



Designation: E2539 – 14 (Reapproved 2021)

## Standard Test Method for Multiangle Color Measurement of Interference Pigments<sup>1</sup>

This standard is issued under the fixed designation E2539; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### INTRODUCTION

Objects that exhibit a change in color with different angles of illumination and view are said to be “gonioapparent.” The tristimulus colorimetric values of gonioapparent objects are derived using the spectral reflectance factors obtained from spectrometric measurements or colorimetric measurements at various angles of illumination and detection. The tristimulus colorimetric values are computed using the spectral reflectance factors of the object, the CIE Standard Observer, and the spectral power distribution of the illuminant, as described in Practice E308. This Test Method, E2539, specifies the color measurement of interference pigments at various illumination and detection angles.

### 1. Scope

1.1 This test method covers the instrumental requirements and required parameters needed to make instrumental color measurements of thin film interference pigments. This test method is designed to encompass interference pigments used in architectural applications, automobiles, coatings, cosmetics, inks, packaging, paints, plastics, printing, security, and other applications.

1.2 Characterization of the optical behavior of materials colored with interference pigments requires measurement at multiple angles of illumination and detection.

1.3 Data taken utilizing this test method are quantitative and are appropriate for quality control of interference pigment color.

1.4 The measurement results are usually expressed as reflectance factors, tristimulus color values, or as CIE  $L^*a^*b^*$  color coordinates and color difference.

1.5 The totality of data taken may not be necessary for evaluating mixtures also containing non-interference pigments. The committee is investigating and evaluating the appropriateness of this test method for those materials. It is the responsibility of the users to determine the applicability of this test method for their specific applications.

1.6 Interference pigments are typically evaluated for color and color appearance in a medium, such as paint or ink. The gonioapparent effect depends strongly on the physical and chemical properties of the medium. Some of the properties affecting color and color appearance include vehicle viscosity, thickness, transparency, and volume solids. As a general rule, for quality control purposes, interference pigments are best evaluated in a masstone product form. In some cases this product form may be the final product form, or more typically a qualified simulation of the intended product form (such as a paint drawdown) that in terms of color and appearance correlates to final product application.

1.7 This standard does not address the requirements for characterizing materials containing metal flake pigments. Measurements of the optical characteristics of materials containing metal flake pigments are described in Test Method E2194.

1.8 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.9 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.10 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.12 on Gonioapparent Color.

Current edition approved June 1, 2021. Published June 2021. Originally approved in 2008. Last previous edition approved in 2017 as E2539 – 14 (2017). DOI: 10.1520/E2539-14R21.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

**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

**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

**E1708** Practice for Electronic Interchange of Color and Appearance Data

**E1767** Practice for Specifying the Geometries of Observation and Measurement to Characterize the Appearance of Materials

**E2194** Test Method for Multiangle Color Measurement of Metal Flake Pigmented Materials

**E2480** Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method with Multi-Valued Measurands

### 2.2 ISCC Publications:<sup>3</sup>

**Technical Report 2003–1** Guide to Material Standards and Their Use in Color Measurement

## 3. Terminology

3.1 Terms and definitions in Terminology **E284**, and Practice **E1767** and Test Method **E2194** are applicable to this test method. See Section 5 of **E284** for “Specialized Terminology on Gonioapparent Phenomena.”

## 4. Summary of Test Method

4.1 This test method describes the instrumental geometries, including abridged goniospectrometry, used to measure interference pigments. Optical characterization requires color measurement at multiple illumination and multiple detection angles specified in this procedure. These sets of illumination and detection angles are specified in the test method. Standardization and verification of the instrument used to measure these materials are defined. The requirements for selection of specimens and measurement procedures are provided. The results are reported in terms of reflectance factors, CIE tristimulus values, and other color coordinate systems that define the color of the object. Expected values of precision are presented.

## 5. Significance and Use

5.1 This test method is designed to provide color data obtained from spectral reflectance factors at specific illumination and detection angles for interference pigments. Information presented in this test method is based upon data taken on materials exclusively pigmented with interference pigments.

5.2 These data can be used for acceptance testing, design purposes, research, manufacturing control, and quality control.

5.3 Specimens must be statistically representative of the end use.

5.4 Applicability of this test method for other materials, including combining interference pigments with absorbing and scattering pigments should be confirmed by the user.

## 6. Environmental Conditions

6.1 If the standard laboratory conditions listed below change during the test or from test to test by an appreciable amount, these conditions may reduce accuracy and precision of this test method. In some cases these effects may only be observed during the performance of the test.

6.2 *Factors Affecting Test Results*—The following factors are known to affect the test results.

6.2.1 *Extraneous Radiation*—Light from sources other than the illuminator(s) and any near-infrared (NIR) must be shielded from entering the test apparatus.

6.2.2 *Vibrations*—Mechanical oscillations that cause components of the apparatus to move relative to one another may cause errors in test results.

6.2.3 *Thermal Changes*—Temperature changes occurring during a test or differences in temperature between testing locations may affect calibration.

6.2.4 *Power Input Fluctuations*—Large changes in the line frequency or supply voltage may cause the apparatus to report erroneous results.

6.3 *Standardization*—The system must allow for successful standardization. If the system cannot be standardized, consult the manufacturer’s user guide.

6.4 *Controlling Factors*—Accuracy and precision can be enhanced by controlling and regulating each factor within the constraints of the allowable experimental error. The values and limits for these factors are typically determined experimentally by the user.

## 7. Apparatus

7.1 *Multiangle Spectrometer*—This test method specifies the required illumination and detection angles of multiangle spectrometers. These multiangle spectrometers are designed specifically to characterize the optical behavior of materials colored with interference pigments. Geometries are specified in Section 8. The spectrometer may either be a goniospectrometer or an abridged goniospectrometer.

7.1.1 Bi-directional spectrometers or colorimeters with a single angle of measurement; such as 45°:0° or 0°:45°, and spectrometers using hemispherical geometry cannot adequately characterize the gonioapparent of these materials.

7.1.2 Multiangle spectrometers or colorimeters similar to those specified in Test Method **E2194** cannot adequately characterize the gonioapparent of these materials.

7.2 *System Validation Materials*—The precision and bias of the entire measurement system, including calculation of CIE

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

<sup>3</sup> Available from the Inter-Society Color Council, 1191 Sunset Hills Road, Reston, VA 20190, [www.iscc.org](http://www.iscc.org).