, and other requirements. Guidance and requirements on the use of each method are provided below.

7.2 Integrating Sphere Systems

7.2.1 General. Integrating sphere systems are suited for total luminous flux and integrated optical measurements of integrated SSL lamps and relatively small-size SSL luminaires. An integrating sphere system has the advantage of allowing for measurements to be made rapidly and does not require a dark room. Air movement is minimized, resulting in minimal DUT temperature fluctuations. It should be noted that the heat from a DUT mounted in or on the integrating sphere may increase the ambient temperature inside the sphere.

Two types of integrating sphere detectors can be used to make measurements: $V(\lambda)$-corrected photometer (sphere-photometer), and spectroradiometer (sphere-spectroradiometer). The $V(\lambda)$-corrected photometer suffers from spectral mismatch errors due to the deviation of the spectral responsivity of the photometer from $V(\lambda)$, compounded by the variations in spectral throughput of the sphere. A spectroradiometer calibrated with a total spectral radiant flux standard has no spectral mismatch errors.

The spectroradiometer method is preferred for measurement of SSL products because when measuring photometric quantities, spectral mismatch errors with the photometer tend to be significant for SSL emissions, and correction is not trivial, requiring knowledge of the system spectral responsivity as well as the spectrum of the DUT. In addition, using the spectroradiometer method, color quantities, radiant flux, and photon flux can be measured at the same time as total luminous flux.

The spectroradiometer method does have disadvantages, such as spectral stray light and long-term stability concerns (refer to ANSI/IES LM-78-20 [see **Section 2.2**] for general recommendations and requirements on making measurements with integrating spheres).

7.2.2 Photometer and Spectroradiometer Characteristics. An integrating sphere with photometer detection (sphere photometer system) shall be calibrated against total luminous flux standards (4π or 2π) traceable to the SI through a national metrology institute (NMI).[*] The f' [a measure of the deviation from the $V(\lambda)$) function] of the total relative spectral responsivity of the sphere and photometer combined shall be 3% or less. If a spectral mismatch correction factor is applied, f' of the total relative spectral responsivity of the sphere and photometer may be larger. Spectral mismatch correction shall be applied for SSL products that emit a narrow-band spectral power distribution (e.g., single-color sources, full width at half maximum (FWHM) < 50 nm). (Refer to *CIE 231:2019, CIE Classification System of Illuminance and Luminance Meters* for more information on this topic.)

An integrating sphere with spectroradiometer detection (sphere spectroradiometer system) shall be calibrated against total spectral radiant flux standards (4π or 2π) traceable to the SI through a national metrology institute. The spectroradiometer system shall cover the wavelength range of at least 380 nm to 780 nm for photometric measurements. For radiant flux and photon flux, a larger wavelength range may be required depending on application. The spectroradiometer

---

[*] A national metrology institute's (NMI) role in a country's measurement system is to conduct scientific metrology, realize base units, and maintain primary national standards. (Metrology. Wikipedia: http://en.wikipedia.org/wiki/Metrology; accessed 2024 Nov 18).

system should account for light outside the wavelength range that may result in stray light within the spectroradiometer system.

The spectroradiometer system shall have a wavelength uncertainty within 0.5 nm (k = 2), and the bandwidth (FWHM) and the scanning interval (for scanning systems) shall not be greater than 5 nm.

The cosine response of the photometer or the spectroradiometer shall have a directional response index, f , of less than 15% (refer to ANSI/IES LM-78-20; see **Section 2.2**).

7.2.3 Self-Absorption and Size of Sphere. When using an integrating sphere, a self-absorption correction using an auxiliary lamp shall be applied. To minimize the self-absorption correction uncertainty for DUTs mounted in the center of the sphere, the total surface area of the DUT should be no more than 2% of the total surface area of the integrating sphere. For DUTs mounted in the 2π geometry, the total surface area of the DUT internal to the sphere should be no more than 1% of the total surface area of the integrating sphere.

Note: The self-absorption correction is impacted by the SSL product size, spectral reflectance, and shape irregularity. Caution should be used in testing larger products, products with lower surface spectral reflectance, and irregularly shaped products (products for which multiple reflections are required for light striking the surface to exit the surface). Validation of the ability to test a product can be determined by testing using both a sphere and goniometer and comparing the results.

7.3 Angular Integration Systems

7.3.1 General. Goniophotometers can measure total luminous flux and/or integrated optical quantities of SSL products. (Refer to ANSI/IES LM-75-19, Section 8.0; see **Section 2.3** in this document.) They can be especially useful in the measurement of relatively large size products, products with lower surface spectral reflectance, or irregularly shaped SSL products for which integrating spheres are not appropriate. A goniophotometer is installed in a dark room, which is normally temperature-controlled, and not subject to heat accumulation from the DUT. Care shall be taken to prevent drafts from ventilation that might affect measurement of DUTs that are temperature sensitive (refer to **Section 4.3**). The goniophotometer type shall be capable of maintaining the intended operating position unchanged with respect to gravity; therefore, only Type C goniophotometers shall be allowed. (Refer to **Section 8.3** in this document and to Section 6.3 in ANSI/IES LM-75-19 for general recommendations and requirements on making measurements with goniophotometers.)

7.3.2 Photometer and Spectroradiometer Characteristics. The goniophotometer system shall be calibrated against standards traceable to the SI through a national metrology institute (NMI). The photometer or spectroradiometer should have cosine angular responsivity, f (ε,ϕ) less than 2% within its field of view for the DUT.

A goniometer system using a photometer shall have an f' of 3% or less. If a spectral mismatch correction factor is applied, f' of the photometer may be larger. Correction for spectral mismatch can be more difficult if there is significant variation in color with angle. Spectral mismatch correction shall be applied for SSL products that emit a narrow-band spectral power distribution (e.g., single-color sources, full width half maximum [FWHM] < 50 nm).

The effects of spectral mismatch of a goniometer system using a tristimulus colorimeter for measurement of chromaticity coordinates should be considered.

A goniometer system using spectroradiometer detection shall cover the wavelength range of at least 380 nm to 780 nm for photometric measurements. For measurement of radiant flux and photon flux, a larger wavelength range may be desirable. The spectroradiometer system should account for light outside of this wavelength range that may result in stray light within the spectroradiometer system, especially during calibration. The spectroradiometer system shall have a wavelength uncertainty within 0.5 nm (k = 2), and the bandwidth (FWHM) shall not be greater than 5 nm.

7.3.3 Angular Scanning Resolution. The angular scanning resolution shall be fine enough to accurately characterize the DUT. For typical wide-angle, smooth-intensity distributions, a 22.5° lateral (horizontal) and 2.5° longitudinal (vertical) grid is generally sufficient. Finer angle resolution (smaller test increments) shall be used for cases in which the luminous intensity from the DUT is changing rapidly as a function of angle, such as in beam-forming sources. (Refer to application specific documents for further guidance on selecting the correct scanning resolution, based on experience gained over years of testing other lighting technologies.) As an example, *ANSI/IES LM-20-20, Approved Method: Photometry of Reflector Type Lamps* provides a recommended angular resolution based on the beam angle of the lamp, as shown in **Table 7-1**.

Table 7-1. Angular Resolution for Beamed Lamps

For Lamps With Beam Angle < 20°	
% of Maximum Luminous Intensity	**Angular Resolution in Degrees**
100% to 50%	1
<50% to 10%	2
<10%	5
For lamps with beam angle ≥ 20°	
% of Maximum Luminous Intensity	**Angular Resolution in Degrees**
100% to 50%	2
<50%	5

7.3.4 Angular Range. The range of the angular scan shall cover the entire solid angle to which the DUT emits light unless regulations or mandatory requirements of application test methods require further measurements. Goniophotometers inherently have an angular region for which light from the SSL product is blocked by the mounting hardware. For isotropic SSL products, this "dead" solid angle should be minimized, or appropriate correction procedures applied. (Refer to ANSI/IES LM-75-19; see **Section 2.3**.)

Two measurements may be required for some DUTs. The first is a normal full sweep of the angular range. The second is taken with the DUT mounted on the goniometer in the proper operating position for the DUT, with the goniometer arm rotated 180°. The two sets of data are then combined.

8.0 Luminous Intensity or Optical Angular Distribution Measurement

8.1 General

The goniophotometer type shall be capable of maintaining the intended operating position unchanged with respect to gravity; therefore, only Type C goniophotometers shall be allowed (refer to ANSI/IES LM-75-19; see **Section 2.3**).

Care should be exercised to prevent light reflected from the mechanical structure of the goniophotometer or any other surface, including secondary reflections from surfaces of the DUT itself, from reaching the photodetector. The speed of rotation of the positioning equipment shall be such as will minimize the disturbance of the thermal equilibrium of the DUT (refer to **Section 4.3**).

8.2 Photometer and Spectroradiometer Characteristics

The photometer or spectroradiometer shall have cosine angular responsivity, $f\ (\varepsilon,\phi)$ less than 2% within its field of view for the DUT.

A goniometer system using a photometer shall have the f' of 3% or less. If a spectral mismatch correction factor is applied, f' of the photometer may be larger. Spectral mismatch correction shall be applied for SSL products that emit a narrow-band spectral power distribution (e.g., single-color sources, FWHM < 50 nm).

A goniometer system using a spectroradiometer detection shall cover the wavelength range of at least 380 nm to 780 nm for photometric measurements. For measurement of radiant flux and photon flux, a larger wavelength range may be required, depending on the application. The spectroradiometer system should account for light outside of this wavelength range that may result in stray light within the spectroradiometer system. The spectroradiometer system shall have a wavelength uncertainty within 0.5 nm ($k = 2$), and the bandwidth (FWHM) shall not be greater than 5 nm.

The goniophotometer system shall be calibrated against standards traceable to the International System of Units (SI) through a national metrology institute (NMI). Luminous intensity distributions shall be absolute measurements reported in units of candelas (cd).

8.3 Test Distance

The test distance should be sufficiently large that the DUT is measured in a far-field condition (for which the inverse-square law applies). The distance shall be greater than five times the longest luminous dimension of the SSL DUT. It should be noted that this requirement is sufficient for SSL products with an angular distribution that is nearly Lambertian. Larger test distances may be required for beam-forming SSL products. This requirement minimizes errors incurred due to the differing measurement angle of light from the edge of the source as compared to light from the center of the source. Since the optical scheme used to produce beam-forming SSL products can be complex, it is recommended that the minimum required measurement distance be determined by experimentally measuring the variation of intensity with distance to find the minimum distance at which the inverse-square law applies. The test distance shall be reported.

Note: The measurement of lamps and luminaires with narrow field angles is challenging using integrating sphere and goniophotometer systems. Integrating sphere systems may possess non-uniform angular responsivity (significantly dependent on the reflectance of the sphere coating). For goniophotometer systems, the distance between the light source and the photodetector should be great enough so that the inverse-square law applies.

8.4 Goniometer Alignment

The photometric center of the DUT shall be aligned to the intersection of the goniometer axes. A description of the location of the photometric center of the DUT and a description of the orientation of the DUT with respect to the goniometer axes shall be reported. The goniometer should have sufficient angular resolution and absolute alignment to characterize the DUT. The required angular resolution and absolute alignment of the goniometer system is dependent on the slope of the DUT luminous intensity distribution with respect to angle. (Refer to application specific documents for further guidance on selecting the correct alignment of DUTs.) For example, *ANSI/IES LM-46-20, Approved Method: Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps* provides information on how to align indoor luminaires correctly.

The goniophotometer axis (the rotation axis of the lamp holder) and the position of the detector should be accurately co-aligned. This should be checked periodically, as the goniophotometer axis can drift over time if the mirror angle deflects. Even a small angle deflection of the mirror can cause large errors for measurement of narrow-beam lamps.

9.0 Chromaticity Uniformity Measurements

9.1 General

SSL products may have variation of chromaticity with angle of emission. The 2008 version of this document (IES LM-79-08) provided a measurement method for integrated chromaticity and spatial non-uniformity of chromaticity when a goniospectroradiometer or a goniocolorimeter was not available. The method presented in IES LM-79-08 shall *not* be used.

9.2 Angular Resolution

Angular resolution shall be fine enough to accurately characterize the DUT. For typical wide-angle, smooth-intensity distributions, a 90° lateral (horizontal) and 10° longitudinal (vertical) grid is generally sufficient. Finer angle resolution (smaller test increments) shall be used for cases in which the chromaticity from the DUT is changing rapidly as a function of angle, such as in beam-forming sources (refer to **Section 7.3.3**).

9.3 Angular Range

The range of the angular scan shall cover the entire solid angle to which the DUT emits light unless regulations or mandatory requirements of application test methods require further measurements. The data in angular regions for which the luminous intensity is less than 10% of the peak intensity shall not be included in the calculation of angular color uniformity.

Goniophotometers inherently have an angular region for which light from the SSL product is blocked by the mounting hardware. For isotropic SSL products, this "dead" solid angle should be minimized, or appropriate correction procedures should be used (refer to ANSI/IES LM-75-19; see **Section 2.3**).

For certain DUTs, two measurements may be required. The first is a normal full sweep of the angular range. The second is when the DUT is mounted on the goniometer in the proper operating position for the DUT but the goniometer arm is rotated 180°. The two sets of data are then combined.

9.4 Integrated Angular Measurements

An integrated measurement over a specified solid angle is simply the integration of smaller solid angles weighted by the measurement quantity. For example, the total luminous flux is calculated by using:

$$\Phi = \int \int I(\theta,\phi)\sin\theta \mathrm{d}\theta \mathrm{d}\phi ,$$

where:

Φ = the total luminous flux of the DUT (lm)

$I(\theta,\phi)$ = the luminous intensity (cd) of the DUT in a direction defined by the circumpolar and a polar angle

θ = the circumpolar angle

ϕ = the a polar angle

The luminous intensity for each measured direction is determined by:

$$I(\theta,\phi) = \left[i\,(\theta,\phi) - i\;\;(\theta,\phi)\right]/R ,$$

where:

R = the goniometer calibration factor, expressed in the units of the signal (amperes, volts, or counts) per candela

$i\;\;(\theta,\phi)$ = the photometer signal in a direction

$i\;\;\;(\theta,\phi)$ = the photometer dark signal (i.e., stray light) in a direction

The stray light signal is measured with the DUT operating but the direct light blocked. The direct light is typically blocked by placing a black cloth over the mirror. An ideal block would be a black cloth that only blocks the image of the DUT. This signal captures the electrical dark noise, along with stray light present in the room (see ANSI/IES LM-75-19, Section 9; refer to **Section 2.3** in this document). Both photometer signals are normally measured as a current, voltage, or counts from an analog-to-digital converter.

For IES-C:

$$\begin{aligned}\Phi \;=\; & \frac{2\pi}{M}\sum_{m=1}^{M}\left\{\frac{1}{2}\left(1-\cos\left(\pi\frac{0.5}{N}\right)\right)\cdot I(m,0)\right. \\ & +\sum_{n=1}^{N-1}\frac{1}{2}\left[\left(\cos\left(\pi\frac{n-0.5}{N}\right)-\cos\left(\pi\frac{n+0.5}{N}\right)\right)\right. \\ & \left.\left.\cdot I(m,n)\right]+\frac{1}{2}\left(\cos\left(\pi\frac{N-0.5}{N}\right)+1\right)\cdot I(m,N)\right\}\end{aligned}$$

For consistent lateral (circumpolar) angular increments from $m = 1$ to M covering the range 0 through 2π.

For consistent vertical angular increments from $n = 0$ to N covering the range 0 through π.

For IES-A and IES-B:

$$\begin{aligned}\Phi_V = & \frac{2\pi}{M}\sum_{m=1}^{M}\left\{\frac{1}{2}\left(1+sin\left(-\frac{\pi}{2}+\pi\frac{0.5}{N}\right)\right)\right. \\ & \cdot I\left(\frac{2\pi m}{M},-\frac{\pi}{2}\right)+\sum_{n=1}^{N-1}\frac{1}{2}\left[\left(sin\left(-\frac{\pi}{2}+\pi\frac{n+0.5}{N}\right)\right.\right. \\ & \left.\left.-\,sin\left(-\frac{\pi}{2}+\pi\frac{n-0.5}{N}\right)\right)\cdot I\left(\frac{2\pi m}{M},-\frac{\pi}{2}+\frac{\pi n}{N}\right)\right] \\ & \left.+\frac{1}{2}\left(1-sin\left(-\frac{\pi}{2}+\pi\frac{N-0.5}{N}\right)\right)\cdot I\left(\frac{2\pi m}{M},\frac{\pi}{2}\right)\right\}\end{aligned}$$

For consistent circumpolar angular increments from m = 1 to M covering the range -π through π.

For consistent planar angular increments from $n = 0$ to N covering the range -π/2 through π/2.

9.5 Angular Color Uniformity

Angular color uniformity, Δ ′ ′, is the largest deviation of chromaticity (u', v') of an SSL product (emitted in different directions), from its angularly averaged chromaticity

(u' , v'), where the deviation is calculated as:

$$\Delta \quad = \sqrt{(u' - u' \ ) \ + (v' - v' \ )}$$

The chromaticity coordinates (u', v') are measured with a goniocolorimeter or goniospectroradiometer. The angularly averaged chromaticity shall be calculated from goniometric data measured over the angular range of interest as a weighted mean of all the measured points (weighted by the luminous intensity and solid angle factor at each point). (Refer to ANSI/IES LM-75-19 for methodology for integrating goniometric data; see **Section 2.3**.) The largest deviation of chromaticity over the angular region of interest shall be reported as the angular color uniformity.

9.6 Signal Limit and Verification

Laboratories shall establish a luminous intensity capability limit for the measurement of chromaticity uniformity. The laboratory shall season a heavily frosted or opal coated incandescent lamp of an appropriate wattage rating to determine the lower luminous intensity level. The use of several lamps of different wattages for which the luminous intensity is above and below the limit to be determined may be required. Other methods of determining the luminous intensity limit are: reduction of the integration time if a spectroradiometer is the detection device; and reduction of the gain if a colorimeter is the detection device. The luminous intensity limit is determined for a reduced integration time or reduced gain, and then divided by the available increase in integration time or gain to arrive at the final luminous intensity limit.

The heavily frosted or opal coated lamp shall be mounted base up and operated with constant current. The lamp filament support shall not be aligned with the 0°or 90° half-plane. Four half-planes of data (lateral or horizontal) shall be collected (0°, 90°, 180°, and 270°), and every 10° from 0° to 150° longitudinal (vertical). The Δ ′ ′, shall be determined for each lateral plane for which the four measurements are referenced to the average u' and v' for the lateral plane. The Δ ′ ′, values for the lateral planes are then averaged to create an overall Δ ′ ′. The lower luminous intensity limit is determined as the condition for which the overall Δ ′ ′, is 0.0015 or greater. **Annex D** provides an example of this verification.

10.0 Measurement Uncertainty

The development of a measurement uncertainty budget is a useful tool in analyzing a measurement system, especially as a method of uncovering problems and justifying improvements. By looking at the individual components of uncertainty, a laboratory can make investment decisions on system improvements that decrease the measurement uncertainty, or dispersion in measurements. The IES is developing Technical Memoranda to guide laboratories in the development of measurement uncertainty budgets by providing the knowledge and implementation examples.

As the tolerance intervals that have been provided throughout this standard are intended to limit the magnitude of the measurement uncertainty, direct calculation of the measurement uncertainty for an SSL product measurement is not required. If the provided guidelines are adhered to, the expected expanded measurement uncertainty for the measurement of total luminous flux is on the order of ±4% ($k = 2$). This is consistent with the summary results of a proficiency test conducted by 118 laboratories worldwide. It should be noted that the largest source of deviation in the proficiency test was the improper application of the 4-pole socket (refer to **Section 5.2.1**).

11.0 Reporting Requirements

11.1 Test Report Content

The test report shall list all identification data for each DUT together with performance data as noted in the following list. The report shall also list all pertinent data concerning conditions of testing, type of test equipment, description of DUT, and reference standards as noted in the following list. Data shall be reported with an appropriate number of significant digits.

Administrative Information:

- Testing laboratory identification
- Report issue date
- Testing date

DUT Identification:

- DUT manufacturer (if available)
- DUT identification, e.g., model number
- Description of DUT

Measurement Test Conditions:

- Ambient temperature
- LED Printed Circuit Board temperature (if measured)
- Relative humidity level (if measured)
- Electrical parameters used to drive DUT (AC or DC, voltage, current, frequency if applicable)

Test Equipment and Reference Standards:

- Instrumentation used (goniometer or sphere) and the photometric measurement conditions
- For sphere measurement: sphere diameter, coating reflectance, 4π or 2π geometry
- For goniophotometer measurement: photometric distance
- Reference standard (SI traceability)
- Correction factors applied (e.g., spectral mismatch, self-absorption)

DUT Results (the scope of the list is determined in collaboration with the customer):

- Optical parameters measured (e.g., total luminous flux, radiant flux, photon flux)
- Luminous intensity, radiant intensity, and photon intensity distribution (if applicable)
- Color parameters: chromaticity coordinates, CCT, ANSI/IES TM-30-24 quantities (R, R, Local Chroma Shift, Local Hue Shift), and CRI for white-light products if applicable)
- Calculated quantities (e.g., luminous efficacy, angular color uniformity)
- Spectral power distribution (if applicable)
- Statement of uncertainties (if required)

11.2 Nonstandard Conditions or Operating Procedures

For measurements that are made under conditions that are nonstandard per the requirements of this document, the laboratory shall identify nonstandard conditions in a prominent location on the test report.

Annex A
High Frequency Current and Measurement Circuit Capacitance

Laboratories have been concerned about measurement circuit capacitance and high frequency current transmission for certain lighting technologies, including SSL products that are intended to replace fluorescent tubes and operate with the electronic ballast. The electronic ballast has a typical output of 300 V RMS at high frequency (20 kHz to 85 kHz). If a laboratory runs, for example, 8 m (about 25 ft) of 14-gauge parallel wire between the ballast and the lamp, 17% of the measured current never reaches the lamp because the capacitance between the two wires shunts the current back to the source.

Certain SSL products have been shown to create a high frequency component of current (greater than 30 kHz) when used with AC power supplies that rely on a digital wave synthesizer to create the AC waveform. Test circuits may be sensitive to high frequency current due to capacitance in the system, which may result from wires running in parallel that are not separated by an appreciable distance. **Figure A-1** shows the voltage and current waves for a lamp powered by two different types of AC power supplies and a laboratory wall outlet.

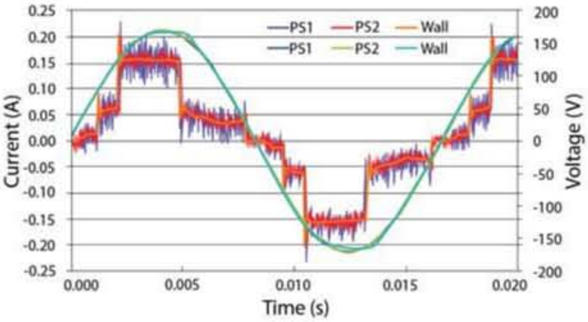


Figure A-1. Voltage (green, grey, and teal) and current (purple, red, and gold) waves for a test lamp powered by three different sources.

Note: It is important to note that the voltage waves are all very similar. However, while the current wave associated with the wall outlet has no high frequency component, the current wave associated with the two power supplies both display high frequency components. The high frequency component correlates to the frequency of the digital wave synthesizer, and the magnitude correlates to the speed of the output voltage response. **Table A-1** shows the measurement of the lamp under test using the three power sources described above and a sphere system with 8 m (about 25 ft) of 14-gauge parallel wire in close proximity. The power lost is due to capacitance in the measurement system. **Table A-2** shows the same measurements with the 8 m of wire with the conductors separated by more than 30 cm (about 1 ft) of air space. As shown, the error due to capacitance is significantly reduced.

Table A-1. Electrical Measurements for the Test Lamp Shown in Figure A-1 With Conductors in Close Proximity

	Voltage	Current	Current % Difference From Wall	Power	Power % Difference From Wall	PF	Power Factor Difference From Wall
Wall	120.1	0.09504		10.378		0.9100	
PS1	120.0	0.09462	0.61%	10.337	0.80%	0.9081	0.0016
PS2	120.1	0.09444	0.42%	10.293	0.38%	0.9104	-0.0007

Table A-2. Electrical Measurements for the Test Lamp With the Conductors Separated by More Than 30 cm (About 1 ft)

	Voltage	Current	Current % Difference From Wall	Power	Power % Difference From Wall	PF	Power Factor Difference From Wall
Wall	120.0	0.09502		10.376		0.9097	
PS1	120.1	0.09508	-0.06%	10.366	0.10%	0.9080	0.0018
PS2	120.0	0.09510	-0.08%	10.391	-0.15%	0.9106	-0.0010

Annex B
Tolerance Interval vs. Acceptance Interval

In this Approved Method, required conditions are stated in terms of a tolerance interval, with specified upper and lower tolerance limits. To ensure that any given parameter is within the specified tolerance interval, the applicable measurement uncertainty shall be considered by deriving the corresponding acceptance interval. The acceptance interval is defined as the tolerance interval reduced by the expanded uncertainty of measurement (at 95% confidence for a normal distribution and a coverage factor $k = 2$) at both limits of the tolerance interval. This relationship is illustrated graphically in **Figure B-1**. The measured value of any specified parameter shall lie within the acceptance interval derived from the corresponding tolerance interval and measurement uncertainty.

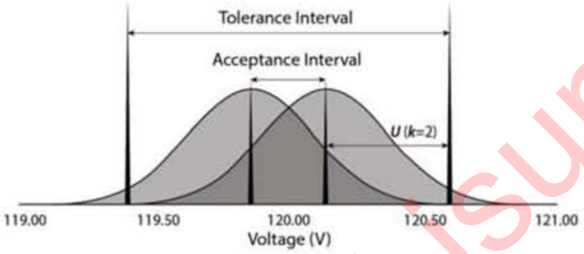


Figure B-1. Graphical relationship between tolerance interval, acceptance interval, and measurement uncertainty for setting 120 V AC

As an example, the specifications for a commonly available AC power analyzer provide the accuracy of the AC voltage measurement for frequencies ranging from 45 Hz to 66 Hz as:

$$Accuracy = 0.1\% \, (Reading) + 0.1\% \, (Range)$$

This accuracy is valid for three months. For a 12-month calibration accuracy, the 3-month accuracy is multiplied by 1.5. This accuracy is revalidated when a calibration laboratory performs a single-point calibration or verification of a range setting on the AC power analyzer.

Therefore, for a 120-volt, 60-Hz reading (*Reading* = 120 V) on a 150-volt range (*Range* = 150 V), the accuracy is 0.41 V for 12 months, which defines the half-width of a uniform or rectangular distribution. Converting the half-width of a uniform distribution to standard uncertainty is done by dividing the half-width by the square root of three. The standard uncertainty for this AC power analyzer for AC voltage measurement is 0.23 V, or 0.19%. With a coverage factor of $k = 2$, the expanded uncertainty or calibration uncertainty is 0.46 V, or 0.38 %. For measuring 220 V, the expanded uncertainty is 0.90 V, or 0.41 %.

To set the AC voltage to 120.00 V using this AC power analyzer for which the tolerance interval is ± 0.5 % (as provided in **Section 5.3.2**), the AC power analyzer should read between 119.86 V and 120.14 V (which defines the acceptance interval). Further information on the concept of acceptance interval is provided in ISO/IEC Guide 98-4.[3]

Another example is the measurement of the ambient temperature, which according to **Section 4.2.1** shall be maintained at 25 °C with a tolerance interval of ±1.2 °C. If the expanded uncertainty ($k = 2$) of the thermometer is 0.2 °C, the reading of the thermometer shall be ±1.0 °C from 25 °C, as shown in **Figure B-2**.

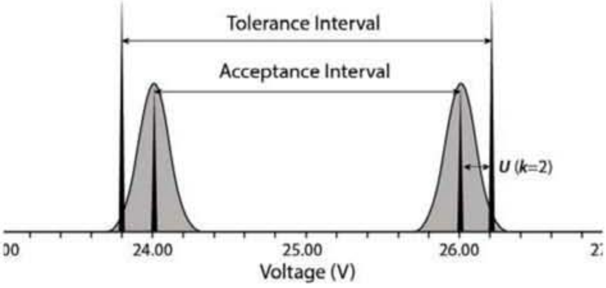


Figure B-2. Graphical relationship between tolerance interval, acceptance interval, and measurement uncertainty for ambient temperature measurement.

Annex C
Benefits of Waveform Measurement

There are several benefits to optical and electrical waveform measurement. One is the avoidance of inaccurate RMS measurement, as it is not always obvious when an oscillating wave goes off scale. **Figure C-1** shows an example of an off-scale wave that results in a 1.1% difference in the RMS measurement.

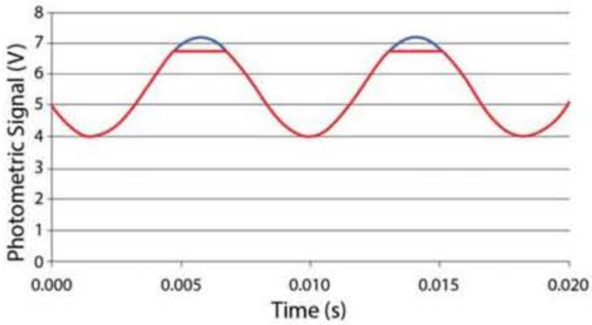


Figure C-1. Example of an off-scale photometer signal.

Measuring the optical waveform also provides assurance that the photometer amplifiers and voltmeters are working properly. For example, a voltmeter set to measure DC voltage that is used to measure a voltage that has an AC component will likely not measure the signal correctly.

AC signals can also be assessed, as shown in **Figure C-2**. In this case, the optical signal has a very sharp change that results in a ringing in the amplifier because it cannot keep up with the sharp transition.

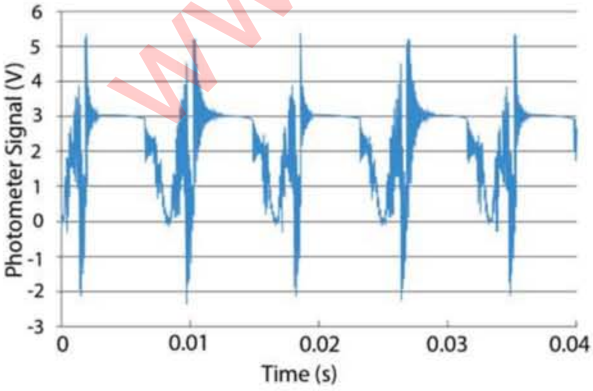


Figure C-2. Signal fluctuation from a slow amplifier.

Another benefit of measuring optical and electrical waveforms is the ability to determine an appropriate integration time for charge-capturing devices (e.g., CCD* spectrometers). As shown in **Figure C-3**, the optical signal is essentially a square wave with a frequency of 120 Hz. The integration time using a small sphere with a high reflectance coating and a sensitive spectrometer may be as small as 6 ms before the CCD wells are charged. Because the data collection start time determines the measured width of the pulse, large repeatability errors are very likely to result.

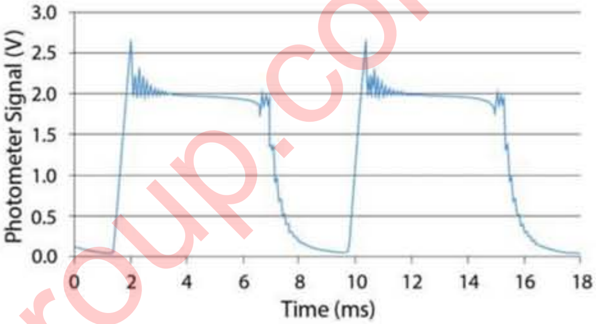


Figure C-3. Example of an optical waveform of a pulsed light source.

RMS and average measurements shall not be affected by the instruments used to measure optical and electrical waveforms.

---

* CCD: A charge coupled device; a silicon-based multichannel array detector of ultraviolet, visible, and near-infrared light. *Source*: Horiba Scientific. Online: http://www.horiba.com/us/en/scientific/products/raman-spectroscopy/raman-academy/raman-faqs/what-is-a-ccd-detector/. (Accessed 2024 Nov 18).

Annex D
Lower Luminous Intensity for Chromaticity Uniformity

A challenge not addressed in the previous version of this document is determination of a luminous intensity limit for measuring chromaticity uniformity. **Figure D-1** shows a correlated color temperature (CCT) distribution for a lamp under test. The data show a gradual change from 2900 K to 3200 K, with abrupt changes on the order of 100 K. **Figure D-2** shows a correlated color temperature distribution for the same lamp under test using a different goniometer. The same gradual change is present but without the abrupt changes.

Without characterizing the capabilities of the measurement system, it is difficult to determine which measurement is correct. The graph in **Figure D-1** may be inaccurate because the signal-to-noise ratio is too small, resulting in the abrupt changes. The graph in **Figure D-2** may be inaccurate because the detection system may not have the necessary analog to digital resolution (number of bits) to detect the changes even though the goniometer system has appropriate display resolution.

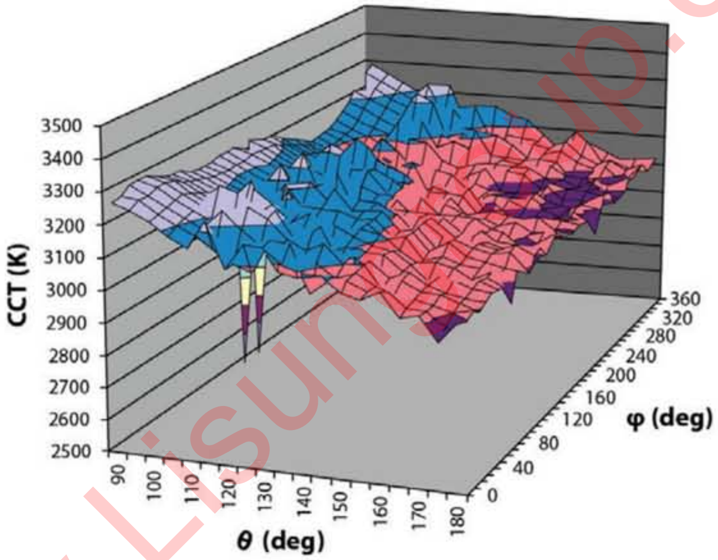


Figure D-1. Correlated color temperature distribution for a test lamp.

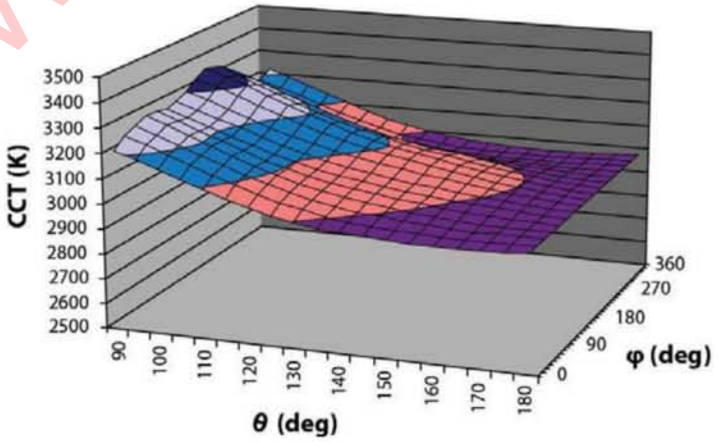


Figure D-2. Correlated color temperature distribution for test lamp shown in Figure D-1, different goniometer system.

To characterize the measurement system for signal-to-noise capabilities, a heavily frosted or opal coated incandescent lamp is seasoned, and five half-planes are measured for chromaticity coordinates. **Figure D-3** shows the correlated color temperature distribution for the set of measurements described in **Section 9.6**. The Δ calculated for the measurements shown in **Figure D-3** is 0.00013. Instead of using lamps that produce different intensity values, the integration time may be reduced, creating the same dependency that would result from a change of lamp.

Figure D-4 shows the dependence of Δ (described in **Section 9.5**) versus luminous intensity measured with different integration times for a lamp producing 100 lm, which, based on a uniform distribution, has a luminous intensity of 8 cd. The change is abrupt at the point where noise dominates the signal. Therefore, for this goniometer system, a minimum luminous intensity of 0.028 cd is required to measure a minimum of 0.0015 for Δ .

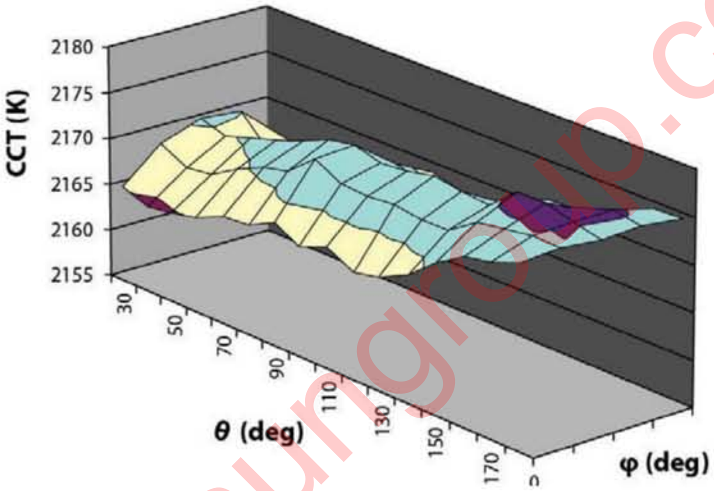


Figure D-3. The correlated color temperature (CCT) distribution for the set of measurements described in Section 9.2 for a heavily frosted or opal coated incandescent lamp.

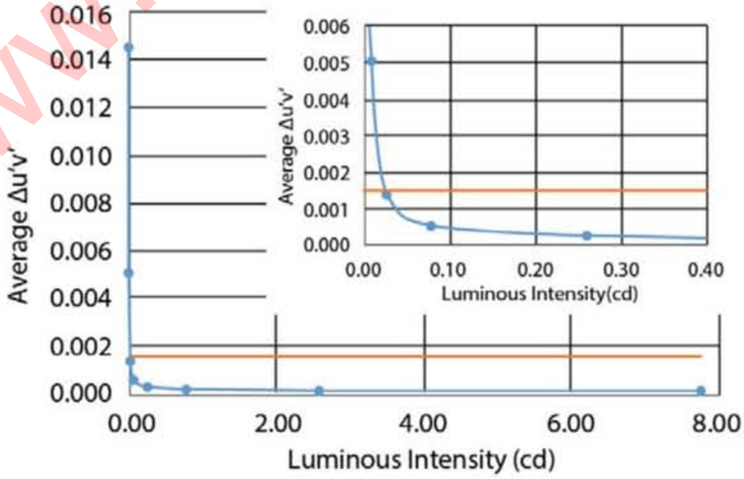


Figure D-4. A graphical representation of Δ versus the luminous intensity; the insert expands the region around the area where the Δ increases quickly.

INFORMATIVE REFERENCES

1 Illuminating Engineering Society. ANSI/IES LP-4-20, Lighting Practice: Electric Light Sources - Properties, Selection and Specification. New York: IES; 2020.

2 International Commission on Illumination (CIE). ILV: International Lighting Vocabulary, 2nd Edition. Vienna: CIE; 2020. (CIE S017/IES:2020).

3 International Standards Organization (ISO) and International Electrotechnical Commission (IEC). Uncertainty of Measurement – Part 4: Role of Measurement Uncertainty in Conformity Assessment. Geneva: IEC; 2012. (ISO/IEC Guide 98-4: 2012. Also: JCGM 106:2012).

4 Illuminating Engineering Society. ANSI/IES LM-82-20, Approved Method: Characterization of Optical and Electrical Properties of Solid-State Lighting Products as a Function of Temperature. New York: IES; 2020.

5 UL, LLC. ANSI/UL 1598-2008: UL Standard for Safety Luminaires. Sec. 19.7 and 19.10-16. Northbrook, Ill.: UL; 2008.

6 UL, LLC. ANSI/UL 153 -2014; UL Standard for Safety Portable Electric Luminaires. Northbrook, Ill.: UL; 2014.

7 International Standards Organization (ISO) and International Commission on Illumination (CIE). Characterization of the Performance of Illuminance Meters and Luminance Meters. Vienna: CIE; 2014. (ISO/CIE 19476:2014. Also: CIE S 023/E:2013).

8 International Commission on Illumination (CIE). CIE Classification System of Illuminance and Luminance Meters. Vienna: CIE; 2019. (CIE 231:2019).

9 Illuminating Engineering Society. ANSI/IES LM-20-20, Approved Method: Photometry of Reflector Type Lamps. New York: IES; 2020.

10 Illuminating Engineering Society. ANSI/IES LM-46-20, Approved Method: Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps. New York: IES; 2020.

11 Miller CC, Hastings H, Nadal ME. A snapshot of 118 solid state lighting testing laboratories' capabilities. Leukos. 2016 Jun 23:47-56. DOI:10.1080/15502724.2016.1189834.

12 Illuminating Engineering Society. ANSI/IES TM-30-24, Technical Memorandum: IES Method for Evaluating Light Source Color Rendition. New York: IES; 2024.

Process for Change to an ANSI/IES Standard Under Continuous Maintenance

This standard is maintained under continuous maintenance procedures, for which IES has an established and documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. Committee consideration will be given to proposed changes by June 30 of any given year for proposed changes received by the IES Director of Standards no later than December 31 of the previous year.

Submittal Format

Proposed changes must be submitted to the IES Director of Standards in the announced published format. However, changes may be accepted in an earlier published format, if the differences are immaterial to the proposed change submittal. If the Director of Standards concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

Specific changes in the text or values are required and must be substantiated. Any change proposals that do not meet these requirements will be returned to the proposer. Supplemental background documents to support changes submitted may be included.

Submission to the Committee Chair

The Director of Standards shall forward proposed changes received on appropriate forms to the committee chair for assigning to committee members (responders) to develop responses to submitters of proposed changes.

Review and Clarification

Responders shall review proposals and should contact the proposer if necessary for clarification.

Response Recommendation

Designated responders shall draft a recommended committee response, including any recommended changes to the standard. The 'responders' recommended responses shall be submitted to the committee chair in electronic form usable by Society Staff, including any recommended change to the standard in response to proposals received.

Options for Committee response are limited to:

a) Proposed change accepted for public review without modification
b) Proposed change accepted for public review with modification
c) Proposed change accepted for further study
d) Proposed change rejected

The responders shall provide reasons for any recommendation other than option (a) above.

The designated responders shall not recommend option (c) unless the further study can be completed by October 1 of that year, and providing the Committee can then vote for option (a), (b), or (d) no later than November 15 of that year.

Editing

The Committee chair or his or her designee shall edit the draft responses and circulate the edited drafts to the committee for review.

Form for Proposing Change to an ANSI/IES Standard Under Continuous Maintenance

NOTE:
Use a separate form for each comment. Submit to the Director of Standards, IES, 85 Broad St, FL 17, New York NY 10004. Email: standards@ies.org. Fax: 212-248-5017.

1. Submitter: ______________________________
Affiliation: ______________________________
Address: ______________________________
City: ______________ State: __________ Zip: __________ Country: __________
Telephone: ______________________________
Fax: ______________________________
E-mail: ______________________________

I hereby grant the Illuminating Engineering Society (IES) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this, or other analogous, form are used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: ______________________________ Date: ______________

2. Title of publications and year published ______________________________
3. Clause (section), sub-clause or paragraph number; and page number: ______________________________
4. My proposal (check one):
[ ] Change to read as follows
[ ] Delete and substitute as follows
[ ] Add new text as follows
[ ] Delete without substitution

Use underscore to show material to be added (added) and strikethrough for material to be deleted (~~deleted~~). Use additional pages if needed.

5. Proposed change:
____
____
____

6. Reason and substantiation:
____
____
____

Select as applicable:
[ ] Additional pages are attached. Number of additional pages:
[ ] Attachments or referenced materials cited in this proposal accompany this proposed change.

Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. Please list your attachments here:

IES™
THE LIGHTING LIBRARY

Lighting Science Standards
Fundamentals, Metrics and Calculations
Lighting Practice Standards
Design, Engineering, and Specifications
Lighting Applications Standards
Design Criteria and Illumination Recommendations
Lighting Measurements and Testing Procedure Standards
Industry Standardization
Roadway and Parking Facility Lighting Standards
Criteria and Illumination Recommendations

Order# ANSI/IES LM-79-24
ISBN 978-0-87995-483-3

www.ies.org