ANSI/IES LM-85-20

Illuminating ENGINEERING SOCIETY

APPROVED METHOD: OPTICAL AND ELECTRICAL MEASUREMENTS OF LED PACKAGES AND ARRAYS

AN AMERICAN NATIONAL STANDARD

Approved American National Standard ANSI

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has been approved by IES.
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The IES Testing Procedures Committee

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1.0 Introduction and Scope

1.1 Introduction

This document is a guide developed for the measurement of high-power light emitting diodes (LEDs), normally in a form of LED packages, used for lighting products. High-power LEDs are those that require a heat sink for their normal operation. The light output of an LED depends strongly on its thermal conditions, in particular, the junction temperatures T_j. Junction temperature, however, is difficult to measure. Various different methods have been used to operate LEDs for photometric measurements, and the results could not be compared. This document provides uniform test methods for operation of high-power LEDs and test methods for photometric and colorimetric measurement of high-power LEDs.

The photometric measurement of high-power LEDs has been difficult because they are highly sensitive to thermal operating conditions, and there has been a lack of common methods that can be used by LED manufacturers and users to acquire reproducible results. LED manufacturers normally use pulse operation, whereby LEDs are measured with no heat sink and with the underlying assumption that the junction temperature under these conditions is equal to the room temperature, typically 25 °C. Therefore, published LED specifications are normally at a junction temperature of 25 °C. High-power LEDs in actual lighting products, however, are operating in DC and at much higher temperatures (junction temperature is typically 60 °C to over 100 °C), where their photometric and colorimetric values tend to deviate significantly from those at the room temperature condition. To assist users, LED manufacturers make efforts to provide data on thermal characteristics for higher operating temperatures; however, because LEDs are usually binned by LED manufacturers for their optical and electrical characteristics at T_j equal to 25 °C, manufacturer data for higher operating temperatures is of limited use. There have been no standard methods for measuring high-power LEDs at high temperatures. This document provides reproducible measurement methods of LEDs at a given junction temperature in pulse or DC mode and provides the grounds for specification of LEDs at high temperature conditions.

Lighting product manufacturers often need to know the performance of LEDs operating in full rated DC current at thermal equilibrium at temperatures much higher than 25 °C. To set or measure thermal conditions of the LED, case temperature, pin temperature, board temperature, solder-point temperature, or heat sink temperature is commonly used, depending on the type of LED. While these methods are useful to reproduce the same condition for the particular LED, the results using these different methods cannot be compared with each other and cannot be reconciled into a universal standard method. Due to the optical characteristics of LEDs and their dependence on junction temperature, the only way to obtain reproducible results universally for all types of LEDs is by setting them to a specified junction temperature. The test method described in this document sets the LED under test to a pre-determined junction temperature, for measurement at either pulse mode or DC mode operation. Such a method can establish equivalence of results between the pulse mode tests (normally performed by LED manufacturers) and the DC mode tests (often preferred by users of LEDs).

The photometric and radiometric information typically required for high-power LEDs for lighting products is total luminous flux (lumens), total radiant flux (watts), total photon flux (mol/s), and luminous efficacy (lm/W). The colorimetric information includes chromaticity coordinates for all LEDs; correlated color temperature (CCT), Duv, and color rendering index (CRI) for white LEDs; and dominant wavelength, centroid wavelength, and peak wavelengths for colored LEDs. For the purpose of this document, the determination of these values is referred to as *optical measurements*.

The electrical characteristics typically required for high-power LEDs for lighting products are input DC current, forward voltage, and input power. For the purpose of this document, the determination of these values is referred to as *electrical measurements*.

For special purposes, it may be useful to determine the characteristics of LEDs when they are operated at conditions other than the nominal conditions described in this Approved Method. When measurements are conducted at conditions other than the nominal

conditions, the results are valid only for the particular conditions under which they were obtained; these conditions shall be stated in the test report.

1.2 Scope

This approved method describes the procedures to be followed and precautions to be observed in performing accurate measurements of total luminous flux, total radiant flux (optical power), total photon flux, electrical power, luminous efficacy, color quantities, and wavelength characteristics of high-power light emitting diodes (LEDs), including white LEDs and single-color LEDs. This approved method covers LED packages (defined in ANSI/IES LS-1-20; see **Section 2**), including those with multiple chips and remote-phosphor LED packages. It also covers LED arrays or modules including remote-phosphor LED arrays or modules. This document covers measurement under pulse operation as well as steady DC operation of LEDs, and in all cases, the *thermal condition* of LEDs refers to their junction temperature. This Approved Method applies to laboratory measurements.

This document does not cover AC-LED packages and AC-LED arrays or modules, nor LED lighting products; it does not apply to measurements in an LED manufacturer's production control, nor to relative measurements of LED thermal characteristics.

2.0 Normative References

2.1 ANSI/IES LS-1-20

Illuminating Engineering Society. Lighting Science: Nomenclature and Definitions for Illuminating Engineering. New York: IES; 2020. Online: www.ies.org/standards/definitions/ (Accessed 2019 Feb 13).

3.0 Definitions

3.1 device under test (DUT)

For the purpose of this document: The high-power LED package under test.

3.2 Duv

The closest distance from the chromaticity coordinate of the light source to the Planckian locus on the CIE (*u*', 2/3 *v*') coordinates, with "+" sign for locations above and "-" sign for locations below the Planckian locus.

3.3 goniophotometer

Photometer for measuring the directional light distribution characteristics of sources, luminaires, media, or surfaces. In this document, the term *goniophotometer* includes gonio-colorimeters and gonio-spectroradiometers.

3.4 gonio-colorimeter

A goniophotometer equipped with a tristimulus colorimeter head as the detector.

3.5 gonio-spectroradiometer

A goniophotometer equipped with a spectroradiometer as the detector.

3.6 heat sink

A device attached to an LED assembly (package, array, or module) to dissipate heat.

3.7 high-power LED

An LED package that requires a heat sink or other means of thermal management for its normal operation.

3.8 national metrology institute (NMI)

A national laboratory that maintains the SI units for the country and is authorized to disseminate calibration standards for measurements.

3.9 photometer head

A unit containing a detector, a V(λ)-correction filter, and any additional components (e.g., aperture, diffuser, amplifier) within the unit.

3.10 remote phosphor LED package

An LED package containing a phosphor that is spatially separated from the pump or source radiation element, but is contained within the LED package.

3.11 settling time

The time needed for a signal to reach a stable level after a fast transition.