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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 *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 Salt Spray (Fog) Testing Apparatus[2]

B 287 Method of Acetic Acid-Salt Spray (Fog) Testing[3]

D 16 Terminology Relating to Paint, Varnish, Lacquer, and Related Products[4]

D 56 Test Method for Flash Point by Tag Closed Tester[5]

D 93 Test Methods for Flash Point by Pensky-Martens Closed Tester[5]

D 185 Test Methods for Coarse Particles in Pigments, Pastes, and Paints[6]

D 215 Practice for the Chemical Analysis of White Linseed Oil Paints[4]

D 344 Test Method for Relative Hiding Power of Paints by the Visual Evaluation of Brushouts[4]

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

D 523 Test Method for Specular Gloss[4]

D 562 Test Method for Consistency of Paints Using the Stormer Viscometer[4]

D 609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products[4]

D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces[7]

D 658 Test Method for Abrasion Resistance of Organic Coatings by the Air Blast Abrasive[8]

D 659 Method for Evaluating Degree of Chalking of Exterior Paints[9]

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

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

D 662 Test Method for Evaluating Degree of Erosion of Exterior Paints[4]

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

D 772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints[4]

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

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

D 869 Test Method for Evaluating Degree of Settling of Paint[7]

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 Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[4]

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

[3] Discontinued; See *1988 Annual Book of ASTM Standards,* Vol 03.02.

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

[5] *Annual Book of ASTM Standards*, Vol 05.01.

[6] *Annual Book of ASTM Standards*, Vol 06.03.

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

[8] Discontinued; see *1995 Annual Book of ASTM Standards*, Vol 06.01.

[9] Discontinued; see *1989 Annual Book of ASTM Standards*, Vol 06.01.

D 1014 Test Method for Conducting Exterior Exposure Tests of Paints on Steel[4]
D 1125 Test Methods for Electrical Conductivity and Resistivity of Water[10]
D 1150 Single and Multi-Panel Forms for Recording Results of Exposure Tests of Paints[11]
D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[4]
D 1200 Test Method for Viscosity by Ford Viscosity Cup[4]
D 1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems[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[7]
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, Lacquers and Related Products[4]
D 1535 Practice for Specifying Color by the Munsell System[4]
D 1540 Practice for Effect of Chemical Agents on Organic Finishes Used in the Transportation Industry[11]
D 1640 Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature[4]
D 1653 Test Method for Water Vapor Transmission of Organic Coating Films[4]
D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments[4]
D 1729 Practice for Visual Evaluation of Color Differences of Opaque Materials[4]
D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting[12]
D 1731 Practices for Preparation of Hot-Dip Aluminum Surfaces for Painting[12]
D 1732 Practices for Preparation of Magnesium Alloy Surfaces for Painting[12]
D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus[4]
D 1737 Test Method for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus[13]
D 1848 Classification for Reporting Paint Film Failures Characteristic of Exterior Latex Paints[7]
D 1849 Test Method for Package Stability of Paint[7]
D 2091 Test Method for Print Resistance of Lacquers[7]
D 2092 Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting[7]
D 2196 Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield) Type Viscometer[4]
D 2197 Test Methods for Adhesion of Organic Coatings by Scrape Adhesion[4]
D 2201 Practice for Preparation of Zinc-Coated and Zinc-Alloy-Coated Steel Panels for Testing Paint and Related Coating Products[4]
D 2243 Test Method for Freeze-Thaw Resistance of Water-Borne Paints[7]
D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[4]
D 2246 Test Method for Finishes on Primed Metallic Substrates for Humidity-Thermal Cycle Cracking[11]
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 2353 Test Method for Flow Ratings of Organic Coatings Using the Shell Flow Comparator[14]
D 2354 Test Method for Minimum Film Formation Temperature (MFT) of Emulsion Vehicles[6]
D 2369 Test Method for Volatile Content of Coatings[4]
D 2371 Test Method for Pigment Content of Solvent-Reducible Paints[4]
D 2454 Practice for Determining the Effect of Overbaking on Organic Coatings[4]
D 2574 Test Method for Resistance of Emulsion Paints in the Container to Attack by Microorganisms[4]
D 2616 Test Method for Evaluation of Visual Color Difference With a Gray Scale[11]
D 2691 Test Methods for Microscopical Measurement of Dry Film Thickness of Coatings on Wood Products[7]
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 Test Method for Filiform Corrosion Resistance of Organic Coatings on Metal[4]
D 2805 Test Method for Hiding Power of Paints by Reflectometry[4]
D 2933 Test Method for Corrosion Resistance of Coated Steel Specimens (Cyclic Method)[14]
D 3002 Guide for Evaluation of Coatings Applied to Plastics[7]
D 3023 Practice for Determination of Resistance of Factory-Applied Coatings on Wood Products to Stains and Reagents[7]
D 3134 Practice for Establishing Color and Gloss Tolerances[4]
D 3168 Practice for the Qualitative Identification of Polymers in Emulsion Paints[4]
D 3170 Test Method for Chipping Resistance of Coatings[7]
D 3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus[4]
D 3281 Test Method for Formability of Attached Organic Coatings with Impact-Wedge Bend Apparatus[15]

[10] *Annual Book of ASTM Standards*, Vol 11.01.
[11] Discontinued; see *1992 Annual Book of ASTM Standards*, Vol 06.01.
[12] *Annual Book of ASTM Standards*, Vol 02.05.
[13] Discontinued; see *1987 Annual Book of ASTM Standards*, Vol 06.01.
[14] Discontinued; see 1990 *Annual Book of ASTM Standards*, Vol 06.01.
[15] Discontinued; see 1995 *Annual Book of ASTM Standards*, Vol 06.02.

D 3359 Test Methods for Measuring Adhesion by Tape Test[4]

D 3361 Practice for Operating Light- and Water-Exposure Apparatus (Unfiltered Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products Using the Dew Cycle[4]

D 3793 Test Method for Low-Temperature Coalescence of Latex Paint Films[7]

D 3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials[4]

D 3925 Practice for Sampling Liquid Paints and Related Pigmented Coatings[4]

D 3928 Test Method for Evaluation of Gloss or Sheen Uniformity[7]

D 4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser[4]

D 4062 Test Method for Leveling of Paints by Draw-Down Method[7]

D 4399 Test Method for Measuring Electrical Conductivity of Electrocoat Baths[4]

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]

E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode[16]

2.2 *U.S. Federal Test Method Standard No. 141c:*[17]

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.

[16] *Annual Book of ASTM Standards*, Vol 15.05.

[17] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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 4 to 0 mils (100 to 0 μm). 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 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*.[18]

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 Practice 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

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