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Standard Test Method for Multi-Axial ~~Tension Test for Geosynthetics~~Elongation of Geomembranes[1]

This standard is issued under the fixed designation D5617; 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 covers the measurement of the out-of-plane response of ~~geosynthetics~~ a geomembrane to a force that is applied perpendicular to the initial plane of the sample.

1.2 When the ~~geosynthetic~~geomembrane deforms to a prescribed geometric shape (arc of a sphere or ~~ellipsoid)~~ellipsoid), formulations are provided to convert the test data to biaxial tensile stress-strain values. These formulations cannot be used for other geometric shapes. With other geometric shapes, comparative data on deformation versus pressure is obtained.

~~1.3 This test method is more commonly used to test geomembranes. Permeable materials may also be tested in conjunction with an impermeable material.~~

1.3 This test method requires a ~~large diameter~~ large-diameter pressure vessel ~~(600~~(610 mm). Information obtained from this test method may be more appropriate for design purposes than many ~~small scale index tests such as Test Method~~ small-scale index tests.~~D6693 or Test Method D7003/D7003M.~~

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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~~safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

D4439 Terminology for Geosynthetics

~~D6693~~D5199 Test Method for ~~Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes~~Measuring the Nominal Thickness of Geosynthetics

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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 D35.10 on Geomembranes.

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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.

~~D7003/D7003M~~D5994/D5994M Test Method for ~~Strip Tensile Properties of Reinforced~~Measuring Core Thickness of Textured Geomembranes

3. Terminology

3.1 *Definitions:*

3.1.1 ~~*geosynthetic,*~~ *multi-axial elongation, n*~~—planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.~~average strain along the arch intercepting the centerpoint, generated by the out-of-plane deformation of a geomembrane specimen fixed by a ring and exposed to a fluid pressure.

~~3.1.2 *multi-axial tension, n*—stress in more than one direction.~~

3.1.2 For definitions of other terms used in this test method, refer to Terminology D4439.

4. Summary of Test Method

4.1 A ~~pre-cut geosynthetic sample~~ geomembrane specimen is secured at the edges of a ~~large diameter (600 mm)~~ large-diameter pressure vessel. Pressure is applied to the ~~sample~~specimen to cause out-of-plane deformation and failure. ~~This deformation~~ The deformation at break with pressure information ~~can then be~~ is analyzed to evaluate various materials.

5. Significance and Use

5.1 Installed ~~geosynthetics~~geomembranes are subjected to forces from more than one direction, including forces perpendicular to the surfaces of the ~~geosynthetic. Out of plane~~ geomembrane. Out-of-plane deformation of a ~~geosynthetic~~geomembrane may be useful in evaluating materials for caps where subsidence of the subsoil may be problematic.

5.2 Failure mechanisms on this test may be different compared to other relatively ~~small scale~~ small-scale index tests and may be beneficial for design purposes.

5.3 In applications where local subsidence is expected, this test can be considered a performance test.

~~NOTE 1—Although, this test specifies a vessel size of 600 mm, larger diameter vessels will better approximate field performance. However, the user is cautioned that different size vessels may yield different results and hence may not be comparable.~~

5.4 For applications where ~~geosynthetics~~geomembranes cannot be deformed in the fashion this test method prescribes, this test method should be considered an index test.

5.5 Due to the time involved to perform this ~~test method,~~ test, it is not considered practical as a quality control test.

6. Apparatus

6.1 Fig. 1 shows an example of the test apparatus that can be used ~~in the performance of~~ to perform this test method. The apparatus requires a pressure vessel ~~rated to~~ capable of sustaining a minimum of 690 kPa. The vessel ~~diameter should be 600~~ inside diameter is 610 ± 10 mm.[3] ~~Other size vessels may be used but it is up to the user to establish correlation to the standard size vessel.~~

6.1.1 Other size vessels may be used as a deviation from the standard size; however, their results are not comparable with those using standard equipment.

NOTE 1—In some jurisdictions, the use of pressure vessels may be regulated for working at the anticipated pressures.

[3] The sole source of supply of the apparatus known to the committee at this time is BT Technology, Inc., PO Box 49, 320 North Railroad St., Rushville, IL 62681. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

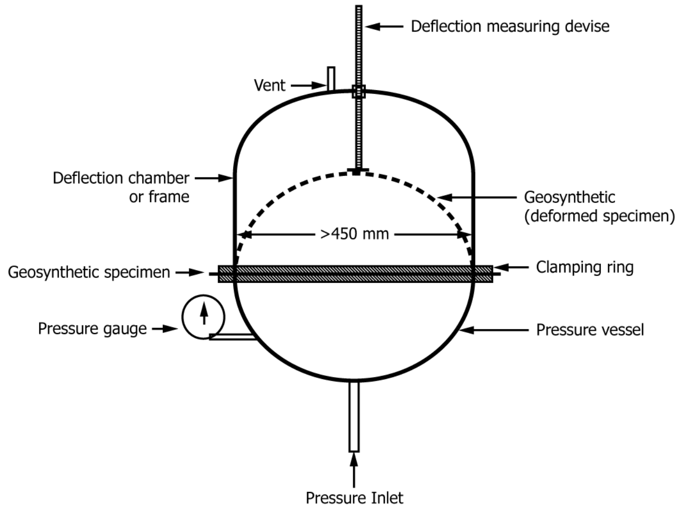

FIG. 1 Multi-Axial Burst Apparatus

~~6.2 If the vessel has a deflection chamber it should not inhibit the geosynthetic from freely deflecting during the test. The deflection chamber shall be vented.~~

~~6.2.1 Some materials will expand laterally beyond the diameter of the pressure vessel and may contact the sides of the deflection chamber. In these cases, the test is no longer valid and a different device must be used. Devices without deflection chambers have worked well in these situations.~~

6.2 The vessel ~~will have~~ must be equipped with a system to measure pressure with an accuracy of 0.35 kPa and the magnitude of central ~~deflection.~~deflection every second with an accuracy of 1 mm or 1 %, whichever is the greatest.

~~6.3.1 The system for measuring deflection shall be capable of being read to an accuracy of 5 mm.~~

~~6.3.2 The system for measuring pressure shall be capable of being read to an accuracy of 3.5 kPa.~~

~~6.4 All test shall be conducted at standard laboratory temperatures of 23 ± –2°C.~~

7. ~~Test Specimen~~Sampling and Specimens

7.1 Cut a roll-width sample from a clean and unscratched section of the roll. The length in the machine direction shall be longer than the diameter of the test specimen including clamping area.

7.2 Do not use test specimens with defects or any other abnormalities, unless this is the item of interest.

~~7.2 Cut the test specimen larger than the area of the main sealing force of the vessel.~~

7.3 ~~If a permeable material such as a geotextile is being tested, an impermeable material such as a geomembrane or thin plastic sheet has to overlay the permeable material to maintain the pressure in the vessel during the test.~~Cut the test specimen to the requirements of the test vessel to entirely fix the specimen and ensure a seal free of leaks.

~~7.3.1 When testing permeable materials, the impermeable material shall be more elastic than the permeable material (unless the combination of the two materials is the desired test variable). This is required so that the permeable material fails first.~~

~~7.3.2 Test results on permeable materials will be affected by the impermeable material used in the test.~~

7.4 ~~Test~~Prepare three ~~replicate specimens on each sample unless otherwise noted.~~specimens equally spaced across the width.

8. Conditioning

8.1 Test specimens shall be conditioned at a temperature of 23 ± –2 °C until reaching thermal equilibrium and for at least 16 h.

8.2 Tests shall be conducted at a temperature of 23 ± –2 °C.

9. Procedure

9.1 Cut the test specimen to the requirements Measured the thickness of the test vessel to ensure aspecimen according to Test Method D5199good seal. Place, Test Method D5994/D5994Mspecimen across the opening of the vessel. Be sure the specimen is not sagging., or the appropriate standard for the material being tested.

8.2 Be sure the specimen remains flat while the edge of the specimen is being securely clamped into place.

9.2 Either air or water can be used to pressurize the vessel. If a water system is used, introduce water into the vessel until it is completely filled.full.

9.3 Place specimen across the opening of the vessel. Be sure the specimen is not sagging. For some types of geomembranes, a rubber seal may be necessary on the underside of the specimen to avoid air leakage while increasing the pressure.

9.4 Place the clamping ring. Be sure the specimen remains flat while the edge of the specimen is being clamped.

9.5 Add water or air air, at room temperature, into the system so as to control the rate of centerpoint deflection at 20 mm/min in a continuous fashion.to 20 ± 2 mm/min. Stepwise increments of flow to control centerpoint deflection are not allowed.

8.4.1 Stepwise increments of center point deflection are not allowed.

NOTE 2—The deflection rate may affect the measured multiaxial elongation. It is therefore recommended to avoid deviations from the target rate of centerpoint deflection throughout the test. In case of dispute, one of the criteria that must be considered to identify the most representative result is the deviation from the target deflection rate, calculated over any 10 s period throughout the test.

9.6 Record the amount of centerpoint deflection and pressure at least every 10 s.second.

9.7 Continue with the test by maintaining a constant rate of centerpoint deflection at the specified rate until the specimen has ruptured (as noted by a sudden loss in pressure) or until some predetermined end point has been reached.

NOTE 3—The user is cautioned that the sudden release of pressure at rupture could potentially be dangerous and cause either personal injury or damage to the surroundings. Regular eyeglass protection and earplugs should be used.

9.8 Repeat the above with two additional specimens from the same sample. specimens.

NOTE 3—If the specimen has deformed in a fashion so that the surface of the specimen approximates an arc of a sphere or an ellipsoid, stress-strain calculations are provided in Appendix X1.

10. Calculations

10.1 The following calculations were developed assuming that the specimens have deformed to a shape which approximates a fraction of an ellipsoid of revolution. Diagrams and details of these calculations are provided in Appendix X1.

10.1.1 The deflection (δ) at failure is equal to or less than half the inside diameter (L) of the vessel and resembles a spherical dome.

10.1.1.1 Strain (ε):

$$\epsilon(\%) = \frac{\left[\left(\frac{L^2+4\delta^2}{8\delta}\right)\cdot\left(2\cdot\tan^{-1}\frac{4(L)\delta}{L^2-4\delta^2}\right)\right]-L}{L}\times 100 \quad (1)$$

10.1.1.2 Stress:

$$\sigma = \frac{L \cdot p}{4 \cdot t \cdot \sin\left(\tan^{-1} \frac{4(L)\delta}{L^2 - 4\delta^2}\right)} \quad (2)$$

10.1.2 The deflection (δ) at failure is equal to or greater than half the inside diameter (*L*) of the vessel and resembles half section of a spheroid.

10.1.2.1 Strain:

$$\epsilon(\%) = \frac{\pi \cdot \sqrt{\frac{L^2+4\delta^2}{8}} - L}{L} \times 100 \quad (3)$$

10.1.2.2 Stress:

$$\sigma = \frac{L \cdot p}{4 \cdot t} \quad (4)$$

where:

δ = deflection (m),
L = inside diameter of the vessel (typically 0.61 m),
p = pressure inside the vessel at failure (Pa), and
t = thickness of the specimen (m).

11. Description of Sample Failure

11.1 Materials will generally fail in a given manner that can be described by the following categories:

11.2 *Failure Location:*

11.2.1 *Edge Tear (ET)*—Failure adjacent to the clamping ring. May not represent the performance of the sample material.

11.2.2 *Non-edge Failure (N-EF)*—A rupture sufficiently far enough away from the edge of the device to assume that the device did not lead to the failure. The data is representative of the sample material.

11.3 *Failure Shape:*

11.3.1 *Machine Direction Tear (MD-T)*—A tear in the machine direction.

11.3.2 *Transverse Direction Tear (TD-T)*—A tear in the transverse direction.

11.3.3 *Multi-Directional Tear (XD-T)*—A tear or several tears that do not follow any single direction.

11.3.4 *Hole*—Circular or elliptical hole in the specimen. Material may or may not have thinned over a broad region.

11.3.5 *Hole in Cat Eye (H-Cat)*—Circular or elliptical hole in an area where the material has significantly necked down and thinned. The large, thinned area resembles the pupil of a cat's eye.

12. Report

12.1 Report the following information:

12.1.1 Sample ~~identification,~~identification and specimen average thickness.

12.1.2 Date, time, and temperature of the test room.

12.1.3 Size of vessel used (inside diameter), if other than standard,standard.

9.1.3 Conditions under which the test was performed, if other than standard,

9.1.3.1 For permeable membranes, identify the impermeable material used during the test including the thickness.

NOTE 4—The impermeable material may have a significant impact on the data and must be considered when reviewing stress-strain results.

12.1.4 Description of the failure and the shape of the specimen after failure.specimens after the failure identified in Section 11.

12.1.5 Plot the full pressure-deflection or stress-strain curves for all specimens.

12.1.6 Plot the deflection versus time points readings for each specimen.

12.1.7 Average and individual specimen results for gauge, pressure at rupture, and centerpoint deflection at rupture. Report stress and strain at rupture if calculations were made.

12.1.8 Name or identification of who ran the test.

13. Precision and Bias

13.1 The precision and bias of this test method have not yet been established.

14. Keywords

14.1 deformation; geosynthetics; multi-axial

APPENDIXES

(Nonmandatory Information)

X1. DESCRIPTION OF SAMPLE FAILURES

X1.1 Materials will generally fail in a given manner that can be described by the following categories:

X1.2 Failure Location

X1.2.1 *Edge Tear (ET)*—Failure adjacent to the clamping ring. May not represent the performance of the sample material.

X1.2.2 *Non-edge Failure (N-EF)*—A rupture sufficiently far enough away from the edge of the device to assume that the device did not lead to the failure. The data is representative of the sample material.

X1.3 Failure Shape

X1.3.1 *Machine Direction Tear (MD-T)*—A tear in the machine direction.

X1.3.2 *Transverse Direction Tear (TD-T)*—A tear in the transverse direction.