



Designation: D4491/D4491M – 15

## Standard Test Methods for Water Permeability of Geotextiles by Permittivity<sup>1</sup>

This standard is issued under the fixed designation D4491/D4491M; 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 ( $\epsilon$ ) 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 procedures for determining the hydraulic conductivity (water permeability) of geotextiles in terms of permittivity under standard testing conditions, in the uncompressed state. Included are three procedures: the constant head and falling head methods using a water flow apparatus, and the air flow method using an air flow apparatus.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the 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 and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

[D123 Terminology Relating to Textiles](#)

[D653 Terminology Relating to Soil, Rock, and Contained Fluids](#)

[D4439 Terminology for Geosynthetics](#)

[D5199 Test Method for Measuring the Nominal Thickness of Geosynthetics](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D35 on Geosynthetics and are the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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<sup>2</sup> 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.

#### 2.2 ASTM Adjuncts:<sup>3</sup>

Detailed Drawings and Materials List for Construction, 10 Drawings

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *geotextile, n*—a permeable geosynthetic comprised solely of textiles.

3.1.2 *permeability, n*—the rate of flow of a liquid under a differential pressure through a material.

3.1.2.1 *Discussion*—The nominal thickness is used as it is difficult to evaluate the pressure on the geotextile during the test, thereby making it difficult to determine the thickness of the fabric under these test conditions.

3.1.3 *permeability, n*—of geotextiles, hydraulic conductivity.

3.1.4 *permittivity, ( $\psi$ ), (T-1), n*—of geotextiles, the volumetric flow rate of water per unit cross sectional area per unit head under laminar flow conditions, in the normal direction through a geotextile.

3.1.5 For the definitions of other terms relating to geotextiles, refer to Terminology D4439. For the definitions of textile terms, refer to Terminology D123. For the definition of coefficient of permeability, refer to Terminology D653.

### 4. Summary of Test Method

4.1 *Water Flow Test Methods*—These test methods describe procedures for determining the permittivity of geotextiles using constant head or falling head test procedures with a water flow apparatus:

4.1.1 *Method A - Constant Head Test*—A head of 50 mm of water is maintained on the geotextile throughout the test. The quantity of flow is measured versus time. The constant head test is used when the flow rate of water through the geotextile is so large that it is difficult to obtain readings of head change

<sup>3</sup> Detailed drawings and a materials list for construction are available from ASTM International Headquarters. Order Adjunct No. ADJD4491.

versus time in the falling head test. The constant head test is the referee method for this standard.

NOTE 1—Data has shown agreement between the falling and constant head methods of determining permittivity of geotextiles.<sup>4</sup> Selection of the test method, that is, constant or falling head, is left to the technician performing the test.

4.1.2 *Method B - Falling Head Test*—A column of water is allowed to flow through the geotextile and readings of head changes versus time are taken. The flow rate of water through the geotextile must be slow enough to obtain accurate readings.

4.1.3 *Method C - Air Flow Test*—A geotextile specimen is subjected to increasing air flow while the flow rate and differential pressure are measured. Two flow rate data points are obtained at pressures of 250 and 500 Pascals, which are used to determine the Characteristic Flow Equation of the specimen. The water permittivity at 50-mm water head is then calculated using the conversion algorithm described in this standard.

## 5. Significance and Use

5.1 These test methods are considered satisfactory for acceptance testing of commercial shipments of geotextiles since the methods have been used extensively in the trade for acceptance testing.

5.1.1 In case of a dispute arising from differences in reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens should then be randomly assigned in numbers to each laboratory for testing. The average results from the two laboratories should be compared using Student's t-test for unpaired data and an acceptable probability level chosen by the two parties before the start of testing. If a bias is found, either its cause must be found and corrected, or the purchaser and the supplier must agree to interpret future test results in light of the known bias.

5.1.2 When the dispute involves test results produced with either the Method B Falling Head Test or the Method C Air Flow Test, the Method A Constant Head Test, performed with a 50-mm head should be used as the referee method.

5.1.3 When the dispute involves Method C, the actual water temperature used for the water flow tests must be recorded and the viscosity of water at the test temperature must be used in the conversion from the air flow to water flow as described in Section 16, without the application of the temperature correction.

5.1.4 Permittivity is an indicator of the quantity of water that can pass through a geotextile in an isolated condition.

5.1.5 As there are many applications and environmental conditions under which a geotextile may be used, care should

be taken when attempting to apply the results of these test methods to the field performance of a geotextile.

5.2 Since there are geotextiles of various thicknesses in use, evaluation in terms of their Darcy coefficient of permeabilities can be misleading. In many instances, it is more significant to evaluate the quantity of water that would pass through a geotextile under a given head over a particular cross-sectional area; this is expressed as permittivity.

5.3 If the permeability of an individual geotextile is of importance, a nominal coefficient of permeability, as related to geotechnical engineering, may be computed. By multiplying permittivity times the nominal thickness of the geotextile, as determined by Test Method D5199, the nominal coefficient of permeability is obtained.

NOTE 2—The nominal thickness is used as it is difficult to evaluate the pressure on the geotextile during the test, thereby making it difficult to determine the thickness of the fabric under these test conditions.

## 6. Apparatus

6.1 *Water Flow Apparatus*—The apparatus for performing the water flow tests shall conform to one of the following arrangements:

6.1.1 The apparatus must be capable of maintaining a constant head of water on the geotextile being tested, or

6.1.2 The apparatus must be capable of being used as falling head apparatus.

6.1.3 The location of the manometer for measuring the head loss in either constant head or falling head methods shall be located directly beneath the specimen. For the device shown in Fig. 1, this may be accomplished by drilling and tapping a small (3-mm) diameter hole in the top plate of the bottom reservoir tank directly beneath the specimen, and attaching the manometer to this plate.

6.2 In addition, the apparatus must not be the controlling agent for flow during the test. It will be necessary to establish a calibration curve of volumetric flow rate versus head for the apparatus alone in order to establish compliance with this requirement (see 11.7).

6.3 Refer to Fig. 1 for a schematic drawing of a device that conforms to all of the above requirements. The device consists of an upper and lower unit, which fasten together. The geotextile specimen is positioned in the bottom of the upper unit. There is a standpipe for measuring the constant head value. The rotating discharge pipe allows adjustment of the head of water at the bottom of the specimen.<sup>3</sup> See ADJD4491.

6.4 *Air Flow Apparatus*—The apparatus for performing the air flow tests shall conform to the following specifications:

6.4.1 *Clean Gas Pressure Source*, with regulation (filtered air).

6.4.2 *Pressure Sensor*—Pressure measurements must be obtained with a digital pressure transducer with an accuracy of  $\pm 5$  Pascals.

6.4.2.1 The head (upstream) pressure manometer tap must be installed immediately upstream, within 10 mm, of the test specimen surface.

<sup>4</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D35-1007. Contact ASTM Customer Service at service@astm.org.



FIG. 1 Constant and Falling Head Permeability Apparatus

6.4.2.2 The tail (downstream) pressure sensor must be installed 25 mm or more from the geotextile test specimen, and within the 25-mm diameter section.

6.4.3 *Closed Specimen Holder:*

6.4.3.1 Specimen holder for the test specimens that fully confines the perimeter of the specimen to prevent any lateral pressure losses.

6.4.3.2 The specimen flow area shall be 25-mm diameter.

6.4.3.3 The filter holder should be checked for leaks by placing an impermeable membrane in the holder and increasing the pressure to the maximum capacity of the pressure sensor and holding it for a period of one minute. The flow rate measured during this period must be zero indicating a leak-free seal.

6.4.4 *Metal Punch*, used to cut a suitable size geotextile from the test sheet to fit the test specimen holder.

6.4.5 *Flow Rate Measurement Sensors*—The apparatus should be equipped with a digital flow meter to measure the flow rates at the two desired pressures. The flow meter must have an accuracy of at least  $\pm 0.5$  lpm or 1.0 % of the measured value, whichever is larger.

6.4.6 *Flow Section*—The geometry of the air flow apparatus at the section where the test specimen is located must have a uniform 25-mm pipe diameter upstream and downstream of the test specimen for a minimum distance in both directions of 50 mm.

**7. Sampling**

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of rolls of geotextile directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of geotextile to be the primary sampling units. If the specification requires sampling during manufacture, select the rolls for the lot sample at uniformly spaced time intervals throughout the production period.

NOTE 3—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of geotextile and between specimens from a swatch from a roll of geotextile so as to provide a sampling plan with a meaningful producer’s risk, consumer’s risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—Take for the laboratory sample a full roll width sample extending a minimum of 1 m along the selvage from each sample roll such that the requirements of Section 9 can be met. Take a sample that will exclude material from the outer wrap of the roll or the inner wrap around the core unless the sample is taken at the production site, at which point inner and outer wrap material may be used.

**8. Test Water Preparation - Water Flow Tests**

8.1 To provide reproducible test results, the test water used for the water flow tests shall be de-aired to bring the dissolved oxygen content down to a maximum of six parts per million. The dissolved oxygen content may be determined by either commercially available chemical kits or by a dissolved oxygen meter.

NOTE 4—The de-airing system may be either a commercially available system or one consisting of a vacuum pump capable of removing a minimum of 150 L/min of air in connection with a non-collapsible storage tank with a large enough storage capacity for the test series, or at least one specimen at a time.

8.2 Allow the de-aired water to stand in a closed storage tank under a slight vacuum until room temperature is attained.

8.3 The test water must be maintained at the standard atmosphere for geosynthetic testing which is  $21 \pm 2^\circ\text{C}$ .

**9. Specimen Preparation**

9.1 To obtain a representative value of permittivity, take four specimens from each full width laboratory sample as described below.

9.2 Referring to Fig. 2, select four specimens, A, B, C, and D, as follows:

9.2.1 Select four specimens equally spaced across the width of the sample. For woven geotextiles, take the test specimens along a diagonal line extending from the lower left hand corner to the upper right hand corner of the laboratory sample. None of the test specimens shall be closer to the corner of the laboratory sample than 200 mm [8 in.].

9.2.2 For the Method C Air Flow tests, take ten test specimens equally spaced across the width of the sample. For woven geotextiles, take the ten test specimens equally spaced along a diagonal line extending from the lower left hand corner to the upper right hand corner of the laboratory sample. None of the specimens shall be closer to the edge of the laboratory sample than 200 mm [8 in.].

9.2.3 Cut specimens shall fit the testing apparatus, for example, 73 mm [2.87 in.] in diameter for the device illustrated in Fig. 1.

NOTE 5—If the illustrated device is used for the water flow tests, the specimens are attached to the specimen ring by contact cement.

**10. Operator Process Control**

10.1 *Water Flow Apparatus:*

10.1.1 Prepare four specimens of a No. 200 Standard U.S. Mesh Sieve to fit the test apparatus.

10.1.2 Following Section 11 or Section 13, depending on the method to be used for the geotextile specimens, perform testing on each mesh specimen.

10.1.3 Based on an interlaboratory test, involving seven laboratories, the permittivity of No 200 Standard US Mesh Sieve material has been determined to be  $5.00 \text{ s}^{-1}$ , with a standard deviation of 0.65.

10.1.3.1 New operator process control shall be performed until it is demonstrated that the operator is proficient in test

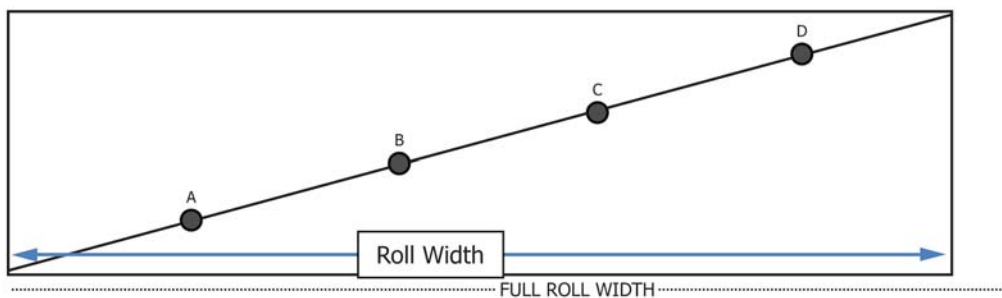


FIG. 2 Specimen Locations for Woven Geotextile Water Flow Tests