



Standard Test Method for Tension and Elongation of Elastic Fabrics (Constant-Rate- of-Extension Type Tensile Testing Machine)¹

This standard is issued under the fixed designation D 4964; 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 tension and elongation of wide or narrow elastic fabrics made from natural or man-made elastomers, either alone or in combination with other textile yarns, when tested with a constant-rate-of-extension (CRE) type tensile testing machine.

NOTE 1—For determination of similar testing using the constant-rate-of-load (CRL) type tensile testing machine, refer to Test Method D 1775.

1.2 The use of this test method requires the selection of, or mutual agreement upon, loop tension(s) and elongation(s) at which the test results will be determined.

1.3 Laundering procedures require mutual agreement on the selection of temperature and number of washing cycles and drying cycles to be used.

1.4 The values stated in SI units 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 of the other, without combining values in any way.

1.5 *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:

D 76 Specification for Tensile Testing Machines for Textiles²

D 123 Terminology Relating to Textiles²

D 1775 Test Method for Tension and Elongation of Wide Elastic Fabrics (Constant-Rate-of-Load Type Tensile Testing Machine)²

D 1776 Practice for Conditioning Textiles for Testing²

3. Terminology

3.1 Definitions:

3.1.1 *constant-rate-of-extension tensile testing machine (CRE)*, *n*—a testing machine in which the rate of increase of specimen length is uniform with time.

3.1.2 *constant-rate-of-load tensile testing machine (CRL)*, *n*—a testing machine in which the rate of increase of the load being applied to the specimen is uniform with time after the first 3 s.

3.1.3 *elastic fabric*, *n*—a textile fabric made from an elastomer either alone or in combination with other textile materials.

3.1.4 *elongation*, *n*—the ratio of the extension of a material to the length of the material prior to stretching.

3.1.5 *extension*, *n*—the change in length of a material due to stretching.

3.1.6 *extension-recovery cycle*, *n*—in tension testing, the continuous extension of a specimen, with a momentary hold at a specified extension, followed by a controlled rate of return to zero extension.

3.1.7 *force*, *n*—a physical influence exerted by one body on another which produces acceleration of bodies that are free to move and deformation of bodies that are not free to move.

3.1.8 *loop tension*, *n*—in elastic material testing, the total tension at any specified extension that is exerted on a specimen in a loop formation.

3.1.9 *narrow elastic fabric*, *n*—an elastic fabric that is less than 150 mm or 6 in. wide.

3.1.10 *tension*, *n*—a uniaxial force tending to cause the stretching of a material.

3.1.11 *tension-recovery chart*, *n*—in tension testing, a continuously plotted graph of tension versus extension resulting from a tension-recovery cycle.

3.1.12 *tension test*, *n*—in textiles, a test designed to measure the tautness in a textile strand or fabric.

3.1.13 *wide elastic fabric*, *n*—an elastic fabric that is at least 150 mm or 6 in. wide.

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

4. Summary of Test Method

4.1 *Loop Tension at Specified Elongation(s)*—A conditioned loop specimen is mounted in a CRE-type tensile testing machine. The specimen is then extended at a specified rate to a specified loop tension, and returned at a specified rate to zero tension. The cycle is repeated two more times to give a total of

¹ This test method is under the jurisdiction of ASTM Committee D-13 on Textiles and is the direct responsibility of Subcommittee D13.24 on Elastomeric Yarns and Fabrics.

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² *Annual Book of ASTM Standards*, Vol 07.01.

three cycles. During the test, extension-recovery curves may be plotted by an automatic recorder for all or only the third cycle. The tension at specified percent elongation(s) is calculated from the graph of the third cycle or obtained from the instrument.

4.2 Elongation at Specified Loop Tension—A conditioned loop specimen is mounted in a CRE-type tensile testing machine. The specimen is then loaded at a specified rate to a specified loop tension, and unloaded at a specified rate to zero loop tension. The cycle is repeated two more times to give a total of three cycles. During the test, tension-recovery curves may be plotted by an automatic recorder for all or only the third cycle. The elongation at a specified loop tension is calculated from the graph of the third cycle or obtained from the instrument.

5. Significance and Use

5.1 This test method for testing loop tension and elongation of elastic fabrics is considered satisfactory for acceptance testing of commercial shipments of elastic fabrics because the test method is used in the trade for acceptance testing.

5.1.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the parties should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using student's *t*-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results with consideration to the known bias.

5.2 This test method specifies the use of the CRE-type tensile testing machine. Users of this test method are cautioned that loop tension test data obtained using this method are not comparable to tension test data obtained using Test Method D 1775 because of the differences in testing machines. Test Method D 1775 uses a CRL-type tensile testing machine.

5.3 The loop tension and extension relationship of an elastic fabric is an important criterion for judging the suitability of the fabric for various end uses, such as: foundation garments, brassieres, and swimsuits.

5.4 Data from loop tension-recovery curves can be compared only if the tension testing machine, rate-of-extension, maximum loading (or extension), and specimen specifications are comparable. Since different machine set-ups will cause different results on the same fabric, machine set-ups must always be specified before making a test and be reported with the test results.

5.5 The test for measuring loop tension at specified elongation(s) is used to determine the tension of an elastic fabric when subjected to a specified elongation which is less than the elongation required to rupture the fabric. The test prescribes

points of measurement on the extending (outgoing) cycle only.

5.6 The test for measuring elongation at specified tension(s) is used to determine the elongation of an elastic fabric when subjected to a specified loop tension which is less than the tension required to rupture the fabric. The test prescribes points of measurement on the loading (outgoing) cycle only.

6. Apparatus

6.1 Tensile Testing Machine, CRE-Type,³ conforming to Specification D 76, equipped with an automatic recording device and cycling controls.

6.2 Band Clamps, to hold loop specimen during testing. The diameter of the anvils will be 13.0 ± 0.25 mm (0.5 ± 0.01 in.) or 6.5 ± 0.25 mm (0.25 ± 0.01 in.). The length of the anvil will not be less than 76 mm (3.0 in.).

6.3 Sewing Machine Single-Needle.

7. Sampling

7.1 Lot Sample—As a lot sample for acceptance testing, take at random the number of rolls of fabric as directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of fabric to be the primary sampling units.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls of fabric, and the variability 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—As a laboratory sample for acceptance testing, take a full width swatch, 2 m (2 yd) long, from the end of each roll of fabric in the lot sample, after first discarding a minimum of 1 m (1 yd) of fabric from the very outside of the roll.

7.3 Test Specimens—Take test specimens as follows:

7.3.1 Wide Elastic Fabrics—If the purchaser and the supplier agree to test the fabric in only one direction, cut five specimens from each swatch in the laboratory sample with the long dimension of the specimens parallel to the direction of test. If the purchaser and the supplier agree to test the fabric in both directions, from each full-width swatch in the laboratory sample, cut five specimens parallel to the long dimension and five specimens perpendicular to the long dimension. Specimens should be spaced along a diagonal to allow for representation in each specimen of different warp and filling areas, or wale and course areas. Take no specimens nearer than one tenth of the fabric width from the selvage.

7.3.2 Narrow Elastic Fabric—Cut five specimens from each swatch in the laboratory sample. For narrow knitted or woven elastic fabrics that are more than 75 mm (3 in.) wide, the purchaser and the supplier may agree to (1) use specimens of the widths specified in 8.1.1 for wide elastic fabrics of

³ Machines available from the following suppliers, or the equivalent, have been found satisfactory for this purpose: E. H. Benz Company, 283 Whitford Ave., Providence, RI 02904, Instron Corporation, 100 Royall St., Canton, MA 02021, Monsanto Instruments, 2689 Wingate Ave., Akron, OH 44314, Thwing-Albert Instrument Company, 10960 Dutton Rd., Philadelphia, PA 19154, and Zwick of America, P.O. Box 997, East Windsor, CT 06088.

comparable construction, or (2) if wide clamps are available, use full-width specimens.

8. Preparation of Test Specimens

8.1 Cut specimens as directed below:

8.1.1 *Wide Elastic Fabric*—Cut specimens 350 by 100 mm (14 by 4 in.). Trim, or ravel woven fabrics by taking yarns alternately from the two sides, to a width as near 75 ± 2 mm (3 ± 0.05 in.), as possible. If fabrics are ravelled to obtain the specimen width, specimens should contain the same number of yarns in the testing direction.

8.1.2 *Narrow Elastic Fabric*—Cut specimens with the 350-mm (14-in.) dimension parallel to the length of the fabric.

8.2 *Preparation of Loop Specimens*—Draw two gage marks on the specimen which are (1) 250 ± 2 mm (10 ± 0.05 in.) apart, (2) approximately the same distance from the specimen ends, (3) parallel to one another, and (4) perpendicular to the long direction of the test specimen. Form a loop by folding the specimen; then aligning and sewing a seam along the two gage marks. Use a single-needle stitch, sewing two rows of stitching and making certain that the beginning and ending stitches do not come loose.

9. Preparation and Verification of Apparatus

9.1 Equip and set-up the CRE-type tensile testing machine according to the manufacturer's instructions and using the following information:

9.1.1 Loop distance around clamps: 250 ± 2 mm (10 ± 0.05 in.).

9.1.2 Loading crosshead speed: 500 ± 15 mm/min (20 ± 0.5 in./min).

9.1.3 Unloading crosshead speed: 500 ± 15 mm/min (20 ± 0.5 in./min).

9.1.4 *Cycling controls*: 100 N (20 lbf) force maximum, or as agreed upon. Force must be less than that which will cause the fabric to rupture. For low elongation fabrics (below 100 %), parties should agree to a slower crosshead speed for loading and unloading, such as 300 ± 15 mm/min, or 12.0 ± 0.5 in./min.

NOTE 3—The slower speed is recommended because the recording devices may not be able to keep up with the machine at elongations below 100 %.

9.2 *Verification of Position of Clamps*:

9.2.1 Use one of the procedures described in 9.2.2 through 10.2.4 to verify or set the position of the clamps.

9.2.2 Use the gage supplied by tensile testing machine manufacturer.

9.2.3 Make and use a paper gage as directed below.

9.2.3.1 Cut a strip of flexible paper that measures 275 ± 2 mm by 10 ± 2 mm, or 11.0 ± 0.05 in. by 0.5 ± 0.05 in.

9.2.3.2 From one end of paper strip, measure a distance of 250 ± 2 mm, or 10.0 ± 0.05 in., and draw a line perpendicular to the long axis.

9.2.3.3 Place a strip of double-faced tape across the strip, and on the short end, coincident with the line.

9.2.3.4 Curl the untaped end of the strip to form a loop, aligning the end with the 250 mm, or 10 in., line. Press down on the strip, fastening it to the double-faced tape.

9.2.3.5 Place the paper loop around the testing machine

clamps with the taped joint between the clamps. See Fig. 1.

9.2.3.6 Adjust the clamp spacing until the loop is just snug on the clamp.

9.2.3.7 Remove the loop.

9.2.3.8 If the anvil diameter is 13 mm (0.5 in.), set the initial anvil spacing so that the distance from the top of the upper anvil to the bottom of the lower anvil is 118 mm or 4.7 in.

9.2.3.9 If the anvil diameter is 6.5 mm (0.25 in.) set the initial anvil setting so that the distance from the top of the upper anvil to the bottom of the lower anvil is 121 mm or 4.9 in.

NOTE 4—The anvil spacing in 9.2.3.8 and 9.2.3.9 will provide a loop circumference of 250 mm or 10 in.

10. Conditioning

10.1 Before making any tests for loop tension or stretch, bring the samples to moisture equilibrium for testing in the standard atmosphere for testing textiles, which is $21 \pm 1^\circ\text{C}$ ($70 \pm 2^\circ\text{F}$) and 65 ± 2 % relative humidity. Allow the samples to relax, free of loop tension, for a minimum of 16 h. After exposure for this time, it may be assumed that moisture equilibrium has been reached. See Practice D 1776 for standard conditions for testing textile materials.

11. Procedure

11.1 Test all specimens in standard atmosphere for testing textiles, which is $21 \pm 1^\circ\text{C}$ ($70 \pm 2^\circ\text{F}$) and 65 ± 2 % relative humidity.

11.2 Mount the specimen with the seam between the clamps.

11.3 Cycle the specimen three times and record at least the loading and extension of the third cycle on the chart.

11.4 Test the remaining specimens.

12. Calculation

12.1 *Manual Calculation for Loop Tension at Specified Elongations*:

12.1.1 Calculate the extension value for 30 %, 50 %, 70 % elongation using Eq 1

$$L = (E \times C) / 200 \quad (1)$$

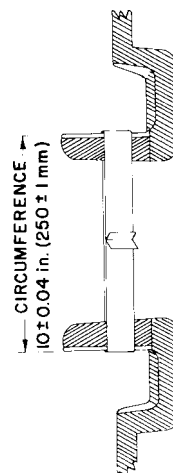


FIG. 1 Loop Specimen in Place on Pins

where:

L = extension, mm (in.)

E = % elongation, and

C = loop circumference, mm (in.)

12.1.2 Using the extension values calculated in 12.1.1, determine the loop tension values corresponding to 30 %, 50 %, and 70 % elongations, or for the agreed upon percent elongation(s).

12.2 *Manual Calculation for Elongation at Specified Loop Tension:*

12.2.1 Calculate the percent elongation at the specified maximum loop tension (100 N (20 lbf)), or other agreed upon loop tension.

12.3 Calculate the average tension (or elongation) for each specified elongation (or loop tension), or both, if requested.

12.4 Calculate the standard deviation, or the coefficient of variation, or both, for each property if requested.

13. Report

13.1 State that the specimens were tested as directed in Test Method D 4964. Describe the material(s) or product(s) sampled and the method of sampling used.

13.2 Report the following information:

13.2.1 The loop tension at 30 %, 50 %, and 70 % elongation, or other specified percent elongation, if requested.

13.2.2 The percent elongation at the loop tension used,

13.2.3 The maximum tension used,

13.2.4 The specimen width.

13.2.5 The CRE-type tensile testing machine used.

13.2.6 The crosshead speed.

13.2.7 The testing conditions, if other than standard.

13.2.8 The number of the cycle from which data were obtained, if other than the third.

13.2.9 The standard deviation, or coefficient of variation, or both, if calculated.

14. Precision and Bias

14.1 *Summary*—The following general statements can be made about the precision of this test method:

14.1.1 Narrow elastic fabrics in widths from 9.5 to 25.4 mm ($\frac{3}{8}$ to 1 in.) seem to have comparable variabilities. The variability in loop tension results seems to increase at higher percent elongation. The critical differences are somewhat larger when comparing different fabrics than when comparing samples of the same fabric.

14.1.2 The variability of loop tension results from warp-knit elastic fabrics tested in the machine direction seems significantly larger than that for narrow elastic fabrics at the lower elongations, but not at higher elongations.

14.1.3 The variability of loop tension results for warp-knit elastic fabrics tested in the cross-machine direction are signifi-

TABLE 1 Components of Variance as Standard Deviation

	Single-Operator	Within-Laboratory	Between-Laboratories
Single Material	0.206	0.053	0.089
Multi-Materials	0.357	0.053	0.233

cantly larger than those for narrow elastic fabrics and for warp-knit elastic fabrics tested in the machine direction.

14.2 *Interlaboratory Test Data*⁴—An interlaboratory test was run in 1984 in which randomly drawn specimens of five materials were tested in each of six laboratories. Two operators in each laboratory tested five specimens of each material for each of the following four properties: (1) loop tension at 30 % elongation in pounds-force, (2) loop tension at 50 % elongation in pounds-force, (3) tension at 70 % elongation in pounds-force, and (4) ultimate elongation in percent. The materials were: (1) 9.5-mm ($\frac{3}{8}$ -in.) wide narrow elastic, (2) 12.7-mm ($\frac{1}{2}$ -in.) wide narrow elastic, (3) 25.4-mm (1-in.) wide narrow elastic, (4) warp-knit elastic fabrics tested in the machine direction, and (5) warp-knit elastic fabrics tested in the cross-machine direction. The components of variance expressed as standard deviations were calculated to be the values listed in Table 1.

NOTE 5—The square roots of the components are being reported to express the variability in the appropriate units of measure rather than as the square of those units of measure.

14.3 *Precision*—For the components of variance reported in 13.2, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences in Table 2.

NOTE 6—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 such comparison being based on recent data obtained on specimens taken from a lot of material of the type being evaluated to be as nearly homogeneous as possible and then randomly assigned in equal numbers to each of the laboratories.

14.4 *Bias*—The procedure in this test method has no bias because the value of those properties can be defined only in terms of a test method.

15. Keywords

15.1 elongation; narrow elastic fabric; strand; tension (tensile) properties/tests; wide elastic fabric

⁴ Supporting data are available from ASTM Headquarters. Request RR: D-13-1047.

TABLE 2 Critical Differences for Conditions Noted^A

Number of Observations in Average	Single-Operator Precision	Within-Laboratory Precision	Between- Laboratories Precision
Single Material Comparisons			
1	10.05	10.05	12.46
2	7.10	7.10	10.23
4	5.02	5.02	8.91
8	3.53	3.53	8.17
16	2.51	2.51	7.78
Multi-Material Comparisons			
1	10.73	10.73	14.49
2	8.05	8.05	12.83
4	6.28	6.28	11.53
8	5.18	5.18	11.03
16	4.54	4.54	10.74

^A Based on 95 % confidence level with $t = 1.960$.

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