



Designation: D 4491 – 99a

Standard Test Methods for Water Permeability of Geotextiles by Permittivity¹

This standard is issued under the fixed designation D 4491; 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 approval. 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 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 two procedures: the constant head method and the falling head method.

1.2 The values stated in SI units are to be regarded as the standard. The inch-pound units stated in parentheses are provided for information only.

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:

D 123 Terminology Relating to Textiles²

D 653 Terminology Relating to Soil, Rock, and Contained Fluids³

D 4439 Terminology for Geotextiles⁴

D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes⁴

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁵

3. Terminology

3.1 Definitions:

¹ These test methods are under the jurisdiction of ASTM Committee D-35 on Geosynthetics and are the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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² *Annual Book of ASTM Standards*, Vol 07.01.

³ *Annual Book of ASTM Standards*, Vol 04.08.

⁴ *Annual Book of ASTM Standards*, Vol 04.13.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

3.1.1 *geotechnics, n*—the application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the earth's crust to the solution of engineering problems.

3.1.1.1 *Discussion*—Geotechnics embraces the fields of soil mechanics, rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.

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

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

3.1.3.1 *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.

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

3.1.5 *permittivity, (ψ), ($T-I$), 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.

3.1.6 For the definitions of other terms relating to geotextiles, refer to Terminology D 4439. For the definitions of textile terms, refer to Terminology D 123. For the definition of coefficient of permeability, refer to Terminology D 653.

4. Summary of Test Methods

4.1 These test methods describe procedures for determining the permittivity of geotextiles using constant head or falling head test procedures, as follows:

4.1.1 *Constant Head Test*—A head of 50 mm (2 in.) 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 versus time in the falling head test.

NOTE 1—Data has shown agreement between the falling and constant head methods of determining permittivity of geotextiles.⁶ Selection of the test method, that is, constant or falling head, is left to the technician performing the test.

4.1.2 *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.

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

5.1.3 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 D 5199, 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 The apparatus 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.

6.2 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.⁷

NOTE 3—The location of the manometer for measuring the headloss in either the constant head or falling head method shall be located directly beneath the specimen. For the device shown in Fig. 1, this may be accomplished by drilling a small (3mm; 1/8 in) diameter hole in the top plate of the bottom reservoir tank directly beneath the specimen, and attaching the manometer to this plate.

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 4—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

8.1 To provide reproducible test results, the test water shall be de-aired under a vacuum of 710 mm (28 in.) of mercury (Hg) for a period of time 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 5—The de-airing system may be either a commercially available system or one consisting of a vacuum pump capable of removing a

⁶ Data available from ASTM Headquarters. Request RR: D-35-1007.

⁷ Detailed drawings and a materials list for construction are available at a nominal cost through ASTM Headquarters. Request adjunct No. ADJD4491.



FIG. 1 Constant and Falling Head Permeability Apparatus

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.

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 along a diagonal line extending from the lower left hand corner to the upper right hand corner of the laboratory sample. Neither specimen A or D shall be closer to the corner of the laboratory sample than 200 mm (8 in.).