Designation: C 1510 – 01 (Reapproved 2007)

Standard Test Method for Color and Color Difference of Whitewares by Abriged Spectrophotometry[1]

This standard is issued under the fixed designation C 1510; 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 ceramic glazes and other whitewares 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 specimens having an exterior flat surface large enough to cover the spectrophotometer sample port.

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:* [2]

C 242 Terminology of Ceramic Whitewares and Related Products

D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

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

E 284 Terminology of Appearance

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

E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials

E 1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry

3. Terminology

3.1 *Definitions*:

3.1.1 The definitions in Guide E 179, Terminologies C 242 and 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 reflectance factors of reflecting ceramic glazes or related whiteware specimens by using a spectrophotometer or spectrocolorimeter equipped with a hemispherical optical measuring system such as an integrating sphere. (See Test Method E 1331.)

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 (Practice E 308, Section 6).

5. Significance and Use

5.1 The most direct and accessible methods for obtaining the color coordinates of ceramic glazes and related whitewares 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(See Practice E 805.):

5.2.1 All types of ceramic glaze and related whiteware specimens to obtain data for use in computer colorant formulation.

5.2.2 Ceramic glaze and related whiteware specimens for color assessment.

[1] This test method is under the jurisdiction of ASTM Committee C21 on Ceramic Whitewares and Related Products and is the direct responsibility of Subcommittee C21.03 on Methods for Whitewares and Environmental Concerns.

Current edition approved May 1, 2007. Published May 2007. Originally approved in 2001. Last previous edition approved in 2001 as C 1510–01.

[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.

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 (satin) specimens, 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. Measurement with specular excluded 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.

5.3 An estimate of gloss may be obtained by measuring the reflection both with the specular component of reflection included and excluded, and then calculating the difference between the two measurements at several wavelengths across the visible spectrum, as described in 10.2.

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 E 1164, Section 9):

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 E 1164, 9.5).

7. Specimen Selection

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

7.1.1 High visual uniformity and freedom from blemishes in the area to be measured,

7.1.2 Opaque specimens that have at least one exterior plane surface sufficiently large to cover the sample port on the spectrophotometer, and

7.1.3 Translucent and clear glaze specimens will give results that come, at least in part, from the underlying substrate.

8. Calibration and Verification

8.1 Set the instrument for inclusion or exclusion of the specular component of reflection; set it 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 E 1164, Section 9):

8.2.1 Zero setting of the reflectance scale (mandatory), and

8.2.2 Wavelength scale (recommended).

8.3 Calibrate the full-scale value of the reflectance scale of the instrument by use of the white reflectance standard (mandatory). This should be done every time the instrument is started up. Follow the instrument manufacturer's instructions.

8.4 Verify the accuracy of the instrumental data by measurement of a series of verification standards (recommended) (Practice E 1164, 9.5). Select the appropriate color scales, observer, and illuminant for the computation of color coordinates before measurement.

9. Procedure

9.1 Select inclusion or exclusion of the specular component of reflection.

9.2 When required, select the color scales, observer, and illuminant for the computation of color coordinates (Practice E 308, Section 6). For most applications, the CIELAB (L*, a*, b*) color scale, 10° observer, and D_{65} illuminant is recommended.

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

9.4 Handle the specimen carefully; avoid touching the area to be measured. When necessary, clean the specimen by using an agreed procedure. Glazed specimens should be washed with soap and water, and dried before measurement.

9.5 Place the specimen against the reflectance measurement port of the integrating sphere.

9.6 Measure the specimen, following the instrument manufacturer's instructions. When areas of high visual uniformity and freedom from blemishes cannot be found, make several measurements over the area of interest, and average the results.

9.7 For color difference, also measure the standard to be compared against.

9.8 If an indication of gloss is desired, measure the specimen both with specular reflectance included and excluded. Many instruments will require recalibration when changing from specular reflectance included to specular reflectance excluded, or vice-versa.

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

10. Calculations

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

10.2 For an indication of gloss, calculate the difference between reflectance with specular included and reflectance with specular excluded at 16 equally spaced wavelengths over the visible spectrum, and then average the results.

10.3 For color difference, calculate:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{\frac{1}{2}} \quad (1)$$

where:

$\Delta L^* = L^*_{sample} - L^*_{standard}$
$\Delta a^* = a^*_{sample} - a^*_{standard}$
$\Delta b^* = b^*_{sample} - b^*_{standard}$

10.4 The direction of the color difference is described by the magnitude and algebraic signs of the components Δ L*, Δ a*, and Δ b*, which have the following approximate meanings:

+ Δ L* = lighter

– Δ L* = darker
+ Δ a* = redder (less green)
– Δ a* = greener (less red)
+ Δ b* = yellower (less blue)
– Δ b* = bluer (less yellow)

11. Report

11.1 Report the following information:
11.1.1 Specimen description,
11.1.2 Instrument used,
11.1.3 Date of measurement,
11.1.4 Instrument parameters selected in 9.1-9.4,
11.1.5 Measurement results, in the form of tables of reflectance factor versus wavelength or color-scale values,
11.1.6 CIELAB color coordinates, and
11.1.7 If desired, the indication of gloss level.
11.1.8 For color difference, report delta E*, and direction if desired.

12. Precision and Bias

12.1 *Precision*:
12.1.1 *Repeatability*—Results reported in the literature,[3] obtained by the use of modem measuring instruments, expressed in terms of CIELAB color differences (see Practice E 308) are within 0.1 units. On this scale, the smallest color difference that can be reliably observed is of the order of 0.5 units, commercial color tolerances range upward from about one unit.

12.1.2 *Reproducibility*—The reproducibility within a group of similar instruments was reported to be about 0.2 units.[4] Inter-instrument agreement comparing different types of instruments, especially if different types of illuminating and viewing conditions are involved, is likely to be an order of magnitude poorer.

12.2 Two measurements should be considered suspect if they differ by more than the previous figures applicable to the two measurements.

13. Keywords

13.1 color; hemispherical geometry; reflectance; reflectance factor; spectrophotometry

[3] Billmeyer, F.W. Jr., and Alessi, P.J., "Assessment of Color-Measuring Instruments," *Color Research and Application*, Vol 6, 1981, pp. 195–202.

[4] Stanziola, R., Momeroff, B., and Hemmendinger, H., "The SpectroSensor—A New Generation Spectrophotometer," *Color Research and Application*, Vol 4, 1979, pp. 157–163.