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## Standard Test Method for Stiffness of Fabrics<sup>1</sup>

This standard is issued under the fixed designation D1388; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

### 1. Scope

1.1 This test method covers the measurement of stiffness properties of fabrics. Bending length is measured and flexural rigidity is calculated. Two procedures are provided.

1.1.1 *Option A—Cantilever Test*, employing the principle of cantilever bending of the fabric under its own mass.

1.1.2 *Option B—Heart Loop Test*, employing the principle of a loop formed in a fabric strip and hung vertically.

1.2 This test method applies to most fabrics including woven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, pile fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated.

1.3 The values stated in SI units are to be regarded as the standard. The U.S. customary units 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:*<sup>2</sup>

D123 Terminology Relating to Textiles

D1776 Practice for Conditioning and Testing Textiles

D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data (Withdrawn 2008)<sup>3</sup>

D2906 Practice for Statements on Precision and Bias for Textiles (Withdrawn 2008)<sup>3</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.60 on Fabric Test Methods, Specific.

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<sup>2</sup> 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.

<sup>3</sup> The last approved version of this historical standard is referenced on www.astm.org.

D3776 Test Methods for Mass Per Unit Area (Weight) of Fabric

D4850 Terminology Relating to Fabrics and Fabric Test Methods

### 3. Terminology

3.1 For all terminology relating to D13.59, Fabric Test Methods, General, refer to Terminology D4850.

3.1.1 The following terms are relevant to this standard: bending length, cross-machine direction, CD, fabric, flexural rigidity, machine direction, MD, stiffness.

3.2 For all other terminology related to textiles, refer to Terminology D123.

### 4. Summary of Test Method Options

4.1 *Option A, Cantilever Test*—A specimen is slid at a specified rate in a direction parallel to its long dimension, until its leading edge projects from the edge of a horizontal surface. The length of the overhang is measured when the tip of the specimen is depressed under its own mass to the point where the line joining the top to the edge of the platform makes a 0.724 rad (41.5°) angle with the horizontal. From this measured length, the bending length and flexural rigidity are calculated.

4.2 *Option B, Heart Loop Test*—A strip of fabric is formed into a heart-shaped loop. The length of the loop is measured when it is hanging vertically under its own mass. From this measured length, the bending length and flexural rigidity are calculated.

### 5. Significance and Use

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

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 should then 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 In general, these procedures are more suitable for testing woven fabrics than knit fabrics.

5.3 The Cantilever Test Option is the preferred procedure because it is simpler to perform. It is, however, not suitable for very limp fabrics or those that show a marked tendency to curl or twist at a cut edge.

5.4 The Heart Loop Test Option is suitable for fabrics that show a tendency to curl or twist.

5.5 Both options can provide a correlation with a subjective evaluation of a given fabric type. That is, a higher number represents a stiffer fabric.

5.6 The stiffness of a fabric may change with storage.

5.7 No evidence has been found showing that bending length is dependent on the width. The tendency for specimens to curl or twist will affect the result, because of the rigidity provided at the edge. Consequently, the wider the strip, the less important is the edge effect.

6. Apparatus

6.1 Option A—Cantilever Bending Tester<sup>4</sup> (Fig. 1).

6.1.1 Horizontal Platform, with a minimum area of 38 by 200 mm (1.5 by 8 in.) and having a smooth low-friction, flat surface such as polished metal or plastic. A leveling bubble shall be incorporated in the platform.

<sup>4</sup> Apparatus is available commercially.

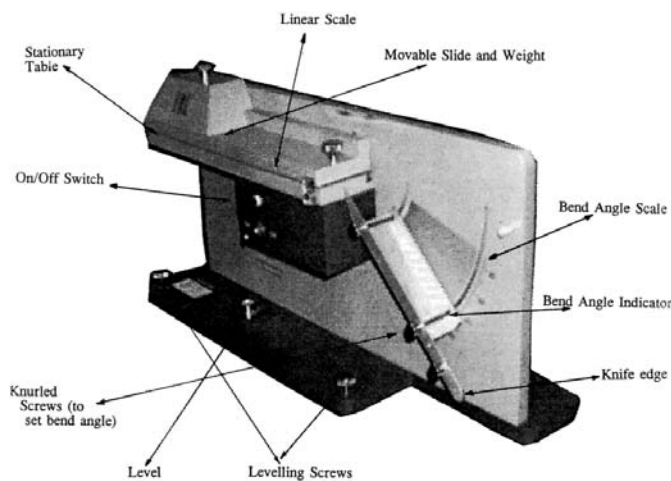


FIG. 1 Example of a Motorized Cantilever Test Apparatus

6.1.1.1 Indicator, inclined at an angle of  $0.724 \pm 0.01$  rad ( $41.5 \pm 0.5^\circ$ ) below the plane of the platform surface.

6.1.1.2 Movable Slide, consisting of a metal bar not less than 25 by 200 mm (1 by 8 in.) by approximately 3 mm ( $1/8$  in.) thick and having a mass of  $270 \pm 5$  g ( $0.6 \pm 0.01$  lb).

6.1.1.3 Scale and Reference Point, to measure the length of the overhang.

6.1.1.4 Specimen Feed Unit, motorized<sup>4</sup> (see Fig. 1) set to 120 mm/min (4.75 in./min)  $\pm 5\%$ , or manual equivalent.

6.1.2 Cutting Die— $25 \pm 1$  mm by  $200 \pm 1$  mm ( $1 \pm 0.04$  in. by  $8 \pm 0.04$  in.).

6.2 Option B—Heart Loop Tester.

6.2.1 Clamp and Stand, for hanging the specimen.

6.2.2 Scale, suitably mounted on the stand for measuring the length of the specimen loop and calibrated either in cm (in.) or directly in bending length.

NOTE 1—If a constant strip length is adopted, the scale may be calibrated to read directly in units of bending length.

6.2.3 Brass Bars, two,  $25 \times 75 \times 3 \pm 0.1$  mm ( $1 \times 3 \times 0.125 \pm 0.005$  in.).

6.2.4 Pressure Sensitive Tape.

6.2.5 Jig, constructed to allow positioning of the two bars with their inner edges parallel and at a distance from each other equal to the selected strip length.

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 specified in Table 1.

NOTE 2—An adequate specification or other agreement between the purchaser and 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 around the core of the roll of fabric, or any end piece.

7.3 Direction of Test—Consider the long dimension of the specimen as the direction of test.

7.4 Number of Test Specimens—From each laboratory sampling unit, take four specimens from the machine direction and

TABLE 1 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 max of 10 rolls or pieces

four specimens from the cross-machine direction as applicable to a material specification or contract order.

**7.5 Cutting Test Specimens**—Cut the specimens to be used for the measurement of machine direction with the longer dimension parallel to the machine direction. Cut the specimens to be used for the measurement of the cross-machine direction with the longer dimension parallel to the cross-machine direction. Label to maintain specimen identity.

**7.5.1** Take specimens, representing a broad distribution across the width and length, 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, etc. on the specimens when handling.

**7.5.2 Cantilever Test**—Cut test specimens 25 by 200 mm, ±1 mm (1 by 8 in. ± 0.04 in.).

**7.5.3 Heart Loop Test**—No standard size for the test specimen is required. Cut test specimens 50 mm (2 in.) longer than the selected strip length to allow for clamping at the ends. See **Table 2**.

**7.5.3.1** Select a specimen width at least 25 mm (1 in.) and no more than 75 mm (3 in.) with respect to the tendency of the fabric to curl. For fabrics having a slight tendency to curl, a 25 ± 1 mm (1 ± 0.04 in.) wide specimen has been found to be satisfactory. As the tendency to curl becomes greater, increase the width up to a maximum of 75 mm (3 in.).

**7.5.3.2** Make several trial tests using various strip lengths selected from **Table 2**. Select a suitable strip length for a corresponding loop length from **Table 2**, such that the bending length is relatively independent of strip length.

**NOTE 3**—Strip length is the circumferential length of the unclamped portion of the specimen.

**NOTE 4**—Specimen strip widths greater than 75 mm (3 in.) have not been investigated and are not recommended since reliability of results are questionable.

**NOTE 5**—The bending length using the heart loop option is not entirely independent of the strip length. In general, the bending length rises with the strip length up to a value that remains relatively constant as the strip length is further increased. An additional rise may further be encountered for much longer strip lengths. Whenever possible, compare fabrics in the range where bending length is independent of strip length.

**8. Preparation of Test Apparatus and Calibration**

**8.1 Option A—Cantilever Test:**

**8.1.1** Set the tester on a table or bench with the horizontal platform and inclined reference lines. Adjust the platform to horizontal as indicated by the leveling bubble.

**8.1.2** Verify that the bend angle indicator is at the 0.724 rad (41.5°) angle marked on the scale.

**9. Conditioning**

**9.1** Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as directed in Practice **D1776**, unless otherwise directed 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 directed in Practice **D1776** or, if applicable, in the specified atmosphere in which the testing is to be performed, unless otherwise directed 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 directed in a material specification or contract order.

**10.2 Option A—Cantilever Test:**

**10.2.1** Remove the movable slide. Place the specimen on the horizontal platform with the length of the specimen parallel to the platform edge. Align the edge of the specimen with the line scribed on the right-hand edge of the horizontal platform.

**NOTE 6**—When known, place the specimen face-side up.

**10.2.2** Place the movable slide on the specimen, being careful not to change its initial position.

**10.2.3** For automatic testers, turn the tester switch on and watch the leading edge of the specimen closely. Turn the switch off the instant the edge of the specimen touches the knife edge.

**10.2.4** For manual testers, move the clamped specimen by hand in a smooth manner at approximately 120 mm/min (4.75 in./min) ± 5 % until the edge of the specimen touches the knife edge.

**10.2.5** Read and record the overhang length from the linear scale to the nearest 0.1 cm (0.1 in.).

**NOTE 7**—If the specimen has a tendency to twist, take the reference point at the center of the leading edge. Do not measure specimens that twist more than 0.785 rad (45°).

**10.2.6** Test the face and back of both ends of each specimen for a total of four readings per specimen.

**10.3 Option B—Heart Loop Test:**

**TABLE 2 Table of Bending Lengths**

Loop Length, cm	Bending Length, cm		
	15-cm Strip Length	20-cm Strip Length	25-cm Strip Length
4.0	2.19	...	...
4.2	2.07	...	...
4.4	1.99	...	...
4.6	1.86	3.44	5.43
4.8	1.76	3.30	5.16
5.0	1.65	3.17	4.91
5.2	1.56	3.03	4.71
5.4	1.45	2.90	4.53
5.6	1.35	2.80	4.36
5.8	1.25	2.67	4.20
6.0	1.14	2.57	4.06
6.2	1.04	2.47	3.92
6.4	0.93	2.37	3.80
6.6	0.81	2.26	3.67
6.8	0.69	2.16	3.56
7.0	0.53	2.06	3.45
7.2	...	1.96	3.34
7.4	...	1.86	3.21
7.6	...	1.76	3.12
7.8	...	1.66	3.02
8.0	...	...	2.91
8.2	...	...	2.82
8.4	...	...	2.72