



Designation: D6701 – 24

Standard Test Method for Determining Water Vapor Transmission Rates Through Nonwoven and Plastic Barriers¹

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1. Scope

1.1 This test method covers a procedure for determining the rate of water vapor transmission ranging between 500 to 100 000 g/(m²·day) through nonwoven and plastic barrier materials. The method is applicable to films, barriers consisting of single or multilayer synthetic or natural polymers, nonwoven fabric, and nonwoven fabrics coated with films up to 3 mm (0.1 in.) in thickness. This method is quantitative and has been demonstrated by the enclosed [Table 1](#) Summary of Precision and Bias Analysis to be effective for measuring the water vapor transmission rate of materials from 7586 g/(m²·day) to 51 996 g/(m²·day).

1.2 This test method provides for the determination of (1) water vapor transmission rate (WVTR), and (2) the permeance to water vapor.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard. The acceptable units for WVTR are usually g/(m²·day).

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

1.5 *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.*

¹ This test method is under the jurisdiction of ASTM Committee F02 on Primary Barrier Packaging and is the direct responsibility of Subcommittee F02.10 on Permeation.

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2. Referenced Documents

2.1 ASTM Standards:²

D123 Terminology Relating to Textiles

D1898 Practice for Sampling of Plastics (Withdrawn 1998)³

D4204 Practice for Preparing Plastic Film Specimens for a Round-Robin Study

D5729 Test Method for Thickness of Nonwoven Fabrics (Withdrawn 2008)³

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

F1249 Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

3. Terminology

3.1 Definitions:

3.1.1 *water vapor permeability coefficient, n*—the ratio of the permeance and the thickness.

3.1.1.1 *Discussion*—This quantity should not be used unless the relationship between thickness and permeance has been verified in tests using several thickness' of the material. The water vapor permeability is meaningful only for homogeneous materials, in which case it is a property characteristic of bulk material. An accepted unit of water vapor permeability is the metric perm centimeter, or 1 g per m² per day per mm Hg·cm of thickness. The SI unit is the mol/(m²·s·Pa·mm).

3.1.2 *water vapor permeance, n*—the ratio of a barrier's water vapor transmission rate to the vapor pressure difference between the two surfaces.

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.

TABLE 1 Summary of Precision and Bias Analysis

NOTE 1—The terms repeatability and reproducibility are used as specified in Practice E177. The repeatability limits stated mean that approximately 95 % of all pairs of test results obtained within a laboratory on specimens from a sample of the stated material can be expected to differ by less than limits shown. The reproducibility limits imply the same level of agreement when the testing is conducted in two well-controlled laboratories.

Material	Average Test Value	Repeatability Standard Deviation	Reproducibility Standard Deviation	95 % Repeatability Limit	95 % Reproducibility Limit
A	51996	3486	6816	9761	19085
B	30065	2542	3124	7118	8748
C	7586	588	653	1646	1829

3.1.2.1 *Discussion*—An accepted unit of water vapor permeance is the metric perm, or 1 g/m^2 per day per mm Hg. The SI unit is the $\text{mol}/(\text{m}^2\text{-s-Pa})$. Since the water vapor permeance of a specimen is generally a function of relative humidity and temperature, therefore those conditions must be stated.

3.1.3 *water vapor transmission rate (WVTR), n*—the steady-state time rate of water vapor flow through unit area of a specimen, normal to the surfaces under specific conditions of temperature and humidity at each surface.

3.1.3.1 *Discussion*—A common practice accepted unit of water vapor transmission rate is metric g/m^2 per day. The test conditions of relative humidity and temperature where the driving force is the difference in relative humidity across the specimen must be stated.

4. Summary of Test Method

4.1 A dry chamber, guard film, and a wet chamber make up a diffusion cell in which the test film is sealed. A first test is made of the WVTR of the guard film and air gap between an assembly that generates relative humidity. A sensor produces an electrical signal, the amplitude of which is proportional to water vapor concentration. The electrical signal is routed to a computer for processing. The computer calculates the transmission rate of the air gap and guard film and stores the value for further use. The barrier is then sealed in the test cell and the apparatus started in the test mode. As before, the electrical signal representing the water vapor is sent to the computer which then calculates the transmission rate of the combination of the air gap, the guard film, and the test barrier. The computer then uses this information to calculate the WVTR of the material being tested. The computer determines when the measured results indicate that the specimens have reached equilibrium values and the testing is considered finished.

5. Significance and Use

5.1 The purpose of this test method is to obtain values for the WVTR of barrier materials.

5.2 WVTR is an important property of materials and can be related to shelf life; product stability, breath-ability, and wear-in comfort.

5.3 Data from this test method is suitable as a referee method of testing, provided that the purchaser and seller have agreed on sampling procedures, test conditions, and acceptance criteria.

6. Apparatus

6.1 This method utilizes water vapor transmission apparatus⁴ comprised of the following:

6.1.1 *Test Cells*, the apparatus has test cells formed by metal halves which, when closed upon the test specimens, will accurately define an area for each. The volume enclosed by each cell half, when clamped, is not critical. It is desirable that the air gap between the RH generator assembly and the guard film be as small as practical, but not so small that an unsupported film which sags or buckles will contact the evaporator assembly. The barrier under test should be in intimate contact with the guard film. A depth of approximately 3.2 mm (0.125 in.) has been found to be satisfactory for the carrier gas side of a test cell.

6.1.1.1 *Test Cell Sealing Surface*, a critical sealing surface against which the test specimen is pressed; it shall be smooth and without radial scratches. The test area is considered to be established by the inside contact area when the test cell is clamped shut against the test specimen.

6.1.1.2 *Test Cell Air Passages*, two holes in the dry half of the diffusion cell that pass carrier gas and water vapor to either exhaust ports or the sensor assembly. One cell at a time can be connected to the sensor assembly by solenoid valves.

6.1.1.3 *Test Cell Guard Film*, a flat film that covers the humid side of each cell. The film is a barrier that stills the air in the gap between the RH generator and the mounting plane of the specimen. The guard film is a very high transmitter of water vapor. Its transmission rate as well as that of the air gap is accounted for in the apparatus' measurements.

6.1.1.4 *Water Vapor Sensor*, a water vapor detector capable of sensing 0 % to 100 % relative humidity with sufficient accuracy so the apparatus can determine transmission rates down to 500 g/m^2 per day.

6.1.1.5 *Mass Flowmeter*, a means for regulating the flow of dry air within an operating range of 0 cc/min to 200 cc/min.

6.1.1.6 *Flow-Metering Valves*, fine-metering valves capable of controlling the dry-air flow rate to each test.

6.1.2 *Computer System*, a computer provides the main control, calculating, and data storage device for the system.

⁴ The sole source of supply of the apparatus known to the committee at this time is MOCON, Inc., 7500 Mendelssohn Ave N, Minneapolis, MN 55428. If you are aware of any alternative suppliers, please provide this information to ASTM headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend. MOCON's apparatus is known as the PERMATRAN-W Model 101K.