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Standard Test Method for Permittivity of Geotextiles Under Load[1]

This standard is issued under the fixed designation D5493; 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 covers the determination of the water permittivity behavior of geotextiles in a direction normal to the plane of the geotextile when subjected to specific normal compressive loads.

1.2 Use of this test method is limited to geotextiles. This test method is not intended for application with geotextile-related products such as geogrids, geonets, geomembranes, and other geocomposites.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given 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~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 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
D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing
D4439 Terminology for Geosynthetics
D4491/D4491M Test Methods for Water Permeability of Geotextiles by Permittivity
D4716/D4716M Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. Terminology

3.1 *Definitions:*

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[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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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.

3.1.1 *geotextile, n*—any permeable textile material used with foundation, soil, rock, earth, or any other geotechnical engineering related material as an integral part of a manmade project, structure, or system (see Terminology D4439).

3.1.2 *hydraulic gradient, i, n*—the loss of hydraulic head per unit distance of flow, dh/dL (see Test Method D4716/D4716M).

3.1.3 *permittivity, (ψ), (T^{-1}~~—~~), ~~n~~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 (see Terminology D4439).

3.2 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 definitions of coefficient of permeability, refer to Terminology D653.

4. Summary of Test Method

4.1 This test method provides a procedure for measuring the water flow, in the normal direction, through a known cross section of a single layer of a geotextile at a predetermined constant hydraulic ~~heads~~head over a range of applied normal compressive stresses.

4.2 The permittivity of a geotextile, ψ, can be determined by measuring the flow rate of water, in the normal direction, through a known cross section of a geotextile at a predetermined constant water ~~heads.~~ head.

4.3 Water flow through geotextiles can be laminar, transient, or turbulent, and therefore permittivity cannot be taken as a constant.

5. Significance and Use

5.1 The thickness of a geotextile decreases with increase in the normal compressive stress. This decrease in thickness may result in the partial closing or the opening of the voids of geotextile depending on its initial structure and the boundary conditions.

5.2 This test method measures the permittivity due to a change of void structure of a geotextile as a result of an applied compressive stress.

6. Apparatus

6.1 The apparatus is a constant head permeameter. General guidance on the hydraulic design of a constant head permeameter can be found in Test Methods D4491/D4491M.

6.2 The components installed around the test specimen are designed in such a way that a normal load can be applied uniformly on the entire flow surface without ~~restraining~~ significantly restraining the flow rate. The permittivity of the apparatus, calculated using the calibration curve established in Section 10, shall be at least ~~10~~ten times greater than the permittivity of the test specimen under the hydraulic conditions prevailing during a given test. However, the central deflection of the loading mechanism on the plane of the geotextile shall not exceed ~~0.025 mm~~ 0.25 mm while subjected to the maximum normal load applied during the test.

6.3 The recommended apparatus configuration for applying the compressive stress is shown in Fig. 1~~:~~.

6.3.1 Stopwatch accurate to 0.1 s.

6.3.2 Water volume container accurate to 2 %.

6.3.3 An optimum flow diameter has been found to be 50 mm to minimize hydraulic side effects while ensuring an optimum rigidity of the loading mechanism.

6.3.4 A wire meshes, 1.0 mm in opening, complying with Specification E11 is installed as the contact surface on both sides of the test specimen.

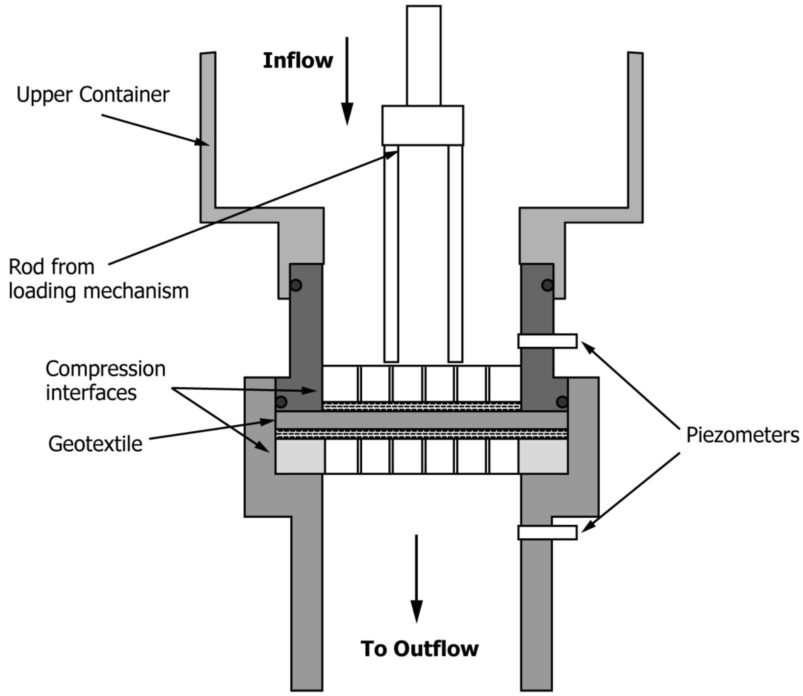

FIG. 1 Specimen Holder and Loading Mechanism

6.3.5 Two rigid metallic plateplates with the geometry shown on Figurein Fig. 1 2 act as a structural component on both sides of the wire meshes. The lower one is supported by the apparatus, while the upper one can move freely but is adjusted to the diameter of the flow channel.

6.3.6 The upper metallic plate is connected to a device capable of applying the requested normal load on the test specimen (dead loads, air piston, or any suitable device). The mechanical connection between the upper metallic plate and the loading mechanism consists of four rods, 3 mm in diameter, distributed on a circle approximately 30 mm in diameter.

6.3.7 A dial or digital indicator can be connected to the loading mechanism to monitor the specimen thickness during the test.

6.4 A de-airing system that may be 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. Allow the de-aired water to stand in closed storage under a slight vacuum until room temperature is attained.

6.5 Thermometer or digital temperature sensor with a resolution of 0.1 °C.

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 and the supplier (for example, Practice D4354) 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 1—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.

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7.2 *Laboratory Sample*—Consider the units in the lot sample as the units in the laboratory sample. 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 the inner and outer wrap material may be used.

8. Test Water Preparation

8.1 The test water shall be potable tap water or deionized water as prepared below.

8.2 De-air the test water to provide reproducible test results.

8.3 De-air the water used for saturation.

8.4 De-air the water under a vacuum of 710 mm (28 in.) of mercury (Hg) for the period of time to bring the dissolved oxygen content down to a maximum of 6 ppm.

8.5 Use dissolved oxygen meter or commercially available chemical kits to determine the dissolved oxygen content.

~~8.5 The deaired system may be 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. Allow the deaired water to stand in closed storage under a slight vacuum until room temperature is attained.~~

8.6 If water temperature other than ~~20°C~~20 °C is being used, make a temperature correction to the resulting value of permittivity.

8.7 Determine the temperature correction factor using the following equation:

$$Rt = ut/u20 \tag{1}$$

where:

ut = water viscosity at test temperature, mP, as determined from Table 1, and
~~*u20* = water viscosity at 20°C, mP.~~
u20 = water viscosity at 20 °C, mP.

9. Specimen Preparation

9.1 Prepare four specimens of the geotextile to be tested, avoiding sampling along the edges of the geotextile roll to ensure homogeneity of the specimens.

9.2 The minimum specimen flow area diameter is 50 mm.

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

9.3.1 Take ~~Specimen A~~the four specimens along a diagonal line. Take Specimen B at the center of the sample, ~~B~~D at one corner (center located 200 mm from the corner), C midway between ~~A and B, and D~~B and D, and A the same distance from ~~A~~B as C, located on ~~a~~the line with ~~A,~~ B, C, and ~~C.~~D.

9.3.2 Cut specimens shall fit the testing apparatus.

10. Calibrations

10.1 *Hydraulic* ~~*Calibration:*~~ *Calibration of Test Apparatus:*

10.1.1 Run at least ~~3~~three tests without any geotextile specimen installed in the apparatus, each of them being ~~ran~~run with the system set to apply different normal loads spread over the equipment capability (that is, 2, 20, and 200 kPa). ~~The specimen shall~~

TABLE 1 Viscosity of Water Versus Temperature

Temperature, °C	Viscosity (Poiseuille)[A]
~~0~~	~~1.7921 × 10^−6~~
~~1~~	~~1.7313 × 10^−6~~
~~2~~	~~1.6278 × 10^−6~~
~~3~~	~~1.6191 × 10^−6~~
~~4~~	~~1.5674 × 10^−6~~
~~5~~	~~1.5188 × 10^−6~~
~~6~~	~~1.4728 × 10^−6~~
~~7~~	~~1.4284 × 10^−6~~
~~8~~	~~1.3860 × 10^−6~~
~~9~~	~~1.3462 × 10^−6~~
~~10~~	~~1.3077 × 10^−6~~
~~11~~	~~1.2713 × 10^−6~~
~~12~~	~~1.2363 × 10^−6~~
~~13~~	~~1.2028 × 10^−6~~
~~14~~	~~1.1709 × 10^−6~~
~~15~~	~~1.1404 × 10^−6~~
~~16~~	~~1.1111 × 10^−6~~
~~17~~	~~1.0828 × 10^−6~~
~~18~~	~~1.0559 × 10^−6~~
~~19~~	~~1.0299 × 10^−6~~
~~20~~	~~1.0050 × 10^−6~~
~~21~~	~~0.9810 × 10^−6~~
~~22~~	~~0.9579 × 10^−6~~
~~23~~	~~0.9358 × 10^−6~~
~~24~~	~~0.9142 × 10^−6~~
~~25~~	~~0.8937 × 10^−6~~

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[A] Poiseuille = kg s^{-1} m^{-1} = Nsm.

~~be replaced by a rigid material approximately 25 to 30 mm in diameter that will not restrain the flow (such as a 1 to 2 mm long section of a thick 25 mm PVC plastic pipe).~~ For each test, measure the water heads corresponding to at least ~~10~~ten different flow rates uniformly spread between ~~0~~zero and the equipment capability.

10.1.2 Draw the 'Water Head versus Flow Rate' curve ~~and calculate the~~as shown in Fig. 3~~intrinsic permittivity of the apparatus for each flow rate using~~. Determine the best fit of a second-order polynomial with ~~Eq 2. Plot both curves on the same graph as shown on~~ a zero y-intercept through the data points.~~Fig. 2.~~

10.2 *Normal Load Calibration*—Use a convenient system to control the precision of the normal load applied on the geotextile. The normal load effectively applied shall be within 5 % of the targeted load.