Designation: D5141 – 11

Standard Test Method for Determining Filtering Efficiency and Flow Rate of the Filtration Component of a Sediment Retention Device[1]

This standard is issued under the fixed designation D5141; 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 filtering efficiency and the flow rate of the filtration component of a sediment retention device, such as a silt fence, silt barrier, or inlet protector.

1.1.1 The results are shown as a percentage for filtering efficiency and cubic metres per square metre per minute ($m^3/m^2/min$) or gallons per square foot per minute ($gal/ft^2/min$) for flow rate.

1.1.2 The filtering efficiency indicates the percent of sediment removed from sediment-laden water.

1.1.3 The flow rate is the average rate of passage of the sediment-laden water through the filtration component of a sediment retention device.

1.2 This test method requires several specialized pieces of equipment, such as an integrated water sampler and an analytical balance, or a vacuum filtration system. At the client's discretion the test soil is either a site-specific soil or a soil that is representative of a target default gradation.

1.3 The values stated in SI units are the standard, while the inch-pound units are provided for information. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining values in any way.

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 practices and determine the applicability of regulatory limitations prior to use.*

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

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

D4759 Practice for Determining the Specification Conformance of Geosynthetics

2.2 *American Public Health Association (APHA) Standard:*

208D Total Nonfiltrable Residue Dried at 103–105°C (Total Suspended Matter)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *filtration component*—a geotextile or other material designed to act as a filter.

3.1.2 *filter*—See Terminology D653.

3.1.3 *geosynthetic, n*—a planar product manufactured from polymeric material used with foundation soil, rock, earth, or any other geotechnical engineering related material as an integral part of a man-made project, structure, or system. (See Practice D4759.)

3.1.4 *performance property, n*—a result obtained by conducting a performance test.

3.1.5 *performance test, n—in geosynthetics*, a laboratory procedure which simulates selected field conditions which can be used in design.

3.1.6 For definitions of other terms relating to geosynthetics, refer to Terminology D4439. For definitions of textile terms, refer to Terminology D123. For definitions of soil terms, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *filtering efficiency, FE, n—in geosynthetics*, the percent of sediment removed from sediment-laden water by the filtration component of a sediment retention device over a specified period of time.

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[1] This test method is under the jurisdiction of ASTM Committee D35Geosynthetics 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] Available from American Public Health Association (APHA), 1015 Eighteenth St. NW, Washington, DC 20036.

3.2.2 *flow rate, FR* $[L^3L^{-2}T^{-1}]$, *n—in geosynthetics*, the volume of fluid per unit time, expressed as an average, which passes through a cross-sectional plane perpendicular to the fluid flow.

3.2.3 *flume, n*—an apparatus that carries a liquid to an outlet.

3.2.4 *sediment retention device (SRD), n—in geosynthetics*, a temporary composite structure used to induce the removal of suspended sediments from sediment-laden flowing water.

3.2.5 *silt fence, n—in geosynthetics*, a type of sediment retention device.

4. Summary of Test Method

4.1 A filtration component of a sediment retention device specimen is placed vertically across a flume or over a horizontal opening at the end of a flume while sediment-laden water is passed through the specimen.

4.1.1 The time that water flows through the filtration component of a sediment retention device and the amount of soil passed by the filtration component of a sediment retention device are measured. The amount of soil retained, filtering efficiency, and flow rate are calculated from these measured values.

4.2 Either a site-specific soil or a soil representative of a target default gradation, at the client's discretion should be used in this test method.

5. Significance and Use

5.1 This test method is used to determine the filtering efficiency and flow rate of the filtration component of a sediment retention device, such as a silt fence, a silt barrier, or a silt curtain, for specific soil tested.

5.2 This test method may be used for the design of the filtration component of a sediment retention device to meet requirements of regulatory agencies in filtering efficiency or flow rate for the specific soil tested.

5.2.1 The designer can use this test method to determine the spacing between sediment retention devices.

5.3 This test method is intended for performance evaluation, as the results will depend on the specific soil evaluated. Unless testing with the default soil is desired, it is recommended that the user or representative perform the test to pre-approve products, as sediment retention device manufacturers are not typically equipped to handle or test soil requirements.

5.4 This test method provides a means of evaluating the filtration component of sediment retention devices with different soils under various conditions that simulate the conditions that exist in a sediment retention device installation. This test method may be used to simulate several storm events on the same sediment retention device specimen. Therefore, the number of times this test is repeated per specimen is dependent upon the user and the site conditions.

6. Apparatus

6.1 *Flume,* constructed from marine-grade plywood, plexiglas, aluminum, or other material. The flume should be watertight and constructed as shown in Fig. 1.

NOTE 1—Metal flumes should be mounted on a wood frame. The flume opening is the standard length of a straw bale. With a standard length flume of 122 cm (48 in.), the height of the back of the flume would be elevated 10 cm (3⅞ in.).

6.2 *Inlet Extension,* constructed from marine-grade plywood, plexiglass, aluminum, or other material. The inlet extension should be watertight and constructed as shown in Fig. 2.

NOTE 2—Metal inlet extensions should be mounted on a wood frame. The inlet extension opening should be appropriate for the type of SRD being tested.

6.3 *Sample Cutter,* appropriate to prepare test specimens.

6.4 *Integrated Water Sampler,*[4] a 500-mL (0.13-gal) device used to collect integrated samples of water.

6.5 *Two Containers,* 75-L (20-gal), plastic or nonmetallic.

6.6 *Stopwatch.*

6.7 *Stirrer,* such as a stirring rod on a portable electric drill.

6.8 *Sediment-Free Water,* containing no flocculent agents.

NOTE 3—Flocculent agents used in water treatment may cause erroneous results by affecting the settling rate of soil particles in the water.

6.9 *Soil,* either site-specific or representative of a target default gradation.

6.10 *Gooch Crucible.*

6.11 *Membrane Filter Apparatus.*

6.12 *Vacuum Pump.*

6.13 *Planchet,* aluminum or stainless steel.

6.14 *Desiccator.*

6.15 *Analytical Balance,* sensitivity of 0.01 g.

7. Sampling

7.1 *SRD Filtration Component:*

7.1.1 *Lot Sample*—Divide the product into lots and take the lot sample as directed in Practice D4354.

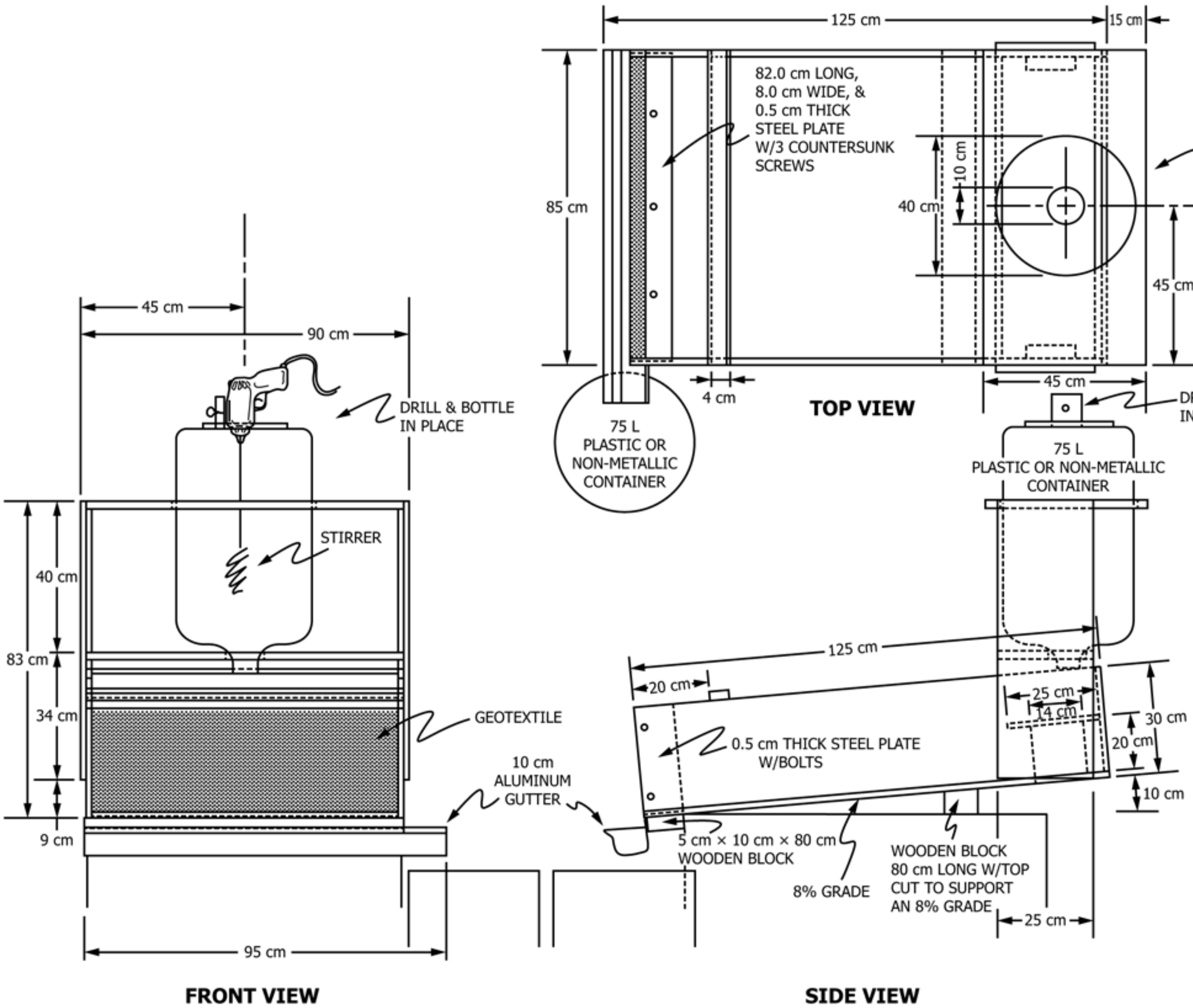
7.1.2 *Laboratory Sample*—Cut off sufficient length of the filtration component of the sediment retention device to get the appropriate number of test specimens. If holes or damaged areas are evident, then damaged material should be discarded and additional material sampled.

7.1.3 *Test Specimens*—Cut the appropriate number of specimens to be tested from the machine direction of the laboratory sample by a random method. Each test specimen should be cut (1 m long by 0.3 m wide (3.3 ft long by 12 in. wide)) to fit the flume or as necessary to fit the inlet opening.

NOTE 4—No specimen should be taken within 0.2 m (6 in.) of a selvage.

7.2 *Soil*—If desired, obtain representative samples of the site-specific soil that is significant to the design of the sediment retention device on the construction project. The size and type of sample required is dependent upon the number of tests to be performed and the percent of coarse particles in the sample. If

[4] The US DH-48 integrated water sampler has been found to be satisfactory. It is available commercially.



NOTE 1—Sides and bottom of flume can be constructed of 2-cm thick marine grade plywood.

FIG. 1 Flume (For Vertical SRDs)

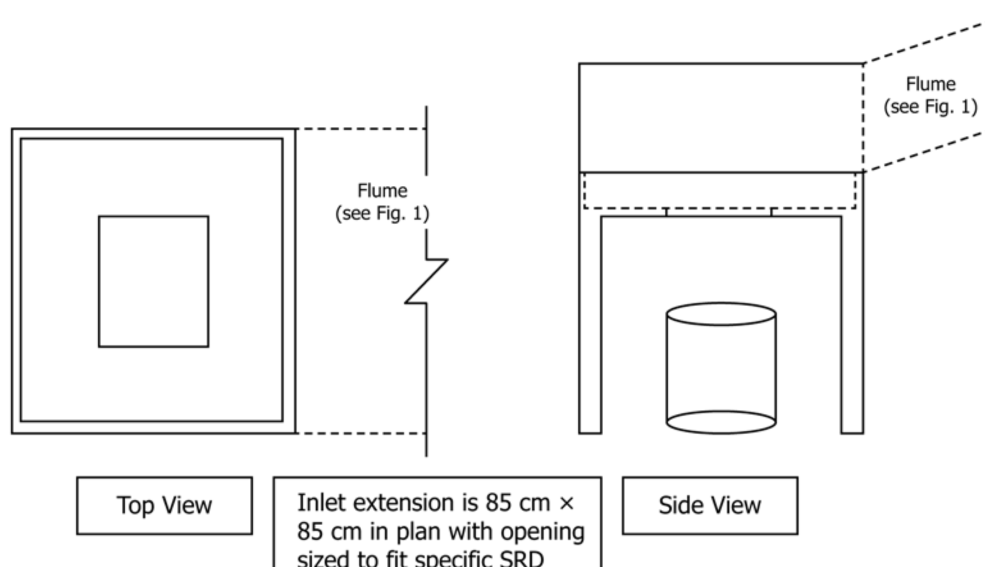


FIG. 2 Inlet Extension (For Horizontal SRDs)

testing is not site-specific, obtain a soil sample representative of the following target default gradation and having a Plasticity Index (PI) ≤ 15:

Percent Passing	Sieve Size (opening size, mm)
100	No. 10 (2.0 mm)
80–100	No. 40 (0.420 mm)
70–90	No. 100 (0.149 mm)
50–70	No. 200 (0.075 mm)

8. Procedure

8.1 Place the filtration component sample tautly across the flume opening or tightly fitted to the inlet opening and fasten securely in place to ensure that the test specimen has no wrinkles or loose sections and there is no seepage around the specimen.

8.2 Elevate the back of the flume to an 8 % slope. (See Fig. 1.)

8.3 Pre-wet the filtration component sample by running one test with 50 L (13.3 gal) of sediment-free water. Record the temperature of the water.

8.4 Mix 0.15 kg (0.33 lb) of air-dried site-specific soil in 50 L (13.3 gal) of untreated water placed in a 75-L (20-gal) container. These soil particles are smaller than 2 mm, the opening size of a No. 10 sieve. Thoroughly agitate the solution with a stirrer for 1 min to obtain a uniform mix.

8.5 While continuing to mix the solution, release the sediment-laden water at the upper end of the flume. Release of the solution should take less than 10 s. Start the timer at release.

8.6 Rinse the mixing container with no more than 2 L (0.5 gal) of additional water and release into the flume.

8.7 Time the flow of water through the filtration component sample until no water remains behind or above the sample or 25 min has elapsed. If 25 min have elapsed and water remains behind or above the sample, then measure the distance from the sample to the edge of the water behind the sample (if tested vertically) or the depth of water above the sample (if tested horizontally).

8.8 Collect all filtrate caught by the gutter in a second container, until no water remains behind the sample or 25 min has elapsed.

8.9 At the completion of the test, agitate the collected filtrate with a stirrer until the mixture is uniformly mixed. After 1 min of mixing, obtain a depth-integrated suspended-solids sample from the mixture while continuing the agitation. Alternatively, the entire collected filtrate may be vacuum filtered.

NOTE 5—With the sampler specified in 6.4, a rate of sampling that requires 30 s to reach the bottom of the container and 30 s to return to the surface is ideal. This sampling procedure allows collection of a sample over the full depth of the mixture or the entire collected mixture may be used.

8.10 Place a glass fiber filter disk either on a membrane filter apparatus or in the bottom of a suitable Gooch crucible. Apply a vacuum and wash the disk with three successive 20-mL portions of distilled water. Continue suction to remove all traces of water from the disk.

8.11 Carefully remove the filter disk from the membrane filter apparatus and transfer to an aluminum or stainless steel planchet. If a Gooch crucible is used, remove the crucible and filter disk combination.

8.12 Dry the filter disk for at least 1 h in an oven at 103 to 105°C.

8.13 Store in a desiccator until cooled to room temperature.

8.14 Weigh the filter disk to an accuracy of 0.01 g.

8.15 Place the filter disk in the membrane filter apparatus and return it or the Gooch crucible to the vacuuming and filtering apparatus.

8.16 Under the vacuum, filter the sample of water collected in 8.9.

8.17 Repeat 8.11 – 8.14.

9. Calculation

9.1 If using a depth-integrated suspended-solids sample, calculate suspended solids, as follows:

$$S_S = \frac{(A - B) \times 1000}{C} \quad (1)$$

where:

S_S = suspended solids, ppm,
A = weight of filter plus residue, and
B = weight of filter, and
C = sample, mL.

9.2 If using a depth-integrated suspended-solids sample, calculate the percent filtering efficiency (F_E) for the filtration component of the sediment retention device specimen, as follows:

$$F_E = \frac{2890 - S_s}{2890} \times 100 \quad (2)$$

where:

S_S = suspended solids after filtration, ppm, (Eq 1), and
2890 = sediment placed behind the filtration component of the sediment retention device, ppm.

9.3 If using the entire collected filtrate, calculate the percent filtering efficiency (FE) for the filtration component of the sediment retention device specimen, as follows:

$$F_E = ((A - B)/150)\ x\ 100 \quad (3)$$

where:

A = weight of filter plus residue (g), and
B = weight of filter (g), and
150 = Initial sediment load, g.

9.4 For vertical sediment retention devices, calculate the flow rate (F_T) of the filtration component of the sediment retention device specimen using Eq 4 (complete drainage) or Eq 5 (25 min elapsed time):

$$F_T\ (\text{m}^3/\text{m}^2/\text{min}) = 1.212856/t \quad (4)$$

or

$$F_T\,(m^3/m^2/min) = \frac{(0.05 - 0.033784x_f^{\,2})}{(0.041231 + 0.033892x_f)}/t \quad (5)$$

where:

T = temperature of the water,
t = time measured in 8.7, min, and
x_f = distance from the filtration component sample to the edge of the water behind the filtration component sample in m (see 8.7).

9.4.1 Correct the flow rate to 20°C using Eq 6:

$$F_{20°C} = \frac{F_T U_T}{U_{20°C}} \quad (6)$$

where:

$\frac{U_T}{U_{20°C}}$ = ratio of viscosity of water at temperature T to viscosity of water at 20°C (see Fig. 3).

9.5 For horizontal sediment retention devices, calculate the flow rate (F_T) of the sediment retention device specimen using Eq 7 (complete drainage) or Eq 8 (25 min elapsed time):

$$F_T\, m^3/m^2/min = (0.05/A)/t \quad (7)$$

or

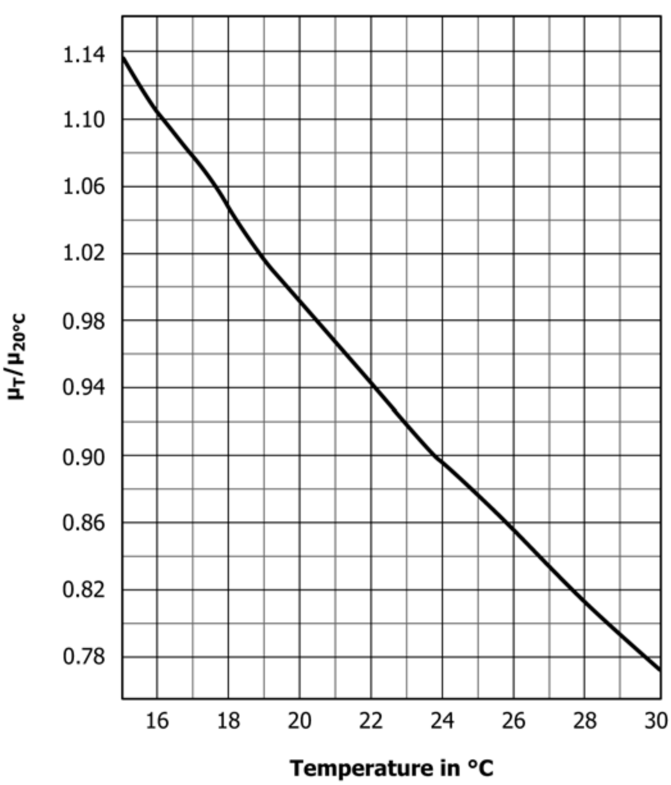


FIG. 3 The Ratio of Viscosity of Water at Temp, *T*, to the Viscosity of Water at 20°C

$$F_T\, m^3/m^2/min = (0.05 - 0.000723y)/t \quad (8)$$

where:

T = temperature of the water,
A = Area of horizontal opening, m^2
t = time measured in 8.7, min, and
x = height of the water above the sediment retention device in mm (see 8.7). (see 8.7).

9.5.1 Correct the flow rate to 20°C using Eq 9:

$$F_{20°C} = \frac{F_T U_T}{U_{20°C}} \quad (9)$$

where:

U_T = ratio of viscosity of water at temperature T to
$U_{20°C}$ = viscosity of water at 20°C (see Fig. 2).

10. Report

10.1 The report of filtering efficiency and flow rate should include the following information:

10.1.1 State that the specimens were tested as directed in this test method, and describe the type of filtration component and associated sediment retention device tested and the sampling method used,

10.1.2 The number of specimens tested and the direction(s) tested (if applicable),

10.1.3 The type of soil used and any data showing pertinent physical properties of the soil, such as gradation curve, Atterberg limits, etc.,

10.1.4 Complete test data including temperature of the water, recorded flow rates, length of test (25 min or elapsed time), suspended solids contents, and filtering efficiencies for each trial, and

10.1.5 A statement of any deviation from the described test method.

11. Precision and Bias

11.1 *Precision*—The precision of the procedure in this test method for measuring filtering efficiency and flow rate of the filtration component of a sediment retention device is being established.

11.2 *Bias*—The procedure in this test method for measuring filtering efficiency and flow rate of a f iltration component of a sediment retention device has no bias because the values of those properties can be defined only in terms of a test method.

12. Keywords

12.1 filtering efficiency; flow rate; sediment retention device; silt barrier; silt fence