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Illuminating ENGINEERING SOCIETY

TECHNICAL MEMORANDUM:
PHOTOMETRIC AND ELECTRICAL MEASUREMENTS OF TUNABLE-WHITE SOLID-STATE LIGHTING PRODUCTS

AN AMERICAN NATIONAL STANDARD

Approved American National Standard ANSI

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1.1 Introduction

Lighting products emitting variable spectral power distributions (SPDs) are increasingly prevalent in the architectural lighting marketplace. While a few variable-spectrum products based on fluorescent lamp technology existed in the past, the capabilities of solid-state lighting (SSL) have enabled the development and widespread use of such products. Variable spectral output, however, is not explicitly accounted for in existing methods for characterizing photometric and electrical performance, which are focused on measurements taken at a single operating state, with the product supplied with the intended voltage and without control devices.

The ability to emit radiant power in hundreds or thousands of spectral combinations—only limited by the precision of the control signal being provided—poses a distinct challenge for measuring product performance. Without a default operating state that is indicative of typical performance, and without a practical means to measure performance in every possible operating state, it is necessary to derive a scheme for capturing product performance that balances absolute accuracy with feasibility. This document establishes a common protocol for achieving this goal, relying on the requirements of ANSI/IES LM-79-19 (see **Section 2.7**) for each measurement. It defines the minimum number of measurements to be made and the order in which measurements are to be made. It also provides a framework for data reporting.

To understand the tradeoff between accuracy and feasibility, it is first important to identify what performance characteristics are of interest. The performance of a conventional, fixed-spectrum lighting product is measured when it is operated at the specified supply voltage, and subsequently rated based on luminous flux, power, luminous efficacy, chromaticity, color rendition, power factor, total harmonic distortion, and luminous intensity distribution, among other characteristics. When the spectral power distribution of a product is variable, many of these performance characteristics are also variable; thus, it is necessary to decide both what characteristics and which level of each characteristic (e.g., minimum, mean, maximum) are important to document. Because true values of these characteristics may not be found with a limited number of measurements, an interpolation procedure can be specified to predict performance at intermediate points.

Products with variable spectral power distributions come in many varieties, each of which may be referred to by several different names. These include products that can emit colored light, products that are restricted to emitting nominally white light, and products that only change spectral power distribution in combination with dimming. Some products may be configurable to operate in more than one way. Each of these varieties presents unique challenges for photometric, colorimetric, and electrical measurement. This Technical Memorandum specifies a procedure of measuring "tunable white" lamps, luminaires, and light engines because it is a subset of variable-spectrum products for which a relatively straightforward measurement protocol can be defined.

1.2 Scope

This document describes a protocol for measuring photometric, colorimetric, and electrical characteristics of tunable-white solid-state lighting products—including lamps, luminaires, and light engines—as covered by ANSI/IES LM-79-19 (see **Section 2.7**). This protocol applies to products for which the spectral power distribution can be adjusted with a single, one-dimensional input having a quantitative, interval format, either continuous or discrete, that is nominally independent of luminous flux control. For example, a product controlled with one variable control input (e.g., slider, rotary knob)—or several presets—for color and one variable control input for lumen output. This document also describes a method for interpolating between measured data to obtain specified characteristics, including correlated color temperature (CCT) range, D_{uv} range, lumen output range (at full intensity control as color changes), efficacy at maximum output, efficacy range, color rendition range (i.e., IES R_f, IES R_g, IES $R_{cs,h1}$, IES $R_{f,h1}$ CIE R_a, CIE R_9,), and chromaticity coordinates (i.e., *x, y; u′, v′).*