Designation: D 1777 – 96 (Reapproved 2007)

Standard Test Method for Thickness of Textile Materials[1]

This standard is issued under the fixed designation D 1777; 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 thickness of most textile materials.

1.2 This test method applies to most fabrics including woven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, and pile fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated. Instructions are provided for testing thickness, except as provided for in another standard such as listed in Section 2.

1.3 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound may be approximate.

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

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 123 Terminology Relating to Textiles

D 1776 Practice for Conditioning and Testing Textiles

D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data

D 2906 Practice for Statements on Precision and Bias for Textiles

2.2 *ASTM Adjuncts:*

TEX-PAC[3]

3. Terminology

3.1 Definitions—For definitions of other textile terms used in this test method, see Terminology D 123.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cross-machine direction, CD*, *n*—the direction in the plane of the fabric perpendicular to the direction of manufacture.

3.2.1.1 *Discussion*—This term is used to refer to the direction analogous to coursewise or filling direction in knitted or woven fabrics, respectively.

3.2.2 *machine direction, MD*, *n*—the direction in the plane of the fabric parallel to the direction of manufacture.

3.2.2.1 *Discussion*—This term is used to refer to the direction analogous to walewise or warp direction in knitted or woven fabrics, respectively.

3.2.3 *pressure*, *n*—the force exerted to a surface per unit area.

3.2.3.1 *Discussion*—Pressure may be expressed in any appropriate or specified units, such as pascals (Pa), newtons per square metre (N/m^2), or pounds-force per square inch (psi).

3.2.4 *thickness*, *n*—the distance between one surface of a material and its opposite.

3.2.4.1 *Discussion*—In textiles, thickness is the distance between the upper and lower surfaces of the material as measured under a specified pressure. It is usually determined as the distance between an anvil or base and a presser foot used to apply the specified pressure.

4. Summary of Test Method

4.1 A specimen is placed on the base of a thickness gauge and a weighted presser foot lowered. The displacement between the base and the presser foot is measured as the thickness of the specimen.

5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments since current estimates of between-laboratory precision are acceptable, and this test method is used extensively in the trade for acceptance testing.

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[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.

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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.

[3] A PC program on floppy disk for analyzing Committee D-13 interlaboratory data are available from ASTM Headquarters. For a 3½-in. disk, request PCN:12-429040-18. For a 5¼-in. disk, request PCN:12-429041-18.

5.1.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. Test specimens then should be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using the appropriate statistical analysis and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either its cause must be found and corrected, or the purchaser and the supplier must agree to interpret future test results with consideration to the known bias.

5.2 Thickness is one of the basic physical properties of textile materials. In certain industrial applications, the thickness may require rigid control within specified limits. Bulk and warmth properties of textile materials are often estimated from their thickness values, and thickness is also useful in measuring some performance characteristics, such as before and after abrasion and shrinkage.

5.3 The thickness value of most textile materials will vary considerably depending on the pressure applied to the specimen at the time the thickness measurement is taken. In all cases, the apparent thickness varies inversely with the pressure applied. For this reason, it is essential that the pressure be specified when discussing or listing any thickness value.

5.4 When using this test method for measuring the thickness of textile materials, the primary method for the specific material such as listed in the Referenced Document section shall take precedence over the directions described in this test method, unless specifically provided for in that test method. This test method is used in its entirety when no test method for measuring thickness is available for the specific material to be tested or unless otherwise specified in a material specification or contract order.

6. Apparatus

6.1 *Thickness Gauge*, having dimensions appropriate to the material to be tested as specified in Table 1, unless otherwise specified in a material specification or contract order. A circular presser foot commonly is used for most materials; however, for certain materials, such as narrow tapes, a rectangular foot is more appropriate when agreed upon between the purchaser and the supplier.

6.1.1 *Automatic Microprocessor Data Gathering Systems*, optional.

6.1.2 *Spring Force or Compression Test Apparatus*, may be substituted for the dead-weight-type thickness gauge providing they meet the specified conditions cited in Table 1.

6.2 *Cutting Dies or Templates*, to cut specimens having minimum dimensions at least 20 % greater than any dimension of the presser foot to be used in measuring the thickness (optional).

7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, randomly select the number of rolls or pieces of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider the rolls or pieces of fabric to be the primary sampling units. In the absence of such an agreement, take the number of fabric rolls specifed in Table 2.

NOTE 1—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls or pieces of fabric and between specimens from a swatch from a roll or piece of fabric to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—For acceptance testing, take a swatch extending the width of the fabric and approximately 1 m (1 yd) along the machine direction from each roll or piece in the lot sample. For rolls of fabric, take a sample that will exclude fabric from the outer wrap of the roll or the inner wrap

TABLE 1 Designated Gauges and Gauge Specifications for Measuring Thickness of Textiles

Testing Option[A]	Material Type	Gauge Type[B]	Presser Foot Diameter	Anvil	Anvil/Foot Parallelism	Foot to Anvil Surface Parallelism	Applied Pressure	Readability
1	Woven fabrics Knitted fabrics Textured fabrics	dead-weight	28.7 ± 0.02 mm (1.129 ± 0.001 in.)	38 mm D, or greater (1.629 in. D, or greater)	0.01 mm (0.0005 in.)	0.002 mm (0.0001 in.)	4.14 ± 0.21 kPa (0.60 ± 0.03 psi)	0.02 mm (0.001 in.)
2	Coated fabrics Narrow fabrics Webbings Tapes Ribbons Braids	dead-weight	9.5 ± 0.02 mm (0.375 ± 0.001 in.)	38 mm D, or greater (1.629 in. D, or greater)	0.01 mm (0.0005 in.)	0.002 mm (0.0001 in.)	23.4 ± 0.7 kPa (3.4± 0.1 psi)	0.02 mm (0.001 in.)
3	Films Glass cloths Glass tapes	dead-weight	6.3 ± 0.02 mm (0.250 ± 0.001 in.)	19 mm D, or greater (0.750 in. D, or greater)	0.002 mm (0.0001 in.)	0.002 mm (0.0001 in.)	172 ± 14 kPa (25 ± 2 psi)	0.002 mm (0.0001 in.)
4	Glass fiber mat	dead-weight	(2.25 ± 0.001 in.)	(2.75 in. D, or greater)	0.01 mm (0.0005 in.)	0.002 mm (0.0001 in.)	18.9 ± 0.7 kPa (2.75 ± 0.1 psi)	0.02 mm (0.001 in.)
5	Blankets Pile fabrics Napped fabrics	dead-weight	28.7 ± 0.02 mm (1.129 ± 0.001 in.)	38 mm D, or greater (1.629 in. D, or greater)	0.01 mm (0.0005 in.)	0.002 mm (0.0001 in.)	0.7 ± 0.07 kPa (0.1 ± 0.01 psi) also 7.58 ± 0.21 kPa (1.1 ± 0.03 psi)	0.02 mm (0.001 in.)

[A] When testing fabrics made with textured yarns or open-end spun yarns, primary consideration should be given to the pressure applied in Option 1, with respect to the size of the presser foot used.

[B] Other spring force or compression test apparatus that meet the stated specifications can be used.

TABLE 2 Number of Rolls or Pieces of Fabric in the Lot Sample

Number of Rolls or Pieces in Lot, Inclusive	Number of Rolls or Pieces in Lot Sample
1 to 3	all
4 to 24	4
25 to 50	5
over 50	10 % to a maximum of 10 rolls or pieces

around the core of the roll of fabric. For finished garments, take a piece of sufficient size to provide the number of specimens required in 7.3.

7.3 *Test Specimens*—From each laboratory sampling unit, take ten specimens. Use the cutting die or template described in 6.2. It is permissible to make thickness tests of a textile material without cutting, providing it can be maintained without distortion in a plane parallel to the presser foot and anvil while making measurements.

7.3.1 *Cutting Test Specimens*—When cutting specimens, cut having minimum dimensions at least 20 % greater than any dimension of the presser foot to be used. Label to maintain specimen identity.

7.3.1.1 Take specimens, representing a broad distribution across the width and length, and preferably along the diagonal, of the laboratory sample and no nearer the edge than one tenth its width. Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, and so forth, on the specimens when handling.

8. Preparation of Test Apparatus and Calibration

8.1 Use Table 1 to select the thickness gauge designated for the material to be tested.

8.2 Verify calibration of the thickness gauge as directed in the manufacturer's instructions.

8.3 When using microprocessor automatic data gathering systems, set the appropriate parameters as defined in the manufacturer's instructions.

9. Conditioning

9.1 Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as specified in Practice D 1776, unless otherwise specified in a material specification or contract order.

9.2 After preconditioning, bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as specified in Practice D 1776 or, if applicable, in the specified atmosphere in which the testing is to be performed, unless otherwise specified in a material specification or contract order.

10. Procedure

10.1 Test the conditioned specimens in the standard atmosphere for testing textiles, which is 21 ± 1°C (70 ± 2°F) and 65 ± 2 % relative humidity, unless otherwise specified in a material specification or contract order.

10.2 Handle the test specimens carefully to avoid altering the natural state of the material.

10.3 Place the specimen face side up, or otherwise as specified, on the anvil of the thickness gauge. Gradually lower the presser foot into contact with the specimen, taking 5 to 6 s to apply full pressure for most textiles and 3 to 4 s for glass material textiles.

10.4 Read and record the thickness value to a readability shown in Table 1.

10.5 Continue as directed in 10.2-10.4 until ten specimens have been tested from each laboratory sampling unit.

TABLE 3 Thickness of Fabrics, mils

Test Options and Materials	Grand Average	Components of Variance Expressed as Standard Deviations[A]		
		Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
Option 1				
Mat 6, S/0002H	7.13	0.19	0.17	0.66
Mat 7, S/28305	11.49	1.46	0.55	0.02
Mat 9, S/Denim	38.65	0.75	0.41	1.54
Option 2				
Mat 6, S/0002H	7.04	0.23	0.00	0.72
Mat 7, S/28305	11.84	0.23	0.27	0.48
Mat 9, S/Denim	38.33	0.64	0.00	1.64
Option 3				
Mat 6, S/0002H	6.68	0.32	0.18	0.58
Mat 7, S/28305	11.50	0.37	0.13	0.49
Mat 9, S/Denim	36.50	0.60	0.19	2.41
Option 4				
Mat 6, S/0002H	10.20	0.40	0.00	...
Mat 7, S/28305	12.85	0.36	0.00	...
Mat 9, S/Denim	43.95	1.08	0.54	...
Option 5 (0.1 psi)				
Mat 10, Pile	178.08	8.79	0.00	3.30
Mat 14, Pile	46.91	1.15	0.16	0.69
Option 5 (1.1 psi)				
Mat 10, Pile	101.67	4.63	0.00	10.08
Mat 14, Pile	38.37	1.51	0.33	0.28

[A] The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

11. Calculation

11.1 *Thickness, Individual Specimens*—The thickness for individual specimens using the readability column of Table 1 is read directly from the thickness gauge or data collection system, unless otherwise specified in a material specification or contract order.

11.2 *Thickness Average*—Calculate the average thickness for each laboratory sampling unit and for the lot.

11.3 *Standard Deviation, Coefficient of Variation*—Calculate when requested.

11.4 *Computer-Processed Data*—When data are automatically computer-processed, calculations generally are contained in the associated software. Record values as read from the direct-reading scale designated in the readability column of Table 1, unless otherwise specified. In any event, it is recommended that computer-processed data be verified against known property values and its software described in the report.

12. Report

12.1 Report that the thickness was determined in accordance with Test Method D 1777. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information for each laboratory sampling unit and for the lot as applicable to a material specification or contract order:

12.2.1 Thickness.

12.2.2 Testing option selected from Table 1.

12.2.3 When calculated, the standard deviation or the coefficient of variation.

TABLE 4 Thickness of Fabrics, mils

Test Options and Materials	Critical Differences for the Conditions Noted[A]			
	Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
Option 1				
Mat 6, S/0002H	1	0.53	0.72	1.96
	2	0.37	0.61	1.93
	5	0.24	0.54	1.91
	10	0.17	0.51	1.90
Mat 7, S/28305	1	4.05	4.33	4.33
	2	2.86	3.25	3.25
	5	1.81	2.37	2.37
	10	1.28	2.00	2.00
Mat 9, S/Denim	1	2.10	2.39	4.89
	2	1.48	1.88	4.66
	5	0.94	1.48	4.52
	10	0.66	1.32	4.47
Option 2				
Mat 6, S/0002H	1	0.63	0.63	2.10
	2	0.44	0.44	2.05
	5	0.28	0.28	2.02
	10	0.20	0.20	2.01
Mat 7, S/28305	1	0.63	0.99	1.65
	2	0.45	0.88	1.59
	5	0.28	0.81	1.55
	10	0.20	0.79	1.54
Mat 9, S/Denim	1	1.76	1.76	4.88
	2	1.25	1.25	4.72
	5	0.79	0.79	4.62
	10	0.56	0.56	4.59
Option 3				
Mat 6, S/0002H	1	0.90	1.03	1.91
	2	0.64	0.81	1.80
	5	0.40	0.64	1.73
	10	0.29	0.58	1.71
Mat 7, S/28305	1	1.04	1.10	1.74
	2	0.73	0.82	1.58
	5	0.46	0.58	1.47
	10	0.33	0.48	1.43
Mat 9, S/Denim	1	1.67	1.75	6.90
	2	1.18	1.29	6.79
	5	0.75	0.91	6.73
	10	0.53	0.74	6.71
Option 4				
Mat 6, S/0002H	1	1.12	1.12	...
	2	0.79	0.79	...
	5	0.50	0.50	...
	10	0.36	0.36	...
Mat 7, S/28305	1	1.00	1.00	...
	2	0.71	0.71	...
	5	0.45	0.45	...
	10	0.32	0.32	...
Mat 9, S/Denim	1	2.99	3.34	...
	2	2.11	2.58	...
	5	1.34	2.00	...
	10	0.94	1.76	...
Option 5 (0.1 psi)				
Mat 10, Pile	1	24.37	24.37	26.03
	2	17.23	17.23	19.50
	5	10.90	10.90	14.22
	10	9.71	7.71	11.95
Mat 14, Pile	1	3.18	3.21	3.75
	2	2.25	2.30	3.00
	5	1.42	1.49	2.44
	10	1.01	1.10	2.22
Option 5 (1.1 psi)				
Mat 10, Pile	1	12.84	12.84	30.75
	2	9.08	9.08	29.38
	5	5.74	5.74	28.52
	10	4.06	4.06	28.23
Mat 14, Pile	1	4.18	4.28	4.35
	2	2.95	3.09	3.19
	5	1.87	2.08	2.23
	10	1.32	1.61	1.79

[A] The critical differences were calculated using $t = 1.960$, which is based on infinite degrees of freedom.

12.2.4 For computer-processed data, identify the program (software) used.

12.2.5 Any modification of this test method.

13. Precision and Bias

13.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 3 for the respective number of tests and for materials having averages similar to those shown in Table 1 in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of material. Larger differences are likely to occur under all other circumstances.

13.2 *Interlaboratory Test Data*—An interlaboratory test was run in 1994–1995 in which randomly drawn samples were tested as specified in the five options of this test method. Two operators in each laboratory each tested ten specimens of each material. Five of the ten specimens were tested on one day, and five specimens were tested on a second day. Analysis of the data was conducted in accordance with Practices D 2904 and D 2906, as well as the adjunct Tex-Pac. The components of variance for thickness, expressed as standard deviations, were calculated to be the values listed in Table 3. The fabric types are shown in Tables 3 and 4. The designated options and number of participating laboratories are shown as follows:

Option	Number of Laboratories
1	6
2	4
3	3
4	1
5	2

13.3 *Precision*—For the components of variance reported in Table 3, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 4. There were sufficient differences related to the material type and structure to warrant listing the components of variance and the critical differences separately. Consequently, no multi-material comparisons were made.

NOTE 2—Since the interlaboratory tests for Options 2, 3, 4, and 5 included less than five laboratories, estimates of between-laboratory precision should be used with special caution.

NOTE 3—The tabulated values of the critical differences should be

considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, between them must be established, with each comparison being based on recent data obtained on specimens taken from a lot of material to the type being evaluated so as to be as nearly homogeneous as possible, and then randomly assigned in equal numbers to each of the laboratories.

13.4 *Bias*—The value of thickness of fabrics only can be defined in terms of a test method. Within this limitation, this test method has no known bias.

14. Keywords

14.1 fabric; thickness