ANSI/ASABE S642 SEP2018
Recommended Methods for Measurement and Testing of LED Products for Plant Growth and Development

American Society of Agricultural and Biological Engineers

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ANSI/ASABE S642 SEP2018
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Recommended Methods for Measurement and Testing of LED Products for Plant Growth and Development

Developed by the Plant Growth LED Lighting Committee. Approved as an ASABE standard May 2018; approved by ANSI September 2018.

Keywords: LED, Measurement, Testing

Introduction

Plant growth and development is dependent on photon (or radiant) flux, photon (or radiant) flux density, photoperiod, and spectral power distribution of electromagnetic radiation. Horticulturalists have traditionally leveraged different intensities and exposure times of fluorescent or HID light sources to control the growth rate of their plants.

As different types of plants react differently to the spectral output and photon (or radiant) flux output of the electrical light source, the use of solid-state lighting (SSL) in the horticultural arena can be seen as a potential benefit for the industry. Solid state lighting (SSL) provides the opportunity to deliver radiation with specific spectral power distributions in accordance with the plants' needs.

Although standards such as IES LM-79-08 exist today to specify the spectral radiation measurements of light sources, they are not specific to SSL horticultural applications. They do not, for example, take into consideration environmental conditions. Further, standards such as IES LM-79-08 are based on the perception of light by the human eye, while this standard is intended to address the plant's response to electromagnetic radiation.

The intent of this standard is to leverage existing standards and provide additional guidance suitable for solid-state radiation for plant growth and development. This includes measured quantities, measurement uncertainty, instrument type, etc. This document describes methods of measurement for different product types. The testing of all quantities outlined in this standard for each defined device is not necessary.

During the development of this standard, concerns were expressed as to the long-term behavior of LED products due to biological and chemical exposure. Since there are insufficient data on the subject and no relevant industry standards have yet been developed, this topic is not covered in the present version of this document, and remains open for consideration in future versions.

During the development of this standard, concerns were also expressed as to the measurement of irradiance in horticultural lighting applications. Since there are limited standards that adequately address how to test for these measurements for horticultural applications, this topic is not covered in the present version of this document and remains open for consideration in future versions.

1 Scope

This document describes methods for measurement and testing of LED packages and arrays or modules, LED lamps, and any other LED optical radiation devices, with a spectral range between 280 nm and 800 nm, used for plant growth and development. These methods are necessary to obtain information about device characteristics and long-term change behaviors.

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2 Normative References

2.1 ASAE/ASABE EP411, Guidelines for Measuring and Reporting Environmental Parameters for Plant Experiments in Growth Chambers

2.2 ANSI/ASABE S640 JUL2017, Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)

2.3 ANSI/IES LM-80-15, Approved Method: Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

2.4 ANSI/IES RP-16-10, Nomenclature and Definitions for Illuminating Engineering, New York, NY: Illuminating Engineering Society

2.5 CIE 127-2007, Measurement of LEDs

2.6 CIE 225-2017, Optical Measurements of High-Power LEDs

2.7 IES LM-79-08, Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products

2.8 IES LM-84-14, Approved Method for Measuring Luminous Flux and Color Maintenance of LED Lamps, Light Engines, and Luminaires

2.9 IES LM-85-14, Electrical and Photometric Measurements of High-Power LEDs

2.10 IES TM-27-14, Standard Format for the Electronic Transfer of Spectral Data

2.11 IES TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources

2.12 IES TM-21-11, Addendum B, Projecting Long Term Lumen Maintenance of LED Light Source

2.13 IES TM-28-14, Projecting Long-Term Luminous Flux Maintenance of LED Lamps and Luminaires

2.14 JESD22-A101D, Steady State Temperature Humidity Bias Life Test

3 Definitions

3.1 Device Under Test (DUT): LED packages, LED lamps, and any other LED radiation device under the test.

4 Measurements of Spectral Radiant Flux, Spectral Photon Flux, Radiant and Photon Intensity

4.1 Spectral Radiant Flux and Spectral Photon Flux Produced by LED Packages and Arrays or Modules

Where applicable, procedures described in IES LM-85-14, CIE-127:2007 for averaged intensity, or CIE-225:2017 for true intensity, shall be used for measuring the radiant or photon flux of the DUT. The full measured wavelength range, as specified per ANSI/ASABE S640, is 280 nm to 800 nm. If the DUT is designed for a specific wavelength range, then only that range may be measured. Measurements outside the 280 nm to 800 nm range are not within the scope of this document.

The relative spectral power distribution (SPD) shall be measured with a minimum resolution of 5 nm. The measured result of the SPD shall be reported using the format specified in IES TM-27-14.

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4.2 Spectral Radiant Flux and Spectral Photon Flux Produced by LED Lamps and Any Other LED Device

Where applicable, procedures described in IES LM-79-08 shall be used for measuring the radiant or photon flux of the DUT. The full measured wavelength range, as specified per ANSI/ASABE S640, is 280 nm to 800 nm. If the DUT is designed for a specific wavelength range, then only that range may be measured.

The SPD shall be measured with a minimum resolution of 5 nm. The measured result of the SPD shall be reported using the format specified in IES TM-27-14.

See Annex A for additional information on the effects of directionality on the irradiance reaching the plant.

4.3 Radiant and Photon Intensity Produced by LED Lamps and Any Other LED Devices

Where applicable, the photon intensity should be measured with a goniometer system using a spectroradiometer detection that covers the wavelength range of at least 280 nm to 800 nm. The spectroradiometer system shall have a wavelength uncertainty within 0.5 nm (confidence interval k = 2) and the bandwidth (full width half maximum) shall not be greater than 5 nm.

When radiant intensity and photon intensity are measured, the procedures above shall be used, to the extent that they apply to the instrumentation described in Section 6 of this document. If measured, the result of the photon intensity angular distribution shall be reported.

5 Measurements of Long-Term Performance Changes

LEDs (packages, arrays, and modules), LED lamps, and any other LED radiation devices used for plant growth and development may be under different integration (assembly) levels, so it is important to consider the applicable requirements in this section for long-term performance changes.

The electrical power characteristics, defined in IES LM-79-08, of the DUT shall be measured and recorded for each of the following tests.

5.1 Spectral Radiant Flux and Spectral Photon Flux Over Time Produced by LED Packages and Arrays or Modules

The DUT shall be tested according to Section 5.1.1 and optionally according to Section 5.1.2 if required for a specific application.

5.1.1 Spectral Radiant Flux and Spectral Photon Flux Maintenance

Procedures described in ANSI/IES LM-80-15 shall be used to test the DUT radiant flux and photon flux, as well as recording the SPD at each measurement interval. Alternatively, test reports written per IES LM-80-08 containing radiant and photon flux measurements at each measurement interval shall also be acceptable.

5.1.2 Humidity and Temperature

Procedures described in JESD22-A101D shall be used with a relative humidity of 90% minimum and at 35°C minimum, at maximum rated current ($I_{F,max}$), and optionally at a lower current as defined by the manufacturer, at a cycle rate of 30 minutes on/off. The test duration shall be a minimum of 1000 hours, and the total test duration shall be reported. Exceptions to the above required test conditions due to specific product ratings may be required and the specific relative humidity and temperature test conditions shall be reported.

Note: Maintenance test duration and measurement intervals for maintenance projections typically requires a minimum of 6000 hours test duration with 1000 hours or less measurement interval.

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