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Tensile Strength and Elongation of Pressure Sensitive Tapes

1. DEFINITION

1.1 Tensile strength is the force required to break a unit width of tape by controlled pulling on opposite ends of the piece.

1.2 Elongation is the distance a tape will stretch lengthwise before breaking under controlled conditions, expressed as a percentage of original length. In the case of high elongation tapes, the elongation may include creep on the jaws that is often partially compensated for by "necking" of the specimen.

2. SIGNIFICANCE

2.1 Tensile strength - Breaking strength of tape is of importance as a measurement of its uniformity, quality, and ability to withstand stress in application and service.

2.2 Elongation - Elongation of tape is important as a measurement of it uniformity and quality, as well as a rough indication of its ability to conform to contours of uneven surfaces.

Table 1
Tester Preparation and Specimen Dimensions

	Gauge length, mm	Crosshead velocity, mm/min.	Chart velocity [A], mm/min.	Specimen width [B], mm	Length, mm
Tapes with ultimate elongation of:					
Up to 150%:					
Machine direction	125	125	125	12 - 24	230
Cross direction [CDE]	25	25	125	12	125
150% and up:					
Machine direction	50	50	125	12	150
Reinforced tapes	250	125	125	12 - 24	700

[A] The chart velocity may be set at other velocities. It should not be slower than the crosshead velocity.
[B] The specimen widths shown are for tests in which the specimen is cut from within the sample dimensions. See 3.2.1.1.
[C] Cross-direction (CD) tests are limited to sample rolls of tape at least 48 mm in width.
[D] It is unusual to test CD tensile strength of tapes having ultimate elongations greater than 150%. Therefore no reference to this is made in Table 1. However, CD tests could be made under that category on the high stretch materials.
[E] If the sample provides ample material, CD tests preferably should be made in the same way machine direction (MD) tests are. This would occur with web material or sufficiently wide rolls.

3. TEST SPECIMEN

3.1 Specimens shall have the dimensions shown in Table 1.

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

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

3.4 The following applies to non reinforced tapes:

3.4.1 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 least 96 mm longer than defined in Table 1.

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

3.4.3 A special specimen preparation is required for cross direction (CD) specimens from rolls of less than 96 mm in width. Lay two rectangular sample strips on a flat surface with the adhesive side facing up (see Figure 1). Each strip shall be as wide as the sample roll and approximately 120 mm in length. Position these strips side by side with one long edge of one strip parallel to and 24 mm separated from one long edge of the second strip.

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

NOTE - Some of the traditional tools for specimen preparation, including chopping dies and sample cutters operating on a shear principle, must be avoided when the backing is composed of thin plastic sheeting. 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.

3.4.3.2 Lay this specimen adhesive side up across the 24 mm separation of the strips. Position it toward one end of the sample strips so that it rest equally on both strips and at right angle to their parallel edges.

3.4.3.3 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.

3.4.3.4 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.

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

NOTE - 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.

3.5 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.

4. EQUIPMENT

4.1 Tensile 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.

4.1.1 Test information should be displayed in at least an alphanumeric digital display or a load-elongation curve plotted by a pen or stylus responding to load and with a chart driven synchronously with the crosshead.

4.1.2 Load elongation curve, plotted by a pen or stylus responding to load and with a servo-chart drive or x-y recorder driven by an extensometer.

4.1.3 Clamps, preferably the pneumatic action type.

NOTE - 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, can be found from the use of urethane film that can be obtained as a pressure sensitive tape approximately 0.048 mm 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.

4.1.3.1 Clamp faces at least 48 mm wide by 276 mm deep. Faces shall have a light cross-hatch serration.

4.1.4 Cylinders, in place of clamps for testing reinforced tapes. Each of two cylinders shall be 100 mm diameter by 37.5 mm 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 Figure 2).

4.1.5 Scale, approximately 24 mm in length divided into increments attached to each cylinder. The zero point (origin) shall be at the point of tangency of the tape with the cylinder upward on the lower cylinder and downward on the upper cylinder.

NOTE: These scales will be observed and measure the tape slippage during the tension test for reinforced tapes.

4.2 Cutter - See Appendix B. The razor blades shall be spaced precisely 12 mm apart.

5. TEST METHOD

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

5.2 For testing all reinforced tapes, set the cylinders 144 mm apart so that at the start of a test, 240 mm of tape will extend between and without contact with the cylinders.

NOTE - 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 Figure 2).

5.3 Condition the sample to equilibrium in standard conditions as described in Appendices A and D for 24 hours. Testing should be conducted in standard conditions according to Appendix A.

5.4 Nonreinforced tapes: 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.

NOTE - 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 materials.

5.4.1 Start the crosshead in motion at the specified velocity (Table 1) and ensure that the mechanism that displays the response (that is charts, plotter, or digital display) is operating. Continue until the specimen ruptures.

5.4.2 Record a numerical display of the results.

5.5 Reinforced tapes: Adhere approximately 220 mm of the specimen on the upper cylinder beginning at the line of tape contact (see 5.2), 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 the skewness prevents nonuniform stress loading across the width of the specimen. The specimen shall also be sufficiently taut to remove slack.

5.5.1 Mark the specimen (and cylinder if not already done) with a marking pen making a line approximately 0.75 mm wide at the line where the tape contacts each cylinder. These bench marks will be 240 mm apart and shall be checked to ensure this.

5.5.2 Start the crosshead 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.

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

5.5.4 When the specimen breaks, record the sum of the upper and lower bench mark changes to the nearest mm. This will be the correction for the elongation.

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

6. REPORT

6.1 Calculations:

6.1.1 Tensile strength: When the recorded load-elongation curve results from the testing, calculate tensile strength as follows:

6.1.1.1 Find the furthest advance of the plotting pen or stylus from the origin in the direction representing increasing force. Record this advance as a percentage of the chart scale.

6.1.1.2 Multiply the full-scale load range used during the test by the percentage found in 6.1.1.1.

NOTE - For this calculation, express the percentage as a decimal fraction, that is, use 0.87 for 87%.

6.1.1.3 Convert the value found in 6.1.1.2 to Newtons per the desired basis of dimension for the final step. For Newtons per width, divide by the specimen width in millimeters.

6.1.2 Ultimate elongation: When the recorded load-elongation curve results from the use of a synchronous chart drive, calculate elongation as follows:

6.1.2.1 Measure the distance from the start of the plot to the indicated breaking point along the motion (time) axis of the chart.

6.1.2.2 When the chart velocity equals the crosshead velocity, the distance from 6.1.2.1 divided by the gauge length and multiplied by 100 equals the ultimate elongation.

6.1.2.3 When the chart and crosshead velocities are different, multiply the calculations completed in 6.1.2.2 by the ratio of the crosshead velocity to the chart velocity to obtain the correct ultimate elongation.

6.1.2.4 When the recorded load-elongation curve results from use of a servo-chart drive or x-y recorder driven by an extensometer, calculate elongation as follows:

6.2.1.4.1 Measure the distance from the start of the plot to the indicated breaking point. Divide this by the magnification ratio (to get the true dimension of elongation). Divide this by the gauge length. Next, multiply by 100 to convert the value to percent ultimate elongation.

NOTE: The magnification ratio is the chart motion over the actual extensometer motion.

6.1.2.5 When testing reinforced tapes, the correction found in 5.5.4 first shall be subtracted from the amount of extension indicated or measured along the time axis of the recording chart and the difference divided by the original gauge length. Multiply this quotient by 100 to convert it into percentage ultimate elongation.

6.1.3 "F" value: When the recorded load-elongation curve results from the use of a synchronous chart drive, calculate the "F" value as follows:

6.1.3.1 Find the chart scale equivalent to the desired elongation point. (If one were determining the F-3 value, that is, the force required to stretch the specimen 3%, one would be finding the chart scale equivalent to 3% elongation.) This equivalent is the distance measured from the start of the plot to the prescribed elongation point on the chart. To calculate the distance in terms of the chart scale, use the equation:

$$d = \frac{E \times G \times C}{100(H)}$$

where:

d = chart scale equivalent distance
E = percentage elongation where the "F" value is to be determined
G = gauge length
C = chart velocity, and
H = crosshead velocity

The units of these measurements shall be in millimeters.

6.1.3.2 Using the calculated d, measure along the chart time axis (same as stretch, extension, or elongation axis) from the origin of the recorded plot to a point distance, d. This point shall be at zero force as was the plot origin. Draw a line from this point parallel to the force axis to intersect with the recorded plot. Measure the scale length of this line from zero force and convert this length into percentage of chart scale and then into force. See 6.1.1.1 and 6.1.1.2.

6.1.3.3 Multiply the full-scale load range used during the test by the percentage found in 6.1.3.2. Express the percentage as a decimal fraction. The product is the "F" value in pounds-force for the specimen width.

6.1.3.4 The final step is the same as 6.1.1.3, except substitute 6.1.1.3 for 6.1.1.2.

6.1.3.5 When the recorded load-elongation curve results from the use of a servo-chart drive or x-y recorder driven by an extensimeter, calculate the "F" value as follows:

$$d = \frac{E \times G \times M}{100}$$

where:

d = scale equivalent
E = percent elongation where "F" value is to be determined.
G = gauge length, and
M = magnification ratio (6.1.2.4.1).

6.1.3.5.2 Using the calculated value of d from 6.1.2.5.1, perform the steps in 6.1.3.2 and 6.1.3.3.

6.2 Report

6.2.1 Report the tensile strength in Newtons per centimeter of width to three significant places or other acceptable units to the same degree of accuracy.

6.2.2 Report the ultimate elongation in percentage to two significant places.

6.2.3 Report the "F" value in the same manner as the tensile strength (6.2.1).

6.2.4 The following test parameters are to be reported:

6.2.4.1 crosshead velocity,

6.2.4.2 gauge length,

6.2.4.3 specimen width.

6.2.5 When the desired test response includes ultimate elongation, indicate whether slippage of material from within the clamps occurred and estimate the amount. Another method for determining tensile and elongation of pressure sensitive tape is ASTM D 3759.

6.2.6 Report if conditioning is different from Appendices A and D.

6.2.7 Report if testing conditions are different from Appendix A.

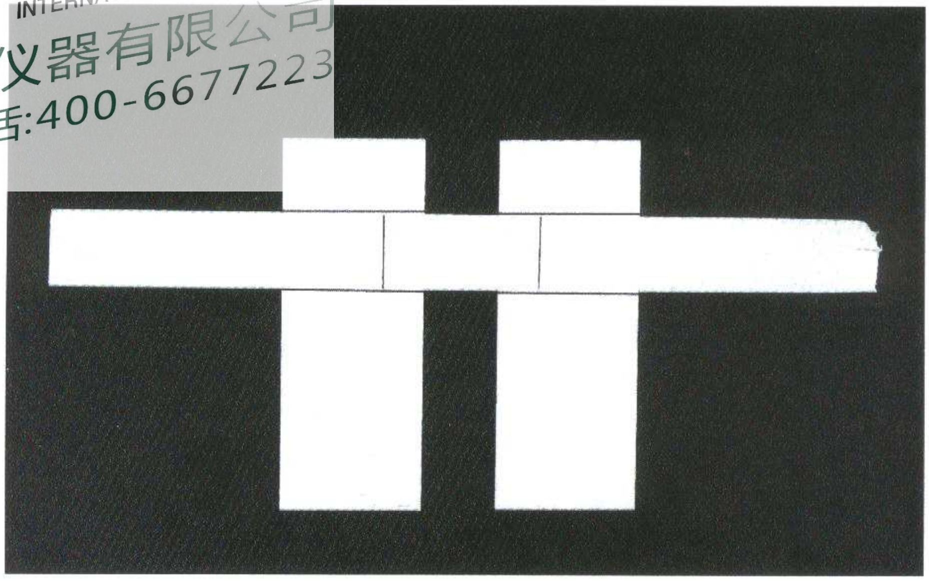

Figure 1. Sample preparation for cross direction tensile testing.

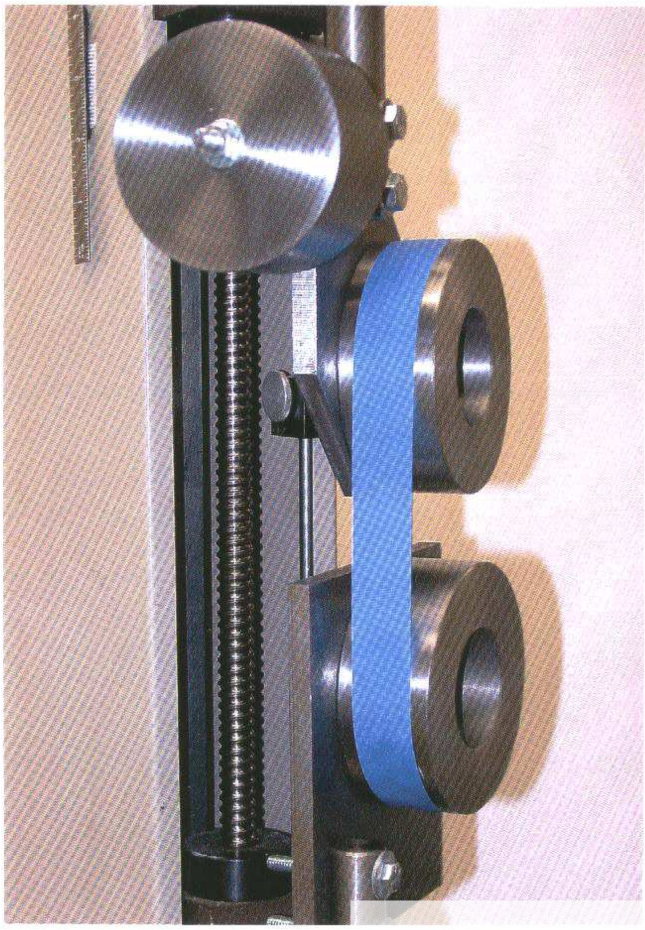

Figure 2. Tensile testing equipment set up.