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# Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation[1]

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## INTRODUCTION

The fundamental procedure for evaluating the color of a reflecting or transmitting object is to obtain spectrometric data for specified illuminating and viewing conditions, and from these data to compute tristimulus values based on a CIE (International Commission on Illumination) standard observer and a CIE standard illuminant. The considerations involved and the procedures used to obtain precise spectrometric data are contained in this practice. The values and procedures for computing CIE tristimulus values from spectrometric data are contained in Practice E308. Considerations regarding the selection of appropriate illuminating and viewing geometries are contained in Guide E179.

## 1. Scope

1.1 This practice covers the instrumental measurement requirements, calibration procedures, and material standards needed to obtain precise spectral data for computing the colors of objects.

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

1.3 Most sections of this practice apply to both spectrometers, which can produce spectral data as output, and spectrocolorimeters, which are similar in principle but can produce only colorimetric data as output. Exceptions to this applicability are noted.

1.4 This practice is limited in scope to spectrometers and spectrocolorimeters that employ only a single monochromator. This practice is general as to the materials to be characterized for color.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics

E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials

E259 Practice for Preparation of Pressed Powder White Reflectance Factor Transfer Standards for Hemispherical and Bi-Directional Geometries

E275 Practice for Describing and Measuring Performance of Ultraviolet and Visible Spectrophotometers

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E387 Test Method for Estimating Stray Radiant Power Ratio of Dispersive Spectrophotometers by the Opaque Filter Method

E805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials

E925 Practice for Monitoring the Calibration of Ultraviolet-Visible Spectrophotometers whose Spectral Bandwidth

[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.02 on Spectrophotometry and Colorimetry.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

does not Exceed 2 nm
E958 Practice for Estimation of the Spectral Bandwidth of Ultraviolet-Visible Spectrophotometers
E991 Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method
E1767 Practice for Specifying the Geometries of Observation and Measurement to Characterize the Appearance of Materials
E2153 Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color
E2194 Test Method for Multiangle Color Measurement of Metal Flake Pigmented Materials

2.2 *NIST Publications:*
LC-1017 Standards for Checking the Calibration of Spectrophotometers [3]
TN-594-12 Optical Radiation Measurements: The Translucent Blurring Effect—Method of Evaluation and Estimation [3]
SP-260-66 Didymium Glass Filters for Calibrating the Wavelength Scale of Spectrophotometers—SRM 2009, 2010, 2013, and 2014 [3]
SP-692 Transmittance MAP Service [3]

2.3 *CIE Publications:*
CIE 15 Colorimetry[4]
CIE 38 Radiometric and Photometric Characteristics of Materials and Their Measurement [4]
CIE 46 Review of Publications on Properties and Reflection Values of Material Reflection Standards [4]
CIE 51 Method for Assessing the Quality of Daylight Simulators for Colorimetry [4]
CIE 130 Practical Applications of Reflectance and Transmittance Measurements [4]

2.4 *ISO Publications:*
ISO 2469 Paper, Board and Pulps — Measurement of Diffuse Reflectance Factor [5]

## 3. Terminology

3.1 *Definitions*—The definitions contained in Terminology E284 are applicable to this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *efflux, n*—the cone of light rays reflected or transmitted by a specimen and collected by the receiver in a color measuring instrument (see Practice E1767).

3.2.2 *influx, n*—the cone of light rays incident upon the specimen from the illuminator in a color measuring instrument (see Practice E1767).

3.2.3 *regular transmittance factor, $T_r$, n*—the ratio of the flux transmitted by a specimen and evaluated by a receiver to the flux passing through the same optical system and evaluated by the receiver when the specimen is removed from the system.

3.2.3.1 *Discussion*—In some cases, this quantity is practically identical to the transmittance, but it may differ considerably. It exceeds unity if the system is such that the specimen causes more light to reach the receiver than would in its absence.

## 4. Summary of Practice

4.1 Procedures are given for selecting the types and operating parameters of spectrometers used to provide data for the calculation of CIE tristimulus values and other color coordinates to document the colors of objects. The important steps in the calibration of such instruments, and the material standards required for these steps, are described. Guidelines are given for the selection of specimens to minimize the specimen's contribution to the measurement imprecision. Parameters are identified that must be specified when spectrometric measurements are required in specific test methods or other documents.

## 5. Significance and Use

5.1 The most general and reliable methods for obtaining CIE tristimulus values or, through transformation of them, other coordinates for describing the colors of objects are by the use of spectrometric data. Colorimetric data are obtained by combining object spectral data with data representing a CIE standard observer and a CIE standard illuminant, as described in Practice E308.

5.2 This practice provides procedures for selecting the operating parameters of spectrometers used for providing data of the desired precision. It also provides for instrument calibration by means of material standards, and for selection of suitable specimens for obtaining precision in the measurements.

## 6. Requirements When Using Spectrometry

6.1 When describing the measurement of specimens by spectrometry, the following must be specified:

6.1.1 The relative radiometric quantity determined, such as reflectance factor, radiance factor, or transmittance factor.

6.1.2 The geometry of the influx and efflux as defined in Practice E1767, including the following:

6.1.2.1 For hemispherical geometry, whether total or diffuse only measurement conditions (specular component of reflection included or excluded) are to be used.

6.1.2.2 For bi-directional geometry, whether annular, circumferential, or uniplanar measurement conditions are to be used, and the number, angle, and angular distribution of the multiple beams.

6.1.3 The spectral parameters, including the wavelength range, wavelength measurement interval, and spectral bandpass or bandpass function in the case of variable bandpass.

6.1.4 Identification of the standard of reflectance factor, (see 10.2.1).

6.1.5 The computation variables specified in Practice E308, Section 6, including the standard observer and standard illuminant, if their values must be set at the time of measurement, whether the spectral bandpass has been adjusted or not, and

[3] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

[4] Available from CIE (International Commission on Illumination), http://www.cie.co.at or http://www.techstreet.com.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.