



Designation: D 3885 – 07

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. Scope

1.1 This test method² 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 AATCC 93.

2. Referenced Documents

2.1 ASTM Standards:³

- D76 Specification for Tensile Testing Machines for Textiles
- D123 Terminology Relating to Textiles
- D1776 Practice for Conditioning and Testing Textiles
- D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data⁴

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

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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* volume information, refer to the standard's Document Summary page on the ASTM website.

⁴ Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

D2906 Practice for Statements on Precision and Bias for Textiles⁴

D3884 Guide for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)

D3886 Test Method for Abrasion Resistance of Textile Fabrics (Inflated Diaphragm Apparatus)

D4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)

D4158 Guide for Abrasion Resistance of Textile Fabrics (Uniform Abrasion)

D4966 Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method)

D5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

2.2 AATCC Test Method:

AATCC 93 Abrasion Resistance of Fabrics: Accelerator Method⁵

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.

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

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 $\pm 1^\circ\text{C}$ (2°F), and a relative humidity of 5 to $25 \pm 2\%$ 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 1776D1776.

3.1.8 For definitions of other textile terms used in this test method, refer to Terminology D 123D123.

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 abradant 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*⁶ (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 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 strokes 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 positioned 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 positioning 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 on the specimen when it ruptures.

6.1.5 *Cycle Counter*, 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 ($\frac{1}{2}$, 1, and 2 lbf) that can provide up to a total of 2500 g (5 lbf) that fit on a weight rack that is attached by cables to the yoke to adjust tension to the specimen. Individual weight tolerances are $\pm 1\%$.

6.1.8 *Calibrated Head Weights*, with individual masses of 250, 500, and 1000 g ($\frac{1}{2}$, 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 $\pm 1\%$.

6.2 *Working Flex Bar*, used for testing, 1.6 ± 0.4 by 11.2 ± 1.6 mm ($\frac{1}{16} \pm \frac{1}{64}$ by $\frac{7}{16} \pm \frac{7}{16}$ 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.

<https://standards.iteh.ai/catalog/standards/sist/335c2ec3-0>

⁶ Apparatus and accessories are commercially available.

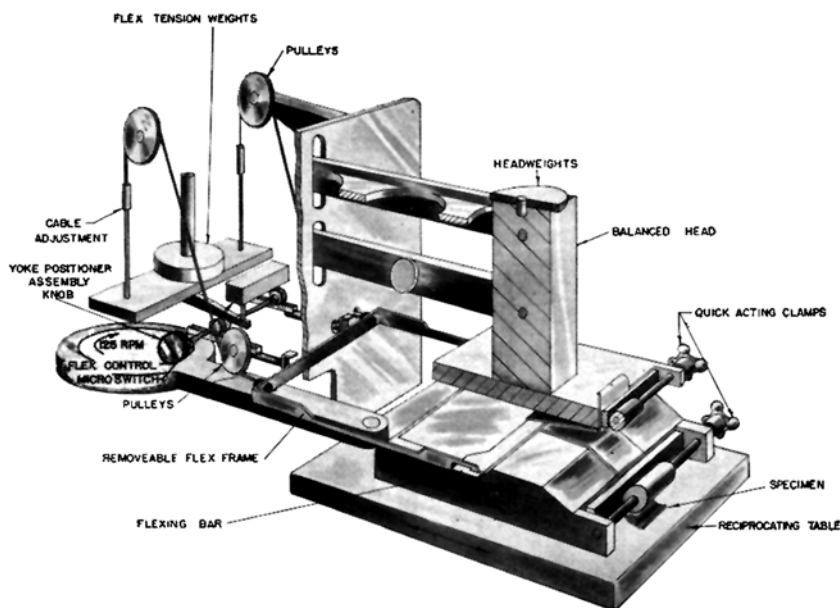


FIG. 1 Schematic Diagram of Flexing and Abrasion Tester



FIG. 2 Commercial Flexing and Abrasion Tester

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*⁶, 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 76D76, 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 *Acetone*, or other appropriate solvent to clean the flex bar (see 7.1)

7. Hazardous Materials

7.1 Solvents used in this test method may be hazardous. Refer to the manufacturer's material safety data sheets for information on use, handling, storage, and disposal of solvents used with this test method.

8. Sampling and Test Specimens

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

8.2 *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 m (1 yd) length. For fabric components of fabricated systems use the entire system

8.3 *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 ($1\frac{1}{4}$ in.) wide if there are 50 yarns per 25 mm (1 in.) or more, or 38 mm ($1\frac{1}{2}$ 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 non-woven 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.

8.3.1 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.

8.3.2 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.

8.3.3 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.

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

9. Conditioning

9.1 Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles in accordance with Practice D 1776D1776.

9.2 Condition the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles in accordance with Practice D 1776D1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

10. Preparation and Calibration of Test Apparatus

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

10.2 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.

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

10.4 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 from 2– 50 m (2–50 yd) rolls of ribbon. 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. Staple one end of each bundle of ten strips and hang freely in a conditioned room reserving for use as needed.

10.4.1 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.)

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

10.5 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.

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

10.7 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:

10.7.1 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.

11. Procedure

11.1 Test the test specimens in the standard atmosphere for testing textiles, in accordance with Section 9.

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

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

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

11.5 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.

11.6 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 upper head. Tighten the yoke positioner set screw to hold the yoke in this position.

11.7 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.

11.7.1 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.

11.8 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.

11.9 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.

11.10 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.

11.11 Grasp the specimen at the front of the lower 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.

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

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

11.13.1 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.

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

11.14.1 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 10.3. Discard the specimen and repeat the test on an additional specimen.

11.14.2 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 resume the test.

11.14.3 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.

11.15 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.

11.16 Continue as directed in Section 11 until a total of 4 warp-wise (lengthwise) and 4 filling-wise (widthwise) test specimens for each laboratory sampling unit have been abraded.

11.17 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 5035D5035, 25 mm (1 in.) strip procedure.

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

12. Calculation

12.1 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.

12.2 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.

12.3 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.

12.4 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).

12.4.1 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.

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

13. Report

13.1 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.

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

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

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

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

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

13.2.5 Tension and pressure.

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

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

13.2.8 Manufacturer and model of test instrument.

14. Precision and Bias

14.1 *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 single-operator precision values shown in Tables 1 and 2 for the respective number of tests in 95 out of 100 cases.