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Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials[1]

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This standard has been approved for use by agencies of the Department of Defense.

INTRODUCTION

The colors of materials depend on the geometric and spectral nature of the illuminating and viewing conditions. This practice specifies standard conditions for appraising the colors and color differences of opaque specimens that are diffusely illuminated. Daylight, the natural illuminant, is usually of primary interest, but natural daylight is highly variable and is not available at night or in interior rooms, so simulated daylight is generally used. Colors may match under a light source with one spectral power distribution, but not under another, so the match is usually confirmed under another very different source. An incandescent lamp of low correlated color temperature has long been used to detect mismatches likely to appear under yellower phases of daylight or incandescent light. Industrial color matchers often verify the match with the kind of light likely to be found where the product is sold or used. Judgments must be made by observers with normal color vision. Even so, there may be substantial individual differences in judgments.

1. Scope

1.1 This practice specifies the equipment and procedures for visual appraisal of the colors and color differences of opaque materials that are diffusely illuminated. These specification are of critical importance in color matching. This practice requires judgments by observers with normal color vision.

1.2 Critical visual appraisal of colors and color differences of materials such as metallic and pearlescent paints requires illumination that is nearly a geometric simulation of sunlight, because such directional illumination permits observation of the glitter and goniochromatism that characterize such materials. Such viewing conditions are beyond the scope of this practice.

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

1.4 *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 4086 Practice for Visual Evaluation of Metamerism

D 5531 Guide for the 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 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation

E 1499 Guide to the Selection, Evaluation, and Training of Observers

2.2 *ISO/CIE Standard:*[3]

10526 CIE Standard Colorimetric Illuminants (1991)[3]

[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.

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This standard has been approved for use by agencies of the Department of Defense to replace Method 4249.1 of Federal Test Method Standard No 141. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

[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 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. Terminology

3.1 For definitions of appearance terms used in this practice, refer to Terminology E 284.

4. Significance and Use

4.1 Although color measuring instruments are widely used, color matches are usually checked visually. The standardization of visual examination has greatly improved the uniformity of products and the accuracy of color matches.

4.2 The use of this practice is essential for critical color matching but is also recommended for any color appraisal, such as the choice or approval of a color. This practice is widely used in industry to choose colors, exhibit colors reproducibly, inspect incoming materials, monitor color producing processes, and inspect finished goods. Visual appraisal is particularly important when the product inspected is not of the same material as the color standard to which it is compared.

4.2.1 *Observers*—This practice is based on the fundamental assumption that the observer has normal color vision and is trained and experienced in observing and classifying color differences. The significance of the results depends on that being so. The selection, evaluation, and training of observers are treated in Guide E 1499.

4.2.2 *Illumination*—Simulated average daylight is recommended by the International Commission on Illumination (CIE), but a slightly bluer simulated north-sky daylight came into widespread use in North America, because it provides a slightly greater distinction between very pale yellow and white, a distinction of great commercial importance.

5. Observers

5.1 The validity of the results obtained by this practice depends on visual judgments by an observer or observers with normal color vision. Even among normal observers, there may be substantial individual variations. Color specifications dependent on this practice may require averaging the results obtained by a specified number of observers. The nature of an observer's color vision can be ascertained by visual tests. Observers should be tested periodically, because an individual's color vision can change (see Guide E 1499).

6. Apparatus

6.1 The apparatus shall consist of luminaires, specimen table, surround, and ambient field having the following spectral, photometric, and geometric characteristics:

6.1.1 *Spectral Power Distribution*—The spectral power distribution of the radiant flux incident on the specimens depends not only on the source used, but on the nature of any diffuser employed and any reflecting surfaces, including those in the ambient field, that reflect flux to the specimens.

6.1.1.1 Daylight illumination shall be a spectral simulation of daylight of one or more of the following three kinds: overcast northern sky light, designated CIE Illuminant D_{75}; average daylight, designated CIE Illuminant D_{65}; or, for applications involving color photography or color printing, CIE Illuminant D_{50}. The spectra of these illuminants are specified in Practice E 308 and CIE Publication 15.2.[4] The quality of the simulation of daylight shall be assessed by the method specified in the latest revision of CIE Publication 51[5] (under revision in 1996). For critical appraisal of colors and color differences, the category determined by that method shall be BC(CIELAB) or better. This rating ensures that the source provides ultraviolet and visible power in the right proportions to make both nonfluorescent and fluorescent materials look very nearly the way they would in the corresponding phase of natural daylight. Users of this practice should be aware of the fact that neither correlated color temperature nor chromaticity alone qualifies simulated daylight for this purpose.

6.1.1.2 Incandescent illumination shall have the spectral quality of the light from an incandescent lamp commonly used for home and business lighting, approximately simulating CIE Illuminant A, specified in Practice E 308 and ISO/CIE 10526.

6.1.1.3 Incandescent illumination of low correlated color temperature shall have spectral quality similar to that of a Planckian radiator having a color temperature of 2300 K. This light is commonly produced by incandescent lamps operated at half their rated voltage.[6]

6.1.1.4 Fluorescent lamps are often provided. Those most often used are of the type known as "cool white" approximately simulated by CIE Illuminant F2, and the type known as "three-band" approximately simulated by CIE Illuminant F11. The spectra of these illuminants are specified in Practice E 308 and ISO/CIE 10526.

6.1.1.5 One or several of these kinds of illumination, or other kinds, as specified, may be provided in a luminaire or viewing booth. Provision must be made for selecting any one of the sources independently.

6.1.2 *Photometric Conditions*—For critical evaluation of color differences of materials of medium lightness, the illumination at the center of the viewed area shall be 1080 to 1340 lx (100 to 125 fc). For general evaluation of materials of medium lightness, the illumination shall be between 810 and 1880 lx (75 and 175 fc). In either case, for viewing very light materials, the illumination may be as low as 540 lx (50 fc), and for viewing very dark materials it may be as high as 2150 lx (200 fc). This higher level of illumination is usually obtained by holding the specimens nearer the source.

6.1.3 *Geometric Conditions*—The illumination shall be provided by an extended-area source located above the specimens and shall be sufficiently directional to reveal the texture of specimens. The illuminance shall be uniform over the viewing area, within ±20 %, with no abrupt changes apparent to the observer.

6.1.4 *Surround and Ambient Field*—The surround, the portion of the visual field immediately surrounding the specimens, shall be the color having the Munsell notation given in Table 1

[4] CIE Publication 15.2, *Colorimetry*, 2nd ed., Central Bureau of the CIE, Vienna, 1986 (see footnote 3).

[5] CIE Publication 51, *A Method for Assessing the Quality of Daylight Simulators for Colorimetry*, Central Bureau of the CIE, Vienna, 1981 (see footnote 3).

[6] The equations describing Planckian radiators and tables of their distributions can be found in Wyszecki, G., and Stiles, W. S., *Color Science Concepts and Methods, Quantitative Data and Formulae*, 2nd ed., John Wiley & Sons, Inc., New York, NY, 1982.