Designation: E 154 – 99

An American National Standard

Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover[1]

This standard is issued under the fixed designation E 154; 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[2] cover the determination of the properties of flexible membranes to be used as vapor retarders in contact with earth under concrete slabs, against walls, or as ground cover in crawl spaces. The test methods are applicable primarily to plastic films, and other flexible sheets. The materials are not intended to be subjected to sustained hydrostatic pressure. The procedures simulate conditions to which vapor retarders may be subjected prior to and during installation, and in service.

1.2 The test methods included are:

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1.3 The values stated in acceptable metric units shall be considered standard. The values in parentheses are for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

C 168 Terminology Relating to Thermal Insulating Materials[3]

C 755 Practice for Selection of Vapor Retarders for Thermal Insulation[3]

D 828 Test Method for Tensile Breaking Strength of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus[4]

D 1709 Test Methods for Impact Resistance of Plastic Film by the Falling Dart Method[5]

D 1985 Practice for Preparing Concrete Blocks for Testing Sealants, for Joints and Cracks[6]

D 2565 Practice for Operating Xenon Arc-Type Light-Exposure Apparatus With and Without Water for Exposure of Plastics[7]

D 4397 Specification for Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications[8]

E 84 Test Method for Surface Burning Characteristics of Building Materials[9]

E 96 Test Methods for Water Vapor Transmission of Materials[3]

E 241 Practices for Increasing Durability of Building Constructions Against Water-Induced Damage[10]

E 437 Specification for Industrial Wire Cloth and Screens (Square Opening Series)[11]

E 631 Terminology of Building Constructions[10]

3. Terminology

3.1 *Definitions:* For definitions of terms used in these test methods, see Terminologies C 168 and E 631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *water–vapor transmission* (WVT), *n*—the steady water vapor flow in unit time through unit area of a flat material or a construction normal to specific parallel surfaces induced

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[2] Some of these test methods were based originally on *Report No. 2040*, U.S. Forest Products Laboratory, and "Vapor Barrier Materials for Use with Slab-On-Ground Construction and as Ground Covers in Crawl Spaces," *Publication 445-1956*, Building Research Advisory Board (currently out-of-print).

[3] *Annual Book of ASTM Standards*, Vol 04.06.
[4] *Annual Book of ASTM Standards*, Vol 15.09.
[5] *Annual Book of ASTM Standards*, Vol 08.01.
[6] *Annual Book of ASTM Standards*, Vol 04.03.
[7] *Annual Book of ASTM Standards*, Vol 08.02.
[8] *Annual Book of ASTM Standards*, Vol 08.03.
[9] *Annual Book of ASTM Standards*, Vol 04.07.
[10] *Annual Book of ASTM Standards*, Vol 04.11.
[11] *Annual Book of ASTM Standards*, Vol 14.02.

by specific temperatures, pressures, and humidities at each surface. Units in SI are kilogram per second, square metre, (kg/s·m^2); in inch-pound grain per hour, square foot, (grain/h·ft^2).

3.2.2 *water–vapor permeance*, *n*—the time rate of water vapor flow through unit area of the known thickness of a flat material or a construction normal to two specific parallel surfaces induced by unit vapor pressure difference between the two surfaces under specific temperature and humidityconditions. While the SI unit is kg/s·m ^{2}·Pa, the practical unit is the perm (see 3.2.3).

3.2.3 *perm*, *n*—the time rate of water vapor migration through a material or a construction of 1 grain/h·ft ^{2}·in. Hg of vapor pressure difference.

3.2.3.1 *Discussion*—There are no SI units that can be combined to give the same mass flow rate as the inch-pound perm without a numerical coefficient. If a specification states that a one perm resistance is required, the same rate of flow will be obtained from the following relationships:

1 perm	= 1 grain/h·ft^2·in. Hg	Inch-pound units
	= 57.2·10^{-12} kg/s·m^2·Pa	SI (fundamental units)
	= 57.2 ng/s·m^2·Pa	SI (frequently used)
	= 0.66 g/24 h·m^2·mm Hg	SI (deprecated, should not be used)

The perm is a specific rate of vapor flow regardless of the units that were used in measuring the flow rate or in converting them into desired units.

3.2.4 *water–vapor permeability*, *n*— the time rate of water vapor flow through unit area of unit thickness of a flat material induced by unit vapor pressure difference between two parallel specified surfaces under specific temperature and humidity conditions.

3.2.4.1 *Discussion*—Since vapor flow rate does not vary directly with thickness for many materials, comparisons of vapor flow rates for retarders of various thicknesses should be made on test results of permeance rather than on permeability.

4. Significance and Use

4.1 In service, vapor retarders may be exposed to a variety of conditions, so no one test will provide evaluations related to performance for all exposures (refer to Practices E 241 and C 755). Neither will all test methods listed be necessary in all evaluations for specific exposures (see 16.2).

4.2 *Limitations*—Prior to use and in service, vapor retarders may be exposed to a variety of conditions so no one test will provide evaluations related to performance for all exposures (refer to Practices E 241 and C 755). Neither will all tests be necessary in all evaluations for specific exposures. Consequently, the tests and required test results shall be agreed upon by the purchaser and the supplier (see 16.2).

5. Sampling

5.1 Obtain samples for preparation of test specimens from each of three separate rolls or packages of each type of material being tested. Samples shall be representative of the material being tested and shall be of uniform thickness. If the samples are of nonsymmetrical construction, designate the two faces by distinguishing marks and report which side was exposed to a specific condition.

6. Test Specimen

6.1 The number and size of test specimens of each material are specified in each test procedure. Great care is required to protect the test areas of the specimens against damage or contamination.

7. Water-Vapor Transmission of Material as Received

7.1 *Significance and Use*—Since the water-vapor flow rate through a material in service is significant in order for comparisons to be made of performance after specific treatments of the material, the water-vapor flow rate of the material as received is needed as a reference value. The as-received material is presumed to be representative of the material that is to be used on the purchaser's project.

7.2 *Apparatus*—The apparatus and test facilities are described in Test Methods E 96.

7.3 *Procedure*:

7.3.1 Make water-vapor transmission tests on at least three specimens of each material in accordance with Procedure B of Test Methods E 96. If the retarder material is coated or treated on one surface to improve its water-vapor resistance, make the test with this surface toward the water unless otherwise specified.

7.3.2 Where wax seals are used with the wet method, it is good procedure to heat the test dishes uniformly to 45°C (113°F) or slightly warmer before sealing the test sample to the dish to avoid having the wax become too viscous for good sealing.

7.4 *Precision and Bias*—The statements regarding precision and bias in Test Methods E 96 shall also apply to this test method.

8. Water-Vapor Transmission after Wetting and Drying and after Long-Time Soaking

8.1 *Significance and Use*—After water-vapor retarders leave the factory they are exposed to many conditions of wetting and drying, and may be subjected to immersion or partial immersion for various periods. To indicate the potential effect of wetting and drying, and relatively long-time exposure to soaking, the data from these tests will be compared with those of the material as received.

8.2 *Apparatus*:

8.2.1 *Controlled-Temperature Vessels*, of suitable size for soaking specimens, and equipped with a temperature controller actuated by a thermostat. The controller shall be of a type that will maintain temperature in the vessels between 22 and 24°C (72 and 75°F). If space permits, the test chamber used for the water-vapor transmission tests may be used to hold soaking pans in place of the thermostatically controlled vessel.

8.2.2 *Oven or Drying Chamber*, for drying test specimens, thermostatically controlled at a temperature between 60 and 62°C (140 and 144°F).

8.2.3 *Water-Vapor Transmission Apparatus*, as prescribed in Test Methods E 96.

8.2.4 *Mandrel*—A round metal bar or rod 25 mm (1 in.) in diameter and approximately 460 mm (18 in.) long.

8.3 *Procedure*:

8.3.1 Cut three specimens, 305 by 305 mm (12 by 12 in.) of the material to be tested.

8.3.2 Immerse the specimens in potable water kept at a temperature between 22 and 24°C (72 and 75°F) for 16 h (overnight). They dry the specimens in an oven kept between 60 and 62°C (140 and 144°F) for 8 h. Repeat the wetting and drying cycle for a total of 5 cycles (Monday through Friday) to be followed by immersing the specimens in water over the weekend (64 h). Repeat the wetting and drying cycle 5 more days and immerse the specimens in water for a period of 16½ days (weekend plus 2 weeks). Dry the specimens between 60 and 62°C (140 and 144°F) and then condition to a constant weight in the chamber where water-vapor transmission tests are made.

8.3.3 Cut the specimens into halves parallel to the machine direction (the long direction as taken from the roll or package). Bend one of the halves of each specimen with one surface up and the other specimen with the opposite surface up at an angle of 90° over a 25-mm (1-in.) diameter mandrel in a period of 2 s or less at a temperature between 22 and 24°C (72 and 75°F). Record evidence of cracking or delamination.

8.3.4 Cut specimens for the water-vapor transmission test so that the full bent portion is installed in the center of the pan with the surface that was concave at the time of bending facing the water. Determine water-vapor transmission in accordance with Section 7.

8.4 *Precision and Bias*—The statements regarding precision and bias in Test Methods E 96 shall also apply to this test method.

9. Tensile Strength

9.1 *Significance and Use*—The thin sheet materials that are used as vapor retarders are subjected to several kinds of handling stresses. Since it is desirable that the material have a tensile strength that will minimize tearing or permanent elongation in normal use, the tensile data may be used to compare different materials that are being considered for use in specific constructions.

9.2 *Apparatus*:

9.2.1 *Controlled-Temperature Vessels*— See 8.2.1.

9.2.2 *Testing Machine*—A pendulum-type tension testing machine such as described in Test Method D 828, or the equivalent.

9.3 *Procedure*:

9.3.1 Cut ten specimens, 25 m (1 in.) wide and 203 mm (8 in.) long, in each principal direction (crosswise and lengthwise) of the sample.

9.3.2 Immerse in potable water controlled at a temperature between 22 and 24°C (1) (72 and 75°F) for 7 days in such a manner that water has free access to all surfaces and edges of the specimens.

9.3.3 Remove the specimens from the water one at a time, lightly blot the free water from both surfaces, and immediately determine the tensile strength and elongation at maximum load. Test both sets of specimens at a temperature between 22 and 24°C (72 and 75°F) with the tester adjusted so the distance between the jaws is about 13 mm (½ in.). Line the jaws of the clamp with emery cloth or other rough material to prevent slippage of the specimen during test. Materials with high elongation may be tested with a requirement for energy absorbed to maximum load in joules or in inch-pounds. Average the ten readings, crosswise and lengthwise, respectively.

9.4 *Precision and Bias*—The statements on reproducibility in Test Method D 828 shall also apply to this test method.

10. Resistance to Puncture

10.1 *Significance and Use*:

10.1.1 One of the major stresses to which sheet materials used as vapor retarders are subjected is puncture. These data may be used to evaluate the resistance to one type of puncture force on different materials to be considered for a specific construction.

10.1.2 The falling dart test in the paragraph on Impact Resistance of Specification D 4397 may be used to evaluate puncture resistance of the material. (See Test Method D 1709 also.)

10.2 *Apparatus*:

10.2.1 *A Square Mounting Frame*, of wood, metal, or rigid plastic 254 by 254 mm (10 by 10 in.) outside with a 152 by 152 mm (6 by 6 in.) central opening, consisting of two parts that are held together with 8 thumbscrews, on each side. The thickness of wood or plastic shall be 32 mm (1¼ in.); of metal 10 mm (⅜ in.). The contact areas of each part shall be faced with well-adhered Grade No. 80 sandpaper to prevent slippage of the sheet under test (see Fig. 1).

10.2.2 *Steel Cylinder*, solid, 25-mm (1-in.) diameter, with the contact face smooth and at 90° with the axis, and with the edge of the end surface slightly rounded.

10.2.3 *Conventional Straightedges and Rules or Dials*, to indicate deflection of the test membrane at the edge of the steel cylinder.

10.3 *Procedure*:

10.3.1 Conduct the tests at a room temperature between 22 and 24°C (72 and 75°F).

10.3.2 Cut three 254-mm (10-in.) square specimens of the material to be tested. Condition specimens to a constant weight between 22 and 24°C (72 and 75°F) and between 45 and 55 % relative humidity.

10.3.3 Place a single sheet between the upper and lower parts of the mounting frame and tighten the thumbscrews.

10.3.4 Make the tests at a room temperature between 22 and 24°C (72 and 75°F). Support the test frame containing the mounted specimen on all sides on a rigid base high enough to enable the specimen to deflect to its maximum. A circular or a square support may be used. Bring the end surface of the solid steel cylinder into contact with the sheet being tested. Lower the cylinder at a rate of 6 mm (¼ in.)/min, and measure the membrane deflection within 6 mm (¼ in.) of the edge of the cylinder. Record the membrane deflection and the load periodically. Continue the test until the maximum load is reached.

10.3.5 Report the maximum load, the membrane deflection at maximum load, and the type of failure of the sheet.

10.3.6 Average the values for the three tests.

10.4 *Precision and Bias*—At this time, insufficient data are available to make a statement on precision and bias. However, when the necessary data have been accumulated, the appropriate statement will be added to this test method.