Designation: D7269/D7269M – 11

Standard Test Methods for Tensile Testing of Aramid Yarns[1]

This standard is issued under the fixed designation D7269/D7269M; 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 tensile testing of aramid yarns, cords twisted from such yarns, and fabrics woven from such cords. The yarn or cord may be wound on cones, tubes, bobbins, spools, or beams; may be woven into fabric; or may be in some other form. The methods include testing procedure only and include no specifications or tolerances.

1.2 The values stated in either 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 shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 This standard includes the following test methods:

	Section
Breaking Strength (Force)	11
Breaking Tenacity	12
Breaking Toughness	17
Elongation at Break	13
Force at Specified Elongation (FASE)	14
Linear Density	10
Modulus	15
Work-to-Break	16

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles
D123 Terminology Relating to Textiles
D1776 Practice for Conditioning and Testing Textiles
D1907 Test Method for Linear Density of Yarn (Yarn Number) by the Skein Method
D1909 Standard Tables of Commercial Moisture Regains and Commercial Allowances for Textile Fibers
D2258 Practice for Sampling Yarn for Testing
D4848 Terminology Related to Force, Deformation and Related Properties of Textiles
D6587 Test Method for Yarn Number Using Automatic Tester

3. Terminology

3.1 *Definitions:*

3.1.1 *slippage, n—with tensile testing*, insufficient quality of clamping, resulting in movement of the test material through the total clamping surface. This can be visualized by the movement of markers at the clamp exit, or by sudden changes in the strain-modulus curves (1st derivative of the strain-stress curve).

3.1.2 *zero twist, n*—twistless, devoid of twist.

3.2 The following terms are relevant to this standard: industrial yarn, moisture equilibrium for testing, aramid, zero twist, standard atmosphere for testing textiles.

3.3 For definitions of terms related to force and deformation in textiles, refer to Terminology D4848.

3.4 The following terms are relevant to this standard: breaking force, breaking strength, breaking tenacity, breaking toughness, chord modulus *in a stress-strain curve*, elongation, force at specified elongation (FASE), initial modulus, tensile strength, and work-to-break.

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

4. Summary of Test Method

4.1 These test methods are used to determine the tensile properties of aramid yarns or cords.

4.2 A conditioned or oven-dried specimen of aramid yarn or cord is clamped in a tensile testing machine and then stretched or loaded until broken. Breaking force, elongation, and force at specified elongation (FASE) are determined directly. Modulus and work-to-break are calculated from the force-elongation curve. The output of a constant-rate-of-extension (CRE) tensile testing machine can be connected with electronic recording and

[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.

computing equipment, which may be programmed to calculate and print the test results of tensile properties of interest.

5. Significance and Use

5.1 The levels of tensile properties obtained when testing aramid yarns and cords are dependent on the age and history of the specimen and on the specific conditions used during the test. Among these conditions are rate of stretching, 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 obtain reproducible test results on a specific sample.

5.2 Because the force-bearing ability of a reinforced 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 products. When needed to compare intrinsic strength characteristics of yarns or cords of different sizes or different types of fiber, breaking tenacity is very useful because, for a given type of fiber, breaking force is approximately proportional to linear density.

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

5.4 The *FASE* is used to monitor changes in characteristics of the textile material during the various stages involved in the processing and incorporation of yarn or cord into a product.

5.5 *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 forces and rates of stretching. Although modulus may be determined at any specified force, initial modulus is the value most commonly used.

5.6 *Work-to-break* is dependent on the relationship of force to elongation. It is a measure of the ability of a textile structure to absorb mechanical energy. *Breaking toughness* is work-to-break per unit mass.

5.7 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.

5.8 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.

6. Apparatus

6.1 *Tensile Testing Machine*—A single-strand tensile testing machine of the constant rate of extension (CRE) type. The specifications and methods of calibration and verification of these machines shall conform to Specification D76. The testing machine shall be equipped with an autographic recorder (rectilinear coordinates preferred). It is permissible to use tensile testing machines that have a means for calculating and displaying the required results without the use of an autographic recorder. It is also permissible to use automated tensile testing equipment.

6.1.1 *Clamps*—Bollard type clamps, in which the specimen is gripped between plane-faced jaws and then makes a partial turn (wrap angle) around a curved extension (or other type of snubbing device) of one jaw before passing to the other similar clamp (see Fig. 1). Clamps with a wrap angle of 3.14 rad [180°] are recommended for yarns with a linear density up to 10 000 decitex [9000 denier]. For linear densities above 10 000 decitex [9000 denier], clamps with a wrap angle of 4.71 rad [270°] are required to prevent slippage.

6.1.1.1 Clamps shall grip the test specimen without spurious slippage or damage to the test specimen which can result in jaw breaks. The clamps shall maintain constant gripping conditions during the test by means of pneumatic or hydraulic clamps. The surface of the jaws in contact with the specimen shall be of a material and configuration that minimizes slippage and/or specimen failure in the clamping zone.

6.1.2 *Gauge Length*—The gauge length shall be the total length of yarn measured between the clamping point A of the first clamp and the point B of the second clamp in the starting position (see Fig. 2).

6.1.3 Use a crosshead travel rate in mm/min [in./min] of 50 % of the nominal gauge length in millimeters [inches] of the specimen for para-aramids; 100 % of the nominal gauge length in millimeters [inches] of the specimen for meta-aramids.

7. Sampling

7.1 Remove and discard a minimum of 25 m [75 yd] from the outside of the package before taking the sample or any specimens.

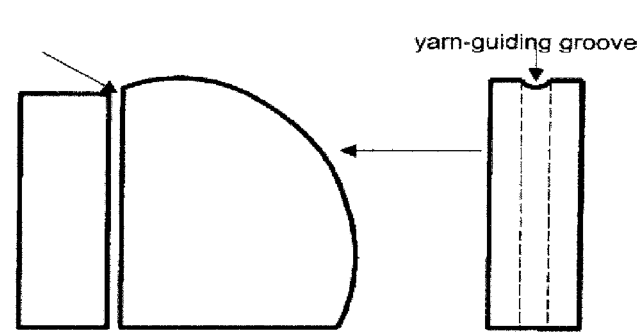

FIG. 1 Principle of Bollard Type Clamps

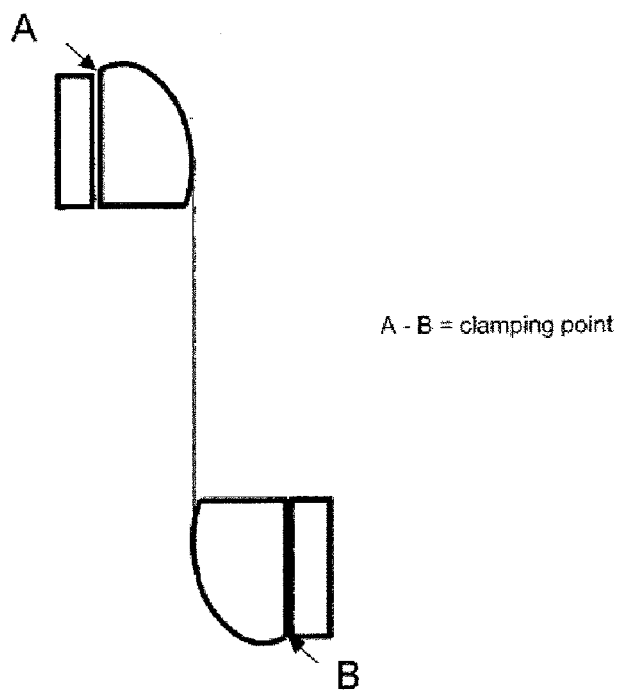

FIG. 2 Principle of Specimen Fixing in Bollard Type Jaws

7.2 *Yarn:*

7.2.1 *Packages*—For acceptance testing, sample each lot as directed in Practice D2258. Place each laboratory sampling unit in a moisture-proof polyethylene bag or other moisture-proof container to protect the samples from atmospheric changes until ready to condition the samples in the atmosphere for testing aramids. Take the number of specimens for testing specified for the specific property measurement to be made.

7.2.2 *Beams*—For acceptance testing, sample by winding yarns on a tube or spool by means of a winder using a tension of 5 ± 1 mN/tex [0.05 ± 0.01 gf/den]. Take the yarn from the outside beam layers unless there is a question or disagreement regarding the shipment; in this case, take the sample only after removing yarn from the beam to a radial depth of 6 mm [¼ in.] or more to minimize the effects of handling and atmospheric changes that may have occurred during shipment or storage. Place each laboratory sampling unit in a moisture-proof polyethylene bag or other moisture-proof container to protect the samples from atmospheric changes until ready to condition the samples in the atmosphere for testing aramids. Take the number of specimens for testing specified for the specific property measurement to be made.

7.3 *Cord:*

7.3.1 *Number of Samples and Specimens*—The size of an acceptance sampling lot of tire cord shall be not more than one truck or rail car load or as determined by agreement between the purchaser and the supplier. Take samples at random from each of a number of cones, tubes, bobbins, or spools within a lot to be as representative as possible within practical limitations. Make only one observation on an individual package for each physical property determination. Take the number of samples, therefore, that will be sufficient to cover the total number of specimens required for the determination of all physical properties of the tire cord. The recommended number of specimens is included in the appropriate sections of specific test methods covered in this standard. Where such is not specified, the number of specimens is as agreed upon between buyer and supplier.

7.3.2 *Preparation of Samples*—If specimens are not taken directly from the original package, preferably 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 sample is collected as a loosely wound package, or in the form of a skein, some shrinkage invariably will occur, in which case, report that the observed results were determined on a relaxed sample. Use care in handling the sample. Discard any sample subjected to any change of twist, kinking, or making any bend with a diameter less than 10 times the yarn/cord thickness (or diameter). Place the sample in a moisture-proof polyethylene bag or other moisture-proof container to protect it from atmospheric changes until ready to condition the sample in the test atmosphere for aramids.

8. Conditioning

8.1 Bring all specimens of yarn, cord, and fabric to moisture equilibrium for testing in the atmosphere for testing industrial yarns for at least 14 h as directed in Practice D1776.

8.1.1 Standard aramid yarn shall be pre-conditioned at 45 ± 5°C [113 ± 40°F] for 3 to 6 h, then condition per 8.1.

8.1.2 The moisture equilibrium of conditioned aramid yarns and tire cords made from such yarns can be affected by heat and humidity conditions to which the samples have been previously exposed.

9. Sample Preparation

9.1 Because of the difficulty of securing the same tension in all the filaments and because of slippage in the clamps, variable results may be obtained when testing zero-twist multifilament yarns unless a small amount of twist is inserted prior to testing. Machine twisting by means of a ring twister using steel insert travelers is recommended. The twist tension should be approximately 10 mN/tex [0.10 gf/den]. If used, anti-balloon rings must be chromium plated. For aramid yarns the amount of twist to be inserted depends upon the linear density and shall be approximately:

Linear density dtex	Twist tpm
180-240	230
240-380	190
380-500	160
500-650	140
650-775	125
775-1050	110
1050-1400	95
1400-2100	80
2100-4500	60
4500-7000	45
7000-9500	35
9500->	30

9.2 Inserting some twist in zero-twist yarns for tensile testing has the following effects on the test results:

9.2.1 Modestly increases breaking force; too much twist reduces breaking force,

9.2.2 Increases elongation at break, and