Designation: ~~D7812 – 16~~ D7812 – 22

Standard Test Method for Tensile Testing of Aramid Paper[1]

This standard is issued under the fixed designation D7812; 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 tensile testing of aramid paper with thickness less than 1 mm. This test method includes testing procedures only and includes no specifications or tolerances.

1.2 The procedures given in this test method are for use with computer-controlled constant-rate-of-elongation tensile testing equipment.

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

~~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.*~~

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles
D123 Terminology Relating to Textiles
D202 Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation
D374M Test Methods for Thickness of Solid Electrical Insulation (Metric) (Withdrawn 2016)[3]
D1776 Practice for Conditioning and Testing Textiles
D4848 Terminology Related to Force, Deformation and Related Properties of Textiles
D6477 Terminology Relating to Tire Cord, Bead Wire, Hose Reinforcing Wire, and Fabrics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is 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.

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

3. Terminology

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

3.1 *Definitions*—For definitions of terms related to force and deformation in textiles, refer to Terminology The following terms are relevant to this standard: aramid paper, breaking force, elongation, initial modulus, tensile strength, and Tensile Energy Absorption.D6477.

3.1.1 For definitions of terms related to industrial fibers and metallic reinforcements, refer to Terminology D6477.

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

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

3.3 *Definitions:*

3.3.1 *aramid paper, n*—planar structures deposited from an aqueous suspension that has a thickness less than 1 mm containing at least 50 mass percent aramid.

3.4 The following terms are relevant to this standard: breaking force, elongation, initial modulus, tensile strength, and Tensile Energy Absorption.

4. Summary of Test Method

4.1 A conditioned sample of aramid paper is clamped in a tensile testing machine and then stretched or loaded until broken.

4.2 The output of a constant-rate-of-extension (CRE) tensile testing machine can be connected with electronic recording and computing equipment, which may be programmed to calculate and print the test results of tensile properties of interest.

4.3 Breaking force and elongation are determined directly. Modulus and Tensile Energy Absorption are calculated from the force-elongation curve.

5. Significance and Use

5.1 The levels of tensile properties obtained when testing aramid paper 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, gauge 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 Tensile strength is used in engineering calculations when designing various types of products.

5.3 Elongation of the paper 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 Stiffness is a measure of the resistance of the paper to extension as a force is applied.

5.5 Tensile Energy Absorption is dependent on the relationship of force to elongation. It is a measure of the ability of a textile structure to absorb mechanical energy. Tensile Energy Absorption is work-to-break per area.

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

5.7 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 *Thickness*—Micrometer, conforming to the specifications as given in Test Method D374M.

6.2 *Grammage*—Weighing device, readable and accurate to within 0.25 % of the applied load. When in use, the weighing device shall be shielded from air currents.

6.3 *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 a data-acquisition system.

6.4 *Clamps*—Side action clamps with rubber-coated flat jaw faces. The test specimen shall be held in such a way that slippage relative to the grips is prevented as much as possible. The width of the jaw faces should be equal to or larger than the sample width. If the clamps are of the air-actuated type, adjust the air pressure to prevent specimens slipping in the jaws, but keep the air pressure below the level that will cause specimens to break at the edge of the jaws. If the break is within 5 mm of the edge, the result must be discarded.

6.5 *Specimen Cutter*—a device capable of cutting specimens for testing that are uniform in width to within ±0.2 mm of the specified specimen width and with edges parallel to within ±0.1 mm. A double-blade strip cutter or a laser cutter is satisfactory for this requirement. Other cutting dies may also be used, provided they are found to comply with or exceed the tolerances within this standard. Single-blade paper cutters do not comply with the requirements for a specimen cutter for purposes of this test method.

7. Sampling, Test Specimens

7.1 For acceptance testing, sample each lot as directed in Test Methods D202. Take the number of samples for testing specified for the specific property measurement to be made.

7.2 *Conditioning*—Bring all specimens to equilibrium in the atmosphere prior to sample cutting as directed in Practice D1776 for Aramids.

7.3 *Preparation*—Cut the test specimens from each conditioned test unit of the sample. The two options for specimen size are:
~~Type 1: Length 205 ± 3 mm; width 15.0 ± 0.2 mm~~Type 1: Length 205 mm ± 3 mm; width 15.0 mm ± 0.2 mm
~~Type 2: Length 205 ± 3 mm; width 25.4 ± 0.3 mm~~Type 2: Length 205 mm ± 3 mm; width 25.4 mm ± 0.3 mm

7.4 *Number of Specimens*—At least five or preferably ten specimens per sample in machine, and at least five or preferably ten specimens per sample in the cross-machine direction.

8. Conditioning

8.1 Bring all specimens to equilibrium in the atmosphere prior to testing as directed in Practice D1776 for Aramids.

9. Procedure

9.1 *Sample Preparation*—Cut the specimens according to Section 7.

9.2 *Conditioning*—Condition the samples as directed in 8.1.

9.3 *Measurement of Thickness*—Measure the thickness of the specimen according to Test Method D374M.

9.4 *Measurement of Mass Per Unit Area*—Measure the grams per square meter by weighing the individual specimens as listed in 9.1.

9.5 *Gauge Length*—The gauge length shall have a total length for type 1 specimen size of ~~100~~ 100 mm ± 1 mm and for type 2 of ~~127 ±~~127 mm ± 1 mm between the jaw faces.

9.6 *Crosshead Travel Rate*—The crosshead travel rate is 10 % of the nominal gauge length of the specimen. This rate of crosshead travel generally results in specimen rupture between ~~10~~10 s and 30 s. In cases where rupture consistently requires greater than 30 s, a more rapid rate of crosshead travel must be used, so that specimen rupture occurs between ~~10 and~~ 10 s and 30 s. Where a crosshead travel rate other than that stated above is used, the actual crosshead travel rate must be reported.

9.7 *Slack Start Procedure*—Clamp one end of the specimen between the jaws of one of the clamps and close it. Place the other end of the specimen through the jaws of the second clamp and keep the specimen just slack (zero tension) and close the clamp, taking care that the paper is positioned in the centerline of the jaws of the clamp. This slack start procedure has the effect that the nominal gauge length of the specimen will be slightly greater as specified in 9.5.

9.8 *Tensile Testing*—Operate the testing machine at the rate as specified in ~~9.7~~9.6 and stretch the specimen until it ruptures. Discard specimens that break in the jaws or within 5 mm of the nip of the jaws. Report the discarded specimen.

10. Calculation or Interpretation of Results

10.1 *Thickness—T* in mm. Measure the thickness of the individual specimen conforming to Test Methods D374M.

Report results as stated in Section 11.

10.2 *Mass Per Unit Area—QM* in g/m^2. Calculate the areal weight of the individual specimen by:

$$QM = \frac{M}{L \cdot W} \cdot 10^6 \quad (1)$$

where:

QM = mass per unit area, g/m^2,
M = mass of the specimen, g,
L = specimen length, mm, and
W = specimen width, mm.

Report results as stated in Section 11.

10.2.1 *Breaking Force—BF* in N. When the specimen breaks, read the breaking force (maximum force) in newtons.

Report results as stated in Section 11.

10.3 *Tensile Strength—BT* in N/m. Compute the tensile strength by dividing the breaking force by the specimen width *W*:

$$BT = \frac{BF}{W} \cdot 1000 \quad (2)$$

where:

BT = tensile strength, N/m,
BF = breaking force, N, and
W = specimen width, mm.

Report results as stated in Section 11.

10.4 *Tensile Stress at Break—SB* in MPa. Compute the tensile stress by dividing the breaking force by the sample cross-section area:

$$SB = \frac{BF}{W \cdot T} \tag{3}$$

where:

SB = stress at break, MPa,
BF = breaking force, N,
W = specimen width, mm, and
T = specimen thickness, mm.

Report results as stated in Section 11.

10.4.1 *Tensile Index—TI* in Nm/g. Tensile Index (*TI*) is the tensile strength scaled on mass per unit area:

$$TI = \frac{BT}{QM} \tag{4}$$

where:

BT = tensile strength, N/m, and
QM = specimen mass per unit area, g/m^2.

Report results as stated in Section 11.

10.5 *Breaking Length—BL* in m. Breaking length is that length in metres under which the sample will fail under its own weight.

$$BL = \frac{BT}{QM \cdot g} \cdot 1000 \tag{5}$$

where:

BL = breaking length, m,
BT = tensile strength, N/m,
QM = specimen mass per unit area, g/m^2, and
g = constant of gravity, m/s^2 (≈ 9.8 m/s^2).

Report results as stated in Section 11.

10.5.1 *Elongation at Break—EAB* in %. Determine the elongation at break of each conditioned specimen when determined at its breaking force point. With the use of slack start, a correction of gauge length is required. The procedure for determining the slack is as shown in Fig. 1. Take force levels $F1$ = 5 % BF and $F2$ = 10 % BF. Determine the extensions $e1$ and $e2$ from the extension-force graph at the force levels $F1$ and $F2$ respectively. Compute the intercept at the extension axis using:

$$\Delta L = \frac{e1F2 - e2F1}{F2 - F1} \tag{6}$$

where:

ΔL = slack, mm,
F1 = force 5 % of the breaking force, N,
F2 = force 10 % of the breaking force, N,
e1 = extension, mm at force $F1$, and
e2 = extension, mm at force $F2$.

10.5.1.1 The equation for elongation at break for the slack start procedure is given by:

$$EB = \frac{e_{BF-\Delta L}}{L_0 + \Delta L} \cdot 100\% \tag{7}$$

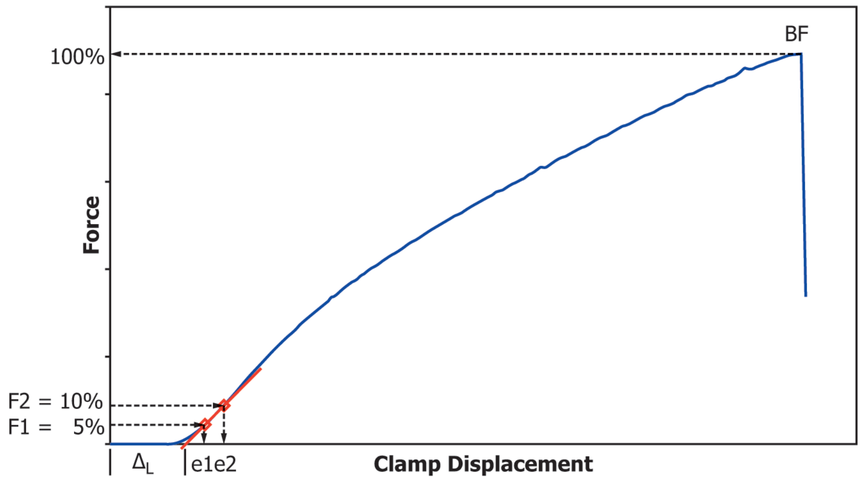

FIG. 1 Determination of Slack

where:

EB	=	elongation at break, %,
~~E_{BF}~~	~~=~~	~~extension of specimen at the breaking force, mm,~~
e_{BE}	=	extension of specimen at the breaking force, mm,
L_0	=	gauge length after clamping specimen (absolute distance nip-to-nip before movement of crosshead), mm, and
ΔL	=	displacement of crosshead to remove slack (see Fig. 1), mm.

Report results as stated in Section 11.

10.6 *Stiffness—STIF* in N/m. *STIF* is the modulus between 5 % and 10 % of the breaking force (see Fig. 1).

10.6.1 From the displacement point $e1$ and $e2$, calculate the strain $s1$ and $s2$ using:

$$s1 = \frac{e1 - \Delta L}{L_0 + \Delta L} \text{ and } s2 = \frac{e2 - \Delta L}{L_0 + \Delta L}$$

$$STIF = \frac{1000}{W} \frac{F2 - F1}{s2 - s1} \tag{8}$$

where:

STIF	=	initial stiffness, N/m,
L_0	=	gauge length after clamping specimen (absolute distance nip-to-nip before movement of crosshead), mm,
ΔL	=	displacement of crosshead to remove slack (see Fig. 1), mm,
F1	=	force 5 % of the breaking force, N,
F2	=	force 10 % of the breaking force, N,
e1	=	extension, mm at force F1,
e2	=	extension, mm at force F2,
s1	=	strain at force F1,
s2	=	strain at force F2, and
W	=	width of the sample, mm.

Report results as stated in Section 11.

10.7 *Stiffness Index—STIFI* in Nm/g. Stiffness index is the stiffness scaled on mass per unit area:

$$STIFI = \frac{STIF}{QM} \tag{9}$$

where:

STIF	=	stiffness, N/m, and

QM = mass per unit area, g/m^2.

Report results as stated in Section 11.

10.8 *Tensile Energy Absorption—TEA* in J/m^2. The equation used to calculate the Tensile Energy Absorption is:

$$TEA = \frac{10^6}{W \cdot (L_0 + \Delta L)} \sum_{i=0}^{n-1} \frac{F_{i+1} + F_i}{2} \cdot (e_{i+1} - e_i) \quad (10)$$

where:

TEA = Tensile Energy Absorption in J/m^2,
W = sample width, mm,
L_0 = gauge length after clamping specimen (absolute distance nip-to-nip before movement of crosshead), mm,
ΔL = displacement of crosshead to remove slack (see Fig. 1), mm,
F_I = force at ith data pair, N,
e_I = extension at ith data pair, mm,

Report results as stated in Section 11.

11. Report

11.1 State that all specimens were tensile tested as directed in Test Methods D7812. Describe the material or product sampled and the methods of sampling used.

11.2 Report the following information:

11.2.1 Sample code,

11.2.2 Machine or cross-machine direction,

11.2.3 Test conditions: temperature, humidity, gauge length and cross-head speed,

11.2.4 Number of specimens tested per sample,

11.2.5 Number of specimen failed within 5 mm of the grips, and

11.2.6 For the determined parameters: average and standard deviation of machine and cross-machine result.

12. Precision and Bias

12.1 *Precision*—The precision of this test method is based on an interlaboratory study of Test Method D7812, conducted in 2015. Two laboratories tested two different types of aramid paper (see 12.3), at two sizes as defined in 7.3, using different cutting techniques (shear, die, and laser cutting) in both machine direction (*MD*) and cross-machine (*XD*) direction. Every test result represents an individual determination, and all participants were instructed to report ten replicate test results per material. Practice E691was followed for the design and analysis of the data; the details are given in a research report.[4]

12.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

12.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1141. Contact ASTM Customer Service at service@astm.org.