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.

Designation: D5994/D5994M – 10 (Reapproved 2021)

Standard Test Method for Measuring Core Thickness of Textured Geomembranes[1]

This standard is issued under the fixed designation D5994/D5994M; 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 a procedure to measure the core thickness of textured geomembranes.

1.2 This test method does not provide thickness values for geomembranes under variable normal stresses.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.5 *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]

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

D4439 Terminology for Geosynthetics

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E2554 Practice for Estimating and Monitoring the Uncertainty of Test Results of a Test Method Using Control Chart Techniques

3. Terminology

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

3.2 *Definitions:*

3.2.1 *core thickness, n*—the average thickness of a textured geomembrane as measured using this particular test method.

3.2.2 *geomembrane, n*—an essentially impermeable geosynthetic composed of one or more synthetic sheets. **D4439**

3.2.3 *pressure, n*—the force or load per unit area.

3.2.4 *textured geomembrane, n*—a geomembrane having one or both surfaces intentionally manufactured with projections or indentations, most commonly for the purpose of providing increased shear strength against adjacent materials.

3.2.5 *thickness, n*—the perpendicular distance between one surface and its opposite.

3.2.6 *thickness gauge points, n*—the tips of a thickness gauge which contact the upper and lower geomembrane surfaces, and between which the thickness is measured.

4. Summary of Test Method

4.1 The core thickness of a textured geomembrane is calculated as the average value of measurements taken on replicate specimens of the sample under investigation. The thickness of each specimen is measured at a specific location as the distance between two gauge points. The opposing thickness gauge points are manufactured to a defined geometry, with a specified force of 0.56 ± 0.05 *N* [2.0 ± 0.2 oz] applied along their axis.

5. Significance and Use

5.1 Thickness is one of the basic index properties used to control and track the quality of many geomembranes. Additionally, many mechanical properties (for example, tensile yield strength, puncture strength, etc.) can be related to core thickness. Core thickness values may also be required in calculation of some parameters such as diffusion coefficients or tensile stresses.

5.2 The measured core thickness of geomembranes may vary considerably depending on the pressure applied to the

[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.

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specimen during measurement. To reduce variation in measurements and the chance of unrealistically low values due to excessively high pressures, a specific gauge point geometry and applied force are prescribed in this test method.

5.3 The test method is applicable to all commonly available textured geomembranes that are deployed as manufactured geomembrane sheets.

6. Apparatus

6.1 *Thickness Gauge*—The thickness gauge shall be of the dead-weight type capable of measuring to an accuracy of at least ±0.01 mm [0.0004 in.]. The gauge shall be constructed to permit application of a specific force of 0.56 ± 0.05 *N* [2.0 ± 0.2 oz]. The gauge shall have a base point (or anvil) and a free-moving presser point whose axes are aligned to each other.

NOTE 1—The geomembrane specimen being measured should be maintained perpendicular to the axes of the opposing gauge points. An underlying support system may be necessary to support large test specimens.

6.2 *Thickness Gauge Points*—The gauge points shall be made of hardened steel. The points shall be tapered at an angle of 60 ± 2° to the horizontal with the tip rounded to a radius of 0.8 ± 0.1 mm [0.031 ± 0.004 in.]. Fig. 1 shows the critical dimensions.

NOTE 2—The gauge and points can be calibrated using standard thickness blocks. Frequent use and rough use of the gauge can dull the gauge points and cause misalignment, both of which will cause incorrect readings. These problems can be detected by frequent calibration.

7. Sampling

7.1 *Sample*—For the sample, take a full-width sample of sufficient length so that the requirements of 7.2 – 7.4.2 can be met. Exclude the inner and outer wraps of the roll or any material not representative of the sample (see Note 1).

7.2 Remove test specimens from the sample in a randomly distributed pattern across the width. The thickness readings must include measurements within 15 cm [6 in.] of both edges of the geomembrane roll.

7.3 *Test Specimens*—From each unit in the sample, remove the specimens so that the edge of the specimen will extend beyond the edge of the gauge points by 10 mm [0.4 in.] in all directions. It is recommended to use circular test specimens of approximately 75 mm [3 in.] diameter.

7.4 *Number of Specimens*—Unless otherwise agreed upon, as when provided in an applicable material specification, take a number of test specimens per sample such that the user may expect, at the 95 % probability level, that the test result is not more than 5 % of the average above or below the true average of the sample. Determine the number of specimens per sample as follows:

7.4.1 *Reliable Estimate of v*—When there is a reliable estimate of v based upon extensive sample records for similar materials tested in the user's laboratory as directed in the method, calculate the required number of specimens as follows:

$$n = (tv/A)^2 \quad (1)$$

where:

n = number of test specimens (rounded upward to a whole number),

t = the value of Student's "t" for one-sided limits (see Table 1 in Practice D4354), a 95 % probability level, and the degrees of freedom associated with the estimate of v,

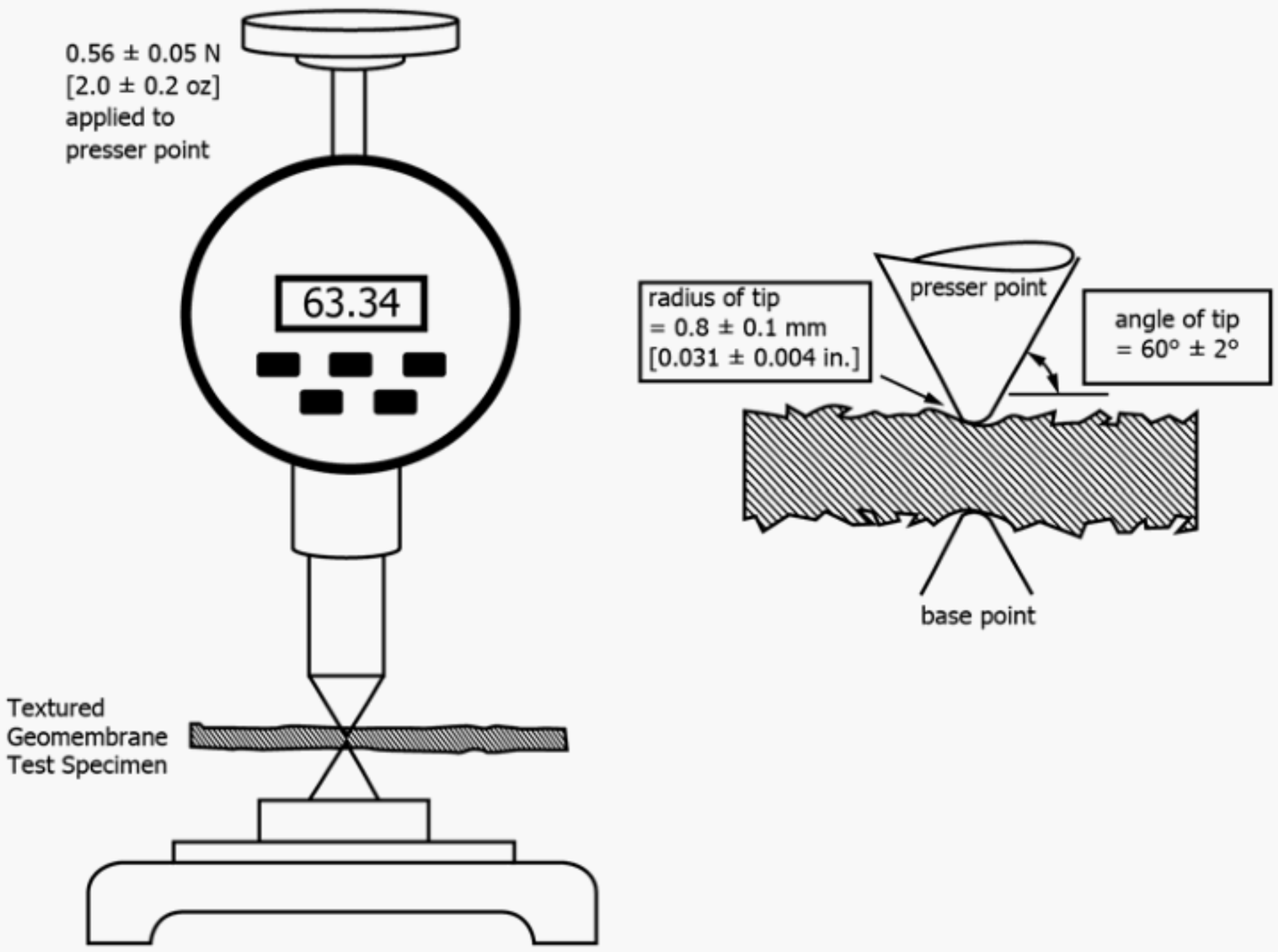

FIG. 1 Dead-Weight Thickness Measurement Device for Textured Geomembranes

v = reliable estimate of the coefficient of variation of individual observations on similar materials in the user's laboratory under conditions of single-operation precision, %, and
A = 5 % of the average, the value of the allowable variation.

7.4.2 *No Reliable Estimate of v*—When there is no reliable estimate of v for the user's laboratory, Eq 1 should not be used directly. Instead, specify the fixed number ten of specimens. The number of specimens is calculated using v = 9.5 % of the average. These values for v are somewhat larger than usually found in practice. When a reliable estimate of v for the user's laboratory becomes available, Eq 1 will usually require fewer than the fixed number of specimens.

8. Conditioning

8.1 Bring the specimens to a temperature equilibrium of 21 ± 2 °C [70 ± 4 °F] and a relative humidity of 60 ± 10 %.

9. Procedure

9.1 Test the conditioned specimens in the standard laboratory atmosphere specified in 8.1.

9.2 With the specified force applied to the presser point on the base point (that is, no specimen present), zero the measuring scale or record the initial non-zero reading.

9.3 Lift the presser point and insert the test specimen. While allowing the presser point to come slowly into contact with the test specimen, adjust the test specimen to locate the gauge points in the "low spots" or "valleys" in between the projections, or into the indentations of the textured surface(s), to obtain the local minimum thickness reading. Repeat the above so that a total of three measurement readings are obtained for each specimen. Record only the lowest value of the three readings to the nearest 0.025 mm or 0.001 in. as the thickness for that specimen.

9.4 Allow the full dead-weight pressure to be applied for 5 s, and record the thickness value to the accuracy of the gauge.

9.5 Repeat the method for each of the remaining specimens.

10. Calculation

10.1 Calculate the average thickness of the sample from the individual specimen results and record to the nearest 0.025 mm or 0.001 in.

11. Report

11.1 Report the following information for the average thickness:

11.1.1 Project, type of geomembrane tested, and method of sampling.

11.1.2 Name or description of thickness apparatus used for testing.

11.1.3 Dimensions of the gauge points (if different than this standard).

11.1.4 Dimensions of the sample and test specimens (if different than this standard).

11.1.5 Loading time interval.

11.1.6 Number of specimens.

11.1.7 Report the individual specimen thickness measurements to the nearest 0.025 mm or 0.001 in.

11.1.8 Report the average thickness of the individual measurements to the nearest 0.025 mm or 0.001 in.

11.1.9 Coefficient of variation of the individual measurements of the sample, in percent (optional).

11.1.10 Any unusual or out-of-standard conditions or observations made during the tests.

12. Precision, Bias, and Uncertainty[3]

12.1 The precision and bias of this test method and the uncertainty of the test results are based on an interlaboratory study of conducted in 2007. Eight laboratories performed the procedure as recorded in Test Method D5994/D5994M, testing five different materials. Every test result represents an individual determination. Three separate laboratory-day determinations were taken in triplicate for each material tested. Each laboratory utilized one technician and one apparatus. One laboratory recorded a single measurement in triplicate for each material. Practice E691 was followed for the design and analysis of the study data. The standard units for the core thickness test results are 0.001 in. or "mils." The details are provided in ASTM Research Report RR:D35-1013.

12.1.1 *Precision for Test Method D5994/D5994M:*

The average test value	51.71 mils
The test range (reported)	35.9 to 67 mils
95 % repeatability limit (within laboratory)	1.51 mils
95 % reproducibility limit (between laboratories)	3.29 mils

12.1.2 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" value for that material; "r" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

12.1.2.1 Repeatability limits are listed in Table 1.

12.1.3 *Reproducibility Limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "R" value for that material; "R" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

12.1.3.1 Reproducibility limits are listed in Table 1.

12.1.4 The terms *repeatability limit* and *reproducibility limit* are used as specified in Practice E177.

12.2 *Uncertainty*—Repeated measurements made on the same three sets of ten test specimens on three different measurement events provided a preliminary estimate of the uncertainty of the test result. The algorithms for these calculations are based on Practice E2554. See Table 2.

12.3 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method; therefore, no statement on bias is being made.

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D35-1013. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Core Thickness of Textured Geomembrane using D5994/D5994M (mils)

Sample	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	$\bar{x}$	s_r	s_R	r	R
1	59.03	0.60	1.30	1.67	3.65
2	38.80	0.52	1.00	1.46	2.79
3	57.54	0.46	0.81	1.28	2.27
4	38.39	0.60	1.27	1.67	3.56
5	64.78	0.52	1.49	1.46	4.16

[A] The average of the laboratories' calculated averages.

TABLE 2 Uncertainty of Core Thickness of Textured Geomembrane Test Results (mils)

Sample	Average[A]	Range of Laboratory Uncertainty Standard Deviations	Average Uncertainty Standard Deviation
	$\bar{x}$		S_u
1	59.03	0.33 to 0.99	0.60
2	38.80	0.43 to 0.83	0.64
3	57.54	0.41 to 1.43	0.62
4	38.39	0.50 to 1.40	0.79
5	64.78	0.20 to 1.14	0.52

[A] The average of the laboratories' calculated averages.

12.4 The precision statement was determined through statistical examination of 330 results from eight laboratories on five materials. These five samples were described as:

Sample 1: 60-mil Textured HDPE (Blown Film A)
Sample 2: 40-mil Textured LLDPE (Blown Film A)
Sample 3: 60-mil One-Side Textured HDPE (Blown Film B)
Sample 4: 40-mil Textured LLDPE (Blown Film B)
Sample 5: 60-mil Textured HDPE (Extruded)

13. Keywords

13.1 geomembrane; geosynthetics; textured geomembrane; thickness

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