



Standard Index Test Method for Determination of Unvegetated Rolled Erosion Control Product (RECP) Ability to Protect Soil from Rain Splash and Associated Runoff Under Bench-Scale Conditions¹

This standard is issued under the fixed designation D7101; 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 index test method establishes the guidelines, requirements and procedures for evaluating the ability of unvegetated rolled erosion control products (RECPs) to protect soils from simulated rainfall (rain splash) and minimal runoff induced erosion. The critical element of this protection is the ability of the unvegetated RECP to absorb the impact force of raindrops, thereby reducing soil particle loosening through “splash” mechanisms, and limiting the ability of runoff to carry the loosened soil particles.

1.2 This index test method utilizes bench-scale testing procedures and is not indicative of unvegetated RECP performance in conditions typically found in the field.

NOTE 1—The values obtained with this bench scale procedure are for initial performance indication, general product comparison and conformance purposes only. These values should not be used in estimating RECP soil protection in actual field use with such calculations as the Universal Soil Loss Equation (USLE) or Revised Universal Soil Loss Equation (RUSLE) without verification from qualified, large-scale tests.

1.3 This index test is not intended to replace full-scale simulation or field testing in acquisition of performance values that are required in the design of erosion control measures utilizing unvegetated RECPs.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.5.1 The procedures used to specify how data are collected/recorded or calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures

used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user’s objectives, and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this index test method to consider significant digits used in analytical methods for engineering design.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use and may involve use of hazardous materials, equipment, and operations. 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. Also, the user must comply with prevalent regulatory codes, such as OSHA (Occupational Health and Safety Administration) guidelines, while using the index test method.*

2. Referenced Documents

2.1 ASTM Standards:²

- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³))
- D6026 Practice for Using Significant Digits in Geotechnical Data
- D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D6459 Test Method for Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion
- D6475 Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets
- D6566 Test Method for Measuring Mass per Unit Area of Turf Reinforcement Mats

¹ This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.25 on Erosion and Sediment Control Technology.

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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.

*A Summary of Changes section appears at the end of this standard

3. Terminology

3.1 *Definitions*—For common definitions of terms in this standard, refer to Terminology [D653](#).

4. Summary of Test Method

4.1 Soil cores consisting of containers with both bare and unvegetated RECP-protected soil are exposed to simulated rainfall.

4.2 The amount of soil that splashes out of or is dislodged and carried by runoff from the containers is collected and weighed. The results can be used to compare bare and RECP-protected situations.

4.3 Key elements of the testing process include: (1) calibration of the rainfall simulation equipment; (2) preparation of the test cores; (3) documentation of the RECP to be tested; (4) installation of the RECP; (5) prosecution of the test; (6) collection of data; (7) analysis of the resultant data; and (8) reporting.

5. Significance and Use

5.1 This index test method indicates a unvegetated RECP's ability to reduce rainsplash-induced erosion under bench-scale conditions. This test method may also assist in identifying physical attributes of RECPs that contribute to their erosion-control performance.

5.2 This test method is bench-scale and therefore, appropriate as an index test for initial indication of product performance, for general comparison of unvegetated RECP capabilities, and for product quality assurance/conformance testing. The results of this test are not indicative of an RECP's actual field performance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice [D3740](#) are generally considered capable of competent and objective testing/sampling/inspections/etc. Users of this standard are cautioned that compliance with Practice [D3740](#) does not itself assure reliable results. Reliable results depend on many factors; Practice [D3740](#) provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Rainfall Simulator*—Rainfall is produced by a laboratory simulator capable of creating uniform drops with a median diameter of 3.0 to 3.5 mm (0.12 to 0.14 in.) from a drop height of 2000.0 mm (78.72 in.) above the lowest point of the incline structure (see [6.3](#)). The rainfall simulator shall be capable of producing rainfall intensities of 51 ± 5 mm/hr (2 ± 0.2 in./hr), 102 ± 5 mm/hr (4 ± 0.2 in./hr), and 153 ± 5 mm/hr (6 ± 0.2 in./hr). The simulator must be centered over the test area to provide uniform rain application over the entire incline structure ([Fig. 1](#)).

6.2 *Soil Cores*—Consist of water-tight containers nominally 200 ± 10 mm (8 ± 0.4 in.) inside diameter plastic pipe section cylinders with height of 100 ± 10 mm (4 ± 0.4 in.) holding soil and test specimens.

6.3 *Incline Structure*—Required is an incline structure comprised of three adjacent “runoff ramps” each having an opening

at its lower end to accommodate a recessed soil core. The ramps shall be 900 ± 20 mm (35 ± 0.8 in.) in length and 250 ± 20 mm wide (10 ± 0.8 in.). The incline structure shall be adjustable to a slope gradient of at least 3:1 (horizontal:vertical) and be able to maintain the desired slope. The incline structure shall have raised dividers (at least 25.0 mm (1 in.) tall) between ramps to prevent cross-ramp soil splash and run-on/runoff ([Fig. 1](#)).

6.4 *Collection Buckets*—Any type of bucket having sufficient diameter and volume to collect all runoff from the runoff ramp may be used.

6.5 *Filters*—Whatman #3 filter paper³ to separate sediment from soil and water solution.

6.6 *Miscellaneous*—Other miscellaneous equipment includes: sieve set (standard US sieves), evaporating dishes, drying oven, and balance.

7. Sampling

7.1 The laboratory sample should be 1 m^2 (10.76 ft^2).

8. Procedure

8.1 Calibration of Rainfall Simulator:

8.1.1 Calibration of the rainfall simulation equipment includes verification of: (1) rainfall intensity; (2) uniformity of rainfall application across the holding container; and (3) drop size. See [Annex A1](#) for details.

8.1.2 At a minimum, calibration shall be conducted on an annual basis and also following initial equipment set-up and any equipment maintenance.

8.2 Test Set-Up:

8.2.1 After calibration, prepare three soil cores for each RECP to be tested and nine cores for the bare soil conditions.

8.2.1.1 Fill/compact (see [8.2.1.2](#)) the cores with the standard soil (see [Annex A2](#) for soil details) flush with the lip of the container.

NOTE 3—The standard sand referenced in this test procedure has been historically used for product comparison purposes. However, site-specific soils, user-defined soils, or both, may be used. If non-standard soils are used, agreement should be established between the testing laboratory and the test user. The effect of utilizing a non-standard soil is unknown.

8.2.1.2 Unless otherwise agreed to prior to testing, compact the soil into the soil cores at $90 \pm 3\%$ of standard dry density at optimum moisture content $\pm 2\%$.

8.2.2 Adjust the incline structure to a gradient of 3:1 (h:v) (see [Note 4](#)).

NOTE 4—An incline of 3:1 (h:v) has been historically used for product comparison purposes. An alternate gradient may be utilized, however, the gradient should be agreed upon between the test laboratory and the user of the test. The effect of utilizing a non-standard gradient is unknown.

³ The sole source of supply of the apparatus known to the committee at this time is Whatman Inc., 200 Park Ave., Suite 210, Florham Park, New Jersey, 07932, www.whatman.com. 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.

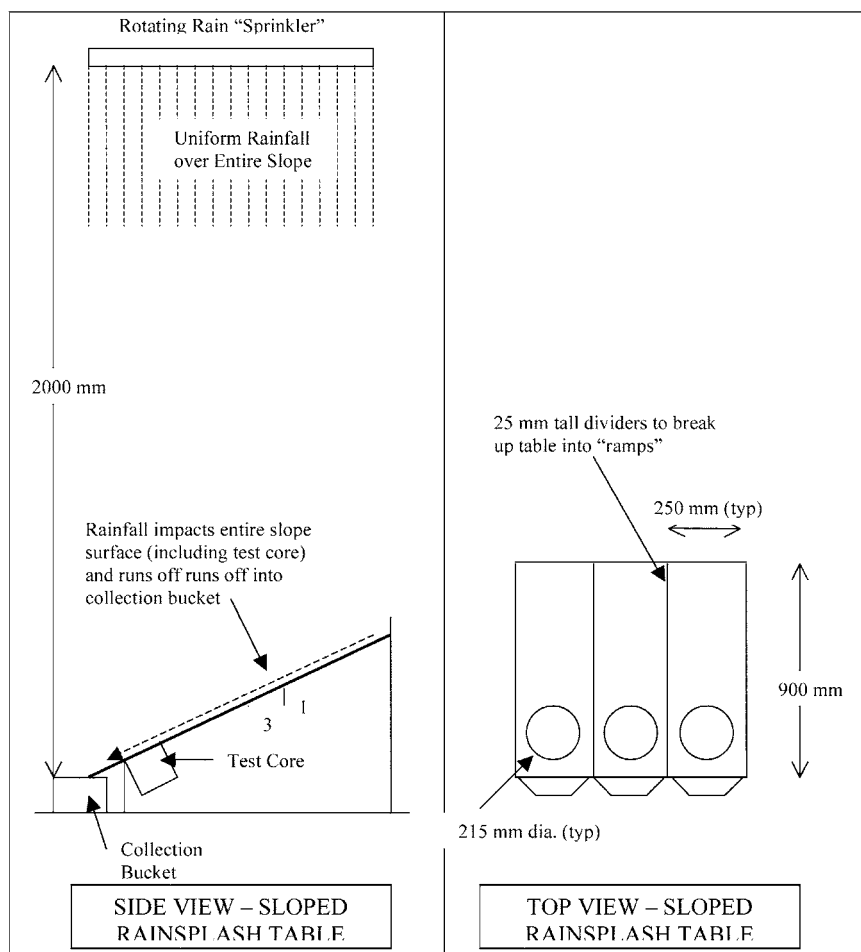


FIG. 1 Slope Erosion: Bench Scale Laboratory Test Apparatus

8.2.3 Place three of the prepared soil cores into the openings of the incline structure. The top edges of the cores are to be a minimum of 2 cm (0.8 in.) away from the sides of the runoff ramps.

8.2.4 For RECP-protected cores, place the RECP test sample over the entire incline structure including the soil core surfaces. Clip or otherwise affix the sample to the raised barriers between runoff ramps in such a way to avoid obstruction of flow and facilitate intimate contact with the runoff ramp and the soil surfaces of the cores.

8.2.4.1 Each RECP specimen shall be weighed and measured to determine its mass per unit area in accordance with Test Methods D6475 and D6566 prior to affixing to the runoff ramps.

8.3 Test Operation and Data Collection:

8.3.1 Cover the incline structure and soil cores with a waterproof lid or canopy and activate rainfall simulator at the target intensity. Both the RECP protected and bare soil control cores shall be subjected to three target rainfall intensities of 51 ± 5 mm/hr (2 ± 0.2 in./hr), 102 ± 5 mm/hr (4 ± 0.2 in./hr), and 153 ± 5 mm/hr (6 ± 0.2 in./hr), unless other intensities are agreed upon between the user of the test and testing laboratory.

8.3.2 After rainfall reaches a steady rate, position the collection buckets at the end of the runoff ramps and remove the cover from the incline structure and begin timing the test.

8.3.3 After five minutes, replace the waterproof cover or turn off the rainfall and take the collection buckets out of the simulator.

8.3.4 Position empty collection buckets at the end of the runoff ramps, remove the cover or turn rainfall back on, and resume the test.

8.3.5 Repeat 8.3.3 and 8.3.4 every 5 min.

8.3.6 Pour the water and soil mixture from the collection buckets through a Whatman #3 filter paper to collect the sediment from the first five minutes of the test. Measure and record the amount of water collected in each bucket. Additional water may be used in order to wash all the soil out of the holding container.

8.3.7 Repeat this process until the set of three soil cores has undergone six five-minute periods of simulated rainfall, which equals 30 min of exposure to simulated rain.

8.3.8 Dry each sediment sample in an oven at 105°C (221°F) for a minimum of 24 h, then weigh sample and determine mass to ± 0.01 g. The data for each pot should be entered into a table such as shown in Fig. 2.

8.3.9 Repeat the procedure with the remaining sets of three test cores at each target rainfall intensity.

9. Calculation

9.1 Average the three masses of sediment corresponding to the same five-minute period(s) to obtain six mean masses of soil loss from the RECP-protected cores at each target rainfall intensity.

9.1.1 The data for each pot should be entered into a table such as shown in Fig. 2 and normalized to the sample roll average mass per unit area based on the specimen-specific mass per unit area for the pot.

9.2 Sum the six mean masses of soil loss from the RECP-protected soil cores to obtain the mean mass (M_{RECP}) for the entire 30 min run at each rainfall intensity.

9.3 Average the three masses of sediment corresponding to the same five-minute period(s) to obtain six mean masses of soil loss from the bare soil cores at each target rainfall intensity.

9.4 Sum the six mean masses of soil loss from the bare soil control cores to obtain the mean mass ($M_{control}$) for the entire 30 min run at each target rainfall intensity.

9.5 Enter the mean masses obtained for the RECP and bare soil control cores as a function of time at each target rainfall intensity into a table.

9.6 Calculate the Bench-Scale Cover Index (BSCI) of the test material at each rainfall intensity as follows:

$$BSCI = M_{RECP}/M_{CONTROL} \quad (1)$$

where:

M_{RECP} = mean mass of soil loss from RECP protected cores according to 9.2, and
 $M_{CONTROL}$ = mean mass of soil loss from unprotected control cores according to 9.4.

9.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

10. Report

10.1 The report shall at a minimum include the following:

10.1.1 General information, including test facility location, date, time and operator name.

10.1.2 Calibration data and analysis (latest information).

10.1.3 Test set-up activities, including (1) test conditions (slope gradient, rainfall intensity); (2) soil type and conditions; (3) RECP product type and description; and (4) soil loss (g).

10.1.3.1 The sand gradation and standard proctor moisture-density relationship shall be reported. If other soils are used, the soils' information shall include: soil type/texture (that is, topsoil, sandy loam, silt loam, clay); standard proctor moisture-density relationship; gradation (including hydrometer test for the P200 fraction); organic matter content; plasticity indices; and pH.

10.1.4 Raw data and mean soil masses.

10.1.5 A table, graph, or both, of the mean soil loss masses as a function of time at each rainfall intensity.

10.1.6 The calculated BSCI for the test material at each rainfall intensity.

11. Precision and Bias

11.1 *Precision*—Test data on precision is not presented due to the nature of the soil materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program.

11.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

12. Keywords

12.1 erosion control; rainfall simulation; RECP; rolled erosion control product; sediment and slope



RECP Slope Simulation Test

Mass/Area (osy)
6.93

		
Bucket 1 Mass 47.83	Bucket 2 Mass 64.52	Bucket 3 Mass 42.78

Client:
Mfr.
TRI Log #
Sample ID:
Slope = 3 TO 1

2 in/hr rainfall
Buckets weighed and volume measured every 5 min.
Test duration: 30 min

Soil only

Bucket No.	5	10	15	20	25	30	Control
1	Runoff Volume (ml) 835	Runoff Volume (ml) 927	Runoff Volume (ml) 906	Runoff Volume (ml) 874	Runoff Volume (ml) 913	Runoff Volume (ml) 934	Total Runoff Volume (ml) 5393
2	Runoff Volume (ml) 802	Runoff Volume (ml) 816	Runoff Volume (ml) 12.43	Runoff Volume (ml) 710	Runoff Volume (ml) 765	Runoff Volume (ml) 785	Average Runoff Volume (ml) 4659
3	Runoff Volume (ml) 578	Runoff Volume (ml) 662	Runoff Volume (ml) 3.85	Runoff Volume (ml) 537	Runoff Volume (ml) 586	Runoff Volume (ml) 609	Runoff Volume (ml) 3619
Average	Runoff Volume (ml) 8.2	Runoff Volume (ml) 8.5	Runoff Volume (ml) 7.3	Runoff Volume (ml) 4.4	Runoff Volume (ml) 5.6	Runoff Volume (ml) 4.7	

Bucket No.	5	10	15	20	25	30	RECP Protective Area
1	Mass Soil Loss (g) 8.38	Mass Soil Loss (g) 17.44	Mass Soil Loss (g) 25.37	Mass Soil Loss (g) 32.34	Mass Soil Loss (g) 39.54	Mass Soil Loss (g) 46.24	Total Runoff Volume (ml) 4688
2	Mass Soil Loss (g) 12.41	Mass Soil Loss (g) 24.84	Mass Soil Loss (g) 34.79	Mass Soil Loss (g) 39.18	Mass Soil Loss (g) 46.11	Mass Soil Loss (g) 51.06	Average Runoff Volume (ml) 3303
3	Mass Soil Loss (g) 3.74	Mass Soil Loss (g) 7.69	Mass Soil Loss (g) 11.66	Mass Soil Loss (g) 13.37	Mass Soil Loss (g) 16.11	Mass Soil Loss (g) 18.63	Runoff Volume (ml) 2830
Average	Mass Soil Loss (g) 8.2	Mass Soil Loss (g) 16.7	Mass Soil Loss (g) 11.66	Mass Soil Loss (g) 13.37	Mass Soil Loss (g) 16.11	Mass Soil Loss (g) 18.63	

RECP over Soil

Bucket No.	5	10	15	20	25	30	Avg Mass/Area (osy)
1	Runoff Volume (ml) 566	Runoff Volume (ml) 750	Runoff Volume (ml) 849	Runoff Volume (ml) 824	Runoff Volume (ml) 829	Runoff Volume (ml) 830	Individual Specimen Mass (g) 47.83
2	Runoff Volume (ml) 360	Runoff Volume (ml) 578	Runoff Volume (ml) 612	Runoff Volume (ml) 575	Runoff Volume (ml) 593	Runoff Volume (ml) 565	Individual Specimen Area (in ²) 360
3	Runoff Volume (ml) 266	Runoff Volume (ml) 482	Runoff Volume (ml) 572	Runoff Volume (ml) 526	Runoff Volume (ml) 509	Runoff Volume (ml) 475	Individual Specimen Mass (g) 42.78
Average	Runoff Volume (ml) 0.9	Runoff Volume (ml) 1.2	Runoff Volume (ml) 1.0	Runoff Volume (ml) 0.9	Runoff Volume (ml) 0.6	Runoff Volume (ml) 0.7	Average Runoff Volume (ml) 360

Bucket No.	5	10	15	20	25	30	30 Normalized
1	Mass Soil Loss (g) 1.4	Mass Soil Loss (g) 2.78	Mass Soil Loss (g) 4.01	Mass Soil Loss (g) 4.94	Mass Soil Loss (g) 5.71	Mass Soil Loss (g) 6.39	Total Average Soil Loss (g) 5.60
2	Mass Soil Loss (g) 0.96	Mass Soil Loss (g) 2.09	Mass Soil Loss (g) 2.9	Mass Soil Loss (g) 3.79	Mass Soil Loss (g) 4.02	Mass Soil Loss (g) 4.63	Total Average Soil Loss (g) 5.47
3	Mass Soil Loss (g) 0.29	Mass Soil Loss (g) 1.42	Mass Soil Loss (g) 2.34	Mass Soil Loss (g) 3.12	Mass Soil Loss (g) 3.82	Mass Soil Loss (g) 4.51	Total Average Soil Loss (g) 3.53

FIG. 2 Example of Table Data

ANNEXES

(Mandatory Information)

A1. CALIBRATION OF RAINFALL SIMULATOR

A1.1 Calibration of Rainfall Intensity and Uniformity of Rainfall Distribution

A1.1.1 Place at least four rain gauges in a holding container and cover with a waterproof lid or canopy.

A1.1.2 Turn on the rain simulator and allow it to reach a steady rate of rainfall.

A1.1.3 Allow the calibration test to proceed for at least 15 min. Operating conditions representing those to be used in practice shall be used.

A1.1.4 Verify that the intensity stated in 6.1 is met in each of the rain gauges.

A1.2 Calibration of Uniformity of Drop-Size

A1.2.1 Fill four pie pans with sifted flour and strike off with a ruler to produce a smooth, uncompacted surface.

A1.2.2 Place the pie pans in a holding container and cover with a waterproof lid or canopy.

A1.2.3 Turn on the rain simulator and allow it to reach a steady rate of rainfall. Remove the waterproof cover briefly to let drops impinge on the flour to form pellets.

A1.2.4 Replace the cover after only a few seconds before the pellets start to touch each other.

A1.2.5 Air-dry the flour-filled pans for a minimum of 12 h.

A1.2.6 Screen the semi-dry pellets by emptying the entire contents of the pans onto a 70 mesh sieve in order to carefully remove as much loose flour as possible.

A1.2.7 Transfer the remaining pellets to evaporating dishes and heat in an oven at 43°C (110°F) for 2 h.

A1.2.8 Weigh the total mass of the hard flour pellets.

A1.2.9 Pour the pellets through standard soil sieves and shake the stack for 2 min. Foreign matter and any double pellets are culled from each sieve and the total weight for each size is recorded.

A1.2.10 Verify that the distribution of pellet sizes meets the conditions of 6.1.

A2. STANDARD SOILS

A2.1 General soil type to be used for testing shall be sand. The sand shall comply with the sand gradation given in Test Method D6459. The target gradation curve for the sand is included in Fig. A2.1. The sand layers shall be compacted to approximately 90 % of Standard Proctor density in accordance with Test Methods D698.

A2.2 If the RECP is to be soil filled, the additional cover soil is placed and compacted after the RECP placement.

Soil Grain Size Distributions

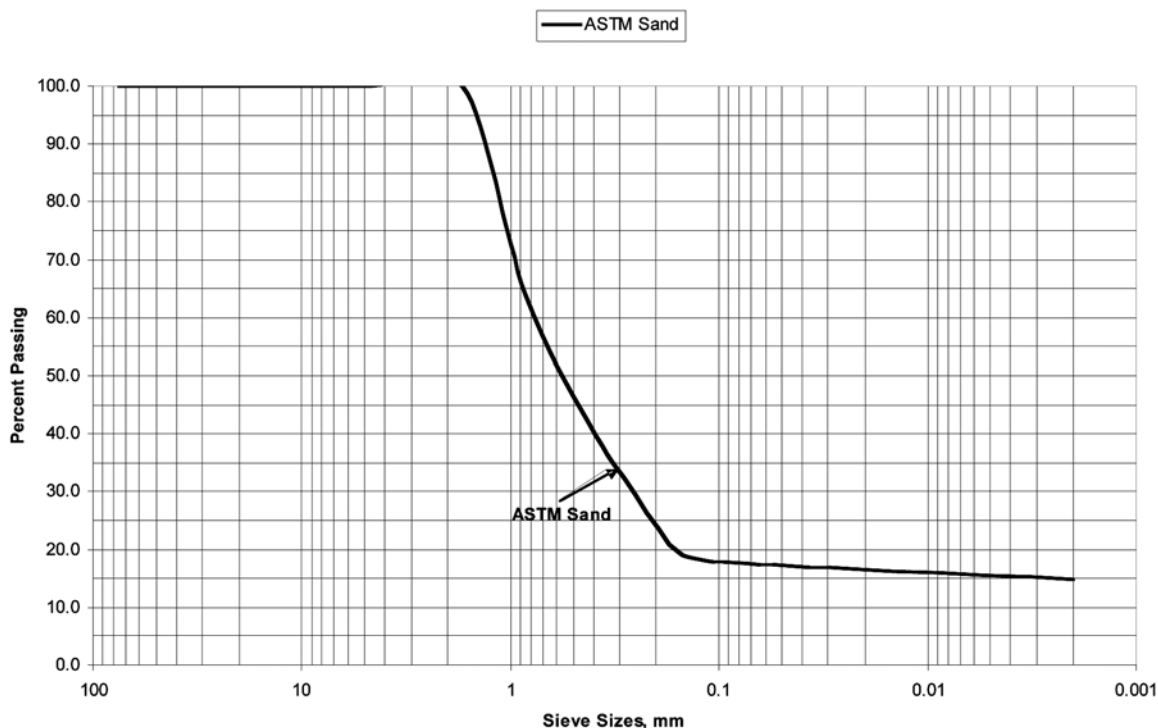


FIG. A2.1 Target Sand Gradation

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D7101 – 08) that may impact the use of this standard. (Approved June 15, 2013.)

(1) Revised **Note 3** and **8.2.2**.

(2) Added **Note 4**.

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