Designation: ~~E1331 – 09~~ E1331 – 15

Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry[1]

This standard is issued under the fixed designation E1331; 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.

1. Scope

1.1 This test method describes the instrumental measurement of the reflection properties and color of object-color specimens by the use of a spectrophotometer or spectrocolorimeter with a hemispherical optical measuring system, such as an integrating sphere.

1.2 The test method is suitable for use with most object-color specimens. However, it should not be used for retroreflective specimens or for fluorescent specimens when highest accuracy is desired. Specimens having intermediate-gloss surfaces should preferably not be measured by use of this geometry.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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:*[2]

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials
E284 Terminology of Appearance
E308 Practice for Computing the Colors of Objects by Using the CIE System
E805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials
E991 Practice for Color Measurement of Fluorescent Specimens Using the One-Monochromator Method
E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation
E1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions in Guide E179, Terminology E284, and Practice E1164 are applicable to this test method.

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 hemispherical optical measuring system such as an integrating sphere.

4.2 This test method includes procedures for calibrating the instrument and for selecting specimens suitable for precision measurement.

4.3 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 select the color system, observer, and illuminant (see Practice E308, Procedure).

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[1] This test method 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~~standard's Document Summary page on the ASTM website.

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 test method provides procedures for such measurement by reflectance spectrophotometry using a hemispherical optical measuring system.

5.2 This test method is especially suitable for measurement of the following types of specimens for the indicated uses (Guide E179 and Practice E805):

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

5.2.2 Object-color specimens for color assessment.

5.2.2.1 For the measurement of plane-surface high-gloss specimens, the specular component should generally be excluded during the measurement.

5.2.2.2 For the measurement of plane-surface intermediate-gloss specimens and of textured-surface specimens, including textiles, where the first-surface reflection component may be distributed over a wide range of angles, measurement may be made with the specular component included, but the resulting color coordinates may not correlate best with visual judgments of the color. The use of bidirectional geometry, such as 45/0 or 0/45, may lead to better correlations.

5.2.2.3 For the measurement of plane-surface, low-gloss (matte) specimens, the specular component may either be excluded or included, as no significant difference in the results should be apparent.

5.2.3 Specimens with bare metal surfaces for color assessment. For this application, the specular component should generally be included during the measurement.

5.3 This test method is not recommended for measurement of the following types of specimens, for which the use of bidirectional measurement geometry (0/45 or 45/0) is preferable (Guide E179):

5.3.1 Object-color specimens of intermediate gloss,

5.3.2 Retroreflective specimens, and

5.3.3 Fluorescent specimens (Practice E991).

5.3.3.1 When there is doubt as to whether the specular component of reflection should be included or excluded, both measurements should be made, and the results correlated with visual judgments. Thereafter, the method with higher visual correlation should be utilized.

5.3.3.2 When measurements of two specimens whose gloss, or texture, are substantially different from each other, are to be utilized in a color-difference comparison, generally the specular component should be included in each measurement. This has the effect of including in both measurements all the first surface reflections whether diffuse or specular. These first surface reflections are subtracted from each other in the color-difference equation, and differences in the body color remain, which is what is usually sought.

6. Apparatus

6.1 *Spectrophotometer or spectrocolorimeter,* designed for the measurement of color coordinates of reflecting specimens by use of integrating-sphere geometry.

6.2 *Calibration standards,* either supplied by the instrument manufacturer or obtained separately, as follows (Practice E1164, Standardization and Material Standards):

6.2.1 *White standard,* of hemispherical reflectance factor (mandatory). (A standard of bidirectional reflectance factor is not satisfactory and should not be used.)

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

6.2.3 *Verification standards,* (recommended) (Practice E1164, Standardization and Material Standards).

7. Specimen Selection

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, and

7.1.3 Translucent specimens that have two essentially plane and parallel surfaces and that have a standard thickness, when one is specified (Practice E1164, Test Specimens).

8. Calibration and Verification

8.1 Set the instrument for inclusion or exclusion of the specular component of reflection; set the same as will be used in 8.4 (if carried out) or 9.1.

8.2 Calibrate or verify the calibration of the following (Practice E1164, Standardization and Material Standards):

8.2.1 Zero setting of the reflectance scale (mandatory),

8.2.2 Wavelength scale (recommended), and