



Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry¹

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1. Scope

1.1 This test method describes the instrumental measurement of the reflection properties and color of object-color specimens by use of a spectrophotometer or spectrocolorimeter with a bidirectional optical measuring system, such as annular, circumferential, or uniplanar 45/0 or 0/45 geometry.

1.2 This test method is generally suitable for any flat object-color specimen. It is especially recommended for measuring retroreflective specimens, fluorescent specimens, and specimens of intermediate gloss.

1.3 . *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:

- D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates²
- E 179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials
- E 284 Terminology Relating to Appearance of Materials²
- E 308 Practice for Computing the Colors of Objects by Using the CIE System²
- E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials²
- E 991 Practice for Color Measurement of Fluorescent Specimens²
- E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation²

3. Terminology

3.1 Definitions:

3.1.1 The definitions contained in Guide E 179, Terminology E 284, and Practice E 1164 are applicable to this test method.

¹ This test method is under the jurisdiction of ASTM Committee E-12 on Appearance and is the direct responsibility of Subcommittee E12.02 on Spectrophotometry and Colorimetry.

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² Annual Book of ASTM Standards, Vol 06.01.

4. Summary of Test Method

4.1 This test method provides a procedure for measuring the reflectance factors of reflecting object-color specimens by using a spectrophotometer or spectrocolorimeter equipped with a bidirectional optical measuring system.

4.2 When the specimens exhibit directionality, and an instrument with uniplanar geometry is used, information on directionality may be obtained by measuring the specimens at more than one rotation angle, typically at two angles 90° apart. When such information is not required, these measurements may be averaged, or an instrument with annular or circumferential geometry may be used.

4.3 This test method includes procedures for calibrating the instrument or verifying its calibration, and for selecting specimens suitable for precision measurement.

4.4 Most modern spectrophotometers have the capacity to compute the color coordinates of the specimen immediately following the measurement. When this is the case, the user must preselect the color system, observer, and illuminant (see Practice E 308, Section 6).

5. Significance and Use

5.1 The most direct and accessible methods for obtaining the color coordinates of object colors are by instrumental measurement using spectrophotometers or colorimeters with either hemispherical or bidirectional optical measuring systems. This method provides procedures for such measurement by spectrophotometry using a bidirectional optical measuring system.

5.2 This test method is especially suitable for measurement of the following types of specimens for the indicated uses (see also Guide E 179, Practice E 805):

5.2.1 Object-color specimens of any gloss level for color assessment.

5.2.2 All types of object-color specimens to obtain data for use in computer colorant formulation.

5.2.3 Retroreflective specimens.

NOTE 1—To ensure inter-instrument agreement in the measurement of specimens with intermediate gloss, for formulation, or of retroreflective specimens, significantly tighter tolerances than those given in Practice E 1164, 8.1.1, may be required for the instrument angles of illumination and viewing. Information on the required tolerances is being developed.

5.2.4 Fluorescent specimens (see Practice E 991).

NOTE 2—For the accurate measurement of fluorescent specimens, it is mandatory that the specimen be illuminated by polychromatic light, usually by direct illumination from a daylight simulator. The monochromator must be located between the specimen and the detector system.

5.3 This test method is not recommended for measurement of specimens with bare metal surfaces for color assessment, for which the use of hemispherical measurement geometry, as with an integrating-sphere type instrument, is preferable (see Guide E 179).

6. Apparatus

6.1 *Spectrophotometer or Spectrocolorimeter*, designed for the measurement of color coordinates of reflecting specimens by use of 45/0 or 0/45 geometry with annular, circumferential, or uniplanar illumination or viewing.

6.2 *Calibration Standards*, either supplied by the instrument manufacturer or obtained separately, as follows: (See Practice E 1164, Section 9.)

6.2.1 *White Standard of Bidirectional reflectance Factor (mandatory)*—(A standard of hemispherical reflectance factor is not suitable and should not be used.)

6.2.2 *Calibration Standards*, (1) for setting or verifying zero on the photometric scale; (2) for verifying the wavelength scale; and (3) for evaluating stray light (optional).

6.2.3 *Verification Standards (recommended)*—(See Practice E 1164, 9.5.)

NOTE 3—If retroreflective or fluorescent specimens are to be measured, the set of verification standards should include appropriate retroreflective or fluorescent product standards.

7. Test Specimen

7.1 For highest precision and accuracy, select specimens with the following properties:

7.1.1 High material uniformity and freedom from blemishes in the area to be measured.

7.1.2 Opaque specimens that have at least one plane surface; translucent specimens that have two essentially plane and parallel surfaces and that have a standard thickness, when one is specified (see Practice E 1164, 10.1.3).

7.2 If specimens exhibit directionality, use appropriate procedures (see 9.7) and calculations (see 10.1.1).

8. Calibration and Verification

8.1 Calibrate or verify the calibration of the following: (See Practice E 1164, Section 9.)

8.1.1 Zero setting of the reflectance scale (mandatory),

8.1.2 Wavelength scale (recommended), and

8.1.3 Stray-light level (optional).

8.2 Calibrate the full-scale value of the reflectance scale of the instrument by use of the white reflectance standard (mandatory). Follow the instrument manufacturer's instructions.

8.3 Verify the accuracy of the instrumental data by measurement of a series of verification standards (recommended). (See Practice E 1164, 9.5.)

9. Procedure

9.1 When required, select the color scales, observer, and illuminant for the computation of color coordinates (see Method E 308, Section 6).

9.2 Select other options, such as wavelength range and interval, when required. Follow instrument manufacturer's instructions or specified procedures.

9.3 If the specimen is translucent, select specified black or white backing material. (See Practice E 1164, 10.1.3, for further instructions on measuring translucent specimens.)

9.4 Handle the specimen carefully; avoid touching the area to be measured. When necessary, clean the specimen by using an agreed procedure.

9.5 Place the specimen, with backing material when required, against the measurement port of the instrument.

9.6 Measure the specimen, following the instrument manufacturer's instructions.

9.7 If the specimen exhibits directionality and the instrument has uniplanar geometry, measure the specimen at two rotation angles 90° apart, usually parallel and perpendicular to the machine or processing direction, or use another specified procedure.

9.8 Transcribe the data required for the report, when not printed by the instrument.

10. Calculation

10.1 Perform any desired calculations of color coordinates that are not made automatically by the instrument (see Test Method D 2244 and Practice E 308).

10.1.1 When specimens exhibiting directionality are measured at two or more rotation angles with instruments using uniplanar geometry, average the instrumental data at all rotation angles measured if information on directionality is not required.

11. Report

11.1 Report the following information:

11.1.1 Specimen description (see Practice E 1164, 12.1.1), and

11.1.2 Date of measurement.

11.1.3 *Instrument measuring geometry*:

11.1.3.1 45/0 or 0/45 illuminating and viewing geometry,

11.1.3.2 Annular, circumferential, or uniplanar geometry, and

11.1.3.3 Number and angular distribution of multiple illumination or viewing beams.

11.1.4 Instrument parameters as selected in 9.1-9.3, and

11.1.5 Measurement results, in the form of tables of reflectance factor versus wavelength or color-scale values.

11.1.5.1 For specimens exhibiting directionality measured at two or more rotation angles with instruments using uniplanar geometry, report individual measurements and corresponding specimen orientations when information on directionality is required; or report the average measurements when such information is not required.

12. Precision and Bias

12.1 Data for the precision and bias of this test method are being determined. In general, the precision and bias for this test method are expected to be approximately the same as those reported in Practice E 1164.

13. Keywords

13.1 bidirectional geometry; color; reflectance; spectrophotometer

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