Designation: D3759/D3759M − 05 (Reapproved 2011)

Standard Test Method for Breaking Strength and Elongation of Pressure-Sensitive Tape[1]

This standard is issued under the fixed designation D3759/D3759M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the measurement of tensile strength at break (breaking strength) and stretch properties (elongation) for pressure-sensitive tapes and labels. It includes procedures for machine direction and cross direction, for high-strength filament reinforced backings and for high stretch backings. It also includes a procedure for obtaining force ("F" value) in conjunction with a specified elongation. These procedures employ a constant-rate-of-extension (CRE)-type testing machine.

1.2 The values stated in either SI or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; conversions between measurement systems must be conducted carefully.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus (Withdrawn 2009)[3]

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D996 Terminology of Packaging and Distribution Environments

D3715/D3715M Practice for Quality Assurance of Pressure-Sensitive Tapes

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

E4 Practices for Force Verification of Testing Machines

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 *AFERA Documents (Association Des Fabricants Europeens De Reubans Auto-Adhesifs–Europe:*

AFERA 4004 Self Adhesive Tapes—Measurement of Breaking Strength

AFERA 4005 Self Adhesive Tapes—Measurement of Elongation

2.3 *European Norm (EN) Documents:*

EN 1940 Self Adhesive Tapes—Measurement of Breaking Strength

EN 1941 Self Adhesive Tapes—Measurement of Elongation at Break

2.4 *PSTC Documents (Pressure Sensitive Tape Council):*

PSTC 131 Tensile Strength and Elongation of Pressure-Sensitive Tapes

3. Terminology

3.1 Terminology found in Terminology D996 shall apply.

4. Summary of Test Method

4.1 *Procedure A–Machine Direction for Tapes with Elongation Under 200 %*—A strip of tape is mounted between two clamps aligned in a straight flat plane and force applied at a specified rate until breaking of the strip of tape occurs. Force and elongation are determined at the moment of breakage.

4.2 *Procedure B–Machine Direction for Filament Reinforced Tape*—A strip of tape is applied to two drums aligned in a flat plane and force applied until breakage of tape occurs. Force and elongation are determined at the moment of breakage. This procedure may also be suited for other high strength tapes such as those with tensilized or highly oriented film backings.

4.3 *Procedure C–Machine Direction for Tapes with Elongation Over 200 %*—A strip of tape is mounted between two

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.14 on Tape and Labels.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

***A Summary of Changes section appears at the end of this standard**

TABLE 1 Test Preparation and Specimen Dimensions

	Gage Length, mm [in.]	Cross Head Velocity, mm [in.]/min	Specimen Width,[A] mm [in.]	Specimen Length, mm [in.]
A. Machine Direction Elongation Under 200 %	100 [4]	300 [12]	12–24 [0.5–1]	225 [9]
B. Machine Direction Reinforced Tapes	250 [10]	300 [12]	12–24 [0.5–1]	700 [28]
C. Machine Direction Elongation Over 200 %	50 [2]	50 [2]	12 [0.5]	150 [6]
D. Cross Direction	25 [1]	25 [1]	12 [0.5]	125 [5]

[A] The specimen widths shown are for tests in which the specimen is cut from within the sample dimension.

clamps aligned in a straight flat plane and force applied at a specified rate until breaking of the strip of tape occurs. Force and elongation are determined at moment of breakage.

4.4 *Procedure D–Cross Direction*—A strip of tape is mounted between two clamps aligned in a straight flat plane and force applied at a specified rate until breaking of the strip of tape occurs. Force and elongation are determined at the moment of breakage.

4.4.1 If the sample provides ample material, CD tests may be made in the same way machine direction (MD) tests are. This would occur with web material or sufficiently wide rolls.

4.4.2 If a tape has an ultimate elongation in the cross direction (CD) over 200 %, it is recommended to use the test preparation for high stretch materials.

4.4.3 Cross direction tests are limited to sample rolls of tape at least 48 mm in width.

NOTE 1—Procedures A and B are harmonized to be technically equivalent with test procedures published by PSTC, AFERA, and EN. Procedures C and D are harmonized to be technically equivalent with test procedures published by PSTC.

5. Significance and Use

5.1 This test method provides information that can be used in material specifications for product design and quality assurance applications. It can be used in comparing different products.

5.2 The use of this test method must be related to the purpose for which the test is performed. One purpose is for determining the relative strength of the tape in the size in which it is purchased or used. Another purpose is to identify or characterize a particular backing material.

5.2.1 The test may be performed on the tape as-received, that is, without cutting the material to a specimen width less than the as-received width. Usually tapes wider than 48 mm [2 in.] are not tested due principally to the limitations of equipment. Tapes as narrow as approximately 3 mm [0.125 in.] can be tested.

5.2.2 The test may be performed on a specimen cut from within the sample material boundaries using a sharp razor cutter, such as that defined in Section 6. This method is usually used for material characterization, determining quality of conformance, and for specification compliance.

5.3 Stretch characteristics of elongation at break or force to a specified elongation can be related to the tape's intended use or for identifying or characterizing a material.

6. Apparatus

6.1 *Tension Tester*—A constant-rate-of-extension (CRE) type with load cell capacity such that the maximum expected specimen strength does not exceed 90 % of its normal limit. The tension tester must be capable of the crosshead speeds described in Table 1 with tolerances of ±10 %.

6.1.1 The tensile testing machine must be equipped with a measurement system which records the force and deformation (elongation) of the test specimen during the test. This may be a pen and stylus, digital output, microprocessor, or computer based system. The accuracy should be verified in accordance with Practice E4 or equivalent.

6.1.2 *Extensometer (Optional)*—A suitable instrument, if desired, may be used for determining the distance between two designated points of the test specimen as the specimen is stretched.

6.1.3 *Integrator (Optional)*—A suitable instrument, microprocessor, or software analysis system may be used for determining the energy or work required to break the specimen.

6.1.4 *Clamps,* preferably the pneumatic action type at least 50 mm [2 in.] wide by 38 mm [1½ in.] deep. Faces shall have a light cross-hatch serration.

NOTE 2—Plastic materials are reduced in width and thickness while being stretched. This causes them to be drawn out of the clamps. Pneumatic clamps minimize this effect. It can be further reduced by the appropriate choice of surface of the clamps. One improvement, both with respect to the above mentioned shrinkage problem and simple slippage, may be found from the use of urethane film which can be obtained as a pressure-sensitive tape approximately 0.5 mm [20 mils] thick. This material has a very high coefficient of friction, is somewhat malleable, and is easily replaced. Alternative materials are coated abrasive, rubber (neoprene or other synthetic type), or other tape.

6.1.5 *Cylinders,* in place of clamps for testing high strength tapes by Procedure B. Each of two cylinders shall be 100 mm [4 in.] in diameter by 38 mm [1.5 in.] thick held in the position ordinarily occupied by the clamps so that the tape, when applied to the cylinders and extending between them, falls in the line of stress otherwise occupied by the specimens when clamps are used. See Fig. 1.

6.1.6 *Scale (Optional),* approximately 22 mm [1 in.] in length divided into 2 mm [0.1 in.] increments attached to each cylinder. The zero point or (origin) shall be at the point of tangency of the tape with the cylinder during the test and the scale shall increase upward on the lower cylinder and downward on the upper cylinder.

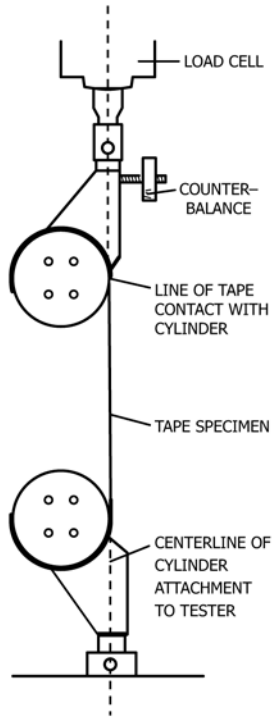

FIG. 1 Test Configuration for Reinforced Tapes

NOTE 3—These scales can be used to observe and measure the tape slippage during the tension test for reinforced tapes. Scales or extensometers shall be used for referee testing.

6.2 *Cutter,*[4]The specimen cutter shall hold two single-edged razor blades in parallel planes a precise distance apart, to form a cutter of exact specimen width. Appropriate widths shall be available as specified.

6.2.1 The 12 mm [½ in.] cutter shall be constructed of aluminum bar stock approximately 12 mm [½ in.] by 12 mm [½ in.] by 200 mm [8 in.]. The edges, for about 125 mm [5 in.] from one end shall be slightly rounded to form a handle. The width of the bar, for approximately 75 mm [3 in.] from the opposite end, shall be narrowed to exactly 12 mm [0.500 in.] minus the thickness of a single razor blade (one of two used as cutting edges). The razor blades shall be held in position using side plates. The end of the cutter shall be cut away at a 0.75 rad [45°] angle to expose the cutting edges at one end of the blades. The cutting edges shall be separated by 12 ± 0.1 mm [0.500 ± 0.005 in.]. Other width cutters shall be constructed similarly.

NOTE 4—Some of the traditional tools for specimen preparation must be avoided when the backing is comprised of thin plastic sheeting. These include chopping dies and sample cutters operating on a shearing principle. The reason for this restraint is that edges sufficiently ragged and damaged resulting from chopping or shearing cause tearing to occur before the true tensile strength level is reached. Tapes with fibrous backings may be cut to satisfactory specimens with these tools.

7. Sampling

7.1 *Acceptance Sampling*—Unless otherwise specified, acceptance sampling shall be in accordance with Practice D3715/D3715M.

7.2 *Sampling for Other Purposes*—The sampling and the number of test specimens depends on the purpose of the testing. Practice E122 is recommended. It is common to test at least five specimens of a particular tape. Test specimens should be taken from several rolls of tape, and whenever possible, among several production runs of tape. Strong conclusions about a specific property of a tape cannot be based on tests of a single unit (roll) of a product.

8. Test Specimens

8.1 Specimens shall have the dimensions shown in Table 1.

8.2 Unwind and discard at least three, but no more than six, outer wraps of tape from the sample roll before taking specimens for testing. Test without liners, if any.

8.3 Test one specimen per sample roll, unless otherwise specified.

8.4 The following applies to non-reinforced tapes for Procedure A:

8.4.1 Specimen ends that are clamped shall be prepared by covering the adhesive with paper, some other tape, or an extension of the specimen. In the latter case the specimen must be cut at lest 100 mm [4 in.] longer than defined in Table 1.

8.4.2 The covering shall be free of wrinkles, leaving the gage-length area uncovered and completely cover the rest of the specimen so that the clamps will apply uniform pressure against the specimen.

8.5 For Procedure D, a special specimen preparation is recommended for cross-direction (C.D.) specimens from rolls less than 125 mm [5 in.] in width.

8.5.1 Lay two rectangular sample strips on a flat surface with the adhesive side facing up. See Fig. 2. Each strip shall be as wide as the sample roll and approximately 125 mm [5 in.] in length. Position these strips side by side with one long edge of one strip parallel to and 25 mm [1.0 in.] separated from one long edge of the second strip.

8.5.2 Cut a specimen from the sample roll to have the width specified in Table 1 and length equal to the width of the roll.

8.5.3 Lay this specimen adhesive side up across the 25-mm [1.0-in.] separation of the strips. Position it toward one end of the sample strips so that it rests equally on both strips and at a right angle to their parallel edges.

8.5.3.1 If needed to prevent slippage, cut two additional strips from the sample roll having the same width as the specimen. *Butt* the end of one of these at one end to form a continuation of the specimen across the remainder of the sample strip. Use the second strip to butt against the other end of the specimen in like manner.

8.5.3.2 Fold each of the original sample strips over onto itself to form a three-ply tab that will be gripped by the clamps during the test.

[4] The sole source of supply of the apparatus known to the committee at this time is Chemsultants International, 9349 Hamilton Dr., Mentor, OH 44061-1118. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

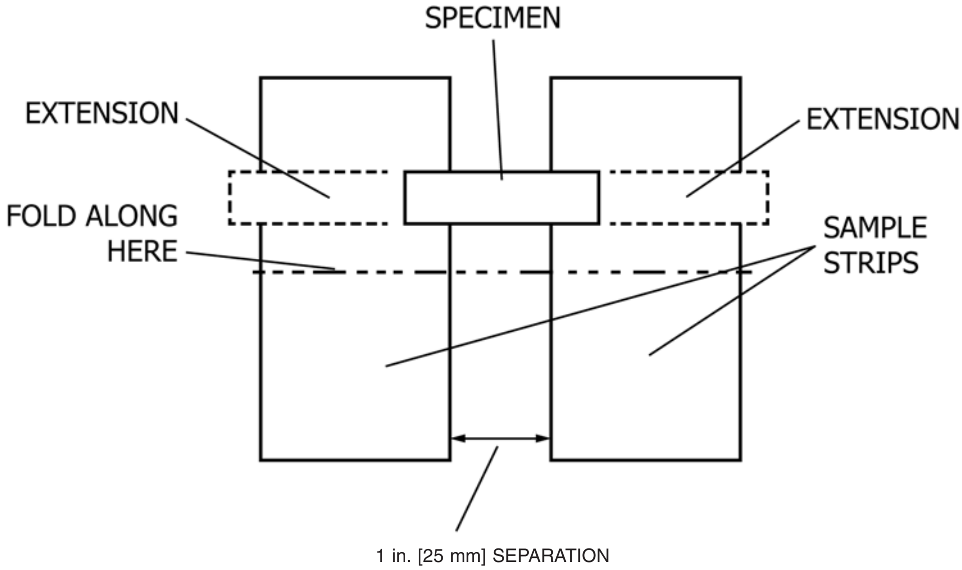

FIG. 2 Cross-Direction (CD) Specimen Preparation

8.5.4 Trim off any excess (single ply of tape) of either the sample strips or the extension strips extending beyond the two- or three-ply parts of the assembly.

8.6 For reinforced tapes, Procedure B, the specimen requires no further preparation than to have the appropriate dimensions (Table 1) and ensure that the adhesive is not contaminated so it will adhere well to the cylinders.

9. Preparation of Apparatus

9.1 Table 1 shows the tension tester settings for use with the specified test categories.

9.2 For testing reinforced tapes, Procedure B, set the cylinders 150 mm [6 in.] apart so that at the start of a test 250 mm [10 in.] of tape will extend between and without contact with the cylinders.

NOTE 5—The upper cylinder should be counterbalanced in order that the line of tape contact on the cylinders intersects an imaginary line running between the points of cylinder attachment to the tester and no side forces are exerted during the test. See Fig. 1.

10. Conditioning

10.1 Condition rolls of tape in the standard conditioning atmosphere if 23°C and 50 % RH as described in Practice D4332 for no less than 24 h. Test at these conditions.

11. Procedure

11.1 *Procedure A–Non-reinforced Tapes:*

11.1.1 Clamp the specimen in the grips of the testing machine. Take care to align the long axis of the specimen with an imaginary line running between the points of attachment of the grips and including the center of the grips. Apply no more tension to the specimen during clamping than is necessary to remove slack.

11.1.2 Start the cross head in motion at the specified velocity (Table 1) and ensure that the mechanism that displays the response is operating. Continue until the specimen ruptures.

11.1.3 Record a numerical display of the results.

11.1.4 It is customary to disregard tests where there has been excessive slippage of the specimen in the jaws or where the break occurred at the jaw.

11.2 *Procedure B–Reinforced Tapes:*

11.2.1 Adhere approximately 230 mm [9 in.] of the specimen on the upper cylinder beginning at the line of tape contact (see 9.2), and wrap the specimen around the top surface of the cylinder. Repeat this with the free end of the specimen on the lower cylinder, except wrap the specimen around the bottom surface of the cylinder. The applied specimen must be centered on the center line around the cylinder surface. This elimination of skewness prevents nonuniform stress loading across the width of the specimen. The specimen shall also be sufficiently taut to remove slack.

11.2.2 When slippage is a factor, mark the specimen (and cylinder if not already done), with a marking pen making a line approximately 1 mm [1⁄32 in.] wide at the line where the tape contacts each cylinder.

11.2.3 Start the cross head in motion at the specified velocity and ensure that the response-indicator mechanism is operating to indicate both load and elongation, if the latter is required.

11.2.4 Observe the bench marks on the specimen to determine their change in position relative to the mark the cylinders. Use the scales appended to the cylinders.

11.2.5 When the specimen breaks, record the sum of the upper and lower bench mark changes to the nearest 2 mm [0.1 in.]. This will be the correction for the elongation.

11.2.6 Also record the indicated responses for tensile strength and elongation when the tester provides a numerical display of this information.

11.3 *Procedure C and D:*

11.3.1 Follow Procedure A with the appropriate sample preparation and the appropriate conditions from Table 1.

TABLE 2 Components of Variation as Coefficient of Variation Percentage Point

Names of Properties	Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component	Replication Component
Specimens of the Same Material:				
M.D. Tensile (nonreinforced)	4.2	2.9	12.4	5.7
C.D. Tensile (nonreinforced)	2.6	15.5	39.1	7.0
Elongation (nonreinforced)	6.6	4.4	28.3	12.6
Tensile (reinforced)	7.1	2.4	4.2	3.3
Elongation (reinforced)	3.3	4.9	27.1	8.3
Specimens of Different Material:				
M.D. Tensile (nonreinforced)	10.0	2.6	7.3	5.7
C.D. Tensile (nonreinforced)	31.8	11.4	25.1	7.0
Elongation (nonreinforced)	27.3	6.4	10.9	12.6
Tensile (reinforced)	7.5	0.0	4.2	3.3
Elongation (reinforced)	5.3	4.8	26.7	8.3

12. Calculation

12.1 *Breaking Strength*—Record the force at break on the load-elongation curve. This can be normalized to the force per unit width of tape, for example, pounds per inch of width, Newtons per meter of width, Newtons per 10 mm of width, or other suitable units.

NOTE 6—The maximum force is often the force at break. With some materials, the force at break is lower than the maximum force. The maximum tensile force may also be of interest for some uses.

12.2 *Elongation*—Record the elongation at break. This may be reported as the percentage of the original effective specimen length. When testing reinforced tapes, correct for slippage, if any. The use of an appropriate extensometer is an allowable option.

12.3 *"F" Values (Optional)*—Record the force at a specified elongation. For example, if an F-3 value was required, one would record the force equivalent to 3 % elongation.

12.4 *Breaking Energy (Optional):*

12.4.1 The tensile energy to break is the area under the stress-strain curve to the point of rupture. This is usually integrated electronically or by a commercially available software program.

12.4.2 The test result is often normalized to a specified tape width under these test conditions. For example, it may be in joules per 100 mm of width. For a homogeneous film, foil, or paper backed tape, the value can be normalized as the energy per unit volume of tape backing based on the initial gauge region of the test specimen.

12.4.3 Pressure sensitive tape is a composite of a backing, adhesive, and sometimes other components. It is often useful to review the test procedures used for evaluating the breaking energy of backing materials: Test Methods D882, D828, or other appropriate methods of test. The breaking energy of a backing material may or may not be the same as the tape made from that backing.

13. Report

13.1 Report the tensile breaking strength in force per unit width to three significant places. If the force at break is different than the maximum force, the maximum force may be reported also.

13.2 Report the ultimate elongation in percent to two significant places.

13.3 (Optional) Report the "F" value or breaking energy.

13.4 Include the manufacturer's name and designation for the tape.

13.5 If slippage of the tape has occurred during the test, report the estimated slippage.

13.6 Any anomalous behavior.

13.7 Any deviations from this test method.

14. Precision and Bias

14.1 *Summary*—The difference between two single observations should not exceed the following critical differences in 95 out of 100 when all of the observations are taken by the same well-trained operator using the same piece of test equipment and specimens randomly drawn from the same sample of material.

M.D. Tensile (nonreinforced)	19.5 % of the average
C.D. Tensile (nonreinforeed)	20.8 % of the average
Elongation (nonreinforced)	39.5 % of the average
Tensile (reinforced)	21.6 % of the average
Elongation (reinforced)	24.7 % of the average

The size of the differences is likely to be affected adversely by different circumstances. The true values of M.D. tensile (nonreinforced), C.D. tensile (nonreinforced), elongation (nonreinforced), tensile (reinforced), and elongation (reinforced) can be defined only in terms of specific test methods Within this limitations the procedures in Test Method D3759 for determining these properties have no known bias. Paragraphs 14.2 through 14.6 explain the basis for this summary and for evaluations made under other conditions.

14.2 *Interlaboratory Test Data*[5]—An interlaboratory study was made in 1980 in which randomly drawn samples of two materials were tested in six laboratories. Two operators in each laboratory each tested three specimens from each of three rolls

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D10-1002. Contact ASTM Customer Service at service@astm.org.

TABLE 3 Critical Differences for the Properties Noted, Percentage Points[A]

Names of Properties	Number of Observations in Each Average	Single-Operator Precision Specimens		Within-Laboratory Precision Specimens		Between-Laboratories Precision Specimens	
		Same Material	Different Material	Same Material	Different Material	Same Material	Different Material
M.D. Tensile (nonreinforced)	1	19.5	32.1	34.8	32.9	40.3	38.6
	5	13.6	28.8	15.8	29.7	37.8	36.0
	10	12.6	28.4	15.0	29.3	37.5	35.6
C.D. Tensile (nonreinforced)	1	20.8	90.3	47.9	95.7	118.0	118.3
	5	11.3	88.6	44.3	94.1	117.0	117.0
	10	9.4	88.4	44.1	93.8	117.0	116.9
Elongation (nonreinforced)	1	39.5	83.3	41.3	85.2	88.7	90.4
	5	24.0	77.2	26.9	79.2	83.0	84.8
	10	21.3	76.4	24.5	78.4	82.3	84.1
Tensile (reinforced)	1	21.6	22.6	22.5	22.6	25.4	25.4
	5	20.0	21.1	21.0	21.1	24.1	24.1
	10	19.8	20.9	20.9	20.9	23.9	23.9
Elongation (reinforced)	1	24.7	27.2	28.1	30.4	80.7	80.1
	5	13.7	17.9	19.2	22.4	77.4	77.5
	10	11.6	16.4	17.8	21.2	77.1	77.1

[A] Critical differences were calculated using $t = 1.96$ which is based on infinite degrees of freedom.

of each material. The components of variance expressed as coefficient of variation were calculated to be the values listed in Table 2.

14.3 *Critical Differences*—For the components of variance listed in Table 2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 3.

14.4 *Confidence Limits*—For the components of variance listed in Table 2, single averages of observed values have the 95 % confidence limits listed in Table 4.

14.5 Elongation measurements of tapes with high elongations typically have higher variability than those of lower elongation tapes.

NOTE 7—The tabulated values of the critical differences and confidence limits 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 between them, if any, must be established with each comparison being based on recent data obtained on specimens randomly drawn from one sample of the material to be evaluated.

14.6 *Bias*—No justifiable statement can be made on the bias of Test Method D3759/D 3759M for testing tensile strength and elongation since the true value cannot be established by an accepted referee method.

15. Keywords

15.1 breaking energy; breaking strength; elongation; pressure-sensitive tape; tensile strength

TABLE 4 Width of 95 % Confidence Limits for the Properties Noted, Percentage Points[A]

Names of Properties	Number of Observations in Each Average	Single-Operator Precision Specimens		Within-Laboratory Precision Specimens		Between-Laboratories Precision Specimens	
		Same Material	Different Material	Same Material	Different Material	Same Material	Different Material
M.D. Tensile (nonreinforced)	1	±13.8	±22.7	±24.6	±23.2	±28.5	±27.3
	5	±9.6	±20.4	±11.1	±21.0	±26.8	±25.4
	10	±8.9	±20.1	±10.6	±20.7	±26.5	±25.2
C.D. Tensile (nonreinforced)	1	±14.7	±63.9	±33.9	±67.7	±83.7	±83.7
	5	±8.0	±62.7	±31.4	±66.5	±82.7	±82.8
	10	±6.7	±62.5	±31.2	±66.4	±82.7	±82.7
Elongation (nonreinforced)	1	±27.9	±58.9	±29.2	±60.2	±62.7	±63.9
	5	±17.0	±54.6	±19.0	±56.0	±58.7	±60.0
	10	±15.1	±54.1	±17.3	±54.5	±58.2	±59.9
Tensile (reinforced)	1	±15.3	±16.0	±16.0	±16.0	±18.0	±18.0
	5	±14.2	±14.9	±14.9	±14.9	±17.0	±17.0
	10	±14.0	±14.8	±14.8	±14.8	±16.9	±16.9
Elongation (reinforced)	1	±17.5	±19.3	±19.9	±21.5	±56.7	±56.7
	5	±9.7	±12.7	±13.6	±15.9	±54.8	±54.8
	10	±8.2	±11.6	±12.6	±15.0	±54.5	±54.5

[A] Critical differences were calculated using $t = 1.96$ which is based on infinite degrees of freedom.

SUMMARY OF CHANGES

Committee D10 has identified the location of selected changes to this standard since the last issue (D3759/D3759M – 04) that may impact the use of this standard.

(1) The crosshead speed and the gauge length have been changed to harmonize with other international standards for Procedures A and B.