Designation: D 5514 – 94 (Reapproved 2001)

Standard Test Method for Large Scale Hydrostatic Puncture Testing of Geosynthetics[1]

This standard is issued under the fixed designation D 5514; 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 evaluates the stress/time properties of geosynthetics by using hydrostatic pressure to compress the geosynthetic over synthetic or natural test bases consisting of manufactured test pyramids/cones, rocks, soil or voids.

1.2 This test method allows the user to determine the relative failure mode, points of failure for geosynthetics, or both.

1.3 This test method offers two distinct procedures.

1.3.1 Procedure A incorporates manufactured test pyramids or cones as the base of the testing apparatus. Procedure A is intended to create comparable data between laboratories, and can be used as a guide for routine acceptance test for various materials.

1.3.2 Procedure B incorporates site specific soil or other material selected by the user as the test base of the testing apparatus. Procedure B is a method for geosynthetic design for a specific site.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.5 *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 136 Method for Sieve Analysis of Fine and Coarse Aggregates[2]
D 751 Test Method for Coated Fabrics[3]
D 4439 Terminology for Geosynthetics[4]
D 4885 Test Method for Determining Performance Strength of Geomembranes by Wide Strip Tensile Method[4]
D 5199 Test Method for Measuring Nominal Thickness of Geosynthetics[4]
E 11 Specification for Wire-Cloth Sieves for Testing Purposes[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *atmosphere for testing geomembranes*, *n*—air maintained at a relative humidity of 50 to 70 % and a temperature of 21 ± 2°C (70 ± 4°F).

3.1.2 *critical height (ch)*, *n*—the maximum exposed height of a cone or pyramid that will not cause a puncture failure of a geosynthetic at a specified hydrostatic pressure for a given period of time.

3.1.3 *failure*, *n*—in testing geosynthetics, water or air pressure in the test vessel at failure of the geosynthetic.

3.1.4 *hydrostatic pressure*, *n*—a state of stress in which all the principal stresses are equal (and there is no shear stress), as in a liquid at rest; induced artificially by means of a gaged pressure system; the product of the unit weight of the liquid and the difference in elevation between the given point and the free water elevation.

4. Significance and Use

4.1 *Procedure A*:

This procedure is an index type test which can be used as a guide for acceptance of commercial shipments of geosynthetics. The standard cone and pyramid test fixtures can establish critical height (ch) consistency with similar material from previous lots or different suppliers, as well as testing from other laboratories. However, due to the time required to perform tests, it is generally not recommended for routine acceptance testing.

4.2 *Procedure B*:

This procedure is a performance test intended as a design aid used to simulate the in-situ behavior of geosynthetics under hydrostatic compression. This test method may assist a design engineer in comparing the ability of several candidate geosynthetic materials to conform to a site specific subgrade under specified use and conditions.

5. Apparatus

5.1 For safe operation, the test vessel should have an appropriate ASME pressure rating. The maximum pressure

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.10 on Geomembranes.

Current edition approved Feb. 15, 1994. Published April 1994.

[2] Discontinued—Replaced by C117.

[3] *Annual Book of ASTM Standards*, Vol 09.02.

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

[5] *Annual Book of ASTM Standards*, Vol 14.02.

rating of the vessel is dependent on the material being tested and expected pressures to be encountered. Pressure can be achieved from a regulated air system or a hydraulic pump.

5.2 *Subgrade Pan*, several removable pans for configuring various subgrades. Subgrade pans are to be built, with a depth of 102 mm (4 in.), and with drain holes in the bottom of the pan to allow the pressurizing medium to flow through. The subgrade pan shall be constructed of a suitable material to support a load of 1800 kPa (250 psi).

5.3 *Leak Detection System*, can be designed by using displacement floats, moisture sensor, pressure sensors, a sight glass, or other means that will accurately detect failure.

5.4 *Layout Grid*, for procedure B, the layout grid is to assist in determining deformation of the tested geosynthetic. The grid is placed flat against the test specimen that has been placed ready for testing. Depth readings will be taken in a prearranged pattern over the entire area of the test specimen. The prearranged area that the geosynthetic displacement depth is checked must remain consistent throughout the complete testing. The depth is taken from the top of the grid to the surface of the test specimen. The layout grid is to be made of 3 mm (0.12 inch) aluminum rod with a grid layout of 50 × 50 mm (2 × 2 in.).

5.5 *Test Pyramids*, the pyramid should be manufactured from aluminum or a hard plastic, i.e., epoxy or Lexan.

5.6 *Test Cones*, cones are more consistent when manufactured out of a hard plastic, that is, epoxy.

5.7 *Temperature Probe*, used to measure the test chamber temperature as well as the liquid temperature (if applicable). The accuracy of the temperature probe shall be ±1°C.

5.8 *Support Bridge*, used to support the center of the subgrade pan to keep the pan from deflecting under load.

5.9 *Pressure Measurement Gages*, should be in a series such that each lower pressure can be closed off as its maximum safe operation pressure is reached. The series of gages should be 0 to 210 kPa (0 to 30 psi), 0 to 690 kPa (0 to 100 psi), and 0 to 1400 kPa (0 to 200 psi). The accuracy shall be ±7.0 kPa (1 psi).

6. Hazards

6.1 **Precaution—**In addition to other precautions, the test apparatus is under pressure and proper precaution should be taken. When drain valves are opened, safety glasses should be worn by the operator. Pressure relief valves are highly recommended to prevent unsafe pressures.

7. Test Specimen

7.1 Cut the geosynthetic test specimen to fit a minimum of 10 mm beyond the clamping area (test vessel flange area) of the designed pressure vessel.

NOTE 1—The conceptual drawing of a pressure vessel as diagrammed in Fig. 1 is acceptable, however, other types of vessels can be used as long as the size does not bias results for a particular material.

NOTE 2—If it is difficult to determine a materials machine direction, after testing, first mark on the specimen before testing a line parallel to the machine direction.

7.2 Measure the geosynthetic specimen thickness accurately by one of the industry standard test methods referenced in Section 2.

NOTE 3—If testing a permeable geosynthetic without the support of a geomembrane, a non-permeable sheet on the liquid medium side may be used, provided adjustments are made for the strength of the non-permeable sheet (that is, 0.4 mm latex).

7.3 The test specimen should be free of any scratches, folds, or other abnormalities, unless the abnormality is the item of interest.

7.4 Examine a total of three replicate test specimens.

8. Conditioning

8.1 Expose the specimens to the standard atmosphere for testing geomembranes for a period long enough to allow the geomembranes to reach equilibrium with the standard atmosphere. Consider the specimen to be at moisture equilibrium when the change in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen. Consider the specimen to be at temperature equilibrium after 1 h of exposure to the standard atmosphere for testing.

8.2 If the test is to simulate actual application, the test specimen should be conditioned for at least 40 h in that environment. If there is not a specific environment, then the conditioning should be in accordance with ASTM standard conditioning for the material being tested. If no such standard exists, state the conditioning procedure used.

9. Procedure A

9.1 *Placement of the Subgrade*—First place a geotextile or other fabric in the bottom of the subgrade pan. The geotextile is to be used to restrict movement of small particles of sand or rocks into the lower portion of the tester. Any geotextile or other fabric which has the capability of retaining the subgrade pan fill material and does not restrict the flow of the liquid medium is adequate.

NOTE 4—The use of any geotextile should not allow movement of the pyramids or cones in relation to the established subgrade. This movement could result in changes in the protrusion height during the test.

9.2 Place the pyramids/cones in the subgrade pan on top of the geotextile. The pyramids/cones are arranged so that a line drawn through the geometric center of the pyramid, cone is on a circumference of a 200 mm (8 in.) diameter circle for a 500 mm (20 in.) minimum diameter vessel.

9.3 If pyramids are selected, four test pyramids shall be used for each test. The pyramids are positioned 90° apart.

9.4 If cones are selected, three test cones shall be used for each test. The cones are arranged 120° apart with their 45° faces each facing the center of the pan.

9.5 The subgrade shall be a clean, washed, ottawa sand used to support the geomembrane materials at final placement level, fill the area between the test pyramids or test cones, and create a water drainage layer below the geomembrane.

9.6 Place the specimen over the prearranged subgrade and secure the top of the test apparatus to the bottom.

9.7 Fill the vessel to obtain a water or liquid medium level that is 127 mm (5 in.) over the test height of the pyramid/cones.

9.8 Be sure all valves are tightly closed, including the air intake valve of the vessel which is between the test apparatus and regulator. This will insure that the testing does not begin prematurely, and a zero point in pressure is monitored. Connect air service to the air regulator.

9.9 Open the regulator valve. The pressure should be increased at 7.0 kPa (1 psi) every 30 min until rupture or the maximum air pressure is achieved. This maximum pressure should be noted and included on the final report. Other incremental pressures can be used if desired and agreed upon by all parties involved in the test program evaluation.

NOTE 5—The 7 kPa (1 psi) pressure increase should be accomplished within the first one minute of the total incremental dwell time.

9.10 Release pressure of the hydrostatic tester by closing the incoming air line valve. Open the drain valve on the hydrostatic tester and let the water or liquid medium drain from the vessel.

9.11 After water or liquid medium has been released, remove the top portion of the test apparatus.

9.12 If the geosynthetic specimen does not fall, increase the height of the pyramids/cones by removing and reshaping the ottawa sand subgrade. Continue to increase the height of the pyramids in 13.0 mm (0.5 in.) increments until failure of the geosynthetic occurs.

9.13 Immediately remove the test specimen from the test apparatus and, using Method D 5199, measure the thickness of test specimen at the points adjacent to failure and at the point of the pyramid/cone. Measure again after 90 min.

9.14 Repeat testing for the three specimens, obtaining an average time and pressure to the point of failure or non-failure.

9.15 *Procedure B*—The testing and data collection will be the same as procedure A; however, site specific material will be used and placed according to the instruction from the requesting parties.

9.16 The site specific fill material will be classified by the testing laboratory by the use of sieves, and the aggregate measured by calipers.

9.17 After the specimen is placed in position for testing, place the layout grid over the specimen. Mark on the specimen at least 20 prearranged areas across the grid. (Measure these areas in depth as defined from the top of the grid to contact with the specimen.)

NOTE 6—To be consistent in a series of analyses, be sure that the same area on all specimens is examined.

9.18 After the test has been discontinued due to failure or maximum pressure is reached, the layout grid is placed directly over the surface of the test specimen.

9.19 Measure the deformation that has occurred during testing by checking the depth at the original 20 points before test. The 20 grid points should be measured corner to corner for each grid. If there is a protrusion in the grid area, measure the highest point and the lowest point.

10. Calculation and Graphs

10.1 *Procedure A*—Thickness and recovery calculations.

$$[(H_2 - H_1)/H_0] \times 100 = \text{Deformation \%} \tag{1}$$

$$[(H_2 - H_1)/(H_0 - H_1)] \times 100 = \text{Recovery \%} \tag{2}$$

where:

H_0 = original thickness,
H_1 = specimen thickness immediately after removal from tester, and
H_2 = specimen thickness 90 min after load is removed.

10.2 *Critical Height (ch)*—Of pyramid or cones.

10.2.1 Graph the pyramid/cone heights versus their respective failure or maximum obtained pressure.

10.2.2 Critical height is the point at which an increase in pressure will result in failure of the geosynthetic.

10.3 *Procedure B*—Deformation percent change.

$$\text{Deformation percent} = (A/B) \times 100 \tag{3}$$

where:

A = change in depth in millimeters (mm), and
B = original depth in millimeters (mm).

NOTE 7—The reported calculation is based on both the maximum depth recorded during the test, and the average measured depth of the 20 measurements taken.

11. Report

11.1 Report the following:

11.2 The complete identification of the material tested.

11.3 The procedure used for the testing.

11.4 Conditions under which the tests were performed.

11.5 *Procedure A*—The following will be listed:

11.5.1 Original thickness,

11.5.2 The type of test apparatus—pyramids or cones,

11.5.3 Thickness of specimen 10 min after pressure release or failure,

11.5.4 Thickness of specimen 1½ h after test,

11.5.5 Calculation of the deformation,

11.5.6 Calculation of recovery percent,

11.5.7 Graph the critical height of the pyramids/cones, and

11.5.8 Pressure and time at failure.

11.6 *Procedure B*—The following information will be listed:

11.6.1 Average of the original depth across specimen,

11.6.2 Average depth of the tested specimen,

11.6.3 The largest deformation recorded,

11.6.4 Deformation as a percent change, and

11.6.5 Pressure and time at failure.

12. Precision and Bias

12.1 Precision and bias of the procedure in ASTM Draft Designation D35.10.88.01 for measuring Large Scale Hydrostatic Pressure Testing of Geosynthetics is being determined.

13. Keywords

13.1 geosynthetic; hydrostatic pressure; puncture resistance