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Standard Test Methods for Steel Tire Cords[1]

This standard is issued under the fixed designation D2969; 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 These test methods cover the testing of cords made from steel that are specifically designed for use in the reinforcement of pneumatic tires. By agreement, these test methods may be used to test similar cords or filaments used for reinforcing other rubber products. The steel cords may be wound on spools or beams. The steel cords may also be woven into fabric, in which case they must be removed from the fabric prior to testing.

NOTE 1—For other methods of testing tire cords and tire cord fabrics, refer to Methods D885, Test Methods D1871, Specifications D122, and Test Methods D2692 and D2970/D2970M. For tolerances on tire cords and tire cord fabrics, refer to Specifications D122 and Methods D885.

1.2 These test methods include test procedures only; they do not establish specifications or tolerances.

1.3 This test method includes the following sections:

Subject	Section
Adhesion of Steel Cords and Filaments to Elastomers	16
Brass Coating Composition and Mass	14, 15
Breaking Force (Strength)	10
Construction	12
Data Form for Reporting Test Results	Appendix X1
Elongation at Break	10
Elongation Between Defined Forces (EDF)	11
Flare	8
Lay	12
Linear Density	9
Visual Appearance	8
Nomenclature System	Annex A1
Residual Torsions	8
Straightness	8
Thickness and Out-of-Roundness	13

1.4 *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.* See 14.3 and Note 11.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles

D122 Tolerances for Tire Fabrics Other Than Tire Cord Fabrics (Withdrawn 1993)[3]

D123 Terminology Relating to Textiles

D885 Test Methods for Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers

D1871 Test Method for Adhesion Between Tire Bead Wire and Rubber

D2229 Test Method for Adhesion Between Steel Tire Cords and Rubber

D2692 Test Method for Air Wicking of Tire Fabrics, Tire Cord Fabrics, Tire Cord, and Yarns

D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data (Withdrawn 2008)[3]

D2970/D2970M Test Methods for Testing Tire Cords, Tire Cord Fabrics, and Industrial Yarns Made From Glass Filaments

D4393 Test Method for Strap Peel Adhesion of Reinforcing Cords or Fabrics to Rubber Compounds

D6477 Terminology Relating to Tire Cord, Bead Wire, Hose Reinforcing Wire, and Fabrics

E663 Practice for Flame Atomic Absorption Analysis (Withdrawn 1997)[3]

2.2 *International Bureau for the Standardization of Man-Made Fibers (BISFA):*

Internationally Agreed Methods for Testing Steel Tire Cords[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms relating to tire cord, bead wire, hose wire, and tire cord fabrics, refer to Terminology D6477.

[1] These test methods are under the jurisdiction of ASTM Committee D13 on Textiles and are the direct responsibility of Subcommittee D13.19 on Industrial Fibers and Metallic Reinforcements.

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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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from BISFA, Lauren Garten Strasse 12, PO Box, CH-4010 BASLE Switzerland.

3.1.1.1 The following terms are relevant to this standard: core, direction of lay, flare, high elongation, in steel tire cord, length of lay, residual torsion, steel cord, steel cord wrap, steel filaments, steelstrand, straightness, in steel cord, and wildness.

3.1.2 For definitions of other terms related to textiles, refer to Terminology D123.

3.1.2.1 The following terms are relevant to this standard: direction of twist.

4. Summary of Test Method

4.1 A summary of the test methods prescribed for the determination of specific properties is stated in each of the sections pertaining to the respective properties.

5. Significance and Use

5.1 The procedures in Test Methods D2969 for the determination of the properties of steel tire cord and related materials are considered satisfactory for acceptance testing of commercial shipments of such products because the procedures are the best available and have been used extensively in the trade. When a purchaser frequently uses a specific supplier, it is recommended that the two parties investigate the methods to determine if there is any bias between their two laboratories as directed in 5.1.1.

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 purchaser and the supplier 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. 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 the appropriate statistical analysis and an acceptable probability level chosen by the two parties before 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 The significance and use of particular properties are discussed in the appropriate sections.

6. Sampling

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

NOTE 2—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between cartons of cords and between spools or other packages within a carton, or the variability between and within rolls of fabric so as to provide a sampling plan with meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

6.2 *Laboratory Sample*—As a laboratory sample for acceptance testing, proceed as follows:

6.2.1 For cords, take at random the number of spools or other packages per carton as directed in the applicable material specification or other agreement between the purchaser and the supplier.

6.2.2 For fabric, take a full-width swatch 1 m long from the end of each roll in the lot sample, after first discarding a minimum of 1 m of fabric from the outside layer of the roll (see 6.2.3).

6.2.3 Place each laboratory sampling unit in a moisture-proof container to protect it from atmospheric corrosion and contamination.

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

6.4 *Specimen Preparation*—For cords, when practical, perform tests on specimens taken directly from the spools or other packages in the laboratory sample.

7. Conditioning

7.1 Conditioning of materials covered by these test methods has not been found necessary, except to maintain cleanliness.

8. Visual Appearance, Residual Torsion, Straightness, Flare

8.1 *Scope*—This test method covers the visual examination of steel cord for appearance and test procedures for residual torsion, straightness, and flare.

8.2 *Significance and Use*—Physical properties of steel tire cord may be affected by the methods of manufacturing and handling procedures. Cleanliness has a direct effect on the adhesion of steel tire cord to elastomers.

8.3 One specimen is taken from each laboratory sampling unit for residual torsion, flare, and straightness. Specimens for other tests may be used for visual appearance.

8.4 *Procedures:*

8.4.1 *Residual Torsion*—Determine residual torsion by removing at least 3 m of cord from the package, cutting it off, and discarding it. Make a right angle bend about 25 mm from the cord end on the package. Hold this bent end tightly so that it cannot turn while pulling out a specimen having a length of 6 ± 0.2 m. Pull the specimen from the package in such a manner that does not change the residual torsions of the specimen from that of the cord on the package. Release the free end of the cord and allow this end to rotate while the cord is free of external tension. Count and record the number of rotations of the cord end to the closest one-half rotation and, viewing the cord from the bent end toward the package, denote clockwise rotations as positive (+) and anti-clockwise rotations as negative (–).

8.4.1.1 Calculate the average residual torsion for the lot.

8.4.2 *Straightness*—Without cutting the specimen from the package, pull out a length of cord 6± 0.2 m and lay it on a smooth, hard surface and allow it to rotate freely. With no tension applied to the cord, place the cord specimen approximately equidistant from two straight parallel lines spaced at a distance of 75 ± 3 mm. If the specimen does not touch both lines consider the specimen straight. Record the observation.

NOTE 3—It is common practice to make residual torsion and straightness observations on the same specimen. Residual torsion is measured first, then straightness.

8.4.3 *Flare*—Cut a straight section of cord (not less than 100 mm) using cutters[5] held at right angles to the axis of the specimen and measure to the nearest 1 mm of the distance along the longitudinal axis that any filament or strand unravelled. Record this distance.

8.4.3.1 Calculate the average flare for the lot.

8.4.4 *Contamination*—Make a visual inspection of the specimen taken as directed in 8.4.1, 8.4.2, or 8.4.3 and record the presence of any dirt, rust, oil, or any other foreign material. Also look for and record any pitting, including rough spots. A visual inspection of the package and its integrity may be included, if appropriate.

8.5 *Report*—State that the inspection of visual appearance was made in accordance with Section 8 of Test Methods D2969. Describe the material sampled and the method used for sampling and report the following information:

8.5.1 *Residual Torsion,* for each sampling unit and the lot.

8.5.2 *Straightness,* for each sampling unit and the lot.

8.5.3 *Flare,* for each sampling unit and the lot.

8.5.4 *Contamination*—Visual appearance observations for each laboratory sampling unit.

8.6 *Precision and Bias*—No justifiable statement can be made either on the precision or bias of the procedures in Test Methods D2969 for the evaluation of visual appearance because the test results merely state conformance to the criteria for success specified in the procedures.

8.6.1 Twenty cord samples of 2X.30 HT construction were measured for residual torsion and flare in accordance with 8.4.1 and 8.4.2. A single operator in a single laboratory performed the testing. A statistical analysis was used to quantify intralaboratory variability for these properties. The property flare showed a strongly right-skewed distribution, with values between 0 and 65 mm; the median value was 3 mm. Repeatability was not calculated for flare because of its non-normal distribution. Results are shown in the following:

Property	Average	S_r	Repeatability	S_R	Reproducibility
Flare	8.6	16.3	-	NA	NA
Residual Torsion	1.45	0.22	0.62	NA	NA

S_r is the intra-laboratory standard deviation. S_R, the total standard deviation, is formed by taking the square root of the sum of intra-laboratory and interlaboratory variance components. S_R cannot be determined from these data.

Method repeatability is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained in the same laboratory. Method reproducibility is defined as the "maximum difference" that can "reasonably" be expected between two test results obtained on the same material when the test results are obtained from different laboratories.

9. Linear Density

9.1 *Scope*—In this test method, a specified length of steel cord is weighed using an analytical balance and linear density is calculated as mass per unit length.

9.2 *Significance and Use*—The linear density of steel cord is used to calculate the expected mass of pneumatic tires and the various components used in their manufacture as a part of the process control procedure.

9.3 *Number and Preparation of Specimens*—Take a specimen having a minimum length of 1 m from each sample of cord (see Note 4 for high-elongation cords). For samples from fabric, use a sufficient number of ends to give a minimum length of 1 m of cord for each specimen. Measure the length of the specimen to within 0.1 % using a tension of 10 ± 1 N to keep the cord straight. Cut the specimen at the required length. Record the length.

NOTE 4—A proposed method for measuring the linear density of high-elongation cords is as follows:

(*1*) Clamp an extensometer onto the specimen that is straight, but under no tension; read the gage length L (0);

(*2*) Apply a tension of 1.5 ± 0.2 N to the cord and read the gage length, L (1);

(*3*) Calculate the extension factor, EF, as follows:

$$EF = (L(1) - L(0))/L(0) \quad (1)$$

(*4*) Calculate and report the linear density, as follows:

$$\text{Linear density, tex} = M/(L(0) \times (1 + EF)) \quad (2)$$

where:

M = mass, g,
L (0) = length, km, and
EF = extension factor.

9.4 *Procedure*—Determine the mass of the specimen of cord by weighing to the nearest 1 mg.

9.5 *Calculation*—Calculate the linear density to the nearest 10 tex using Eq 3:

$$\text{Linear density, tex} = M/L \quad (3)$$

where:

M = mass, g, and
L = length, km.

9.5.1 Calculate the average linear density for the lot.

9.6 *Report*—Report that the specimen was tested in accordance with Section 9 of Test Methods D2969. Describe the material sampled and the method of sampling used. Report the linear density for each laboratory sampling unit and for the lot.

9.7 *Precision and Bias:*

9.7.1 *Summary*—In comparing two averages of four observations, the difference between averages should not exceed 10 tex in 95 out of 100 cases when all of the observations are taken by the same well-trained operator using the same piece of test equipment and the specimens are randomly drawn from the same sample. Larger differences are likely to occur under all other circumstances.

[5] The sole source of supply of the apparatus known to the committee at this time is Felix Flisch Felco, 2206 Les Geneveys-s/Coffrane Switzerland or Loos and Co., 900 Industrial Blvd., Naples, FL 33942. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.