Designation: D4838 – 88 (Reapproved 2016)

Standard Test Method for Determining the Relative Tinting Strength of Chromatic Paints[1]

This standard is issued under the fixed designation D4838; 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 describes the determination of the absorption tinting strength of a chromatic test paint relative to that of a standard or reference paint of the same chemical type. The procedures are based on dilution of the paints with a standard mixing white paint, followed by instrumental measurement and calculation. Provision is made for correcting the results for small differences in hue or chroma, or both, between the test and reference chromatic paints.

1.2 This test method is intended for the comparison of paints containing the same type of vehicle (acrylic, alkyd, or oil) and single-pigment colorants of the same Colour Index[2] name and number. The amounts of the pigment and of the other components of the paint need not be known.

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:*[3]

D1640 Test Methods for Drying, Curing, or Film Formation of Organic Coatings

D4303 Test Methods for Lightfastness of Colorants Used in Artists' Materials

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

3. Terminology

3.1 *Definitions:*

3.1.1 *tinting strength, n*—measure of the effectiveness with which a unit quantity of a colorant alters the color of a material. For scattering and absorbing colorants (pigments), both absorption and scattering tinting strength must be specified.

3.1.2 *tinting strength, absorption, n*—relative change in the absorption properties of a standard white material when a specified amount of an absorbing pigment, black or chromatic, is added to it.

3.1.2.1 *Discussion*—This is the common definition of tinting strength; however, this definition of the term can be misleading. For example, the tinting strength of a yellow colorant depends on its scattering as well as its absorption. Its tinting strength as determined from a mixture with white provides no information about its behavior when mixed with low-scattering colorants, such as a black.

3.1.3 *tinting strength, scattering, n*—relative change in the scattering properties of a standard black material (with no white pigment present) when a specified amount of a white or chromatic scattering pigment is added to it.

3.1.4 For other definitions, see Terminology E284.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *drawdown, n*—a layer of paint deposited on a substrate by use of a drawdown bar to evaluate the characteristics of the paint.

3.2.2 *drawdown bar, n*—a bar designed to deposit a specified thickness of wet paint film uniformly on a specified test panel or other substrate.

4. Summary of Test Method

4.1 Chromatic paints are diluted with white paint to obtain mixtures that will produce a drawdown having 35 to 45 % reflectance factor at the wavelength of maximum absorption.

[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 D01.57 on Artist Paints and Related Materials.

Current edition approved July 1, 2016. Published July 2016. Originally approved in 1988. Last previous edition approved in 2010 as D4838 – 88 (2010). DOI: 10.1520/D4838-88R16.

[2] *Colour Index*, The Society of Dyers and Colourists, London, 1987. Available from the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

[3] 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.

4.2 Drawdowns of these mixture paints are produced at complete hiding.

4.3 The drawdowns are measured to obtain tristimulus filter readings *R, G, B* either directly or by computation from CIE tristimulus values *X, Y, Z*.

4.4 One of the samples is designated the standard, and the percents of tinting strength, *% TS*, of the others are calculated relative to that of the standard. Provision is made for correcting this tinting strength for small differences in hue, chroma, or both, between the standard and the test specimen, and for obtaining an average tinting strength and a range.

5. Significance and Use

5.1 Tinting strength may be one factor in judging the relative economic value of paints, since pigment concentration contributes to strength in a major way; other factors are formulation and color development in grinding. The user may also select products for other properties, such as transparency, that are accompanied by different tinting strengths. The results of this test method may be used for production control or quality comparisons.

5.2 The product with the greatest or the least tinting strength may not be the most desirable for a given artistic use. For example, low tinting strength may lead to the need to use an excessively high pigment concentration to obtain a desired color effect, and this may lead to defects in the dry paint film.

5.3 This test method applies only to single-pigment paints. The tinting strength of paints that contain two or more chromatic pigments with different optical properties cannot be evaluated by this test method.

5.4 The term “similar chemical type” used in 1.1 does not limit the ingredients in the paints to identity, but refers to compatibility in the case of vehicles and to similarity in the case of pigment types.

5.5 While the instrumental evaluation of tinting strength is described, visual comparisons can also be used, with lower precision, and should be made to provide confirmation of the instrumental and computational results.

5.6 If the sample and standard are widely different in appearance when prepared at the same ratio of chromatic to white paint, another sample should be prepared to bring the two closer in appearance, to obtain the most accurate results.

5.7 The quantities of chromatic and white paints mixed must be accurately known, on either a weight or a volume basis, but the concentration of pigment in the chromatic paint need not be known.

5.8 When the paints being compared have the same vehicle and pigment (same Colour Index name and number) the values of uncorrected tinting strength from 9.1 and corrected tinting strength from 9.2 should be nearly the same. If they are not, an average of the two tinting strengths is recommended as the best estimate of the true value, and a range provides a measure of the magnitude of the uncertainty, which is due to differences in hue or chroma, or both, between the paints.

5.9 Strictly speaking, the Kubelka-Munk-type analysis of this test method should not be applied to the tristimulus filter readings used, but only to spectral data. For the purposes of the relative comparisons of this test method, however, the errors introduced by the calculations used cancel to an adequate degree.

6. Apparatus and Materials

6.1 *Laboratory Balance,* top-loading, having a sensitivity of 0.01 g.

6.2 *Drawdown bars,* capable of producing smooth paint films with wet-film thicknesses between 0.075 and 0.25 mm (0.003 and 0.010 in.).

6.3 *Opacity charts,* sealed-paper type with black and white areas.

6.4 *Color-Measuring Instrument,* either a spectrophotometer providing 1931 CIE tristimulus values *X, Y, Z* for CIE standard illuminant *C*, or a tristimulus colorimeter providing either such tristimulus values or colorimeter readings *R, G, B*.

6.5 *Mixing White Paint,* prepared as described in the Specimen Preparation, Mixing Whites for Dilution of Colors section of Test Methods D4303. Alternatively, a commercial titanium-dioxide white artists’ paint may be used. The mixing white paint must be made with the same vehicle type (acrylic, alkyd, or oil) as the paints to be tested.

7. Specimen Preparation

7.1 Obtain representative samples of the chromatic paints to be tested. For tube paints, expel the entire contents of the tube and mix thoroughly before sampling.

7.2 Determine the approximate amount of chromatic paint to be added to 20 g of mixing white paint to obtain a drawdown with 35 to 45 % reflectance factor at the wavelength of maximum absorption. If the amount of chromatic paint is not known in advance, consult the table in Appendix X1. For pigments other than those listed, use as the general guideline the addition of 5 g of chromatic paint containing an inorganic pigment or 1 g of chromatic paint containing an organic pigment to the 20 g of mixing white paint.

NOTE 1—Appendix X1 of Test Methods D4303 describes a method for computing the necessary adjustments in quantities required if additional trials are needed to obtain the desired level of reflectance factor.

7.3 Weigh out the chromatic and mixing white paints to the nearest 0.01 g, and mix thoroughly.

7.4 Prepare drawdowns by placing the paint mixture at one end of an opacity chart and pulling the drawdown bar smoothly through the paint and across the chart. Paste paints should be spread with a spatula or palette knife over the entire chart area to be covered before pulling the bar down the chart.

7.5 Allow the drawdowns to reach the dry-to-touch time as described in the Procedure section of Test Methods D1640. Acrylic paints should dry in air overnight. Alkyd paints may require 5 days to dry. Oil paints may require 2 months to dry.

7.6 Determine whether each drawdown is at complete hiding by measuring the portions of it over the black and over

the white areas of the chart to determine tristimulus value Y or colorimeter reading G. If the quotient Y_B/Y_W or G_B/G_W, where the subscripts refer to measurements over black and white, respectively, is greater than 0.98, the drawdown can be considered at complete hiding. If the drawdown is not at complete hiding, prepare a thicker drawdown or a drawdown made with multiple coats of paint, one over another.

NOTE 2—At the required dilution with white, a drawdown bar with an aperture of 0.15 mm (0.006 in.) will usually make a drawdown at complete hiding. In the cases of some acrylic paints and a few oil paints it may be necessary to increase the aperture to 0.25 mm (0.010 in.) to obtain complete hiding. If this leads to a slow-drying film or a film that is wrinkled when dry, multiple coats can be applied by depositing a second 0.15 mm (0.006 in.) coat, drawing down at a right angle to the first coat. After this coat dries, a third coat can be applied if necessary by using a shorter bar that rides over the previous coats.

8. Procedure

8.1 Obtain values of *R, G, B* for each sample by either of the two following procedures.

8.1.1 Measure the drawdown with a spectrophotometer or a tristimulus colorimeter to determine 1931 CIE tristimulus values *X, Y, Z* for CIE standard illuminant *C*. Follow Practice E1164 and Practice E308. If hemispherical (integrating-sphere) geometry is used, measure with the specular component excluded.

8.1.2 If a colorimeter that is direct reading in *R, G, B* is used, measure these quantities.

8.2 If *X, Y, Z* are measured, calculate *R, G, B* by use of the following equations:

$$R = (X/0.98 - 0.2Z/1.18)/0.8 \quad (1)$$

$$G = Y \quad (2)$$

$$B = Z/1.18 \quad (3)$$

NOTE 3—The use of the 1931 CIE system (and standard observer) and standard illuminant *C* is specified because all known tristimulus colorimeters that are direct reading in *R, G, B* measure for these conditions. If values of *X, Y, Z* are obtained by spectrophotometry, the 1964 CIE system and other CIE standard illuminants may be used. Eq 1-3 are specific to the conditions, and must be replaced by the appropriate equations if other conditions are specified.[4] The article referenced also discusses correcting the measured values for surface reflections.

9. Calculation

9.1 Calculate uncorrected relative tinting strength, % TS_{UC} as follows:

9.1.1 Using decimal-fraction values of *R, G, B*, calculate Kubelka-Munk-type ratios of absorption coefficient, *K*, to scattering coefficient, *S*:

$$(K/S)_R = (1 - R)^2/2R \quad (4)$$

$$(K/S)_G = (1 - G)^2/2G \quad (5)$$

$$(K/S)_B = (1 - B)^2/2B \quad (6)$$

9.1.2 Calculate the pigment concentration term C_P:

$$C_P = Q_c/(Q_c + Q_w) \quad (7)$$

where:

Q_c = quantity of chromatic paint, g,
Q_w = quantity of white paint, g.

NOTE 4—If it is desirable to use volume rather than weight as the basis for comparison of tinting strengths, determine the densities of the paints and compute the volumes of the weighed samples. Calculate C_P by use of Eq 7 using volumes instead of weights.

9.1.3 Calculate normalized values of (*K/S*), denoted *N*, as follows:

$$N_R = (K/S)_R/C_P \quad (8)$$

$$N_G = (K/S)_G/C_P \quad (9)$$

$$N_B = (K/S)_B/C_P \quad (10)$$

9.1.4 Select one of the specimens to be denoted the standard and assigned the value of 100 % tinting strength. The tinting strength of the remaining specimens will be determined relative to that of the standard.

9.1.5 Select the value of *N* to be used in the calculation of % TS_{UC} by one of the following three methods:

9.1.5.1 Select *N* based on the visually determined color of the specimen: For blue and green specimens, select N_R; for purple and red specimens, select N_G; and for yellow and orange specimens, select N_B. Relabel the selected value $N1_{SPEC}$ and N_{STD} for the specimens and the standard, respectively. Relabel the remaining two values of *N* as $N2_{SPEC}$ and $N3_{SPEC}$ for the specimens and $N2_{STD}$ and $N3_{STD}$ for the standard.

9.1.5.2 If the specimen color cannot be classified accurately in 9.1.5.1, select the lowest value of *N* as *N*1. The same selection must be made for the standard and all specimens to be compared. Relabel the values of *N* as in 9.1.5.1.

9.1.5.3 If the values of N_R and N_B for the specimen are both low and approximately equal, follow the procedure in Annex A1 to select *N* and calculate the tinting strength.

9.1.6 Calculate % TS_{UC} as follows:

$$\%\ TS_{UC} = 100\,(N1_{SPEC}/N1_{STD}) \quad (11)$$

9.2 Calculate tinting strength corrected for differences in hue and chroma, % TS_C, by use of the following equations:

$$d_{SPEC} = N2_{SPEC} + N3_{SPEC} \quad (12)$$

$$d_{STD} = N2_{STD} + N3_{STD} \quad (13)$$

$$D = (d_{SPEC} - d_{STD})/2 \quad (14)$$

$$\%\ TS_C = 100\,(N1_{SPEC} - D)/N1_{STD} \quad (15)$$

9.3 Calculate average tinting strength, % TS_{AV}, and range *E* as follows:

$$\%\ TS_{AV} = (\%\ TS_{UC} + \%\ TS_C)/2 \quad (16)$$

$$E = \pm(\%\ TS_{UC} - \%\ TS_C)/2 \quad (17)$$

10. Report

10.1 Report the following information:

10.1.1 Complete identification of the specimens, including brand and color name, date of manufacture, and lot number if available.

10.1.2 Name of color-measuring instrument used, method of standardization, and other information required in the Report section of Practice E1164 and Practice E308.

10.1.3 Date of test.

[4] Johnston-Feller, R. M., and Bailie, C. W., "Determination of the Tinting Strength of Chromatic Pigments," *Journal of Coatings Technology*, Vol 54, No. 692, 1982, pp. 43–56.

10.1.4 Test results for % TS_{UC}, % TS_C, or % TS_{AV}, and range.

11. Precision and Bias[5]

11.1 Based on interlaboratory intercomparisons, the results of this test method agree to within ±6 % on an absolute basis.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1057. Contact ASTM Customer Service at service@astm.org.

12. Keywords

12.1 artists' paints; chromate coatings; tinting strength

ANNEX

(Mandatory Information)

A1. PROCEDURE for PIGMENTS WITH TWO SEPARATED ABSORPTION MAXIMA

A1.1 The tinting strength of pigments, such as chromium oxide green, for which both N_R and N_B are low and approximately equal, must be calculated by the following equations:

$$\text{NUM} = (N_{\text{R.SPEC}} + N_{\text{B.SPEC}})/2 \quad \text{(A1.1)}$$

$$\text{DENOM} = (N_{\text{R.STD}} + N_{\text{B.STD}})/2 \quad \text{(A1.2)}$$

$$D = (N_{\text{G.SPEC}} + N_{\text{G.STD}})/2 \quad \text{(A1.3)}$$

$$\%\ TS_{\text{UC}} = 100\ \text{NUM/DENOM} \quad \text{(A1.4)}$$

$$\%\ TS_{\text{C}} = (\text{NUM} - D)/\text{DENOM} \quad \text{(A1.5)}$$

APPENDIX

(Nonmandatory Information)

X1. TABLE ILLUSTRATING WEIGHT of ACRYLIC PAINT to MIX WITH 20-g of MIXING WHITE PAIN

TABLE X1.1 Approximate Weight of Acrylic Paint to Mix With 20-g of Mixing White Paint

Pigment Name	Colour Index Name	Chromatic Paint, g
Alizarin crimson	PR 83	2.5
Azo yellow medium	PY 74	2.5
Burnt umber	PBr 7	3.0
Cadmium-barium orange	PO 20:1	2.5
Cadmium-barium red medium	PR 108:1	4.0
Cadmium-barium yellow light	PY 35:1	4.0
Cadmium-barium yellow medium	PY 37:1	3.3
Cerulean blue Co-Cr	PB 36	9.0
Cerulean blue Co-Sn	PB 35	10.0
Chromium oxide green	PG 17	4.0
Cobalt blue	PB 28	5.0
Dioxazine purple	PV 23 RS	1.0
Hansa yellow light	PY 3	3.0
Naphthol AS-OL red	PR 9	2.5
Naphthol red light AS-D	PR 14	2.0
Phthalocyanine blue	PB 15	0.4
Phthalocyanine green	PG 7, PG 36	0.5
Raw sienna	PBr 7	4.0
Raw umber	PBr 7	6.0
Red oxide	PR 101	1.0
Ultramarine blue	PB 29	4.0
Yellow oxide	PY 42	4.0

X1.1 Table X1.1 shows the approximate weight of acrylic paint to mix with 20-g of mixing white paint.