Product Categories

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- Spectroradiometer ›
- Integrating Sphere ›
- LED Test Instruments ›
- CFL Testing Instruments ›
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- EMI and EMC Test Systems ›
- Electronic Ballast Tester ›
- Electrical Safety Tester ›
- Environmental Test Chamber ›
- Plug and Switch Testing ›
- AC and DC Power Supply ›
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LM-79 Moving Detector Goniophotometer (Mirror Type C)

Product No: LSG-6000

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Related Applications

LM-79 and LM-80 Test Solutions


LEDs and Luminaire Test Solutions


HID Lamp Test Solutions


Fluorescent Lamp Test Solutions


CFL Lamp Test Solutions


LED Driver Test Solutions


Automotive Electronics Test Solutions

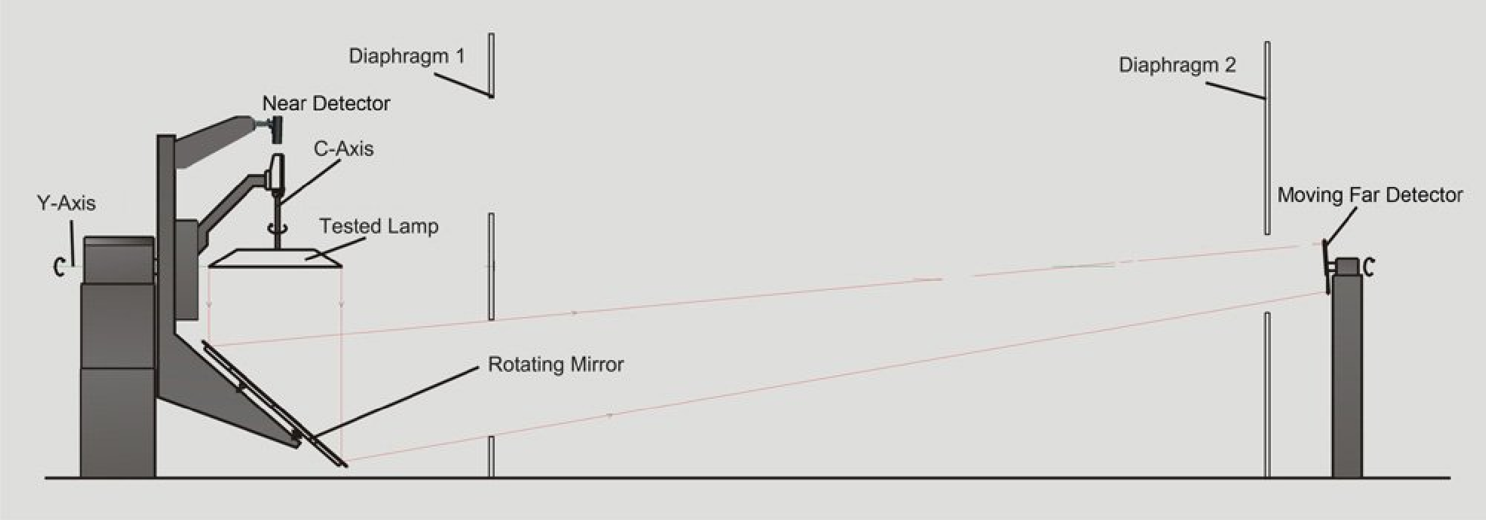
Related Standards

CIE International Commission on Illumination

standard Clause 7.3.1, its an automatic light distribution intensity 3D curve testing system for measuring light. The measuring distance is from 5m to 30m.

What is the use of goniophotometer?

LSG-6000 gonio photometer manufacturer 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

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ANSI American National Standards Institute

GB China Guo Biao

NOM Norma Oficial Mexicana

SASO Saudi Arabian Standards Organization

TSE Turkish Standards Institution

PTB Physikalisch-Technische Bundesanstalt

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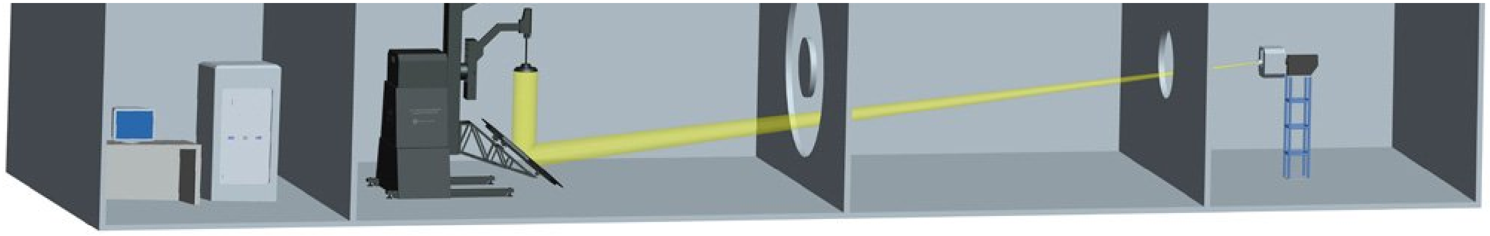

LSG-6000 Moving Detector Goniophotometric Dark Room

Measurement:

Luminous Intensity Data, Photometric Data, Luminous Intensity Distribution, Zonal Luminous Flux, Luminaries Efficiency, Luminance Distribution, 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.

Features:

- 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-80, 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.

Specifications:

- The luminaire under test rotates around the mirror 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 othe illumination and luminaire design software such as DiaLux.

- Led test instruments supplier in China
- Goniophotometer | Guide to working, application & LSG-6000 goniophotometer
- Type C goniophotometer and type B goniophotometer test difference and how to choose correct goniophotometer type
- Based on the LM-79 standard, how to use the integrating spheres and spectrophotometers to test the LED luminaire
- What type of Goniophotometer do you need for your product
- Luminance measurement using the Goniophotometer
- How you can use a Goniophotometer to get photometric led intensity measurement
- Gonio photometric procedure for light measurement

Related Successful Case

- 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

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

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.

S

Steve Gibbons

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.

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ANSI/IES LM-79-19

Illuminating
ENGINEERING SOCIETY

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

AN AMERICAN NATIONAL STANDARD

Approved American National Standard
ANSI

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ANSI/IES LM-79-19

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

AN AMERICAN NATIONAL STANDARD

Publication of this Technical Memorandum
has been approved by IES.
Suggestions for revisions should be directed to IES.

Approved by the IES Standards Committee February 28, 2019, as a Transaction of the Illuminating Engineering Society.

Approved as an American National Standard May 14, 2019.

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005.

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Printed in the United States of America.

ISBN# 978-0-87995-004-0

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Foreword

This document is a revision of IES LM-79-2008, *Approved Method: Electrical and Photometric 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.

The structure of the document has been changed significantly to match the approved IES Testing Procedure Committee document structure.

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 the optical radiation sources to generate light for illumination purposes. An overview of LEDs and lighting is available in IES TM-16-17.[1] 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; system efficacy; luminous, radiant, or photon intensity distribution; and color quantities and/or spectrum of solid-state lighting (SSL) products for illumination purposes, 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 products or device under test* (DUT). SSL products, 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

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* "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. (Accessed 2018 Feb 23) www.allaboutcircuits.com/textbook/alternating-current/chpt-1/measurements-ac-magnitude/

SSL products, such as LED packages or LED arrays. This document does not cover housings or luminaires designed for SSL products and 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 RP-16-17

Nomenclature and Definitions for Illuminating Engineering. New York: Illuminating Engineering Society; 2017. Free viewing online: www.ies.org/standards/ansi-ies-rp-16/

2.2 IES LM-78-17

IES Approved Method for Total Luminous Flux Measurement of Lamps Using an Integrating Sphere. New York: Illuminating Engineering Society; 2017.

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

2.3 IES LM-75-01/R12

IES Guide to Goniometer Measurements, Types, and Photometric Coordinate Systems. New York: Illuminating Engineering Society; 2012.

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

3.0 Definitions

(Refer to ANSI/IES RP-16-17)

3.1 acceptance interval

Interval of permissible measured quantity values. (See **Annex D** in this document, and ISO/IEC Guide 98-4,[2] 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 (95% confidence) 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 tolerance interval

Interval of permissible values of a property. (See **Annex D** in this document, and ISO/IEC Guide 98-4,[2] 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 D**.) 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 other than this recommended temperature constitute a nonstandard 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 LM-82-2012).[3] 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_b, and a driver temperature monitoring point, T_d, if applicable (refer to LM-82-12). 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 D**.) 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*.[4,5]

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. **Annex A** provides more information regarding airflow.

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 IES LM-75-01/R12 for more detailed information and requirements.) 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 IES LM-78-17).

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. 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.

For SSL products operated with DC voltage, a DC voltmeter and a DC ammeter shall be connected between the DC power supply and the DUT. 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 meter shall be connected between the low voltage side 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).

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 1.5 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 while a purely resistive load (e.g., an incandescent lamp) is mounted in the socket.

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 >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 B**.

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. A discussion of this topic is presented in **Annex C**.

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 meter) shall be at least 1 MΩ as measured by disconnecting the power supply and measuring the resistance at the test lamp socket.

5.3.2 AC Power Meter Accuracy. AC power meters shall be operated with all line filters off and all frequency filters off.

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

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

For the measurement of RMS AC current, the meter shall have an expanded uncertainty (k=2) of 0.6% or less for measurement frequencies ranging from 0.5 Hz to 1 kHz, and an expanded uncertainty (k=2) of 2.0% or less for measurement frequencies ranging from 1 kHz to 100 kHz.

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

For the measurement of active AC power, the meter shall have an expanded uncertainty (k=2) of 1.0% or less for measurement frequencies ranging from 0.5 Hz to 1 kHz, and an expanded uncertainty (k=2) of 2.0% or less for measurement frequencies ranging from 1 kHz to 100 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 B**), some SSL products generate high-frequency components above the bandwidth of the 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 for a 100-kHz meter, and orders of magnitude of 2 to 100 for a 1-MHz meter, 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 with multiple rated voltages including 120 volts, should be operated at 120 volts. If an integrated LED lamp 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°. The AC power supply should be set to begin applying current when 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 need 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 dimmed 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

It is always good laboratory practice to mark or clearly identify DUTs.

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 equilibrium. 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 a 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 E**.

7.0 Total Luminous Flux and Integrated Optical Measurements

7.1 General

The total luminous flux (lumens) and/or 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(λ)-corrected photometer head (sphere-photometer), and spectroradiometer (sphere-spectroradiometer). The V(λ)-corrected photometer suffers from spectral mismatch errors due to the deviation of the spectral responsivity of the photometer from V(λ), 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 head 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 IES LM-78-17 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_1' [a measure of the deviation from the V(λ) function] of the total relative spectral responsivity of the sphere and photometer combined shall be 3% or less.[6] If a spectral mismatch correction factor is applied, f_1' 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., monochromatic sources).

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 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 (full-width at half maximum, 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_2, of less than 15% (refer to LM-78-17).

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 and 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, color, and shape irregularity. Caution should be used in testing larger products, darker products, 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

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* 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 2018 Jan 6).

SSL products. They can be especially useful in the measurement of relatively large size, dark colored, 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. The distance requirement is not critical if only integrated quantities are to be measured. (Refer to **Section 8.3** and to IES LM-75-01/R12 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_2 (ε,ϕ) less than 2% within its field of view for the DUT.[6]

A goniometer system using a photometer shall have an f_1' of 3% or less. If a spectral mismatch correction factor is applied, f_1' of the photometer may be larger. Correction for spectral mismatch can be more difficult if there is significant variation in color with angle. For SSL products that emit a narrow-band spectral power distribution (e.g., monochromatic sources), the impact of spectral mismatch error shall be evaluated, and spectral mismatch correction shall be applied if necessary.

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, *IES LM-20, IES 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**.[7]

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 IES LM-75-01/R12.)

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 IES LM-75-01/R12).

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**).

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).

8.2 Photometer and Spectroradiometer Characteristics

The photometer or spectroradiometer shall have cosine angular responsivity, $f_2\ (\varepsilon,\phi)$ less than 2% within its field of view for the DUT.

A goniometer system using a photometer shall have the f_1' of 3% or less. If a spectral mismatch correction factor is applied, f_1' of the photometer may be larger. For SSL products that emit a narrow-band spectral power distribution (e.g., monochromatic sources), the impact of spectral mismatch error shall be evaluated, and spectral mismatch correction shall be applied if necessary. Correction for spectral mismatch can be more difficult if there is significant variation in color with angle.

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.

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, *IES LM-46-04/R14), IESNA Approved Method for Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps*, provides information on how to align indoor luminaires correctly.[8]

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 previous 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 IES LM-75-01/R12).

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 Angular Color Uniformity

Angular color uniformity, $\Delta_{u'v'}$, is the largest deviation of chromaticity (u', v') of an SSL product (emitted in different directions), from its angularly averaged chromaticity (u'_a, v'_a), where the deviation is calculated as:

$$\Delta_{u',v'} = \sqrt{\left(u' - u'_a\right)^2 + \left(v' - v'_a\right)^2}$$

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 IES LM-75-01/R12 for methodology for integrating goniometric data.) The largest deviation of chromaticity over the angular region of interest shall be reported as the angular color uniformity.

9.5 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 $\Delta_{u'v'}$ 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 $\Delta_{u'v'}$ values for the lateral planes are then averaged to create an overall $\Delta_{u'v'}$. The lower luminous intensity limit is determined as the condition for which the overall $\Delta_{u'v'}$ is 0.0015 or greater. **Annex F** 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 Memorandums 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.[9] 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 Typical Report Content

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

The reporting metrics listed below are typical. Required data are often determined in collaboration with the customer.

- Test date and testing organization
- Manufacturer's name; designation of DUT
- Optical parameters measured (e.g., total luminous flux, radiant flux, photon flux)
- Measured electrical values (clarify AC, including frequency, or DC)
- Calculated quantities (e.g., luminous efficacy, angular color uniformity)
- Ambient temperature during measurements, along with light engine monitoring temperature, if measured
- 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
- Source of SI traceability

- Correction factors applied (e.g., spectral mismatch, self-absorption)
- Luminous intensity, radiant intensity, and photon intensity distribution (if applicable)
- Color parameters—chromaticity coordinates, CCT, ANSI/IES TM-30-18 quantities[10] (R_f, R_g, Local Chroma Shift, Local Hue Shift), and CRI for white-light products
- 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 – Airflow Considerations for Testing SSL Products

Airflow that passes over an SSL product can change the operating temperature, resulting in a change in the luminous flux without a proportional change in the electrical power consumption. However, as discussed below, this potential effect is deemed to be sufficiently small that it is not a concern.

Figures A-1 and **A-2** show the change in light output and RMS electrical power for two different typical residential products. The results show a significant dependence on air speed.

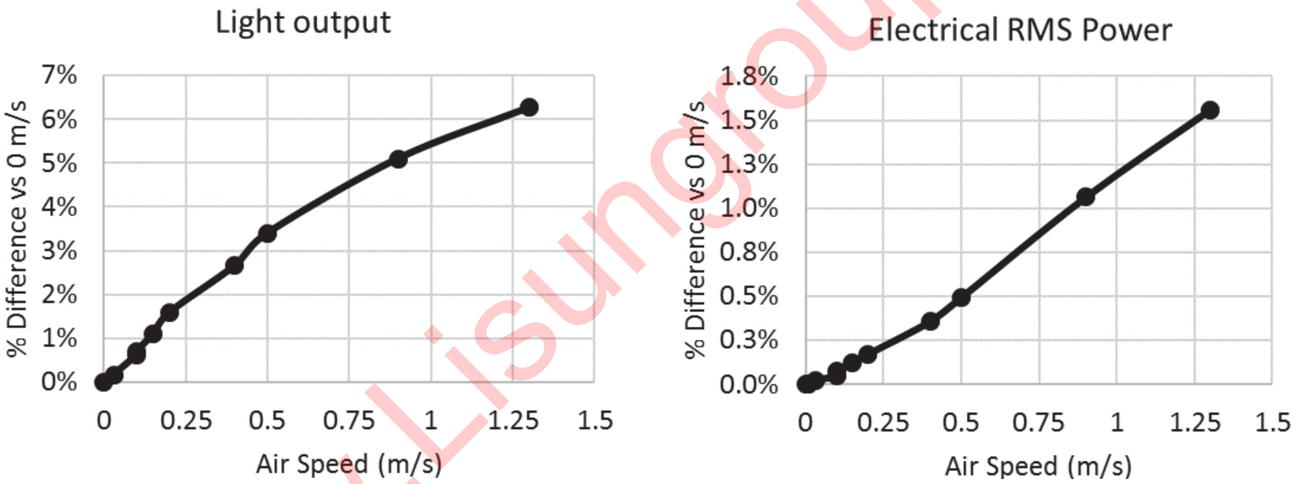

Figure A-1. Change in light output and electrical RMS power vs. speed of airflow for a typical residential product.

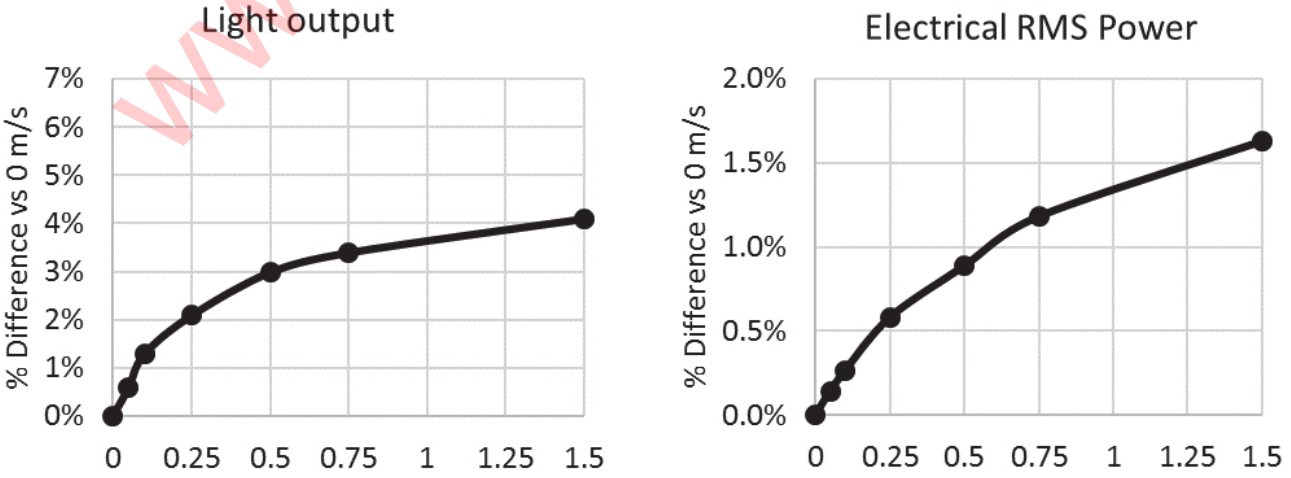

Figure A-2. Change in light output and electrical RMS power vs. speed of airflow for a second typical residential product.

Airflow is often swirling, thus requiring an omnidirectional measurement technique. To measure omnidirectional airspeed, a calibrated thermal anemometer (sometimes called a hot wire anemometer) or a thermal air velocity meter is typically employed. Thermal anemometers can measure from 0 m/s to 1 m/s or greater and should be calibrated to the SI units meter and second. When using the thermal anemometer, the sensor should be mounted at the photometric center of the goniophotometer or integrating sphere. The air velocity should be measured for 30 minutes at an interval of at most 2 minutes in order to capture several duty cycles of the temperature controls. All the measurements within the 30-minute measurement period should be within the acceptance tolerance, which is dependent on the uncertainty of the thermal anemometer.

This document does not require specific measurements for airflow. Current laboratory intercomparisons have demonstrated that there is not a concern with laboratory ambient airflow. Data from the Measurement Assurance Program run by the National Institute of Standards and Technology (NIST)[*] from 2010 to 2014 show that the airflow difference among laboratories that used spheres compared with laboratories that used goniometers was small and within the uncertainty of measurements. The graph shown in **Figure A-3** uses a normal probability plot analysis.[†] The standard deviation for total luminous flux for all lamps measured with sphere systems is 2%, resulting in a 95% confidence interval of ±4.0%. The standard deviation of total luminous flux for all lamps measured with goniometer systems is 2.3%, resulting in a 95% confidence interval of ±4.6%. The bias between NIST and the average laboratory is 0.53% for sphere system measurements. The bias between NIST and the average laboratory is 0.37% for goniometric system measurements. One would expect the goniometer measurements to show more variation or a bias that is greater than NIST. While there are subtle indications, these are not statistically significant, since the typical testing laboratory has an expanded uncertainty of at least 3% (*k*=2).

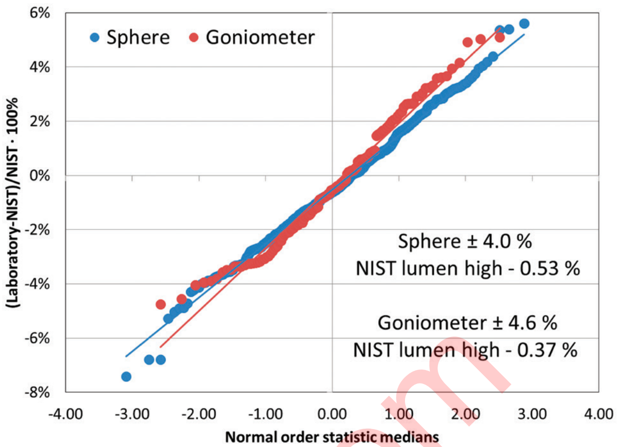

Figure A-3. Linear fits to the normal probability plot for sphere system measurements and goniometer system measurements from the NIST Measurement Assurance Program, 2010 to 2014.

Based on the above considerations, effects due to airflow are not currently a concern.

Annex B – 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

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[*] 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.

[†] http://www.itl.nist.gov/div898/handbook/eda/section3/normprpl.htm (Accessed 2018 Mar 5).

by an appreciable distance. **Figure B-1** shows the voltage and current waves for a lamp powered by two different types of AC power supplies and a laboratory wall outlet.

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 B-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 B-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.

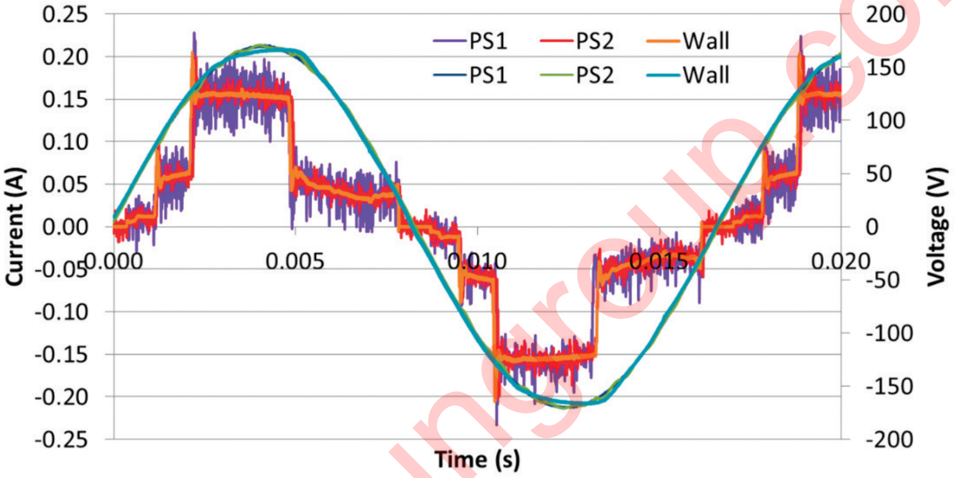

Figure B-1. Voltage (green, grey, & teal) and current (purple, red, & gold) waves for a test lamp powered by three different sources.

Table B-1. Electrical Measurements for the Test Lamp Shown in Figure B1 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 B-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 C – Power Supply Resistance and Inductance Dependency

No reference circuit is required for testing SSL products. Almost all SSL products have some sensitivity to the impedance of the measurement system and the dynamic impedance of the AC power supply, although for many lamps, the sensitivity is slight, as shown in **Figure C-1** for a particular lamp.

The first graph in **Figure C-1** shows the percent difference in the luminous flux of the SSL product using two (dotted and solid lines) different types of power supplies (different output voltage response speeds), with the SSL product plugged into the laboratory AC power source (wall). The colored points show the effect when inductors are added to the circuit, and the abscissa shows the effect of adding resistors to the circuit. The second graph in **Figure C-1** shows the percent difference for the RMS current, and the third graph shows the percent difference for the RMS power.

Other lamps show sensitivity to resistance and/or inductance, as shown in **Figure C-2** and **Figure C-3**. The lamp in **Figure C2** shows a potential for large differences in RMS current measurement made among different laboratories based on resistance and inductance in the measurement systems. The lamp in **Figure C3** shows a potential for large differences in RMS current and luminous flux measurement made among different laboratories.

Figure C-4 shows an SSL product that is extremely sensitive and represents a very small fraction of the products on the market. A standard AC power supply measurement technique that would allow different laboratories to make consistent measurements and that would represent how the SSL product would perform under real world conditions has not been developed by the IES Testing Procedures Committee.

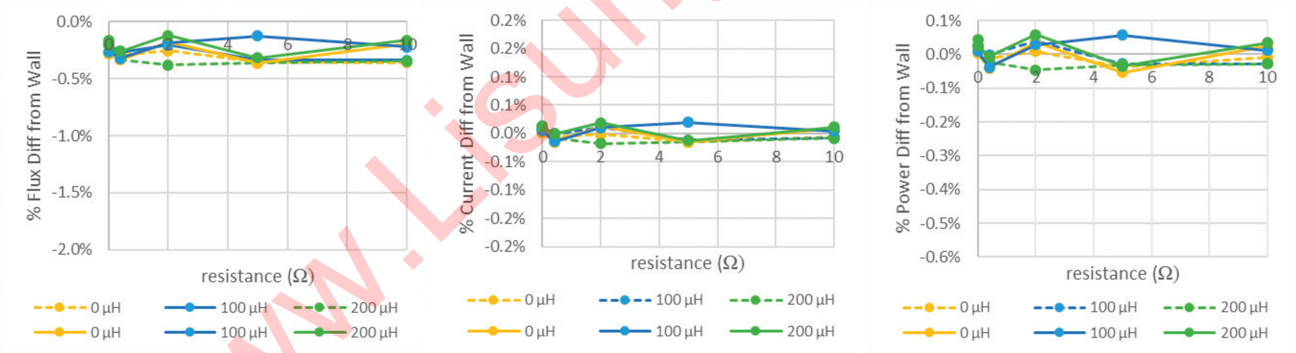

Figure C-1. SSL product (1) with a small sensitivity to resistance and inductance.

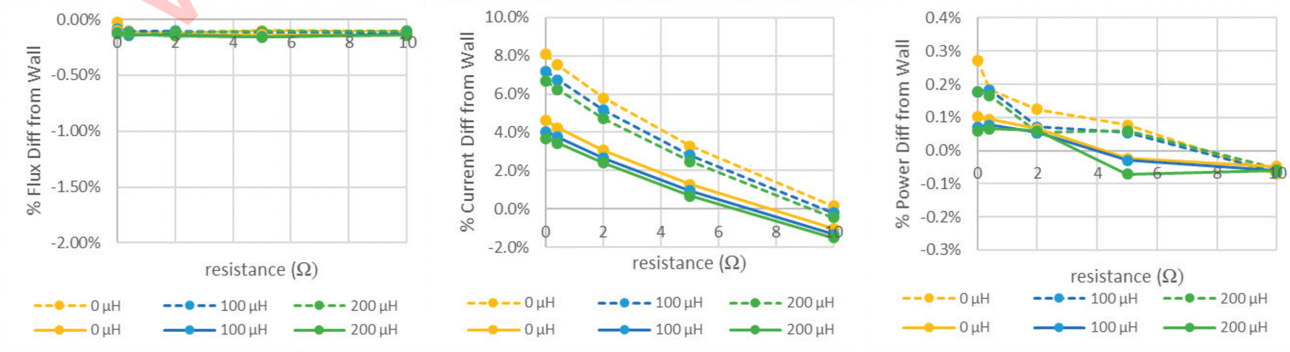

Figure C-2. SSL product (2) with sensitivity to resistance and inductance in RMS current.

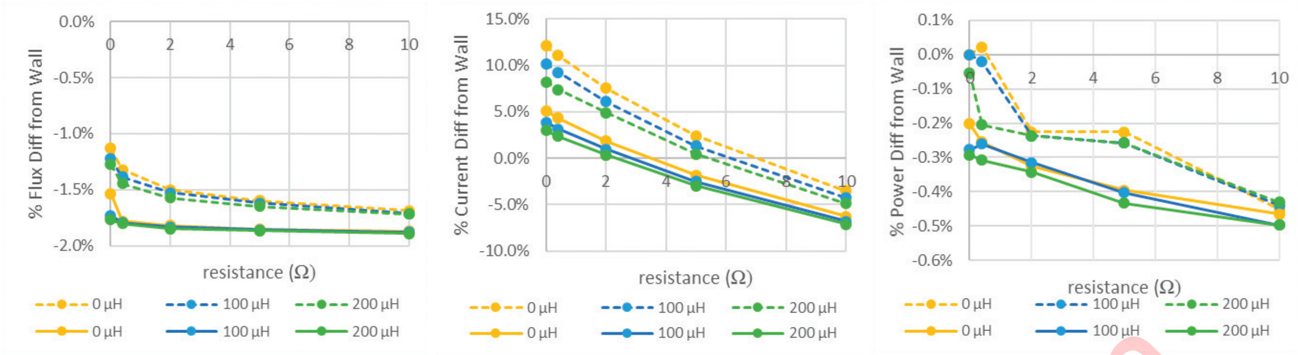

Figure C-3. SSL product (3) with sensitivity to resistance and inductance in RMS current and luminous flux.

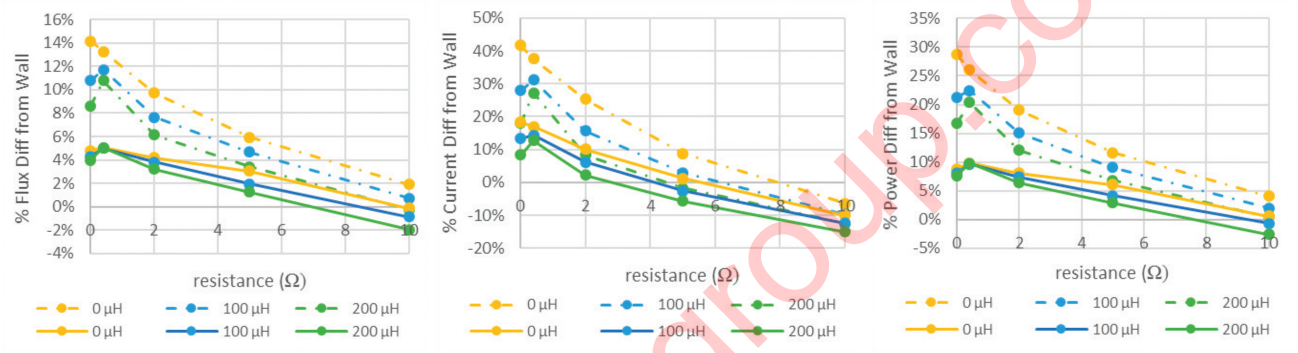

Figure C-4. SSL product (4) with sensitivity to resistance and inductance in RMS current, luminous flux, and RMS electrical power.

Annex D – Tolerance Interval vs. Acceptance Interval

In this document, 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) at both limits of the tolerance interval. This relationship is illustrated graphically in **Figure D-1**. The measured value of any specified parameter shall lie within the acceptance interval derived from the corresponding tolerance interval and measurement uncertainty.

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

$$\mathit{Accuracy} = 0.1\%\ (\mathit{Reading}) + 0.1\%\ (\mathit{Range})$$

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 %.

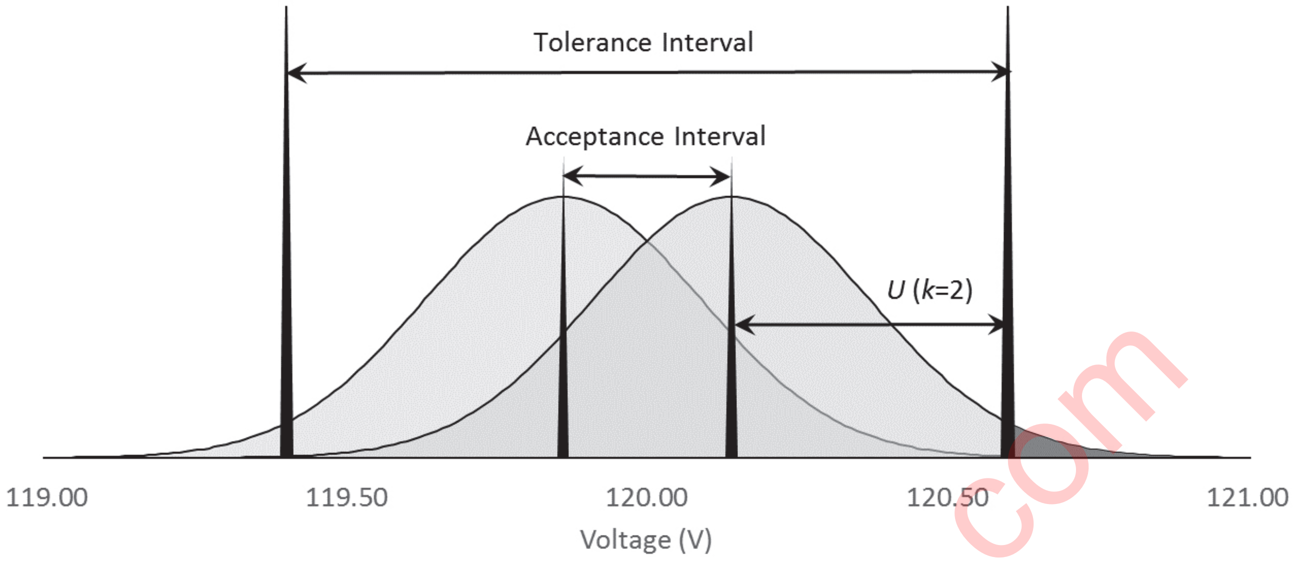

Figure D-1. Graphical relationship between tolerance interval, acceptance interval, and measurement uncertainty for setting 120 V AC.

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.*

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 -D2**.

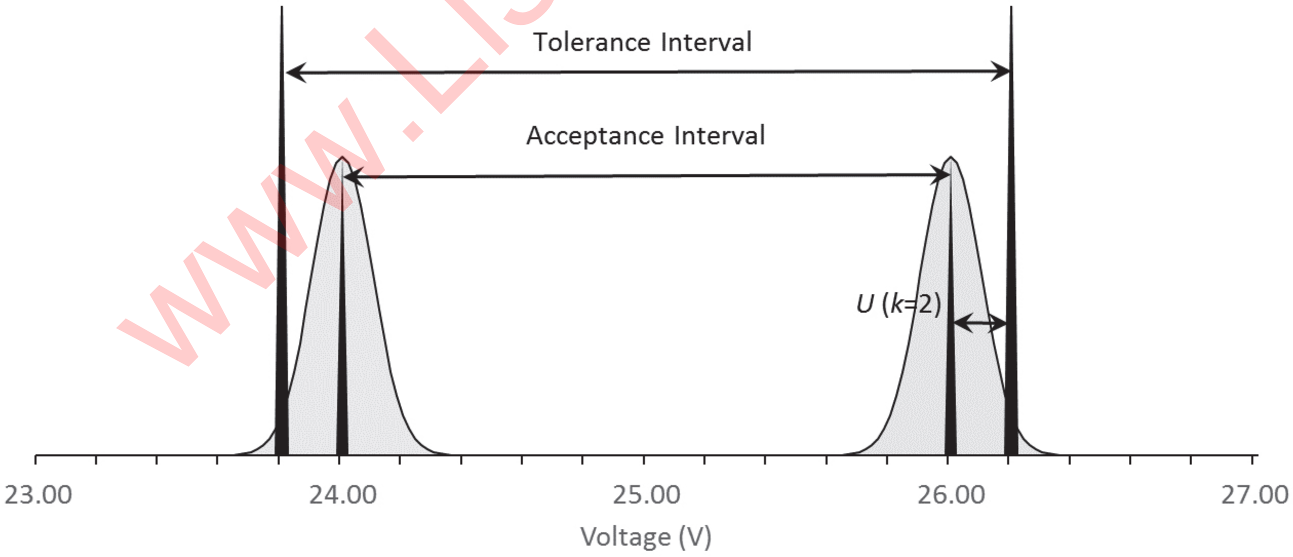

Figure D-2. Graphical relationship between tolerance interval, acceptance interval, and measurement uncertainty for ambient temperature measurement.

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

Annex E – 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 E-1** shows an example of an off-scale wave that results in a 1.1% difference in the RMS measurement.

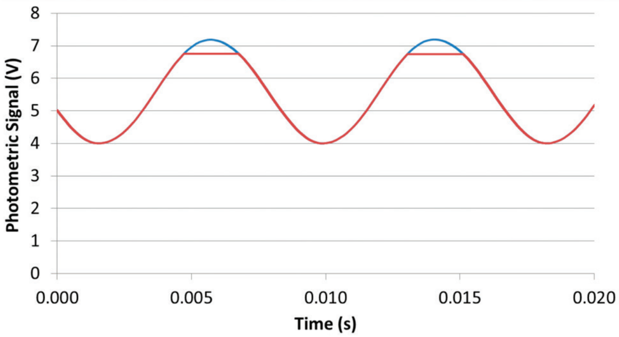

Figure E-1. Example of an off-scale photometer signal.

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 E-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.

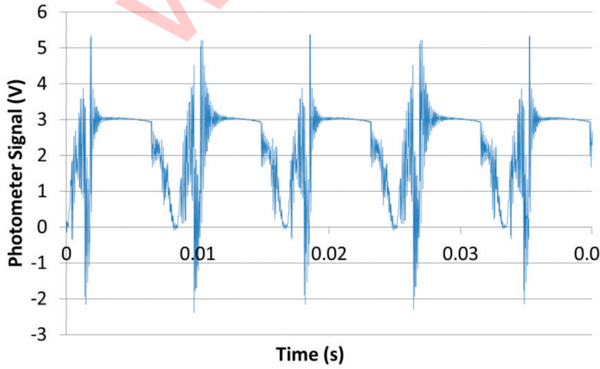

Figure E-2. Signal fluctuation from a slow amplifier.

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 E-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.

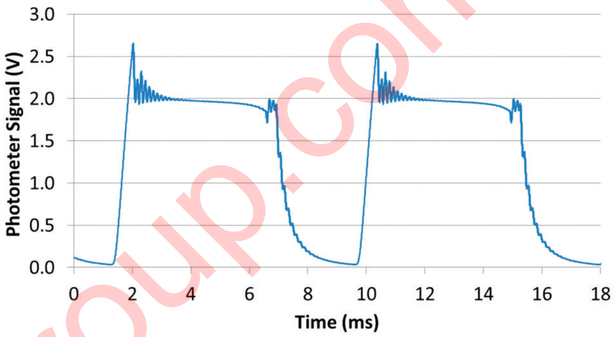

Figure E-3. Example of an optical waveform of a pulsed light source.

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

Annex F – 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 F-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 F-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.

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* CCD: A charge coupled device; a silicon-based multichannel array detector of ultraviolet, visible, and near-infrared light. Source: Horiba Scientific. (Accessed 2018 Mar 2) http://www.horiba.com/us/en/scientific/products/raman-spectroscopy/raman-academy/raman-faqs/what-is-a-ccd-detector/

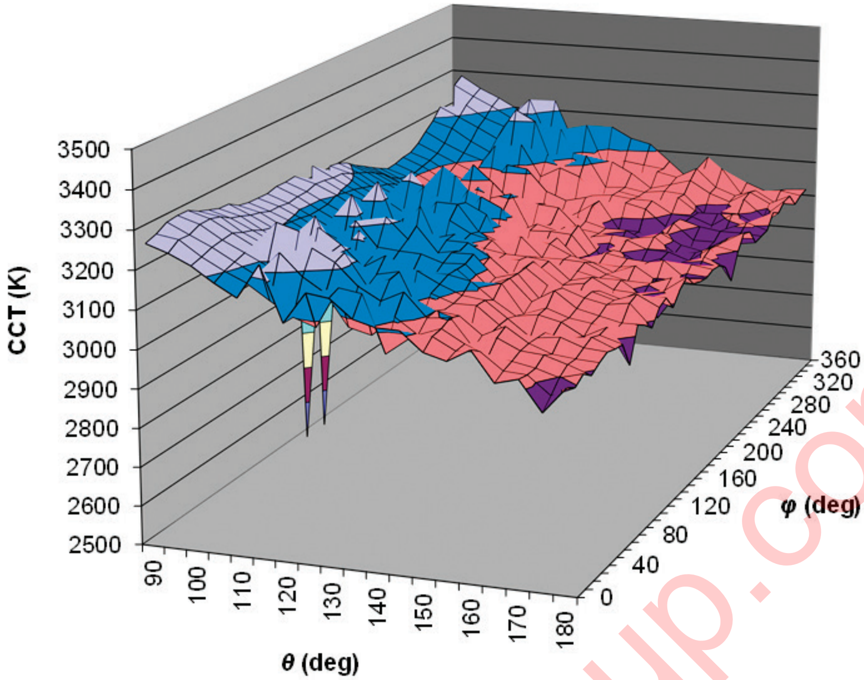

Figure F-1. Correlated color temperature distribution for a test lamp.

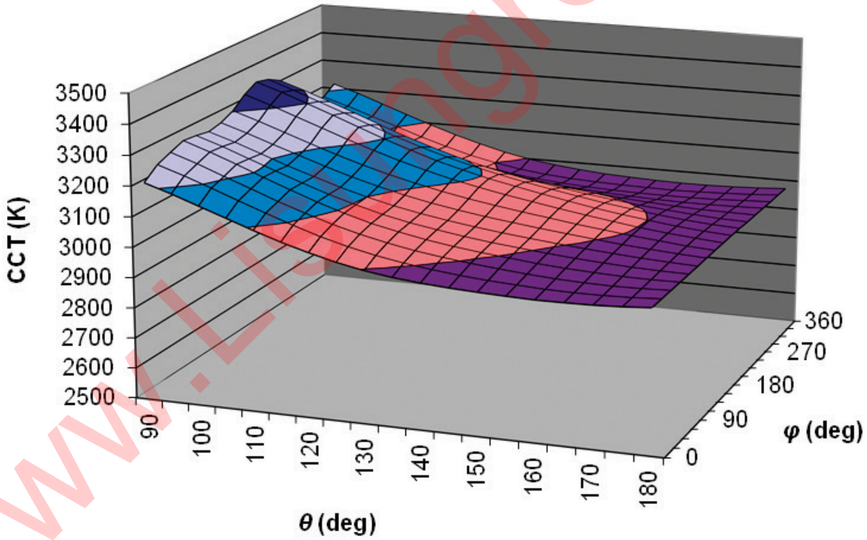

Figure F-2. Correlated color temperature distribution for test lamp shown in Figure E-1 (Annex E), different goniometer system.

Without characterizing the capabilities of the measurement system, it is difficult to determine which measurement is correct. The graph in **Figure F-1** may be inaccurate because the signal-to-noise ratio is too small, resulting in the abrupt changes. The graph in **Figure F-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.

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. The lamp produces approximately 97 lm and, therefore, based on a uniform distribution, has a luminous intensity of 7.8 cd. **Figure F-3** shows the correlated color temperature distribution for the set of measurements described in **Section 9.5**. The $\Delta_{u'v'}$ calculated for the measurements shown in **Figure F-3 is** 0.00013. Instead of using lamps that produce different luminous intensity values, the integration time was reduced, creating the same dependency that would result from a change of lamp.

Figure F-4 shows the dependence of$\Delta_{u'v'}$ (described in **Section 9.5**) versus luminous intensity. 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 $\Delta_{u'v'}$.

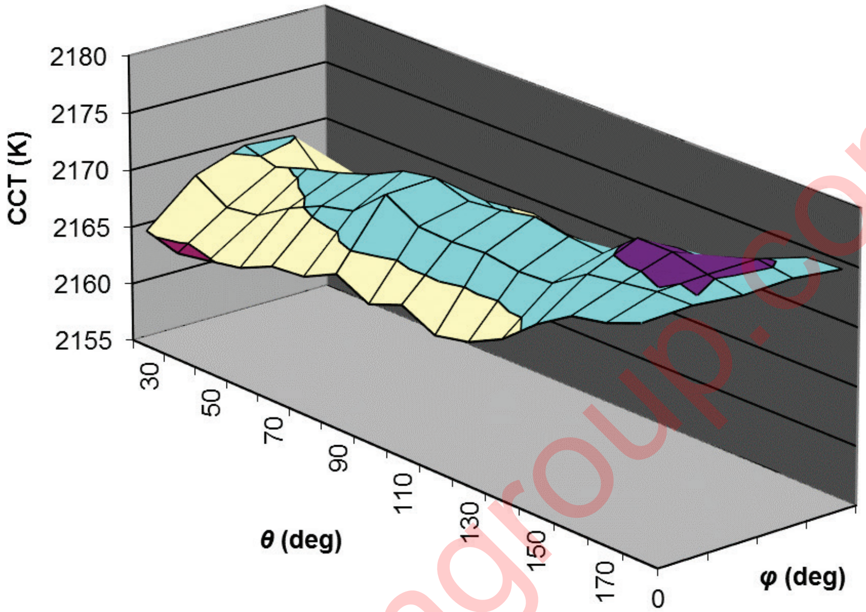

Figure F-3. The correlated color temperature (CCT) distribution for the set of measurements described in Section 9.2 for a heavily frosted or opal coated incandescent lamp.

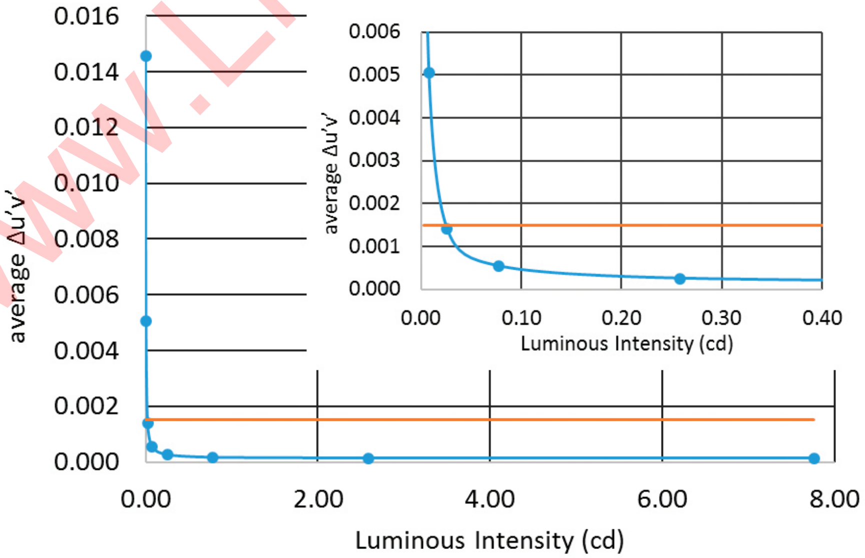

Figure F-4. $\Delta_{u'v'}$ versus the luminous intensity; the insert expands the region around the area where the $\Delta_{u'v'}$ increases quickly.

References

1 Illuminating Engineering Society. TM-16-17; Solid State Lighting Sources and Systems. New York: IES; 2017.

2 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).

3 Illuminating Engineering Society. LM-82-12; IES Approved Method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature. New York: IES; 2012.

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

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

6 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).

7 Illuminating Engineering Society. LM-20-13; IES Approved Method: Photometry of Reflector Type Lamps. New York: IES; 2015.

8 Illuminating Engineering Society. LM-46-04/R14; IESNA Approved Method for Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps. New York: IES; 2015.

9 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.

10 Illuminating Engineering Society. ANSI/IES TM-30-18; IES Method for Evaluating Light Source Color Rendition. New York: IES; 2018.

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Order# ANSI/IES LM-79-19
ISBN# 978-0-87995-004-0

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