Designation: D 3885 – 0~~2~~4

Standard Test Method for Abrasion Resistance of Textile Fabrics (Flexing and Abrasion Method)[1]

This standard is issued under the fixed designation D 3885; 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] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.60 on Fabrics, Specific.

Current edition approved~~ April 10, 2002.~~ Jan. 1, 2004. Published~~ August 2002.~~ February 2004. Originally~~ published as D 3885 – 80.~~ approved in 1980. Last previous edition approved in 2002 as D 3885 – ~~99~~02.

1. Scope

1.1 This test method[2] covers the determination of the abrasion resistance of woven or nonwoven textile fabrics using the flexing and abrasion tester.

1.2 This test method applies to most woven and nonwoven fabrics providing they do not stretch excessively. It is not applicable to floor coverings.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as the standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with this test method.

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.*

NOTE 1—For other test methods for abrasion resistance of textiles refer to Test Methods D 3884, D 3886, D 4157, D 4158, D 4966, and AATCC93.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

D 76 Specification for Tensile Testing Machines for Textiles
D 123 Terminology Relating to Textiles
D 1776 Practice for Conditioning Textiles for Testing
D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data
D 2906 Practice for Statements on Precision and Bias for Textiles
D 3884 Test Method for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)
D 3886 Test Method for Abrasion Resistance of Textile Fabrics (Inflated Diaphragm Method)
D 4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)
D 4158 Test Method for Abrasion Resistance of Textile Fabrics (Uniform Abrasion Method)
D 4966 Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method)
D 5035 Test Method for Breaking Strength and Elongation of Textile Fabrics (Strip Method)

2.2 *AATCC Test Method:*

AATCC 93 Abrasion Resistance of Fabrics: Accelerotor Method[4]

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 *abrasion cycle*, *n*—one complete movement across the surface of a textile.

3.1.2.1 *Discussion*—The complete movement for an abrasion cycle is dependent on the action of the abrasion machine and the test method used. It may consist of one back-and-forth unidirectional movement or one circular movement, or a combination of both. For the flexing and abrasion method it is commonly called a double stroke as defined in 3.1.4.

3.1.3 *breaking force*, *n*—the maximum force applied to a material carried to rupture. (Compare *breaking point*, *breaking strength*.)

3.1.4 *double-stroke*, *n— in flexing and abrasion testing*, an abrasion cycle that consists of one forward and one backward motion.

3.1.5 *flexibility*, *n*—that property of a material by virtue of which it may be flexed or bowed repeatedly without undergoing rupture.

3.1.6 *standard atmosphere for preconditioning textiles*, *n*—a set of controlled conditions having a temperature not over 50°C (122°F), with respective tolerance of ±1°C(2°F), and a relative humidity of 5 to 25 ± 2 % for the selected humidity, so that drying can be achieved prior to conditioning in the standard atmosphere for testing textiles.

3.1.7 *standard atmosphere for testing textiles*, *n*—laboratory conditions for testing fibers, yarns, and fabrics in which air temperature and relative humidity are maintained at specific levels with established tolerances.

3.1.7.1 *Discussion*—Textile materials are used in a number of specific end-use applications that frequently require different testing temperatures and relative humidities. Specific conditioning and testing of textiles for end-product requirements can be carried out using Table 1 in Practice D 1776.

---

[2] This test method is based upon the development described by Stoll, R.G.," Improved Multipurpose Abrasion Tester and its Application for the Evaluation of the Wear Resistance of Textiles," *Textile Research Journal*, July, 1949, p. 394.

[3] 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*, Vol 07.01.volume information, refer to the standard's Document Summary page on the ASTM website.
Annual Book

[4] Available from the American Association of ASTM Standards, Vol 07.02. Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

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

4. Summary of Test Method

4.1 Abrasion resistance is measured by subjecting the specimen to unidirectional reciprocal folding and rubbing over a specific bar under specified conditions of pressure, tension, and abrasive action. Resistance to abrasion is evaluated by either determining the percent loss in breaking force of an abraded specimen compared to an unabraded specimen or the cycles to rupture, or both.

5. Significance and Use

5.1 This test method is not recommended for acceptance testing of commercial shipments because information on between-laboratory precision is known to be poor.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, the test samples to be used are as homogenous as possible, are drawn from the material from which the disparate test results were obtained, and are randomly assigned in equal numbers to each laboratory for testing. Other fabrics with established test values may be used for this purpose. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 The measurement of the resistance to abrasion of textile fabrics is very complex. The resistance to abrasion is affected by many factors that include the inherent mechanical properties of the fibers; the dimensions of the fibers; the structure of the yarns; the construction of the fabrics; the type, kind, and amount of treatment added to the fibers, yarns, or fabric; the nature of the abradant; the variable action of the abradant over the specimen area abraded; the tension on the specimen; the pressure between the specimen and the abradant; and the dimensional changes in the specimen.

5.3 The measurement of the relative amount of abrasion can be affected by the method of evaluation and is often influenced by the judgment of the operator. It is recognized that with this test method other means of evaluation besides cycles to rupture and breaking strength have been used by the industry, such as color change, appearance change, and so forth. Experience has shown these to be highly variable parameters and they are not recommended without exact criteria identified in an applicable material specification or contract. Consequently, the criteria of breaking strength and cycles to rupture are the recommended means of evaluation because they are considered the least variable and interlaboratory agreement is likely to be obtained more easily.

5.4 Abrasion tests are subject to variations due to changes in the abradant bar during specific tests. The abrasion bar is considered a permanent abradant that uses a hardened metal surface. It is assumed that the abradant will not change appreciably in a specific series of tests, but obviously similar abradants used in different laboratories will not likely change at the same rate due to differences in usage. Permanent abradants may also change due to pickup of treatments or other material from test fabrics and must accordingly be cleaned at frequent intervals. Consequently, depending upon its usage, the abradant bar must be checked periodically against a standard.

5.5 The resistance of textile materials to abrasion as measured by this test method does not include all the factors which account for wear performance or durability in actual use. While the abrasion resistance stated in terms of the number of cycles 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. Different factors may be necessary in any calculation of predicted durability from specific abrasion data.

5.5.1 Laboratory tests may be reliable as an indication of relative end use 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, the results should not be relied upon for prediction of performance during actual wear life for specific end uses unless there are data showing the specific relationship between laboratory abrasion tests and actual wear in the intended end use.

5.6 This test method is useful for pretreating material for subsequent testing for strength or barrier performance.

5.7 The pressure and tension used is varied, depending on the mass and nature of the material and the end-use application. Whenever possible, all materials that are to be compared with each other should be tested under the same pressure and tension.

5.8 When abrasion tests are continued to total destruction, abrasion resistance comparisons are not practical for fabrics having a different mass because the change in abrasion resistance is not directly proportional to the change in the fabric mass.

5.9 All the test methods and instruments that have been developed for abrasion resistance may show a high degree of variability in results obtained by different operators and in different laboratories, however, they represent the methods most widely used in the industry. Because there is a definite need for measuring the relative resistance to abrasion, this test method is one of several standardized test methods that is useful to help minimize the inherent variation that may occur in results.

5.10 These general observations apply to most fabrics, including woven and nonwoven fabrics that are used in automotive, household, and wearing apparel applications.

6. Apparatus

6.1 *Flex Abrasion Testing Machine*[4] (see Figs. 1 and 2), consisting of the following:

6.1.1 *Balanced Head and Flex Block Assembly*, that has two parallel, smooth plates.

6.1.1.1 The balanced head is rigidly supported by a double-lever assembly to provide free movement in a direction

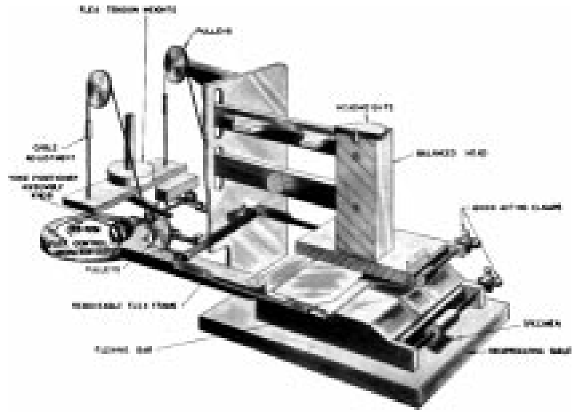

FIG. 1 Schematic Diagram of Flexing and Abrasion Tester

FIG. 2 Commercial Flexing and Abrasion Tester

perpendicular to the plate of the flex block. This head must remain stationary during the test and must be balanced to maintain a uniform vertical pressure from the dead weights.

6.1.1.2 The flex block is capable of reciprocating at 115 ± 10 double stokes per minute of 25 ± 2-mm (1 ± 0.1-in.) stroke length.

6.1.1.3 Clamps are secured to the front of each plate of the head and flex-block assemblies to permit mounting of the specimen. The clamps have surfaces that prevent slippage of the specimen and permit the specimen after it has been folded over the abradant bar to be centrally position and aligned with its long direction parallel to the reciprocating flex bar.

6.1.2 *Flexing Bar Yoke*, sufficiently rigid to prevent distortion during the specimen loading and capable of applying tension to the rigidly secured flexing bar with the force acting parallel to the surface of the head and block assembly plates and perpendicular to the fold of the specimen such that an evenly distributed tension is provided across the fold of the specimen.

6.1.2.1 A positioning device is provided to position the flexing bar and yoke assembly while loading the specimen such that the edge of the flexing bar is parallel to the fold of the specimen during the test. The position device is capable of moving into contact with the yoke prior to loading the specimen and moving away from contact with the yoke just prior to starting the test machine.

6.1.3 *Thumb Screw*, that allows moving the clamp to provide slack take-up of the specimen.

6.1.4 *Machine Stopping Mechanism* , a microswitch, or equivalent, to stop the machine, actuated by the release of the tension release on the specimen when it ruptures.

6.1.5 *Cycle Counter*, with stop mechanism to record the number of cycles (double strokes) and stop the machine at fabric failure.

6.1.6 *Automatic Shutoff*, as part of the cycle counter or in-line timer, or equivalent, with set and stop mechanism capable of stopping the machine at a predetermined number of cycles.

6.1.7 *Calibrated Tension Weights* , with individual masses of 250, 500, and 1000 g (½ , 1, and 2 lbf) that can provide up to a total of 2500 g (5 lbf) that fits on a weight rack that is attached by cables to the yoke to adjust tension to the specimen. Individual weight tolerances are ±1 %.

6.1.8 *Calibrated Head Weights*, with individual masses of 250, 500, and 1000 g (½ , 1, and 2 lbf) that can provide up to a total of 2500 g (5 lbf) that fits on the balanced head, to apply pressure to the specimen. Individual weight tolerances are ±1 %.

6.2 *Working Flex Bar*, used for testing, 1.6 ± 0.4 by 11.2 ± 1.6 mm (1⁄16 ± 1⁄64 by 7⁄16 ± 7⁄16 in.) in cross section, made with tool steel tipped with an edge of cemented carbide. The top, bottom, and edge of the bar that is in contact with the specimen is finished by grinding and polishing, leveling off the microscopic projection without breaking the edges of the bar. The bar is capable of firmly attaching to the yoke.

6.3 *Standardized Master Flex Bar* , to standardize the working flex bar, including storage container to prevent bar damage, available from the manufacturer.

6.4 *Calibration Ribbon*, fused acetate ribbon, 25 mm (1 in.) wide, available from the manufacturer.

6.5 *Tensile Testing Machine*, of the CRE, CRL, or CRT type conforming to Specification D 76, with respect to force indication, working range, capacity, and elongation indicator and designed for operation at a speed of 300 ± 10 mm/min (12 ± 0.5 in./min); or, a variable speed drive, change gears, or interchangeable full-scale force range as required to obtain 20 ± 3-s time-to-break.

6.6 *Nylon Brush*, medium bristle, or equivalent.

6.7 *Stoddard Solvent*, or equivalent degreasing agent, for cleaning flexing bar.

6.8 *Hazards*—Working with Stoddard solvent may be hazardous. When using Stoddard solvent, wear safety glasses; avoid prolonged skin contact; if splashed in eyes, flush thoroughly with water and consult physician; perform operations under a fume hood with the exhaust on; store in an approved, labeled safety can; and dispose of used Stoddard solvent as directed by city, state, or federal ordinances, as required. Refer to the manufacturer's Material Safety Data Sheets (MSDS) for information on handling, use, storage, and disposal of material and reagents used with this test method.

7. Sampling and Test Specimens

7.1 *Primary Sampling Unit*—Consider rolls of fabric or fabric components of fabricated systems to be the primary sampling unit, as applicable.

7.2 *Laboratory Sampling Unit*—As a laboratory sampling unit take from rolls at least one full-width piece of fabric that is 1 m (1 yd) in length along the selvage (machine direction), after removing a first 1-mm (1-yd) length. For fabric components of fabricated systems use the entire system

7.3 *Test Specimens*— From each laboratory sampling unit, cut 4 warp-wise (lengthwise) and 4 filling-wise (widthwise) test specimens at least 200 mm (8 in.) long. For woven fabrics, cut specimens either 32 mm (1¼ in.) wide if there are 50 yarns per 25 mm (1 in.) or more, or 38 mm (1½ in.) wide if there are less than 50 yarns per 25 mm. Ravel each specimen to a 25-mm width by removing from each side approximately the same number of yarns. For woven fabrics, the long dimensions are cut parallel to the warp yarns for lengthwise abrasion and parallel to the filling yarns for widthwise abrasion. For nonwoven fabrics or fabrics not easily raveled, cut each specimen 25 mm wide. Take lengthwise specimens from different positions across the width of the fabric. Take widthwise specimens from different positions along the length of the fabric. Consider the long direction as the direction of test. Specimens preparation need not be carried out in the standard atmosphere for testing. Label to maintain specimen identity. If tests are to be performed on unabraded tests, cut a second set of 4 specimens from each fabric direction.

7.3.1 For fabric widths 125 mm (5 in.) or more, take no specimen closer than 25 mm (1 in.) from the selvage edge, or within 0.5 m (0.5 yd) from the end of the roll or piece.

7.3.2 For fabric widths less than 125 mm (5 in.), use the entire width for specimens but take no specimen closer than one tenth of the width of the fabric, or within 0.5 m (0.5 yd) from the end of the roll or piece.

7.3.3 Cut specimens representing a broad distribution diagonally across the width of the laboratory sampling unit. Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, and so forth on the specimens when handling.

7.3.4 If the fabric has a pattern, ensure that the specimens are a representative sampling of the pattern.

8. Conditioning

8.1 Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles in accordance with Practice D 1776.

8.2 Condition the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles in accordance with Practice D 1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

9. Preparation and Calibration of Test Apparatus

9.1 Ensure the test machine is on a level, study table or base and free from vibration. This will minimize wobbling of the flex bar.

9.2 Prepare, operate, and verify calibration of the abrasion tester using directions supplied by the manufacturer. Refer to Annex A1 for additional information on maintenance of the test apparatus.

9.3 For master and working bars, when installed, secure in the test machine with the identification numbers facing up.

9.4 Randomly take 10 strips of calibration ribbon and abrade Following this, randomly take 10 strips of calibration ribbon and abrade until rupture using the working flex bar using a head load of 250 g (0.5 lbf) and a tension of 1000 g (2 lb). In addition, this procedure should be used to verify the working bar on a regular schedule, such as weekly or monthly, depending upon use. If working flex bars cannot be maintained within the 25 % limit, discard or return to the manufacturer to be reground and calibrated.

NOTE 2—The calibration ribbon can be prepared and randomized by cutting 175 to 300-mm (9 to 12-in.) long strips 175 to 300 mm long from a typical 50-m (50-yd) roll. While cutting strips, place on a work bench such that the first 30 strips are laid side by side, left to right. Cut 30 additional strips and lay on top of the first set of strips, left to right. Continue cutting groups of 30 specimens and in turn lay on the previous set, left to right until a total of 30 bundles of 10 strips each have been prepared. Stable one end of each bundle of ten strips and hang freely in a conditioned room reserving for use as needed.

9.4.1 Reserve master flex bars to verify working flex bars. (Economically, it is good practice to maintain a working master flex bar to verify the working bar. The working master bar can then be verified to the master bar on a less frequent basis, such as a year.)

9.4.2 Maintain an average and range process control chart of calibration control ribbon test results to assess any change.

9.5 Ensure that the flexing bar and yoke assembly is properly aligned. Proper alignment can be checked by abrading a strip of fabric and noting whether the bar shifts laterally to either side of the normal rest position during the course of the abrasion. If shifting of the bar occurs, unlock the cable locknuts and lengthen or shorten the cables that connect the bar to the load platform. Continue until the proper length of the cable is obtained and the flex bar no longer shows any shifting. Clamp the cables securely with the locknuts.

9.6 Rinse the flexing bar in degreasing solvent after each test. Wipe the plate surfaces with solvent-saturated tissue after each test.

9.7 Place the calibrated weight(s) on the tension bar to the specified tension and on the balanced head to the specified pressure. In the absence of a specified tension set the tension and pressure as follows:

9.7.1 Make abrasion trial runs on the fabric to be tested at various tensions until the cycles to produce rupture are in excess of 300 in combination with the lowest head pressure to prevent vibration of the upper plate at the start of the test. A 4 to 1 ratio of bar tension to head pressure has been found satisfactory.

NOTE 3—A low level of head pressure is required to prevent rippling of the fabric during testing. The rippling is caused by a high degree of friction between fabric and the bar when abnormally high head pressures are applied and results in insufficient relative motion between the bar and the fabric specimen under test.

10. Procedure

10.1 Test the test specimens in the standard atmosphere for testing textiles, in accordance with Section 8.

10.2 Handle the test specimens carefully to avoid altering the natural state of the material.

10.3 Alternately press the start and stop buttons in rapid succession to jog the flex block to the rear starting position.

10.4 Rinse the flexing bar in degreasing solvent after each test. Wipe the plate surfaces with solvent-saturated tissue after each test.

10.5 Place the working flex bar into the yoke, ensuring it is properly seated with the carbide edge facing the rear of the machine and the bar number face up.

10.6 Loosen the yoke positioner set screw and, using the yoke positioner, move the flex bar forward, such that the carbide edge is approximately 3 mm (0.125 in.) to the rear of the scribed centerline mark on the left side of the upped head. Tighten the yoke positioner set screw to hold the yoke in this position.

10.7 Mount one end of the specimen centrally and squarely in the upper balance head plate clamp such that the face of the fabric will be in contact with the bar. Secure by rotating the locking knob clockwise.

10.7.1 Ensure that the specimen is clamped between the clamp bar with the rubber gasket and the faceplate of the upper head. Do not clamp the specimen between the cam and the clamp bar, otherwise the specimen may move in the clamp causing erroneous results.

10.8 Thread the specimen around and under the carborundum edge of the flex bar, then place squarely and centrally in the clamp of the lower platform plate, making sure the specimen is between the clamp bar with the rubber gasket and the faceplate of the flex block. Do not tighten the clamp. Ensure that any pills or other fiber debris that may interfere with the contact between the flex bar and test specimen are removed.

10.9 Press the head release button and slowly lower the balanced head. Do not allow the head to drop with any force on to the flex bar or flex block.

10.10 Apply the required tension head weights to provide a 4:1 tension to head weight ratio. For many fabrics, 4 lb of tension weights to 1 pound of head weights has been found satisfactory. For some fabrics, other weight-tension combinations may be used to shorten or lengthen the number of test cycles, but, in any event, the 4:1 ratio must be maintained.

10.11 Grasp the specimen at the front of the lower back clamp, maintaining equal tension across the short direction and draw the specimen taut until the edge of the bar is aligned with the scribe line (centerline) on the upper balanced head, ensuring that the top section of the specimen lays directly over the bottom section of the specimen, then rotate the lower clamp knob counterclockwise to secure the specimen.

10.12 Release the yoke positioner locking screw and allow the yoke positioner to position itself.

10.13 Set the cycle counter to zero and start the test machine.

10.13.1 If breaking force after a predetermined number of cycles is to be determined, manually stop or set the automatic cycle stop to stop at the specified number of cycles. In the absence of a specified number of cycles, set to 2000.

10.14 Monitor the test throughout its duration and when required make the following adjustments:

10.14.1 After the first 25 cycles, check the bar for lateral shifting. If lateral shifting occurs, stop the test and adjust yoke cables in accordance with 9.3. Discard the specimen and repeat the test on an additional specimen.

10.14.2 Carefully clip and remove pills of matted fiber debris interfering with proper contact between the specimen and flexing bar if they cause a marked vibration of the pressure plate, then repeat 10.14.1.

10.14.3 If the specimen slips in the clamps, if the tension and pressure on the folded specimen do not remain constant during the test, or an irregular wear pattern is obtained, stop the test, discard the specimen, and repeat the test on an additional specimen.

10.15 After the machine has stopped at the predetermined number of cycles or at fabric failure, lift the balanced head and secure it in the top position, then remove the test specimen.

10.16 Continue as directed in Section 10 until a total of 4 warp-wise (lengthwise) and 4 filling-wise (widthwise) test specimens for each laboratory sampling unit have been abraded.

10.17 If breaking force is to be performed after the specimens have been abraded to the set number of cycles, remove from the abrading machine and determine the breaking force of the 4 warp-wise (lengthwise) and 4 filling-wise (widthwise) abraded specimens and 4 warp-wise (lengthwise) and 4 filling-wise (widthwise) unabraded specimens taken from the laboratory sampling unit, using Test Method D 5035, 25-mm (1-in.) strip procedure.

10.17.1 Read and record the individual test results to the nearest 1 %.

11. Calculation

11.1 When required, average the cycles to rupture the abraded specimens separately for each the lengthwise and widthwise directions for the laboratory sampling unit and for the lot.

11.2 When required, calculate the average breaking strength of the abraded specimens separately for each the lengthwise and widthwise directions rounded to three significant digits for the laboratory sampling unit and for the lot.

11.3 When required, calculate the average breaking strength of the unabraded specimens separately for each the lengthwise and widthwise directions rounded to three significant digits for the laboratory sampling unit and for the lot.

11.4 When required, calculate the percentage loss in breaking strength to the nearest 1 % as the abrasion resistance separately for each the lengthwise and widthwise directions using Eq 1, for the laboratory sampling unit and for the lot.

$$AR = 100(A-B)/A \quad (1)$$

where:

AR = abrasion resistance, %,
A = average breaking strength of the unabraded specimens, g (lb), and
B = average breaking strength of the abraded specimens, g (lb).

11.4.1 When data are automatically computer processed, calculations are generally contained in the associated software. It is recommended that computer-processed data be verified against known property values and its software described in the report.

11.5 When requested, calculate standard deviation and coefficient of variation.

12. Report

12.1 Report that the abrasion resistance was determined in accordance with Test Method D 3885. Describe the material or product sampled and the method of sampling used.

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

12.2.1 Abrasion resistance, number of cycles to rupture, lengthwise and widthwise.

12.2.2 Abrasion resistance, percent loss in breaking strength, lengthwise and widthwise.

12.2.3 Breaking strength of abraded test specimens, lengthwise and widthwise.

12.2.4 Breaking strength of unabraded test specimens, lengthwise and widthwise.

12.2.5 Tension and pressure.

12.2.6 When calculated, the standard deviation or the coefficient of variation.

12.2.7 For computer-processed data, identify the program (software) used.

12.2.8 Manufacturer and model of test instrument.

13. Precision and Bias

13.1 *Summary*—Based upon limited information from five laboratories, the single-operator and between-laboratory standard errors and critical differences shown in Tables 1 and 2 are approximate. These tables are constructed to illustrate what these laboratories found when all the observations are taken by well-trained operators using specimens randomly drawn from quarterly production lots. For these laboratories, in comparing two averages, it was found that differences should not exceed the

TABLE 1 Test Method D 3885 Abrasion Resistance—Flexing and Abrasion Method Standard Error and Critical Differences for Conditions as Noted

Single Fabric Comparison					
Standard Error			Critical Differences, Cycles to Rupture[A]		
Number of Observations in each Average	Single Operator	Between Laboratory	Number of Observations in each Average	Single Operator	Between Laboratory
2	374	430	2	1047	1204
4	264	339	4	740	950
6	216	303	6	604	848
8	187	283	8	523	792

TABLE 2 Test Method D 3885 Abrasion Resistance—Flexing and Abrasion Method Standard Error and Critical Differences for Conditions as Noted

Multiple Fabric Comparison					
Standard Error			Critical Differences, Cycles to Rupture[A]		
Number of Observations in each Average	Single Operator	Between Laboratory	Number of Observations in each Average	Single Operator	Between Laboratory
2	374	509	2	1047	1424
4	264	434	4	740	1216
6	216	407	6	604	1139
8	187	392	8	523	1098

[A]The critical differences were calculated using t = 1.960, which is based on infinite degrees of freedom.

single-operator precision values shown in Tables 1 and 2 for the respective number of tests in 95 out of 100 cases. Differences for other laboratories may be larger or smaller. To the extent the data set from the interlaboratory test represents the universe, differences in two single-operator averages of 6 determinations each, will be significant at about 600 cycles for both single and multiple fabric comparisons. Differences in two laboratory averages will be significant at about 850 cycles for single fabric comparisons and about 1150 cycles for multiple fabric comparisons.

13.2 *Interlaboratory Test Data*[5]—Warp direction tests were run in six laboratories during the years 1994 through 1996 in which randomly drawn samples of two materials were tested. The six laboratories were part of one larger company but were independent and located in different areas of the world. Each laboratory used material from one lot produced in one plant. One operator in each laboratory tested eight specimens (four representing one quarter of production and four representing another quarter of production during the years cited) from each fabric material using Test Method D 3885. Because only one operator was used in each laboratory, the within laboratory variation was excluded. The precision statement is based upon the testing plan described in Practices D 2904 and D 2906. The grand average, components of variation, standard error, and critical differences for flex abrasion values listed in Tables 1-3 for conditions noted were calculated using a single factor ANOVA software program. The two fabric styles were: S/843, 13.5 oz/yd^2 with 65 ends of 725-cm ^{3} singles yarn and 41 picks of 5.75-cm^3 singles yarn, and S/798, 13.5 oz/yd^2 with 65 ends of 725-cm^3 singles yarn and 45 picks of 5.75-cm^3 singles yarn. Both fabrics were plain weave and had less than 10 % cornstarch finish.

13.3 *Precision*—Because tests were conducted on a limited basis, 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.

[5] ASupporting data are available from the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709. ASTM Headquarters. Request RR: D-13-

TABLE 3 Grand Average of Individual Fabrics and Components of Variance Multiple Fabrics Expressed as Standard Deviations[A]

Fabric Style (Grand Average Cycles to Failure)	Components of Variance Multiple Fabrics Expressed as Standard Deviations[A]		
S/843 (3990) S/798 (2806)	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
	529	. . .	212

[A]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.

13.4 *Bias*—The procedure of this test method produces a test value that can be defined only in terms of a test method. There is no independent, referee method by which bias may be determined. This test method has no known bias.

14. Keywords

14.1 abrasion; flexing and abrasion; textile fabric

ANNEXES

(Mandatory Information)

A1. FLEXING AND ABRASION TESTER MAINTENANCE INSTRUCTIONS

A1.1 *Flex Cables, Pulleys, and Weight Rack*:

A1.1.1 Inspect flex cables periodically for wear. Replace when they become frayed.

A1.1.2 Keep pulley bearings clean to maintain free movement. If movement becomes restricted, mark the location of the pulleys and bearings so they can be reinstalled in the same position, then remove the bearings from the unit and flush with degreasing solvent, followed by soaking in No. 10 machine oil prior to installation.

A1.1.3 Inspect the weight rack periodically to make sure the rods are straight. If rods become bent, bend them back to their original straightness. Replace rods if they cannot be straightened.

A1.2 *Flex Block* :

A1.2.1 Periodically examine the flex block for smoothness and parallelism to the upper head. If the test block becomes scratched or uneven, return it to the factory to be reground or replaced. As needed, adjust flex cables when wear is observed on the sides of the flex block due to contact with the positioning yoke.

A1.2.2 If the flex block wobbles from side to side, adjust or replace the gib. Refer to the manufacturer's instruction manual to make this adjustment.

A1.2.3 Place a few drops of sewing machine oil into the two holes on the left side of the reciprocating table on a monthly basis, particularly when subjected to heavy use.

A1.3 *Upper Head Assembly*:

A1.3.1 Periodically examine the bottom surface of the upper head for smoothness. If the bottom surface of the upper head becomes scratched or uneven, replace or return it to the factory to be reground.

A1.3.2 Periodically check the upper head assembly balance and alignment. With no weights on the head it should maintain balance and the upper head should be parallel with the flex block. If balance and alignment is not evident, remove bearings, clean with degreasing solvent, soak in No. 10 oil and replace in their original position.

A1.3.3 Periodically examine the alignment of the upper head by lowering the head, without the flex bar in position, until it makes contact with the flex block. The edges of the head and the flex block should be parallel within 0.08 mm (0.003 in.) of any corner.

A1.3.4 Keep pulley bearings clean to maintain free movement. If movement becomes restricted, mark the location of the pulleys and bearings so they can be reinstalled in the same position, then remove the bearings from the unit and flush with degreasing solvent, followed by soaking in No. 10 machine oil prior to installation.

A1.4 *Yoke*—Periodically examine the yoke for wear, particularly in the grooves that hold the flex bar. Replace the yoke if worn as indicated by a loose fit of the flex bar.

A1.5 *Weight Rack* :

A1.5.1 If the weight rack makes contact with the end-point switch when a specimen is properly loaded, loosen the locknuts on the weight rack, then tighten the cable-adjusting nuts approximately one turn each. Tighten the nuts equally. Start the instrument again to verify sufficient clearance. If necessary, continue to adjust cable nuts until clearance during operation is obtained.

A1.5.2 If the weight rack makes contact with the pulleys when a specimen is properly loaded, loosen the lock nuts on the weight rack, then loosen the cable adjusting nuts approximately one turn each. Tighten the nuts equally. Start the instrument again to verify sufficient clearance. If necessary, continue to adjust cable nuts until clearance during operation is obtained.

A1.5.3 If the position of the flex bar and yoke assembly shifts laterally to the left before 25 cycles have been completed on two consecutive specimens, loosen the locknuts holding the flex cable to the weight rack and tighten the right side cable adjusting nut until proper tracking is observed. Tighten the nuts equally. Start the instrument again to verify proper tracking. If necessary, continue to adjust right-side cable nuts until proper tracking during operation is obtained.

A1.5.4 If the position of the flex bar and yoke assembly shifts laterally to the right before 25 cycles have been completed on two consecutive specimens, adjust the left-side cable adjusting nut in a like manner as described in A1.5.3.

A2. Ruggedness Test

A2.1 Modification of Flex Tester

A2.1.1 Ruggedness testing indicated that assembly of the flex tester was problematic and contributed to misalignment of the yoke and flex bar during operation. The reliability of D3885 also was compromised by problems related to inability to consistently center specimens in the specimen holders, non-uniform tensioning of specimens, and random starting position of the flex block. Addition of new centering guides and specimen grips and fixing the location of the flex block prior to operation were approved by project committee members and are commercially available as a retrofit from manufacturers of the flex tester[5].

A2.1.2 The reliability of D3885 is optimized by the following conditions: yoke and flex bar run square with other components of the flex tester, uniform tension is applied to specimens, specimens are centered and evenly held in specimen grips, rate of abrasion is consistent, flex bars are uniform and consistently calibrated, specimen length and width are constant, and testing is done using standard temperature and humidity. These criteria are met if recommendations from the Ruggedness Test of D3885 are adopted and the approved testing protocol is used.

A2.2 Calibration Ribbon

A2.2.1 Ruggedness testing indicated that non-uniformity of the calibration ribbon contributed to the poor reliability of D3885. Evaluation of alternative materials led to the recommendation that the current calibration ribbon be replaced with a less variable ribbon. A new acetate ribbon with plain woven selvages was approved by the Ruggedness Project Steering Committee and Sponsors and is available commercially. The improved calibration ribbon is commercially available[5].