Designation: D4751 – 21

Standard Test Methods for Determining Apparent Opening Size of a Geotextile[1]

This standard is issued under the fixed designation D4751; 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 the determination of the apparent opening size (AOS) of a geotextile either by dry-sieving glass beads through a geotextile (Method A) or by using a capillary porometer (Method B).

1.2 Method B will not be used in lieu of Method A unless the pre-qualification procedure specified in this standard is followed.

1.3 These test methods show the values in both SI units and inch-pound units. SI units is the technically correct name for the system of metric units known as the International System of Units. Inch-pound units is the technically correct name for the customary units used in the United States. The values in inch-pound units are provided 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, 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]

D1331 Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials

D1776/D1776M Practice for Conditioning and Testing Textiles

D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing

D4439 Terminology for Geosynthetics

D6767 Test Method for Pore Size Characteristics of Geotextiles by Capillary Flow Test

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—For general geosynthetics terms used in this standard, refer to Terminology D4439.

3.2 *Definitions:*

3.2.1 *apparent opening size* (AOS), O_{95}, *n—for a geotextile*, a property that indicates the approximate largest particle that would effectively pass through the geotextile.

3.2.1.1 *Discussion*—While the same "O95" symbol is used both in these test methods for defining the AOS of a geotextile as well as in Test Method D6767 for determining the pore size of geotextiles by capillary flow, they are not necessarily equivalent. The O95 values are defined in terms of their respective test methods. Therefore, the AOS version of the O95 value that is determined with Method B may not be identical to the O95 value determined per Test Method D6767.

4. Summary of Test Methods

4.1 *Glass Bead Dry-Sieving, Method A*—A geotextile specimen is placed in a sieve frame, and sized glass beads are placed on the geotextile surface. The geotextile and frame are shaken laterally so that the jarring motion will induce the beads to pass through the test specimen. The procedure is repeated on the same specimen with various size glass beads until its apparent opening size has been determined. This method is considered the referee method in the case of inter-laboratory disputes involving Method B.

4.2 *Capillary Porometer, Method B*—A geotextile specimen is subjected first to an air flow test, where the air flow rate and pressure are measured. Then the same specimen is wetted with mineral oil and subjected to an increasing air pressure while

[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 July 1, 2021. Published July 2021. Originally approved in 1993. Last previous version approved in 2020 as D4751 – 20b. DOI: 10.1520/D4751-21.

[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.

measuring the resulting flow rate. The opening sizes are calculated from this data using standard capillary theory and the specific algorithm defined in these test methods.

4.2.1 The apparent opening size of a geotextile is defined in terms of the dry-sieving test method. This method includes a procedure for correlating the porometer test data to the Method A results so that Method B is qualified to generate values equivalent to the glass bead dry-sieving Method A.

5. Significance and Use

5.1 Using a geotextile as a medium to retain soil particles necessitates compatibility between it and the adjacent soil. This test method is used to indicate the apparent opening size in a geotextile, which reflects the approximate largest opening dimension available for soil to pass through.

5.2 Test Methods D4751 for the determination of opening size of geotextiles is acceptable for testing of commercial shipments of geotextiles. Current estimates of precision, between laboratories, have been established.

5.3 Apparent opening test results obtained using Method A may differ from test results obtained with Method B. It is the intent of this test method to confirm the equivalency of the Method B results before permitting the use of this alternative. Laboratories electing the use of Method B must first determine any bias that exists between the two methods and document a reliable correlation in accordance with this test method.

5.3.1 The correlation between the Method B results and the Method A results must be established and meet the requirements of this test method for every different geotextile product type tested with Method B. Geotextiles from different manufacturers or with different nominal unit weights are considered different products. A minimum of three test results must be compared with all three satisfying the established correlation.

NOTE 1—The correlation should be confirmed for a particular product by comparing a minimum of three test results when there are changes in the manufacturing of a specific pre-qualified geotextile.

5.4 In case of a dispute arising from differences in reported test results when using Test Methods D4751 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 equal 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 testing is begun. 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 the light of the known bias.

5.4.1 In the event that the dispute involves test results produced with the capillary porometer, Method A is considered the referee method for Test Methods D4751.

6. Sampling

6.1 *Sampling of Planar Geotextiles:*

6.1.1 *Lot Sample*—For routine quality control testing, divide the product into lots and take the lot sample as directed in Practice D4354, Section 7, Procedure B—Sampling for Manufacturer's Quality Assurance Testing. For specification conformance testing, sample as directed in Practice D4354, Section 8, Procedure C—Sampling for Purchaser's Specification Conformance Testing.

6.1.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a full-width swatch 1 m (1 yd) long from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m (1 yd) of fabric from the very outside of the roll.

6.1.3 *Test Specimens*—Cut five specimens from each swatch in the laboratory sample, with each specimen being cut to fit the appropriate specimen holder for Method A or the porometer sample holder for Method B. Cut the specimens from a single swatch spaced along a diagonal line on the swatch.

6.2 *Sampling of Circular-Knitted Sock Geotextiles:*

6.2.1 For a lot sample for manufacturer's quality control (MQC) testing, divide rolls of circular-knitted sock geotextile fabric into lots and take the lot sample as directed in Practice D4354, Section 7, Procedure B—Sampling for Manufacturer's Quality Assurance Testing. For a lot sample for specification conformance testing, sample as directed in Practice D4354, Section 8, Procedure C—Sampling for Purchaser's Specification Conformance Testing.

6.2.2 *Laboratory Sample*—To obtain a laboratory sample for MQC testing of the circular-knitted sock geotextile, follow the procedure below:

6.2.2.1 Apply the knitted sock geotextile sample over the outside of the corresponding diameter of a 406-mm (16-in.) length of perforated tubing or reasonable facsimile having the same diameter as the pipe material for which the sock is intended.

6.2.2.2 Tie a knot in each end of the fabric so as to fully encase the pipe in the fabric.

6.2.2.3 Using the knot from one end of the fabric, suspend the geotextile-encased pipe vertically. Gently suspend a 1.13-kg (2.5-lb) weight from the bottom to ensure intimate contact with the perforated pipe. See Fig. 1a. Allow the suspended pipe with weight to hang for 2 min.

NOTE 2—Pipes with diameters larger than 75 to 150 mm (3 to 6 in.) may require heavier weights to ensure intimate contact between the pipe and sock material.

6.2.2.4 For Method A, using a flexible 203-mm (8-in.) diameter round template as a guide, trace a circle on the surface of the fabric using an indelible marker. See Fig. 1c. Remove the fabric from the pipe section by untying or cutting off the knots at one or both ends in the fabric. Cut the fabric tube in a lengthwise direction at a position opposing the drawn circle, taking care to not cut the fabric within the circle. If so desired, the length of the specimen may be shortened by cutting the fabric in a crosswise direction, taking care not to cut the fabric closer than 75 mm (3 in.) from the outside of the circle. The

Fig 1a Square Template with Hole Cut in It

Fig 1b

Fig 1c

Fig 1d

Round Template

FIG. 1 Specimen Cutting Templates for Circular-Knitted Sock Geotextiles

result will be a planar specimen of more or less rectangular shape with a circle drawn approximately in its center.

6.2.2.5 For Method B test specimens, affix an adhesive-backed foil to the fabric which has a 25-mm (1-in.) or 50-mm (2-in.) diameter hole die cut from the center, and a sufficient outside diameter to exceed the outside diameter of the porometer sample holder. This foil must be rigid enough to preserve the geometry of the material produced by this technique. The five foil-taped porometer specimens are then cut with the porometer specimen die, positioning the 25-mm (1-in.) or 50-mm (2-in.) opening in the center.

6.3 *Lot Sample for Specification Conformance Testing*—Sample as directed in Practice D4354, Section 8, Procedure C—Sampling for Purchaser's Specification Conformance Testing.

6.3.1 *Laboratory Sample*—To obtain a laboratory sample of the circular-knitted geotextile fabric for acceptance testing of each lot of pipe, follow this procedure:

6.3.1.1 Select a 3-m (10-ft) section on each lot of the sock-covered pipe to be tested.

6.3.2 Using a length of string, twine, or cord, secure the fabric to the pipe at each end of the 3-m (10-ft) pipe section that was chosen in 6.3.1.1 in order to prevent the sock fabric from contracting lengthwise when the sock-covered pipe sample is removed from the roll or pipe section. Remove the 3-m (10-ft) sock-covered pipe section from the roll or pipe section by cutting the pipe at each end of the 3-m (10-ft) sample, outside of the ties.

6.3.3 *Test Specimens*—With the fabric still secured to the pipe sample, using a flexible 203-mm (8-in.) diameter round template for Method A, draw five 203-mm (8-in.) diameter circles at various locations around the circumference of each laboratory sample, equally spaced along its length, and not closer than 100 mm (4 in.) from either end of the pipe sample. For Method B, affix adhesive-backed foil to the fabric which has a 25-mm (1-in.) or 50-mm (2-in.) diameter hole die cut from the center, and a sufficient outside diameter to exceed the outside diameter of the porometer sample holder. This foil must be rigid enough to preserve the geometry of the material produced by this technique. The five foil-taped porometer specimens are then cut with the porometer specimen die, positioning the 25-mm (1-in.) or 50-mm (2-in.) opening in the center.

6.3.3.1 Remove the ties from the laboratory sample and remove the fabric from the pipe.

6.3.3.2 When securing specimens by wedging between two sieve frames, cut the laboratory sample in a crosswise direction to create five specimens, taking care not to make these cuts closer than 75 mm (3 in.) from the outside of the circle. Continue to prepare the specimens by cutting the fabric in a lengthwise direction at a position opposing the circle. Care must be taken not to cut through the circle. The result will be the creation of five planar fabric specimens of more or less a rectangular shape with a circle drawn at its center.

METHOD A—DRY-SIEVING WITH GLASS BEADS

7. Specimen Preparation

7.1 Weigh the Method A test specimens and then submerge them in distilled water for 1 h at the standard atmosphere for testing. Bring the specimens to moisture equilibrium in the atmosphere for testing geosynthetics. Equilibrium is considered to have been reached when the change in the mass of the specimen in successive weight measurements made at intervals of not less than 2 h does not exceed 0.1 g.

7.2 The drying process may be accelerated with the use of a fan. The specimens shall not be dried in an oven or by exposing them to elevated temperatures above the standard laboratory atmosphere for geosynthetic testing.

NOTE 3—It is recognized that in practice, geosynthetic materials are frequently not weighed to determine when moisture equilibrium has been reached. While such a method cannot be accepted in cases of dispute, it may be sufficient in routine testing to expose the material to the standard atmosphere for testing geosynthetics for a reasonable period of time before the specimens are tested. A time of at least 24 h has been found acceptable in most cases. However, certain fibers may contain more moisture upon receipt than after conditioning. When this is known, a preconditioning cycle as described in Practice D1776/D1776M may be agreed upon by the contractual parties.

8. Apparatus

8.1 *Mechanical Sieve Shaker*—A mechanical sieve shaker, which imparts lateral and vertical motion to the sieve, causing the particles thereon to bounce and turn so as to present different orientations to the sieving surface, should be used. The sieve shaker should be a constant frequency device utilizing a tapping arm to impart the proper motion to the glass beads.[3]

NOTE 4—Care should be given to the cork or rubber contact point on shakers when the vertical motion comes from an arm striking the cork or rubber. Excessive wear on the cork or rubber could affect the motion imparted to the glass beads and, therefore, the test result.

8.2 *Pan, Cover, and 200-mm (8-in.) Diameter Sieves.*

8.3 *Spherical Glass Beads* in size fractions in accordance with Table 1. It is only necessary to have on hand the bead size fractions necessary for the range of geotextiles for which testing is anticipated. The sizing of all beads shall be verified prior to each use by sieving on the pairs of sieves shown in Table 1. Prepare at least 50 g of each size fraction to be used prior to beginning the test. Bead sizes to be used in this test method are shown in Table 1.

8.4 *Balance,* having a capacity adequate for the mass of samples anticipated and accurate to ±0.05 g.

[3] The sole source of supply of the apparatus known to the committee at this time is W.S. Tyler, Inc., 8200 Tyler Blvd., Mentor, OH 44060. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

TABLE 1 Glass Bead Sizes

Bead Size Range				Bead Size Designation[A]	
Passing		Retained			
mm	Sieve Number[B]	mm	Sieve Number[B]	mm	Sieve Number
2.0	10	1.70	12	1.7	12
1.4	14	1.18	16	1.18	16
1.00	18	0.850	20	0.850	20
0.710	25	0.600	30	0.600	30
0.500	35	0.425	40	0.425	40
0.355	45	0.300	50	0.300	50
0.250	60	0.212	70	0.212	70
0.180	80	0.150	100	0.150	100
0.125	120	0.106	140	0.106	140
0.090	170	0.075	200	0.075	200

[A] The designated bead size is the "retained on" size of the sieve pair used to size the beads. For example, beads designated No. 40 are beads that pass the No. 35 sieve and are retained on the No. 40 sieve. These beads are typically sold as 35-40 beads.
[B] See Specification E11.

8.5 *Static Elimination,* to prevent the accumulation of static electricity when the beads are shaken on the surface of the geotextile. Commercially available devices or anti-static sprays are acceptable.

8.6 *Pan,* for collecting sieved beads.

8.7 *Flexible Rubber Template,* either a square-shaped, flexible rubber template with a 203-mm (8-in.) diameter hole cut in it, or a 203-mm (8-in.) diameter template, constructed from a durable, yet flexible material such as rubber or neoprene. This template is used to trace the 203-mm (8-in.) diameter circles on the geotextile fabric for mounting into the sieves described in 8.2. (See Fig. 1.)

9. Procedure

9.1 Run the test at the atmosphere for testing geotextiles in such a manner that static electricity is prevented from affecting test results. If standard atmosphere cannot be maintained and static electricity is noticed, two methods are available that will prevent static electricity:

9.1.1 Install static-eliminating devices equally spaced about the circumference of sieve and one on center of cover, or

9.1.2 Apply commercially available anti-static spray uniformly to the geotextile.

9.2 Secure the geotextile in such a way that it is taut, without wrinkles or bulges. The geotextile must not be stretched or deformed such that it changes or distorts the openings in the fabric. Two systems may be used to secure the geotextiles sample:

9.2.1 Wedge between two sieve frames.

9.2.2 Secure with the perimeter seal device inside the sieve frame.

NOTE 5—For knitted sock geotextiles, some manipulation of the specimens may be necessary to ensure that the marked-out circle is fitted to the sieve frame properly.

9.3 Prior to use, sieve the glass beads in the laboratory to verify size of beads.

NOTE 6—All size glass beads are sieved through a single specimen of geotextile unless the geotextile has an average thickness equal to or greater than 2.3 mm (0.091 in.). A geotextile of this thickness or greater (especially nonwovens) may trap beads within the layers of the fabric, which may pass through the specimen when testing with a different bead size, thus creating an error in the test results. In the case of the thicker geotextiles, a different specimen may be used for each bead size; however, it should be noted in the report that different specimens were used.

9.4 Start with the smallest diameter glass beads that will be tested. Place 50 g of one size glass beads on the center of the geotextile.

9.5 Place cover and pan on sieve frame and place in shaker. Shake sieves for 10 min.

9.6 Place the glass beads still on the surface of the specimen in a pan and weigh. Include beads that fall off as a result of turning the specimen over and tapping the rims of the sieves.

NOTE 7—This step provides information concerning the amount of glass beads trapped within the geotextile and the amount of any beads lost during testing.

9.7 Weigh the glass beads that pass through the specimen, and record data. (See Fig. 2 for a sample worksheet which can be used to record the desired data.)

9.8 Repeat 9.3 – 9.7 using the next larger bead size fraction. Repeat the trial using successively larger bead size fractions until the weight of beads passing through the specimen is 5 % or less. Perform the trials such that the percent passing decreases from a value greater than 5 % to a value less than or equal to 5 %.

9.9 Repeat 9.2 – 9.8 for all five specimens.

10. Calculations for Method A

10.1 Record calculations and percent beads passing (see Fig. 2).

10.2 For each specimen, plot the values of percent passing (ordinate) versus bead size, mm (abscissa) percent passing (ordinate) versus bead size, mm (abscissa) on semi-log graph. Draw a straight line connecting the two data points representing the bead sizes that are immediately on either side of the 5 % passing ordinate. The particle size in millimetres (abscissa) at the intersection of the straight line plotted and the 5 % passing ordinate is the AOS of the specimen in millimetres, that is, the theoretical bead size that would result in exactly 5 % passing the specimen.

10.3 Determine the sample AOS, in millimetres, by averaging the five AOS values obtained by the graphic interpolation in 10.2.

10.4 *Optional*—When requested, determine the sample AOS, expressed in terms of sieve number, as the number of the U.S. Sieve (see the sieve number column under Bead Size Designation in Table 1) having nominal opening, in millimetres, equal to or next larger than the AOS, in millimetres, obtained in 10.2.

11. Report

11.1 Report that the specimens were tested as directed in Test Methods D4751, Method A. Describe the material or product sampled and the method of sampling used.

11.1.1 For report formats that do not incorporate the phrase in 11.1 on the same page as the reported test values (that the