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Standard Guide for Setting Object Color Specifications[1]

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1. Scope

1.1 This guide leads the user through a process for establishing color specifications, including the target color and allowable tolerances. It refers to the appropriate ASTM standards that more thoroughly describe each step of the process beginning with expectations, encompassing caveats within the process and finally concluding with reporting.

1.2 This guide does not suggest numerical values for tolerances. These values must be agreed upon by the parties involved.

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

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D523 Test Method for Specular Gloss
D1003 Test Method for Haze and Luminous Transmittance of Transparent Plastics
D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D3134 Practice for Establishing Color and Gloss Tolerances
D3964 Practice for Selection of Coating Specimens for Appearance Measurements
D4086 Practice for Visual Evaluation of Metamerism
D4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance
D5531 Guide for Preparation, Maintenance, and Distribution of Physical Product Standards for Color and Geometric Appearance of Coatings
E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials
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

[1] This guide is under the jurisdiction of ASTM Committee E12 on Color and Appearance and is the direct responsibility of Subcommittee E12.04 on Color and Appearance Analysis.

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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.

E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry
E1499 Guide for Selection, Evaluation, and Training of Observers
E1708 Practice for Electronic Interchange of Color and Appearance Data
E1808 Guide for Designing and Conducting Visual Experiments
E2214 Practice for Specifying and Verifying the Performance of Color-Measuring Instruments
E2867 Practice for Estimating Uncertainty of Test Results Derived from Spectrophotometry

2.2 *CIE Publications:*[3]

CIE Publication 015 Colorimetry

3. Terminology

3.1 *Definitions*—For definitions of terms related to this guide see Terminology E284.

4. Summary of Guide

4.1 This guide describes the process for establishing color specifications for a material, including the decision as to whether this specification will be based on visual or instrumental methods.

4.2 General considerations of appearance, evaluation of observers, and measurement techniques are included.

4.3 It begins the process of setting a tolerance by first selecting a standard or target color for the material, including the production, measurement, and storage of that target.

4.4 It next identifies methods to establish acceptable color tolerances.

4.5 Finally, it discusses reporting techniques.

5. Significance and Use

5.1 The rejection of materials due to color is a common and expensive occurrence, and it is useful for a customer and producer to set color specifications with an associated tolerance before the transaction. This guide discusses the concept and details the ASTM standards to be used in the process.

6. Introduction

6.1 A common reason stated for rejection of goods or materials is that the product color does not meet expectations. The best way to avoid the problem of returned goods or materials because of color is to establish color specifications with associated tolerances. Then the producer can be confident that if they supply material that falls within the specification, the customer will accept the product.

6.2 To supply product within specification consistently requires production that is under statistical process control, and a program of color measurement and evaluation.

6.3 This guide will lead the user through the decision-making process and point to the appropriate ASTM standards that are pertinent to each step. It will include the discussion points on which the two parties must agree and will provide caveats for various options selected.

7. General Discussions

7.1 In setting up the specification, one must first decide whether there will be a visual or instrumental evaluation of the color. Observers have different color perception skills. A highly trained colorist can see very minute color differences whereas the more casual observer or color-anomalous observer would not normally detect very small differences. Additionally, the visual abilities or perception levels of observers, may vary between persons and over time within an individual. Thus if the color of the material

[3] Available from CIE (International Commission on Illumination), http://www.cie.co.at or http://www.techstreet.com.

will be evaluated visually, we must ensure consistent conditions for the evaluation. Guide E1499 provides detailed information about the selection of observers. Guide E1808 provides guidance on how to conduct critical visual observations.

7.2 Numerous advances have occurred in both the accuracy and repeatability of color measurement instruments. However, there may still be considerable differences between instruments of different make, type, and geometry. Advances have also occurred in the equations and software programs for evaluating color and color quality control. It is not uncommon for the specification to be set numerically and evaluated by instrumental measurement, but then the question, "what should my tolerance be?" must be resolved.

7.3 A number of color difference calculations are widely used throughout industry. See Practice D2244 for more details on color difference and color tolerance equations. Which color-difference metric will be used should be agreed upon by the two parties involved. For years, color tolerances were set up as rectangular tolerancing. In some industries the phrase "box tolerancing" is the accepted terminology. However, elliptical tolerancing is preferred.

7.4 In most cases, the limits of acceptability will be greater than a just perceptible difference, but in some cases, the tolerance may be less than a perceptible difference. If it is less than a perceptible difference, then instrumental methods should be used. Both the producer and the customer should refer to Practice E2214.

7.5 While the goal is to have an agreed color specification with an acceptable tolerance for both the producer and the customer, each party must carefully consider their position. The producer should be assured that they are able to control the color in production to the level specified without excessive waste and undue loss. The customer should be assured that the tolerance is such that the color of the goods will be acceptable.

7.6 Color is one aspect of the appearance of a material. Other appearance parameters include, but are not limited to, gloss, haze, and texture. In order to compare the color of a test material to a target material, either visually or instrumentally, all aspects of appearance should be the same, or as similar as possible. Test Method D4449 covers the visual evaluation of gloss difference, while Test Method D523 covers instrumental gloss measurement. Test Method D1003 covers the measurement of transmission and haze of transparent plastics.

7.7 It is important to use established and consistent viewing conditions. These include the illumination, the positioning of the standard and specimen, and the receptor system, whether human or instrumental. If one is trying to have instrumental readings that correlate with the visual appearance of a material, one needs to establish consistency between the visual situation and the instrumental set up. Guide E179 discusses the terminology and instrumentation for evaluating appearance characteristics. Some of the considerations when choosing the geometry of evaluation are:

7.7.1 What are one's internal needs such as formulation, quality control, auditing, trouble shooting?

7.7.2 What are one's customer's specifications and needs?

7.7.3 Does one want the numbers to match visual evaluation?

7.7.4 If the gloss or surface texture of the standard and specimen are different, does one want specimen's gloss or grain levels to produce the same colorimetric values as the standard when measured?

7.7.5 Does one want to deal with a small or large process window?

7.8 It is important to have the producer and the customer agree on the target color and the criteria for acceptance. For many users the final criterion is visual acceptance, that is, visual color is the final deciding factor. However, some users have demonstrated that more consistent product quality is obtained instrumentally, avoiding the "final visual inspection." Once the color is agreed upon, then one should decide whether to use visual or objective standards and tolerances.

7.8.1 Some of the advantages of using a digital standard are:

7.8.1.1 Both supplier and customer have the same absolute numbers to judge against, the same starting point,

7.8.1.2 Reduced costs of making and maintaining master standards,

7.8.1.3 Easy to communicate an absolute number electronically, and

7.8.1.4 Faster; and fewer subjective calls.

7.8.2 Some of the disadvantages of using a digital standard are:

7.8.2.1 For best consistency, both supplier and customer must have the same instrument,

7.8.2.2 There is no physical standard available to use for a visual comparison,

7.8.2.3 The risk increases if different materials, technologies or different suppliers are used, and

7.8.2.4 There is less opportunity to ship acceptable-color product that matches but have numbers on the borderline or slightly greater than the numerical tolerance.

7.9 Maintaining master and working physical standards is discussed in detail in Guide D5531. However, some important aspects are repeated here.

7.9.1 Store master standards in a suitable protective material, under appropriate temperature and humidity conditions for the material to keep it in optimal condition (in the dark, away from heat sources, chemical fumes, direct sun-rays, etc.) and only remove when necessary to verify new working standards.

7.9.2 Maintain multiple working standards, with only one in circulation at a given time.

7.9.3 Handle master standards with lint-free gloves.

7.9.4 Record dates on all master and working standards when they are approved and by whom.

7.9.5 Frequently inspect working standards for scratches, changes in gloss or color.

7.9.6 Match to an approved (working master) part and routinely check the color difference between the master and the working master to ensure that the working standard has not changed.

NOTE 1—Once the working master has been established, it is desirable to use this rather than going back to the master because reference to the master can open the door for instrumental measurements and visual evaluations to be different.

7.10 All measured values have an uncertainty associated with the measurement. Estimate the uncertainty of test results using Practice E2867. To reduce the confidence limits associated with color or color-difference measurements statistical analysis of the results of multiple measurements on a single specimen or the measurement of multiple specimens can be used. This procedure is described in Practice E1345.

7.11 It is best if the standard and the trial material can be measured at the same time, on the same equipment by the same operator. Single operator precision is the best way to estimate production, test and raw material effects.

8. Procedure for Setting a Tolerance

8.1 Section 8 gives the steps for setting a tolerance. Table 1 summarized the ASTM ~~Standards~~standards referenced for each of these steps.

8.2 The first step is to establish a physical (master) standard that represents the required color and to assure that all the (working) standards used in the control program match that color within a very small tolerance. See Practice D3964. Additionally, a program should be established to monitor the color quality of those working standards. See Guide D5531. Sample preparation is a very important issue. The surface characteristics and texture are important considerations and should be consistent.

NOTE 2—For coatings one might spray (using a specific procedure) or draw down the specimens. For other materials use techniques appropriate for those materials.