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Standard Guide for Preparation, Maintenance, and Distribution of Physical Product Standards for Color and Geometric Appearance of Coatings[1]

This standard is issued under the fixed designation D 5531; 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 guide covers three levels of physical product standards for color commonly used in the coatings industry, provides terminology to describe each level, and describes techniques for generating standards.

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

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:*

D 16 Terminology for Paint, Related Coatings, Materials and Applications[2]

D 523 Test Method for Specular Gloss[2]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[2]

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials[2]

D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates[2]

D 3134 Practice for Establishing Color and Gloss Tolerances[2]

D 4086 Practice for Visual Evaluation of Metamerism[2]

D 4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance[2]

E 284 Terminology of Appearance[2]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[2]

E 430 Test Methods for Measurement of Gloss of High-Gloss Surfaces by Goniophotometry[2]

E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials[2]

E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[2]

E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry[2]

E 1345 Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements[2]

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[2]

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry[2]

2.2 *Society of Automotive Engineers Standard:*

SAE J1545 Recommended Practice for Instrumental Color Difference Measurement for Exterior Finishes, Textiles, and Colored Trim[3]

3. Terminology

3.1 The definitions in Terminology E 284 and D 16 are applicable to this test method. The terms in E 284 take precedence over those in D 16 if there are differences.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *concept color, n*—the color of the material submitted by the customer as the target for generating the master standard.

3.2.2 *master standard, n*—the physical standard for color that the customer approves as the target for visual, spectrophotometric, and colorimetric evaluation of all products referenced to that standard.

3.2.2.1 *Discussion*—in SAE J1545 this is referred to as the "official" standard.

3.2.3 *duplicate master standard, n*—a replicate of the master standard that serves as the master standard at a secondary location.

3.2.3.1 *Discussion*—in SAE J1545 this is referred to as the "reference" standard.

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[2] *Annual Book of ASTM Standards*, Vol 06.01.

[3] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

3.2.4 *working standard, n*—the physical product standard for color used for routine measurements and visual assessments in the laboratory and at the production site.

4. Summary of Guide

4.1 Product standards are the only standards by which products should be accepted or rejected for color. A master standard is generated from the concept color submitted by the customer. Duplicate master standards, when needed, are generated from the master standard. Working standards are generated from a duplicate master standard. They are used in the laboratory or on the production line to accept or reject the color of coatings. After initial generation, product standards must be maintained to ensure that they remain valid. This guide considers the characteristics of product standards, factors to be considered in their creation, and factors to be considered in their replacement.

5. Significance and Use

5.1 High quality physical product standards for color are the keystone of a successful color control program. Standards are often grouped into three major categories: product standards, intermediate production control standards, and instrument standards. This guide deals only with physical product standards. Some instrumentally based color control programs use "numerical standards," derived from instrumental measurements of a physical product standard.

6. Characteristics of Physical Product Standards for Color

6.1 Physical product standards for color should be made of the same material as the specimens to be evaluated. This is more difficult in the case of coatings because they are not usually sold in their final form, that is, they may be sold as a liquid or a powder but will end up as a finished film. The coating must be applied to a substrate, usually metal or paper, and cured before evaluation. Agreement must be reached between the buyer and the seller on the method of application and cure for the coating before the master standard is fabricated.

6.2 The coatings supplier should produce the physical product standards for color. They must have the same spectral character at all viewing and illuminating geometries of concern as the coating.

6.3 The standard should have the same geometric appearance (nonspectral) characteristics as the final product. Changes in geometric characteristics may influence the noncolor aspects of appearance such as gloss and texture. They may also affect the perceived color of the coating with respect to both instrumental measurement and visual perception.

6.4 The desire for permanent physical product standards for color will sometimes lead people to use other material such as ceramic for standards. Fairman[4] states: "While a ceramic tile may be recognized as a material of greater permanence than the organic material being standardized, the probability of the introduction of metamerism between the two dissimilar materials far outweighs any possible permanence gains."

7. Three Levels of Physical Product Standards for Color

7.1 The concept color submitted by the customer should not become the master standard because it may be made of different material or have gloss or texture (geometric appearance) different from the final product. The concept color simply represents the customer's best effort to illustrate the desired color for the coating. The concept color is to be "matched" by the master standard. The master standard represents the target, both spectrally and geometrically, for the manufactured coating. It becomes the reference by which the coating is accepted or rejected. Once the master standard is approved by the customer, the concept color should be filed for possible future use.

7.2 The master standard is the reference for judging the color of duplicate master standards. Although in the case of a major dispute it is the ultimate reference for color and geometric appearance, it should not be used for routine evaluations in the laboratory or at the production site.

7.3 Duplicate master standards should be prepared at the same time. Duplicate master standards are intended to be identical to the master standard. Because there will be variation in perceived or measured characteristics of duplicate master standards, buyer and seller must agree on tolerances for "duplicate master standards." Fairman[4] suggests that the measured color difference be less than 0.2 CIELAB unit, and Sherman[5] suggests that the measured color difference be less than 0.5 FMC-2 unit. SAE J1545 judges standards by stating that the tolerance should be the greater of 0.2 unit in each CIELAB color difference component, DL*, DC*, and DH*, or one-tenth the accepted tolerance for the product (see Practice D 3134 and E 1345). The number of duplicate master standards to be made will depend upon the life expectancy of the color or product, or both, the standard's resistance to physical abuse, its cleanability, its resistance to color and geometric appearance change, and the number of times each standard will be used.

7.4 Each duplicate master standard should be given a unique identification with date of fabrication. A sufficient number of duplicate master standards should be generated initially to last for the lifetime of the color.

7.5 When a coating is manufactured at more than one location, each location should treat one duplicate standard as the master for that location. Another duplicate standard should be designated for the location. The remaining duplicate standards should be designated working standards to be used for routine evaluation of the coating.

7.6 Working standards may become unsuitable for use because of physical damage, dirt, contamination, or changes in geometric appearance and color due to exposure or use. Therefore, it is essential to compare working standards frequently to duplicate master standards.

[4] Fairman, H. S., "A Standards Program for Color Control," *Color Research and Application*, Vol 6, 1981, pp. 5–6.

[5] Sherman, C. J., "A Color Standards Program for Color Control," *Technical Paper FC84-880*, Society of Manufacturing Engineers, presented at FINSTRAT '84 Conference, November 27–29, 1984, Anaheim, California.

7.7 The duplicate master should be compared to the master only rarely. The master should be kept in a secure, environmentally stable and clean area.

NOTE 1—The master standard should be treated as you would an original software disk; make sure you have a copy, then store it in a safe place. It should be used only when necessary to confirm or replace the duplicate master.

8. Preparation Considerations

8.1 *Application Methods*:

8.1.1 The buyer and seller should agree upon the methods of application and cure. Ideally they should duplicate those methods by which the final coating is applied and cured. Practices D 823 describes methods for producing films of uniform thickness on test panels.

8.1.2 Application and cure parameters that should be considered include, but are not limited to, the following:

8.1.2.1 Substrate,

8.1.2.2 Application device such as drawdown, hand spray, automatic spray, and electrostatic deposition,

8.1.2.3 Application thickness,

8.1.2.4 Flash time, and

8.1.2.5 Cure method and schedule, such as air dry, force dry, bake for specified time, and specified temperature.

8.1.3 A physical product standard for color should be uniform in color at all viewing and illuminating geometries of concern and geometric appearance aspects, such as gloss and texture, if uniformity is to be a characteristic of the coating. Otherwise the pattern of color and the geometric aspects of appearance should be representative of those of the desired coating.

8.1.4 The buyer and seller should agree upon the size of standards. In Practice D 1729, panels 90 by 165 mm (3½ × 6½ in.) are preferred for critical visual evaluation of color and geometric appearance differences.

9. Storage of Product Standards

9.1 All physical product standards for color should be stored so as to minimize drift in color or geometric aspects. Individual opaque paper envelopes of neutral pH and the approximate size of the panel should be used.

9.2 These standards should be handled by the edges and exposed to light and the environment only when being used for product evaluation.

9.3 Low temperature storage[6] or freezing of these standards has been recommended to minimize color change with time. When a standard is to be frozen, it should first be placed in a paper envelope and then in a sealable plastic bag. The plastic bag will protect the panel from condensation. It also may protect the standard from fumes. The standard should be kept at a temperature of − 18°C (0°F) or lower. When the bagged standard is removed from the freezer, it should be allowed to come to room temperature before being opened.

[6] Huey, S. J., "Low Temperature Storage of Color Standard Panels," *Color Engineering*, Vol 3, No. 5, Sept–Oct 1965, pp. 24–27.

10. Maintenance of Product Standards

10.1 Use of a well maintained, carefully monitored color measuring instrument is the best way to determine whether the color of a product standard has changed.

10.2 Working standards should be replaced when they become dirty, damaged, or reach the expiration date. They should be compared frequently and regularly to a duplicate master standard to ensure that the color and geometric aspects of appearance have not changed. When a change larger than the tolerance is found, the standard should be replaced.

10.3 Duplicate master standards should be replaced if they become dirty or damaged. They should be compared infrequently but regularly to the master standard to ensure that the color and geometric aspects of appearance have not changed. When a change larger than the tolerance is found, the standards should be replaced.

10.4 A master standard should be replaced if it becomes dirty or damaged. The buyer and the seller should always notify each other when a new master standard is produced and both parties should change to new master standards.

10.5 Determining drift in color or geometric aspects of a master standard is difficult because there is no higher level standard for comparison. A carefully maintained instrument of proven long term stability should be used to evaluate possible color change of a master standard. Measurements should be made as to when the master standard was originally calibrated. If the master standard is no longer acceptable because of measured color change, a new hierarchy of product standards should be generated. Upon agreement between buyer and seller the old master standard could serve as a new concept color. Otherwise a new hierarchy should be generated instrumentally by producing new standards whose measurements reproduce those of the original within acceptable tolerances.

11. Use of Product Standards

11.1 Only a working product standard should be used for making color and appearance judgments.

11.2 Product tolerances should be generated in accordance with Practice D 3134 or its equivalent.

11.3 A test panel should be prepared from the coating material in accordance with Practices D 823.

11.4 The batch should be compared visually to the working standard as described in Practices D 1729, D 4086 and Test Method D 4449.

11.5 Instrumental measurements should be made in accordance with Test Methods and Practices D 523, D 2244, E 308, E 805, E 1164, E 1345, and with one of the following Test Methods: E 430, E 1331, E 1347, E 1349.

11.6 Conformance to the tolerances should be reported in accordance with Practice D 3134 or its equivalent.

12. Keywords

12.1 color; color measurements; physical standards; product standard