Designation: D 1987 – 95 (Reapproved 2002)

Standard Test Method for Biological Clogging of Geotextile or Soil/Geotextile Filters[1]

This standard is issued under the fixed designation D 1987; 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 is used to determine the potential for, and relative degree of, biological growth which can accumulate on geotextile or geotextile/soil filters.

1.2 This test method uses the measurement of flow rates over an extended period of time to determine the amount of clogging.

1.3 This test method can be adapted for nonsaturated as well as saturated conditions.

1.4 This test method can use constant head or falling head measurement techniques.

1.5 This test method can also be used to give an indication as to the possibility of backflushing and/or biocide treatment for remediation purposes if biological clogging does occur.

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

1.7 *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 Textiles[2]

D 1776 Practice for Conditioning Testing Textiles[2]

D 4439 Terminology for Geotextiles[3]

D 4354 Practice for Sampling of Geosynthetics for Testing[3]

D 4491 Test Methods for Water Permeability of Geotextiles by Permittivity[3]

D 5101 Test Method for Measuring the Soil-Geotextile System Clogging Potential By the Gradient Ratio

G 22 Practice for Determining Resistance of Plastics to Bacteria[4]

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*—*In geotextiles*, permeability refers to hydraulic conductivity.

3.1.3 *permittivity*, $(\Psi)(t^{-1})$, *n*—of *geotextiles*, the volumetric flow rate of water per unit, in a cross sectional area head under laminar flow conditions.

3.1.4 *aerobic*, *n*—a condition in which a measurable volume of air is present in the incubation chamber or system.

3.1.4.1 *Discussion*—*In geotextiles*, this condition can potentially contribute to the growth of micro-organisms.

3.1.5 *anaerobic*, *n*—a condition in which no measurable volume of air is present in the incubation chamber or system.

3.1.5.1 *Discussion*—*In geotextiles*, this condition cannot contribute to the growth of microorganisms.

3.1.6 *back flushing*, *n*—a process by which liquid is forced in the reverse direction to the flow direction.

3.1.6.1 *Discussion*—*In other drainage application areas*, this process is commonly used to free clogged drainage systems of materials that impede the intended direction of flow.

3.1.7 *biocide*, *n*—a chemical used to kill bacteria and other microorganisms.

3.2 For definitions of other terms used in this test method, refer to Terminology D 123 and D 4439.

4. Summary of Test Method

4.1 A geotextile filter specimen or geotextile/soil filter composite specimen is positioned in a flow column so that a designated liquid flows through it under either constant or falling head conditions.

4.1.1 The designated liquid might contain micro-organisms from which biological growth can occur.

4.2 Flow rate is measured over time, converted to either permittivity or permeability, and reported according.

4.2.1 Between readings, the test specimen can be allowed to be in either nonsaturated or saturated conditions.

4.2.2 Back flushing can be introduced from the direction opposite to the intended flow direction and evaluated accordingly.

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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 D35.02 on Endurance Properties.

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

[3] *Annual Book of ASTM Standards*, Vol 04.09.

[4] Discontinued; see 2001 *Annual Book of ASTM Standards*, Vol 14.04.

4.2.3 Biocide can be introduced with the back flushing liquid, or introduced within the test specimen, and evaluated accordingly.

5. Significance and Use

5.1 This test method is performance oriented for determining if, and to what degree, different liquids create biological activity on geotextile filters thereby reducing their flow capability. The use of the method is primarily oriented toward landfill leachates but can be performed with any liquid coming from a particular site or synthesized from a predetermined mixture of biological microorganisms.

5.2 The test can be used to compare the flow capability of different types of geotextiles or soil/geotextile combinations.

5.3 This test will usually take considerable time, for example, up to 1000 h, for the biological activity to initiate, grow, and reach an equilibrium condition. The curves resulting from the test are intended to indicate the in situ behavior of a geotextile or soil/geotextile filter.

5.4 The test specimen can be incubated under non-saturated drained conditions between readings, or kept saturated at all times. The first case allows for air penetration into the flow column and thus aerobic conditions. The second case can result in the absence of air, thus it may simulate anaerobic conditions.

5.5 The flow rate can be determined using either a constant head test procedure or on the basis of a falling head test procedure. In either case the flow column containing the geotextile or soil/geotextile is the same, only the head control devices change.

NOTE 1—It has been found that once biological clogging initiates, constant head tests often pass inadequate quantities of liquid to accurately measure. It thus becomes necessary to use falling head tests which can be measured on the basis of time of movement of a relatively small quantity of liquid between two designated points on a clear plastic standpipe.

5.6 If the establishment of an unacceptably high degree of clogging is seen in the flow rate curves, the device allows for backflushing with water or with water containing a biocide.

5.7 The resulting flow rate curves are intended for use in the design of full scale geotextile or soil/geotextile filtration systems and possible remediation schemes in the case of landfill lechate collection and removal systems.

6. Apparatus

6.1 *The flow column and specimen mount*, consists of a 100 mm (4.0 in.) inside diameter containment ring for placement of the geotextile specimen along with upper and lower flow tubes to allow for uniform flow trajectories (see Fig. 1). The flow tubes are each sealed with end caps which have entry and exit tubing connections (see Fig. 1). The upper tube can be made sufficiently long so as to provide for a soil column to be placed above the geotextile. When this type of combined soil/geotextile cross section is used, however, it is difficult to distinguish which material is clogging, for example, the soil or the geotextile. It does however simulate many existing filtration systems. In such cases, a separate test setup with the geotextile by itself will be required as a control test and the difference in behavior between the two tests will give an indication as to the contribution of soil clogging to the flow reduction.

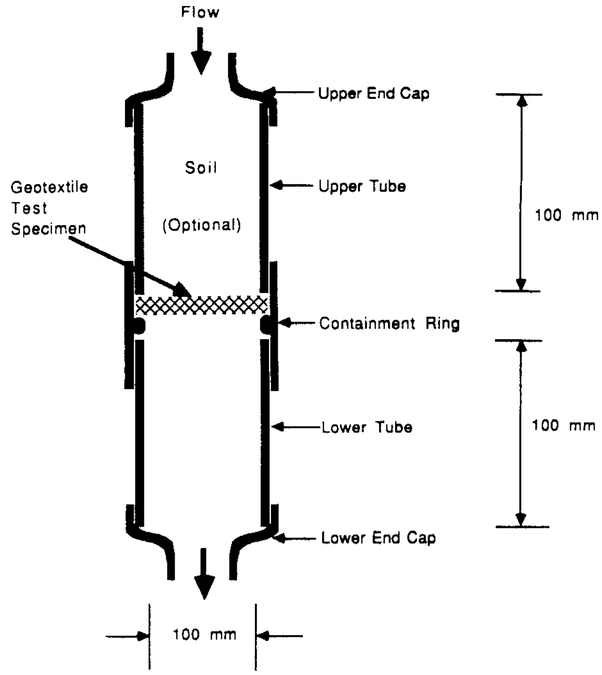

FIG. 1 Flow Column to Contain Geotextile Test Specimen

NOTE 2—If piezoemetric heads in the material (soil or solid waste) located above the filter are desired, the upper flow column of the permeameter can be modified to accommodate such measurements. Recommended are ports immediately above the filter (as close to it as possible), and at 1⁄4, 1⁄2, 3⁄4 and above the soil or solid waste in question. Duplicate ports on each side of the permeameter at the above elevations are considered good practice in measurements of this type. Other configurations are at the option of the parties involved.

The ports are connected by flexible tubing to a manometer board for readings in a manner that is typical for measurements of this type. See Test Method D 5101, the Gradient Ratio test, for additional details.

6.2 *Hydraulic head control devices*, are required at both the inlet and outlet ends of the flow column. Fig. 2 shows the complete setup based on constant hydraulic head monitoring where concentric plastic cylinders are used with the inner

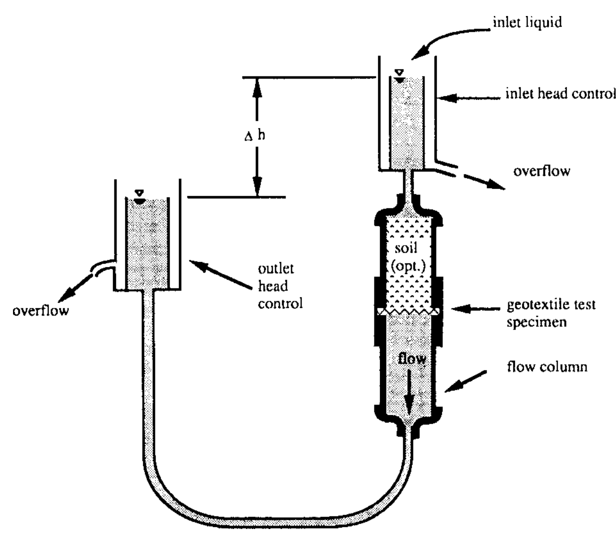

FIG. 2 Flow Column with Inlet and Outlet Hydraulic Head Control Devices for Constant Head Test

cylinders being at the elevation from which head is measured. The elevation difference between the inner cylinder at the inlet end and the inner cylinder at the outlet end is the total head across the geotextile test specimen (or soil/geotextile test specimen in the case of a combined test column). Note that the elevation of the outlet must be above the elevation of the geotextile.

6.3 *A hydraulic head standpipe*, above the flow column is required for falling hydraulic head monitoring. Fig. 3 shows this type of test configuration in which a clear plastic standpipe is placed above the flow column. Liquid movement is monitored for the time of flight between two marks on the standpipe. Note that the elevation of the outlet must be above the elevation of the geotextile.

6.4 *The overall test system*, dimensions are sufficiently small so that either of the above mentioned units can be used at a field site if desirable. They can either be kept stationary in the laboratory or in the field, or they can be transported from the laboratory to the field site when required.

6.5 *The permeating liquid*, is generally site specific and often comprises landfill leachate. Other liquids for which biological clogging is of concern can also be evaluated. The liquid can be synthesized on an as-required basis.

NOTE 3—A synthesized liquid which has been used in determining the resistance of plastics to bacteria is Pseudomonas aeruginosa ATCC 13388[5] or MYCO B1468.[6] Specific details must be agreed upon by the parties involved. See also Practice G 22.

7. Sampling

7.1 *Lot Sample*—Divide the product into lots and take the lot sample as directed in Practice D 4354.

7.2 *Laboratory Sample*—For the laboratory sample, take a swatch extending the full width of the geotextile of sufficient length along the selvage from each sample roll so that the requirements of the following section can be met. Take a sample that will exclude material from the outer wrap and inner wrap around the core unless the sample is taken at the production site, then inner and outer wrap material may be used.

7.3 *Test Specimens*—From the laboratory sample select the number of specimens as per the number of flow columns to be evaluated. Space the specimens along a diagonal on the unit of the laboratory sample. Take no specimens nearer the selvage or edge of the laboratory sample than 10 % of the width of the laboratory sample. The minimum specimen diameter should be 100 mm (4.0 in.) so that full fixity can be achieved around the inside of the flow column.

8. Conditioning

8.1 There is no conditioning of the geotextile test specimen, per se, since this test method is a hydraulic one and the conditions of the permeating fluid will be the controlling factor. See also Practice D 1776.

8.2 The relative humidity should be 100 % except during times of air drying between nonsaturated test readings. For saturated conditions the relative humidity should always be 100 %.

8.3 The temperature of the test over its entire duration is important. It is desirable to track temperature continuously. If not possible, frequent readings at regular intervals are required.

9. Procedure

9.1 *Procedure A—Constant Head Test*:

9.1.1 Select and properly prepare the geotextile test specimen. Trim the specimen to the exact and full diameter of the inside of the flow column.

9.1.2 Fix the geotextile test specimen to the inside of the containment ring. If a water insoluble glue is used be sure that any excess does not extend into the flow area of the geotextile.

9.1.3 Caulk the upper surface of the geotextile to the inside of the containment ring using a silicon based caulk and allow it to completely cure. The caulk must be carefully placed so as not to restrict flow through the geotextile.

9.1.4 Insert the upper and lower tubes into the containment ring and create a seal. If polyvinyl chloride (PVC) tubing and fittings are being used, first a cleaner and then a solvent wipe is used to make the bond.

9.1.5 If a screen or gravel of approximately 50 mm (2 in.) size is necessary to support the geotextile it must be placed with the device in an inverted position.

9.1.6 Place the lower end cap on the device and make its seal.

9.1.7 If soil is to be placed over the geotextile, place it at this time. Place the soil at its targeted moisture content and density taking care not to dislodge or damage the geotextile beneath.

9.1.8 Place the upper end cap on the device and make a permanent seal.

9.1.9 Connect flexible plastic tubing from the flow column's top and bottom to the head control devices. At this point the system should appear as shown in the photograph of Fig. 2.

9.1.10 Adjust the total head lost to 50 mm (2.0 in.) and

[5] Available from American Type Culture Collection, 12301 Parklawn Drive, Rockville, MD 20852.

[6] Available from Mycological Services, P.O. Box 126, Amherst, MA 01002.

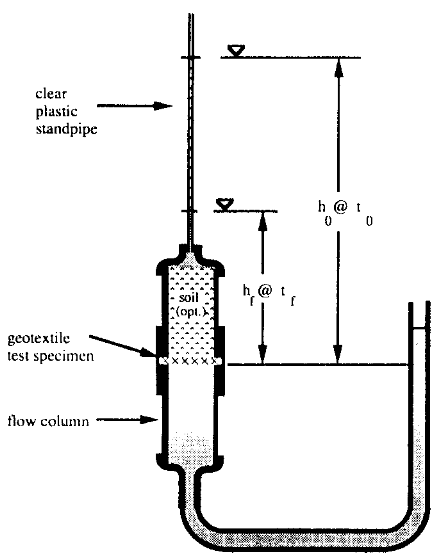

FIG. 3 Flow Column with Standpipe for Variable (Falling) Head Test

initiate flow via the introduction of the permeating fluid to the system. When using leachate, proper safety and health precautions must be maintained depending upon the nature of the leachate itself.

NOTE 4—It is suggested to use 50 mm (2 in.) total head difference since this is the prescribed value used in the permittivity test of Test Method D 4491. Other values of head or hydraulic gradient, as mutually decided upon by the parties involved, could also be used.

9.1.11 Convert the liquid collected from the discharge tube to flow rate (liters/min or gal/min) and repeat the measurement three times. Report the average of this value.

9.1.12 Increase the total head lost if desired. Heads of 100 mm (4.0 in.), 200 mm (8.0 in.), and 300 mm (12.0 in.) might be considered. These relatively high values of total head may be required if the geotextile begins to clog.

9.1.13 After readings are completed, disconnect the head control devices. If non-saturated (aerobic) conditions are desired, the bottom end cap outlet is allowed to vent to the atmosphere. If saturated conditions are desired, the flexible plastic tubing from the bottom end cap must remain in position and be brought higher than the elevation of the geotextile or soil within the test column. This will maintain saturated conditions between readings.

9.1.14 Use fresh liquid for each set of measurements since changes, either biological or particulate in nature, may influence the test results.

9.2 *Procedure B—Falling Head Test*:

9.2.1 Select and properly prepare the geotextile test specimen. Trim the specimen to the exact and full diameter of the inside of the flow column.

9.2.2 Fix the geotextile test specimen to the inside of the containment ring. If a water insoluble glue is used be sure that an excess amount does not extend into the flow area of the geotextile.

9.2.3 Caulk the upper surface of the geotextile to the inside of the containment ring using a silicon based caulk and allow it to completely cure. The caulk must be carefully placed so as not to restrict flow through the geotextile.

9.2.4 Insert the upper and lower tubes into the containment ring and create a permanent seal. If polyvinyl chloride (PVC) tubing and fittings are being used, first a cleaner and then a solvent wipe is used to make the bond.

9.2.5 If a screen or a gravel of approximately 50 cm (2 in.) size is necessary to support the geotextile it must be placed with the device in an inverted position.

9.2.6 Place the lower end cap on the device and make it seal.

9.2.7 If soil is to be placed over the geotextile, place it at this time. The soil should be placed at its targeted moisture content and density taking care not to dislodge or damage the geotextile beneath.

9.2.8 Place the upper end cap on the device and make a seal.

9.2.9 Attach a clear, rigid plastic standpipe to the upper end cap. The standpipe should have clearly visible markings at regular intervals to monitor the movement of liquid. At this point the system should appear as shown in the photograph of Fig. 3.

9.2.10 Fill the standpipe to a level above its upper mark.

9.2.11 Allow for flow through the system until the liquid level reaches the upper mark and then start a stopwatch.

9.2.12 Allow flow to continue unimpeded until the liquid level reaches the lower standpipe mark and immediately stop the stopwatch so as to record the elapsed time.

9.2.13 Repeat this measurement procedure three times. The average of this value is to be reported.

9.2.14 After readings are completed, disconnect the head control devices. If nonsaturated conditions are desired, the bottom end cap outlet is allowed to vent to the atmosphere. If saturated conditions are desired, the flexible plastic tubing from the bottom end cap must remain in position and be brought higher than the elevation of the geotextile or soil within the test column. This will maintain saturated conditions between readings.

9.2.15 Use fresh liquid for each set of measurements since changes, either biological or particulate in nature, may influence the test results.

10. Calculation

10.1 *Procedure A—Constant Head Test*:

10.1.1 *Flow rate per unit area*, is calculated on the basis of the average flow rate measured during conducting of the test. This value is then divided by the cross sectional area of the geotextile for the flow rate per unit area, or "flux." The units are liters/min-cm^2 or gal/min-ft^2.

10.1.2 Permittivity can be calculated using Darcy's formula for a constant head flow test.

$$q = kiA \tag{1}$$

$$\frac{q}{A} = ki$$

$$= k\frac{\Delta h}{t}$$

$$\frac{q}{A(\Delta h)} = \frac{k}{t}$$

$$\text{and } \frac{k}{t} = \Psi = \frac{q}{A(\Delta h)}$$

where:

q = flow rate (L^3/T),
A = cross sectional area (L^2),
k = coefficient of permeability (L/T),
t = geotextile thickness (L),
i = hydraulic gradient (L/L),
Δh = change in total head (L), and
Ψ = permittivity (T^{-1}).

10.1.3 Plotting of the results is very descriptive of the process as it is ongoing. Fig. 4 presents a number of possible trends in the resulting behavior.

10.2 *Procedure B—Falling Head Test*:

10.2.1 Permittivity is calculated when using the geotextile by itself with no soil. It is based on Darcy's formula which is integrated over the head lost during the arbitrary time interval Δt and results in the following equation.

$$\frac{k}{t} = \Psi = 2.3\frac{a}{A\Delta T}\log_{10}\frac{h_o}{h_f} \tag{2}$$

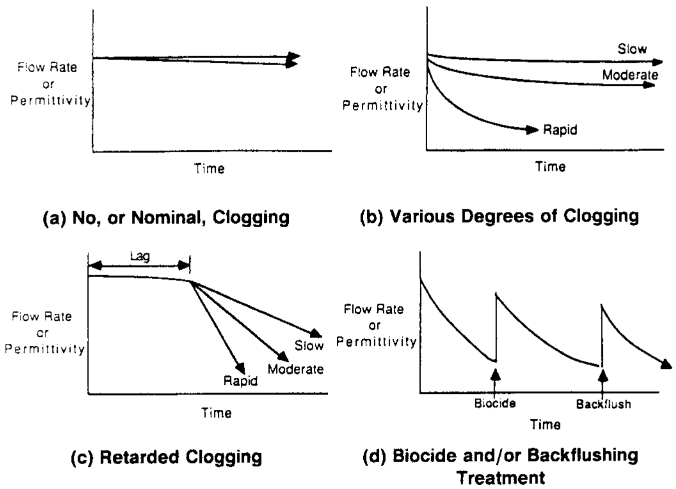

FIG. 4 Possible Long-Term Flow Behavior of Geotextile Filters Subjected to Liquids Containing Biological Microorganisms

where:

k = coefficient of permeability (L/T),
t = thickness (L),
Ψ = permittivity (T^{-1}),
a = area of liquid supply standpipe (L^2),
A = area of test specimen (L^2),
ΔT = time change between h_o and h_f(T),
h_o = head at beginning of test (L), and
h_f = head at end of test (L).

10.2.2 The permeability coefficient is calculated when using soil and geotextile together. It uses the exact formulation as above in the following form.

$$k = 2.3 \frac{at}{A\Delta T} \log_{10} \frac{h_o}{h_f} \tag{3}$$

10.2.3 Plotting of the results is very descriptive of the process as it is ongoing. Fig. 4 presents a number of possible trends in the resulting behavior.

11. Report

11.1 State that the specimens were treated as directed in this test method or state what modifications were made.

11.2 Report on the following information:

11.2.1 The method of holding the test specimen in the containment ring.

11.2.2 The use or nonuse of soil above the geotextile.

11.2.3 The type, style and description of the geotextile test specimen.

11.2.4 The type of permeating liquid.

11.2.5 Whether nonsaturated or saturated test conditions.

11.3 Report on trends in the results:

11.3.1 The behavior of the curves (see Fig. 4 for possible trends).

11.3.2 The reasons for terminating the tests.

11.3.3 The temperature of the liquid used in the tests.

11.3.4 Possible remediation schemes if clogging occurred.

11.4 Identify the microorganisms which caused the clogging if it occurred (optional).

12. Precision and Bias

12.1 *Precision*—The precision of the procedure in this test method for measuring the biological clogging of geotextiles is being established.

12.2 *Bias*—The procedure in this test method for measuring the biological clogging of geotextiles has no bias because the value of that property can be defined only in terms of a test method.