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Standard Practice for Establishing Color and Gloss Tolerances[1]

This standard is issued under the fixed designation D 3134; 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.

ε^1 NOTE—Corrections were made editorially in Footnote 4, 7.2.1, and Section 12 in December 2008.

INTRODUCTION

Permissible color and gloss deviations from a standard are generally dependent upon the color discrimination of the observer, on the lighting and surround in which the material is viewed, and on special considerations related to the design, manufacture, and practical usage of the colored material or object. The tolerances, therefore, may be influenced by economic, technical, psychological, and practical requirements. In many circumstances, acceptability of color and gloss deviations from a standard may differ appreciably from the perceptibility of deviations such as on-tone fading preferences, large tolerances for luminance variation, nongreen bias, or nonyellow bias. With proper allowances, perceptibility data can be used as an aid to develop permissible tolerances. Finally, the sum of all these considerations should result in a specification acceptable to both buyer and seller.

1. Scope

1.1 This practice describes a procedure for establishing tolerances and evaluating the color and gloss of specimens with respect to specified standards. This practice is appropriate for nonfluorescent opaque specimens.

1.2 This practice does not indicate the extent of tolerances, but gives guidance on how they can be set. For product specification, the tolerances between specimens and the specified standard should be agreed upon between the purchaser and the seller.

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]

D 523 Test Method for Specular Gloss
D 1535 Practice for Specifying Color by the Munsell System
D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D 3964 Practice for Selection of Coating Specimens for Appearance Measurements
D 4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance
D 5531 Guide for Preparation, Maintenance, and Distribution of Physical Product Standards for Color and Geometric Appearance of Coatings
E 284 Terminology of Appearance
E 308 Practice for Computing the Colors of Objects by Using the CIE System
E 312 ~~Practice for Description and Selection of Conditions for Photographing Specimens~~ Practice for Description and Selection of Conditions for Photographing Specimens Using Analog (Film) Cameras and Digital Still Cameras (DSC)
E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials
E 1164 Practice for Obtaining ~~Spectrophotometric~~Spectrometric Data for Object-Color Evaluation
E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry
E 1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements

[1] This practice is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.11 on Visual Methods. Current edition approved Dec. 1, ~~2003.~~2008. Published December ~~2003.~~2008. Originally approved in 1972. Last previous edition approved in ~~1997~~2003 as D 3134 – 97 (2003).

[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.

E 1349 ~~Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry~~ Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45:0 or 0:45) Geometry
E 1360 Practice for Specifying Color by Using the Optical Society of America Uniform Color Scales System
E 1499 Guide ~~to the~~for Selection, Evaluation, and Training of Observers
E 1541 Practice for Specifying and Matching Color Using the Colorcurve System
E 1708 Practice for Electronic Interchange of Color and Appearance Data

2.2 *CIE Publication:*
~~No. 15.2~~ No. CIE S 014-4/E2007 Colorimetry 2nd ed.[3]

3. Terminology

3.1 *Definitions*—For definitions of terms related to this practice see Terminology E 284.

4. Summary of Practice

4.1 This practice consists of recommendations for the selection of a standard, the necessary physical measurements to assess the permanence of the standard to reproduce it when needed, and to establish tolerances.

4.2 Recommendations are given for the determination of the conformance of a specimen to preestablished color and gloss tolerances by instrumental or visual means.

5. Significance and Use

5.1 Color specifications are centered around exact positions in color space. Correspondingly, gloss specifications are centered around an exact position on the gloss scale. Because it is difficult to achieve these exact positions repeatedly, it is necessary to specify tolerances that are acceptable to both the buyer and the seller. This practice details the procedure for accomplishing this goal.

6. Specimens

6.1 The exact method of preparation of the specimen shall be agreed upon between the purchaser and the seller. However, for the highest precision in instrumental measurements the specimens should be opaque, uniform in color, plane, and uniform in texture. The specimens should be relatively permanent, and capable of being cleaned. Preferred sizes of specimens for visual evaluation are given in Practice D 1729, the specific size being governed by the use of the specimens.

7. Procedure

7.1 *Selection and Specification of Color and Gloss Standard*:

7.1.1 Select a standard in accordance with Practice D 3964 that is preferably the same type of material as the specimens to be evaluated for color or gloss, or both. Prepare, in sufficient quantity, secondary standards in accordance with Guide D 5531 that are representative of the desired color and gloss, in the permanent material. Standards should have the same spectral characteristics as the manufactured product. This is usually accomplished by use of the same colorant composition, incorporated in the same manner into the same material. The standard should have the same texture as the manufactured product.

7.1.1.1 In order to obtain a permanent record, use Practice E 805 and either Test Method E 1331 or Test Method E 1349 to correctly identify the instrumental measurement method. Measure the color in accordance with Practices E 1164 and E 805. Report the color as described in Practice E 308. Do this even if the standard is textured. (If the standard is textured, note the texture orientation during measurement.) The variability of the measurements due to texture may be reduced by following the recommendations outlined in Practice E 1345.

7.1.1.2 *Visual Color Assessment*—Use Guide E 1499 to select an observer for the assessment. Assess and specify the color in terms of a color system described in Practices ~~D1535, E1360, or E1541~~D 1535, E 1360, or E 1541.

7.1.1.3 Measure the gloss in accordance with Test Method D 523, or evaluate it in accordance with Test Method D 4449.

7.1.1.4 Employ photography for permanently recording the appearance of the surface texture (see Practice E 312). While Practice D 3134 does not deal with texture tolerances or specifications, it should be recognized that significant differences in surface texture between standard and test specimens significantly affect both color and gloss, whether examined visually or instrumentally. In the case of visual evaluation of the effect of color and gloss, differences can be minimized by strict adherence to recommended illuminating and viewing geometry (see Practice D 1729).

7.2 *Selection and Specification of Color Tolerances*:

7.2.1 The purchaser and the seller shall agree on color tolerances with respect to a previously selected standard and on the color scales in which they are expressed. Selection of the magnitude and direction of color tolerances shall be based on careful

[3] ~~Available from The U.S. National Committee of the CIE (International Commission on Illumination), C/o Thomas M. Lemons, TLA-Lighting Consultants, Inc., 7 Pond St., Salem, MA 01970.~~
[3] Available from CIE (International Commission on Illumination) webshop, http://www.techstreet.com/cgi-bin/browsePublisher?publisher_id=60&subgroup_id=16861.

consideration of all applicable factors. For example, tolerances may be selected on the basis of perceptibility of the magnitude of color difference, rejection of or closer limits on certain directions of color difference, and costs of controlling the magnitude and direction of color difference. Recommendations on color scales appear in CIE Publication No. ~~15.2~~CIE S 014-4/E2007 and Practice E 308.

7.2.1.1 Express color differences between the specimen and the standard in terms of a set of three independent parameters. The CIE 1976 L*a*b* (CIELAB) approximately uniform color space and color difference equations have been recommended for use by the International Commission on Illumination (CIE). See Practice D 2244 and Practice E 308. While this color metric (CIELAB) is convenient for expressing color differences, it must be understood that a given calculated color difference in one region of color space may not represent the same visual difference in other regions of color space.

7.2.2 Gloss differences can affect instrumental measurement of color differences. Large gloss differences between visually identical colors can cause their color measurements to exhibit larger color differences than in fact exist. When using historical data to establish color tolerances, exercise care to limit the specimens to those that have quite similar gloss values. When establishing gloss tolerances, be aware that changes in gloss values may have an effect upon color measurements.

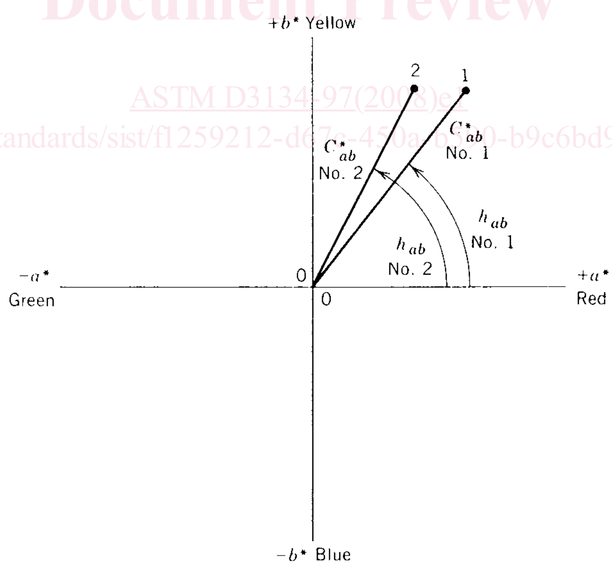
7.2.3 When color difference formulae are used in practice, it is often desirable to identify the components of color difference, in terms of correlates of lightness, hue, and perceived chroma (saturation). It is also desirable to express color specifications in terms of such correlates. The CIE terminology appropriate to this usage is CIE 1976 lightness, CIE 1976 hue-angle, h_{ab}, and CIE 1976 chroma, C^*_{ab}. Refer to Practice D 2244 and Practice E 308 for equations and definitions. The CIELAB 1976 hue-angle and chroma are illustrated in Fig. 1.

7.2.4 The CIELAB opponent-color red-green coordinate *a**, and the yellow-blue coordinate *b** are defined in Practice D 2244 and Practice E 308.

7.2.5 *Graphical Interpretation of Historical Data*:

7.2.5.1 Color tolerances can be determined from a graphical interpretation of historical data (batches accepted, rejected, or considered borderline). Fig. 2 (*a*) and Fig. 3(*b*) show plots of specimens rated by multiple observers with respect to how well they match a standard, along with figures defining the tolerances. To illustrate the principle recommended: (*1*) rate a number of specimens for acceptability, (*2*) plot them, and (*3*) prepare to draw the tolerance figure dictated by the data.

7.2.5.2 In such cases it is customary to plot the hue angle of the standard by drawing a line from the origin (0, 0) through the standard color on the *a***b** plot. This line of constant hue becomes the major axis. Similarly, a line perpendicular to the constant-hue line and passing through the standard color is a line of constant chroma (or saturation) and becomes the minor axis of the ellipse, if the data plot indicates the ellipse should be symmetrical around the standard color. These lines assist in drawing the tolerance ellipse, Fig. 2(*a*).



NOTE 1—Hue angle is measured in degrees starting with $h_{ab} = 0$ in the + *a** (red) direction and increasing counterclockwise. Chroma is measured as the length of the line from the neutral point ($a^* = b^* = 0$) to the sample point. Sample Point 2 has a larger value of h_{ab} than Point 1 and therefore is yellower in hue. Point 2 also has a smaller value of $C_{ab}*$ than Point 1 and is therefore lower in chroma or duller.

NOTE 2—Original source is Billmeyer, F. W., Jr., and Saltzman, M., *Principles of Color Technology*, 2nd ed., John Wiley and Sons, New York, NY, 1981. (Reprinted by permission of John Wiley & Sons, the copyright owner.)

FIG. 1 CIE 1976 L* a * b* (CIELAB) Hue Angle and Chroma