INTERNATIONAL

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Standard Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting[1]

This standard is issued under the fixed designation D1434; 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 This test method utilizes a manometric method to determine the steady-state rate of transmission of a gas through plastics in the form of film, sheeting, laminates, and plastic-coated papers or fabrics. This test method provides for the determination of *(1)* gas transmission rate (GTR), *(2)* permeance, and, in the case of homogeneous materials, *(3)* permeability.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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]

D618 Practice for Conditioning Plastics for Testing

D1898 Practice for Sampling of Plastics (Withdrawn 1998)[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *gas transmission rate, GTR, n*—the quantity of a given gas passing through a unit of the parallel surfaces of a plastic film in unit time under the conditions of test. The SI unit of GTR is mol/(m^2·s). The test conditions, including temperature and partial pressure of the gas on both sides of the film, must be stated. Other factors, such as relative humidity and hydrostatic pressure, that influence the transport of the gas must also be stated. A commonly used unit of GTR is mL (STP)/(m^2·d) at a pressure differential of one atmosphere.

3.1.2 *permeance, P, n*—the ratio of the gas transmission rate to the difference in partial pressure of the gas on the two sides of the film. The SI unit of permeance is mol/ (m^2·s·Pa). The test conditions (see 5.1) must be stated.

3.1.3 *permeability, $\underline{P}$', n*—the product of the permeance and the thickness of a film. The permeability is meaningful only for homogeneous materials, in which it is a property characteristic of the bulk material. This quantity should not be used unless the constancy of the permeability has been verified using several different thicknesses of the material. The SI unit of $\underline{P}$ is (mol·m)/(m^2·s·Pa) = mol ⁄(m·s·Pa). The test conditions (see 5.1) must be stated.

NOTE 1—One milliliter (STP) is 44.62 µmol, one atmosphere is 0.1013 MPa, and one day is 86.4×10^3 s. GTR in SI units is obtained by multiplying the value in inch-pound units by 5.160×10^{-10}. Additional units and conversions are shown in Appendix X1.

3.1.4 *steady state*—the state attained when the amount of gas absorbed in the film is in equilibrium with the flux of gas through the film.

4. Summary of Test Method

4.1 The sample is mounted in a gas transmission cell so as to form a sealed semi-barrier between two chambers. One chamber contains the test gas at a specific high pressure, and the other chamber, at a lower pressure, receives the permeating gas.

4.1.1 The lower pressure chamber is initially evacuated. Following the evacuation, the low-pressure chamber is allowed to accumulate the permeating test gas. The transmission of the gas through the test specimen is determined from monitoring the slope of the increasing pressure over time.

[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] 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.

5. Significance and Use

5.1 These measurements give semiquantitative estimates for the gas transmission of single pure gases through film and sheeting. Correlation of measured values with any given use, such as packaged contents protection, must be determined by experience. The gas transmission rate is affected by conditions not specifically provided for in these tests, such as moisture content (Note 2), plasticizer content, and nonhomogeneities. These tests do not include any provision for testing seals that may be involved in packaging applications.

NOTE 2—The tests are run using gas with 0 % moisture changes.

5.2 The historic Interlaboratory testing has revealed that permeances measured by these procedures exhibit a strong dependence on the procedure being used, as well as on the laboratory performing the testing. The historic method relied upon manual calibrations of Hg capillary columns and manual data readings of pressure. The references and use of Hg and capillary columns have been removed from this standard as current D1434 instruments rely upon readily calibrated vacuum gauges and automated recording of data. It is planned that the next revision of this standard includes an updated ILS with modern instrumentation. Additionally, it has been noted that an agreement with other gas transmission rate methods is sometimes poor and may be material-dependent. The materials being tested often affect the between-laboratory precision. The causes of these variations are not precisely known at this time, but is likely due to the fact that this method analyzes ALL gasses from the sample and not just the Test gas. This includes pre-absorbed water vapor within the sample and any free solvents remaining within the specimen. The 48 hr desiccator drying period outlined within the method may not be long enough for all materials. Additionally, other gas transmission rate methods (as those used for oxygen transmission rate, water vapor transmission rate and carbon dioxide transmission rate) often incorporate test gas specific sensors and therefore would minimize influence from other gasses. It is suggested that this method not be used for referee purposes unless purchaser and seller can both establish that they are measuring the same quantity to a mutually agreed upon level of precision.

5.3 Use of the permeability coefficient (involving conversion of the gas transmission rate to a unit thickness basis) is not recommended unless the thickness-to-transmission rate relationship is known from previous studies. Even in essentially homogeneous structures, variations in morphology (as indicated, for example, by density) and thermal history may influence permeability.

6. Test Specimen

6.1 The test specimen shall be representative of the material, free of wrinkles, creases, pinholes, and other imperfections, and shall be of uniform thickness and be capable of being mounted airtight (for example, no edge leakage, which can occur with papers). The test specimen shall be cut to an appropriate size (generally circular) to fit the test cell.

6.2 Use three specimens unless otherwise specified or agreed upon among interested parties.

6.3 Mark the side of the material facing the test gas. Note: It's most common to orientate the sample as it is utilized in real-life (for example, if measuring oxygen passing from the outside of a package to the inside, then the "outside face" of the sample should be exposed to the high pressure oxygen and the "inside face" should be exposed to the vacuum side of the test cell).

6.4 If required for permeability normalization, the thickness of the specimen shall be measured to the nearest 2.5 µm with a calibrated dial gage (or equivalent) at a minimum of five points distributed over the entire test area. Maximum, minimum, and average values should be recorded. An alternative measure of thickness involving the weighing of a known area of specimens having a known density is also suitable for homogeneous materials.

7. Conditioning and Test Temperature

7.1 *Standard Conditioning*—To reduce innate outgassing concerns of the material (such as absorbed water vapor or solvents), condition all test specimens at 23 °C ± 2 °C in a desiccator over calcium chloride or other suitable desiccant for not less than 48 h prior to test in accordance with Practice D618, for those tests where conditioning is required.

7.2 *Alternative Conditioning*—Alternatives to 7.1 may be used for conditioning the specimens provided that these conditions are described in the report. As an example, an alternative conditioning could be placing the sample into a N2 purging box to remove absorbed humidity or solvents.

7.3 *Test Temperature*—For ambient testing, the temperature of the cell should be controlled at 23 °C ± 2 °C. For instruments that can control the cell temperature a tolerance of ± 1 °C shall be utilized.

8. Sampling

8.1 The techniques used in sampling a batch of material to be tested by these procedures must depend upon the kind of information that is sought. Care should be taken to ensure that samples represent conditions across the width and along the length of rolls of film. Practice D1898 provides guidelines for deciding what procedures to use in sampling a batch of material. Enough specimens must be tested to ensure that the information obtained is representative of the batch or other lot size being tested.

9. Apparatus

9.1 The apparatus shown in Fig. 1 outlines the components needed for a manometric GTR test.

The apparatus consists of a test cell that clamps a test specimen between two cell halves, creating high-pressure and low-pressure chambers. A pressure differential during the test creates the environment for gas transmission through the sample. On the test gas (high-pressure) side of the sample is a feeder that ensures that the supply and pressure of the test gas remains a constant driving force. On the measurement (low-pressure) side of the sample is a pressure sensor (vacuum gauge) that measures the pressure change of the system as gas permeates through the specimen. Plumbed beneath the low-pressure chamber is a vacuum pump to initially evacuate the