Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)[1]

This standard is issued under the fixed designation D 5035; 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.

ε1 NOTE—Editorial changes were made in October 2008.

1. Scope

1.1 This test method covers raveled strip and cut strip test procedures for determining the breaking force and elongation of most textile fabrics. Provision is made for wet testing.

1.1.1 The raveled strip test is applicable to woven fabrics while the cut strip test is applicable to nonwoven fabrics, felted fabrics, and *dipped* or coated fabrics.

1.2 This test method is not recommended for knitted fabrics or for other textile fabrics which have high stretch (more than 11 %).

NOTE 1—For the determination of the breaking force and elongation of textile fabrics using the grab test and modified grab test procedures, refer to Test Method D 5034.

NOTE 2—For determination of the breaking force and elongation of some specific types of fabrics which use the strip test, refer to Specifications D 579 and D 580.

1.3 This test method shows the values in both inch-pound units and SI units. Inch-pound units is the technically correct name for the customary units used in the United States. SI units is the technically correct name for the system of metric units known as the International System of Units. The values stated in either acceptable metric units or in other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of the other, without combining in any way.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D 76 Specification for Tensile Testing Machines for Textiles
D 123 Terminology Relating to Textiles
D 579 Specification for Greige Woven Glass Fabrics
D 580 Specification for Greige Woven Glass Tapes and Webbings
D 629 Test Methods for Quantitative Analysis of Textiles
D 1776 Practice for Conditioning and Testing Textiles
D 4848 Terminology Related to Force, Deformation and Related Properties of Textiles
D 4849 Terminology Related to Yarns and Fibers
D 4850 Terminology Relating to Fabrics and Fabric Test Methods
D 5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

3. Terminology

3.1 For definitions of textile terms used in this test method: breaking force, elongation, tensile test, refer to Terminology D 4848.

3.2 For definitions of textile terms used in this test method: constant-rate-of-extension, constant rate of load, constant rate of traverse, refer to Terminology D 4849.

3.3 For definitions of textile terms used in this test method: cut strip test, raveled strip test, strip test, refer to Terminology D 4850.

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

4. Summary of Test Method

4.1 A test specimen is clamped in a tensile testing machine and a force applied to the specimen until it breaks. Values for

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[2] 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.

the breaking force and elongation of the test specimen are obtained from machine scales, dials, autographic recording charts, or a computer interfaced with the testing machine.

4.2 This test method describes procedures for carrying out fabric tensile tests using four types of specimen, and three alternative types of testing machines. For reporting, use the following system to identify specific specimen and machine combinations.

4.2.1 *Type of specimen*:

4.2.1.1 1R—25 mm (1.0 in.) raveled strip test

4.2.1.2 2R—50 mm (2.0 in.) raveled strip test

4.2.1.3 1C—25 mm (1.0 in.) cut strip test

4.2.1.4 2C—50 mm (2.0 in.) cut strip test

4.2.2 *Type of tensile testing machine*:

4.2.2.1 E—constant-rate-of-extension (CRE)

4.2.2.2 L—constant-rate-of-load (CRL)

4.2.2.3 T—constant-rate-of-traverse (CRT)

4.2.3 Possible combinations can be identified as follows:

	Type of Tester		
Test Specimen	Constant-Rate-of-Extension	Constant-Rate-of-Load	Constant-Rate-of-Traverse
25-mm (1-in.) raveled strip	1R-E	1R-L	1R-T
50-mm (2-in.) raveled strip	2R-E	2R-L	2R-T
25-mm (1-in.) cut strip	1C-E	1C-L	1C-T
50-mm (2-in.) cut strip	2C-E	2C-L	2C-T

4.2.3.1 For example, 1R-E refers to a 25-mm (1-in.) raveled strip test carried out on a constant-rate-of-extension tensile testing machine.

5. Significance and Use

5.1 The raveled strip test in this test method is considered satisfactory for acceptance testing of commercial shipments of woven textile fabrics because the method has been used extensively in the trade for acceptance testing. The same is true for the cut strip test for felted or nonwoven textile fabrics.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative test should be performed to determine if there is a statistical bias between them, using competent statistical assistance. At a minimum, use the samples for such a comparative test that are as homogeneous as possible, drawn from the same lot of material as the samples that resulted in disparate results during initial testing and randomly assigned in equal numbers to each laboratory. The test results from the laboratories involved should be compared using a statistical test for unpaired data, a probability level chosen prior to the testing series. If bias is found, either its cause must be found and corrected, or future test results for that material must be adjusted in consideration of the known bias.

5.2 The method is not recommended for knitted fabrics because of their high stretch.

5.3 Some modification of the techniques may be necessary for any fabric having a strength in excess of 200 N/cm (1140 lbf/in.) width. Special precautionary measures are provided for use when necessary with strong fabrics, or fabrics made from glass fibers (see Specification D 579), to prevent them from slipping in the clamps or being damaged as a result of being gripped in the clamps.

5.4 All of the procedures are applicable for testing fabrics either conditioned or wet.

5.5 Comparison of results from tensile testing machines operating on different principles is not recommended. When different types of machines are used for comparison testing, constant time-to-break at 20± 3 s is the established way of producing data. Even then the data may differ significantly.

5.6 Although a constant-rate-of-extension tensile testing machine is preferred in these methods, in cases of dispute, unless there is agreement to the contrary between the purchaser and supplier, a constant-time-to-break (20 ± 3 s) is to be used.

5.7 The raveled strip procedure is applicable to the determination of the force required to break a specific width of fabric. The breaking force information on woven fabrics is particularly useful for comparison of the effective strength of the yarns in the fabric with the combined strength of an equal number of the same yarns which are not woven. The procedure is not recommended for fabrics having fewer than 20 yarns across the width of the specimen. If a 20-yarns-per-specimen width cannot be obtained with a 25-mm (1-in.) strip, a 50-mm (2-in.) strip should be used. In general, the observed force for a 50-mm (2-in.) specimen is not double the observed force for a 25-mm (1-in.) specimen and the results should be reported as observed on a 50-mm (2-in.) strip without mathematical adjustment to 25 mm (1 in.). If a fabric cannot be raveled readily, use either a cut strip or grab procedure.

5.8 The cut strip procedure is applicable to heavily fulled fabrics, woven fabrics that cannot be readily raveled, felted fabrics and nonwoven fabrics. This procedure is not recommended for fabrics which can be raveled because the yarns at the edges tend to unravel during testing. The recommendation regarding the minimum number of yarns in a woven specimen discussed in 5.7 for raveled strips applies equally to cut strips.

6. Apparatus, Reagents, and Materials

6.1 *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 loads as required to obtain the 20 ± 3 s time-to-break (see 5.5 and 5.6).

6.2 *Clamps and Jaw Faces*—Each jaw face shall be smooth, flat, and with a metallic or other agreed upon surface. The faces shall be parallel and have machining centers with respect to one another in the same clamp and to the corresponding jaw face of the other clamp.

6.2.1 For all strip tests or for narrow fabrics and tapes being tested full width, each jaw face shall measure at least 10 mm (0.5 in.) wider than the specimen being tested and at least 25 mm (1.0 in.) in the direction of the applied force.

6.3 *Metal Clamp*, auxiliary, weighing 170 g (6.0 oz) with 100-mm (4-in.) width anvils.

6.4 *Distilled Water*, for wet testing.

6.5 *Nonionic Wetting Agent*, for wet testing.

6.6 *Container*, for wetting out specimens.

6.7 *Standard fabrics*[3], for use in verification of apparatus. (See Annex A1.)

6.8 *Pins*, stainless-steel, 10-mm (3⁄8-in.) diameter by 125 mm (5 in.) long, two required if used.

7. Sampling

7.1 *Lot Sample*—Take a lot sample as directed in the applicable material specification. In the absence of such a specification randomly select the rolls or pieces that constitute the lot sample using the following schedule:

Number of Rolls, Pieces in Lot, Inclusive	Number of Rolls or Pieces in Lot Sample
1 to 3	All
4 to 24	4
25 to 50	5
Over 50	10 % to a maximum of 10 of the rolls or pieces

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

7.2 *Laboratory Sample*—From each roll or piece of fabric taken from the lot sample, cut at least one laboratory sample the full width of the fabric and 1 m (1 yd) along the selvage (machine direction).

NOTE 4—Results obtained on small hand samples or swatches can only be considered as representative of the sample swatch submitted and cannot be assumed to be representative of the fabric piece from which the hand sample or swatch was taken.

7.3 *Test Specimens*—From each laboratory sample, take five specimens from the warp (machine) direction and eight specimens from the filling (cross) direction (if tested) for each testing condition.

7.3.1 Testing conditions include the following:

7.3.1.1 *Warp or Machine Direction*—Standard conditions for testing textiles,

7.3.1.2 *Warp or Machine Direction*—Wet at 21°C (70°F),

7.3.1.3 *Filling or Cross Direction*—Standard conditions for testing textiles, and

7.3.1.4 *Filling or Cross Direction*—Wet at 21°C (70°F).

7.3.2 When using the constant-time-to-break technique and unfamiliar fabrics, prepare two or three extra specimens to establish the proper rate of loading (speed for testing).

8. Conditioning

8.1 *For Conditioned Testing*:

8.1.1 If the samples have a higher moisture content than the moisture present when at equilibrium in the standard atmosphere for testing textiles, precondition as directed in Practice D 1776.

8.1.2 Bring samples to moisture equilibrium in the standard atmosphere for testing textiles as directed in Practice D 1776. Equilibrium is considered 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.

NOTE 5—It is recognized that, in practice, materials are frequently not weighed to determine when moisture equilibrium has been reached. While conditioning for a fixed time cannot be accepted in cases of dispute, it may be sufficient in routine testing to expose the material to the standard atmosphere for testing textiles for a reasonable period of time before the specimens are tested. As a guide, the following conditioning periods are suggested:

Fiber	Minimum Conditioning Period, h[4]
Animal Fibers (for example, wool and regenerated proteins)	8
Vegetable Fibers (for example, cotton)	6
Viscose	8
Acetate	4
Fibers having a regain less than 5 % at 65 % relative humidity	2

8.2 *For Wet Testing*:

8.2.1 Specimens to be tested in the wet condition shall be immersed in water at room temperature until thoroughly wetted (Note 6). To thoroughly wet a specimen, it may be necessary to add not more than 0.05 % of a nonionic wetting agent to the water. A test of any specimen shall be completed within 2 min after its removal from the water.

NOTE 6—The material has been thoroughly wet out when it has been determined that additional immersion time does not produce any additional changes in breaking strength of test specimens. This method of determination must be used in cases of dispute; however, for routine testing in the laboratory, it may be sufficient to immerse the material 1 h.

8.2.2 The procedures in this test method should be used with caution when testing fabrics that do not wet out uniformly and thoroughly because of the presence of sizing, oil, protective coatings, or water repellents.

8.2.3 When the strength of wet specimens without sizing, water repellents, etc. is required, before preparing the test specimens, treat the material as directed in Test Methods D 629, using appropriate de-sizing, etc. procedures, that will not affect the normal physical properties of the fabric.

9. Preparation of Specimens

9.1 *General*:

9.1.1 Cut specimens with their long dimensions parallel either to the warp (machine) direction or to the filling (cross) direction, or cut specimens for testing both directions as required. Preferably, specimens for a given fabric direction should be spaced along a diagonal of the fabric to allow for representation of different warp and filling yarns, or machine and cross direction areas, in each specimen. When possible, filling specimens should contain yarn from widely separated filling areas. Unless otherwise specified, take specimens no nearer to the selvage or edge of the fabric than one tenth of the width of the fabric (see 7.3.2).

9.1.2 Ribbons and other narrow fabrics which are 50 mm (2 in.) or less wide are usually tested full width.

9.2 *Raveled Strip Test—1R, 25 mm (1 in.)*:

[3] Apparatus and accessories are commercially available.

[4] These periods are approximate and apply only to fabrics, spread out in single thickness, and exposed to freely moving air in the standard atmosphere for testing textiles. Heavy or coated fabrics may require conditioning periods longer than those suggested. If a fabric contains more than one fiber, it should be conditioned for the period required by the fiber component which requires the most time (for example, 8 h for a wool and acetate blend).

9.2.1 Cut each specimen either 35 mm (1.5 in.) or 25 mm (1 in.) plus 20 yarns, whichever is wider, by at least 150 mm (6 in.) long (Note 7). The long dimension should be accurately parallel to the direction of testing and force application.

NOTE 7—The length of the specimen depends on the type of clamps being used. The specimen should be long enough to extend through the clamps and project at least 10 mm (0.5 in.) at each end. The specimen length may be calculated using Eq 1or Eq 2:

$$\text{Specimen length, mm} = C + 2W \tag{1}$$

$$\text{Specimen length, in.} = K + 2W \tag{2}$$

where:
C = constant based on a gage length of 75 mm + 20 mm for projections beyond clamp, 95 mm,
K = constant based on a gage length of 3 in. + 1 in. for projections beyond clamps, 4 in., and
W = jaw face width in direction of load, mm (in.).

9.2.2 Ravel each specimen to give a testing width of 25 mm (1 in.) by removing an approximately equal number of yarns from each side, or 10 yarns from each side, depending upon the width cut in 9.2.1.

9.2.3 If, by mutual consent, it is agreed to perform a test on strips containing less than 20 yarns across the width to be tested, the actual number of yarns shall be stated in the report.

NOTE 8—Under some circumstances it may be necessary to ravel the strip to a constant number of yarns instead of a constant width. This number shall never be less than 20 mm (0.75 in.) and the width never less than 15 mm (0.5 in.). This technique is particularly useful when comparing the breaking force of a conditioned fabric after a wet finishing operation in which shrinkage has taken place with that of the same fabric before finishing. Such a procedure may be used by mutual consent of the interested parties.

9.3 *Raveled Strip Test—2R, 50 mm (2.0 in.)*:

9.3.1 Cut each specimen either 65 mm (2.5 in.) or 50 mm (2.0 in.) plus 20 yarns, whichever is wider, by at least 150 mm (6 in.) long (Note 7). The long dimension should be parallel to the direction for which the breaking force is required.

9.3.2 Ravel each specimen to give a testing width of 50 mm (2.0 in.) by removing an approximately equal number of yarns from each side, or 10 yarns from each side, depending upon the width cut in 9.3.1 (Note 8).

9.4 *Cut Strip Test—1C, 25 mm (1 in.)*:

9.4.1 Cut each specimen 25 ± 1 mm (1 ± 0.02 in.) wide by at least 150 mm (6 in.) long with the long dimension accurately parallel to the direction of testing and force application (Notes 7 and 8).

9.5 *Cut Strip Test—2C, 50 mm (2 in.)*:

9.5.1 Cut each specimen 50 ± 1 mm (2 ± 0.02 in.) wide by at least 150 mm (6 in.) long with the long dimension accurately parallel to the direction for which the breaking force is required (Notes 7 and 8).

9.6 When the breaking force of wet fabric is required in addition to that of conditioned fabric, cut one set of specimens with each test specimen twice the normal length (Note 9). Number each specimen at both ends and then cut the specimens, in half cross-wise, to provide one set for determining the conditioned breaking force, and another set for determining the wet breaking force. This allows for breaks on paired specimens which leads to more direct comparison of conditioned vs. wet breaking force because both specimens of a pair contain the same test yarns (nonwoven fabric channel and cross direction areas).

NOTE 9—For fabrics which shrink excessively when wet, it will be necessary to cut the test specimens to allow for longer wet breaking force specimens than conditioned breaking force specimens.

10. Preparation, Calibration, and Verification of Apparatus

10.1 *Tensile Testing Machine*:

10.1.1 Prepare the testing machine according to the manufacturer's instructions and using the conditions given in 10.1.2-10.2.4 (see Annex A1).

10.1.2 Set the distance between the clamps (gage length) at 75 ± 1 mm (3 ± 0.05 in.).

10.1.3 Select the force range of the testing machine for the break to occur between 10 and 90 % of full scale force. Calibrate or verify the testing machine for this range.

10.1.4 Set the testing machine for a loading rate of 300 ± 10 mm/min (12 ± 0.5 in./min) unless otherwise specified.

10.2 *Clamping System*:

10.2.1 Check the jaw face surfaces for flatness and parallelism.

10.2.2 Make a four-ply sandwich of white tissue paper, two soft carbon papers placed back-to-back and a second white paper (or fold the first white paper over the two carbons).

10.2.3 Mount the paper-carbon sandwich in the clamps with normal pressure.

10.2.4 Remove the paper-carbon sandwich and examine the jaw face imprint for uniformity of carbon deposition on the tissue paper.

10.2.5 If the imprint is incomplete or off-size, make appropriate adjustments of the clamp gripping system and recheck the clamping system with the paper-carbon sandwich.

NOTE 10—Some sources of clamping irregularities are surface contact, metal surface, or jaw coating-cover surface, condition, and pressure application.

10.3 *Verification of the Total Operating System of the Apparatus*:

10.3.1 Verify the total operating system (loading, extension, clamping, and recording or data collecting) by testing specimens of standard fabrics for breaking force and elongation by the type of strip test to be used and comparing the data with that given for the standard fabrics. Verification of the system on at least a weekly basis is recommended. In addition, the total operating system should be verified whenever there are changes in the loading system (especially an increase) or clamping mechanism.

10.3.2 Select the standard fabric which has breaking forces and elongations in the range of interest.

10.3.3 Prepare the standard fabric test specimens as directed in Section 9.

10.3.4 Check for adequacy of clamping pressure by mounting a specimen and marking the inner jaw face-to-fabric junctions. Break a specimen and watch for movement of either line away from the junction indicating slippage. If slippage occurs, adjust the air pressure of pneumatic clamps or be prepared to tighten manual clamps more when testing. If pressures cannot be increased without causing jaw breaks, other techniques for eliminating slippage, such as jaw cushions or specimen tabbing, will be needed.

10.3.5 Test the required number of specimens as directed in Section 11.

10.3.6 Calculate the breaking forces and elongations, the averages and the standard deviation as directed in Section 12.

10.3.7 Compare the data with previous data. If the average is outside the tolerances established, recheck the total system to locate the cause for the deviation.

11. Procedure

11.1 Mount the specimen securely in the clamp of the testing machine. Take care that the specimen is centrally located and that the long dimension is as nearly parallel as possible to the direction of force application. Be sure that the tension on the specimen is uniform across the clamped width.

11.1.1 For high-strength fabrics where the specimen cannot be satisfactorily held in clamps, place each specimen around the pins and between the jaws as illustrated in Fig. 1, using jaw padding if necessary. Tighten the clamps to distribute the holding pressure along the clamping surface of the top (front) jaw. Clamps which are too tight will produce breaks at the front of jaws; clamps which are too loose will cause slippage or breaks at the back of the jaws and pin. For glass fabric failures, see Specification D 579.

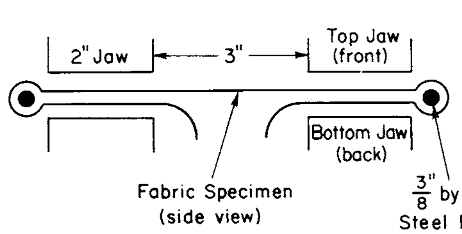
11.2 Elongation depends on the initial specimen length which is affected by any pretension applied in mounting the specimen in the testing machine. If measurement of specimen elongation is required, mount the specimen in the upper clamp of the machine, and apply a uniform pretension, not to exceed 0.5 % of the full scale force, to the bottom end of the specimen before gripping the specimen in the lower clamp.

11.2.1 To achieve uniform and equal tension, attach an auxiliary clamp (6.3) to the bottom of the specimen and at a point below the lower clamp of the testing machine. Tighten the lower clamp and remove the auxiliary clamp.

11.3 Mark across the specimen at the front inner edge of each jaw to check for specimen slippage. When slippage occurs, the mark will move away from the jaw edge.

11.4 Operate the machine and break the specimen.

11.5 Read the breaking force, and elongation if required, from the mechanism provided for such purpose (11.2). Record warp and filling (machine and cross) direction results separately.



Metric Equivalents

in.	3	⅜ by 5
mm	75	10 by 125

FIG. 1 Illustration of Specimen Placement for Strong Fabrics

11.5.1 For some testing machines, data may be obtained using an interfaced computer.

11.6 If a specimen slips in the jaws, or breaks at the edge of or in the jaws, or if for any reason the result falls markedly below the average of the set of specimens, discard the result and take another specimen. Continue this until the required number of acceptable breaks have been obtained. In the absence of other criteria for rejecting a *jaw break*, any break occurring within 5 mm (0.25 in.) of the jaws which results in a value below 50 % of the average of all the other breaks should be discarded. No other break should be discarded unless it is known to be faulty.

NOTE 11—The decision to discard a break should be based on observation of the specimen during the test and upon the inherent variability of the fabric.

11.7 If a fabric manifests any slippage in the jaws or if more than 25 % of the specimens break at a point within 5 mm (0.25 in.) of the edge of the jaw, one of the following modifications may be tried. If any of these modifications are used, state the method of modification in the report.

11.7.1 The jaws may need to be padded,

11.7.2 The fabric may need to be coated under the jaw face area, or

11.7.3 The jaw face may need to be modified.

NOTE 12—It is difficult to determine the precise reason that certain specimens break near the edge of the jaws. If such a break is caused by damage to the specimen by the jaws, then the results should be discarded. If, however, the break is merely due to randomly distributed weak places, it is a legitimate result. In some cases, it may also be caused by a concentration of stress in the area adjacent to the jaws because the jaws prevent the specimen from contracting in width as the force is applied. In such cases, a break near the edge of the jaw is inevitable and should be accepted as a characteristic of the particular method of test.

12. Calculation

12.1 *Breaking Force*—For each laboratory sample and testing condition, calculate the average of the breaking force observed for all acceptable specimens, that is, the maximum force exerted on the specimen as read directly from the testing machine indicating mechanism.

12.2 *Measurement of Apparent Elongation*—Unless some other force is specified, measure the apparent elongation of acceptable specimens at the breaking force. Measure the increase in length from the start of the force-extension curve to a point corresponding with the breaking force, or other specified force, as shown on the autographic record. Calculate the apparent elongation as the percentage increase in length based on the gage length (initial nominal testing length of the specimen).

12.2.1 For each testing situation, calculate the average apparent elongation at the breaking force or other specified force, of acceptable specimens.

NOTE 13—The elongation calculated as a percentage of the gage length for the specimen should be referred to as the *apparent elongation* because the actual length of fabric between the jaws is usually greater than the initial (gage) length. This difference in length is frequently due to fabric pull-out from between the jaws. Thus, elongation, calculated on the gage length, has an error which is dependent upon the amount of pull-out.

13. Report

13.1 State that the specimens were tested as directed in Test Method D 5035. Describe the material or product sampled and the method of sampling used.

13.2 Report the following information for each laboratory sample:

13.2.1 The average breaking force of acceptable specimens for each test condition and strip test.

13.2.2 The average percent apparent elongation of acceptable specimens for each test condition and strip test, if calculated. Identify this elongation as *apparent elongation at breaking force* or *apparent elongation at specified force*, as required by the test specifications.

13.2.3 Number of specimens tested in each direction.

13.2.4 Type of strip test and testing machine used.

13.2.5 Maximum force obtainable in the range used for testing.

13.2.6 Pretension used, if any.

13.2.7 Size of jaw faces used.

13.2.8 Type of padding used in jaws, modification of specimen gripped in the jaws, or modification of jaw faces, if any.

13.2.9 Number of yarns in the width of the strip, if less than 20.

13.2.10 Average time required to break, if applicable, for all specimens giving acceptable breaks.

13.2.11 Whether conditioned or wet testing, or both.

13.2.12 In the case of tests on wet specimens, state whether allowance was made for shrinkage.

13.2.13 Whether sizing or finishes have been removed and, if so, by what procedure.

14. Precision and Bias

14.1 *Interlaboratory Test Data*—An interlaboratory test was conducted in 1991 in which randomly-drawn samples of three materials were tested in each of three laboratories. Two operators in each laboratory each tested ten specimens of each material using Test Method D 5035. Five of the ten specimens were tested on one day and five specimens were tested on a second day. Tests were separately conducted in laboratories at the standard atmosphere for testing textiles separately using the Constant-Rate-Of-Extension (CRE) and the Constant-Rate-Of-Traverse (CRT) types of tensile testers. In addition, tests were conducted at 72F and 50 % Relative Humidity using the Constant-Rate-Of-Extension (CRE) type tester. The components of variance for breaking strength expressed as standard deviations were transformed to percent coefficient of variation and are listed in Table 1. There were sufficient differences related to the type of tensile tester, material tested, and test conditioning to warrant listing the components of variance and the critical differences separately. The three classes of fabrics were: S/441 cotton filter fabric, S/9407R plain weave standard break fabric, and S/9408R sateen standard break fabric.

14.2 *Precision*—For the components of variance reported in Table 1, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 2.

NOTE 14—Since the interlaboratory test included only three laboratories, estimates of between-laboratory precision should be used with special caution.

NOTE 15—The tabulated values of the critical differences should be considered to be a general statement, particularly with respect to between-laboratory precision. 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.

14.3 *Bias*—The true values of breaking strength by the strip method can only be defined in terms of a specific test method. Within this limitation, the procedure in Test Method D 5035 for measuring breaking strength by the strip procedure has no known bias.

15. Keywords

15.1 breaking-strength; fabric; elongation; fabric; nonwoven-fabric; woven fabric

TABLE 1 Breaking Strength Strip Method (Components of Variance, Coefficient of Variation, %

Fabric Type and Test Atmosphere	Type Machine	Grand Average Pounds	Single-Operator Component	Within-Laboratory Component	L
Filter Fabric					
72F, 65 % RH	CRE	52.2	5.1	3.4	2
72F, 50 % RH	CRE	52.4	3.6	0.0	2
72F, 65 % RH	CRT	54.3	3.6	1.4	3
Plain Weave Fabric					
72F, 65 % RH	CRE	89.2	3.9	0.3	0
72F, 50 % RH	CRE	87.7	6.1	0.6	1
72F, 65 % RH	CRT	91.0	3.4	1.8	0
Sateen Fabric					
72F, 65 % RH	CRE	182	4.2	0.9	1
72F, 50 % RH	CRE	180	4.5	2.8	2
72F, 65 % RH	CRT	190	2.5	0.0	0

TABLE 2 Breaking Strength Strip Method
Critical Difference for Conditions Noted, % of Average

Fabric Type and Test Atmosphere	Type Machine	Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between Laboratory Precision
Filter Fabric					
72F, 65 % RH	CRE	2	10.1	13.9	15.9
		5	6.4	11.5	13.8
		10	4.5	10.6	13.1
72F, 50 % RH	CRE	2	7.0	7.0	10.7
		5	4.4	4.4	9.2
		10	3.1	3.1	8.6
72F, 65 % RH	CRT	2	7.1	8.0	11.7
		5	4.5	5.8	10.3
		10	3.2	4.9	9.8
Plain Weave Fabric					
72F, 65 % RH	CRE	2	7.6	7.6	7.6
		5	4.8	4.8	4.8
		10	3.4	3.4	3.4
72F, 50 % RH	CRE	2	11.9	12.0	12.5
		5	7.6	7.7	8.4
		10	5.3	5.6	6.4
72F, 65 % RH	CRT	2	6.6	8.3	8.3
		5	4.2	6.6	6.6
		10	2.9	5.9	5.9
Sateen Fabric					
72F, 65 % RH	CRE	2	8.2	8.5	9.0
		5	5.2	5.7	6.4
		10	3.7	4.4	5.2
72F, 50 % RH	CRE	2	8.9	11.8	13.8
		5	5.6	9.6	12.0
		10	4.0	8.7	11.3
72F, 65 % RH	CRT	2	5.0	5.0	5.0
		5	3.1	3.1	3.1
		10	2.2	2.2	2.2

ANNEX

(Mandatory Information)

A1. ERROR AND LOW PRECISION IN TENSILE TESTING

A1.1 Some of the most common sources for error and causes for low precision in tensile testing are given in the following sections.

A1.1.1 Failure to recheck the tester zero after changing load cell or scale.

A1.1.2 Failure to make sure each test is started at the zero point due to application of excessive tension on the specimen as it is mounted and clamped for testing.

A1.2 One of the most serious problems, of which many users are unaware, is faulty clamping mechanisms. Many calibration/verification procedures for tensile testing machines, whether performed by the manufacturer's representative or the user, check for gage length, loading variability, and speed, but do not check out the total operating system which also includes the clamping mechanism.

A1.3 Use standard fabrics with known breaking forces as a means for checking the total operating system.