Designation: D 4032 – 94

Standard Test Method for Stiffness of Fabric by the Circular Bend Procedure[1]

This standard is issued under the fixed designation D 4032; 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 determination of the stiffness of fabrics by the circular bend procedure.

1.2 This test method is generally applicable to all types of fabrics, including woven, knitted and nonwovens, of any fiber content.

NOTE 1—For other methods of testing for stiffness, refer to Test Methods D 1388.

1.3 The values stated in SI units are to be considered as standard; the values in inch-pound units are included for information only.

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 1388 Test Methods for Stiffness of Fabrics[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *circular bend, n*—simultaneous, multidirectional deformation of a fabric in which one face of a flat specimen becomes concave and the other becomes convex.

3.1.2 *stiffness, n*—resistance to bending.

3.1.3 *stiffness, n*—with regard to the circular bending of textiles, resistance to multidirectional bending.

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

4. Summary of Test Method

4.1 A plunger forces a flat, folded swatch of fabric through an orifice in a platform. The maximum force required to push the fabric through the orifice is an indication of the fabric stiffness (resistance to bending).

5. Significance and Use

5.1 Test Method D 4032 for testing stiffness of fabrics is considered satisfactory for quality control testing. It may also be used for acceptance testing of commercial shipments since the test method has been used extensively in the trade field. In cases of differences in values reported by purchaser and seller using Test Method D 4032 for acceptance testing, the statistical bias, if any, between the laboratories of the purchaser and the seller should be determined with each comparison being based on the testing of specimens taken homogeneously from a lot of material of the type being evaluated. Specimens should be randomly assigned in equal numbers to each of the laboratories.

5.2 The circular bend procedure gives a force value related to fabric stiffness, simultaneously averaging stiffness in all directions. The stiffness tests in Test Methods D 1388 are of the single directional type.

5.3 The circular bend procedure is simple to perform and may be used for knitted, woven, or nonwoven fabrics, provided gage capacity is in keeping with fabric range tested.

6. Apparatus

6.1 *Circular Bend Stiffness Tester,*[3] (Figs. 1 and 2), having the following parts:

6.1.1 *Platform*, 102 by 102 by 6 mm (4 by 4 by ¼ in.) smooth-polished chrome-plated steel plate with a 38.1-mm (1.50-in.) diameter orifice. The lap edge of the orifice should be at a 45° angle to a depth of 4.8 mm (3⁄16 in.) (see Fig. 3).

6.1.2 *Plunger*, 25.4-mm (1.00-in.) diameter, mounted concentric with orifice, 6.4 mm (0.25 in.) clearance on all sides. The bottom of the plunger should be set at 3 mm (⅛ in.) above the top of the orifice plate. From this position, the downward stroke length is 57 mm (2¼ in.).

6.1.3 *Force-Measurement Gage*, dial or digital type (see 9.3).

6.1.3.1 Dial gages with maximum reading pointer in different capacities ranging from 1 to 50 lbf, 0.5 to 25 kgf, or 5 to 200 N with 100 graduations minimum; or

6.1.3.2 Digital gage with maximum reading "hold" feature and capacity of 100 lbf, 50 kgf, or 500 N, with 1000 graduations minimum.

6.1.4 *Actuator*, manual or pneumatic.

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[1] This test method is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.60 on Fabric Test Methods, Specific.

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

[3] Available from J. A. King and Co., Inc., 2620 High Point Road, Greensboro, NC 27420.

FIG. 1 King Manual Operated Dial Model

6.2 *Specimen Marking Template*, (102 by 204 mm) 4.0 by 8.0 in.

6.3 *Stop Watch*, for checking stroke speed.

7. Sampling

7.1 *Lot Size*—For sampling purposes, a lot is defined as a single shipment of a single style of fabric. A lot may constitute all or part of a single customer order.

7.2 *Lot Sample*—As a lot sample for acceptance testing; take at random the number of rolls of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of fabric to be the primary sampling units.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric and between specimens from a swatch from a roll of fabric to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.3 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a full swatch 1 m (1 yd) long from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m (1 yd) of fabric from the very outside of the rolls.

8. Number and Preparation of Test Specimens

8.1 Using the specimen marking template specified in 6.2, mark and cut five test specimens from staggered areas of each swatch in the laboratory sample. The short side of the specimen must be parallel to the machine (length) direction of the fabric. Cut no specimens closer to the selvage than one tenth of the fabric width. Lay each specimen face down and fold the specimen once to form a square 4 by 4 in. (102 by 102 mm). After folding, use the template and hand pressure to flatten the crease. Handling of specimens must be kept to a minimum and to the edges to avoid affecting stiffness properties.

NOTE 3—When otherwise agreed upon, as when specified in an applicable material specification, the purchaser and the seller may change the number of test specimens per swatch from the laboratory sample.

NOTE 4—Fabrics may also be tested face-to-face when the technical back is used for the outer surface or when there are significant differences in face and back surface properties. In reporting, indicate that the fabric was tested face-to-face.

9. Conditioning

9.1 Bring the specimens to moisture equilibrium, as directed in Practice D 1776.

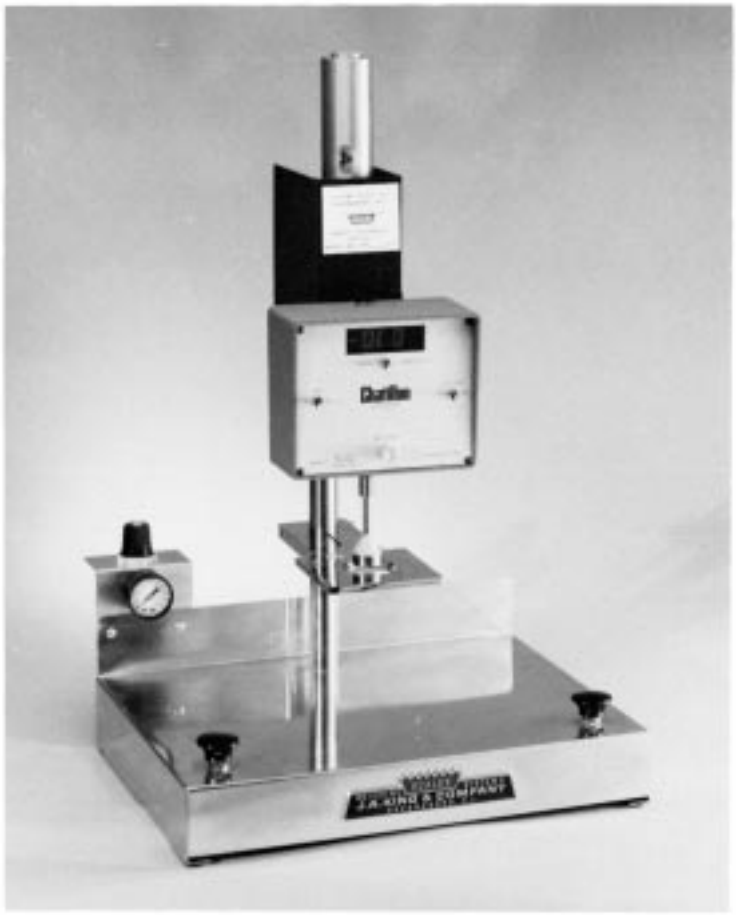

FIG. 2 King Air Operated Digital Model

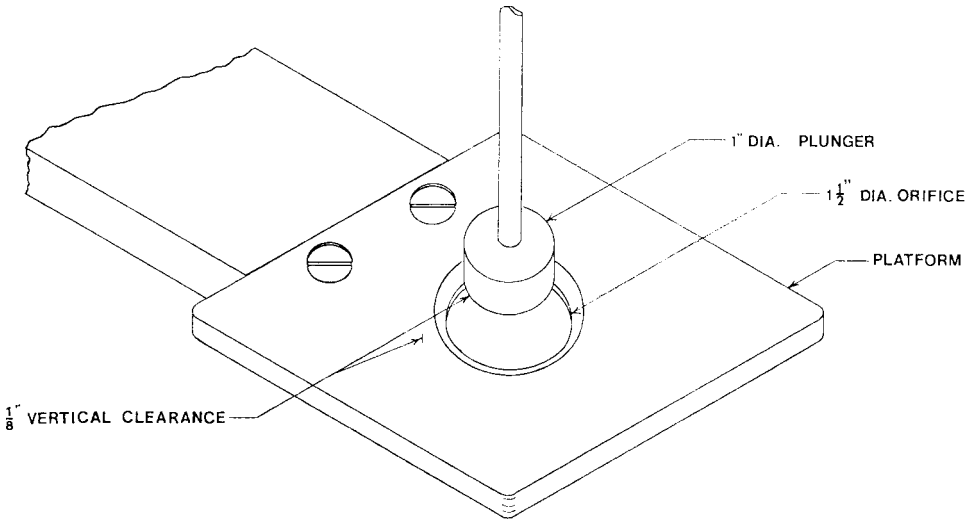

FIG. 3 Platform and Plunger

10. Procedure

10.1 Test the adequately conditioned specimens in the standard atmosphere for testing textiles which is 21 ± 1°C (70± 2°F) and 65 ± 2 % relative humidity.

10.2 Set the tester on a flat surface with dial at eye level.

10.3 Select a gage with a capacity in which results will fall within 15 to 100 % of dial gage force or 1.5 to 100 % of digital gage force.

10.4 Check tester plunger speed control for full stroke length.

10.4.1 *Pneumatic Actuator*—Set the air pressure control to the actuator at 324 kPa (47 psi). Using a stop-watch, adjust the

pneumatics to provide plunger speed of 1.7 ± 0.15 s under no load conditions.

10.4.2 *Manual Actuator*—Using a stop-watch, establish and confirm a plunger speed of 1.7 ± 0.3 s.

NOTE 5—The use of the pneumatic actuated tester gives a more controlled result than the manual actuated tester which is subject to operator variances in the speed at which the plunger is operated (see Table 1 and Table 2).

10.5 Center a double-ply specimen on the orifice platform below the plunger.

NOTE 6—If 3.2 mm (⅛ in.) clearance under plunger prevents ease of entry of specimen due to fabric thickness, the clearance may be increased to 6.3 mm (¼ in.) maximum. In reporting, the results should indicate the plunger clearance, if not standard.

10.6 Check the gage zero and adjust, if necessary.

10.7 Set the maximum force reading switch.

10.8 Actuate the plunger for the full stroke length. Avoid touching the specimen during testing.

10.9 Record maximum force reading to nearest gage graduation.

10.10 Continue as directed in 10.5-10.9, until all specimens have been tested.

11. Calculation

11.1 Average the individual specimen readings and round to the nearest gage increment.

12. Report

12.1 State that the specimens were tested as directed in Test Method D 4032. Describe the material or product sampled, and the method of sampling used.

TABLE 1 Number of Fabric Rolls

In Lot	In Lot Sample
1 to 10	1
11 to 20	2
21 to 30	3
31 to 40	4
41 or more	5

12.2 Report the following information:

12.2.1 Average force in gage units.

12.2.2 Number of specimens tested.

12.2.3 Actuator type.

12.2.4 Gage type and capacity.

12.2.5 How fabric was folded, if not standard (back-to-back).

12.2.6 Plunger clearance, if not standard 3.2 mm (⅛ in.).

13. Precision and Bias

13.1 *Interlaboratory Test Data*—An interlaboratory test was conducted in 1979 in which 29 laboratories each tested 5 specimens from 3 different fabrics. Eleven laboratories used pneumatic actuated testers and 18 laboratories used manual. The first fabric was a 153 g/m^2 (4½ oz/yd^2) "pocketing," 65 % polyester and 35 % cotton. The second was a 339 g/m^2 (10 oz/yd^2) broken twill, 50 % polyester and 50 % cotton. The third was a 492 g/m^2 (14½ oz/yd^2) 100 % cotton denim. All specimens were cut at one laboratory from the three fabric samples. Each laboratory had one operator test each material. The critical differences for stiffness based on all laboratories are as specified in Table 2. The critical differences for stiffness comparing pneumatic versus manual actuated testers are specified in Table 3.

13.2 *Precision*—For the critical differences reported in 13.1, 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 2 and Table 3.

13.3 *Bias*—The procedure in Test Method ASTM D 4032 has no bias because the value of stiffness of fabric by the circular bend procedure is defined in terms of this test method.

14. Keywords

14.1 fabric; stiffness

TABLE 2 Stiffness Critical Differences (Summary of all Laboratories and Tester Models) (95 % Confidence Limits)

Fabric Type	Number of Observations in Each Average	Average Stiffness, N (lbf)	Critical Differences, N (lbf)	
			Within-Laboratory Precision	Between Laboratory Precision
153 g/m^2(4½ oz/yd^2) pocketing	3	6.2 (1.4)	5.3 (1.2)	7.6 (1.7)
	5	6.2 (1.4)	4.4 (1.0)	7.1 (1.6)
339 g/m^2(10 oz/yd^2) twill	3	25.4 (5.7)	10.2 (2.3)	22.7 (5.1)
	5	24.9 (5.6)	10.2 (2.3)	21.4 (4.8)
492 g/m^2(14½ oz/yd^2) denim	3	69.4 (15.6)	27.1 (6.1)	28.9 (6.5)
	5	68.9 (15.5)	27.6 (6.2)	28.5 (6.4)

TABLE 3 Stiffness Critical Differences (Air Tester versus Manual Tester) (95 % Confidence Limits)

Fabric Type	Number of Observations in each Average	Average Stiffness, N (lbf)		Critical Differences, N (lbf)			
		Air	Manual	Within-Laboratory Precision		Between-Laboratory Precision	
				Air	Manual	Air	Manual
153 g/m^2(4½ oz yd^2) pocketing	3	6.2 (1.4)	6.7 (1.5)	53 (1.2)	4.9 (1.1)	2.7 (0.6)	9.3 (2.1)
	5	5.8 (1.3)	6.7 (1.5)	4.4 (1.0)	4.9 (1.1)	2.7 (0.6)	8.9 (2.0)
339 g/m^2(10 oz/yd^2) twill	3	21.4 (4.8)	27.6 (6.2)	9.3 (2.1)	10.7 (2.4)	11.6 (2.6)	25.4 (5.7)
	5	21.4 (4.8)	26.7 (6.0)	8.0 (1.8)	10.7 (2.4)	10.2 (2.3)	24.5 (5.5)
492 g/m^2 14½ oz/yd^2 denim	3	66.3 (14.9)	71.2 (16.0)	24.0 (5.4)	28.9 (6.5)	26.2 (5.9)	30.2 (6.8)
	5	67.2 (15.1)	69.8 (15.7)	27.1 (6.1)	27.6 (6.2)	21.8 (4.9)	25.8 (5.8)