Designation: E 2366 – 05

Standard Test Method for Measurement of Daytime Chromaticity of Pavement Marking Materials Using a Portable Reflection Colorimeter[1]

This standard is issued under the fixed designation E 2366; 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 covers measurement of the daytime chromaticity coordinates (*x*, *y*) of horizontal pavement markings, such as traffic stripes and surface symbols, and pavement surfaces under diffuse illumination, using a portable reflection colorimeter that can be placed on the surface to measure the chromaticity in a particular viewing direction.

1.2 The co-viewing angle of the reflection colorimeter affects the readings. As specified by the European Committee for Standardization (CEN EN 1436), the co-viewing angle shall be 2.29°.

1.3 This test method is intended to be used for field measurement of pavement markings but may be used to measure the chromaticity and the luminance coefficient under diffuse illumination of materials on sample panels before placing the marking material in the field.

1.4 The portable reflection colorimeter may integrate measurement of the luminance coefficient under diffuse illumination Qd according to Test Method E 2302 and thus be an integrated reflectometer/reflection colorimeter.

1.5 *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]

D 6628 Specification for Color of Pavement Marking Materials

E 284 Terminology of Appearance

E 308 Practice for Computing Colors of Objects by using the CIE System

E 811 Practice for Measuring Colorimetric Characteristics of Retroreflectors under Nighttime Conditions

E 2302 Test Method for Measurement of the Luminance Coefficient under Diffuse Illumination of Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Reflectometer

2.2 *Other Standard:*

CEN EN 1436 Road Marking Materials—Road Marking Performance for Road Users[3]

3. Terminology

3.1 The terminology used in this test method generally agrees with that used in Terminology E 284. The definitions given in Test Method E 2302 and Practice E 811 apply in this test method as well.

3.2 *Definitions:*

3.2.1 *reflection colorimeter*, *n*—an instrument that illuminates a specimen and applies a colorimeter to the light reflected.

4. Summary of Test Method

4.1 This test method involves the use of portable reflection colorimeters for determining the chromaticity coordinates (*x*, *y*) of horizontal coatings materials used in pavement markings, and of pavement surfaces.

4.2 Illumination is diffuse and the co-viewing angle is fixed at 2.29°.

4.3 The reflection colorimeters use one or more external panels or other instrument standards of known chromaticity coordinates (*x*, *y*), or known spectral reflectance factor.

4.4 The portable reflection colorimeter's illuminator is placed directly over the pavement marking to be measured, ensuring that the measurement area of the reflection colorimeter fits within the width of the stripe, and the readings displayed by the reflection colorimeter are recorded.

4.5 Readings shall be taken for the direction of traffic. Readings shall be taken for each direction of traffic separately for centerlines.

5. Significance and Use

5.1 The chromaticity of the stripe is determined by means of the tristimulus values *X*, *Y* and *Z* for the CIE 1931 (2°) standard

[1] This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.10 on Retroreflection.

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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.

[3] Available from European Committee for Standardization, Central Secretariat (CEN), rue de Stassart 36, B1050 Brussels, Belgium.

observer for CIE Standard Illuminant D65, which are converted to the chromaticity coordinates (x, y) and shown in the CIE 1931 (x, y)-chromaticity diagram. Refer to Practice E 308.

5.2 Under the same conditions of illumination and viewing, the chromaticity coordinates (x, y) represent the daytime color of pavement markings in daylight illumination as seen by drivers of the vehicles.

5.3 The chromaticity of pavement (road) markings may change with traffic wear and require periodic measurement to ensure that the chromaticity is maintained within boundaries (see Specification D 6628 for examples of color boundaries).

5.4 As specified by CEN, the measurement geometry of the instrument is based on a viewing distance of 30 m and an eye height of 1.2 m.

5.5 It shall be the responsibility of the user to employ an instrument having the specified illumination and co-viewing angle.

6. Apparatus

6.1 *Portable Reflection Colorimeter*:

6.1.1 The reflection colorimeter shall be portable, with the capability to be placed on various horizontal pavement markings in different locations.

6.1.2 The reflection colorimeter shall be constructed so that placement on the highway pavement markings will preclude any stray light entering the measurement area of the instrument and affecting the reading. This may be done by shielding against stray light, or by subtraction of the stray light reading, or both.

6.1.3 For the convenience of the user, a marking shall be placed on the instrument to permit it to be aligned with the direction of traffic, or the instrument design shall itself indicate the measuring direction in an obvious manner.

6.2 *Illumination System Requirements*:

6.2.1 The illumination system shall comply with requirements of Test Method E 2302, section on Illumination System Requirements.

6.3 *Colorimeter Requirements*:

6.3.1 The colorimeter shall have sufficient sensitivity and range to accommodate values expected in use, such as presented by a range of the luminance coefficient under diffuse illumination Qd from 80 to 300 $mcd \cdot m^{-2} \cdot lx^{-1}$(the theoretical maximum is $1000/\pi = 318\ mcd \cdot m^{-2} \cdot lx^{-1}$).

6.3.2 The colorimeter shall provide X, Y and Z tristimulus values according to the CIE 1931 (2°) color matching functions. The reflection colorimeter must be able to apply illumination condition correction for CIE Standard Illuminant D65, and may either be a tristimulus colorimeter or a spectrocolorimeter.

6.3.2.1 A tristimulus colorimeter may have filters that can be inserted individually in front of a receiver to provide matches of the combined spectral distribution of the illumination and the spectral responsivity of the receiver to the combined spectral distribution of CIE Standard Illuminant D65 and the CIE 1931 (2°) x (λ), y (λ) and z (λ) color-matching functions, respectively. The x (λ) function has two distinct lobes. This may be dealt with by splitting x (λ) into x_{short} (λ) and x_{long} (λ), each with a separate filter. The filters may be manually or automatically operated.

6.3.2.2 A spectrocolorimeter may measure the spectral reflectance in equal wavelength steps covering at least the wavelength range from 400 to 700 nm, with a maximum half power bandwidth of 10 nm in maximum step increment of 10 nm and from these data derive X, Y and Z tristimulus values.

NOTE 1—Use of filters provides larger signals than measurement of the spectral distribution.

6.3.3 The colorimeter shall be able to determine the chromaticity coordinates (x, y) for CIE D65 and the CIE 1931 Observer of white and yellow pavement markings with a value of the luminance coefficient under diffuse illumination Qd of 80 $mcd \cdot m^{-2} \cdot lx^{-1}$, or higher, with a minimum reproducibility 0.005, when calibrated and used according to the instrument manufacturers instructions.

6.3.4 The colorimeter shall comply with requirements of Test Method E 2302, Receiver Requirements sections concerning respectively receiver aperture, combined stability of the output of the light source and receiver, and linearity.

6.4 *Measurement Geometry*:

6.4.1 The measurement geometry shall comply with requirements of Test Method E 2302, Measurement Geometry section.

7. Standardization and Procedure

7.1 The instrument will either require an external black standard or it will incorporate an internal black standard or some other internal means of zeroing.

7.1.1 If the instrument standardization requires a black standard then the black standard shall have virtually no reflection over the range of wavelengths for the visible part of the spectrum. The black standard may be a light trap formed as a wedge of two black acrylic plates. For some instruments, the black standard may be an unobstructed free path obtained by a lift or a tilt of the instrument.

7.2 A portable instrument with a tristimulus colorimeter, refer to 6.3.2, can be calibrated using a black standard (if required) and one, two, three or more instrument standards consisting of separate panels or other instruments standards.

7.2.1 The instrument standard(s) shall have known and reproducible X_S, Y_S and Z_S tristimulus values measured at the same geometry as used in the portable instrument. Alternatively, the values of Y_S and the (x, y) chromaticity coordinates may be known instead of the tristimulus values.

NOTE 2—Some instruments measure Qd in addition to the chromaticity coordinates (x, y), and for these instruments Y_S should be in the scale of Qd.

7.2.2 The producer of the instrument shall provide the software needed to guide the user through the calibration procedure and to obtain the chromaticity values (x, y) from the measurements.

7.2.3 The accuracy of the measurement depends in particular on the quality of the match of the filters described in 6.3.2. Additional factors are signal to noise ratio, photometric scale linearity and other matters.

7.2.4 Use of three suitable instrument standards may lead to a more accurate determination of the chromaticity of white and yellow pavement markings than use of only one instrument standard. Use of more than three standards may further improve the accuracy for white and yellow road markings, or may extend the applicability of the instrument to more colors.

NOTE 3—A convenient choice of three instrument standards is a white tilted reflection standard, either without any filter in front, or covered with a yellow or an amber long pass absorption filter with pass wavelengths of 515 nm and 550 nm, respectively. Such instrument standards have typically (*x*, *y*) coordinates as shown in Fig. 1.

7.3 A portable instrument with a spectrocolorimeter, refer to 6.3.2, can be standardized using a black standard (if required) and one instrument standard.

7.3.1 The instrument standard shall have a spectral distribution of reflected power P_{Si} measured at the same geometry, and at the same wavelengths, as used in the portable instrument.

7.3.2 The producer of the instrument shall provide the software needed to guide the user through the calibration procedure and to obtain the chromaticity values (*x*, *y*) from the measurements.

NOTE 4—The spectrum M_b of the black standard (if required) and the spectrum M_i of the instrument standard are measured, the resulting spectrum $M_{Si} = M_i - M_b$ is formed and a spectrum of calibration factors F_i is formed by $F_i = P_{Si}/M_{Si}$. When a spectrum M_i has been measured for a pavement marking, the spectrum of reflected power P_i of the pavement marking is determined by $P_i = F_i\ (M_i - M_b)$. The tristimulus values *X*, *Y* and *Z* are determined by weighted summations of P_i, using the spectral distributions of CIE Standard Illuminant D65 and of the x (λ), y (λ) and z (λ) color-matching functions, respectively, as weights.

7.3.3 The accuracy of the measurement depends on wavelength accuracy, signal to noise ratio and other matters.

7.3.4 A suitable choice of the instrument standard is a white tilted reflection standard, which provides a fairly strong signal for all wavelengths of the measured spectrum M_i.

7.4 Note that transporting the instrument from an air conditioned area to the test site may result in fogging of mirrors or glass surfaces (if any) in the instrument. If there is any doubt concerning the calibration or the readings are not constant, allow the instrument to reach ambient conditions and recalibrate with the instrument standard(s).

8. Procedure

8.1 Follow the manufacturer's instructions for operation of the reflection colorimeter, which generally uses the following procedure:

8.1.1 Ambient temperature shall not be less than 4°C (40°F).

8.1.2 The surface of the marking shall be clean and dry.

8.1.3 Turn on the reflection colorimeter, and allow it to reach equilibrium following the manufacturer's instructions.

8.1.4 Standardize the reflection colorimeter using the black standard, if any, and the instrument standard(s) supplied with the instrument according to the manufacturer's instructions.

8.1.5 For instruments with an internal reference surface, insert that surface into the light path and read the signals from the display. Record these readings.

8.1.6 Place the reflection colorimeter squarely on the pavement marking material, ensuring that the measurement area of the reflection colorimeter fits within the width of the stripe. The reading direction of the reflection colorimeter shall be placed in the direction of traffic. Readings shall be taken for each direction of traffic separately for centerlines.

8.1.7 Record the reflection colorimeter readings, and then move to other locations on the sample set separated sufficiently to provide meaningful data (typically 1 metre), and record the results. At intervals of one hour or less, check the standardization according to the manufacturer's instructions and repeat standardization according to 8.1.4, if necessary.

9. Test Report

9.1 Include the following data in the test report:

9.1.1 Test date.

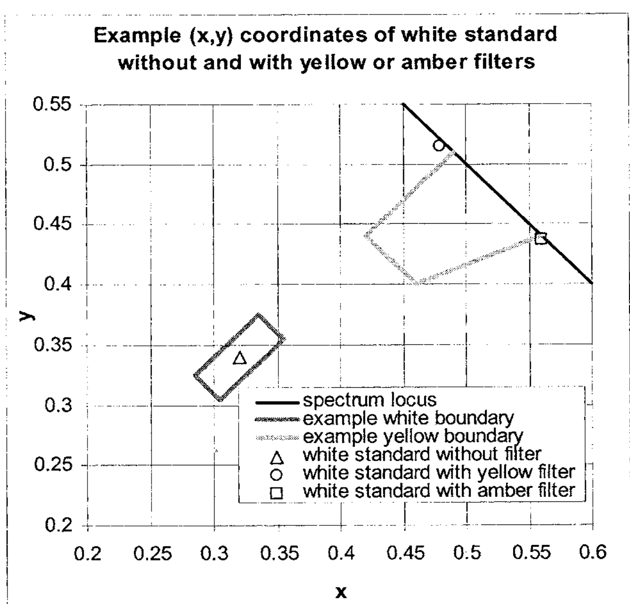

FIG. 1 Example Chromaticity Co-Ordinate Plot of White Standard and Test Filters

9.1.2 Average of the readings at each test location, expressed as chromaticity coordinates *x* and *y*. The average values shall be reported for each traffic direction for centerlines.

9.1.3 Geographical location of the test site, including distance from nearest permanent site identification, such as a mileage marker or crossroad.

9.1.4 Identification of the pavement marking material tested: type, color, age, and transverse location on road (edge line, first line, second line, and center).

9.1.5 Identification of the instrument used.

9.1.6 Value(s) and date(s) of standardization of the instrument standard(s) used.

9.1.7 Remarks concerning the overall condition of the line, such as rubber skid marks, carryover of asphalt, snow plough damage, and other factors that may affect the measurement.

9.1.8 Ambient temperature.

10. Sample Variability

10.1 There are many factors that cause variability when taking readings in the field. Some of these are as follows:

10.1.1 Slight changes in the position of the reflection colorimeter on the traffic line may yield different readings.

10.1.2 Transverse lines may yield less uniform readings than longitudinal lines. Transverse lines have high wear in the wheel track area and less wear in the non-wheel track area.

10.1.3 Population and clarity of glass beads will affect the readings.

10.1.4 The pigment loading of the binder, road films, dirt, salt, dust, water, etc., will also affect the readings.

10.1.5 Tilt of the instrument with respect to the specimen plane will be affected by the physical characteristics of the specimen.

11. Sources of Error

11.1 Sources of error are in particular uncompensated daylight and instrument standards in need of recalibration.

12. Precision and Bias

12.1 These data are under development.

13. Keywords

13.1 chromaticity; pavement; pavement markings; portable reflection colorimeters; reflection