



Designation: D 2970/D 2970M – 98^{ε1}

Standard Test Methods for Testing Tire Cords, Tire Cord Fabrics, and Industrial Yarns Made From Glass Filaments¹

This standard is issued under the fixed designation D 2970/D 2970M; 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 reappraisal. A superscript epsilon (ε) indicates an editorial change since the last revision or reappraisal.

^{ε1} NOTE—The designation was corrected in September 1999.

1. Scope

1.1 These test methods cover the testing of industrial yarns made of glass filaments, cords twisted from such yarns, and fabric woven from such cords—products that are made specifically for use in the manufacture of pneumatic tires. By agreement, these test methods may be applied to similar glass yarns and cords used for reinforcing other rubber goods and for other industrial applications. The yarn or cord may be wound on cones, tubes, bobbins, spools, or beams, woven into fabric, or in other forms. These test methods include testing procedures only. These test methods do not include specifications or tolerances.

1.2 No procedure is included for the determination of fatigue resistance of cords, but several articles relating to the measurement of fatigue resistance of cords made from man-made filaments and cured in rubber were published in the bibliography of Test Methods D 885.²

1.3 The following sections are included:

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1.4 These test methods show the values in both SI units and in inch-pound units. “SI units” is the technically correct name for the system of metric units known as the International System of Units. “Inch-pound units” is the technically correct name for the customary units used in the United States. The values stated in either acceptable metric units or other units shall be regarded separately as standard. The values expressed in each system may not be exact equivalents; therefore, each system must be used independently of each 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 Textiles³
- D 123 Terminology Relating to Textile³
- D 578 Specification for Glass Fiber Strands³
- D 885 Methods of Testing Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Man-Made Organic-Base Fibers³
- D 1423 Test Method for Twist in Yarns by the Direct-Counting Method³
- D 2258 Practice for Sampling Yarn for Testing³
- D 4393 Test Method for Strap Peel Adhesion of Reinforcing Cords or Fabrics to Rubber Compounds⁴
- D 4848 Terminology of Force, and Deformation Properties of Textiles⁴

3. Terminology

3.1 Definitions:

- 3.1.1 *breaking force, n*—the maximum force applied to a

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NOTE: D 2970 and D 2970 M were combined editorially with no change in technical requirements in September, 1998.

² 1967 *Annual Book of ASTM Standards*, Part 24, and earlier issues of Test Method D 885.

³ *Annual Book of ASTM Standards*, Vol 07.01.

⁴ *Annual Book of ASTM Standards*, Vol 07.02.

material carried to rupture.

3.1.1.1 *Discussion*—Materials that are brittle usually rupture at the maximum force. Materials that are ductile usually experience a maximum force before rupturing. It has been the usual practice in the tire and related industries to characterize yarn and cord of a specified size and type without any reduction to unit size. Numerically, *breaking strength* is equal to *breaking force* for the same specimen. The average of the *breaking force* observed on two or more specimens of a specific sample is referred to as the sample breaking strength, that is the property used in engineering calculations for a specific textile material. *Tensile strength* and *breaking tenacity* are derived or calculated values that characterize a type or class of material reduced to unit size. These terms can be used to compare intrinsic strengths of yarns and cords of different materials. The term *tensile strength* in Mpa (psi), is not synonymous with either *breaking force* or *breaking* in N (lbf), or *breaking tenacity* in mN/tex (gf/den).

3.1.2 *breaking tenacity, n*—the tenacity at the breaking force.

3.1.3 *catenary length, n*—the difference between the length of the shortest and the longest component in a plied yarn or cabled cord after twisting.

3.1.4 *cord twist, n*—the amount of twist in a cord made from two or more single or plied yarns.

3.1.4.1 *Discussion*—*Cord twist* is expressed as the number of turns divided by the length of the untwisted cord.

3.1.5 *dip, n*—a chemical composition that is applied to a textile cord or fabric to improve its adhesion to rubber or other elastomer.

3.1.6 *dip pick-up, n*—in *glass cords*, the amount of dip solids present as supplied.

3.1.7 *fabric, n*—a planar structure consisting of yarns or fibers.

3.1.7.1 *Discussion*—For fabrics made of tire cord, consists of tire cord warp yarns with widely spaced singles filling yarn.

3.1.8 *industrial yarn, n*—a yarn composed of continuous filaments, usually of high breaking tenacity, produced with or without twist, and intended for applications in which functional properties are of primary importance; for example, in reinforcing material in elastomeric products (tires, hose, belting), in protective coverings, and in cordage and webbing, etc.

3.1.9 *initial modulus, n*—the slope of the initial straight portion of a stress-strain (or force-elongation) curve.

3.1.9.1 *Discussion*—For tire cords, modulus is force divided by elongation.

3.1.10 *standard atmosphere for testing textiles, n*—laboratory conditions for testing fibers, yarns, and fabrics in which air and relative humidity are maintained at specific levels within established tolerances.

3.1.10.1 *Discussion*—Air is maintained at a relative humidity of $55 \pm 2\%$ and at a temperature of $24 \pm 1^\circ\text{C}$ ($75 \pm 2^\circ\text{F}$) for this test method.

3.1.11 *tabby sample, n*—the section of tire cord fabric between two tabbies that have been woven separately with a distance of 0.5 to 1.0 m (18 to 36 in.) between them.

3.1.12 *tensile strength, n*—the strength of a material under tension as distinct from compression, torsion, or shear.

3.1.12.1 *Discussion*—Technically, strength is a characteristic that is expressed in terms of force. Historically, however, tensile strength has been commonly expressed in terms of force per unit base; for example, the cross-sectional area of the unstrained material. Some common units are Pascal (Pa) which is newtons per square meter (N/m^2) and pounds-force per square inch (psi). See Section 3.1.1.1.

3.1.13 *tire cord, n*—a twisted or formed structure composed of one or more single or plied filaments, strands, or yarns of organic polymer or inorganic material.

3.1.14 *tire cord fabric, n*—a fabric consisting of tire cord warp with widely spaced (usually 40 to 200 picks/m (1 to 5 picks/in.)) single yarn filling.

3.1.15 For definitions of terms related to force and deformation in textiles, refer to Terminology D 4848. For definitions of other terms related to textiles, refer to Terminology D 123.

3.2 *Abbreviation:*

3.2.1 *CRE*—constant-rate-of-extension.

4. Summary of Test Methods, General

4.1 A summary of the directions prescribed for the determination of specific properties is stated in the appropriate sections of specific test methods or the referenced standard.

5. Significance and Use

5.1 The procedures in these test methods may be used for the acceptance testing of commercial shipments, but caution is advised because technicians may fail to get good agreement between results on certain yarns, cords, or fabrics. Comparative tests as directed in Section 5.1.1 may be advisable.

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, test samples should be used that are as homogeneous as possible, that are drawn from the material from which the disparate test results were obtained, and that are randomly assigned in equal numbers to each laboratory for testing. Other materials with established test values may be used for this purpose. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If a bias is found, either its cause must be found and corrected, or future test results must be adjusted in consideration of the known bias.

5.2 The significance and use of particular properties are discussed in the appropriate sections of the specific test methods.

SAMPLING AND CONDITIONING

6. Yarn and Cord

6.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of shipping cases or beams directed in an applicable material specification or Practice D 2258. Consider shipping cases to be the primary sampling unit.

6.2 *Laboratory Sample:*

6.2.1 *Yarn or Cord in Cases*—As a laboratory sample for acceptance testing, select packages at random from each

shipping case in the lot sample. Take the number of packages for the laboratory sample as directed in an applicable material specification or Practice D 2258. Preferably, the same number of packages should be taken from each shipping case in the lot sample. If differing numbers of packages are to be taken from shipping cases in the lot sample, determine at random which shipping cases are to have each number of packages drawn from them.

6.2.2 Yarn on Beams—As a laboratory sample for acceptance testing, select ends at random from each beam in the lot sample. Take the number of ends for the laboratory sample as directed in an applicable material specification or Practice D 2258. Wind the laboratory samples on a tube or spool using a winder with a tension of 5 ± 1 mN/tex (0.05 ± 0.01 gf/den) using the general technique directed in Practice D 2258.

6.2.2.1 Take laboratory samples from the outside of the beams unless there is a question or disagreement about a shipment. In that case, take laboratory samples after removing a radial depth of 6 mm ($\frac{1}{4}$ in.) or more to minimize the effects of handling and atmospheric changes that occurred during shipment or storage. Place the laboratory samples in a moisture resistant container to protect them from atmospheric changes until the yarn is conditioned in the atmosphere for testing tire cords and industrial yarns.

6.3 Test Specimens—Take the number of specimens from each laboratory sampling unit as directed in each test method.

6.3.1 Preparation of Specimens—Unwind and discard at least six layers of yarn or cord from the package to eliminate ultraviolet and physically damaged material (except from beams). If specimens are not taken directly from the original package, it is advisable to wind the sample on a tube or spool by means of a winder using a tension of 5 ± 1 mN/tex (0.05 ± 0.01 gf/den). If the specimen is collected as a loosely wound package, or in the form of a skein, report that the observed results were determined on a relaxed sample. Use care in handling the specimen. Discard any specimen subjected to any change of twist, kinking or making any bend with a diameter less than 6 mm ($\frac{1}{4}$ in.). Place the specimen in a moisture resistant polyethylene bag or other moisture resistant container to protect it from atmospheric changes until ready to condition in the atmosphere for testing industrial yarns and tire cords.

6.3.2 If the yarn or cord has been treated with a resorcinol-formaldehyde-latex (RFL) type adhesive, samples should be protected against exposure to ultraviolet light, high humidity (over 60 % relative humidity) and high temperature (over 38°C (100°F)).

7. Tire Cord Fabric

7.1 Lot Sample—As a lot to be sampled for acceptance testing, take tire cord fabric comprising only one loom creel. As a primary sampling unit, select one roll of fabric from the lot and prepare tabby sample to yield the laboratory sampling units as directed in Section 7.2.

7.2 Preparation of Laboratory Sample—Take a sample equal to the length of cord between the regular tabby woven at the end of the roll and a special tabby woven a short distance from the end when the roll of fabric is manufactured. For rolls that do not have a special woven tabby, improvise a tabby by the use of gummed tape or strips of cemented fabric applied

across a section of the cord fabric. The length of the tabby sample shall be as agreed upon by the purchaser and the supplier. The recommended minimum is 0.5 m (18 in.). The width of the sample shall be at least one tenth of the roll width. Cut the warp cords of the fabric along the center line of the special tabby across for a distance equal to the width of the required sample. If this distance is less than the full width of the fabric, cut the filling yarns of the sample and of the special and regular tabbies in the direction parallel with the warp cords. The resulting section of cord fabric is the tabby sample. Attach the tabby sample to a piece of cardboard or fiber board, the length of which shall be equal to at least the length of the cord warp between tabbies. Fold the tabby portions of the sample over each end of the board, and secure the sample to the board with pressure-sensitive tape or staples. Use care to avoid contact of tape or staples with the area to be tested. Handle the sample carefully and hold it under sufficient tension in the warp direction to prevent the cords from kinking. The board with the sample may be folded lengthwise and parallel with the warp for convenience. Place the board with the fabric sample in a polyethylene bag, or wrap it with several layers of polyethylene film to protect the sample from changes in atmospheric moisture content until ready to condition in the atmosphere for testing industrial yarns and tire cords. Use care during subsequent handling of the sample to prevent any change in the cord twist and to avoid kinking of the cords in the area to be tested.

7.3 Test Specimens—Take the number of specimens at random from each laboratory sampling unit as directed in each of the specific test methods.

8. Conditioning

8.1 Bring all specimens of yarn, cord, and fabric to moisture equilibrium for testing in the atmosphere for testing industrial yarns and tire cords.

TENSILE PROPERTIES OF YARNS AND CORDS

9. Scope

9.1 These tests are used to determine the tensile properties of yarns and cords.

10. Summary of Test Method

10.1 A continually increasing force is applied longitudinally to a conditioned specimen of yarn or cord placed in the clamps of a tensile testing machine until broken. The breaking force and elongation are observed depending upon the option employed. Two clamping options are provided: Option 1, drum clamp; and Option 2, pneumatically-operated clamps having fixed snubbing surfaces that are integral with one of the clamping surfaces. Elongation and modulus are calculated from the force-extension curve when using Option 2. Breaking tenacity is calculated using yarn number.

11. Significance and Use

11.1 In some laboratories, the output of the CRE-type of tensile testing machine may be connected with electronic recording and computing equipment that may be programmed to calculate and print the results of tests for each required property. Because of the variety of electronic equipment

available, and the various possibilities for recording test data, use of this type of equipment is not covered in this test method.

11.2 The levels of tensile properties obtained when testing industrial yarns and tire cords are dependent to a certain extent on the age and history of the sample and on the specific conditions used during the test. Among these conditions are rate of tensioning, type of clamps, gage length of specimen, temperature and humidity of the atmosphere, rate of airflow across the specimen, and temperature and moisture content of the specimen. Testing conditions accordingly are specified precisely to give reproducible test results on a specific sample.

11.3 Because the load-bearing ability of a reinforced rubber product is related to the strength of the yarn or cord used as a reinforcing material, breaking strength is used in engineering calculations when designing various types of textile reinforced rubber products. When intrinsic strength characteristics of yarns and cords of different sizes or different types of fiber are to be compared, breaking tenacity is very useful, because for most types of fiber, breaking force is approximately proportional to linear density.

11.4 The drum clamp option gives a more accurate measure of strength since it minimizes the effect of clamping and is recommended when strength only is required. Elongation and modulus are not readily measured by this option.

11.5 The pneumatic-type clamp option provides for the measurement of strength, elongation, and modulus. However, the strength of the yarn or cord may be lower and subject to greater variation due to the effect of clamping.

11.6 Elongation of yarn or cord is taken into consideration in the design and engineering of reinforced rubber products because of its effect on uniformity of the finished product and its dimensional stability during service.

11.7 Modulus is a measure of the resistance of yarn or cord to extension as a force is applied. It is useful for estimating the response of a textile-reinforced structure to the application of varying force and its rate. Although modulus may be determined at any specified force, initial modulus is the value most commonly used.

11.8 It should be emphasized that, although the preceding parameters are related to the performance of a textile-reinforced product, the actual configuration of the product is significant. Shape, size, and internal construction also can have appreciable effect on product performance. It is not possible, therefore, to evaluate the performance of a textile reinforced product in terms of the reinforcing material alone.

12. Apparatus

12.1 *Tensile Testing Machine*—A single-strand CRE-type tensile testing machine. The specifications and methods of calibration and verification of this machine shall conform to Specification D 76. The testing machine shall be suitable for operation at a rate of crosshead travel not to exceed response of the read-out device to follow force and speed changes. The machine shall be equipped with an autographic recorder (rectilinear coordinates preferred) or digital read-out.

12.1.1 In these test methods, a machine speed of 5 ± 0.2 mm/s (12 ± 0.5 in./min) is specified.

12.2 Clamps:

12.2.1 *Option 1, Drum Clamps*, (1800 to 2200 N (400 to

500 lb) capacity)—see Fig. 1 for clamps that conform to the drawing in Fig. 2. The clamps must be equipped with rubber sleeves, 50-55 Type A Durometer, 1.6 by 50.0 wide by 90.0 mm diameter (0.0625 by 2.0 wide by 3.5 in. diameter). Check each rubber sleeve for Type A hardness to ensure conformance to the 50-55 Durometer requirement.

12.2.2 *Option 2, Pneumatic-Type Clamps*, having fixed snubbing surfaces that are integral with one of the clamping surfaces. The snubbing surfaces may be circular with a diameter not less than 12.5 mm (0.5 in.) or semi-involute.

13. Procedure for Breaking Strength (Force) of Conditioned Yarns and Cords

13.1 Option 1, Drum Clamps:

13.1.1 *Number of Specimens*—Determine the breaking force of ten specimens from each lot sampling unit.

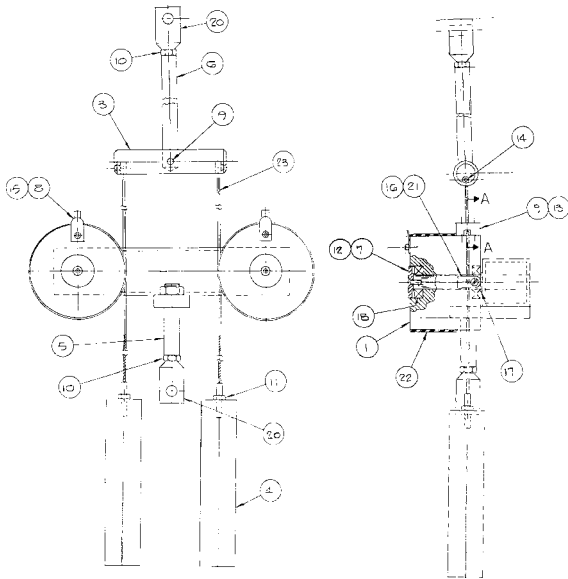
13.1.2 *Preparation of Apparatus*—Select a force scale such that the estimated breaking force of the specimen will fall in the range from 10 to 90 % of the full scale range in use. The range selected must be capable of handling twice the strength of the material. Insert the drum clamps in the tensile testing machine so that the spring steel cord clamping clip on the left drum is at approximately an eleven o'clock position. Adjust, if necessary, by turning the top thread rod in the direction required to bring the clip to the appropriate position. The cables that support the counterweights should pass in front of the cables connected to the yoke. The distance between the drums is fixed at 200 mm (8 in.), center to center. Examine rubber sleeves and replace as required (see Note 1). In these test methods, set the rate of crosshead travel to 5 ± 0.2 mm/s (12 ± 0.5 in./min). This results in a strain rate of 10 mm/s (24 in./min) applied to the specimen.

NOTE 1—With use, glass fibers may become entrapped in the rubber sleeves and contribute to low breaking force values. Replace rubber sleeves when test values tend to be different from normal for the material under test.

13.1.3 *Procedure*—Place the sample cord package on a suitable unwinding spindle located to the right of the drum clamps. Unwind and discard enough yarn or cord from the package to ensure that the undamaged yarn or cord is being tested. If there is any question that the cord has been damaged during conditioning or in subsequent handling, discard. Grasp the loose cord end and secure it in the spring clip on the left drum with the loose end hanging out the left side of the clip. Wrap the cord three times around the drum in a clockwise



FIG. 1 Drum Clamps—Option One



METRIC SIZES

DET	ITEM	QTY	DESCRIPTION	Material
1	A	2	BAR 102 mm (Diameter × 76 mm LG	STEEL
2	B	1	Tubing 50 mm sq × 3.2 mm W × 248 mm LG	STEEL
	C	2	50 mm × 50 mm × 3.2 mm	STEEL PL
	D	2	BAR 16 mm Diameter × 125 mm LG	STEEL
	E	1	33 mm × 86 mm × 13 mm	STEEL BAR
3	F	1	25 mm Diameter × 120 mm LG	STEEL BAR
4	G	2	38 mm Diameter × 178 mm LG	STEEL BAR
5	H	1	16 mm Diameter × 76 mm LG	STEEL BAR
6	J	1	16 mm Diameter × 330 mm LG	STEEL BAR
7	K	2	35 mm Diameter × 4.8 mm LG	STEEL BAR
8	L	2	25 mm × 13 mm × 3.04 mm	BLUE SPRING STEEL
9	M	2	25 mm × 13 mm × 7.9 mm	STEEL BAR
10	...	2	HEX. JAM NUT 10 mm-1.5	CHROME PLATED
11	...	2	HEX. JAM NUT 6 mm-1	CHROME PLATED
12	...	2	FLAT SOCHD. SCR #10-0.7150 × 13 mm	...
13	...	4	SOC. HD. CAPSCR. 5 mm-0.8150 × 13 mm	...
14	...	2	SOC. HD. SETSCR 6 mm-1.0150 × 6 mm	...
15	...	2	SOC. HD. CAPSCR. 3 mm-0.5150 × 6 mm	...
16	...	2	ROUND HD. SCR. #10-0.7150 × 10 mm	CAD PLATE
17	...	2	"BOSTON" WASHER #18838	16 mm I.D. × 1.6 mm T 16 mm I.D.
18	...	4	"NICE" BEARING C10-D5	...
19	...	1	HARDENED STEEL PIN 6 mm φ × 25 mm	...
20	...	2	"SCOTT" QCC-1 PREC. SCIEN. FITT.	...
21	...	2	"H.H. SMITH 4.8 mm NYLON CLAMP	#8956
22	...	2	SLEEVE - "CASTLE RUBBER CO."	...
23	...	2	CABLE ASSY-MACWHYTE CO.	...

FIG. 2 Drawing for Drum Clamps for Option One Tensile Properties Procedure

manner. Try to keep the cord wraps parallel to the front of the drum and parallel to each other. Do not cross the cord. Extend the cord over the right drum and wrap clockwise three times in a similar manner as the left drum. Keep the cord taut when wrapping. Then, secure the cord on the front of the right drum with the spring clip. Do not touch with the bare hand that portion of the specimen that will be between the drums. Handle in such a manner that no change in twist can occur prior to securing to the drums. Use more wraps if necessary to prevent the cord from slipping out of the clips during the test. If in

handling, the cord sample is kinked, scraped, untwisted or otherwise damaged, discard the specimen. Operate the testing machine at the specified rate. When the specimen breaks, read the breaking force to the nearest 0.5 N (0.1 lbf) from the recording chart, dial, or by electronic means.

13.1.4 Calculation

13.1.4.1 Calculate the breaking force of individual specimens to the nearest 0.5 N (0.1 lbf) using Eq 1:

$$B = F/2 \quad (1)$$

where:

B = breaking force, N (lbf), and
F = observed breaking force, N (lbf).

13.1.4.2 Calculate the average breaking strength for the lot to the nearest 0.5 N (0.1 lbf).

13.1.5 Report

13.1.5.1 State that the specimens were tested as directed in Section 13.1, Option 1, of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

13.1.5.2 Report the number of specimens tested and the breaking strength for the lot.

13.1.6 Precision and Bias—See Sections 25-27.

13.2 Option 2, Pneumatic Clamps:

13.2.1 Procedure—Determine the breaking force of five individual specimens as directed in the breaking strength procedure described in Test Methods D 885.

13.2.1.1 Because of the tendency of glass cords and yarns to break at the nips or on the snubbing surfaces, it is necessary to keep the clamp surfaces in good condition. Frequent cleaning with a solvent, and polishing are recommended. In some cases it has been found helpful to use jaw liners made from vinyl or leather strips, or to apply rosin or soap-stone to the ends of the specimen before they are inserted in the clamps. Clamp faces coated with urethane have been used satisfactorily to minimize slippage and jaw breaks.

13.2.2 Report

13.2.2.1 State that the specimens were tested as directed in Section 13.2, Option 2, of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

13.2.2.2 Report the number of specimens tested and the breaking strength for the sample.

13.2.3 Precision and Bias—See Sections 25-27.

14. Breaking Tenacity of Conditioned Yarns and Cords

14.1 Calculation

14.1.1 Calculate the breaking tenacity of the lot to the nearest 10 mN/tex (0.1 gf/den), from the average breaking force and the average yarn number of the dipped glass (as determined in Section 19) using Eq 2:

$$BT = [S \times (P + 100) / LD] \times 100 \quad (2)$$

where:

BT = breaking tenacity, mN/tex (gf/den),
S = average breaking force of the conditioned specimens, N (gf),

LD = average yarn number of the conditioned specimens, tex (denier), and
 P = dip pickup, %, (see Section 23).

14.2 Report

14.2.1 State that the specimens were tested as directed in Section 14 of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

14.2.2 Report the number of specimens tested and the breaking tenacity for the lot.

15. Elongation at Break of Conditioned Yarns and Cords

15.1 Determine the elongation at break of the conditioned glass yarns and cords as directed in the corresponding section of Test Methods D 885.

15.2 Calculation

15.2.1 Calculate the observed elongation of each specimen to the nearest 0.1 % based on its nominal gage length.

15.2.2 Calculate the average elongation for the lot to the nearest 0.1 %.

15.3 Report

15.3.1 State that the specimens were tested as directed in Section 15 of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

15.3.2 Report the number of specimens tested and the elongation at break for the lot.

15.4 *Precision and Bias*—See Sections 25-27.

16. Initial Modulus of Conditioned Yarns and Cords

16.1 Determine the initial modulus of the conditioned glass yarns and cords as directed in the corresponding section of Test Methods D 885.

16.2 Calculation

16.2.1 Calculate the initial modulus of each specimen to the nearest 10 mN/tex (0.1 gf/den) using Eq 3:

$$M_i = [B \times (P + 100)] / (E \times LD) \quad (3)$$

where:

M_i = initial modulus, mN/tex (gf/den),

B = average breaking force of the conditioned specimens, mN (gf),

P = dip pickup, % (see Section 23),

E = breaking elongation obtained by extrapolation of the tangent of the initial portion of the force-extension curve to the force axis, %, and

LD = average yarn number of the conditioned specimens, tex (denier).

16.2.2 Calculate the average initial modulus for the lot to the nearest 10 mN/tex (0.1 gf/den).

16.3 Report

16.3.1 State that the specimens were tested as directed in Section 16 of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

16.3.2 Report the number of specimens tested and the initial modulus for the lot.

16.4 *Precision and Bias*—See Section 25-27.

17. Report, Tensile Properties, General

17.1 State that the tensile property tests were made as directed in Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

17.2 Report the following information:

17.2.1 test option used,

17.2.2 type of clamp used,

17.2.3 air pressure and padding material, if used,

17.2.4 rate of recording chart, if applicable,

17.2.5 the number of specimens tested, and,

17.2.6 Any modifications to this test method.

OTHER PROPERTIES OF GLASS YARNS AND CORDS

18. Construction of Yarns and Cords

18.1 Determine the construction of yarn or cord as directed in Specification D 578, except condition the cords in the atmosphere for testing tire cords and industrial yarns.

19. Yarn Number of Dipped Yarns and Cords

19.1 *Procedure*—Determine the yarn number of both yarns and cords in tex (yd/lb) as directed in Specification D 578 test method for yarn number, except do not dry the specimen in a muffle furnace.

20. Twist in Yarns and Cords

20.1 Determine the twist in single yarn, plied yarn, and tire cord as directed in Test Method D 1423, except use a tension of 10 to 20 mN/tex (0.1 to 0.2 gf/den) on the specimen, based on the yarn number of the yarn or cord. When all but one of the components of the untwisted cord have been cut prior to the determination of the twist of an individual component, leave the total mass unchanged even though the total force applied per unit yarn number in the single component will be higher than in the original plied yarn or cord. Record the length of the single component after all but one of the cord components have been cut from the untwisted cord. Remove the twist from the component and calculate the amount of twist using Eq 6 of Test Method D 1423.

20.1.1 When calculating twist of single yarn or strand component of a cord, use the length of the specimen noted after all but one of the components have been cut from the untwisted cord.

20.1.2 Due to the adhesion of the filaments of resorcinol-formaldehyde-latex (RFL) treated yarns and cords, it is not always feasible to determine accurately the twist in a single component in a plied yarn or cord.

20.2 Report

20.2.1 State that the specimens were tested as directed in Section 20 of Test Methods D 2970. Describe the material(s) or product(s) sampled and the method of sampling used.

20.2.2 Report the number of specimens tested and the twist for the lot.

20.3 *Precision and Bias*—See Sections 25-27.

21. Thickness of Cords

21.1 Determine the thickness of cords as directed in the corresponding section of Test Methods D 885.

22. Count, Width, and Mass of Tire Cord Fabric

22.1 Determine the count, width and mass of the fabric made from glass cord as directed in the sections on these properties of tire cord fabric of Test Methods D 885.