Designation: E 1341 – 96

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
Reprinted from the Annual Book of ASTM Standards. Copyright ASTM

Standard Practice for Obtaining Spectroradiometric Data from Radiant Sources for Colorimetry[1]

This standard is issued under the fixed designation E 1341; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

The fundamental procedure for characterizing the color and absolute luminance of radiant sources is to obtain the spectroradiometric data under specified measurement conditions, and from these data to compute CIE chromaticity coordinates and luminance values based on the CIE 1931 Standard Observer. The considerations involved and the procedures to be used to obtain precision spectroradiometric data for this purpose are contained in this practice. The values and procedures for computing CIE chromaticity coordinates are contained in Method E 308. This practice includes minor modifications to the procedures given in Method E 308 that are necessary for computing the absolute luminance of radiant sources.

1. Scope

1.1 This practice prescribes the instrumental measurement requirements, calibration procedures, and physical standards needed for precise spectroradiometric data for characterizing the color and luminance of radiant sources.

1.2 This practice lists the parameters that must be specified when spectroradiometric measurements are required in specific methods, practices, or specifications.

1.3 This practice describes the unique calculation procedures required to determine basic colorimetric data of luminous sources.

1.4 This practice is general in scope rather than specific as to instrument, object, or material.

1.5 The values stated in SI units are to be regarded as the standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 275 Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near-Infrared Spectrophotometers[2]

E 284 Terminology Relating to Appearance[3]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[3]

E 387 Test Method for Estimating Stray Radiant Power Ratio of Spectrophotometers by the Opaque Filter Method[2]

E 925 Practice for the Periodic Calibration of Narrow Band-Pass Spectrophotometers[2]

E 958 Practice for Measuring Practical Spectral Bandwidth of Ultraviolet-Visible Spectrophotometers[2]

2.2 *NIST Publications:*

NIST Technical Note 594-1 Fundamental Principles of Absolute Radiometry and the Philosophy of the NBS Program (1968–1971)[4]

NIST Technical Note 594-3 Photometric Calibration Procedures[4]

2.3 *CIE Publications:*

Publication CIE No. 15.2 Colorimetry, 2nd ed., 1986[5]

Publication CIE No. 38 Radiometric and Photometric Characteristics of Materials and their Measurement, 1977[5]

Publication CIE No. 63 Spectroradiometric Measurement of Light Sources, 1984[5]

2.4 *IES Standard:*

[1] This test method is under the jurisdiction of ASTM Committee E-12 on Appearance and is the direct responsibility of Subcommittee E12.06 on Appearance of Displays.

Current edition approved June 10, 1996. Published August 1996. Originally published as E 1341 – 91. Last previous edition E 1341 – 91.

[2] *Annual Book of ASTM Standards*, Vol 03.06.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] Available from National Institute of Standards and Technology (NIST), Gaithersburg, MD 20899–0001.

[5] Currently available through the U.S. National Committee of the CIE, c/o Mr. Thomas M. Lemons, TLA-Lighting Consultants, Inc., 7 Pond Street, Salem, MA 01970-4819.

IES Guide to Spectroradiometric Measurements, 1983[6]

2.5 *ANSI Standard:*

ANSI/IES RP-16-1980 Nomenclature and Definitions for Illuminating Engineering[6]

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions of appearance terms in Terminology E 284 are applicable to this practice.

4. Summary of Practice

4.1 Procedures are given for selecting the types and operating parameters of spectroradiometers used to produce data for the calculation of CIE tristimulus values and other color coordinates to describe the colors of radiant sources. The important steps of the calibration of such instruments, and the standards required for these steps, are described. Parameters are identified that must be specified when spectroradiometric measurements are required in specific methods or other documents. Modifications to Practice E 308 are described in order to account for the differences between objects and radiant sources.

5. Significance and Use

5.1 The fundamental method for obtaining CIE tristimulus values or other color coordinates for describing the colors of radiant sources is by the use of spectroradiometric measurements. These measurements are used by summation together with numerical values representing the CIE 1931 Standard Observer (CIE publication No. 15.2) and normalized to K_m, the maximum spectral luminous efficacy function, with a value of 683 lm/W.

5.2 This practice provides a procedure for selecting the operating parameters of spectroradiometers used for providing the desired precision spectroradiometric data, for their calibration, and for the physical standards required for calibration.

5.3 Special requirements for characterizing sources of light possessing narrow or discontinuous spectra are presented and discussed. Modifications to the procedures of Practice E 308 are given to correct for the unusual nature of narrow or discontinuous sources.

6. Requirements When Using Spectroradiometry

6.1 When describing the measurement of radiant sources by spectroradiometry, the following must be specified.

6.1.1 The radiometric quantity determined, such as the irradiance (W/m^2) or radiance (W/m^2-sr), or the photometric quantity determined, such as illuminance (lm/m^2) or luminance (lm/m^2-sr or cd/m^2). The use of older, less descriptive names or units such as phot, nit, stilb (see ANSI/IES RP-16-1980) is not recommended.

6.1.2 The geometry of the measurement conditions, including whether a diffuser was used and its material of construction, the distances from the source of irradiation to the entrance to the spectroradiometer, and the presence of any special intermediate optical devices such as integrating spheres.

6.1.3 The spectral parameters, including the spectral region, wavelength measurement interval, and spectral bandwidth.

6.1.4 The type of standard used to calibrate the system, a standard lamp, a calibrated source, or a calibrated detector, and the source of the calibration.

7. Apparatus

7.1 The basic instrument requirement is a spectroradiometric system designed for the measurement of spectral radiance or irradiance of light sources. The basic elements of a spectroradiometric system are calibration sources with their regulated power supplies, a light detector, electronics for measuring the photocurrents, a monochromator with control equipment for computer interfacing, receiving optics, and a computer as described in CIE 63 and IES Guide to Spectroradiometric Measurements. The computer is listed as an integral part of the system since the required precision is unobtainable without automated control. The characteristics of each element are discussed in the following sections.

7.2 *Calibration Sources*—The standard calibration lamp for spectroradiometry is a tungsten-filament lamp operated at a specified current. Such lamps are available from many standardizing laboratories. Typical of such standards is the tungsten filament, 1000 W, halogen cycle, quartz-envelope FEL-type lamp recommended by the National Institute of Standards and Technology (NIST). (See NIST Tech Note 594-1, and 594-3.) Uncertainties in the transfer of the scale of spectral radiance or irradiance are about 1 %. It is preferable to have more than one standard source to permit cross-checks and to allow calibration at a range of illuminance levels. Such sources can be constructed from lamps operating at any color temperature and spectral nature that have been characterized against a standard lamp. Monochromatic emission sources, such as a low-pressure mercury arc lamp or tunable laser, should also be available for use in calibrating the wavelength scale in accordance with Practice E 925. Multiline lasers, such as continuous wave (cw) argon-ion and helium-neon, are preferred since they can be tuned to a small number of lines of well known wavelengths.

7.2.1 *Calibration Source Power Supplies*—The electrical supplies for the calibration sources should be of the constant current type. The supply should be linear and not a switching supply. Current regulation should be maintained to better than 0.1 %. This level of regulation is required to maintain a constant flux across the entrance to the spectroradiometer.

7.2.2 A standard for the measurement of length (such as a high-quality metric rule) should also be available since absolute irradiance calibrations must be performed at exact distances from the filament of the standard lamp.

7.3 *Detectors*:

7.3.1 *Photomultiplier Tubes*—Photomultiplier tubes are the traditional detectors in spectroradiometers. This is due to their superior performance in low-light-level conditions such as are encountered at the exit slit of a low-efficiency monochromator. The photocathodes of photomultipliers are sensitive to temperature, polarization, and magnetic fields. Light levels on the photocathode should never be allowed to generate photocurrents in excess of 10^{-6} A. The high-voltage supply should be stabilized to better than 0.01 % since the gain of the multiplier

[6] Available from American National Standards Institute, 1430 Broadway, NY, NY 10018–3308.