Designation: D 5732 – 95 (Reapproved 2001)

Standard Test Method for Stiffness of Nonwoven Fabrics Using the Cantilever Test[1]

This standard is issued under the fixed designation D 5732; 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 stiffness properties of nonwoven fabrics by employing the principle of cantilever bending of the fabric under its own weight. Bending length is measured and flexural rigidity calculated.

1.2 This test method applies to most nonwoven fabrics that are treated or untreated, including those heavily sized, coated, or resin-treated.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses 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:*

D 123 Terminology Relating to Textiles[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 2904 Practice for Interlaboratory Testing of a Textile Test Method That Produces Normally Distributed Data[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *bending length, n—in textiles,* a measure of the interaction between fabric weight and fabric stiffness as shown by the way in which a fabric bends under its own weight.

3.1.1.1 *Discussion*—Bending length reflects the stiffness of a fabric when bent in one plane under the force of gravity and is one component of drape.

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

3.1.2.1 *Discussion*—In nonwoven fabrics, the term cross-machine direction is used to refer to the direction analogous to crosswise or filling direction in a woven fabric.

3.1.3 *flexural rigidity, n*—a measure of stiffness, the couple on either end of a strip or unit width bent into unit curvature, in the absence of any tension.

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

3.1.4.1 *Discussion*—In nonwoven fabrics, the term machine direction is used to refer to the direction analogous to lengthwise or warp direction in a woven fabric.

3.1.5 *nonwoven fabric, n*—a textile structure produced by bonding or interlocking of fibers, or both, accomplished by mechanical, chemical, thermal, or solvent means, or combination thereof.

3.1.6 *stiffness, n*—resistance to bending.

3.2 For definitions of other terms used in this test method, refer to Terminology D 123.

4. Summary of Test Method

4.1 A specimen is slid at a specified rate in a direction parallel to its long dimension, so that 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 weight to the point where the line joining the top to the edge of the platform makes a 0.785 rad (41.5°) angle with the horizontal. The stiffer the fabric, the longer it takes to bend, thus, the higher numbers indicate a stiffer fabric.

5. Significance and Use

5.1 This test method may be used for acceptance testing of commercial shipments of nonwoven fabrics, however, caution is advised since information about between-laboratory precision is incomplete. A comparative test as directed in 5.1.1 may be advisable.

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 a comparative test 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 Student's *t*-test 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

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.64 on Nonwoven Fabric.

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

supplier must agree to interpret future test results in the view of the known bias.

5.2 This test method measures the drape stiffness of the nonwoven fabric. This test is not, however, suitable for very limp fabrics or those that show a marked tendency to curl or twist.

6. Apparatus

6.1 *Cantilever Bending Tester*[3] *(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.

6.1.2 *Indicator*, inclined at an angle of 0.724 rad (41.5°) below the plane of the platform surface.

6.1.3 *Movable Slide*, consisting of a metal bar not less than 25 by 200 mm (1 by 8 in.) by approximately 3 mm (⅛ in.) thick and having a mass of 270 ± 5 g (0.6 ± 0.01 lb).

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

6.1.5 *Motorized Specimen Feed Unit*, set for 120 mm/min (4¾ in./min), preferred. Manual units are permitted.

6.2 *Analytical Balance*, having a capacity and sensitivity to weigh within ± 0.1 % of the weight of the specimens being tested.

6.3 *Cutting Die*, 25 by 200 mm ± 1 mm (1 by 8 in. ± 0.002 in.).

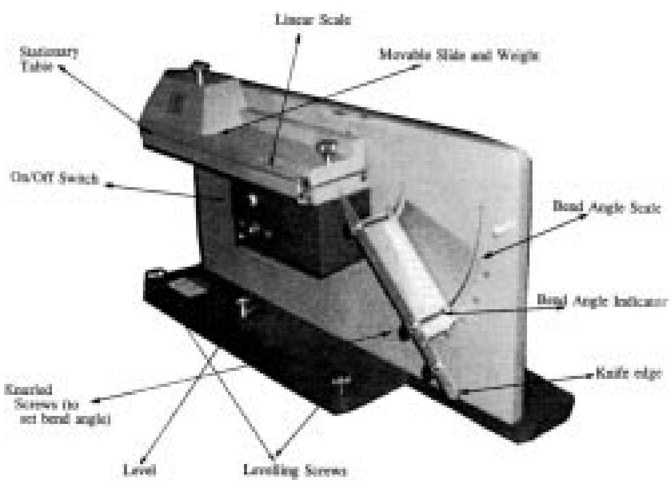

FIG. 1 Cantilever Bending Tester

7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random 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 1—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 pieces 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 the laboratory sample, 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.

7.3 *Test Specimens*—From each laboratory sampling unit, take five specimens from the machine direction and five specimens from the cross-machine direction as applicable to a material specification or contract order. For nonwoven fabrics, take specimens only in the machine direction unless otherwise specified.

7.3.1 *Direction of Test*—Consider the long dimension as the direction of the test.

7.3.2 *Specimen Size and Direction of Test*—Cut test specimens 25 by 200 mm ± 1 mm (1 by 8 in. ± 0.002 in.). Take the specimens for the measurement of the machine direction from different positions across the fabric width with the longer dimension parallel to the machine direction. Take the specimens for the measurement of the cross-machine direction from different positions along the length of the fabric with the longer dimension parallel to the cross-machine direction. Label to maintain specimen identity.

7.3.2.1 Cut specimens representing a broad distribution across the width 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. Conditioning

8.1 No conditioning is required unless otherwise specified in a material specification or contract order.

8.2 When specified, precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as directed in Practice D 1776.

8.3 After preconditioning, bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as directed in Practice D 1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

TABLE 1 Number of Rolls, or Pieces, of Fabric in the Lot Sample

Number of Rolls, 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 ten rolls or pieces

[3] The F.R.L. cantilever bending tester has been found suitable and is available from Testing Machines, Inc., 400 Bayview Ave., Amityville, NY 11710; U.S. Testing, 1415 Park Ave., Hoboken, NJ 07030; and FAST (The Wool Bureau, Inc., U.S. Branch-International Wool Secretariat, Technical Service Center), 225 Crossways Park Drive, Woodbury, NY 11797-0403.

9. Procedure

9.1 Set the tester on a table or bench and while observing the inclined reference line at eye level adjust the platform to a horizontal as indicated by the leveling bubble.

9.2 Remove the movable slide. Place the specimen (faceside up) on the stationary table with the length of the specimen parallel to the edge of the table. Align the edge of the specimen with the line scribed 6 mm (¼ in.) from the right-hand edge of the table.

9.3 Place the movable slide onto the specimen careful not to change its initial position.

9.4 Verify that the bend angle indicator is at the 0.785 rad (41.5°) angle marked on the scale.

9.5 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.

9.5.1 For manual testers, move the clamped specimen by hand in a smooth even manner until the edge of the specimen touches the knife edge.

9.6 Read and record the overhang length from the linear scale to the nearest 1 mm.

NOTE 2—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°).

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

9.8 Weigh the individual test specimens to the nearest 0.001 g.

9.9 Continue as directed in 9.2-9.8 until five specimens have been tested for each principal direction from each laboratory sampling unit. This gives 20 readings for each direction.

10. Calculation

10.1 *Bending Length Individual Specimens*:

10.1.1 Calculate the overhang length, *O*, for individual specimens by averaging the four readings obtained to the nearest 1 mm, unless otherwise agreed upon between the purchaser and the supplier.

10.1.2 Calculate the bending length for each principal direction to the nearest 1 mm, using Eq 1:

$$c = O/2 \tag{1}$$

where:
c = bending length, mm, and
O = overhang length, mm.

10.1.3 In some cases it may be of interest to differentiate between the sides of the fabric by averaging those readings made with the face-side up separately from those with the reverse-side up. If this is done, specify the direction of bending.

10.2 *Mass per Unit Area (g/m²)*—Calculate the mass per unit area by dividing the weight (see Note 3) in grams by 5000 mm²(area of the specimen) and multiplying the result by 10^6, for each principal direction.

NOTE 3—In 10.2 the phrase mass per unit area is retained because the unit g (gram) is a mass unit in the SI system. This does cause some confusion because colloquially phrases like "weigh the sample" and "weight in grams" are frequently used. In the following calculations, gram is used as a mass unit.

10.3 *Flexural Rigidity Individual Specimens*—Calculate the flexural rigidity for each principal direction to three significant digits, using Eq 2:

$$G = 9.809 \times 10^6 M_c^{\,3} \tag{2}$$

where:
G = flexural rigidity, μN·m, and
M = fabric mass per unit area, g/m².

10.4 *Average Values*—Calculate the average bending length and flexural rigidity, as applicable, for each principal direction for the laboratory sample and the lot.

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

11. Report

11.1 Report that the bending length and flexural rigidity were determined as directed in this test method. Describe the material or product sampled and the method of sampling used.

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

11.2.1 Bending length,

11.2.2 Flexural rigidity,

11.2.3 Number of specimens tested for each direction,

11.2.4 When calculated, the standard deviation or the coefficient of variation,

11.2.5 Make and model of testing machine, and

11.2.6 Any modification of the test method.

12. Precision and Bias

12.1 *Precision*—Preliminary interlaboratory test data have shown that the variance in stiffness testing is dependent upon the manufacturing method of the material under evaluation; therefore, no general statement can be made concerning least critical differences. The following data were generated during the interlaboratory test and are presented for reference. In comparing two averages of five observations, the difference between averages should not exceed the following values 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 are randomly drawn from the same sample:

Manufacturing Method (Critical Differences)	Bending Length, mm (in.) (Critical Differences)
Hydroentangled	3.81 (0.15)
Dry Laid	12.19 (0.48)
Needlepunch	17.53 (0.69)
Resin Bonded	7.87 (0.31)
Thermal	4.06 (0.16)
Wet Laid	9.65 (0.38)

Larger differences are likely to occur under all other circumstances. This procedure for determining stiffness has no other known bias and is considered a referee method.

12.2 *Interlaboratory Test Data*—A preliminary interlaboratory test was run in 1992 in which randomly drawn samples of six materials were tested in each of four laboratories. Two operators in each laboratory tested five specimens of each material. The six materials used in this evaluation were all manufactured by different processes as shown in 12.1. Analysis of the data using the adjunct to Practice D 2904 suggested reporting the components of variance and least critical differences based upon the method of manufacturing. The components of variance, expressed as standard deviations, for each method of manufacturing are listed in Table 2 (see Note 4). Further testing is in progress to elucidate the dependence on manufacturing process and possible test method revision.

12.3 *Precision*—For the components of variance listed in Table 2, the averages of two observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences in Table 3 (see Note 5). Due to the dependence of the components of variance on the manufacturing process no meaningful statement can be made at this time relative to between-material comparisons.

NOTE 4—The square roots of the components of variance are listed in Table 2 so that the variability is expressed in the appropriate units of measure rather than as the square of those units of measure.

NOTE 5—The values of the tabulated 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 of the type being evaluated so as to be as homogeneous as possible, and then randomly assigned in equal numbers to each of the laboratories.

TABLE 2 Components of Variance as Standard Deviations

NOTE 1—Bending length expressed in mm.[A]

Manufacturing Process	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
Hydroentangled	3.099	3.835	3.327
Dry Laid	9.779	4.420	6.782
Needlepunch	14.072	0	4.902
Resin Bonded	6.299	2.515	5.817
Thermal	3.226	3.886	1.270
Wet Laid	7.772	5.410	0

[A] 1 in. = 25.4 mm.

TABLE 3 Critical Differences for Conditions Noted 95 % Probability Level

NOTE 1—Bending length expressed in mm.

Manufacturing Process	Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
Hydroentangled	1	8.64	13.72	16.51
	5	3.81	11.43	14.48
	10	2.79	10.92	14.22
Dry Laid	1	27.18	29.72	35.31
	5	12.19	17.27	25.65
	10	8.64	14.99	24.13
Needlepunch	1	39.12	39.12	41.40
	5	17.53	17.53	22.10
	10	12.45	12.45	18.29
Resin Bonded	1	17.53	18.80	24.64
	5	7.87	10.41	19.30
	10	5.59	8.89	18.29
Thermal	1	8.89	13.97	14.48
	5	4.06	11.43	11.94
	10	2.79	11.18	11.68
Wet Laid	1	21.59	26.16	26.16
	5	9.65	17.78	17.78
	10	6.86	16.51	16.51

12.4 *Bias*—The procedure in this test method for determining the stiffness bending length of nonwoven fabrics has not been checked against accepted reference materials but contains no known bias other than the effect of manufacturing process, as noted. This test method is accepted as a referee method.

13. Keywords

13.1 bending length; cantilever; fabric; flexural rigidity; nonwoven fabric; stiffness