



TECHNICAL MEMORANDUM:
PHOTOMETRIC AND ELECTRICAL
MEASUREMENTS OF TUNABLE-WHITE
SOLID-STATE LIGHTING PRODUCTS
AN AMERICAN NATIONAL STANDARD



ANSI/IES TM-38-21

**TECHNICAL MEMORANDUM:
PHOTOMETRIC AND ELECTRICAL MEASUREMENTS OF
TUNABLE-WHITE SOLID-STATE LIGHTING PRODUCTS
AN AMERICAN NATIONAL STANDARD**

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

**Prepared for IES
IES Testing Procedures Committee**



Copyright 2021 by the Illuminating Engineering Society.

Approved by the IES Standards Committee, August 8, 2021, as a Transaction of the Illuminating Engineering Society.

Approved November 2, 2021, as an American National Standard.

All rights reserved. No part of this publication may be reproduced in any form, in any electronic retrieval system or otherwise, without prior written permission of the IES.

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

IES Standards are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to Brian Liebel, Director of Standards, at standards@ies.org or the above address for verification and correction. The IES welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN# 978-0-87995-413-0

DISCLAIMER

IES publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IES administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IES disclaims liability for any injury to persons or property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document.

In issuing and making this document available, the IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IES and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Prepared by the IES Testing Procedures Committee.

K. C. Fletcher, *Chair*

Andrew Jackson, *Vice Chair*

David N. Randolph, *Secretary*

Members

C. K. Andersen	M. L. Grather	J. E. Leland	S. Mitsuhashi
R. P. Bergin	Y. H. Hiebert	K. M. Liepmann	E. Radkov
R. S. Bergman	J. N. Hulett	S. Longo	D. Rogers
B. Boudreaux	P.-C. Hung	L. Loudin	M. B. Sapcoe
E. Bretschneider	J. Jiao	J. P. Marella	J. C. Vollers
F. Carpenter	M. Kotrebai	P. McCarthy	
D. J. Ellis	B. Kuebler	C. C. Miller	

Advisory Members

L. M. Ayers	K. J. Hemmi	D. Park	D. Spicer
C. A. Bloomfield	S. Hua	E. S. Perkins	G. A. Steinberg
P.-T. Chou	G. John	M. Piscitelli	M. Stevenson
P. Cruz	J. Juhasz	D. P. Ramer	L. Swainston
L. Davis	H. Kashaninejad	T. W. Rasinski	S.-H. Teoh
J. J. Demirjian	R. Kelley	M. P. Royer	A. Thorseth
M. Duffy	J. D. Kramer	M. Ruffin	R. C. Tuttle
P. Elizondo	K. C. Lerbs	M. Schneider	J. E. Walker
A. A. Feldman	J. Lockner	T. Schneider	
B. Feagin Jr.	G. McKee	A. W. Serres	
J. Frazer	E. Page	P. Sharma	

CONTENTS

1.0	Introduction and Scope	1
1.1	Introduction	1
1.2	Scope	1
2.0	Normative References	2
2.1	ANSI C78.377-2017	2
2.2	ANSI/IES LS-1-20	2
2.3	CIE 13.3-1995	2
2.4	CIE 15:2018	2
2.5	ANSI/IES TM-27-20	2
2.6	ANSI/IES TM-30-20	2
2.7	ANSI/IES LM-79-19	2
3.0	Definitions	2
3.1	color-control signal	2
3.2	device under test (DUT)	2
3.3	interval format	2
3.4	tunable white	2
4.0	Preparation and Measurement	2
4.1	System	3
4.2	Color-Control Signal	3
4.2.1	Seven or Fewer Levels of Color-Control Signal	3
4.2.2	More Than Seven Levels of Color-Control Signal	3
4.3	Procedure	3
5.0	Data Interpolation	3
6.0	Test Report	4
	Annex A: Interpolation Implications	5
	Annex B: Example Report	6
	References	9

1.0 Introduction and Scope

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 products 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').