



Designation: D8163 – 18 (Reapproved 2023)

Standard Test Method for Determination of Strength of Colorants and Bases for Architectural, Marine, Maintenance, Commercial, and Industrial Coatings¹

This standard is issued under the fixed designation D8163; 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 test method covers the determination of strength of colorant dispersions, colored and white bases, for architectural, marine, maintenance, commercial, and industrial coatings.

1.2 This test method applies to colorant dispersions and colored and white bases regardless of the methods used to disperse these materials.

1.3 The resultant test value is in terms of percent strength in which a material stronger than standard is implied by values larger than 100 % and weaker than standard is implied by values less than 100 %. The value of 100 % implies exact strength conformance to the test method.

1.4 This test method is suitable for the determination of strength when tolerances are set about standards that are prepared either by weight concentration or volume concentration.

1.5 The test result is empirically determined. The user determines and supplies the standard for strength of the product under test and the test result is relative to that supplied standard.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.7 *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.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization 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

D823 Practices for Producing Films of Uniform Thickness of Paint, Coatings and Related Products on Test Panels

D1475 Test Method for Density of Liquid Coatings, Inks, and Related Products

D3964 Practice for Selection of Coating Specimens for Appearance Measurements

E284 Terminology of Appearance

E308 Practice for Computing the Colors of Objects by Using the CIE System

E1164 Practice for Obtaining Spectrometric Data for Object-Color Evaluation

E1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry

E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry

3. Terminology

3.1 *Definitions:* Terms and definitions in Terminology E284 are applicable to this test method.

3.1.1 *reflection factor, n*—in strength of colorant or base, a value representative of the fraction of incident radiant energy that is reflected from a surface under conditions specified.

3.1.2 *strength, n*—of a colorant or base, a value that is quantitatively related to the effective concentration of a test colorant or test base relative to the effective concentration of the standard or reference for that colorant or base.

¹ This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.26 on Optical Properties.

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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.

4. Summary of Test Method

4.1 The user supplies a standard base and a standard colorant. A standard sample is prepared from these ingredients by a predetermined formula that will achieve a target reflectance. A test sample is made using the same formula by mixing the material being tested with the appropriate standard material depending upon whether the material under test is a colorant or a base.

4.2 The standard sample and the test sample are drawn down side by side on a black-and-white test chart.

4.3 The drawdown is dried by appropriate means, and the spectral reflectance factor of each standard and sample are measured on a spectrophotometer.

4.4 A value is selected, or calculated, from among the spectrophotometric reflection functions to represent the relative reflection factors of each of the two specimens.

4.5 These two values are converted by calculation to optical parameters, K -over- S , where K is the Kubelka-Munk absorption coefficient and S the Kubelka-Munk scattering coefficient. These values are appropriately put in ratio with each other and multiplied by 100 to achieve the test value, relative strength in percent of the standard value. The ratio assumes that the optical parameters are directly, linearly proportional to the relative concentration of the dispersed media in the range of concentration used in the test.

5. Significance and Use

5.1 The test method results are suitable for use by manufacturers of colorants and bases for quality control purposes on manufactured product.

5.2 The test method results are suitable for use by purchasers of colorants and bases for incoming quality control or the determination of money value of colorants and bases.

6. Interferences

6.1 Differences between the standard and the test materials in the following properties may be interpreted by the test method as a strength difference and thus comprise an interference with the test: color difference between the standard specimen and the test specimen in the hue or chroma directions, gloss difference, metamerism, measurement geometry differences, hiding differences, and flocculation differences.

6.2 The presence of any one or more of these interferences could invalidate the test results.

7. Apparatus

7.1 *Electronic Scale*, with readability of at least 0.001 g and resolution of at least 0.01 g.

7.2 Weight per gallon cup if strength is assessed by volume.

7.3 Black-and-white sealed drawdown charts.

7.4 *Drawdown Bars*, capable of applying a coating typically 15.25 cm [6 in.] wide. The applicators shall be capable of applying 200 μm and 300 μm [8 mils and 12 mils] wet film or other wet film thickness as appropriate. Bird type bars are

usually marked with values that are half these dimensions and so would be marked 100 μm and 150 μm [4 mils and 6 mils], respectively. Under some circumstances, drawdown bars with other clearances may be appropriately used.

7.5 *Apparatus* to hold the drawdown chart in place while the drawdown is made and this may consist of a glass plate or a vacuum plate to hold the drawdown flat on a smooth and level surface.

7.6 *Color Measuring Instrument*: a colorimetric spectrophotometer meeting the requirements of Practice E1164 having a spectral range of at least 400 nm to 700 nm at 10 nm intervals and having a measuring port ideally 25 mm in size, and measuring Total:Normal (di:0), sometimes called SPIN or SIN. Alternatively, but less desirably, one may utilize a smaller measuring aperture and measuring geometry Diffuse:Normal (de:0), 45°:Normal (45:0) or (0:45).

8. Reagents and Materials

8.1 Users are responsible for providing standard strength white base and standard strength colorants for each colorant or base put under test. These materials will have to be replaced when they are depleted, and special care shall be taken that the replacement materials have exact continuity of strength with the materials they are replacing.

9. Calibration and Standardization

9.1 Verify the calibration of the weight per gallon cup at least once each month in accordance with the instructions for doing so in accordance with Test Method D1475.

9.2 Verify the calibration of the spectrophotometer at least once each month in accordance with Practice E1164 in which this process is called standardization and verification.

10. Conditioning

10.1 Assure that all materials have been shaken on a paint shaker for at least 2 min on the day on which they will be used.

10.2 The viscosity ranges of most materials within the scope of this test method are such that the vigorous shaking necessary to homogenization of the materials causes air to be entrapped in the liquid. As part of the sample conditioning, users shall employ at least one of the three methods given in Test Method D1475 for the removal of air from the sample. The methods are centrifugation, vacuum deaeration, and reduction of viscosity with solvent, including water if applicable. Only the sample under current consideration need be deaerated, not the entire stored standard material.

11. Procedure

METHOD A

11.1 *Colorant Test Method*:

11.1.1 Prepare a wet standard by blending an amount of standard white base and standard colorant to achieve a reflectance at the wavelength of maximum absorption of between 35 % and 50 % reflectance with 40 % reflectance considered ideal. Prepare this sample by weight even though the strength value sought may be by volume.

11.1.2 Prepare a wet sample by blending the identical weight of standard white base as is contained in the wet standard and an identical weight of test colorant as is contained in the wet standard if the test colorant is to be assessed by weight, otherwise an identical volume as contained in the wet standard.

11.1.3 The standard white base used in both samples shall be of the same lot and from the same deaerated subsample of standard white base.

11.1.4 Drawdown the two wet samples side by side on a black-and-white sealed drawdown card in accordance with Practices D823 Method C for motor-driven blade or Method E for hand-held blade. Use a drawdown bar that will achieve a film thick enough to be opaque when dry. This is usually considered to be met by a contrast ratio of 0.98 or more. Place the test sample on the left half of the card and the standard sample on the right.

11.1.5 Rub up both samples immediately after the drawdown by rubbing a small circle in the wet paint several times with light pressure from a finger to assess for differences in flocculation. Perform this rub up over the black portion of the card. Inspect the drawdown for differences in color as a result of flocculation in either sample. Any visual differences in these properties shall cause a termination of the test at this juncture in the test process.

11.1.6 Dry the specimen card by air dry overnight, force drying in a low (approximately 25 °C (77 °F) oven with moving air), or in a microwave oven.

11.1.7 Inspect the drawdown for differences in color in the hue difference direction, metamerism, or gloss. Any visual differences in these properties shall cause a termination of the test at this juncture in the test process.

11.1.8 Select a representative area of the standard specimen over the white portion of the card and the test specimen over the white portion of the card to be measured. Such selection shall be in accordance with Practice D3964.

11.1.9 Measure the reflectance factor of both the standard and the test specimens in accordance with Test Method E1331 if hemispherical illumination is used or Test Method E1349 if bidirectional instrumentation (0:45) is used.

11.1.10 Select a value to be used as the reflection factor in the calculations from the list of possibilities in Table 1. If a tristimulus value is chosen, it shall be the minimum value from among X, Y, and Z. Further, if a tristimulus value is chosen, select an illuminant-observer weight set for tristimulus integration from Practice E308. Perform the tristimulus integration in accordance with Practice E308. Scale the reflection factor to be in the range zero to unity. Perform the strength calculations in accordance with Section 12.

METHOD B

11.2 *Base Test Method:*

11.2.1 Prepare a wet standard by blending an amount of standard white base and standard colorant to achieve a reflectance of between 35 % and 50 % reflectance factor with 40 % reflectance factor considered ideal. Prepare this sample by weight even though the strength value sought is by volume.

11.2.2 The standard colorant used in both samples shall be of the same lot and from the same deaerated subsample of standard colorant.

11.2.3 Prepare a wet sample by blending the identical weight of test white base, if the test result is to be assessed by weight; otherwise, an identical volume, as is contained in the wet standard and an identical weight; otherwise, an identical volume of standard colorant as is contained in the wet standard. The standard colorant used in both samples shall be taken from the same lot and the same deaerated subsample of standard colorant.

11.2.4 Follow the procedure of 11.1.4 – 11.1.10 as the balance of the test method procedure is identical for test base to that of the test colorant.

METHOD C

11.3 *White Colorant Method:*

11.3.1 Prepare a wet standard by blending an amount of standard white colorant and standard black colorant to achieve a reflectance in neutral base of between 35 and 50 % reflectance factor with 40 % reflectance factor considered ideal. Prepare this sample at an appropriate level of total colorant concentration to achieve hiding in the neutral base. Prepare this sample by weight even though the strength value sought is by volume.

11.3.2 Prepare a wet sample by blending the identical weight of neutral base, test white colorant, and standard black colorant, if the test result is to be assessed by weight, otherwise, an identical volume as is contained in the wet standard. The standard colorant and neutral base used in both samples shall be of the same lot and from the same deaerated subsample of standard colorant and neutral base.

11.3.3 Follow the procedure of 11.1.3 – 11.1.10 as the balance of the test method procedure is identical for test white colorant to that of the test colorant.

12. Calculation

12.1 Using the selected or calculated value of the reflection factors of the standard sample and the test sample, calculate the following values for each specimen:

$$P = \frac{(1 - p)^2}{2p} \tag{1}$$

where:

P = reflection factor of the standard or test specimen in the numeric range of zero to unity.

12.2 Then, for colorant strength, ratio the results as follows:

$$S_c = \frac{100P_{test}}{P_{std}} \tag{2}$$

and, for base strength:

TABLE 1 List of Allowable Values to be Chosen for Reflection Factor

Value of Reflection Factor	Priority
CIE tristimulus value X	1
CIE tristimulus value Y	1
CIE tristimulus value Z	1
Reflection factor at wavelength of maximum absorption	4
Reflection factor at commonly agreed wavelength	5
Area under the <i>K-over-S</i> curve	6

$$S_b = \frac{100P_{std}}{P_{test}} \quad (3)$$

13. Report

13.1 Report the following values:

13.1.1 Description of the material under test, including the product identification and the lot number;

13.1.2 The date of the test;

13.1.3 The name of the appraiser of the test;

13.1.4 The calculated strength value obtained by the test and the parameter used for assessing the strength test;

13.1.5 The make, model, and serial number of the spectrophotometric instrument used in the test as well as the instrument setup conditions, including the specular port setting and the aperture size; and

13.1.6 The wet film thickness designation of the drawdown bar used to make the drawdown.

14. Precision and Bias

14.1 *Precision*—A robustness test has been carried out by Subcommittee D01.26. In this test of the strength of a colorant

in a white base, three samples were prepared and one specimen drawdown was prepared from each sample. After the spectrophotometric measurements, the analysis was carried out using a minimum of four different analyses allowed by the choice, in the standard, of reflection function. The standard deviation of all results was 0.35 % strength. That places the 95 % confidence limit at 0.7 % strength and means that two results, obtained by identical procedures under reproducibility conditions, are to be held suspect if they should differ by more than 1 % strength.

14.2 A complete interlaboratory study of this test method is being conducted and a complete precision statement is expected to be available on or before January 2019.

14.3 *Bias*—There can be no bias in the test result because the test method is empirical.

15. Keywords

15.1 strength of base; strength of color; strength of colorant; tint strength

APPENDIX

(Nonmandatory Information)

X1. INTERPRETATION OF THE TEST METHOD AND RATIONALE USED IN ITS DEVELOPMENT

X1.1 Interpretation of the Test Method

X1.1.1 In 8.1, the user is required to supply standard materials in support of the test method. It is advisable to select an amount of these standard materials that will support a year’s worth of anticipated tests, unless this amount is more than is reasonable and feasible to store.

X1.1.2 In 10.2, at least one method of deaeration is required to be used on all prepared samples. This source of uncertainty is most important to constrain when it becomes necessary to make a weight-per-gallon assessment, as may happen when a conversion between volume formula and weight formula is necessary. It may be prudent in the interest of accuracy to use two methods of deaeration in this circumstance.

X1.1.3 In X1.1.1, the user is asked to estimate a concentration of colorant in the standard white base that will achieve a reflection factor of 40 %. Users of this test method are likely to be engaged in computer color matching of their color catalog and are thus likely to have prior knowledge of the Kubelka-Munk K s and S s of the standard materials being used in this test method. Select a wavelength nearest the largest values of K for the colorant. Gather the K s and S s of both standard colorant and standard base at this wavelength, and apply the following equation:

$$C_c = \frac{K_w - \left(\frac{K}{S}\right)_{mix} S_w}{\left(\frac{K}{S}\right)_{mix} S_c - \left(\frac{K}{S}\right)_{mix} S_w + K_w - K_c} \quad (X1.1)$$

where:

C_c = concentration, on a scale of zero to unity, of the colorant in the white, and the white concentration is $1 - C_c$.

X1.1.4 The K -over- S of the mix is chosen from Table X1.1 and K_w and K_c are the Kubelka-Munk absorption constants of the white and colorant, respectively, and S_w and S_c the scattering constants of the white and colorant. Table X1.1 provides those values of K -over- S of the mix at 40 % reflectance for the values of K1 and K2 listed in the left-hand columns. K1 and K2 are the first-surface reflectance and the internal reflectance from the underside of the specimen, respectively. These values are used in the Saunderson correction, if applied.

TABLE X1.1 Selection of K/S_{mix} Value Given Certain Values of K1 and K2

K1	K2	K/S_{mix}
No correction applied		0.4500
0.00	0.00	0.4500
0.00	0.40	0.2132
0.00	0.45	0.1865
0.00	0.60	0.1125
0.02	0.40	0.2304
0.02	0.45	0.2018
0.02	0.60	0.1222
0.03	0.40	0.2399
0.03	0.45	0.2102
0.03	0.60	0.1276
0.04	0.40	0.2500
0.04	0.45	0.2190
0.04	0.60	0.1333