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Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials[1]

This standard is issued under the fixed designation E96/E96M; 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 U.S. Department of Defense.

1. Scope

1.1 These test methods cover the determination of water vapor transmission rate (WVTR) of materials, such as, but not limited to, paper, plastic films, other sheet materials, coatings, foams, fiberboards, gypsum and plaster products, wood products, and plastics. Two basic methods, the Desiccant Method and the Water Method, are provided for the measurement of WVTR. In these tests, the desired temperature and side-to-side humidity conditions, with resultant vapor drive through the specimen, are used. The test conditions employed are at the discretion of the user, but in all cases, are reported with the results.

1.2 The values stated in either Inch-Pound or SI units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, each system shall be used independently of the other. Derived results are converted from one system to the other using appropriate conversion factors (see Table 1).

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

C1809 Practice for Preparation of Specimens and Reporting of Results for Permeance Testing of Pressure Sensitive Adhesive Sealed Joints in Insulation Vapor Retarders

D449/D449M Specification for Asphalt Used in Dampproofing and Waterproofing

D2301 Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 Definitions of terms used in this standard will be found in Terminology C168, from which the following is quoted:

"*water vapor permeability*—the time rate of water vapor transmission through unit area of flat material of unit thickness induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions.

Discussion—Permeability is a property of a material, but the permeability of a body that performs like a material may be used. Permeability is the arithmetic product of permeance and thickness.

water vapor permeance—the time rate of water vapor transmission through unit area of flat material or construction induced by unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions.

Discussion—Permeance is a performance evaluation and not a property of a material.

water vapor transmission rate—the steady water vapor flow in unit time through unit area of a body, normal to specific

[1] These test methods are under the jurisdiction of ASTM Committee C16 on Thermal Insulation and are the direct responsibility of Subcommittee C16.33 on Insulation Finishes and Moisture.

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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.

TABLE 1 Units and Conversion Factors[A,B]

Multiply	by	To Obtain (for the same test condition)
	WVTR	
g/h·m^2	1.43	grains/h·ft^2
grains/h·ft^2	0.697	g/h·m^2
	Water Vapor Permeance (WVP)	
ng/Pa·s·m^2	1.75×10^{-2}	perm
g/Pa·s·m^2	1.75×10^{7}	perm
perm	57.2	ng/Pa·s·m^2
perm	5.72×10^{-8}	g/Pa·s·m^2
	Permeability	
ng/Pa·s·m	0.688	perm-inch
g/Pa·s·m	6.88×10^{8}	perm-inch
perm-inch	1.45	ng/Pa·s·m
perm-inch	1.45×10^{-9}	g/Pa·s·m

[A] These units are commonly used in the construction and building materials industries. Additional units are used in other industries, such as packaging.
[B] All conversions of mm Hg to Pa are made at a temperature of 0°C.

parallel surfaces, under specific conditions of temperature and humidity at each surface."

4. Summary of Test Methods

4.1 In the Desiccant Method the test specimen is sealed to the open mouth of a test dish containing a desiccant, and the assembly placed in a controlled atmosphere. Periodic weighings are used to determine the rate of water vapor movement through the specimen into the desiccant.

4.2 In the Water Method, the dish contains distilled water, and the weighings are used to determine the rate of vapor movement through the specimen from the water to the controlled atmosphere.

4.3 Given a common controlled atmosphere, the vapor pressure difference is nominally the same in both methods, but the water method exposes the specimen to higher humidity, which potentially affects the water vapor transmission through the material. The controlled atmosphere temperature and humidity levels are selected by the user.

5. Significance and Use

5.1 The purpose of these tests is to determine water vapor transmission rate of materials by means of a simple gravimetric procedure.

5.2 *Test Conditions:*

5.2.1 A WVTR result obtained in one method under one set of test conditions cannot be used to predict the result that would be obtained using the same method with a different set of conditions, or using the other method. See Appendix X3 for discussion of determining dependency of WVTR on different relative humidity (at a given temperature).

5.2.2 Test conditions that are commonly used or are considered standard in various industries or research applications are listed as Procedures A-E in Appendix X1, but use of these conditions is not mandatory in the methods herein.

5.2.3 Given the caution in 5.2.1, the selection of test conditions that closely approach exposure conditions of material in actual use is advised when possible.

5.2.4 Where tests are conducted for classification or compliance purposes, test conditions are typically defined in codes, specifications, and manufacturer's technical literature.

6. Apparatus

6.1 *Test Dish*—The test dish shall be of any noncorroding material, impermeable to water or water vapor. There is no specified shape or maximum size for the test dish. Light weight is desirable. A shallow dish is preferred, but its size and weight are limited when an analytical balance is chosen to detect small weight changes. The mouth of the dish shall be as large as practical and at least 4.65 in.^{2} [3000 mm^2] in area. The desiccant or water area shall not be less than the mouth area except when a grid is used, as provided in 13.1, with its effective area not exceeding 10 % of the mouth area. A flange or ledge around the mouth, on which the specimen rests is commonly used to ensure sealing, but other configurations are allowed.

6.1.1 When the specimen area is larger than the mouth area, this overlay upon the ledge is a source of error. The magnitude of this error increases with the width of the overlay upon the ledge. The overlay material results in a positive error, indicating excessive water vapor transmission. To minimize this error, this overlay material is to be masked as described in 11.1 so that the mouth area defines the test area. The magnitude of the edge mask error is a complex function of the specimen thickness, ledge width, mouth area, and in some cases the specimen permeability. This error is discussed by Joy and Wilson (**1**)[3] (see 14.4.3). This type of error is to be limited to no more than 12 %. For a thick specimen the ledge width shall not exceed ¾ in. [19 mm] for a 10-in. [254-mm] or larger span mouth (square or circular) or ⅛ in. [3 mm] for a 5-in. [127-mm] span mouth (square or circular). For a 3-in. [76-mm] span mouth (square or circular) the ledge shall not exceed 0.11 in. [2.8 mm] wide. An allowable ledge that limits error to 12% shall be determined by interpolation for intermediate sizes. Per Joy and Wilson (**1**), using Equation 7, it is possible to solve for the ledge width that results in a specific or lower error rate. To achieve a lower error rate or to calculate specific intermediate ledge widths, the ledge width is solved for using Equation 7. When a rim is incorporated, it shall not be more than ¼ in. [6 mm] higher than the specimen as attached. See sections 12.1 and 13.1 for requirements for the clearance for the test dishes for the Desiccant Method and Water Method, respectively.

6.2 *Test Chamber*—The room or cabinet where the assembled test dishes are to be placed shall have a controlled temperature and relative humidity. Common test conditions are listed in Appendix X1. If not listed among these, temperature and relative humidity corresponding to the intended application of, or specification for, the material to be tested (see Appendix X1) are used. Refer to product standard specification for test conditions for classification or compliance purposes. Temperature shall be maintained at ± 5 °F [2.8 °C] at a given measurement point, with the average at the end of the test period being within ± 2 °F [1.1°C] of the specified test

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

condition. Relative humidity shall be maintained at ± 5 % at a given measurement point, with the average at the end of the test period being within ± 2% of the specified test condition. Provisions shall be made to prevent water from dripping onto the surface of a specimen when tested at high humidity, when condensation on the chamber walls is possible. Both temperature and relative humidity shall be measured and recorded at a frequency of at least once every 15 min for the duration of the test. Air shall be continuously circulated throughout the chamber, with a velocity sufficient to maintain uniform conditions within the chamber. Test dishes shall be placed in the chamber in such a way that air flow is not restricted over the top of the specimen. Barometric pressure shall be measured and recorded at every weighing for use in the still air correction. See 15.6.1.1.

6.3 *Balance*—Weighing shall be performed using an electronic analytical balance of suitable capability (See Note 1).

NOTE 1—Various aspects of balance specifications and performance other than capacity and resolution should be considered in choosing equipment suitable for the weighing demands of these tests. In use, best laboratory practices for verification of balance performance, along with proper care and maintenance should be followed.

6.3.1 The balance shall have sufficient capacity to accommodate the assembled dish mass and, in the case of desiccant method tests, added mass of any moisture gained.

6.3.2 Resolution (or readability) of the balance shall be no more than 1 % of the assembled dish assembly weight change during the span of six or more consecutive steady state weighings utilized per 14.3.

6.3.2.1 If the resolution does not meet the requirement of 6.3.2, weighing shall be extended until such a point that the weight change is at least 100 times the resolution of the balance (See Note 2).

NOTE 2—Example: The following table lists the days at steady state required at various balance resolutions less than that of the balance used for the hypothetical specimen shown.

Balance Resolution = 0.1 mg (0.0001 g)
Weighed once every 24 h
Steady state observed, six points chosen (five days)
Weight gain over steady state span = 0.7815 g

Balance Resolution	Number of Days
0.1 mg	5
0.001 g	5
0.01 g	7
0.1 g	64
1.0 g	640

6.3.2.2 In cases where WVTR is near zero and weight gain or loss is so small that the requirements of this section cannot be fulfilled regardless of test duration, the report shall make note of such.

6.4 *Thickness-Measuring Gage*—The gage shall have an accuracy of ±1 % of the reading or 0.0001 in. [0.0025 mm], whichever is greater.

7. Materials

7.1 *Desiccant*—For the Desiccant Method, anhydrous calcium chloride in the form of small pellets that will pass a No. 8 [2.36-mm] sieve, and free of fines that will pass a No. 30 [600-µm] sieve, shall be used.

7.1.1 Desiccant to be re-used shall be dried at 400°F [200°C] for 4 hours per inch, or any fraction thereof, of desiccant depth in vessel. Re-dried desiccant shall be stored in a sealed container and be at room temperature before use.

7.1.2 Virgin material that has been in a sealed container does not have to be dried before use.

7.2 *Water*—For the Water Method, distilled water shall be used in the test dish (Note 5).

7.3 *Sealant*—The sealant used for attaching the specimen to the dish must be impervious to the passage of water vapor (and water). Seals of molten asphalt or wax are required for tests producing results below 4 perms [230 $ng \cdot m^{-2} \cdot s^{-1} \cdot Pa^{-1}$]. Sealing methods are discussed in Appendix X2.

8. Sampling

8.1 The material shall be sampled in accordance with standard methods of sampling applicable to the material or product under test. For homogenous materials, the sample shall be of uniform thickness. When the opposing faces of a product are dissimilar, the two faces shall be designated by distinguishing identification (for example, on a one-side-coated sample, "I" for the coated side and "II" for the uncoated side).

9. Test Specimens

9.1 Test specimens shall be representative of the material tested. When a product is designed for use in only one position, three specimens shall be tested by the same method with the vapor flow in the designated direction. When the faces of a product are indistinguishable, three specimens shall be tested by the same method. When the faces of a product are different, and the location of the vapor source is independent of the installation, six specimens shall be tested by the same method, three being tested with the vapor flow in each direction and so reported. A blank specimen for both orientations is required (see 9.6).

9.2 Materials of homogeneous composition and physical structure shall be tested at any thickness to determine water vapor permeance (WVP). When determining permeability, the specimen must be a minimum of ½ in. [12.5 mm] thick.

9.3 A slab of a singular material that varies in physical structure by layer (such as a foamed plastic or rubber with natural "skins") shall be tested at the thickness of use.

9.4 When a material has a pitted or textured surface, the tested overall thickness, if less than that of use, shall be at least five times the sum of the maximum pit depths in both its faces.

9.5 When testing pressure sensitive adhesive sealed joints used in insulation vapor retarder systems, prepare the specimens according to Practice C1809.

9.6 *Use of a Blank Specimen:*

9.6.1 All tests require an additional blank specimen to be tested exactly like the others, except that no desiccant or water is put in the dish. Failure to use this blank specimen to establish modified dish weights may significantly increase the time required to complete the test. The time to reach equilibrium of water vapor transmission increases as the square of thickness.