Standard Test Method for Tensile Strength and Elongation of Pressure-Sensitive Tapes[1]

This standard is issued under the fixed designation D 3759/D 3759M; 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 method covers the measurement of tensile strength (breaking strength) and stretch properties (elongation and "F" value) for pressure-sensitive tapes. It includes procedures for machine direction cross-direction tests and tests for tapes with low and high stretch and reinforced backings. It also includes a procedure for obtaining stretch force ("F" value) in conjunction with a determination of tensile strength. These procedures employ a constant-rate-of-extension (CRE)-type testing machine. They apply to the principle of stretching the specimen at a fixed strain rate of 25 mm per 25 mm [1 in. per inch] of specimen length per minute with the exception of the procedure for reinforced tapes.

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; therefore, each system must be used independently, without combining values in any way.

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]

D 828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus

D 882 Test Method for Tensile Properties of Thin Plastic Sheeting

D 996 Terminology of Packaging and Distribution Environments

D 3715 Practice for Quality Assurance of Pressure-Sensitive Tapes

D 4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

E 4 Practices for Force Verification of Testing Machines

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process

3. Terminology

3.1 Terminology found in Terminology D 996 shall apply.

4. Significance and Use

4.1 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.

4.2 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.

4.2.1 When relative strength is of interest, 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.

4.2.1.1 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.

4.2.1.2 Comparison of materials by different test methods should be avoided because the test parameters of specimen dimensions and cross head velocity determine the outcome. Changes in the parameter levels will produce different results for the same material.

NOTE 1—It is usual to find the tensile strength increasing significantly with increasing cross head velocity and, therefore, strain rate.

4.2.2 When identity or material characterization is of interest, the test should be performed on a specimen cut from within the sample material boundaries using a sharp razor cutter, such as that defined in Section 5.

NOTE 2—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.

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[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.

4.2.3 Stretch characteristics can be related to the tape's intended use or for identifying or characterizing a material.

NOTE 3—Elongation measurements become difficult to perform on stretchy materials (greater than 25 % ultimate elongation) when the ratio of specimen length to width is small (approaching 2). The results show high variability and do not allow for practical use of this information except when one wishes to demonstrate large differences between a material.

5. Apparatus

5.1 *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.

5.1.1 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 shall be verified in accordance with Practice E 4 or equivalent.

5.1.2 *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.

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

5.1.4 *Clamps*, preferably the pneumatic action type.

5.1.4.1 Clamp faces at least 50 mm [2 in.] wide by 38 mm [1½ in.] deep. Faces shall have a light cross-hatch serration.

NOTE 4—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. The greatest 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 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.

5.1.5 *Cylinders*, in place of clamps for testing reinforced tapes. 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 fine of stress otherwise occupied by the specimens when clamps are used. See Fig. 1.

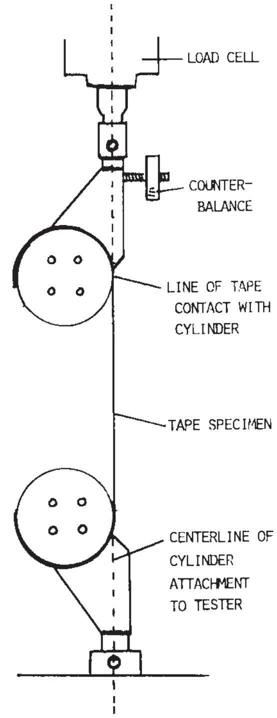

FIG. 1 Test Configuration for Reinforced Tapes

5.1.6 *Scale*, 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.

NOTE 5—These scales will be used to observe and measure the tape slippage during the tension test for reinforced tapes.

5.2 *Cutter*,[3] holding 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 (refer to specimen width in Table 1) patterned after the 12 mm [½-in.] cutter in 5.2.1. The differences between cutters of various widths is in the final width of the bar after removing the thickness of one razor blade.

[3] Available from Chemsultants International, 9349 Hamilton Dr., Mentor, OH 44061-1118.

TABLE 1 Test Preparation and Specimen Dimensions

	Gage Length, mm [in.]	Cross Head Velocity, mm [in.]/min	Specimen Width,^{A} mm [in.]	Length, mm [in.]
Machine Direction				
Elongation under 150 %	125 [5]	125 [5]	12-24 [0.5-1]	225 [9]
Elongation over 150 %	50 [2]	50 [2]	12 [0.5]	150 [6]
Reinforced Tapes	250 [10]	125 [5]	12-24 [0.5-1]	700 [28]
Cross Direction^{B,C,D}	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. See 4.2.1.
^{B} Cross-direction (CD) tests are limited to sample rolls of tape at least 48 mm in width.
^{C} If a tape has an ultimate elongation in the cross direction (CD) over 150 %, it is recommended to use the test preparation for high stretch materials.
^{D} If the sample provides ample material, CD tests should preferably be made in the same way machine-direction (MD) tests are. This would occur with web material or sufficiently wide rolls.

5.2.1 The cutter shall consist of a 12 mm [½ in.] thick by approximately 200 mm [8-in.] length of aluminum bar stock ½ in. wide. 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.

6. Sampling

6.1 *Acceptance Sampling*—Acceptance sampling shall be in accordance with Practice D 3715/D 3715M.

6.2 *Sampling for Other Purposes*—The sampling and the number of test specimens depends on the purpose of the testing. Practice E 122 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.

7. Test Specimens

7.1 Specimens shall have the dimensions shown in Table 1.

7.2 Unwind and discard at least three, but no more than six, outer wraps of tape from the sample roll before taking specimens for testing.

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

7.4 The following applies to nonreinforced tapes:

7.4.1 Specimen ends that are clamped shall be prepared by covering the adhesive with paper, some other tape, or a 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.

7.4.2 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.

7.4.3 A special specimen preparation is required for cross-direction (C.D.) specimens from rolls less than 100 mm [4 in.] in width. 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.

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

7.4.3.2 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.

7.4.3.3 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.

7.4.3.4 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.

7.4.3.5 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.

NOTE 6—The extension serves to keep the clamping pressure uniform over the whole area of the specimen. This is an imperative factor to a successful test.

7.5 For reinforced tapes 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.

8. Preparation of Apparatus

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

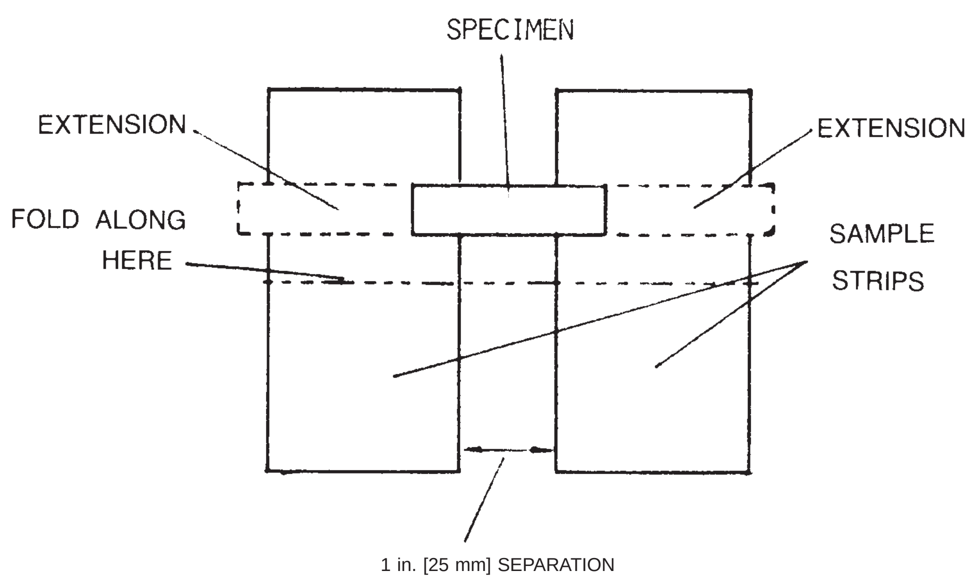

FIG. 2 Cross-Direction (CD) Specimen Preparation

8.2 For testing reinforced tapes, set the cylinders 150 mm [6 in.] apart so that at the start of a test 25 mm [10 in.] of tape will extend between and without contact with the cylinders.

NOTE 7—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.

9. Conditioning

9.1 Condition rolls of tape in the standard conditioning atmosphere as described in Practice D 4332 for no less than 24 h. Test at these conditions.

10. Procedure

10.1 *Nonreinforced Tapes*:

10.1.1 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.

10.1.2 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.

10.1.3 Record a numerical display of the results.

10.1.4 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.

10.2 *Reinforced Tapes*:

10.2.1 Adhere approximately 230 mm [9 in.] of the specimen on the upper cylinder beginning at the line of tape contact (see 8.2), 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.

10.2.2 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. These bench marks will be 25 mm [10 in.] apart and shall be checked to ensure this.

10.2.3 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.

10.2.4 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.

10.2.5 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.

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

11. Calculation

11.1 *Tensile Strength*—Record the maximum force 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, or other suitable units.

NOTE 8—The maximum force is often the force at break. With some materials, the force at break is lower than the maximum force. Unless otherwise indicated, the maximum force is to be used.

11.2 *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 any slippage noted in 10.2.5.

11.3 *"F" Values ()ptional)*—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.

11.4 *Breaking Energy (Optional)*—Record the work or the energy to break the specimen. Pressure sensitive tape is a composite of a backing, adhesive, and sometimes other components. If is often desirable to review the test procedures used for evaluating the breaking energy of backing materials.: Test Methods D 882, D 828, 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.

12. Report

12.1 Report the tensile strength in pounds-force per inch of width to three significant places. If the force at break is different than the maximum force, indicate which is being reported.

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

12.3 Report the "F" value in the same manner as the tensile strength (12.1).

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

12.5 Report the following test parameters:

12.5.1 Cross head velocity,

12.5.2 Gage length, and

12.5.3 Specimen width.

12.6 When the desired test response includes ultimate elongation, indicate whether slippage of material from within the clamps occurred and estimate the amount.

12.7 Any anomalous behavior noticed besides slippage.

13. Precision and Bias

13.1 *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 D 3759 for determining these properties have no known bias. Paragraphs 13.2 through 13.5 explain the basis for this summary and for evaluations made under other conditions.

13.2 *Interlaboratory Test Data*[4]—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 of each material. The components of variance expressed as coefficient of variation were calculated to be the values listed in Table 2.

13.3 *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.

13.4 *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.

NOTE 9—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.

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

14. Keywords

14.1 elongation; pressure-sensitive tape; tensile strength

[4] Supporting data are available from ASTM Headquarters, Request RR:D-10-1002.

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

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.

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.