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Standard Test Methods for
Measuring the Hiding Power of Powder Coatings[1]

This standard is issued under the fixed designation D6441; 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 These test methods determine and report the hiding power of a powder coating with respect to two parameters:

1.1.1 *Test Method A*—Contrast Ratio at a given film thickness

1.1.2 *Test Method B*—Film thickness at 0.98 (98 %) contrast ratio.

NOTE 1—The measured parameters follow powder coating industry practice by measuring hiding power in relation to film thickness, rather than the "Spreading Rate" function employed in Test Methods D344 and D2805 and other hiding power test methods.

NOTE 2—Hiding power is photometrically defined as the spreading rate at 0.98 contrast ratio. See definitions of spreading rate and hiding power in Terminology D16, D2805, and the *Paint and Coatings Testing Manual*.

NOTE 3—The contrast ratio 0.98 is conventionally accepted in the coatings industry as representing "complete" hiding for reflectometric hiding power measurements. But visually, as well as photometrically, it is slightly less than complete.

1.2 These test methods cover the determination of the hiding power of powder coatings applied by electrostatic spraying.

1.3 These test methods determine hiding power by means of reflectometric and thickness gage measurements. They are limited to coatings having a minimum CIE-Y reflectance of 15 %.

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

1.5 *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 to determine in advance the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D16 Terminology for Paint, Related Coatings, Materials, and Applications

D344 Test Method for Relative Hiding Power of Paints by the Visual Evaluation of Brushouts

D2805 Test Method for Hiding Power of Paints by Reflectometry

D3451 Guide for Testing Coating Powders and Powder Coatings

E284 Terminology of Appearance

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

E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry

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

2.2 *Other Standard:*

1-GP-71 Method 14.7, Hiding Power, Contrast Ratio Method, October 1982[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *reflectance, n*—term of wide applicability, referring herein to the *luminous reflectance factor* as defined in Terminology E284, and equivalent to the CIE Tristimulus value Y measured in accordance with Test Methods E1331, E1347 or Test Method E1349 with specular reflection excluded. It is expressed as a percentage in this standard.

3.1.2 *white substrate, n*—For purposes of this test, a substrate of neutral shade with a minimum reflectance of 78 %.

3.1.3 *black substrate, n*—A substrate with a maximum reflectance of 1 %, which is effectively zero for the purpose of measuring hiding power.

3.1.4 *white reflectance (R_W), n*—Reflectance of the applied test film over a white substrate of reflectance *W*.

3.1.5 *black reflectance (R_o), n*—Reflectance of the applied test film over a black substrate.

3.1.6 *reflectivity (R_∞), n*—The reflectance of a coating applied thickly enough to be completely opaque, as evidenced by equal reflectance over the black and a white test substrate.

3.1.7 *contrast ratio (C_W), n*—(*1*) The ratio of the reflectance of a film applied on a black substrate to a film of equal thickness applied on a white substrate. (*2*) An instrumental measure of film opacity.

3.1.7.1 *Discussion*—Contrast ratio can be expressed as a decimal fraction (R_O/R_W) or as a percentage ($100R_O/R_W$), the latter being preferred for the general concept of hiding or opacity, and employed in these test methods.

3.1.8 *opacity, n*—The degree to which a coating film hides a black and white substrate, as perceived visually or as measured instrumentally, (see *contrast ratio* defined in 3.1.7).

3.1.9 *wedge of coating, n*—A film of coating having a range of film thickness giving a corresponding range of opacities on a black and white substrate. (see Fig. 1).

3.2 *Definitions of Symbols Used in Calculations Specific to This Standard*:

3.2.1 *T, n*—the specified or measured thickness of the test coating on the substrate.

3.2.2 *t_o, n*—the amount by which the black substrate exceeds the white substrate in thickness.

3.2.3 *T', n*—$T + t_o$; the thickness reading corresponding to *T* over the black substrate when measured with the gage calibrated to the white substrate as zero.

3.3 For additional definitions applicable to these test methods see Terminology E284.
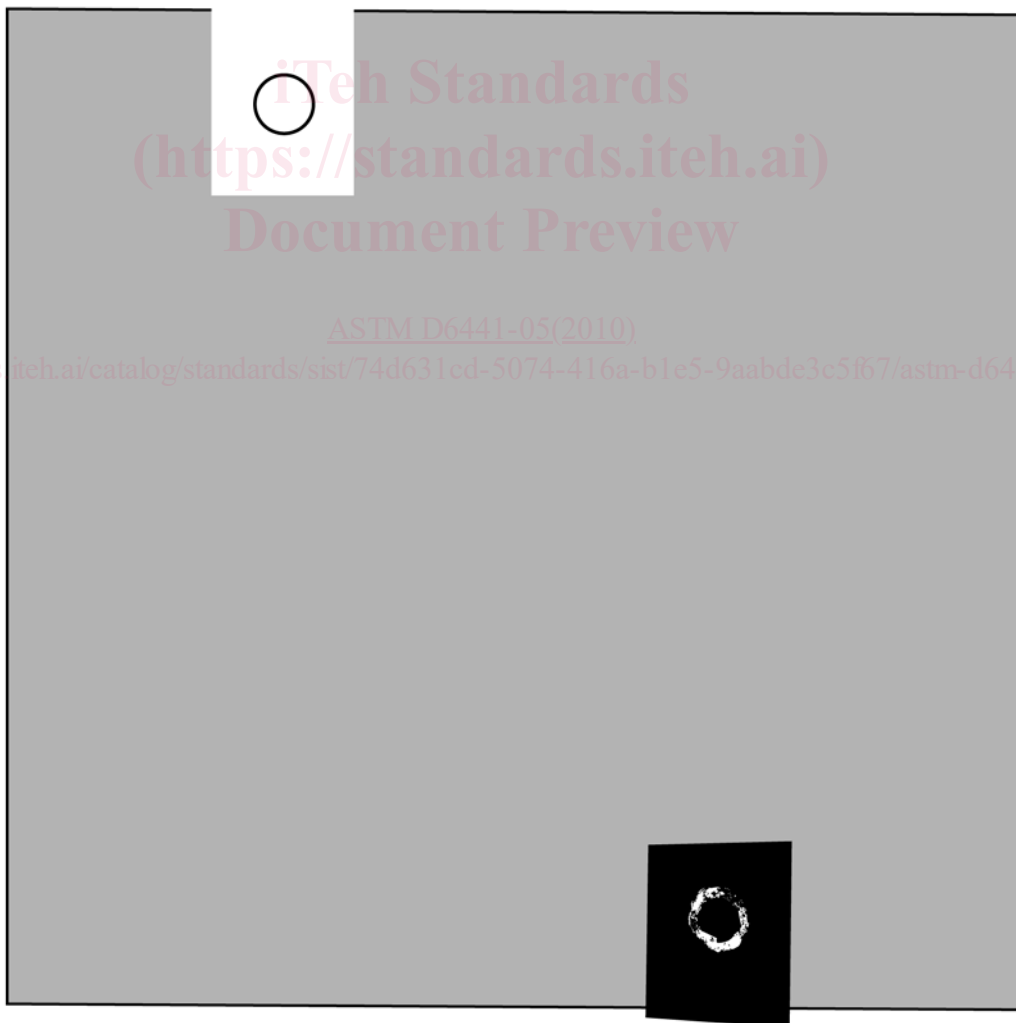
NOTE 1—Shows black and white substrate areas exposed after removal of masking tape.

FIG. 1 "Wedge" Film Application

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FIG. 2 Examples of Commercially Available Test Panels

3 × 5-3/16 in.   5-3/16 × 11 in.

4. Summary of Test Method

4.1 *Test Method A—Contrast Ratio (C_W) at a Specified Film Thickness:*

4.1.1 The coating is applied as a "wedge" on a specified test panel.

4.1.2 Several pairs of points are encircled over the black and white substrate at the specified coating thickness, their reflectances R_O and R_W are measured, and their contrast ratios ($C_W = 100\, R_O/R_W$) calculated.

4.1.3 The mean contrast ratio for the panel is calculated.

4.2 *Test Method B—Film Thickness (T_{98}) at a Contrast Ratio of 98 %:*

4.2.1 The coating is applied as a "wedge" on the specified test panel.

4.2.2 Several equal thickness pairs of black and white substrate points, at varying thicknesses, are located and their contrast ratios determined.

4.2.3 Contrast ratio versus film thickness is plotted on suitable graph paper, and the thickness at T_{98} determined from the graph.

5. Significance and Use

5.1 Contrast ratio at a specified film thickness is a useful hiding power parameter for production control and purchasing specifications.

5.2 The greater the hiding power, the less coating is required per unit area to obtain adequate hiding. Knowledge of hiding power is therefore important in regard to coating costs and for comparing coating value.

6. Apparatus and Material

6.1 *Reflectometer,* that measures the luminous reflectance factor, (specular reflection excluded) using CIE standard illuminant C and the CIE 1931 (2°) standard observer, in accordance with Test Method E1331, E1347 or E1349. The instrument shall be capable of viewing a diameter of at least 3 to 5 mm (⅛ to ³/₁₆ in.).

Note 4—Other observer-illuminant combinations and apertures may be used by agreement.

6.2 *Test Panels:* Smooth, glossy, pre-painted steel panels, thickness approximately 0.28 mm (0.011 in.), divided equally into black and white areas by a straight boundary. The black area shall have a maximum reflectance of 1 % and the white area a minimum reflectance of 78 %. The white area shall not yellow or darken appreciably when subjected to a normal powder coating baking schedule.[4] (see Fig. 2 for commercially available sizes.)

Note 5—Some test panels require a pre-bake before using, to expel residual volatiles that can create pinholes in the subsequently applied powder coating. When necessary pre-bake for 10 min at 180°C (350°F) to eliminate this problem.

6.3 Suitable equipment for applying and baking the test coatings.

6.4 *Electronic Gage,* adequately sensitive for measuring coating film thickness.

6.5 *Heat-Resistant Tape,* 20-mm (¾-in.) wide, easily removed after baking, leaving no discoloration or adhesive residue.[5]

6.6 *Permanent Marker,* extra fine point.

6.7 *Suitable Graph Paper.*

7. Measurements—General Rules

7.1 For each powder and test method, fill out an individual work sheet in the form of a table (see Fig. 3 for Test Method A, Fig. 4 for Test Method B), into which all test data and calculated values are entered in the indicated locations.

7.2 Measure reflectance as a percentage to two decimal places. Calculate (or measure) contrast ratio (C_W) as a percentage ($100 R_B/R_W$) to two decimal places, and report final results to one decimal place.

% Contrast Ratio at a Specified Film Thickness (T)

$(T' = T + t_0)$

Coating ID: _____   Circle: mils   μm

Color Description: _____   Reflectivity R_∞ _____ %

Gloss Description: _____   Laboratory: _____

T=	**Panel 1**	$t_0 =$			**Panel 2**	$t_0 =$			**Panel 3**	$t_0 =$			**Panel 4**	$t_0 =$		
		$T' =$				$T' =$				$T' =$				$T' =$		
Pair No.	R_O	R_W	C_W		R_O	R_W	C_W		R_O	R_W	C_W		R_O	R_W	C_W	
1																
2																
3																
4																
5																
Mean																

Operator: _____   Date: _____   Overall Mean % C_W: _____

T=	Panel 1	$t_0 =$			Panel 2	$t_0 =$			Panel 3	$t_0 =$			Panel 4	$t_0 =$		
		$T' =$				$T' =$				$T' =$				$T' =$		
Pair No.	R_O	R_W	C_W		R_O	R_W	C_W		R_O	R_W	C_W		R_O	R_W	C_W	
1																
2																
3																
4																
5																
Mean																

Operator: _____   Date: _____   Overall Mean % C_W: _____

FIG. 3 Work Table for Test Method A

7.3 The circles drawn to locate measurement points must be at least larger than the measurement opening of the reflectometer.

7.4 Measure thickness as accurately as possible, reporting to nearest 1.3 micrometers (0.05 mils), or closer if possible.

8. Calibration and Panel Preparation

8.1 Select a panel and pre-bake if necessary, as discussed in Note 5.

8.2 Locate and encircle a point of mean thickness in the white and in the black areas about 20-mm (¾ in.) from the panel edge, and mask each point with a short length of the specified tape, extending over the edge.

8.3 With the panel thus prepared, apply the test coating as a thickness "wedge," cure at the specified schedule, then remove the tapes to expose the uncoated white and black substrate points (see Fig. 1).

8.4 Recalibrate the film thickness gage to zero on the white-substrate points, measure the thickness of the black substrate point and record as t_0 in the indicated location of the relevant work sheet in the form of a table (see 7.1).

NOTE 6—The black substrate is always thicker than the white by an amount t_0 that is determined for each panel.

NOTE 7—With thickness gages capable of dual calibration, calibrate also to zero on the black substrate point and store both the white and black calibrations.

8.5 Measure the coating reflectance of one panel for each test coating, at a location of visually complete opacity. Record this value as the reflectivity R_∞ of the coating, in the indicated location of the work table.

9. Procedure and Calculations—Test Method A, Percent Contrast Ratio (C_W) at a Given Film Thickness

9.1 Use Fig. 3 for entries in this test method.

9.2 Record the thickness (T) for which the contrast ratio is to be determined.

NOTE 8—For significance and adequate sensitivity, the thickness should be such that the mean contrast ratio is not much over 98 % and preferably less.

9.3 Enter the value T' as the reading on the black substrate corresponding to the coating thickness T. ($T' = T + t_0$).

9.4 Find and encircle five pairs of points over the black and the white substrates, where the powder coating is at the specified thickness T.