



Designation: D1388 – 23

Standard Test Method for Stiffness of Fabrics¹

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 (ϵ) 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.

1.2.1 This method may be used to determine the stiffness of nonwoven materials (for example, hydroentangled, dry laid, needlepunch, resin bonded, thermal, and wet laid) or refer to Test Method [D5732](#). To determine the stiffness of medical textiles (for example, surgical mesh, films, and membranes), refer to Test Method [F3260](#).

NOTE 1—The formula to calculate flexural rigidity in [D5732-95](#) (2001) is incorrect and should not be used. Utilize the formula presented in 11.5 of Test Method D1388.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

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 Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 *ASTM Standards:*²

[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 \(Withdrawn 2008\)](#)³

[D2906 Practice for Statements on Precision and Bias for Textiles \(Withdrawn 2008\)](#)³

[D3776 Test Methods for Mass Per Unit Area \(Weight\) of Fabric](#)

[D4850 Terminology Relating to Fabrics and Fabric Test Methods](#)

[D5732 Test Method for Stiffness of Nonwoven Fabrics Using the Cantilever Test \(Withdrawn 2008\)](#)³

[F3260 Test Method for Determining the Flexural Stiffness of Medical Textiles](#)

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.

NOTE 2—Machine direction (MD) may represent wale and warp directions and cross-machine direction (CD) may represent course and weft directions in knit fabrics or woven fabrics or both.

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

¹ This test method is under the jurisdiction of ASTM Committee [D13](#) on Textiles and is the direct responsibility of Subcommittee [D13.60](#) on Fabric Physical Test Methods B.

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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 The last approved version of this historical standard is referenced on www.astm.org.

*A Summary of Changes section appears at the end of this standard

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 tip to the edge of the platform makes a 0.724 rad (41.5°) angle with the horizontal. From this measured length and the specimen's fabric mass per unit area, the bending length and flexural rigidity are calculated.

NOTE 3—When the tip of the specimen reaches a plane inclined at 41.5° below the horizontal, the overhanging length is then twice the bending length.

4.1.1 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 (see Fig. 1 and Note 12).

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 and the specimen's fabric mass per unit area, the bending length and flexural rigidity are calculated.

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

4.3 The two methods will not necessarily give the same numerical values or rank different types of fabrics in the same order. 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. Significance and Use

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

5.2 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.

5.2.1 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.

5.3 The stiffness of a fabric may change with storage.

5.4 No evidence has been found showing that bending length is dependent on the width of the test specimen. The tendency for specimens to curl or twist will affect the result, because of the rigidity provided at the edge of the specimen. Consequently, the wider the strip, the less important is the edge effect. For fabrics having only a slight tendency to curl, a 2.5 cm wide strip has been found to be satisfactory. As the tendency to curl increases, this width may be increased (see Note 10).

5.5 This method differs from Test Method F3260 which requires tracking of sample surface orientation, and is used to evaluate absorbable and partially absorbable medical textiles.

6. Apparatus

6.1 *Option A—Cantilever Bending Tester*⁴ (Fig. 2).

6.1.1 *Horizontal Platform*, with a minimum area of 38 mm by 200 mm (1.5 in. by 8 in.) and having a smooth, low-friction, flat surface such as polished metal or plastic.

6.1.2 *Bend Angle Indicator*, inclined at an angle of 0.724 rad \pm 0.01 rad (41.5° \pm 0.5°) below the plane of the horizontal platform surface.

6.1.3 *Movable Specimen Slide*, consisting of a metal bar not less than 25 mm by 200 mm (1 in. by 8 in.) by approximately 3 mm (1/8 in.) thick and having a mass of 270 g \pm 5 g (0.6 lb \pm 0.01 lb). A motorized specimen feed unit set to 120 mm/min \pm 5% (4.75 in./min \pm 5%) may be used.

6.1.4 *Scale*, to measure the length of the overhang.

NOTE 4—The original instrument this method is based on included a scale demarcated in centimeters of bending length.

6.2 *Cutting Die (optional)*—25 mm \pm 1 mm by 200 \pm 1 mm (1 in. \pm 0.04 in. by 8 in. \pm 0.04 in.).

6.3 *Option B—Heart Loop Tester* (Fig. 3.)

⁴ Apparatus is available commercially.

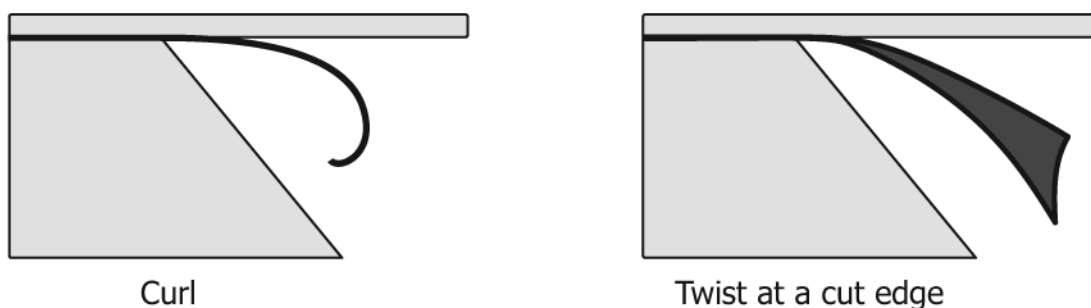


FIG. 1 Fabric Examples Not Suitable for Cantilever Test

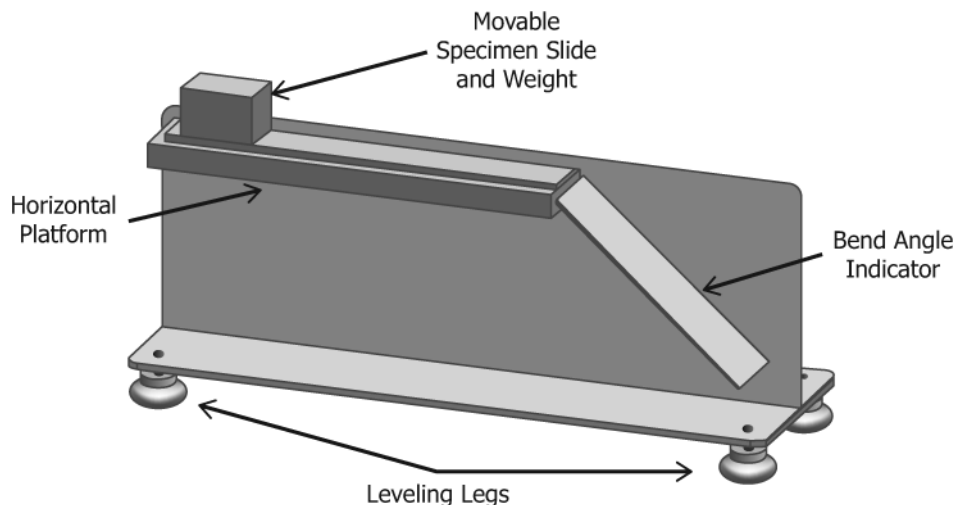


FIG. 2 Example of a Cantilever Bending Tester

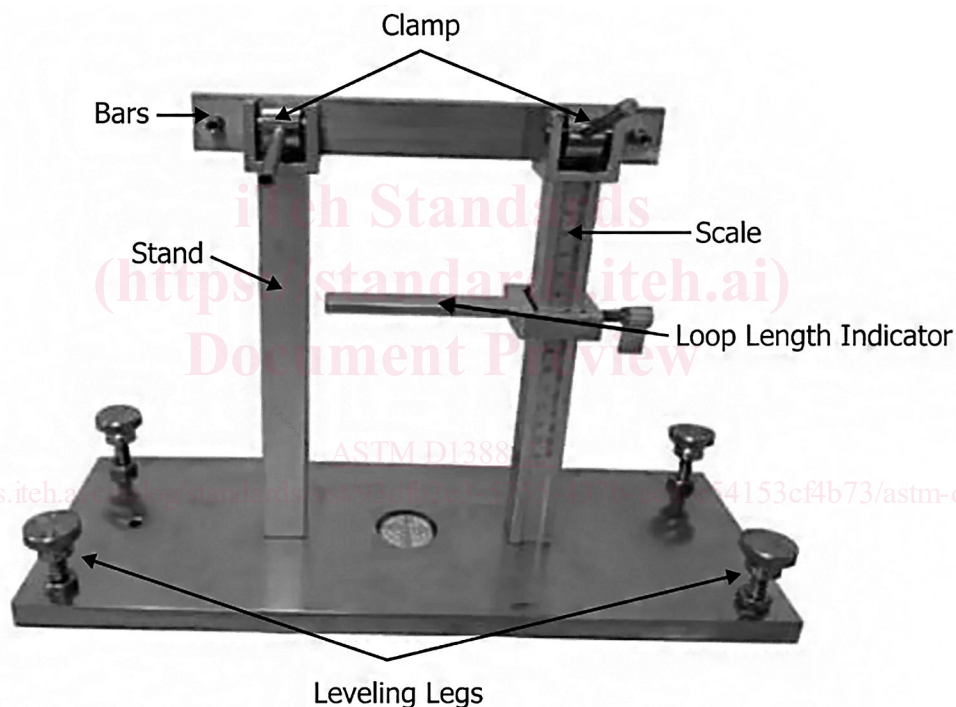


FIG. 3 Example of a Heart Loop Tester

6.3.1 *Clamp and Stand*, for hanging the specimen.

NOTE 5—A convenient method for mounting and measuring the specimen involves the use of two bars 25 mm by 75 mm by 3 mm (1 in. by 3 in. by 0.125 in.), to which the strip is fastened and a clip for holding these bars and the attached strip in a suitable position in front of scale.

6.3.2 *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 6—If a constant strip length is adopted, the scale may be calibrated to read directly in units of bending length.

6.4 *Pressure Sensitive Tape*.

6.5 *Jig (optional)*, 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.

6.6 *Balance*, having a capacity and sensitivity to weigh within $\pm 0.1\%$ of the specimen weight being tested.

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 7—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 (MD) 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 (MD) and four specimens from the cross-machine direction (CD) 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 (MD) with the longer dimension parallel to the machine direction (MD). Cut the specimens to be used for the measurement of the cross-machine direction (CD) with the longer dimension parallel to the cross-machine direction (CD). 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, so no two machine direction (MD) specimens contain the same warp threads and no two cross-machine direction (CD) specimens contain the same weft threads. The specimens shall be taken 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 mm by 200 mm, ±1 mm (1 in. by 8 in. ± 0.04 in.).

7.5.3 Heart Loop Test—No standard size for the test specimen is required. When using two bars as described in **Note 4**, cut test specimens 5 cm (2 in.) longer than the selected strip length to allow for clamping at the ends. For other size bars, adjust the length of the strip length accordingly. As a starting point, use **Table 2** to determine a suitable strip length for any given fabric.

NOTE 8—Strip length, *L*, is the circumferential length of the unclamped portion of the specimen.

7.5.3.1 Make several trial tests using various strip lengths selected from **Table 2** to obtain an estimate of the loop length.

TABLE 2 Strip Lengths for Various Fabric Types

Bending length, cm	Strip length, cm
Less than 2	15
2 to 3	20
Over 3	At least 25

Select a suitable strip length for a corresponding loop length from **Table 3**, such that the bending length is relatively independent of strip length.

NOTE 9—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.

7.5.3.2 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 mm ± 1 mm (1 in. ± 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.).

NOTE 10—Specimen strip widths greater than 75 mm (3 in.) have not been investigated and are not recommended.

8. Preparation of Test Apparatus and Calibration

8.1 Option A—Cantilever Test:

8.1.1 Set the tester on a table or bench and adjust the platform so that it is level to horizontal.

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

8.2 Option B—Heart Loop Test:

8.2.1 A suitable procedure for mounting and measuring the specimen is the use of two brass bars to which the specimen strip is fastened. The bars and the attached specimen strip are

TABLE 3 Table of Bending Lengths for Heart Loop Test

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

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

clamped to the stand in a suitable vertical position in front of a scale calibrated either in cm (in.) or directly in bending length.

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 as indicated in Practice D1776, unless otherwise directed in a material specification or contract order.

10.2 Option A—Cantilever Test:

10.2.1 Remove the movable specimen slide. Place the specimen on the horizontal platform with the length of the specimen parallel to the platform edge. For instruments equipped with a reference point, align the leading edge of the specimen with the line scribed on the right-hand edge of the horizontal platform. For all other instruments, align the leading edge of the specimen with the edge of the horizontal platform edge (closest to the bend angle indicator).

NOTE 11—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.

10.2.2.1 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 bend angle indicator.

10.2.2.2 For manual testers, advance the moveable specimen slide by hand in a smooth manner at approximately 120 mm/min \pm 5% (4.75 in./min \pm 5%) until the edge of the specimen touches the bend angle indicator.

10.2.3 Using the scale, read and record the overhang length from the fulcrum (edge of the horizontal platform) to the nearest 1 mm (0.04 in.) (see Fig. 4).

NOTE 12—If the specimen has a tendency to twist, take the reading from at the center of the leading edge. Do not measure specimens that twist more than 0.785 rad (45°).

10.2.4 Repeat 10.2.1 – 10.2.3 to test the face and back of both ends of each specimen for a total of four readings per specimen. Test the face and back of one specimen end before proceeding to test the face and back of the other end of the specimen.

10.3 Option B—Heart Loop Test:

10.3.1 Remove the two bars from the clamp and stand, and place them parallel to one another on a horizontal surface such that the inner edges are separated by a distance equal to the selected strip length. This can be done easily with a jig (see 6.5).

10.3.2 Lay the test specimen across the two bars (see 7.5.3).

10.3.3 Attach one end of the specimen strip to one bar using pressure-sensitive tape, being careful to align to one edge of the bar. Apply just enough tension to the specimen to hold it taut, but without stretching, and attach the other specimen end to the second bar in a similar manner.

10.3.4 Turn the bars and mounted specimen over, such that the fabric is on the underside of each bar. Grasp one bar in each hand, lift and rotate each bar three-quarter turn or 4.71 rad (270°). Rotate the left-hand bar in a clockwise direction and the right-hand bar in a counterclockwise direction. Bring the bars together such that the fabric ends are touching one another. Insert the assembly on a suitable holder with the loop formed free to hang vertically.

10.3.5 Allow the looped specimen to hang freely for 60 s \pm 5 s. Measure the loop length as the distance from the top of the bars to the bottom of the loop to the nearest 2 mm (0.1 in.), see Fig. 5.

10.3.6 Remove the bars from the holder and free the adhering tape from each end of the strips carefully to prevent distortion of the fabric. Turn the specimen strip and test the other side of the fabric by re-attaching to the bars and testing as described in 10.3.1 – 10.3.5.

10.4 Specimen Mass—Determine the fabric mass per unit area, M , as directed in Test Method D3776, Option C in g/m².

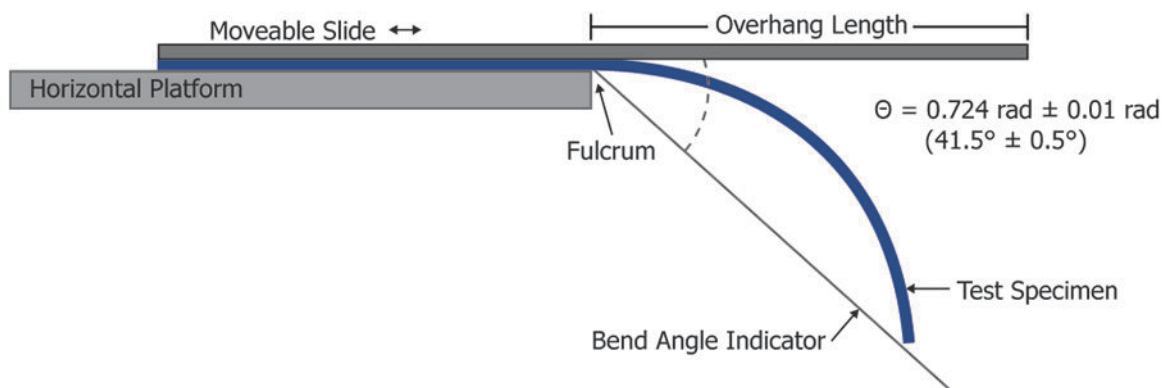


FIG. 4 Cantilever Bending Length Test – fabric in bent position