Designation: D 3786 – 01

Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method[1]

This standard is issued under the fixed designation D 3786; 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 describes the measurement of the resistance of textile fabrics to bursting using the hydraulic diaphragm bursting tester. This test method is generally applicable to a wide variety of textile products.

1.2 This test method may also be applicable for stretch woven and woven industrial fabrics such as inflatable restraints.

1.3 The values stated in S. I. Units are to be regarded as the standard.

NOTE 1—For the measurement of the bursting strength by means of a ball burst mechanism, refer to Test Method D 3787.

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 5034 Test Methods for Breaking Load and Elongation of Textile Fabrics[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 3787 Test Method for Bursting Strength of Knitted Textiles—Constant-Rate-of-Traverse (CRT) Ball Burst Test[3]

2.2 *Other Standard:*

TAPPI T 403, OM.91 Bursting Strength of Paper[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *bursting strength, n*—the distending force, which is applied at right angles to the plane of the fabric, under specified conditions, which will result in the rupture of a textile.

3.1.2 *knitted fabric, n*—a structure produced by interlooping one or more ends of yarn or comparable material.

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

3.1.3.1 *Discussion*—The term does not include paper or fabrics that are woven, knitted or tufted.

3.1.4 *woven fabric, n*—a structure produced when at least two sets of strands are interlaced, usually at right angles to each other according to a predetermined pattern of interlacing, and such that at least one set is parallel to the axis along the lengthwise direction of the fabric.

3.1.5 *stretch woven fabric, n*—a woven fabric which is capable of at least 20 % stretch in either warp or filling direction, or both, under loads and conditions encountered in use and of almost complete recovery on removal of the load.

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

4. Summary of Test Method

4.1 A is clamped over an expandable diaphragm. The diaphragm is expanded by fluid pressure to the point of specimen rupture. The difference between the total pressure required to rupture the specimen and the pressure required to inflate the diaphragm is reported as the bursting strength.

5. Significance and Use

5.1 This method for the determination of diaphragm bursting strength of knitted, nonwoven and woven fabrics is being used by the textile industry for the evaluation of a wide variety of end uses.

5.2 In cases where test results obtained using the procedures in Test Method D 3786 have not been correlated with actual performance, Test Method D 3786 is considered satisfactory for acceptance testing of commercial shipments of textile fabrics for bursting strength since the method has been used extensively in the trade for acceptance testing. In cases where disagreement arising from differences in values reported by the purchaser and the supplier when using Test Method D 3786 for acceptance testing, the statistical bias, if any, between the laboratory of the purchaser and the laboratory of the supplier

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

[3] *Annual Book of ASTM Standards*, Vol 07.02.

[4] Available from Technical Association of the Pulp and Paper Industry, 1 Dunwoody Park, Atlanta, GA 30341.

should be determined with comparison based on testing specimens randomly drawn from one sample of material of the type being evaluated.

NOTE 2—The kind of load transfer and stretch that occur when knitted goods and nonwoven fabrics are worn are prevented by clamping them as described in this method.

6. Apparatus and Materials

6.1 *Hydraulic Diaphram Bursting Tester*[5]— A testing machine that meets the requirements of 6.1.1-6.1.4. In cases of dispute, a motor-driven tester shall be used unless the purchaser and the supplier agree otherwise.

6.1.1 *Clamps*, for firmly and uniformly securing the test specimen between two annular, plane, parallel, and preferably stainless steel surfaces, without slippage during the test. Use sufficient pressure to effect the practicable minimization of slippage.

6.1.1.1 The upper and lower clamping surfaces shall have a circular opening at least 75 mm (3 in.) in diameter and coaxial apertures of 31 ± 0.75 mm (1.22 ± 0.03 in.) in diameter: The surfaces of the clamps between which the specimen is placed shall have concentric grooves spaced not less than 0.8 mm (1⁄32in.) apart and shall be of a depth not less than 0.015 mm (0.0006 in.) from the edge of the aperture. The surfaces of the clamps shall be metallic and any edge which might cause a cutting action shall be rounded to a radius of not more than 0.4 mm (1⁄64 in.). The lower clamp shall be integral with the chamber in which a screw shall operate to force a liquid pressure medium at a uniform rate of 95 ± 5 mL/min against the rubber diaphragm.

NOTE 3—Since the clamping mechanism and clamping surfaces are subject to considerable wear and distortion, they should be examined periodically and repaired or replaced when necessary. The effectiveness of grooving the clamping surfaces in the manner specified has not been determined.

6.1.2 *Diaphragm*[5]—A 48 mm (1.875 in) diaphragm of molded synthetic rubber, 1.80 ± 0.05 mm (0.070 ± 0.002 in.) in thickness with reinforced center, clamped between the lower clamping plate and the rest of the apparatus so that before the diaphragm is stretched by pressure underneath it the center of its upper surface is below the plane of the clamping surface. The pressure required to raise the free surface of the diaphragm plane shall be 30 ± 5 kPa (4.3 ± 0.8 psi). This pressure shall be checked at least once a month. To test, a bridge gage[5] may be used, the test being carried out with the clamping ring removed. The diaphragm should be inspected frequently for permanent distortion and renewed as necessary.

6.1.3 *Pressure Gage*—A maximum-reading pressure gage of the Bourdon type of appropriate capacity graduated in pounds and accurate throughout the entire range of its scale to within a value of 1 % of its maximum capacity. The capacity of the gage shall be such that the individual readings will be not less than 25 % nor more than 75 % of the total capacity of the gage.

6.1.4 *Hydraulic Pressure System*—A mean of applying controlled increasing hydrostatic pressure to the underside of the diaphragm until the specimen bursts through a fluid displaced at the rate of 95 ± 5 mL/min. The fluid is displaced by a piston in the pressure chamber of the apparatus. The recommended chamber fluid is USP chemically pure 96 % glycerin. The hydraulic system, including the gages shall be mounted so as to be free of externally induced vibrations. Means shall be provided at the instant of rupture of the specimen for stopping any further application of the loading pressure and for holding unchanged the contents of the pressure chamber until the total bursting pressure and the pressure required to inflate the diaphragm indicated on the gage have been recorded.

NOTE 4—Ethylene glycol may be substituted for the glycerine if desired.

6.1.5 *Aluminum Foil For Calibration of Tester*[6]—Pieces of pretested aluminum sheet having a known bursting strength in the range of 70 to 790 kPa (10 to 115 psi) are use for checking the overall performance of the tester.

7. Sampling

7.1 *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 5—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.

7.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, take a full width 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 roll. From each roll or piece of circular knit fabric selected from the lot sample, cut a band at least 305 mm (1 ft) wide.

7.3 *Test Specimens*—Cut ten test specimens from each swatch in the laboratory sample with each specimen being 125 mm (5 in.) square.

8. Calibration

8.1 *Routine Verification of Testing Machine*—Check the operation of the testing machine at least once each month by bursting five specimens of standard aluminum sheet. The average of the indicated bursting resistance for the five specimens of aluminum sheet should be between ±5 % of that marked on the package of the pretested aluminum sheet standard.

[5] The Hydraulic Diaphragm Bursting Testers, hand driven Model LC (Fig. 1A) and motor driven Models C (Fig. 1B) and (Fig. 1C), and accessories, manufactured by B. F. Perkins & Son, Inc., have been found satisfactory. The motor driven Model A (Fig. 1D) has been found to be satisfactory for heavyweight fabrics, but may be unsuitable for some lightweight fabrics. Model C and Model A have different pumping rates and different diaphragms therefore it is not likely these two machines will give the same result. The testers also can be obtained from Testing Machines, Inc., 400 Bayview Ave., Amityville NY

[6] Standardized aluminum sheets for this purpose, bursting over the range from 51 to 150 psi (350 to 1035 kPa) may be obtained from the Pulp and Paper Research Institute of Canada, 3420 University St., Montreal, Canada; from Testing Foil Service, 304 N. Stevens St., Rhinelander, WI 54501; and from Testing Machines, Inc., 400 Bayview Ave., Amityville, NY 11701.

8.2 *Calibration of Gage*—Calibrate the gage, while inclined at the same angle at which it is used, by means of a dead-weight tester of the piston type, or by means of a column of mercury. Such calibration is preferably carried out with the gage in its normal position in the tester.

8.3 Where agreement is not attained, check the tester according to the instructions given in Tappi Method T-403 OS-74.

NOTE 6—Possible causes of low readings are gage error (bias or nonlinearity), gage expansivity too high, excessive gage pointer friction, air in hydraulic system or gage, diaphragm collapsed too far at zero, and low pumping rate (hand-driven tester). Possible causes of high readings are: gage error (bias nonlinearity), loose gage pointer (overshoot), gage pointer bent by stop-pin, insufficient clamping force (slipping), nonuniform clamping (partial slipping), stiff or inelastic diaphragm, diaphragm above clamping plate at zero, multiple sheet testing, high pumping rate (hand-driven tester), and double bursts. If a gage is accidently used beyond its capacity, it must be recalibrated before it is used again.

9. Conditioning

9.1 Bring the specimens (or laboratory samples) from the prevailing atmosphere to moisture equilibrium for testing in the standard atmosphere for textile testing as directed in Practice D 1776.

10. Selection and Number of Specimens

10.1 Unless otherwise agreed upon, as when specified in an applicable material specification, take ten specimens of the laboratory sample(s) of fabric. Each specimen shall be at least 125 mm (5 in.) square, or a circle 125 mm (5 in.) in diameter. Specimens need not be cut for testing. No two specimens from knitted fabric should contain the same wale or course yarns. Take no specimens nearer the selvage than one tenth the fabric width. This restriction does not apply to tubular knitted fabric.

11. Procedure

11.1 Make all tests on specimens conditioned in the standard atmosphere for testing textiles as directed in 9.1.

11.2 *Hand Driven Tester*:

11.2.1 Insert the conditioned specimen under the tripod, drawing the specimen taut across the plate, and clamp specimen in place by bringing the clamping lever as far to the right as possible.

NOTE 7—For specimens with considerable stretch, it may be necessary to extend the fabric uniformly over the plate to remove some of the stretch before clamping.

11.2.2 Rotate the hand wheel, clockwise at a uniform speed of 120 rpm until the specimen bursts.

11.2.3 Stop turning the hand wheel at the instant of rupture of the specimen (see Note 8).

11.2.4 Immediately after rupture and in rapid succession, release the clamping lever over the specimen. Immediately release the strain on the diaphragm by turning the wheel counterclockwise to its starting position and record the pressure required to inflate the diaphragm (tare pressure). Record the total pressure required to rupture the specimen.

NOTE 8—If the pressure stops increasing, as indicated by the dial, and the specimen has not broken, push the operating lever to remove the pressure. Record that the stretch of the fabric exceeds the dimensional limitations of the tester. If slippage of the specimen is noted, discard the result and use a new specimen.

11.3 *Motor-Driven Tester*:

11.3.1 Insert the specimen under the tripod, drawing the specimen taut across the plate, and clamp specimen in place by bringing the clamping lever as far to the right as possible (see Note 6).

11.3.2 Inflate the diaphragm by moving the operating handle to the left.

11.3.3 While the diaphragm is inflating, take hold of the latch that is located below, or to the right, of the operating handle. At the instant of rupture of the specimen, swing the latch as far as it will go to bring the operating handle to an idling (neutral) position (see Note 8). Record the total pressure required to rupture the specimen.

11.3.4 Immediately after rupture, and in rapid succession, release the clamping lever over the specimen. Immediately relieve the strain on the diaphragm by dropping the latch back to its normal position, throw the operating handle to the right, and record the pressure required to inflate the diaphragm (tare pressure).

12. Calculation

12.1 Calculate the bursting pressure of each specimen by subtracting the tare pressure required to inflate the diaphragm from the total pressure required to rupture the specimen.

12.2 Report the pressure reading of each individual specimen and the average for each laboratory sampling unit and the lot.

12.3 Report the type of bursting tester used.

13. Report

13.1 State that the specimens were tested as directed in Test Method D 3786 using the Hydraulic Diaphragm Bursting Tester. Describe the material or product sampled and the method of sampling used.

13.2 Report the bursting strength of each individual specimen and their average in kPa (psi).

13.3 Report the type of bursting tester used.

14. Precision and Bias

14.1 *Summary*—In comparing two averages of ten observations each, the difference should not exceed the following critical differences in 95 out of 100 cases when both sets of observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the same sample of material.

Spun yarn in circular knit	41 kPa (6.0 psi)
Filament yarn in tricot knit	14 kPa (2.0 psi)

Larger differences are likely to occur under all other circumstances. The value of the bursting strength of knitted goods can only be defined in terms of a specific test method.

Within this limitation, the procedure for bursting strength in Test Method D 3786 has no known bias. Sections 14.2-14.4 explain the basis for this summary and for evaluations made under other conditions.

14.2 *Interlaboratory Test Data*[7]—An interlaboratory test was run in 1977 in which randomly drawn specimens of six fabrics were tested in each of four to five laboratories. Three fabrics were circular knit fabrics containing spun yarns and three of the fabrics were tricot knit fabrics containing filament yarns. The components of variance for bursting strength results expressed as standard deviations were calculated to be the values reported in Table 1.

NOTE 9—The difference in variability between the two groups of fabrics is thought to be the result of the differences between the source yarns rather than the type of equipment on which the fabrics were knit. There is no objective evidence to substantiate this belief.

NOTE 10—The interlaboratory test data were obtained with motor-driven testers. The precision of the method using a hand-operated tester has not been determined.

14.3 *Critical Differences*—For the components of variance reported in 14.2, 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 (Note 9).

NOTE 11—The tabulated values of the critical differences should be considered to be a general statement particularly with respect to between-laboratory precision. Before a 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 randomly drawn from a sample taken at random from a lot of the material to be evaluated.

14.4 *Bias*—The procedure in Test Method D 3786 has no known bias because the value of bursting is defined in terms of this test method.

15. Keywords

15.1 diaphragm bursting pressure; knitted fabric; non woven fabric

[7] ASTM Research Report No. RR:D13-1061. A copy is available from ASTM Headquarters.

TABLE 1 Components of Variance for Bursting Strength Expressed as Standard Deviations, Percentage Points

	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
Spun yarns in circular knit	6.8	1.1	2.5
Filament yarns in tricot knit	2.3	3.1	2.6

TABLE 2 Critical Differences for Bursting-Pressure for the Conditions Noted, Percentage Points[A]

	Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
Spun yarns in circular knit	5	8.4	9.0	11.3
	10	6.0	6.7	9.6
	20	4.2	5.2	8.7
	40	3.0	4.3	8.1
Filament yarns in tricot knit	5	2.9	9.1	11.6
	10	2.0	8.8	11.4
	20	1.4	8.7	11.3
	40	1.0	8.7	11.3

[A] The critical differences were calculated using t = 1.645, which is based on infinite degrees of freedom.