ASTM INTERNATIONAL

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Standard Test Method for
Tensile Properties of Elastomeric Yarns (CRE Type Tensile Testing Machines)[1]

This standard is issued under the fixed designation D 2653; 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 determination of the tensile properties of "as produced" elastomeric yarns made from natural rubber, spandex or other elastomers, using a constant-rate-of-extension (CRE) type tensile testing machine. The properties included in this test method are: (*1*) force at first filament break, (*2*) tenacity at first filament break, (*3*) elongation at first filament break, (*4*) work to break at first filament break, and (*5*) toughness at first filament break.

1.2 This test method does not apply to covered, wrapped, or core-spun yarns or yarns spun from elastomeric staple.

1.3 This test method is applicable to elastomeric yarns in the range from 40 to 3200 dtex (36 to 2900 denier).

1.4 The values stated in either SI units or U.S. Customary units are to be regarded separately as standard. Within the text, the U.S. Customary units are given in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other.

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 Textiles[2]
D 123 Terminology Relating to Textiles[2]
D 1776 Practice for Conditioning and Testing Textiles[2]
D 2258 Practice for Sampling Yarn for Testing[2]
D 2591 Test Method for Linear Density of Elastomeric Yarns (Short-length Specimens)[2]
D 4848 Terminology for Force, Deformation and Related Properties of Textiles[3]

D 6717 Test Method for Linear Density of Elastomeric Yarns (Skein Specimens)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *elastomeric yarn, n*—a nontextured yarn which can be stretched repeatedly at room temperature to at least twice its original length and which after removal of the tensile force will immediately and forcibly return to approximately its original length.

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

3.1.2.1 *Discussion*—In this test method, the elongation is determined at the first filament break.

3.1.3 *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.

3.1.3.1 *Discussion*—In elastomeric yarns, force at first filament break is more important than breaking force or force at rupture.

3.1.4 *linear density, n*—*for fiber and yarn,* mass per unit length.

3.1.5 *tenacity, n*—in a tensile test, the force exerted on the specimen based on the linear density of the unstrained specimen.

3.1.6 *toughness, n*—the capacity of a material to absorb energy.

3.1.6.1 *Discussion*—In a force-extension curve, toughness is represented by the area under the curve from the origin to a specified extension, usually extension at break but, for elastomeric yarns, the extension at first filament break.

3.1.7 *work, n*—the energy expended in displacing a body; mathematically, force times distance.

3.1.8 *work to break, n*—the energy expended up to the breaking force.

3.1.8.1 *Discussion*—For elastomeric yarns, the work to break is calculated using the force at first filament break rather than the traditional breaking force.

3.1.9 For definitions of other terms related to force and deformation, refer to Terminology D 4848. For definitions of other terms related to textiles used in this standard, refer to Terminology D 123.

4. Summary of Test Method

4.1 A specimen is clamped in a CRE-type tensile testing machine and extended to rupture. Force at first filament break and elongation at first filament break, work and toughness are calculated from a force-elongation curve or with an interfaced computer. Tenacity at first filament break can be calculated based on the determined linear density of the yarn. Other properties, such as force at specified elongation (FASE), elongation at specified force (EASF), may also be calculated.

5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments since current estimates of between-laboratory precision are acceptable and the method is used extensively in the trade for acceptance testing.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, use samples for such comparative tests 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, at 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 force at first filament break of elastomeric yarns may depend on its construction and manufacturing process and provides an indication of the breaking strength of fabrics made from the yarn.

5.3 Elongation is an indication of the ability of a fiber to absorb energy. The elongation of yarn or fabric must be great enough to withstand strains experienced in processing and end use, and to absorb the energies of applied forces repeatedly.

5.4 Fabric manufacturers use force and elongation information of elastomeric yarns in determining machine set-up conditions.

5.5 Other parameters such as elongation at specified force (EASF), force (or tenacity) at specified elongation (FASE, TASE), work and toughness may be calculated from force-elongation curves. EASF and FASE information is needed for tests involving cycling of yarn in determination of elastic properties.

5.6 This test method was developed using elastomeric yarns in the "as-produced" condition, but may be used for treated elastomeric yarns provided the treatment is specified. The method does not cover the removal of finish for determination of tensile properties of "finish-free" elastomeric yarns.

6. Apparatus [4]

6.1 *Specimen Boards*, with short pile or plush surfaces or black or contrasting color, for storing specimens during conditioning.

6.2 *Tensile Testing Machine*, CRE-type, conforming to Specification D 76 with respect to force indication, working range, capacity and verification of recorded elongation, and designed for operation at a pulling speed of 500 mm/min (20 in./min) or 1000 % extension per min.

6.3 *Clamping Assembly*, pneumatically operated, with jaw faces as described in 6.3.1 or 6.3.2.

6.3.1 *Option A, Preferred*—One jaw with a flat acrylic face nominally 25 mm × 12.5 mm (1 in. × 0.5 in.) and the opposing jaw approximately 12.5 mm (0.5 in.) wide with a convex [approximately 7.1 mm (0.28 in.) radius], steel or chrome face.

6.3.2 *Option B*—One jaw with a flat, steel or chrome face nominally 25 mm × 12.5 mm (1 in. × 0.5 in.) and the opposing jaw approximately 12.5 mm (0.5 in.) wide with a convex [approximately 8.5 mm (0.375 in.) radius] acrylic face.

6.4 *Computer or Microprocessor*, interfaced, with automatic data gathering system, optional.

6.5 *Tensioning Weights*, with various masses from 10 mg to 3 g as required to pretension the specimen to 30 to 50 mN/tex (0.3 to 0.5 mgf/d) before testing.

6.6 *Air Supply*, capable of providing 415 kPa (60 psi) to the pneumatic clamps.

7. Sampling, Test Specimens, and Test Units

7.1 *Lot Sample*—As a lot sample for acceptance testing, take a random number of shipping units directed in an applicable material specification or other agreement between the purchaser and the supplier, such as an agreement to use Practice D 2258. Consider shipping cases or other shipping units to be the primary sampling units.

NOTE 1—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between shipping units, between packages or ends within a shipping unit, and between specimens from a single package to provide a sampling 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 at random from each shipping unit in the lot sample the number of packages directed in an applicable material specification or other agreement between the purchaser and the supplier, such as an agreement to use Practice D 2258. Preferably, take the same number of packages from each of the shipping units, determine at random which shipping units are to have each number of packages for testing.

7.3 *Test Specimens*—From each package or end in the laboratory sample, take specimens as directed in 7.3.1.

7.3.1 Remove the outer layer of yarn from the package. Avoid any damaged areas in selecting segments for testing. Carefully unwind yarn from the package with as low as tension

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[4] Apparatus and accessories are commercially available. Clamps may need to be modified to accept jaw faces and attachment to some tensile testing machine.

as possible to avoid stretching. As test specimens, cut approximately 125 mm (5 in.) long segments of yarn from each package, taking them at intervals of at least 1 m (1 yd). Three of the six specimens are used as spare to allow for unacceptable breaks, such as caused by slippage or breaking in the clamps.

7.4 Determine the tex (denier) of the yarn for each laboratory sample using Test Method D 2591 or Test Method D 6717.

8. Preparation of Apparatus

8.1 Prepare and verify the calibration of the tensile testing machine as directed in the manufacturer's instructions.

8.2 Set up and adjust the CRE-type tensile testing machine as follows:

8.2.1 Examine the acrylic jaw face of the clamps for wear and replace as needed. Position the clamp faces with their contact line horizontal.

8.2.2 Set the distance between clamps, (gage length) to 50 ± 1 mm (2 ± 0.05 in.), nip to nip.

NOTE 2—A convenient technique for checking the gage length is to place a piece of carbon paper and white paper in the clamps and close the clamps. The distance between the marks made on the white paper by the carbon paper represents the set gage length.

8.2.3 Use a force measuring system such that the breaking force will fall between 30 and 80 percent of its full scale capacity.

8.2.4 Set the crosshead speed to 500 mm/min (20 in./min) or 1000 % extension per min.

8.2.5 Set the extension measuring system as follows:

8.2.5.1 When using a chart recorder, set the chart speed to 500 mm/min (20 in./min). Not needed with computer interfaced testing machines.

8.2.5.2 When using an interfaced computer or microprocessor, set parameters to obtain selected properties using supplier's directions and Specification D 76.

8.2.6 Set air pressure for pneumatic clamps to 415 kPa (60 psi). At this pressure, the clamping force is approximately 450 N (100 lb).

9. Conditioning

9.1 No preconditioning is required. for currently produced rubber yarns and other elastomeric yarns.

9.2 Condition the specimens relaxed on specimen boards in the standard atmosphere for testing textiles as directed in Practice D 1776 which is 21 ± 1°C (70 ± 2°F) and 65 ± 2 % relative humidity for a minimum of 4 h.

10. Procedure

10.1 Test the relaxed specimens in the standard atmosphere for testing textiles.

NOTE 3—The force measuring system should be zeroed prior to running any specimens and periodically during the course of the test, particularly if drift is observed in the zero value of the force measuring system.

10.2 Select the appropriate pretensioning weight based on the linear density of the yarn that will provide a 30 to 50 mN/tex (0.3 to 0.5 mgf/d) tension to the yarn.

10.3 Attach the selected tensioning weight (10.2) to the specimen such that when the specimen is place in the lower clamp, the tensioning weight will hang freely.

10.4 Position a specimen centrally between the top clamp faces and close the clamp. Ensure that the tensioning weight is hanging freely below the botton clamp.

10.5 Close the lower clamp and remove the tensioning weight.

10.6 Start the tester and observe the specimen behavior. Record the breaking force when the first filament break is observed.

10.6.1 If the specimen breaks within 3 mm (0.13 in.) of either jaw, or the slippage is indicated by a leveling in the force direction with abnormally high elongation, discard the result and test another specimen from the same package.

10.6.2 If many specimens exhibit what appears to be slippage, replace the acrylic jaw face and retest.

10.7 Remove the specimen and continue testing until a total of 3 specimens have been tested for each laboratory sampling unit.

11. Calculation or Interpretation of Results

11.1 *Force at First Filament Break*—Calculate the Force at First Filament Break (FFB) as follows:

11.1.1 Read the force at FFB value to the nearest 0.1 cN (0.1 gf) from the force elongation curve and record the value.

NOTE 4—In elastomeric yarns, FFB is the first on the force-elongation curve that is followed by a drop in force of at least 5 % of the force at that point for this specimen or the equivalent in a computer algorithm.

11.1.2 Calculate the average force at FFB for each laboratory sampling unit and for the lot.

11.2 *Tenacity at First Filament Break*—Calculate the Tenacity at First Filament break as follows:

11.2.1 Calculate the tenacity at FFB for each specimen to the nearest 0.1 cN/tex (0.01 gf/d), using Eq 1.

$$T = F/D \qquad (1)$$

where:
T = tenacity at FFB, cN/tex (gf/d),
F = force at FFB, cN (gf), and
D = average linear density, tex (denier).

11.2.2 Calculate the average breaking tenacity for each laboratory sampling unit and for the lot.

11.3 *Percent Elongation at First Filament Break*—Calculate the Percent Elongation at First Filament Break as follows:

11.3.1 Read the elongation at the force at FFB value for each specimen to the nearest 0.1 % from the force-elongation curves.

11.3.1.1 If force-extension curves are used, determine the extension corresponding to the force at FFB and calculate the percent elongation at FFB, using Eq 2.

$$E = 100 \times L/G \qquad (2)$$

where:
E = elongation at FFB, %,
L = the extension (distance on the extension axis from the origin to the extension line corresponding to the force at FFB), mm (in.), and
G = the nominal gage length, mm (in.).

11.3.2 Calculate the average percent elongation at FFB for each laboratory sampling unit and for the lot.