Designation: D1653 – 13

Standard Test Methods for Water Vapor Transmission of Organic Coating Films[1]

This standard is issued under the fixed designation D1653; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 These test methods cover the determination of the rate at which water vapor passes through films of paint, varnish, lacquer, and other organic coatings. The films may be free films or they may be applied to porous substrates.

1.2 A similar, but more generally applicable test method is Test Methods E96 which should be considered when other materials are involved.

1.3 Two test methods are covered in Test Methods D1653 as follows:

1.3.1 *Test Method A*—Dry Cup Method, and

1.3.2 *Test Method B*—Wet (Payne) Cup Method.

1.3.3 Agreement should not be expected between results obtained by different methods or test conditions. The method that most closely approaches the conditions of use should be selected.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. Factors for conversion are stated in 13.2.1.2 and 13.2.2.2.

1.5 There are instruments on the market that purport to measure water vapor transmission of films more easily and rapidly than the methods described in Test Methods D1653 and E96. They run essentially the same kinds of tests as in the ASTM methods, but do so instrumentally. However, it appears that no side-by-side tests have been run comparing results from measurements with such instruments to these ASTM methods for precision and accuracy.

1.6 *This standard does not purport to address 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]

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

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

D1193 Specification for Reagent Water

D4708 Practice for Preparation of Uniform Free Films of Organic Coatings

E96 Test Methods for Water Vapor Transmission of Materials

E104 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *water vapor transmission rate, WVT, n*—the steady water vapor flow in unit time through unit area of a body, between two specific parallel surfaces, under specific conditions of temperature and humidity at each surface. Accepted inch-pound unit is grains per square foot per hour. Accepted SI unit is grams per square metre per 24 h.

3.1.2 *water vapor permeance, WVP, n*—the steady water vapor flow in unit time through unit area of a body (WVT) induced by unit vapor pressure difference (Δp) between the two surfaces of a coating. Therefore, WVP = WVT/Δp. Accepted inch-pound unit is grains per square foot per hour per inch of mercury (called a perm). Accepted SI unit is grams per square metre per 24 h per millimetre of mercury (called a metric perm).

3.1.3 *vapor source, n*—humidity in the dry cup method and water in the wet cup method.

3.1.4 *vapor sink, n*—desiccant used in the dry cup method and 50 % or near 0 % relative humidity in the wet cup method.

4. Summary of Test Methods

4.1 In Test Method A (Dry Cup Method), the test specimen is sealed to the open mouth of a cup or dish containing

[1] These test methods are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved June 1, 2013. Published July 2013. Originally approved in 1959. Last previous edition approved in 2008 as D1653 – 03 (2008). DOI: 10.1520/D1653-13.

[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.

***A Summary of Changes section appears at the end of this standard**

desiccant, and the assembly placed in a test chamber with a controlled atmosphere. Two sets of exposure conditions are acceptable for this test method.

4.1.1 *Condition A,* consisting of 50 % relative humidity at 73°F (23°C), and

4.1.2 *Condition B,* consisting of 90 % relative humidity at 100°F (38°C).

4.2 In Test Method B (Wet Cup Method), the test specimen is sealed to the open mouth of a cup or dish containing water, and the assembly placed in a test chamber with a controlled atmosphere. Two sets of exposure conditions are acceptable for this test method:

4.2.1 *Condition A,* consisting of 50 % relative humidity at 73°F (23°C), and

4.2.2 *Condition C,* consisting of very low (near zero) relative humidity at 73°F (23°C).

4.3 In both methods, periodic weighings of the cup or dish are made to determine the rate of water vapor movement through the specimen.

5. Significance and Use

5.1 One of the factors affecting the performance provided by an organic coating is its capability of resisting or aiding the passage of water vapor. In some services, for example, exterior wood and masonry, the coating has to allow moderate amounts of water vapor to pass through the film without damage to it. Hence, the water vapor transmission characteristics of coatings are important in assessing their performance in practical use.

5.2 The purpose of these test methods is to obtain values of water vapor transfer through coatings that range in permeability from high to low. These values are for use in design, manufacture, and marketing.

5.3 The water vapor transmission is not a linear function of film thickness, temperature or relative humidity.

5.4 Values of water vapor transmission rate (WVT) and water vapor permeance (WVP) can be used in the relative rating of coatings only if the coatings are tested under the same closely controlled conditions of temperature and relative humidity, and if their thicknesses are equal.

5.5 *Test Method A*—The Dry Cup Method is the preferred test method for obtaining values that relate to conventional dwellings where high relative humidities are not anticipated.

5.6 *Test Method B*—The Wet Cup Method is the preferred test method for obtaining values that relate to applications where high relative humidities are anticipated in the vicinity of the barrier material. In general, the more permeable a coating is to the passage of moisture as is typical of many water-reducible coatings, the greater its affinity for water and the greater the increase in transmission when tested in and exposed to high humidities. Absorption of water may make a coating less dense, thus allowing moisture to diffuse easily and cause a much higher moisture vapor transmission rate, (WVTR) than would occur in drier environments.

6. Apparatus

6.1 *Perm Cup or Dish,* consisting of a container made of a noncorroding material, impermeable to water or water vapor. If the cup or dish is made of aluminum, it must be anodized or given a protective clear coating to prevent corrosion.

6.1.1 One type of cup that is suitable has a flanged edge and is equipped with a separate corresponding flange, so that the test specimen can be held between them. The contacting faces of the flanges shall be ground to such flatness that when the film is in position, moisture transfer can occur only through the exposed film area. For hard films, or films having a very rough surface, a soft rubber gasket may be inserted between the film and the flange. The flanges shall then be held together with suitable clamps.

6.1.2 Another suitable cup is any open circular or rectangular dish to which the test film can be sealed with wax or sealant.

6.2 *Test Chamber,* with a controlled temperature and relative humidity as specified in Section 4. Air shall be circulated throughout the chamber to maintain uniform conditions at all test locations. For low or high humidity conditions, a standard desiccator or other suitable cabinet may be used. For maintaining constant relative humidity by means of aqueous solutions, refer to procedures outlined in Practice E104.

6.3 *Analytical Balance,* having an adequate capacity for the weight of the test cups and a sensitivity of 1 mg.

7. Reagents and Materials

7.1 *Purity of Water*—Unless otherwise indicated, reference to water shall be understood to mean reagent water conforming to Type IV of Specification D1193.

7.2 *Desiccant,* consisting of either anhydrous calcium chloride ($CaCL_2$) or anhydrous magnesium perchlorate ($Mg(CLO_4)_2$). The calcium chloride should be dried at 400°F (200°C) before use. If calcium chloride will react with the test specimen, an adsorbing desiccant such as a silica gel may be used but the moisture gain by this desiccant during the test must be limited to 4 %. Use caution in handling magnesium perchlorate because of possible chemical reaction that may be produced if it comes in contact with some organic materials and is subsequently heated to regenerate the anhydrous salt.

7.3 *Sealant,* such as wax for attaching the test specimen to the top of the perm cup or dish. It must be highly resistant to the passage of water vapor. It must not lose weight to, or gain weight from, the atmosphere in an amount, over the required period of time, that would affect the test results by more than 2 %. It must not affect the vapor pressure in a water-filled dish.

NOTE 1—Among acceptable sealants are (*1*) a 60:40 mixture of microcrystalline wax and refined crystalline parafin wax, (*2*) tissue embedding wax, and (*3*) a 50:50 mixture of beeswax and rosin.

7.4 *Release Substrate,* prepare free films, whenever possible to eliminate the potential interference of substrates, on release paper[3] glass coated with halosilane compound, polyhexafluoropropylene sheet, or metal panels wrapped with Tedlar[4]

[3] The sole source of supply of release Paper, Form RP-1K, known to the committee at this time is the Leneta Co., 15 Whitney Rd., Mahwah, NJ 07430. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, [1] which you may attend.

[4] Tedlar is a registered trademark of E. I. du Pont de Nemours and Company or its affiliates.