Designation: D4491/D4491M – 22

Standard Test Methods for Water Permeability of Geotextiles by Permittivity[1]

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 (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 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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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]

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

2.2 *ASTM Adjuncts:*[3]

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, (ψ), (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

[1] 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.

Current edition approved May 1, 2022. Published June 2022. Originally approved in 1985. Last previous edition approved in 2021 as D4491/D4491M – 21. DOI: 10.1520/D4491_D4491M-22.

[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] 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.[4] 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 Pa, 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. See ADJD4491.[3]

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 accurate to ±5 Pa to 1000 Pa, and ±1 % above 1000 Pa.

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

[4] 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 to 50 mm diameter. Smaller diameter devices are not acceptable.

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 1 min. 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