LUMILEDS

WHITE PAPER

Optical Measurement Guidelines

for high-power LEDs and solid state lighting products

Introduction

The LED industry is growing rapidly and this naturally brings up an important need for reliable measurements of LEDs and solid state lighting (SSL) products. These measurements often form the foundation for a fair comparison between SSL products from different vendors. Consequently, there is an industry-wide push for standards that ensure accurate and repeatable measurements of optical properties for LEDs and SSL products.

The CIE 127:2007 report from the International Commission on Illumination covers guidelines on how photometric, radiometric, and colorimetric quantities for individual LEDs should be measured in calibration labs. However, the report defers responsibility to manufacturers of LEDs and SSL products to ensure that their equipment measure the optical properties of their products correctly.

The optical performance of LEDs and SSL products can be measured with an integrating sphere. However, standard integrating sphere calibration procedures are not always adequate to accurately measure the optical properties of LEDs due to the high spectral radiant flux in the blue region. The objective of this paper is to introduce appropriate calibration procedures, as well as practical operating guidelines for integrating spheres which are used for the characterization of LEDs and SSL products.

Optical Measurement Basics

The spectral radiant flux distribution of a light source describes how much radiometric power is emitted by the light source per unit of wavelength across the electromagnetic spectrum. Knowledge of the spectral radiant flux distribution of a light source allows the user to derive other useful optical properties for the light source, including total luminous flux, x-y chromaticity coordinates, dominant wavelength, purity, Correlated Color Temperature (CCT), Color Rendering Index (CRI), peak wavelength, centroid wavelength, and full width at half maximum (FWHM). A list of several common engineering terms, which are regularly used to refer to certain optical quantities derived from the spectral radiant flux distribution, can be found in Appendix A.

For Consideration

Performance discrepancies, which are observed for the same SSL product when tested in two different optical measurement systems, are often due to inconsistent calibration procedures and differences in the handling of the device under test. In particular, equipment calibration guidelines used for conventional light sources are not always adequate for LED and SSL product due their high spectral content in the blue region.

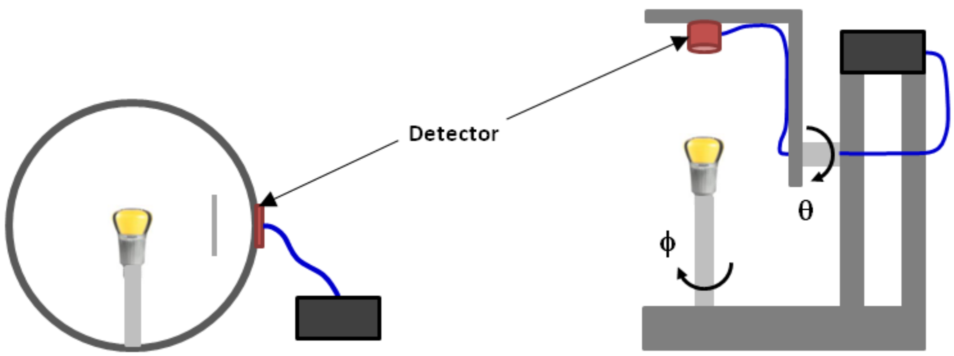


Figure 1. An integrating sphere (left) or a goniometer (right) are typically used to measure the optical performance of an LED or SSL product.

Two different measurement tools are typically used to measure the spectral radiant flux distribution of a light source (see Figure 1):

1. An integrating sphere collects all the lights from a light source placed inside the sphere.
2. A goniometer measures the spectral radiant flux distribution of a light source from many different angles around the source and integrates the results to yield a combined spectral radiant flux distribution for the light source.

Due to its ease of use, an integrating sphere is often preferred over a goniometer to measure the performance of individual LEDs and SSL products (see Appendix B for a detailed comparison). Therefore, the remainder of this paper discusses recommendations and practical guidelines for optical measurements with an integrating sphere.

Integrating Sphere Measurements and Calibration

There are two different integrating sphere configurations that are typically used to characterize the optical performance of LEDs and SSL products, see Figure 2. A 4π configuration (left) is best suited for an omnidirectional light source while a 2π configuration (right) is best suited for a forward emitting light source.

A complete integrating sphere test system consists of:

- An integrating sphere with appropriate ports and baffles
- Reference calibration standards (spectral lamp, reference LED), calibrated by an ISO/IEC 17025 certified laboratory, and appropriate power supplies

- A temperature controlled socket may be required for LED standards to ensure consistent results
- Spectroradiometer
- Auxiliary lamp and power supply
- Computer plus software for calibration and measurement

Integrating spheres can be used to characterize a variety of light sources, including LEDs and SSL products. However, in order to obtain accurate measurement results for LEDs, certain calibration procedures and best practices, as outlined in the remainder of this section, should be followed. In particular, the standard calibration process for an integrating sphere must be tailored to LEDs in order to properly account for their high spectral radiant flux in the blue region.

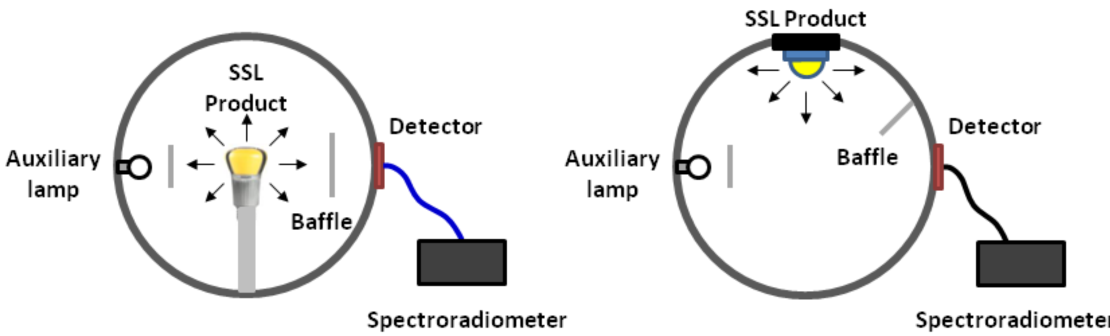


Figure 2. Typical integrating spheres configurations for optical measurements: an omnidirectional 4π configuration (left) and a forward emitting 2π configuration (right).

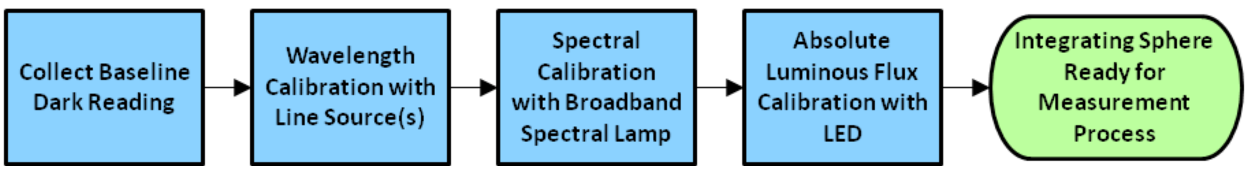


Figure 3. Recommended calibration procedure for an integrating sphere.

Recommended Calibration Procedure

The integrating sphere and corresponding spectroradiometer must be properly calibrated before any LED or SSL product is measured. If the calibration of an integrating sphere is determined to be out of specification, Lumileds recommends the following calibration procedure (see also Figure 3):

1. Collect baseline dark reading for the integrating sphere. This baseline reading is used to reset the detector of the integrating sphere to "zero". For this measurement, the sphere system must be sealed from all ambient light. It is best to maintain the same ambient light level (zero or minimum) throughout the measurement process.

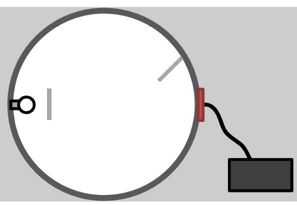
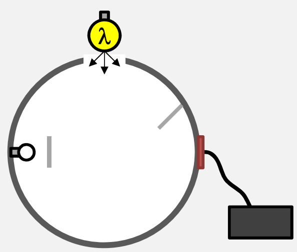
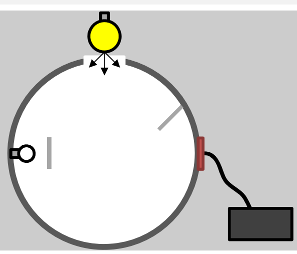
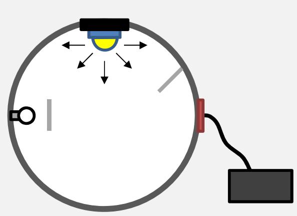
2. Wavelength calibration with well-defined wavelength reference standard(s). The integrating sphere must be calibrated first for wavelength accuracy. To do so, light from one or more well-defined wavelength reference standards (e.g. HgAr and HeNe source lamps) should be directed into the integrating sphere.

3. Spectral calibration with broadband spectral lamp. The combined spectral response of the integrating sphere and spectroradiometer must be calibrated to a broadband spectral flux standard, calibrated by an ISO/IEC 17025 certified laboratory. To ensure an accurate response across the visual spectrum, light from a broadband spectral lamp should be directed into the integrating sphere.

4. Absolute luminous flux calibration with a white LED. A typical broadband (incandescent) spectral lamp has very low energy in the blue region and significantly higher energy in the red and infrared regions. This can result in higher amounts of stray light from the infrared region to the visible region of the spectrometer during spectral calibration step (see Stray Light section for more details). Also the low signal-to-noise ratio in the blue region makes the spectral calibration less reliable in the blue region than in the red and infrared regions. A white LED, in contrast, only emits light in the visible spectrum and none in the infrared spectrum. So the amount of stray light that reaches the spectrometer is significantly less. Also, compared to other light sources, white LEDs typically emit a large part of their energy in the blue spectrum. Consequently, a sphere which is calibrated with a broadband spectral lamp may yield incorrect absolute flux readings for (white) LEDs. It is, therefore, important to calibrate the absolute photometric flux reading for the sphere with a white LED standard calibrated by an ISO/IEC 17025 certified laboratory. This reference LED should be mounted onto a temperature-controlled socket to ensure consistent readings. Since this reference LED is typically placed inside the integrating sphere, any absorption losses due to the LED socket and the LED package should be corrected for (as explained in the Absorption Correction for Light Source section) before any measurements are performed.

Each step in this calibration procedure can be further broken down into several sub-steps, as shown in Table 1.

Table 1. Recommended steps for calibration of an integrating sphere.

	**Step 1: Collect Baseline Dark Reading** a. Close the integrating sphere and close/cover all ports to prevent any ambient light from entering the sphere. b. Measure the baseline spectral radiant flux distribution for the dark sphere. c. Record the baseline dark reading in the system software.
	**Step 2: Wavelength Calibration** a. Direct light from a wavelength reference standard with well-defined emission peaks (e.g. HgAr or HeNe lamp) into the integrating sphere. Ensure that no ambient light enters the sphere. b. Turn on the wavelength reference standard and allow it to stabilize. c. Measure the spectral radiant flux distribution for the wavelength reference standard. d. Compare the measured emission peaks with the known spectral content of the wavelength reference standard and use the system software to correct the spectroradiometer, if needed.
	**Step 3: Spectral Calibration** a. Direct light from a broadband spectral flux standard, calibrated by an ISO/IEC 17025 certified laboratory, into the integrating sphere. b. Turn on the broadband spectral flux standard and allow it to stabilize. c. Measure the spectral radiant flux distribution for the broadband spectral flux standard. d. Generate a calibration file that captures the difference between the measured and actual spectral radiant flux distribution of the broadband spectral flux standard.
	**Step 4: Absolute Luminous Flux Calibration** a. Mount a white LED standard, calibrated by an ISO/IEC 17025 certified laboratory, with a known luminous flux on a temperature controlled socket. b. Place the white LED and temperature controlled socket in the integrating sphere and perform an absorption correction as outlined in Section 3.2. c. Turn on the white LED and allow it to stabilize. d. Measure the spectral radiant flux distribution for the white LED and calculate its luminous flux (see Appendix C). e. Use the calibration software to derive an appropriate correction factor such that the measured luminous flux equals the actual luminous flux for the white LED.

Notes:

- The spectral radiant flux distribution of each reference standard is a function of the drive current and temperature. To ensure reproducible results, always control the drive current and the temperature of the reference standard according to the vendor's specifications. In addition, allow all reference standards to warm up for at least 30-45 minutes before making any measurements.
- The illustrations in this table are for a forward emitting (2π) configuration. For an omnidirectional (4π) configuration, the spectral standard, and white LED standard are typically positioned at the center of the integrating sphere. When placing a source inside the sphere, always correct for any absorption by the source and its mechanical fixture (see Section 3.2).
- Ensure that the spectroradiometer port is baffled to avoid direct illumination from any lamp in the sphere.
- For some spheres, the reference calibration standards are positioned outside the sphere and light from these standards is directed into the sphere through a view port.
- The user should always refer to the system manuals for system-specific calibration and measurement steps.
- Typical normalized spectral radiant flux distributions for the various reference standards are presented in Appendix C.

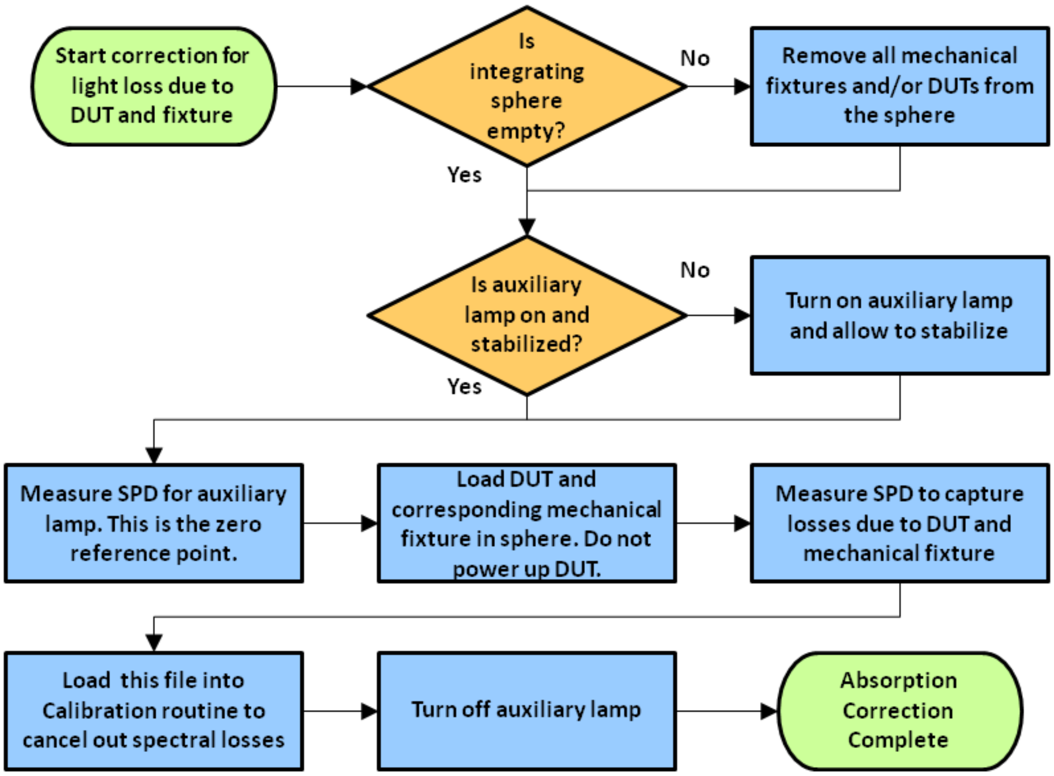


Figure 4. Recommended absorption correction procedure.

Absorption Correction for Light Source and its Mechanical Fixture

Whenever an object is introduced inside an integrating sphere, the spectral reflectivity of the sphere is changed. This, in turn, affects the overall measurement accuracy of the integrating sphere. So it is important that any absorption losses due to the device under test (DUT) and its mechanical fixture are first accounted for before any measurements are performed.

Absorption correction is typically performed with an auxiliary broadband lamp which is mounted inside the integrating sphere. Light from this auxiliary broadband lamp is used to collect the spectral response of the sphere without and with the DUT and its mechanical fixture. The spectral absorption losses due to the DUT and its mechanical fixture can then be extracted from the difference between the two measured spectral responses. Figure 4 outlines the procedure that Lumileds uses to correct for any absorption losses. This procedure is sometimes also referred to as Substitution Error Measurement. Once the absorption due to the DUT and its mechanical fixture is properly characterized, the integrating sphere is ready to perform actual measurements with the DUT.

It is important to note that the DUT should remain off throughout the Absorption Correction procedure. Also, the auxiliary broadband lamp should be allowed to stabilize before the procedure is started. Finally the procedure should be repeated for any new DUT or mechanical fixture that is placed in the integrating sphere.

Best Practices

Prior to using an integrating sphere it is essential to perform all the calibration steps mentioned above. However, this poses some practical difficulties, in particular in terms of the time it takes to measure a single LED. The following practices are recommended to ensure that the calibration for the integrating sphere is valid:

- In a production or laboratory environment where LEDs are characterized on a routine basis, calibration of the measurement sphere is typically performed only periodically (e.g. monthly, quarterly, or annually). To ensure the integrating sphere is properly calibrated, Lumileds recommends monitoring the sphere performance regularly (e.g. daily or weekly) with special Monitor LEDs (see Figure 5). If the errors between the measured and "golden" performance of these monitor LEDs fall outside acceptable tolerances set by the lab, the integrating sphere should be recalibrated according to the calibration procedure in the Recommended Calibration Procedure section.

- A lab or production environment should maintain multiple monitor LEDs to check for stability. Also, a lab should maintain extra sets of primary calibration reference standards (wavelength, broadband spectral and LED reference standards) in case one needs to be recalibrated.

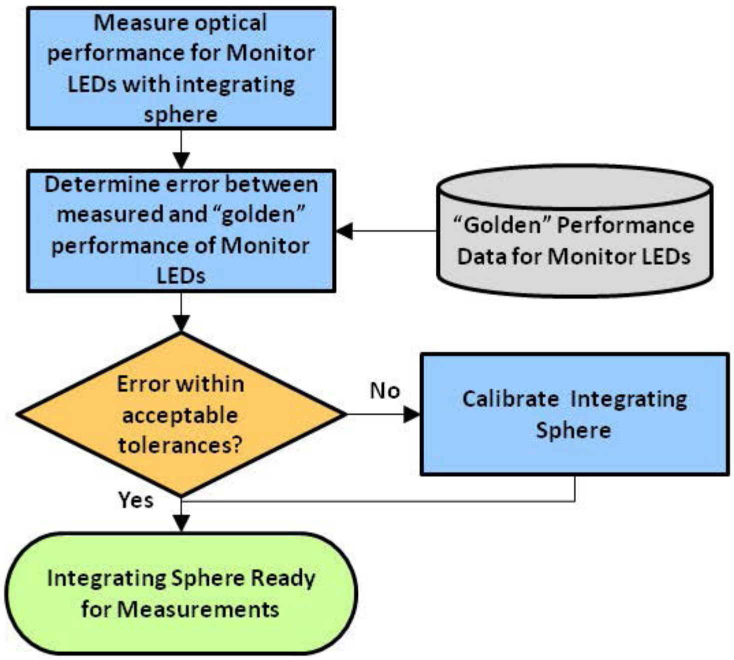


Figure 5. The performance of an integrating sphere should be monitored regularly with special Monitor LEDs. If the measured performance of the Monitor LEDs is out of specification, the integrating sphere should be recalibrated

- It is important that all reference lamps remain in calibration per the dates on the calibration certificates provided by the national calibration laboratory.
- Often, similar types of LED packages are routinely measured in labs and production environments. In general, the absorption correction factors for these LED packages and corresponding test fixtures (see the Absorption Correction for Light Source section) do not vary as long as their form factors remain the same. Therefore, these absorption correction factors can be saved in the measurement system's computer database and can be applied depending on the package under test. It is important, though, to re-measure these absorption correction factors on a regular basis

Guidelines to Prevent Common Equipment Errors

Users sometimes report measurement discrepancies for the same LED when measured on two different systems. This could arise either because of errors with the system or different levels of accuracies between the two systems. This section describes several common sources of equipment errors and provides suggestions to minimize those.

Integrating Sphere

Choosing an appropriately sized integrating sphere is important since it will directly impact overall throughput and accuracy of the measurements. Unfortunately, this choice is complicated due to two conflicting requirements:

1. A smaller sphere increases sphere throughput, i.e. the amount of light at the output port divided by the amount of light entering the sphere. A higher throughput, in turn, yields an increased signal-to-noise ratio at the detector.
2. A large sphere enhances spatial integration of light and improves overall system accuracy. It is, therefore, important to strike an appropriate balance between system throughput and accuracy.

Sphere throughput is also a function of the sphere wall reflectance. It is therefore best to use a sphere with a wall reflectance greater than 95% in the visible spectrum.

When acquiring a sphere system, it is critical to explain to the vendor key parameters such as DUT dimensions and DUT measurement geometry (4π or 2π configuration) to ensure optimal system performance. Table 2 summarizes several key considerations for sphere design and selection.

Detector

For luminous flux measurements, two types of detectors can be used, a photometer or a spectroradiometer. The choice of detector dictates the level of error associated with the measurement.

Spectroradiometer vs. Photometer

A photometer consists of a broadband detector with a photopic filter that resembles the human eye response. The output current of a photometer is proportional to the luminous flux. A spectroradiometer, in contrast, measures the total spectral radiant flux distribution of the light source. CIE color matching functions are then weighed with this distribution (in software) to obtain other optical performance metrics such as luminous flux.

The photopic filter used in a photometer typically resembles the human eye sensitivity curve fairly well. However, there are some deviations, especially in the blue spectral region..

Table 2. Integrating Sphere Design and Selection Considerations [1]

DESIGN / SELECTION CONSIDERATION	REMARKS
Coating Reflectance > 95% in visible region	Improve sphere throughput and signal-to-noise ratio at the detector
Size: • Total port area < 5% of sphere wall area • Total surface area of DUT < 2% of sphere wall area • Longest linear dim of DUT < 2/3 of sphere diameter • DUT port diameter (ext mount) < 1/3 sphere diameter	Strike balance between throughput and measurement accuracy
Baffles should be placed at 1/3 to 1/2 of sphere radius from detector port	Shield direct illumination from light sources to detector causing artificially higher reading at detector

[1] Courtesy IESNA LM-79-08

When measuring the luminous flux of an incandescent lamp, these deviations in spectral response may not be very obvious as most of the energy from an incandescent lamp is in the red region and diminishing towards blue. However, if a typical white LED is measured with a photometer, these deviations are magnified as a white LED typically has substantial spectral radiant flux in the blue region. Consequently, the use of a photometer for measurement of white LEDs will cause an error. The best way to avoid this is by using a spectroradiometer. An additional benefit of using a spectroradiometer is the ability to obtain other optical performance metrics such as x-y chromaticity coordinates, dominant wavelength, purity, CCT, CRI, peak wavelength, centroid wavelength, and FWHM.

Spectral Resolution

Spectrometer bandpass determines the resolution with which a spectrometer can resolve a spectral radiant flux distribution. A smaller bandpass results in a higher resolution. A relatively broad bandpass can cause artificial “fattening” of the spectral radiant flux distribution of an LED, yielding measurement errors in derived optical parameters such as luminous flux. To minimize this error, the bandpass should be set to approximately 1/5 of the FWHM of the LED; this translates into a bandpass which is not much larger than 3nm for narrow band LEDs.

Stray Light

A typical array spectrometer consists of a diffraction grating that splits the incoming light spatially into its spectral components and projects the split components onto a detector array, such that each pixel of the array receives a split light component characterized by wavelength. Stray light is the measured quantity of light that is of a wavelength other than that selected. For example, if a particular pixel in an array normally collects light for 575–576 nm, stray light in that pixel is any light contribution coming from wavelengths other than 575–576 nm.

High levels of stray light in a spectrometer will undermine the calibration accuracy. Therefore, stray light within the spectrometer should be minimized. National Institute of Standards and Technology, USA (NIST) has come up with an algorithm to reduce stray light in spectrometers (see Reference [8]). Using software that includes this algorithm may reduce stray light effects during calibration.

Reference Standards

A measurement system is not complete without appropriate reference lamp standards which are calibrated by an ISO/IEC 17025 certified laboratory.The procedure in the Recommended Calibration Procedure section calls for spectral calibration of the spectroradiometer and absolute luminous flux calibration of the integrating sphere system. Spectral calibration is typically performed with a halogen spectral lamp. If the source to be measured is a broadband incandescent lamp, the spectral calibration standard can be used as an absolute luminous flux calibration standard as well. However, if an integrating sphere is used to measure LEDs (especially white or blue LEDs) the halogen spectral lamp cannot be used as an absolute luminous flux calibration standard because:

1. The stray light in the blue region of the spectroradiometer is higher when calibrated with a tungsten halogen source, which has most of its energy in the infrared region.
2. The signal-to-noise ratio in the blue region for a tungsten halogen source is poor.

Therefore, Lumileds recommends using a calibrated LED source as an absolute luminous flux calibration standard to ensure accurate luminous flux measurements for LEDs and SSL products.

Current Sources

Integrating sphere measurements are normally collected with monopulse or continuous DC input drive currents. In monopulse mode, the DUT is briefly subjected to a constant current pulse with a typical duration of 20–50ms, while the spectrometer integration time is set slightly shorter than the duration of the current pulse. In continuous DC mode, the DUT is subjected to a constant current and the integration time is automatically selected to get the best signal to noise ratio.

The spectral radiant flux distribution of a broadband light source is a function of the current through the lamp. Hence the current must be well controlled to a value within an acceptable tolerance (e.g. ±0.1mA) to ensure relative stability and reproducibility of the light source standard. In case of LEDs, the spectral radiant flux distribution is very sensitive to fluctuations in the drive current and temperature. So it is imperative that the current source which is used to power the absolute calibration LED standard and the DUT, is stable and accurate and that the LED has reached a steady state temperature.

Handling Guidelines for the Device Under Test

Although equipment based errors can be minimized by adopting the best practices discussed in the previous section, measurement discrepancies for the same LED between two different systems may persist. For example, a customer may measure an LED in a properly calibrated integrating sphere system and still report a different luminous flux value than the luminous flux reported by the vendor of that LED. This section discusses possible sources of such discrepancies and measures to minimize those.

Unequal Operating Conditions

The luminous flux of an LED is a strong function of drive current and junction temperature. Unequal operating conditions when comparing two measurements, is one of the biggest sources of discrepancy and should be checked first before proceeding with further troubleshooting. The calibration status of the test equipment as well as any differences in ambient temperature and/or DUT positioning in the sphere can affect measurement accuracy. So Lumileds recommends documenting the following pieces of information with each measurement:

- Ambient temperature and humidity
- LED drive conditions (socket temperature, type of current pulse, current duration and amplitude)
- Location of the LED and its mechanical fixture in the integrating sphere
- Date of last calibration

Inconsistent DUT Positioning

LEDs are typically kept in place by a mechanical fixture, which, in turn, is mounted on a port of the integrating sphere or is positioned in the center of the sphere. Inconsistencies in the relative placement of DUTs in two integrating spheres are a common source of measurement discrepancies.

When the DUT is mounted onto a sphere port, the mechanical fixture should not obstruct any of the light from the DUT, i.e. all light from the DUT should be captured inside the sphere (see Figure 6). In addition, if the DUT is tested in a sphere with a 4π configuration, the center of the DUT emitting area should be placed at the center of the sphere, facing away from the detector.

An ideal sphere system is designed such that baffles shield the detector from direct illumination by the DUT. The baffle size and position is optimized to ensure maximum light integration and proper light shielding at the same time. The appropriate position of a baffle in an integrating sphere depends on where the DUT is normally mounted. The baffle position for a DUT mounted in the center is typically different than the baffle position for a DUT mounted at a port. In case the DUT can be mounted either on a port or in the center of the sphere, two separate baffles must be positioned inside the sphere. In case a DUT is placed off-center inside a sphere, the detector is likely to see direct light instead of spatially integrated light, causing skewed readings.

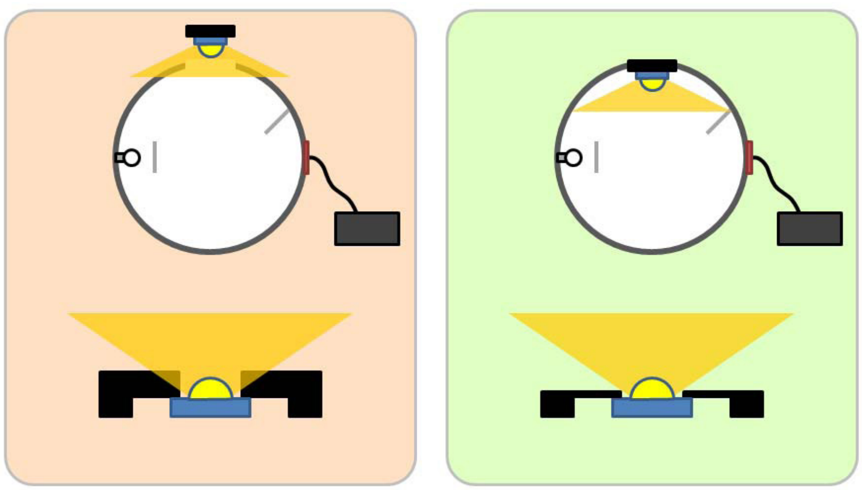


Figure 6. The light from an LED should enter an integrating sphere without encountering any obstructions. Examples of poor LED placement in the sphere and mechanical fixture are shown on the left. Proper placement is shown on the right.

Near Field Absorption

Sometimes a portion of the total light emitted from a DUT gets lost due to the presence of a high absorbance material near the DUT. As a result, the measurement system records a reduced value for the luminous flux. This near-field absorption can occur due to LED sockets, Printed Circuit Boards (PCBs) or mechanical mounting brackets. It is nearly impossible to correct for this type of absorption with an auxiliary lamp. However, this can be minimized by either selecting a low absorbance material or by painting that material with a high reflectance coating.

Level 1 to Level 2 Measurement Differences

A single LED package, which is not mounted on any board or heat sink, is often referred to as a Level 1 solution. A Level 2 solution, on the other hand, typically refers to one or more LEDs mounted in an array on a PCB with several contact points for electrical power.

LEDs which are placed in close proximity to each other, such as in a Level 2 solution, can sometimes absorb some of the light from their neighbors, reducing the overall luminous flux of the array.Therefore the measured flux of a Level 2 solution is not always equal to the combined flux of the individual LEDs on the Level 2 solution. However, this effect is often difficult to estimate in advance since the LED package type, the dome size, the distance between devices as well as the absorption properties of the PCB on which the LEDs are mounted can all adversely affect the total luminous flux of the Level 2 solution.

References and Recommended Reading Material

1. Technical Guide to Integrating Sphere Radiometry and Photometry, Labsphere
   https://www.labsphere.com/site/assets/files/2550/a-guide-to-integrating-sphere-radiometry-and-photometry.pdf
2. Field Guide to Illumination, SPIE
3. The Radiometry of Light Emitting Diodes: Technical Guide, Labsphere
   https://www.labsphere.com/site/assets/files/2570/the-radiometry-of-light-emitting-diodes-leds.pdf
4. Handbook of LED Metrology, Instrument Systems
   http://www.instrumentsystems.com/fileadmin/editors/downloads/Products/LED_Handbook_e.pdf
5. CIE 127:2007 Measurement of LEDs
6. IESNA LM-79: Electrical and Photometric Measurements of Solid-State Lighting Products
7. IESNA LM-80: Measuring Lumen Maintenance of LED Light Sources
8. Characterization and Correction of Stray Light in Optical Instruments: Zong, Y.; Brown, S. W.; Meister, G.; Barnes, R.; Lykke, K. R.

Appendix A

In any discussion related to LED measurements it is essential to clearly define what physical quantity is measured. Moreover it is important to choose the appropriate instrumentation to do so. Sometimes engineering nomenclature overlaps with terms in common use, e.g. power could mean luminous flux, radiant flux or electrical power; brightness could mean luminance or radiance; illumination could mean illuminance or irradiance. To avoid any confusion, it is best to use correct engineering terms and corresponding units. The table below summarizes several common engineering terms, including their SI units, which are regularly used for certain radiometric and photometric quantities.

	RADIOMETRIC	PHOTOMETRIC
Flux	Radiant Flux W	Luminous Flux lm
Flux/Area	Irradiance W/m^2	Illuminance lux = lm/m^2
Flux	Radiant Intensity W/sr	Luminous Intensity candela = lm/sr
Flux/(Area · Solid Angle)	Radiance W/(m^2 · sr)	Luminance nit = lm/(m^2 · sr)

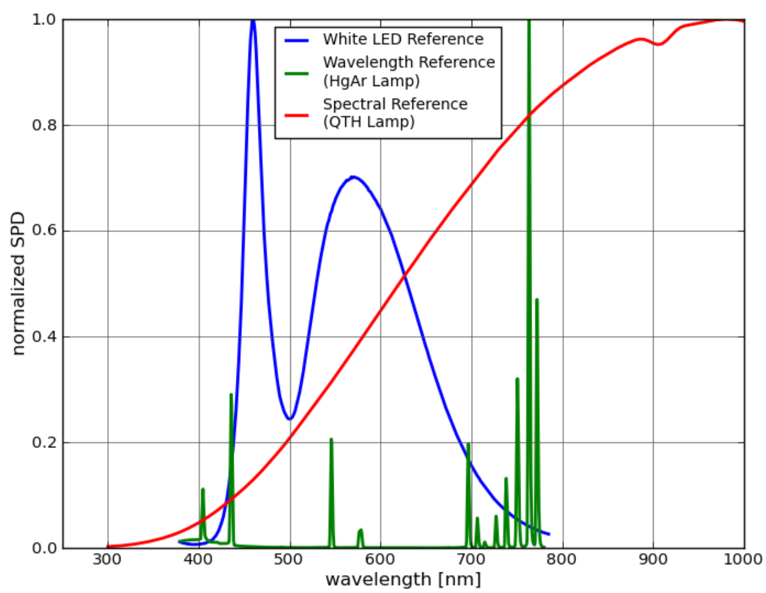
Appendix B

Integrating Sphere vs. Goniometer

	INTEGRATING SPHERE	GONIOMETER
Operating Procedure	Place Device Under Test (DUT) inside an integrating sphere or at port of sphere and sample total light output. A single measurement yields all the relevant optical information.	Measure spectral irradiance with a detector at all angles (4π) and sum to get resulting radiometric flux. The size of the detector and the distance between the detector and DUT remain fixed for all measurements.
Measured Quantity	Total spectral flux (with a spectroradiometer as detector)	Spectral intensity vs. angle (radiometric with a spectroradiometer)
Pros	• Fast: One measurement for single luminous flux value • Relatively low cost • Does not require a dark room • Easy to monitor/control ambient temperature and light conditions • Easy to Use/Repeat Measurement • Can be used at all stages of product development (raw LED to finished product). Note: Size of sphere will depend on size of DUT.	• Complete spatial angular profile of source output. • Suited for very large directional luminaire measurements • Less sensitive to the geometry and spectral characteristics of the DUT
Cons	• quantization of spatial/angular distribution • Geometric and spectral sources of error need to be taken into account correctly to ensure accurate results.	• Expensive equipment (and testing services) • Requires large dedicated dark room • Long measurement period (spectral – even longer)

Appendix C

Typical normalized spectral radiant flux distributions for various calibration reference standards



About Lumileds

Lumileds is the global leader in light engine technology. The company develops, manufactures and distributes groundbreaking LEDs and automotive lighting products that shatter the status quo and help customers gain and maintain a competitive edge.

With a rich history of industry "firsts," Lumileds is uniquely positioned to deliver lighting advancements well into the future by maintaining an unwavering focus on quality, innovation and reliability.

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