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Standard Guide for Testing Industrial Water-Reducible Coatings[1]

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1. Scope

1.1 This guide covers the selection and use of procedures for testing water-reducible coatings, both pigmented and clear, utilizing synthetic latices, synthetic resin emulsions, or water-reducible alkyds. The methods included are listed in Table 1. Where more than one standard is listed for the same characteristic, no attempt is made to indicate superiority of one standard over another. Selection of the standards to be followed must be governed by experience and the requirements in each individual case, together with agreement between producer and user.

1.2 This guide covers the testing of liquid coatings as applied by conventional spray, airless spray, electrostatic spray, dip, fancoat, flowcoat, roller coat, and curtain coat.

1.3 This guide includes procedures relating to proper and safe packaging, shipping and receiving, and storage and handling during use and application.

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 determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

B 117 Practice for Operating Salt Spray (Fog) Apparatus
B 287 Method of Acetic Acid-Salt Spray (Fog) Testing[3]
D 16 Terminology for Paint, Related Coatings, Materials, and Applications
D 56 Test Method for Flash Point by Tag Closed Cup Tester
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D 185 Test Methods for Coarse Particles in Pigments, Pastes, and Paints
D 215 Practice for the Chemical Analysis of White Linseed Oil Paints
D 344 Test Method for Relative Hiding Power of Paints by the Visual Evaluation of Brushouts
D 522 Test Method for Mandrel Bend Test of Attached Organic Coatings
D 523 Test Method for Specular Gloss
D 562 Test Method for Consistency of Paints Using the Stormer Viscometer
D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products
D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces
D 658 Test Method for Abrasion Resistance of Organic Coatings by the Air Blast Abrasive[3]
D 659 Method for Evaluating Degree of Chalking of Exterior Paints[3]
D 660 Test Method for Evaluating Degree of Checking of Exterior Paints
D 661 Test Method for Evaluating Degree of Cracking of Exterior Paints
D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints
D 714 Test Method for Evaluating Degree of Blistering of Paints
D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints
D 822 Practice for Filtered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels
D 869 Test Method for Evaluating Degree of Settling of Paint
D 870 Practice for Testing Water Resistance of Coatings Using Water Immersion
D 968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
D 1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers
D 1014 Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates

[1] This guide is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.55 on Factory Applied Coatings on Preformed Products.

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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.

[3] Withdrawn.

D 1125 Test Methods for Electrical Conductivity and Resistivity of Water
D 1150 Single and Multi-Panel Forms for Recording Results of Exposure Tests of Paints[3]
D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base
D 1200 Test Method for Viscosity by Ford Viscosity Cup
D 1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage
D 1212 Test Methods for Measurement of Wet Film Thickness of Organic Coatings
D 1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes
D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base
D 1474 Test Methods for Indentation Hardness of Organic Coatings
D 1475 Test Method for Density of Liquid Coatings, Inks, and Related Products
D 1535 Practice for Specifying Color by the Munsell System
D 1540 Test Method for Effect of Chemical Agents on Organic Finishes Used in the Transportation Industry
D 1640 Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature
D 1653 Test Methods for Water Vapor Transmission of Organic Coating Films
D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
D 1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials
D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
D 1731 Practices for Preparation of Hot-Dip Aluminum Surfaces for Painting
D 1732 Practices for Preparation of Magnesium Alloy Surfaces for Painting
D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
D 1737 Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus[3]
D 1848 Classification for Reporting Paint Film Failures Characteristic of Exterior Latex Paints[3]
D 1849 Test Method for Package Stability of Paint
D 2091 Test Method for Print Resistance of Lacquers
D 2092 Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting
D 2196 Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer
D 2197 Test Methods for Adhesion of Organic Coatings by Scrape Adhesion
D 2201 Practice for Preparation of Zinc-Coated and Zinc-Alloy-Coated Steel Panels for Testing Paint and Related Coating Products
D 2243 Test Method for Freeze-Thaw Resistance of Water-Borne Coatings
D 2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
D 2246 Test Method for Finishes on Primed Metallic Substrates for Humidity-Thermal Cycle Cracking[3]
D 2247 Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
D 2248 Practice for Detergent Resistance of Organic Finishes
D 2353 Test Method for Flow Ratings of Organic Coatings Using the Shell Flow Comparator[3]
D 2354 Test Method for Minimum Film Formation Temperature (MFT) of Emulsion Vehicles
D 2369 Test Method for Volatile Content of Coatings
D 2371 Test Method for Pigment Content of Solvent-Reducible Paints
D 2454 Practice for Determining the Effect of Overbaking on Organic Coatings
D 2574 Test Method for Resistance of Emulsion Paints in the Container to Attack by Microorganisms
D 2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale
D 2691 Test Methods for Microscopical Measurement of Dry Film Thickness of Coatings on Wood Products[3]
D 2697 Test Method for Volume Nonvolatile Matter in Clear or Pigmented Coatings
D 2794 Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
D 2803 Guide for Testing Filiform Corrosion Resistance of Organic Coatings on Metal
D 2805 Test Method for Hiding Power of Paints by Reflectometry
D 2933 Test Method for Corrosion Resistance of Coated Steel Specimens (Cyclic Method)[3]
D 3002 Guide for Evaluation of Coatings Applied to Plastics
D 3023 Practice for Determination of Resistance of Factory-Applied Coatings on Wood Products to Stains and Reagents
D 3134 Practice for Establishing Color and Gloss Tolerances
D 3168 Practice for the Qualitative Identification of Polymers in Emulsion Paints
D 3170 Test Method for Chipping Resistance of Coatings
D 3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus
D 3281 Test Method for Formability of Attached Organic Coatings with Impact-Wedge Bend Apparatus[3]
D 3359 Test Methods for Measuring Adhesion by Tape Test
D 3361 Practice for Unfiltered Open-Flame Carbon-Arc Exposures of Paint and Related Coatings
D 3793 Test Method for Low-Temperature Coalescence of Latex Paint Films
D 3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials

D 3925 Practice for Sampling Liquid Paints and Related Pigmented Coatings
D 3928 Test Method for Evaluation of Gloss or Sheen Uniformity
D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D 4062 Test Method for Leveling of Paints by Draw-Down Method
D 4399 Test Method for Measuring Electrical Conductivity of Electrocoat Baths
D 4585 Practice for Testing Water Resistance of Coatings Using Controlled Condensation
D 4587 Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings
E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode

2.2 *U.S. Federal Test Method Standard No. 141c:*[4]
2131.1 Application of Sprayed Films
3011.1 Test Method
3011.2 Condition in Container
4331.1 Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this guide, refer to Terminology D 16.

4. Significance and Use

4.1 This compilation of standards is intended to provide assistance in selecting appropriate tests for evaluating water-reducible coatings and for determining what characteristics should be considered for a given end use. Either single-coat operations or multicoat systems may be addressed by the proper selection of tests. Results from the various tests are not all necessarily useful in evaluating the performance of different systems for various end uses. The list can be useful to those developing coatings and coating systems and to those seeking coating systems for products.

5. Equipment

5.1 Use the equipment as specified in each standard.

6. General Requirements

6.1 Tests and observations shall be at standard laboratory conditions as specified in Specification D 3924 unless otherwise specified or agreed upon by the producer and user.

7. Sampling and Specimen Preparation

7.1 Sample the water-reducible coatings in accordance with Practice D 3925.

7.2 Prepare specimens as required for the specific tests on the liquid coating and the dry coating.

8. Conditions Affecting Performance

8.1 Practical requirements and performance of water-reducible coatings may vary with:

8.1.1 Type of substrate.

8.1.2 Substrate condition, for example, porosity, hardness, smoothness, flexibility, etc.

8.1.3 Type, quality, and suitability of the surface treatment or primer used under the water-reducible coating and the time before coating application.

8.1.4 Application methods and techniques.

8.1.5 Contaminants on the surface of the substrate.

8.1.6 Environmental conditions such as temperature and relative humidity.

8.1.7 Damage to container, size, and type of container.

8.1.8 Storage variables, for example storage time, excessive temperature fluctuations that may cause physical or chemical change. Special needs arise due to carbon dioxide absorption, dissolved metal compatibility, and ultrafiltration treatments.

9. Liquid Coatings Properties

9.1 *Condition in Container*—Thickening, settling, and separation are undesirable and objectionable if a liquid coating cannot be reconditioned and made suitable for application with a reasonable amount of stirring. The referenced method covers procedures for determining changes in properties after storage. Determine the condition in the container in accordance with Test Method 3011.1 of U.S. Federal Test Method Standard No. 141c.

9.2 *Coarse Particles and Foreign Matter*—To form uniform films of good appearance, the liquid coating must be free of coarse particles as agreed upon between the producer and the user, a typical maximum being 1 % by weight of the total paint. Determine coarse particles and foreign matter in accordance with Test Methods D 185.

9.3 *Density or Weight Per Gallon*—The density as measured by weight per gallon is used to help assure product uniformity from batch to batch. In the referenced test method, the density is expressed as the weight in pounds avoirdupois of 1 U.S. gal or the weight in kilograms of 1 L of the paint at a specified temperature. A calibrated weight-per-gallon cup is used. Determine the density in accordance with Test Method D 1475.

9.4 *Fineness of Dispersion*—The more finely a pigment is dispersed, the more efficiently it is being used. One test method for measuring the degree of dispersion (commonly referred to as "fineness of grind") is to draw the material down a calibrated, tapered groove in a hardened steel block with the groove varying in depth from 100 to 0 µm (4 to 0 mils). The point at which continuous groupings of particles or agglomerates, or both, protrude through the surface of the liquid is taken as the fineness reading. Lower readings in mils or µm or higher readings in Hegman units indicate better fineness of dispersion. Determine fineness of dispersion in accordance with Test Method D 1210.

9.5 *Pigment Suspension*—The amount and type of settling is an indication of how well the pigments remain in suspension and how easily settled pigment can be remixed. Determine degree of settling in accordance with Test Method D 869.

9.6 *Viscosity*—Viscosity refers to the flow resistance of a fluid and should fall within an agreed-upon range. Viscosities of Newtonian fluids (constant viscosity regardless of shear rate) may be measured with a Ford Cup. Viscosities of non-Newtonian materials should be measured at two or more

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098.

TABLE 1 List of Test Methods by Properties

Test Method	Section	ASTM Standard	Federal Test Method Standard 141
I. *Liquid Coating Properties:*	9		
Coarse particles and foreign matter	9.2	D 185	
Condition in container	9.1	...	3011.1
Conductivity	9.14	D 1125 or D 4399	...
Consistency	9.7	D 562	...
Density or weight per gallon	9.3	D 1475	...
Fineness of dispersion	9.4	D 1210	...
Flash point	9.13	D 56, D 93 or D 3278	...
Freeze-thaw stability	9.9	D 2243	...
Microorganism resistance	9.11	D 2574	...
pH	9.8	E 70	...
Package stability	9.10	D 1849	...
Pigment suspension	9.5	D 869	...
Surface tension	9.12	...	...
Viscosity	9.6	D 1200 or D 2196	...
II. *Application and Film Formation:*	10		
Panel preparation	10.1	D 609, D 1730, D 1731, D1732, D 2092, D 2201	...
Drying properties	10.2.2	D 1640	...
Leveling properties	10.3	D 4062, D 2353	...
Low temperature coalescence	10.5	D 3793, D 2354	...
Spray properties	10.2.1	...	2131.1, 4331.1
Touch-up	10.6	D 3928	...
Uniform film preparation	10.4	D 823	...
Wet film thickness	10.3	D 1212	...
III. *Appearance of Dry Film:*	11		
Color difference by visual evaluation	11.1.1	D 1729, D 2616	...
Color difference by instrumental evaluation	11.1.2	D 2244 and D 3134	...
Color description by visual evaluation	11.1.3	D 1535	...
Color description by instrumental evaluation	11.1.4	D 2244	...
Gloss	11.2	D 523	...
Hiding power	11.3	D 344, D 2805	...
IV. *Properties of Dry Film:*	12		
Abrasion resistance	12.1	D 658, D 968, D 4060	...
Adhesion	12.2	D 2197, D 3359	...
Elongation	12.3	D 522, D 1737, D 3281	...
Exterior exposure	12.4		...
Blistering	12.4.1	D 714	...
Chalking	12.4.2	D 659	...
Checking	12.4.3	D 660	...
Cracking	12.4.4	D 661	...
Erosion	12.4.5	D 662	...
Flaking	12.4.6	D 772	...
Rusting	12.4.7	D 610, D 2933	...
Accelerated weathering	12.4.8	D 822, D 3361, D 4587	...
Corrosive environments	12.4.9	D 1654	...
Hardness	12.5	D 1474	...
Impact resistance	12.6	D 2794, D 3170	...
Resistance to various forms of water	12.8		
Water immersion	12.8.1	D 870	...
Water fog	12.8.2	D 1735	...
Humidity resistance	12.8.3	D 2247	...
Moisture vapor permeability	12.8.4	D 1653	...
Salt spray	12.8.5	B 117, B 287	...
Humidity-thermal cycling	12.8.6	D 2246	...
Filiform corrosion	12.8.7	D 2803	...
Condensation	12.8.8	D 4585	...
Detergent resistance	12.8.9	D 2248	...
Resistance to chemicals	12.7	D 1308, D 1540, D 3023	...
Overbaking	12.9	D 2454	...
Print resistance	12.10	D 2091	...
Reporting results	12.4.10	D 1848	...
Dry film thickness	12.11	D 1186, D 1400	
V. *Analysis of Paint:*	13		
Volatile content	13.2	D 2369	...
Volume of nonvolatile	13.3	D 2697	...
Weight of nonvolatile	13.3	D 2369	...
Pigment content	13.4	D 2371	...
Identification of vehicle solids	13.6	D 3168	...

speeds with a Brookfield rotational viscometer. Determine viscosity in accordance with Test Methods D 1200 or D 2196.

9.7 *Consistency*—Consistency is a less precise term than viscosity for evaluating the flow properties of a material. In the referenced test method, consistency is defined as the load in grams required to produce a specific rate of rotation in a specimen using the Stormer Viscometer. This is a one-speed test method and is not recommended for paints that show shear thinning or thixotropy. Determine consistency in accordance with Test Method D 562.

9.8 *pH*—The pH of a water-reducible coating depends on the type of vehicle used and the general formulation. It may vary from about 4 to 10. A change in pH during storage may indicate poor stability or a change in properties of a water-reducible coating. Determine pH in accordance with Test Method E 70.

9.9 *Freeze-Thaw Resistance*—Water-reducible coatings may be subjected to freezing conditions during shipping and storage. Suitably stabilized paints will resist several cycles of freezing and thawing without showing deleterious changes. The referenced method covers the determination of the extent to which water-reducible coatings retain their original consistency and freedom from lumps when subjected to freezing and subsequent thawing. Determine freeze-thaw resistance in accordance with Test Method D 2243.

9.10 *Package Stability*—Since liquid coatings cannot normally be used immediately after manufacture, they must remain stable in the package for some time. The referenced test method covers the change in consistency and in certain related properties that may take place in packaged water-reducible coatings when stored at a temperature above room temperature. Determine package stability in accordance with Test Method D 1849, at a temperature and for a period of time agreed upon by the purchaser and the seller.

NOTE 1—Although there is no ASTM or Federal test method for determining gassing during normal storage, special containers may be necessary to vent any spontaneous pressure buildup.

9.11 *Microorganism Resistance*—Microorganisms in water-reducible coatings can cause gassing, putrefaction or fermentation odors, and loss of vicosity. Determine if the liquid coating contains living bacteria and if it is resistant to attack by bacteria in accordance with Test Method D 2574.

9.12 *Surface Tension*—Although there is no ASTM or Federal test method for determining surface tension of liquid coatings, this is an important property of a water-reducible resin or coating. If surface tension is too high, poor pigment and substrate wetting may occur, leading to cratering, low gloss, or other surface defects. The most common methods for measuring the surface tensions of coatings probably are the ring pull method and drop weight method. For a comprehensive discussion of these and other aspects of surface tension, see *Paint Flow and Pigment Dispersion*.[5]

9.13 *Flash Point*—Nearly all water-borne coatings are incapable of sustaining combustion, but many do contain volatile solvents whose vapors can ignite if near open flame. Because they do give flash points, water-borne coatings must be tested for flash point temperature to conform with many government regulations concerning transportation, labeling, packaging, etc. Determine flash point in accordance with Test Methods D 56, D 93 or D 3278.

9.14 *Conductivity*—Conductivity is an important factor in the application of some water-borne coatings. Test Methods available for determining conductivity are D 1125 (specifically Methods A and B) and D 4399.

10. Application and Film Formation

10.1 *Panel Preparation*—Select a substrate as agreed upon by the producer and the user. Prepare panels for testing the coating in accordance with Practices D 609, D 1730, D 1731, D 1732, D 2201, or Guide D 2092. The preparation of plastics for paint testing is covered in Guide D 3002.

10.2 *Application Properties*—Determine the ease with which the liquid coating can be applied to various surfaces with brush, spray, or other application equipment. Application properties are generally compared to a standard, or described by requirements in a product specification. Application properties are related to such characteristics as kinematic viscosity, non-Newtonian rheology, surface tension, shear sensitivity, micelle stability, electrical resistivity, erosion abrasiveness, conductivity, heat capacity, and corrosiveness.

10.2.1 *Sprayed Film Application*—Liquid coatings can be applied by spray. Determine the spray application properties in accordance with Method 2131.1 of Federal Test Method Standard No.2.2. The method can be modified to include application by airless spray equipment.

10.2.2 *Drying Properties*—The drying time of water-reducible coatings is important in determining when the applied coatings can be handled or packed. Also, inadequate drying of the film may result in poor film and poor appearance and, if used on an exterior surface, rain, dew, or snow may cause a nonuniform appearance. Determine drying time in accordance with Test Method D 1640, or as agreed upon by producer or user.

10.3 *Leveling Properties*—Leveling is an important factor when uniform surfaces are to be produced, as it affects hiding and appearance. The referenced methods cover the laboratory determination of the relative leveling characteristics of liquid coatings. Determine the leveling characteristics in accordance with Test Method D 4062. Measure wet film thickness in accordance with Test Method D 1212.

10.4 *Producing Films of Uniform Thickness*—The following test method covers the preparation of various films of uniform thickness essential in conducting tests. Prepare films in accordance with Practices D 823.

10.5 *Low Temperature Coalescence of Paints*—A test method to determine how well the latex particles in coating will fuse together or coalesce to form a continuous film at low temperature is described in Test Method D 3793. A test for the minimum film formation temperature is described in Test Method D 2354.

10.6 *Touch-Up*—For many coating systems it is important to be able to repair damage sustained during production, delivery, or after delivery. A coating can be tested by applying

[5] Patton, T., *Paint Flow and Pigment Dispersion*, 2nd Ed., Wiley-Interscience, New York, 1979, pp. 205–246.

it with a small nylon bristle brush or air brush to a small section of a panel previously coated with it. When the touch-up area has dried, it is examined to see if it differs significantly from the initial coating. Determine the ability to touch up the coating in accordance with Test Method D 3928. Test the adhesion of the original and touch-up areas in accordance with Test Methods D 3359 or other agreed-upon test method.

11. Appearance of Dry Film

11.1 *Color*—The color of a water-reducible coating may be specified independently or as the color-difference with respect to another color that is usually the standard. Visual and instrumental methods are both applicable. An opaque film is preferred that may be prepared by making one or more applications of water-reducible coating onto a black and white substrate until the substrate is completely obscured. Each application should be performed in a normal manner with respect to application method, drying, and film thickness.

11.1.1 *Color Differences by Visual Evaluation*—Visual comparison of color is fast and often acceptable although numerical values are not obtained. The referenced standard covers the spectral, photometric, and geometric characteristics of light source, illuminating and viewing conditions, size of specimens, and general procedures to be used in the visual evaluation of color differences of opaque materials. Determine color difference by visual evaluation in accordance with Practice D 1729 or Test Method D 2616.

11.1.2 *Color Differences of Opaque Material by Instrumental Evaluation*—Color difference between a product and the standard can be measured by an instrument. Generally, the tolerance is agreed upon by the purchaser and the seller and may also be required if a product specification is involved. Color instruments provide numerical values that can be subsequently compared to later measurements. The referenced method covers the instrumental determination of small color differences observable in daylight illumination between nonfluorescent, nonmetameric, opaque surfaces such as coated specimens. If metamerism is suspected, visual evaluation (11.1.1) should be used to verify the results. Make instrumental measurement of color difference in accordance with Practice D 2244. Tolerances are discussed in Practice D 3134.

11.1.3 *Color Description by Visual Evaluation*—In some cases it is necessary to specify or identify a color instead of a color difference from some standard. Various color atlases are available, the most common being the Munsell System. Describe or identify the Munsell color in accordance with Practice D 1535.

11.1.4 *Color Description by Instrumental Evaluation*—Instrumental measurements involve the determination of CIE tristimulus values, X, Y, and Z, from which other color coordinates such as L*, a*, b*, or L, a, b values may be calculated or obtained directly with some instruments. Describe or identify in accordance with Practice D 2244.

11.2 *Gloss*—Water-reducible coatings vary in gloss and the end use determines whether the gloss should be high, semigloss, eggshell, or flat. Determine the gloss in accordance with Test Method D 523 using 20, 60, or 85° geometry as appropriate.

11.3 *Hiding Power (Dry Opacity)*—Hiding power is the measure of the ability of a paint to hide the substrate. It is, however, dependent upon uniform film thickness which is influenced by flow and leveling. Test Method D 344 is a practical test in which paint is applied with a brush, film thickness is approximately measured, and opacity is evaluated visually as compared to a standard paint. Results are affected by flow and leveling application properties of the paint. Test Method D 2805 is considered to be a more precise and accurate test that does not need a material paint standard. Paint is applied with an applicator bar to minimize the effects of flow and leveling, film thickness is rigorously measured, and opacity is instrumentally evaluated. Determine hiding power in accordance with Test Methods D 344 or D 2805.

12. Properties of Dry Film

12.1 *Abrasion Resistance*—Abrasion resistance is a measure of the ability of a dried coating to withstand wear and marring from objects rolled or pulled across the surface. Determine abrasion resistance in accordance with Test Method D 658, D 968, or D 4060 (see methods to determine the applicability for interlaboratory use).

12.2 *Adhesion*—Adhesion is the property of the coating that resists removal from the substrate when scraped. Test Methods D 2197 covers the use of a scrape adhesion tester and a parallel groove adhesion tester. In Test Methods D 3359 cuts are made in the film and pressure-sensitive tape applied and removed. Determine adhesion in accordance with Test Methods D 2197 or D 3359.

12.3 *Elongation*—Elongation is a measure of the flexibility of coating films. Determine elongation in accordance with Test Methods D 522, D 1737, or D 3281.

12.4 *Exterior Exposure*—If the paint is intended for exterior exposure, tests may be run in accordance with Practice D 1014, and Standard D 1150 and evaluated by the following methods:

12.4.1 *Blistering*—Determine the degree of blistering in accordance with Test Method D 714.

12.4.2 *Chalking*—Determine the degree of chalking in accordance with Method D 659.

12.4.3 *Checking*—Determine the degree of checking in accordance with Test Method D 660.

12.4.4 *Cracking*—Determine the degree of cracking in accordance with Test Method D 661.

12.4.5 *Erosion*—Determine the degree of erosion in accordance with Test Method D 662.

12.4.6 *Flaking*—Determine the degree of flaking in accordance with Test Method D 772.

12.4.7 *Rusting*—Determine the degree of rusting in accordance with Test Methods D 610 or D 2933.

12.4.8 *Accelerated Weathering*—Determine the resistance to accelerated weathering in accordance with Practices D 822, D 3361, or D 4587.

12.4.9 *Corrosive Environment*—Determine the resistance to corrosive environment in accordance with Test Method D 1654.

12.4.10 *Reporting of Results*—The reporting of results can often be helped by reference to the classifications prescribed in Classification D 1848.

12.5 *Hardness*—Hardness is a measure of the ability of a dried coating to resist indentation. Determine hardness in accordance with Test Method D 1474.

12.6 *Impact Resistance*—An important property of a water-reducible coating is its ability to withstand a striking blow or impingement. Determine the impact resistance in accordance with Test Methods D 2794 or D 3170.

12.7 *Resistance to Chemicals*—An important property of a water-reducible coating is its ability to resist spotting, softening, or removal when subjected to household chemicals or strong cleaners. Determine resistance to chemicals in accordance with Test Methods D 1308 or D 1540 or Practice D 3023.

12.8 *Resistance to Various Physical Forms of Water*—The ability of a dried coating to resist water in many different forms is an especially important property of water-reducible coatings.

12.8.1 *Water Immersion*—Determine the resistance to water absorption in accordance with Practice D 870.

12.8.2 *Water Fog*—Determine the resistance to water fog in accordance with Practice D 1735.

12.8.3 *Humidity Resistance*—Determine the resistance to 100 % relative humidity in accordance with Practice D 2247.

12.8.4 *Moisture Vapor Permeability*—Determine the resistance to moisture vapor transmission in accordance with Test Methods D 1653.

12.8.5 *Salt Spray*—Determine the resistance to salt spray (fog) in accordance with Practice B 117 or Method B 287.

12.8.6 *Humidity-Thermal Cycling*—Determine the resistance to humidity-thermal cycling in accordance with Test Method D 2246.

12.8.7 *Filiform Corrosion*—Determine the resistance to filiform corrosion in accordance with Guide D 2803.

12.8.8 *Condensation*—Determine the resistance to condensed water such as dew in accordance with Practice D 4585.

12.8.9 *Detergent Resistance*—Determine the resistance to detergent solution in accordance with Practice D 2248.

12.9 *Overbaking*—The ability of a coating to withstand a baking temperature moderately higher than initial bake or for a longer period of time is an important property. Measure the resistance to overbaking by Practice D 2454.

12.10 *Print Resistance*—Print resistance is the ability of a dried coating to withstand pressure from a textured surface without any noticeable marking on the coating. Measure print resistance in accordance with Test Method D 2091.

12.11 *Dry Film Thickness*—There are several methods currently being used for determining dry film thickness. Depending on the substrates being used, the following test methods should be considered: D 1005, D 1186, D 1400, and D 2691.

13. Analysis of Paint

13.1 *Chemical Analysis*—If a specification requires certain raw materials or certain components in a given amount, then chemical analysis is required. Chemical analysis determines whether the specified components are present, and if they are, in what amounts. It does not necessarily establish quality, which can also be greatly affected by manufacturing techniques. Most ASTM analytical methods, such as Practice D 215, apply to solvent-type coatings. However, some of these can be adapted for analysis of water-reducible coatings.

13.2 *Volatile Content*—The percent of volatile matter indicates the water and organic solvent released from the film as it dries. This quantity subtracted from 100 % gives the nonvolatile content. Determine the volatile content in accordance with Test Method D 2369.

13.3 *Nonvolatile Content*—The percent of nonvolatile matter indicates the amount of material present that can be converted to the desired film. Determine the weight percent of nonvolatile in accordance with Test Method D 2369. Determine the volume percent of nonvolatile in accordance with Test Method D 2697.

13.4 *Pigment Content*—Although the referenced method describes the procedure for quantitative separation of the vehicle from the pigment in solvent-reducible coatings, it can be adapted for water-reducible coatings to determine the weight percent pigment in the paint. Determine the pigment content in accordance with Test Method D 2371.

13.5 *Pigment Analysis*—The analysis of pigment may be required if the product is covered by a specification, or if it is agreed upon between the producer and the user. Analyze the pigment in accordance with methods appropriate for the constituents present or specified.

13.6 *Identification of Vehicle Solids*—The suggested method covers the qualitative characterization or identification of separated paint vehicle solids by infrared spectroscopy. It is useful in detecting uniformity, batch to batch, and the presence of adulterants. Characterize vehicle solids in accordance with Practice D 3168.

14. Keywords

14.1 alkyds; appearance of materials; application properties; brush application; color; curtain coat; dip application; electrostatic spray; emulsion vehicles; exterior exposure; fancoat; film formation rates; flowcoat; instrumental evaluation; opaque film; paints and related coatings; paints; roller coat; spray method; visual examination; water-base; water-reducible coatings