



# Standard Test Method for Abrasion Resistance of Textile Fabrics (Inflated Diaphragm Apparatus)<sup>1</sup>

This standard is issued under the fixed designation D 3886; 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.

## 1. Scope

1.1 This test method<sup>2</sup> covers the determination of the resistance to abrasion of woven and knitted textile fabrics, both conditioned and wet, using the inflated diaphragm tester. This procedure is not applicable to floor coverings.

NOTE 1—Other procedures for measuring the abrasion resistance of textile fabrics are given in Test Methods D 3884, D 3885, D 1175, and AATCC Test Method 93.

1.2 The values stated in SI units are to be regarded as standard; the values in English units are provided as information only and are not exact equivalents.

1.3 *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<sup>3</sup>
- D 1776 Practice for Conditioning Textiles for Testing<sup>3</sup>
- D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data<sup>3</sup>
- D 2906 Practice for Statements on Precision and Bias for Textiles<sup>3</sup>
- D 3884 Test Method for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double Head Method)<sup>4</sup>
- D 3885 Test Method for Abrasion Resistance of Textile Fabrics (Flexing and Abrasion Method)<sup>4</sup>
- D 4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)<sup>4</sup>

### 2.2 AATCC Standard:

Test Method 93 Abrasion Resistance of Fabrics: Accelerator Method<sup>5</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *abrasion, n*—the wearing away of any part of a material by rubbing against another surface.

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

## 4. Summary of Test Method

4.1 A specimen is abraded by rubbing either unidirectionally or multidirectionally against an abradant having specified surface characteristics. A specimen is held in a fixed position and supported by an inflated rubber diaphragm which is held under constant pressure. A specimen is abraded by rubbing either unidirectionally or multidirectionally against an abradant having specified surface characteristics. The resistance to abrasion is determined using Option 1, the number of cycles to wear a hole in the specimen, or Option 2, visual assessment of the specimen surface after a specified number of cycles.

## 5. Significance and Use

5.1 The measurement of the resistance to abrasion of textile and other materials is very complex. The resistance to abrasion is affected by many factors, such as the inherent mechanical properties of the fibers; the dimensions of the fibers; the structure of the yarns; the construction of the fabrics; and the type, kind, and amount of finishing material added to the fibers, yarns, or fabric.

5.2 The resistance to abrasion is also greatly affected by the conditions of the tests, such as the nature of abradant, variable action of the abradant over the area of specimen abraded, the tension of the specimen, the pressure between the specimen and abradant, and the dimensional changes in the specimens.

5.3 Abrasion tests are all subject to variation due to changes in the abradant during specific tests. The abradant must accordingly be discarded at frequent intervals or checked periodically against a standard. With disposable abradants, the abradant is used only once or discarded after limited use. With

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<sup>2</sup> This test method is based upon the development described by R. G. Stoll, in "Improved Multipurpose Abrasion Test and Its Application for the Wear Resistance of Textiles," *Textile Research Journal*, July 1949, p. 394.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 07.01.

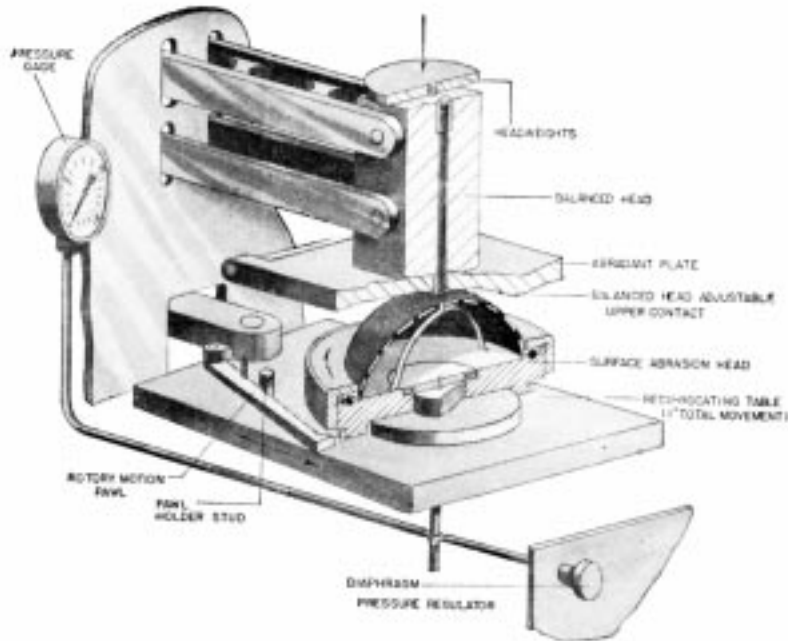
<sup>4</sup> *Annual Book of ASTM Standards*, Vol 07.02.

<sup>5</sup> Available from American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

permanent abrasants that use hardened metal or equivalent surfaces, it is assumed that the abrasant will not change appreciably in a specific series of tests. Similar abrasants used in different laboratories will not change at the same rate, due to differences in usage. Permanent abrasants may also change due to pick up of finishing or other material from test fabrics and must accordingly be cleaned at frequent intervals. The measurement of the relative amount of abrasion may also be affected by the method of evaluation and may be influenced by the judgment of the operator.

hold fabrics, industrial fabrics, and floor coverings. It is not surprising, therefore, to find that there are many different types of abrasion testing machines, abrasants, testing conditions, testing procedures, methods of evaluation of abrasion resistance and interpretation of results.

5.6 All the test methods and instruments so far developed for measuring abrasion resistance may show a high degree of variability in results obtained by different operators and in different laboratories; however, they represent the test methods now most widely in use.



**FIG. 1 Schematic Diagram of Inflated Diaphragm Abrasion Tester**

5.4 The resistance of textile materials to abrasion as measured on a testing machine in the laboratory is generally only one of several factors contributing to wear performance or durability as experienced in the actual use of the material. While “abrasion resistance” (often stated in terms of the number of cycles on a specified machine, using a specified technique to produce a specified degree or amount of abrasion) and “durability” (defined as the ability to withstand deterioration or wearing out in use, including the effects of abrasion) are frequently related, the relationship varies with different end uses, and different factors may be necessary in any calculation of predicted durability from specific abrasion data. Laboratory tests may be reliable as an indication of relative end-use performance in cases where the difference in abrasion resistance of various materials is large, but they should not be relied upon where differences in laboratory test findings are small. In general, they should not be relied upon for prediction of actual wear-life in specific end uses unless there are data showing the specific relationship between laboratory abrasion tests and actual wear in the intended end-use.

5.5 These general observations apply to all types of fabrics, including woven, nonwoven, and knit apparel fabrics, house-

5.7 Because there is a definite need for measuring the relative resistance to abrasion, standardized test methods are needed and useful and may clarify the problem and lessen the confusion.

5.8 Because of the conditions mentioned above, technicians frequently fail to get good agreement between results obtained on the same type of testing instrument both within and between laboratories, and the precision of these test methods is uncertain.

5.9 Test Method D 3886 is not recommended for acceptance testing of commercial shipment because of the poor between-laboratory precision.

5.9.1 In cases 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 which are as homogeneous as possible and which are from a lot of material of the type in question. The 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 appropriate statistical analysis for unpaired data and an acceptable probability level chosen by the two parties before the testing begins. 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 in the light of the known bias.

## 6. Apparatus

6.1 *Inflated Diaphragm Abrasion Tester*, shown in Fig. 1<sup>6</sup> and Fig. 2 with the following essential parts:

6.1.1 *Surface Abrasion Head*—The specimen is mounted in a circular clamp over a rubber diaphragm by means of a clamping ring and a tightening collar. The circular opening of the clamping ring is  $94.0 \pm 1.3$  mm ( $3.70 \pm 0.05$  in.) in diameter and that of the collar  $95.3$  mm ( $3.75$  in.) or more. The height from the surface of the clamped-in specimen to the upper edge of the tightening collar shall not exceed  $9.5$  mm ( $\frac{3}{8}$  in.). The clamping area of the body of the clamp and the ring should have gripping surfaces to prevent slipping of the specimen and leakage of air pressure during the test. Means should be provided for supplying air pressure to the body of the clamp so that the pressure under the diaphragm can be controlled between 0 and 41 kPa (0 and 6 psi) with an accuracy of  $\pm 5\%$  of range.

6.1.2 *Diaphragm*—The rubber diaphragm should be  $1.40 \pm 0.25$  mm ( $0.055 \pm 0.010$  in.) in thickness. A metallic contact pin  $3.2$  mm ( $\frac{1}{8}$  in.) in diameter is sealed into the center of the diaphragm flush with the diaphragm surface. Provision should be made for a flexible electrical connection from this contact pin to the ground of the machine. The strain distribution on the diaphragm must be uniform so that when inflated without the specimen, it assumes the shape of a section of a sphere. Pressure can be controlled from 0 to 41 kPa (0 to 6 psi).

6.1.3 *Driving Mechanism*—The design of the driving mechanism is such that the circular clamp makes a reciprocal motion of  $115 \pm 15$  double strokes per minute of 25-mm (1-in.) stroke length. Provision shall be made for rotation of the clamp in addition to the reciprocating motion so that one revolution can be completed in  $100 \pm 10$  double strokes.

6.1.4 *Balance Head and Abradant Plate*—The abradant is mounted upon a plate, which is rigidly supported by a double-lever assembly to provide for free movement in a direction perpendicular to the plane of the reciprocating specimen clamp. The abradant plate assembly should be well balanced to maintain a vertical pressure equivalent to a mass of 0 to 2.2 kg (0 to 5 lb) by means of dead weights. Provision should be made to mount different abradants such as abrasive paper, fabrics, etc., on this plate, and to stretch them into an even position. An electrically insulated contact pin, adjustable to the thickness of the abradant is mounted into this plate on the length axis at one of the turning points of the center of the clamp.

<sup>6</sup> The Stoll-Quartermaster has been found suitable and is available from Custom Scientific Instrument, Inc., 13 Wing Drive, Whippany, NJ 07981.



**FIG. 2 One Type of Commercial Inflated Diaphragm Abrasion Tester**

6.1.5 Some testers can also be equipped with a continuous changing abrasant head which is optional.

NOTE 2—The machine manufacturer does not provide adequate instructions for the use of the continuous changing abrasant head. Work is being done with the manufacturer to write a set of instructions.

6.1.6 *Machine Stopping Mechanism*—Contact between the adjustable pin on the lower side of the abrasant plate and the contact pin inserted into the center of the diaphragm closes a low-voltage circuit and stops the machine.

6.1.7 *Indicators*—Means should be provided for indicating the diaphragm pressure, and the number of abrasion cycles (1 cycle = 1 double stroke).

6.1.8 Fig. 2 shows a commercially available machine that conforms to the requirements of this method.

## 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 unit.

NOTE 3—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric and between test specimens from a swatch from a roll of fabric to produce a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—Take a laboratory sample from each roll or piece of fabric in the lot sample. The laboratory sample should be full width and at least 50 cm (approximately 20 in.) long and should not be taken any closer to the end of the roll or piece of fabric than 1 m (1 yd).

7.3 *Test Specimens*—Test five specimens from each laboratory sampling unit. Cut the specimens 112 mm (4<sup>3</sup>/<sub>8</sub> in.) in diameter and space them on a diagonal to represent different machine and cross-machine direction areas of the laboratory sampling units. Take no specimen within one tenth of the fabric width from the edges.

## 8. Conditioning

8.1 Precondition and condition samples or specimens as directed in Practice D 1776. Consider equilibrium to have been reached when the increase in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen.

## 9. Procedure

9.1 Test the specimen in the standard atmosphere for testing textiles, which is 70 ± 2°F (21 ± 1°C) and 65 ± 2 % relative humidity.

9.2 Place the specimen over the rubber diaphragm in a smooth condition, clamp the specimen in place without distorting it.

9.3 Place the abrasive paper or other abrasant on the abrasant plate under sufficient tension to be held smooth and in such a position that the contact pin, reaching through a hole in the abrasant, is even with the surface of the abrasant. No. 0 emery polishing paper is the standard abrasant. The method may be modified to use other abrasants but this information should be included in the final report.

NOTE 4—If the continuous changing abrasant head is used, it should be noted that, although the weight of the head is counter-balanced, the balance changes during use as the paper passes from the back roll to the front roll unless the continuous changing abrasant head is used.

NOTE 5—Unless the continuous changing abrasant head is used, it is recommended that the abrasant paper be changed at some regular frequency, such as every 100 to 300 cycles. As this frequency is dependent upon the type of fabric being tested, the task group is working on devising a more extensive system.

9.4 Set the air pressure under the diaphragm and force on the abrasant plate. The air pressure should be 28 kPa (4 psi) and the load on the abrasant should be 454 g (1 lb). Be sure that the air pressure control and contact between inflated specimen and loaded abrasant is in a state of equilibrium before abrasion is started. To ensure consistent inflation of the diaphragm, inflate to a higher air pressure (25 %) and then reduce to testing pressure.

9.5 *Direction of Abrasion*:

9.5.1 *Standard Multidirection*—Engage the rotation mechanism of the specimen clamp.

9.5.2 *Unidirection*—When this is used, disengage the rotation mechanism of the specimen clamp and bring the specimen into the desired direction by turning and setting the clamp after the diaphragm has been inflated. Include this information in the final report.

9.6 Remove pills of matted fibers interfering with proper contact between the specimen and abrasant during the test if they cause a marked vibration of the abrasant plate.

9.7 If the specimen slips in the clamp or the air pressure does not remain constant during the test or an anomalous wear pattern is obtained, discard such individual measurements and test an additional specimen.

9.8 This table is intended as a guide for visual assessment:

oz/yd <sup>2</sup>	assess @ cycle #
under 3 oz.	1000
3-5 oz.	3000
over 5 oz.	5000

9.9 If abrasion of wet specimens is desired, cover the dry clamped-in specimen with 10 ml of distilled water at a temperature of 20 ± 2°C (70 ± 2°F).

## 10. Interpretation of Results

10.1 Determine the end point by one of the following methods as specified by the requesting individual.

10.1.1 *Option 1, Failure*—Abrade the specimen until all fibers in the center of the abrasion area are worn off so that the contact pin in the abrasant plate comes in contact with the pin in the diaphragm, actuating an electrical relay and stopping the machine.

10.1.2 *Option 2, Visual Rating*—Abrade the specimen a specified number of cycles and then evaluate visually for the effect of the abrasion on luster, color, or fabric structure as follows:

Grade	Abrasion Assessment	
	Description	
5	No, or essentially no luster, color, or fabric structure change	
4	Slight change in color with no broken threads	
3	Moderate change in color with visual fraying	
2	Substantial change in color with 2 or less broken threads	
1	Severe change in color with more than 2 broken threads	

NOTE 6—Unless the continuous changing abrasant head is used, it is

recommended that the abradant paper be changed at some regular frequency, such as every 100 to 300 cycles. As this frequency is dependent upon the type of fabric being tested, the task group is working on devising a more extensive system.

## 11. Report

11.1 State that the specimens were tested as directed in Test Method D 3886. Describe the material or product sampled and the method of sampling used.

11.2 Report the following information:

11.2.1 Type of abradant,

11.2.2 Frequency with which abradant paper was changed,

11.2.3 Air pressure under the diaphragm and load on the abradant plate,

11.2.4 Type of abrasion (unidirectional or multidirectional),

11.2.5 Number of cycles to reach the end point as determined by electrical contact,

11.2.6 Effect of abrasion on luster, color, and fabric structure at a specified number of cycles recorded by qualitative or comparative ranking, and

11.2.7 Any deviations from the standard test procedure.

## 12. Precision and Bias

12.1 *Summary*—Based upon limited information from two laboratories, the single-operator, within-laboratory, and between-laboratory components of variation and critical differences shown in Tables 1 and 2 are approximate. These tables are constructed to illustrate what two laboratories found when all the observations are taken by well-trained operators using specimens randomly drawn from the sample of material. For these laboratories, in comparing two averages, it was found that differences should not exceed the single-operator precision values shown in Table 2 for the respective number of tests in 95 out of 100 cases. Differences for other laboratories may be larger or smaller.

12.2 *Single-laboratory Test Data*<sup>7</sup>—A two-laboratory test was run in 1997 in which randomly drawn samples of three materials were tested. Two operators in each laboratory each

<sup>7</sup> A copy is available from ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

**TABLE 1 Grand Average and Components of Variance<sup>A</sup> Expressed as Standard Deviations for Inflated Diaphragm Abrasion Cycles to Failure**

Grand Average and Component	Material 1	Material 2	Material 3
Grand average	4510	1585	309
Single-operator component	475	226	76
Within-laboratory component	0	290	68
Between-laboratory component	573	0	0

<sup>A</sup>The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

**TABLE 2 Critical Differences for Inflated Diaphragm Abrasion Cycles to Failure for the Conditions Noted<sup>A</sup>**

Materials	Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
1	1	1316	1316	2061
	2	930	930	1841
	5	588	588	1694
	10	416	416	1642
2	1	626	1018	1018
	2	443	917	917
	5	280	850	850
	10	198	827	827
3	1	212	284	284
	2	150	241	241
	5	95	212	212
	10	67	201	201

<sup>A</sup>The critical differences were calculated using  $t = 1.960$ , which is based on infinite degrees of freedom.

tested ten specimens (five on each of two days) from each fabric material using the cycles to failure procedure in Test Method D 3886. Analysis of the data was conducted using Practices D 2904 and D 2906 and the Adjunct “Tex-Pac.” The components of variance for inflated diaphragm abrasion expressed as standard deviations were calculated to be the values listed in Table 1.

12.3 *Precision*—Because tests were conducted in only two laboratories, estimates of between laboratory precision may be either underestimated or overestimated to a considerable extent and should be used with special caution. 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 nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories. However, when agreed upon between the contractual parties, for the approximate components of variance reported in Table 1, two averages of observed values may be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 2, for inflated diaphragm abrasion cycles to failure. Tex-Pac grouped materials into two separate groups, therefore, the components of variance and the critical differences are reported separately. Consequently no multi-material comparisons were made.

12.4 *Bias*—The value of inflated diaphragm abrasion cycles to failure of textile fabrics can only be defined in terms of a test method. Within this limitation, Test Method D 3886 has no known bias.

## 13. Keywords

13.1 abrasion; woven fabric; and knitted fabric



## D 3886

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