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# Standard Guide for Clear and Pigmented Lacquers[1]

This standard is issued under the fixed designation D333; 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 cover procedures for testing lacquers and lacquer coatings. The test methods included are listed in Table 1.

NOTE 1—In accordance with Terminology D16, a lacquer is defined as a coating composition that is based on synthetic thermoplastic filmforming material dissolved in organic solvent(s) and that dries primarily by solvent evaporation. Typical lacquers include those based on nitrocellulose, other cellulose derivatives, vinyl resins, acrylic resins, etc.

NOTE 2—Lacquers may be applied under such diverse conditions, to so many different surfaces, and their dried films may be subjected to so many kinds of wear and exposure that it is not possible to assure desired performance from a single selection of test methods and numerical results therefrom. Those skilled in lacquer technology may find partial assurance of obtaining desired qualities in various types of lacquers through careful selection of the methods covered herein and intelligent interpretation of results therefrom.

NOTE 3—It is intended ultimately to remove all experimental procedures from Test Methods D333 and to establish them as a guide to the selection of test methods for lacquer and perhaps to interpretation of results therefrom. Temporarily there remain in Test Methods D333 a few tests that are too short or otherwise presently unsuitable for establishment under separate ASTM designations.

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:*[2]

B117 Practice for Operating Salt Spray (Fog) Apparatus

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

D56 Test Method for Flash Point by Tag Closed Cup Tester

D88 Test Method for Saybolt Viscosity

D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D522 Test Methods for Mandrel Bend Test of Attached Organic Coatings

D523 Test Method for Specular Gloss

D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products

D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces

D658 Test Method for Abrasion Resistance of Organic Coatings by Air Blast Abrasive (Withdrawn 1996)[3]

D659 Method for Evaluating Degree of Chalking of Exterior Paints (Withdrawn 1990)[3]

D660 Test Method for Evaluating Degree of Checking of Exterior Paints

D661 Test Method for Evaluating Degree of Cracking of Exterior Paints

D662 Test Method for Evaluating Degree of Erosion of Exterior Paints

D714 Test Method for Evaluating Degree of Blistering of Paints

D772 Test Method for Evaluating Degree of Flaking (Scaling) of Exterior Paints

D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

D870 Practice for Testing Water Resistance of Coatings Using Water Immersion

D968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

D1014 Practice for Conducting Exterior Exposure Tests of Paints and Coatings on Metal Substrates

D1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to

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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] The last approved version of this historical standard is referenced on www.astm.org.

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**TABLE 1 List of Test Methods**

| Test Method | Section | ASTM Method |
|---|---|---|
| General Requirements | 4 | ... |
| Liquid Materials: | | |
| Color of Clear Lacquers: | | |
| Gardner Color Scale | 9 | D1544 |
| Platinum-Cobalt Scale | 9 | D1209 |
| Flash Point: | | |
| Tag Closed Cup | 11 | D56, D93, D3278 |
| Homogeneity: | | |
| Clarity and Cleanness | 8 | D2090 |
| Fineness of Pigment Grind | 8 | D1210 |
| Nonvolatile Matter | 7 | D1644 |
| Sample Preparation | 5 | ... |
| Viscosity: | | |
| Ford Cup (Efflux) | 10 | D1200 |
| Kinematic High Precision | 10 | D445 |
| Weight per Gallon (Density) | 6 | D1475 |
| Dried Films: | | |
| Abrasion Resistance: | | |
| Air Blast Abrasion Tester | 19 | D658 |
| Falling Sand Method | 19 | D968 |
| Chip Resistance: | 30 | D3170 |
| Color-Pigmented Coatings: | | |
| Spectrophotometric Method | 15 | E308 |
| Munsell Color System | 15 | D1535 |
| Color Difference-Pigmented Coatings: | | |
| Visual Method | 16 | D1729 |
| Instrumental Evaluation of Color Differences of Opaque Materials | 16 | D2244 |
| Elongation: | | |
| Conical Mandrel | 17 | D522 |
| Cylindrical Mandrel | 17 | D1737 |
| Film Thickness: | | |
| Nondestructive Magnetic Base | 13 | D1186 |
| Nondestructive Nonmagnetic Metallic Base | 13 | D1400 |
| Penetration Thickness Gage | 13 | D1400 |
| Dial Comparator | 13 | D1005 |
| Gloss: | | |
| Specular Gloss | 14 | D523 |
| Hardness Indentation Method | 18 | D1474 |
| Hiding Power | 27 | D2805 |
| Household Chemical Resistance | 21 | D1308 |
| Light Stability | 31 | D2620 |
| Outdoor Exposure: | | |
| Preparation of Coated Panels: | | |
| Aluminum Alloy Panels | 22 | D1733 |
| Steel Panels | 22 | D609 |
| Test Procedures: | | |
| Exposure Tests Using Steel Panels | 22 | D1014 |
| Evaluating Blistering | 22 | D714 |
| Evaluating Chalking | 22 | D659 |
| Evaluating Checking | 22 | D660 |
| Evaluating Cracking | 22 | D661 |
| Evaluating Rusting | 22 | D610 |
| Evaluating Erosion | 22 | D662 |
| Evaluating Flaking | 22 | D772 |
| Panel Preparation: | | |
| Manual Spraying Method | 12 | ... |
| Automatic Application | 12 | D823 |
| Perspiration Resistance | 28 | D2204 |
| Plasticizer Migration | 29 | D2199 |
| Print Test | 20 | D2091 |
| Salt Fog | 24 | B117 |
| Temperature-Change Resistance | 23 | D1211 |
| Water Fog Testing | 25 | D1735 |
| Water Immersion Test | 26 | D870 |

a Ferrous Base (Withdrawn 2006)[3]

D1200 Test Method for Viscosity by Ford Viscosity Cup

D1209 Test Method for Color of Clear Liquids (Platinum-Cobalt Scale)

D1210 Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage

D1211 Test Method for Temperature-Change Resistance of Clear Nitrocellulose Lacquer Films Applied to Wood (Withdrawn 2006)[3]

D1308 Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes

D1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base (Withdrawn 2006)[3]

D1474 Test Methods for Indentation Hardness of Organic Coatings

D1475 Test Method For Density of Liquid Coatings, Inks, and Related Products

D1535 Practice for Specifying Color by the Munsell System

D1544 Test Method for Color of Transparent Liquids (Gardner Color Scale)

D1644 Test Methods for Nonvolatile Content of Varnishes

D1729 Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials

D1733 Method for Preparation of Aluminum Alloy Panels for Testing Paint, Varnish, Lacquer, and Related Products (Withdrawn 1979)[3]

D1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus

D1737 Method of Test for Elongation of Attached Organic Coatings with Cylindrical Mandrel Apparatus (Withdrawn 1988)[3]

D2090 Test Method for Clarity and Cleanness of Paint and Ink Liquids (Withdrawn 2007)[3]

D2091 Test Method for Print Resistance of Lacquers

D2199 Test Method for Measurement of Plasticizer Migration From Vinyl Fabrics to Lacquers

D2204 Method of Test for Perspiration Resistance of Organic Coatings (Withdrawn 1976)[3]

D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates

D2620 Test Method for Light Stability of Clear Coatings (Withdrawn 2001)[3]

D2805 Test Method for Hiding Power of Paints by Reflectometry

D3170 Test Method for Chipping Resistance of Coatings

D3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus

E308 Practice for Computing the Colors of Objects by Using the CIE System

## 3. Significance and Use

3.1 These test methods are intended to compile as well as provide screening tests in evaluating clear and pigmented lacquers as used in different coating operations.

3.2 Each coating system may contain from a simple one coat operation to a multicoat finishing system.

3.3 The substrates may be varied, ferrous and non ferrous, plastic or wood which can affect the performance of a given coating system.

3.4 Substrate cleaning, chemically or physically, is an essential and critical aspect to the performance of the coating system.

3.5 Results from the various tests are not necessarily all useful in evaluating the performance of the different types of coating systems used on the many varied substrates.

## 4. General Requirements

4.1 All tests shall be made in diffused light (not in direct sunlight), and at 23 ± 2°C (73.5 ± 3.5°F) and 50 ± 5 % relative humidity, unless otherwise specified.

## 5. Preparation of Sample

5.1 Many clear lacquers and all pigmented lacquers contain suspended solids that have a tendency to settle to the bottom of the container. Stir any settled portion with a paddle or spatula and then shake vigorously for 10 min on a mechanical agitator. Since many lacquer solvents are extremely volatile, care should be taken during sampling and testing to avoid loss of significant amounts of volatile matter.

## 6. Weight Per Gallon

6.1 Determine the density as described in Test Method D1475. This method is particularly adaptable for high-viscosity fluids or where a component is too volatile for a specific gravity balance determination. If a weight per gallon cup of 83.2-mL capacity is used, calculation of weight per gallon is simplified.

## 7. Nonvolatile Matter

7.1 Nonvolatile matter determination is an indication of the amount of permanent film-forming material contained in a lacquer. At ambient temperatures, drying of a lacquer film may involve gradual loss of slowly volatile solvents, hence solids determinations may differ from those resulting from a nonvolatile determination accelerated by a higher temperature.

7.2 Determine the nonvolatile content of lacquers as described in Test Methods D1644. As an additional requirement, the specimen shall be reheated and reweighed until the weight is constant to within 1 mg. Test Method A of Test Methods D1644 is preferred since Method B is potentially dangerous when used with lacquers.

## 8. Homogeneity

8.1 Good quality lacquers and their ingredients should be uniformly constituted and free from particles of foreign matter.

8.2 Determine the presence or absence of foreign matter in nonpigmented liquids for use in paints and lacquers or lacquers themselves as described in Test Method D2090.

8.3 Determine the degree of dispersion (commonly referred to as "fineness of grind") of pigment, semiquantitatively, in pigmented coating systems in accordance with Test Method D1210.

## 9. Color

9.1 The color of a clear lacquer is only a preliminary indication of the color of a dried film of lacquer. The initial color may bleach and another color may appear under certain conditions of exposure.

9.2 Determine the color of clear lacquers as described in Test Method D1544. This method gives a comparison of the color of the sample with that of a color reference standard.

9.3 Determine the color of essentially water-white lacquers in accordance with Test Method D1209. This method shall be used where the color-producing bodies in the lacquer have very nearly the same light-absorption characteristics as those of the platinum-cobalt standards.

## 10. Viscosity

10.1 The viscosity of a lacquer is a property that can be used as a guide in determining the ease with which a given lacquer may be applied. For example, lacquers designed for spray application may be low in viscosity whereas they are high for doctor blade or roller application.

10.2 Determine the viscosity of clear and pigmented finishes designed for spray application as described in Test Method D1200. This method is not recommended for lacquers with viscosities requiring more than 100 s efflux time.

10.3 For precise viscosity determinations in the range from 0.4 to 16 000 cSt proceed in accordance with Test Method D445.

NOTE 4—Caution should be observed in that it is recognized that changes in viscosity may occur in lacquers upon aging.

## 11. Flash Point

11.1 The organic solvents used in lacquers have characteristic flash points. The flash point of a liquid is defined as the lowest temperature, corrected to 760 mmHg (101.3 kPa ) of pressure, of the sample at which application of an ignition source causes the vapor of the sample to ignite under specified conditions of test.

11.2 Determine the flash point by Test Method D56 or Test Methods D93 for liquid storage regulations of Occupational Safety and Health Administration (OSHA) of U. S. Department of Labor and for classification of hazardous liquids for shipments under the regulations of U. S. Department of Transportation and bulk shipments by water.

11.2.1 Determine the flash point of lacquer or lacquer materials having a viscosity less than 9.5 cSt at 25°C (77°F) or 45 SUS at 37.8°C (100°F) (Test Method D88) by Test Method D56 and of lacquers having a viscosity of more than 9.5 cSt at 25°C (77°F) or 45 SUS at 37.8°C (100°F) by Method A of Test Methods D93. Use Method B of Test Methods D93 whenever there is a question that the heat transfer within a viscous lacquer is not sufficient to assure an accurate flash point. In addition, use Method B when testing pigmented lacquers or suspensions of solids and liquids which tend to skin under test conditions.

11.3 Test Methods D3278, which give comparable results to Test Method D56 and Test Methods D93 while requiring a smaller specimen and less time to run, may be used as an alternative method.

## 12. Panel Preparation

12.1 In the evaluation of coated panels a uniform dry film thickness of lacquer is essential in order to eliminate any effect due to film thickness. Unless otherwise specified, the dry film thicknesses shall be as follows:

| | Mils | Micrometres |
|---|---|---|
| Lacquer primer | 0.3 to 0.6 | 8 to 15 |
| Lacquer primer surfacer | 1.0 to 2.0 | 25 to 50 |
| Clear lacquer | 1.0 to 1.2 | 25 to 31 |
| Gloss pigmented lacquer | 1.0 to 1.2 | 25 to 31 |
| Lacquer putties | 4.0 to 6.0 | 100 to 150 |

12.2 Panels may be prepared by either manual or automatic application of lacquers. First reduce lacquers with the specified thinner (if reduction is required) to the required dilution solids or viscosity. If no viscosity is specified, spray with standard-type guns at a viscosity of 17 to 25 s in a No. 4 Ford Cup at 25°C determined as described in Test Method D1200.

12.3 *Cold Spray*—In manual application by cold spray, keep the air pressure constant and provide the air line with a moisture trap. Adjust the flow, gun distance from test panel, and spray pattern that the deposited film is kept smooth, level, and wet. Apply the number of coats or thickness, or both, specified in the product specification.

12.4 *Hot Spray*—The packaged material shall be applied with hot spray equipment approved by the Underwriter's Laboratory. When dilution is necessary, the material shall be reduced with the specified thinner to the viscosity required for hot spray application. The conditions of operation with respect to temperature of the heating unit, type of spray gun, atomization pressure and pressure on feed tank type, adjustment of air cap and fluid tip, distance of gun from work, and rate of flow of material at the spray nozzle shall be as agreed upon between purchaser and seller.

12.5 *Automatic Application*—Four methods of applying films of uniform thickness automatically are described in Practices D823. The methods are as follows:

Test Method A—Automatic Spraying Machine,
Test Method B—Automatic Dip-Coater,
Test Method C—Automatic Blade Film Applicator, and
Test Method D—Motor-Driven Blade Film Applicator.

## 13. Film Thickness

13.1 Many properties of lacquer films vary with the thickness of the dry film. The measurement of dry film thickness may be accomplished with various apparatus depending upon the substrate to which the film is applied. Three nondestructive methods of thickness determination are given for films that are not easily removable from their substrate and thus do not lend themselves to simple measurement with a constant-pressure micrometer. Two destructive methods are given. The methods are as follows:

13.2 *Nondestructive Methods:*

13.2.1 Test Methods D1186. This method is also recommended for thin films, less than 0.013 mm (0.005 in.) (0.5 mil) in thickness.

13.2.2 Test Method D1400, Method A. By the use of plastic shims of known thickness, the film thickness can be estimated to approximately ± 10 %.

13.2.3 Test Method D1400, Method C.

13.3 *Destructive Methods:*

13.3.1 Test Method D1005.

13.3.2 Test Method D1400, Method B.

## 14. Gloss

14.1 This property relates to that aspect of the reflecting properties of a coating as determined by the brightness and configuration of reflected images.

14.2 Determine gloss of nonmetallic finishes in accordance with Test Method D523. This method covers the measurement of the amount of light reflected specularly from a film's surface. While this property is a function of film gloss, correlation with visual observations is not always obtained.

## 15. Color-Pigmented Coatings

15.1 The colors of opaque objects such as painted surfaces may be specified using visual or instrumental means.

15.2 By visual means the colors of painted surfaces in terms of the Munsell Color System may be determined in accordance with Test Method D1535. This method provides a simple alternative to the more precise and more complicated method of color specification based on spectrophotometry.

15.3 By spectrophotometer, either visual or photoelectric types, the colors of light-reflecting coatings and spectral characteristics may be determined using Practice E308.

## 16. Color Difference-Pigmented Coatings

16.1 The small daylight color differences between two similarly homogeneously colored, opaque objects such as painted surfaces may be determined using visual evaluating techniques or by instrumental means.

16.2 Determine by visual evaluation color differences of opaque materials using Practice D1729. This practice specifies characteristics of light sources, illuminating and viewing conditions, size of specimens, and general procedures.

16.3 Determine small daylight color differences between opaque paint specimens in accordance with Practice D2244. This test method correlates reasonably well with visual judgments of character and perceptibility of color differences provided specimens are illuminated and viewed under conditions substantially the same as used in the instrument. For nonfluorescent opaque paint specimens or materials that do not contain metallic pigments ("bronze" powders and aluminum powders) or "pearly" pigments or other materials that produce optical phenomena that contribute to the visual effect, test in accordance with Practice D2244.

## 17. Elongation

17.1 An elongation test may be used as an indication of the flexibility of an attached organic coating. It can also show whether there is any change during aging.

17.2 Determine the elongation of attached organic coatings when applied to flat sheet metal of uniform surface texture in accordance with Test Methods D522 or Method D1737.

## 18. Hardness

18.1 Determine film hardness of lacquers applied to plane rigid surfaces in accordance with Test Methods D1474. In this method the resistance of a coating to penetration by an indenter is measured and converted to a hardness value.

## 19. Abrasion Resistance

19.1 Determine the abrasion resistance as described in either Test Method D658 or Test Methods D968. Both methods cover measurement of the resistance to abrasion of coatings applied to metal panels.

## 20. Print Test

20.1 A print test can be used to determine two characteristics of a film. If a film is thoroughly dry, the test will give a measure to the susceptibility of the film itself to pressure marring. However, as the test is used in a production situation, it can be used to determine the degree to which a film has released solvents and hence whether the product can be safely packed.

20.2 Determine imprinting of dried films as described in Test Method D2091.

## 21. Household Chemical Resistance

21.1 Household chemicals may alter the surface of organic coatings, for example through discoloration, change in gloss, blistering, swelling, and loss of adhesion.

21.2 Determine, qualitatively, the effects of household chemicals in accordance with Test Method D1308.

## 22. Outdoor Exposure

22.1 It is important to determine the resistance to outdoor exposure of lacquers destined for exterior use prior to their application to surfaces which may be difficult or costly to refinish, or both. Systems of primer and lacquer should be tested as a whole rather than as separate components. Experience indicates that the type of substrate employed has a marked bearing on weathering results. It is the purpose of several ASTM methods to minimize the influence of substrate variation by providing uniform panel selection and uniform procedures for conducting exposure tests and for evaluating and recording results.

22.2 *Preparation of Panels*—Depending on the substrate anticipated to be coated, panels for outdoor exposure testing should be prepared and tested in accordance with the following methods:

22.2.1 Method D1733.
22.2.2 Practice D609.
22.2.3 Practice D1014.

22.3 *Test Procedures*—Many properties of organic coatings should be evaluated periodically throughout the outdoor exposure period. These properties may be evaluated as follows:

22.3.1 *Blistering*—Test Method D714.
22.3.2 *Chalking*—Method D659.
22.3.3 *Checking*—Test Method D660.
22.3.4 *Cracking*—Test Method D661.
22.3.5 *Rusting*—Test Method D610.
22.3.6 *Erosion*—Test Method D662.
22.3.7 *Flaking*—Test Method D772.

## 23. Temperature-Change Resistance

23.1 A test for resistance to temperature change, or a cold cracking test (as it is sometimes called), is designed to give an indication of the resistance of a coating system to fracturing or checking, caused both by changes in temperature and humidity and by age. The degree of correlation between test results and long-term room temperature aging varies with the type of lacquer. The industry uses the test widely and feels that systems showing good cold crack resistance usually will give satisfactory performance in service. Some factors that can affect results are the type of substrate, its thickness, the rate at which the individual panels are cooled, the film thickness, and the nature of any priming or sealer coats.

23.2 Determine the temperature-change resistance in accordance with Test Method D1211. This method specifies that the test panels be aged 10 days. If the panels are much older than this, the resistance to checking is expected to be less and sometimes considerably so depending on the nature of the film.

## 24. Salt Fog

24.1 Salt spray (fog) testing of lacquers applied to metal substrates is helpful in determining their resistance to failure in service under atmospheric conditions that might prevail in sea coast areas.

24.2 Under accelerated conditions of laboratory testing, only the temperature, the pH, or concentration of the salt solution, and other physical properties can be controlled, the selection of the substrate, the coating technique, the manner in which the coating is scribed (parallel or X's), the location or position of the panels within the cabinet, the length of the test, the inspection of the panels, and the method of reporting results must generally be as agreed upon between purchaser and seller. Systems of primer and lacquer should be tested as a whole rather than as separate components.

24.3 Determine the salt spray resistance as described in Practice B117.

## 25. Water Fog Testing

25.1 Water fog testing of lacquers is helpful in determining their resistance to failure in service under conditions of high humidity. Failure is usually evidenced by blushing, dulling, blistering, or excessive softening that does not disappear upon evaporation of the absorbed water. Systems of primer and top-coat lacquer should be tested as a whole rather than as separate components. The use of unrealistically short drying times or excessively low temperature bakes will give erratic and misleading results.

25.2 Determine resistance to failure under conditions of high humidity in accordance with Practice D1735.