Designation: D5617 – 23

Standard Test Method for Multi-Axial 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 a geomembrane to a force that is applied perpendicular to the initial plane of the sample.

1.2 When the geomembrane deforms to a prescribed geometric shape (arc of a sphere or 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 requires a large-diameter pressure vessel (610 mm). Information obtained from this test method may be more appropriate for design purposes than many small-scale index tests.

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, 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

D5199 Test Method for Measuring the Nominal Thickness of Geosynthetics

D5994/D5994M Test Method for Measuring Core Thickness of Textured Geomembranes

3. Terminology

3.1 *Definitions:*

3.1.1 *multi-axial elongation, n*—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 For definitions of other terms used in this test method, refer to Terminology D4439.

4. Summary of Test Method

4.1 A geomembrane specimen is secured at the edges of a large-diameter pressure vessel. Pressure is applied to the specimen to cause out-of-plane deformation and failure. The deformation at break with pressure information is analyzed to evaluate various materials.

5. Significance and Use

5.1 Installed geomembranes are subjected to forces from more than one direction, including forces perpendicular to the surfaces of the geomembrane. Out-of-plane deformation of a 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 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.

5.4 For applications where 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, 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 to perform this test method. The apparatus requires a

[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.

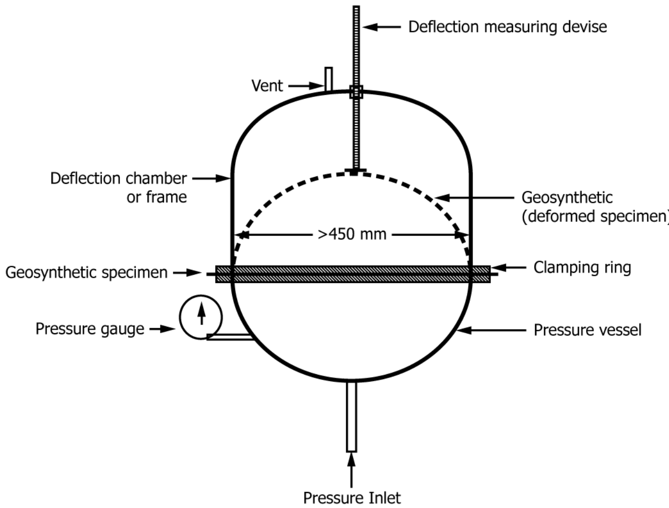

FIG. 1 Multi-Axial Burst Apparatus

pressure vessel capable of sustaining a minimum of 690 kPa. The vessel inside diameter is 610 ± 10 mm.[3]

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.

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

7. 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.

7.3 Cut the test specimen to the requirements of the test vessel to entirely fix the specimen and ensure a seal free of leaks.

7.4 Prepare three 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 Measured the thickness of the test specimen according to Test Method D5199, Test Method D5994/D5994M, or the appropriate standard for the material being tested.

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 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, at room temperature, into the system so as to control the rate of centerpoint deflection to 20 ± 2 mm/min. Stepwise increments of flow to control centerpoint 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 centerpoint deflection and pressure at least every 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.

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:

[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.