Designation: E 2301 – 03

Standard Test Method for Daytime Colorimetric Properties of Fluorescent Retroreflective Sheeting and Marking Materials for High Visibility Traffic Control and Personal Safety Applications Using 45°:Normal Geometry[1]

This standard is issued under the fixed designation E 2301; 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 colorimetric properties (CIE tristimulus values, luminance factors, and chromaticity coordinates) of fluorescent-retroreflective sheeting and marking materials when illuminated by daylight.

1.2 This test method is generally applicable to any sheeting or marking material having combined fluorescent and retroreflective properties used for daytime high visibility traffic control and personal safety applications.

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 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates[2]

E 179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials[3]

E 284 Terminology of Appearance[3]

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

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

E 1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation[4]

E 1767 Practice for Specifying the Geometry of Observations and Measurements to Characterize the Appearance of Materials[4]

E 2152 Practice for Computing the Colors of Fluorescent Objects from Bispectral Photometric Data[4]

E 2153 Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color[4]

2.2 *CIE Document:*

CIE 15.2 Colorimetry[5]

3. Terminology

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

4. Summary of Test Method

4.1 This test method provides a procedure for measuring the colorimetric properties of fluorescent-retroreflective sheeting and markings under simulated daylight illumination. Colorimetric properties are determined for CIE D65, which approximates outdoor illumination at midday, and Daylight 15 000 K, which is an alternate D illuminant chosen to represent low ambient light/dawn/dusk daylight illumination conditions (see CIE 15.2).

4.2 This test method requires the use of a calibrated bispectrometer (two-monochromator spectrometer) with either 45:0 or 0:45 geometry that can measure the specimen's Donaldson matrix (see Practice E 2153).

4.3 This test method provides for calculation and reporting of separated fluorescence, reflectance and total tristimulus values (*XYZ*) and luminance factors (*Y*, %), and total chromaticity coordinates (*x*,*y*) from the Donaldson matrix for the CIE 1931 Standard Colorimetric Observer.

[1] This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.05 on Fluorescence.

Current edition approved July10, 2003. Published August 2003.

[2] *Annual Book of ASTM Standards*, Vol 04.03.

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

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] Available from the U.S. National Committee of the CIE (International Commission on Illumination), c/o Thomas M. Lemons, TLA-Lighting Consultants, 7 Pond St., Salem, NC 01970-4819.

5. Significance and Use

5.1 This test method provides procedures for obtaining tristimulus values, luminance factors and chromaticity coordinates of fluorescent-retroreflective materials by bispectral colorimetry using a 45:0 or 0:45 optical measuring system.

5.2 The CIE 1931 (2°) standard observer is used to calculate the colorimetric properties of fluorescent-retroreflective sheeting and markings used in daytime high visibility traffic control and personal safety applications because in practice these materials are primarily viewed from a distance where they subtend less than 4° of the visual field.

5.3 This test method is applicable to object-color specimens of any gloss level.

5.4 Due to the retroreflective properties of these materials the colorimetric data may not be suitable for use in computer colorant formulation.

5.5 This test method is suitable for quality control testing of fluorescent-retroreflective sheeting and marking materials.

NOTE 1—Separation of the fluorescence and reflectance components from the total colorimetric properties provides useful and meaningful information to evaluate independently the luminescent and diffuse reflective efficiency and consistency of these materials.

5.6 This test method is the referee method for determining the conformance of fluorescent-retroreflective sheeting and marking materials to standard daytime colorimetric specifications.

6. Apparatus

6.1 *Bispectrometer*, with either 45:0 or 0:45 (illumination:viewing) geometry.

6.1.1 The tolerance on the inclination of the 45-degree axis shall be 2 degrees (45 ± 2 degrees).

6.1.2 The tolerance on the 0-degree axis shall be 2 degrees from the normal (0 ± 2 degrees).

NOTE 2—For maximum reproducibility smaller tolerances on the axis angles are recommended.

6.1.3 For the 45:0 condition, the illumination geometry may be annular, circumferential or uniplanar and the viewing shall be normal to the specimen. For the 0:45 condition, the illumination shall be normal to the specimen and the viewing geometry may be annular, circumferential or uniplanar.

6.1.4 The referee geometry shall be annular 45:0.

NOTE 3—Reciprocity between 45:0 and 0:45 geometry for commercial instruments may not be observed in practice for retroreflective materials because of the variation in axis angles and aperture sizes of instruments.

6.1.4.1 Circumferential instruments are acceptable provided the procedure described in 9.3.1 is followed.

6.1.4.2 Uniplanar instruments are acceptable provided the procedure described in 9.3.2 is followed.

6.1.5 The referee aperture sizes shall be 10 degrees for illumination and 10 degrees for viewing. Use of aperture sizes deviating from these may affect the measurement results. See Practice E 1767 for fundamentals of specification of apertures.

NOTE 4—Fluorescent colorimetric properties (for example, Fluorescence tristimulus values $(XYZ)_F$) are not significantly influenced by the aperture sizes. Reflectance colorimetric properties (for example, Reflectance tristimulus values $(XYZ)_R$) may be greatly affected by aperture sizes. Consequently total colorimetric properties (for example, Total tristimulus values $(XYZ)_T$) may be greatly affected.

6.1.6 The illumination monochromator shall illuminate the specimen over the wavelength range from 300 to 780 nm at intervals of 10 nm or less.

6.1.7 The viewing monochromator shall detect the specimen radiance over the wavelength range from 380 to 780 nm at intervals of 10 nm or less.

6.1.8 The minimum illuminated sample area shall be 100 mm^2 with no dimension less than 5 mm.

6.2 *Calibration Standards*, as outlined in Practice E 2153, supplied by the instrument manufacturer or obtained separately, with calibration values no older than 24 months.

6.3 *Verification Standards*—Verification of the precision and bias of the entire system, including calculation of tristimulus values, shall be conducted on an annual basis using non-retroreflective/non-fluorescent, fluorescent/non-retroreflective and fluorescent retroreflective color standards with calibration values traceable to an accredited National Standards Laboratory. The calibration values for the verification panels shall be no older than 36 months.

NOTE 5—Stable fluorescent/non-retroreflective and fluorescent retroreflective color artifact standards are not widely available as Standard Reference Materials (SRMs). However, measurement services are available from Independent Testing Laboratories and National Standards Laboratories to calibrate artifacts for use as Verification Standards.

7. Test Specimen

7.1 *Specimen Preparations*:

7.1.1 Samples shall be tested mounted on the substrate that will be utilized for the intended application. Apply the sample to the substrate in accordance with the recommendations of the material's manufacturer.

7.1.2 If the sample is not supplied with its intended substrate, or if the intended substrate is not defined, then the sample shall be mounted or backed by a black panel, such as a black tile. The black panel shall have a luminance factor (*Y*) of less than 4 %.

NOTE 6—The measurement results will depend upon the spectral reflectance properties of the material behind the specimen as well as the specimen thickness.

7.1.3 Specimens should be uniform in physical properties over the area measured.

7.1.4 *Number of Test Specimens*—Measurements shall be made on a minimum of 3 test specimens.

7.1.5 Specimens that have been subjected to additional testing, such as outdoor or machine exposure testing, shall be tested on the substrate used for these additional tests.

7.2 *Test Conditions*—Unless otherwise specified, condition all test specimens at a temperature of 73 ± 3°F (23 ± 2°C) and 50 ± 5 % relative humidity for 24 h prior to testing.

7.3 *Sampling*—Unless otherwise specified test samples shall be selected according to the following sampling plan.

7.3.1 *Sheeting for Traffic Control Applications*—Test samples shall be cut from 1 m^2 of sheeting. The test samples shall be cut from the lower left corner, center and upper right