Designation: D 3794 – 00

Standard Guide for Testing Coil Coatings[1]

This standard is issued under the fixed designation D 3794; 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 procedures for testing coil coatings. The test methods included are listed in Table 1. Where more than one test method is listed for the same characteristic, no attempt is made to indicate superiority of one method over another. Selection of test methods to be followed must be governed by the requirements in each individual case, together with agreement between the producer and user.

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:*

B 117 Practice for Operating of Salt Spray (Fog) Apparatus[2]

B 368 Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (Cass Test)[3]

D 522 Test Methods for Mandrel Bend Test of Attached Organic Coatings[4]

D 523 Test Methods for Specular Gloss[4]

D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces[5]

D 660 Test Method for Evaluating Degree of Checking Exterior Paints[4]

D 661 Test Method for Evaluating Degree of Cracking of Exterior Paints[4]

D 714 Test Method for Evaluating Degree of Blistering of Paints[4]

D 822 Practice for Conducting Tests on Paint and Related Coatings and Materials Using Filtered Open-Flame Carbon-Arc Apparatus[4]

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Tests Panels[4]

D 870 Practice for Testing Water Resistance of Coatings Using Water Immersion[4]

D 968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive[4]

D 1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[4]

D 1014 Practice for Conducting Exterior Exposure Tests of Paints on Steel[4]

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[4]

D 1193 Specification for Reagent Water[6]

D 1200 Test Method for Viscosity by Ford Viscosity Cup[4]

D 1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage[4]

D 1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings[4]

D 1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes[5]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[4]

D 1474 Test Methods for Indentation Hardness of Organic Coatings[4]

D 1475 Test Method for Density of Paint, Varnish, Lacquer, and Related Products[4]

D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments[4]

D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials[4]

D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus[4]

D 1823 Test Method for Apparent Viscosity of Plastisols and Organosols at High Shear Rates by Extrusion Viscometer[7]

D 1824 Test Method for Apparent Viscosity of Plastisols and Organosols at Low Shear Rates by Brookfield Viscometer[7]

D 2092 Guide for Treatment of Zinc-Coated (Galvanized)

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[2] *Annual Book of ASTM Standards*, Vol 03.02.

[3] *Annual Book of ASTM Standards*, Vol 02.05.

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

[5] *Annual Book of ASTM Standards*, Vol 06.02.

[6] *Annual Book of ASTM Standards*, Vol 11.01.

[7] *Annual Book of ASTM Standards*, Vol 08.01.

Steel Surfaces for Painting[5]
D 2196 Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Viscometer[4]
D 2197 Test Method for Adhesion of Organic Coatings by Scrape Adhesion[4]
D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[4]
D 2247 Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity[4]
D 2248 Practice for Detergent Resistance of Organic Finishes[4]
D 2369 Test Method for Volatile Content of Coatings[4]
D 2454 Practice for Determining the Effect of Overbaking on Organic Coatings[4]
D 2697 Test Method for Volume Nonvolatile Matter in Clear or Pigmented Coatings[4]
D 2794 Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)[4]
D 2803 Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal[4]
D 3003 Test Method for Pressure Mottling and Blocking Resistance of Organic Coatings on Metal Substrates[5]
D 3134 Practice for Establishing Color and Gloss Tolerances[4]
D 3170 Test Method for Chipping Resistance of Coatings[5]
D 3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus[4]
D 3359 Test Methods for Measuring Adhesion by Tape Test[4]
D 3361 Practice for Operating Light- and Water-Exposure Apparatus (Unfiltered Open-Flame Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products Using the Dew Cycle[4]
D 3363 Test Method for Film Hardness by Pencil Test[4]
D 3960 Practice for Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings[4]
D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser[4]
D 4138 Test Method for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive Means[5]
D 4141 Practice for Conducting Accelerated Outdoor Exposure Tests of Coatings[4]
D 4145 Test Method for Coating Flexibility of Prepainted Sheet[5]
D 4146 Test Method for Formability of Zinc-Rich Primer/Chromate Complex Coatings on Steel[5]
D 4147 Practice for Applying Coil Coatings Using the Wire-Wound Drawdown Bar[5]
D 4212 Test Method for Viscosity by Dip-Type Viscosity Cups[4]
D 4214 Test Methods for Evaluating Degree of Chalking of Exterior Paint Films[4]
D 4287 Test Method for High-Shear Viscosity Using the ICI Cone/Plate Viscometer[4]
D 4518 Test Methods for Measuring Static Friction of Coating Surfaces[8]
D 4585 Practice for Testing Water Resistance of Coatings Using Controlled Condensation[4]
D 4587 Practice for Conducting Tests on Paint and Related Coatings and Materials Using a Fluorescent UV-Condensation Light- and Water-Exposure Apparatus[4]
D 5031 Practice for Conducting Tests on Paints and Related Coatings and Materials Using Enclosed Carbon-Arc Light and Water Exposure Apparatus[4]
D 5178 Test Method for Mar Resistance of Organic Coatings[4]
D 5402 Practice for Assessing the Solvent Resistance of Organic Coatings Using Solvent Rubs[5]
D 5531 Guide for Preparation, Maintenance and Distribution of Physical Product Standards for Color and Geometric Appearance of Coatings[4]
D 5723 Practice for Determination of Chromium Treatment Weight on Metal Substrates by X-Ray Fluorescence[5]
D 5796 Test Method for Measurement of Dry Film Thickness of Thin Film Coil-Coated Systems by Destructive Means Using a Boring Device[5]
D 5894 Practice for Cyclic Salt Fog-UV Exposure of Painted Metal (Alternating Exposure in a Fog/Dry Cabinet and UV/Condensation Cabinet)[4]
D 6093 Test Method for Percent Volume Nonvolatile Matter in Clear or Pigmented Coatings Using a Helium Gas Pycnometer[4]
D 6491 Practice for Evaluation of Aging Resistance of Prestressed Prepainted Metal in a Dry Heat Test[5]
D 6492 Practice for Detection of Hexavalent Chromium On Zinc and Zinc/Aluminum Alloy Coated Steel[5]
E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode[9]
E 84 Test Method for Surface Burning Characteristics of Building Materials[10]
E 284 Terminology of Appearance[4]
E 308 Practice for Computing the Colors of Objects by Using the CIE System[4]
E 408 Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques[11]
E 643 Test Method for Ball Punch Deformation of Metallic Sheet Material[12]
E 903 Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres[13]
E 1164 Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation[4]
E 1356 Test Method for Glass Transition Temperatures by Differential Scanning Calorimetry or Differential Thermal Analysis[14]
E 1541 Practice for Specifying and Matching Color Using

[8] Discontinued; see *1999 Annual Book of ASTM Standards*, Vol 06.01.
[9] *Annual Book of ASTM Standards*, Vol 15.05.
[10] *Annual Book of ASTM Standards*, Vol 04.07.
[11] *Annual Book of ASTM Standards*, Vol 15.03.
[12] *Annual Book of ASTM Standards*, Vol 03.01.
[13] *Annual Book of ASTM Standards*, Vol 12.02.
[14] *Annual Book of ASTM Standards*, Vol 14.02.

the Colorcurve System[4]
E 1545 Test Method for Assignment of the Glass Transition Temperature by Thermomechanical Analysis[14]
E 1640 Test Method for Assignment of the Glass Transition Temperature by Dynamic Mechanical Analysis[14]
E 1808 Guide for Designing and Conducting Visual Experiments[4]
E 1918 Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field[10]
G 7 Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials[15]
G 60 Test Method for Conducting Cyclic Humidity Tests[2]
G 85 Practice for Modified Salt Spray (Fog) Testing[2]
G 87 Practice for Conducting Moist SO_2 Tests[2]
G 90 Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight[15]
G 113 Terminology Relating to Natural and Artificial Weathering Tests of Nonmetallic Materials[15]
G 151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources[15]
G 152 Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials[15]
G 153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials[15]
G 154 Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials[15]
G 155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials[15]
G 159 Tables for References Solar Spectral Irradiance at Air Mass 1.5: Direct Normal and Hemispherical for a 37° Tilted Surface[15]

[15] *Annual Book of ASTM Standards*, Vol 14.04.

3. Terminology

3.1 *Definitions:*

3.1.1 *coil coating*—application of coatings or films to continuous metal coil stock.

3.1.2 *direct roller coat*—coating with the applicator or coating roll revolving in the same direction as the strip.

3.1.3 *metal pretreatment*—chemical treatment normally applied to the metal substrate prior to prime or finish coating.

3.1.3.1 *Discussion*—The treatment is designed to react with and modify the metal substrate to produce a surface suitable for coating or adhesive bonding.

3.1.4 *reverse roller coat*—coating with the applicator or coating roll revolving in a direction opposite to that of the strip.

3.2 The definitions given in Terminology G 113 are applicable to this guide.

4. Significance and Use

4.1 This guide represents a collection of pertinent ASTM test methods used within the coil coatings industry. In the past, coil coaters world wide depended on industry standards written by the National Coil Coaters Association. That association, working cooperatively with ASTM, will no longer issue new, nor update old, standards.

5. General Requirements

5.1 All standard tests shall be made at 25 ± 3°C (77 ± 25°F) and 50 ± 5 % relative humidity, immediately after baking unless otherwise specified.

6. Sampling

6.1 The number of samples per unit of production shall be agreed upon between the producer and user.

TABLE 1 List of Test Methods and Recommended Practices

	Section	ASTM Standard
Liquid Coatings Properties:		
Viscosity:	7.1	
Ford cup viscosity	7.1.2	D 1200
Zahn cup viscosity	7.1.2	D 4212
High-Shear extrusion viscometer	7.1.3	D 1823
Plastisol and organosol low-shear viscosity	7.1.4	D 1824
Brookfield-type viscometer	7.1.5	D 2196
Cone and Plate viscometer	7.1.6	D 4287
Weight Solids	7.2	D 2369
Volatile Content	7.2	D 2369
Volume Solids	7.3	D 2697, D 6093
Fineness of dispersion	7.4	D 1210
Density (weight per gallon)	7.5	D 1475
VOC Determination	7.6	D 3960
pH	7.7	E 70
Flash Point	7.8	D 3278
Metal Pretreatment:		
Preparation of galvanized steel for painting	8.2	D 2092
Detecting Cr+6	8.3.1	D 6492
X-ray fluorescence, chrome determination	8.3.2	D 5723
Panel Preparation:		
Wire-wound drawdown bars	9.4.1.1	D 4147
Blade film applicator	9.4.1.2	D 823

TABLE 1 *Continued*

	Section	ASTM Standard
Wet film thickness	9.5	D 1212
Material Properties of a Cured Coil Coating System:	10	
Dry film thickness (DFT)	10.1	. . .
DFT, destructive methods	10.1.1	. . .
DFT, micrometer	10.1.1.1	D 1005
DFT, microscope	10.1.1.2	D 4138
DFT, boring method	10.1.1.3	D 5796
DFT, non-destructive methods	10.1.2	. . .
DFT, eddy current, non-ferrous base	10.1.2.1	D 1400
DFT, magnetic flux, ferrous base	10.1.2.2	D 1186
Color	10.2	
Glossary of color	10.2.1	E 284
Preparation and control of color standards	10.2.1	D 5531
Color and gloss tolerances	10.2.1	D 3134
Conducting visual experiments	10.2.1	E 1808
Color differences by visual evaluation	10.2.2	. . .
Visual evaluation of color and color difference	10.2.2.1	D 1729
Color differences by instrumental evaluation	10.2.3	. . .
Color matching, color curve system	10.2.3	E 1541
CIE color difference	10.2.3	E 308
Obtaining spectral data	10.2.3	E 1164
Calculation of color differences	10.2.3	D 2244
Specular gloss measurement	10.3	D 523
Hardness	10.4	
Pencil hardness	10.4.1	D 3363
Indentation hardness	10.4.2	D 1474
Flexibility	10.5	—
Impact resistance	10.5.2	D 2794
Mandrel bend	10.5.3	D 522
T bends	10.5.4	D 4145
Ball punch deformation	10.5.5	E 643
Draw test	10.5.6	D 4146
Adhesion:	10.6	
Cross hatch tape adhesion	10.6.2	D 3359
Scrape adhesion	10.6.3	D 2197
Degree of Cure:		
Glass transition TMA	10.7.2	E 1545
Glass transition, DMA	10.7.2	E 1640
Glass transition, DSC	10.7.2	E 1356
Solvent resistance	10.7.3	D 5402
Dry heat test	10.7.4	D 6491
Other Tests:	10.8	
Pressure mottling/blocking resistance	10.8.1	D 3003
Effect of overbaking	10.8.2	D 2454
Detergent resistance	10.8.3	D 2248
Effect of household chemicals	10.8.4	D 1308
Abrasion and mar Resistance	10.8.5	
Taber abraser	10.8.5.1	D 4060
Falling (sand) abrasive	10.8.5.2	D 968
Mar resistance	10.8.5.3	D 5178
Flame spread	10.8.6	E 84
Chip resistance	10.8.7	D 3170
Coefficient of friction	10.8.9	D 4518
Weathering and Corrosion Resistance Properties of a Cured Coil Coating System:		
Real-time weathering	11.1	
Conducting exterior weathering tests	11.1.1	D 1014, G 7
Chalk resistance	11.1.2.2	D 4214
Degree of rusting	11.1.2.5	D 610
Degree of blistering	11.1.2.1	D 714
Checking	11.1.2.3	D 660
Cracking	11.1.2.4	D 661
Corrosion creepage	11.1.2.6	D 1654
Accelerated corrosion and environmental resistance characteristics	11.2	—
Salt spray	11.2.1	B 117
Water fog	11.2.3	D 1735
100 % Relative humidity	11.2.3	D 2247
Condensation humidity	11.2.4	D 4585
Water immersion	11.2.5	D 870
Cyclic salt spray	11.2.6	G 85
Cyclic salt fog/UV condensation	11.2.6	D 5894
Cyclic humidity	11.2.6	G 60
Moist SO_2 testing (Kesternich)	11.2.7	G 87
Copper-accelerated salt spray (CASS)	11.2.8	B 368

TABLE 1 *Continued*

	Section	ASTM Standard
Filiform corrosion	11.2.9	D 2803
Specification for reagent water	11.2.9	D 1193
Accelerated weathering tests	11.3	
Dew cycle (Unfiltered open-flame Carbon arc)	11.3.2	D 3361, G 151
Filtered, open-flame carbon arc	11.3.3	D 822, G 151, G 152
Fluorescent UV-condensation	11.3.4	D 4587, G 151, G 154
Enclosed carbon arc	11.3.5	D 5031, G 153, G 151
Xenon arc	11.3.6	G 151, G 155
Accelerated outdoor tests (black box, heated black box, Fresnel)	11.3.7	D 4141, G 7, G 90
Solar reflectance	11.4	
Measuring solar reflectance of horizontal and low-slope surfaces in the field	11.4.1	E 1918
Measuring total normal emittance	11.4.2	E 408
Method for solar absorbance, reflectance, and transmittance	11.4.3	E 903
Tables for references solar spectral irradiance at air mass 1.5: direct normal and hemispherical for a 37° tilted surface	11.4.4	G 159

7. Liquid Coatings Properties

7.1 *Viscosity*:

7.1.1 It is common to measure the viscosity of coil coatings using an efflux technique (Ford or Zahn cup). This provides a simple, rapid technique for controlling the viscosity of a product, either in a paint production facility, or on-line at a coil coating facility. Coatings in the coil industry, however, cover a wide range of generic qualities, with many of them having nonNewtonian rheological characteristics. It is important, therefore, to consider the behavior of these coatings under different shear conditions, as well as measuring efflux viscosity. Some of the test methods require little expertise, where other test methods involve costly equipment and a high level of experience to run and interpret the rheological data.

7.1.2 *Efflux Viscosity*—Determine efflux viscosity in accordance with Test Methods D 4212 (Zahn cup) or D 1200 (Ford cup).

7.1.3 *High-Shear Extrusion Viscosity*—Determine the high-shear extrusion viscosity for plastisols and organosols in accordance with Test Method D 1823.

7.1.4 *Low-Shear Viscosity for Plastisols and Organosols*—Test in accordance with Test Method D 1824.

7.1.5 *Brookfield-type Viscosity*—Determine the Brookfield viscosity with a rotational viscometer in accordance with Test Method D 2196.

7.1.6 *Cone and Plate Viscometer*—Determine the viscosity using a cone and plate viscometer in accordance with Test Method D 4287.

7.2 *Weight Solids*—Determine the level of nonvolatile mass in accordance with Test Method D 2369.

7.3 *Volume Solids*—Determine the level of nonvolatile volume in accordance Test Method D 2697 or D 6093.

7.4 *Fineness of Dispersion*—Determine the fineness of grind of a coating in accordance with Test Method D 1210.

7.5 *Density*—Determine the density (weight per gallon) in accordance with Test Method D 1475.

7.6 *VOC*—Determine the VOC (volatile organic component) content in accordance with Practice D 3960.

7.7 *pH*—Controlling the level of acidity or alkalinity (pH) in the pretreatment section of a coil line, as well as that of waterborne coatings, is important. Determine pH in accordance with Test Method E 70.

7.8 *Flash Point*—Test the flash point of a coating in accordance with Test Methods D 3278.

8. Metal Pretreatment

8.1 The successful performance of any coil-coated system is dependent on metal substrate preparation. Metal preparation in the coil coating industry usually consists of one of the following methodologies: clean, rinse, formation of conversion coating, rinse, posttreatment of conversion coating, and dry; or, clean, rinse, application of a roll-on pretreatment, and dry. The metal pretreatment promotes maximum formability and adhesion of the organic coatings to the substrate, as well as promoting environmental exposure resistance, including anticorrosive properties, of the coil coated system. Cleaners, conversion coating treatments, dried-in-place roll-on pretreatments, and posttreatments vary with the performance desired, the coating system used, and the metal substrate. Because there is an interdependency between the cleaning, pretreating, and posttreatment steps, in order to obtain acceptable performance, it is necessary that the reaction times, concentrations, temperatures, and application methods used in the laboratory be as close as possible to those encountered under production condition—and that both laboratory and production conditions be in strict accordance with the pretreatment suppliers' specifications.

8.2 In the case of zinc coated steel surfaces, Guide D 2092, Methods A, B, C, D, and F illustrate the variety of pretreatments available.

8.3 *Coating Weight of Metal Pretreatment*—The one parameter to ensure that a substrate is properly cleaned and pretreated is the measurement of the level of pretreatment and posttreatment.

8.3.1 Determine the presence of hexavalent chromium on zinc and zinc/aluminum alloy coated steel in accordance with Practice D 6492.

8.3.2 *X-ray Fluorescence*—Determine the chromium level in accordance with Practice D 5723.

9. Panel Preparation

9.1 *Summary of Method*—This method includes substrate and pretreatment selection for application of coatings by wire wound draw-down bars on laboratory panels.

9.2 *Choice of Substrate*—The substrate to be coated, substrate size, gage, temper, alloy, and pretreatment to be used shall be agreed upon between the producer and user. Avoid using substrates that have been contaminated by handling.

9.3 *Degassing of Substrate*—Some galvanized substrates tend to absorb gasses on aging. To avoid blistering when the substrate is coated and baked it may be necessary to de-gas the substrate by heating and cooling to room temperature prior to application of the coating. The time and temperature of the degassing cycle shall be agreed upon between the producer and user.

9.4 *Drawdowns, Apparatus*:

9.4.1 *Stainless Steel Wire-wound Draw-down Bars*, (preferably 12.7 mm (½ in. in diameter to prevent bowing during application) are used to achieve dry film thickness up to 38 µ (1.5 mils). The choice of the specific drawdown bar is dependent on the dry film thickness required, the rheological properties of the coating, and the volume solids of the coating being tested. Other methods of applying thicker coatings >38 µ (>1.5 mils) are available, such as a blade applicator.

9.4.1.1 *Drawdown Bars*—Prepare drawdowns in accordance with Practice D 4147.

9.4.1.2 *Blade Film Applicator*—Prepare samples (at film thicknesses greater than 38 µ (1.5 mils) in accordance with Practices D 823.

9.5 *Wet Film Thickness*—Determine the wet thickness of an applied coating in accordance with Test Methods D 1212.

9.6 *Bake Schedule*—Bake the panel at a time and temperature to meet a metal temperature range agreed upon between the producer and user. The critical parameter in this baking process is the "peak metal temperature." This term refers to the maximum temperature that the substrate has reached during the baking cycle. In addition to peak metal temperature, other baking conditions, which influence the long-term performance of a coil coating, are the oven air temperature, and the time in which the coated metal is exposed to the heat within the oven (also called "dwell time"). The peak metal temperature may be measured using infrared thermometry or a thermocouple, but the most common method is to utilize "temperature tapes." These self-adhesive strips contain temperature-sensitive indicators covering a range of temperatures.

10. Physical Properties of Cured Coil Coating System

10.1 *Dry Film Thickness (DFT)*—There are several methods used for determining the dry film thickness of a coil coating. The ability to measure the dry film thickness accurately is of utmost importance when one considers that the typical coil coating system (primer+topcoat) is often no more than 25-µ (1-mil) thick. It is always advisable to take at least three DFT measurements to obtain an average value of DFT. There are both non-destructive and destructive means of measuring film thickness for ferrous and aluminum substrates. Coatings applied to commercially-available hot-dipped galvanized steel, zinc-aluminum, and other nonferrous alloys, may only be measured, due to the uneven nature of the alloy layer, by destructive means.

10.1.1 *Destructive Determination of Dry Film Thickness*:

10.1.1.1 *Micrometer*—Determine the DFT of a coil coating with a micrometer in accordance with Test Method D 1005. The micrometer must be capable of reading to ≤0.00005 in. (0.05 mils).

10.1.1.2 *Microscope (Tooke Gage)*—Determine the DFT of a coil coating with a microscope in accordance with Test Method D 4138.

10.1.1.3 *Boring Method*—Determine the DFT of a coil coating with a boring device in accordance with Test Method D 5796[16].

10.1.2 *Non-Destructive Determination of Dry Film Thickness*:

10.1.2.1 *Eddy-Current*—Determine the DFT of a coil coating on aluminum in accordance with Test Method D 1400.

10.1.2.2 *Magnetic Flux*—Determine the DFT of a coil coating on a ferrous substrate in accordance with Test Method D 1186.

10.2 *Color*:

10.2.1 The color difference between two homogeneously colored opaque films may be determined by visual evaluation or by instrumental means. The color standard used shall be agreed upon between the producer and user. Terminology E 284 provides a glossary of terms relating to the field of color. It is common to compare a color sample to a standard. Guide D 5531 describes the control of standards, and Guide E 1808 describes methods of conducting visual color experiments. Establish color and gloss tolerances in accordance with Practice D 3134.

10.2.2 *Color Differences of Opaque Materials by Visual Evaluation*:

10.2.2.1 *Visual Evaluation*—Visual comparison of color is fast and often acceptable, although numerical values are not obtained. The referenced test method covers the spectral, photometric and geometric characteristics of light source, illumination and viewing conditions, size of specimens, and general procedures to be used in the visual evaluation of color differences, in accordance with Practice D 1729.

10.2.2.2 *Metamerism*—Metamerism results when a sample and a standard have varying degrees of color difference under different light sources (for example, natural sunlight versus fluorescent lighting).

10.2.3 *Color Difference of Opaque Material by Instrumental Evaluation*—Color difference between a product and its standard can be determined from results of instrumental measurement. Measure products and color standards using Practices E 308, E 1164, or E 1541. Compute color difference using Test Method D 2244. Color tolerance is agreed upon between producer and user.

10.3 *Specular Reflectance*:

10.3.1 Specular reflectance in the coil industry is generally determined by readings at angles of 20° (also called "clarity"),

[16] The sole source of supply of a suitable device known to the committee at this time is the DJH Designs, 2366 Wyecroft Rd., Unit D4, Oakville, Ontario Canada L6L 6M1. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.