



Designation: D 2443 – 95

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St. Philadelphia, Pa 19103

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Technology Standard No. Lf 3-67

Standard Test Methods for Lacing Twines and Tapes Used as Harnesses in Electrical Equipment¹

This standard is issued under the fixed designation D 2443; 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 procedures for braided and nonbraided fiber lacing and tying twines and tapes used to secure electrical harnesses, armatures, and similar apparatus. Both round twines and flat narrow tapes made from synthetic or natural fibers are included, and either may or may not be coated with waxes, resins, or elastomers.

1.2 The procedures appear as listed in the first column:

Procedure	Sections	ASTM Method Reference
Sampling	3	...
Conditioning	4	...
Weight (Yield)	5 to 13	D 123, D 1907
Breaking Strength and Knot Strength or Knot Slip Resistance	14 to 19	D 76
Volatile Content	20 to 27	...
Thickness and Width of Lacing Tapes and Diameter of Twines	28 to 35	D 374
Wax Content	36 to 42	...
Fiber Identification	43 to 45	D 276
Creep	46 to 53	...
Elastic Properties	54 to 61	...
Braid Pick of Lacing Tapes	62 to 68	...

1.3 The values stated in inch-pound units are to be regarded as the 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.* Specific hazard statements are given in Section 37.

2. Referenced Documents

2.1 ASTM Standards:

D 76 Specification for Tensile Testing Machines for Textiles²

D 123 Terminology Relating to Textiles²

D 276 Test Methods for Identification of Fibers in Textiles²

D 374 Test Methods for Thickness of Solid Electrical Insulation³

¹ These methods are under the jurisdiction of ASTM Committee D-9 on Electrical and Electronic Insulating Materials and are under the direct responsibility of Subcommittee D09.07 on Flexible and Rigid Insulating Materials.

Current edition approved May 15, 1995. Published July 1995. Originally published as D 2443 – 65 T. Last previous edition D 2443 – 90.

² Annual Book of ASTM Standards, Vol 07.01.

³ Annual Book of ASTM Standards, Vol 10.01.

D 739 Methods of Testing and Tolerances for Spun, Twisted, or Braided Products Made from Flax, Hemp, Ramie, or Mixture Thereof⁴

D 1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications³

D 1907 Test Method for Yarn Number by the Skein Method²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵

3. Sampling

3.1 For purposes of sampling, a lot shall consist of all twine or tape of the same type, color, and size treated in one production run and offered for inspection at one time.

3.2 From each lot of material, two spools or tubes or 2 % of the total spools or tubes, whichever is greater, shall be randomly selected, and the tests prescribed shall be made on specimens cut from the sampled spools.

4. Conditioning

4.1 All specimens shall be conditioned to equilibrium moisture content by exposure in air at a temperature of $21 \pm 1.1^\circ\text{C}$ and a relative humidity of $65 \pm 2\%$, unless otherwise specified herein or unless otherwise agreed upon by the supplier and the consumer. Equilibrium shall be taken as that point where two successive weighings made not less than 4 h of conditioning apart show not more than 0.1 % change in weight.

YIELD

5. Terminology

5.1 Definitions:

5.1.1 The definitions of all terms employed in these test methods shall be in accordance with Terminology D 123.

6. Significance and Use

6.1 This test provides a convenient method of determining the yield of lacing material as well as an approximation of the amount of impregnating material present in lacing twines.

Procedure A—Skein Method

7. Procedure

7.1 Determine the yield in accordance with Test Method

⁴ Discontinued, see 1971 Annual Book of ASTM Standards, Part 25.

⁵ Annual Book of ASTM Standards, Vol 14.02.

 D 2443

D 1907, using Option 1 except that the skein length shall be 30 yd (27.4 m) and a skein reel with a perimeter of 90 in. (2286 mm) may be used.

*Procedure B—Scale Measurement***8. Apparatus**

8.1 *Scale*, capable of measuring 2 yd (1.8 m), graduated in $\frac{1}{32}$ in. (1-mm) divisions.

8.2 *Analytical Balance*, sensitive to 1 mg.

9. Test Specimens

9.1 Three specimens, free of folds, crushing, or abnormal distortion, shall be selected at random to be representative of the material to be tested.

10. Procedure

10.1 Unwind the specimen carefully from the sample spool and cut to a length of $6 \text{ ft} \pm \frac{1}{16} \text{ in.}$ ($1.80 \text{ m} \pm 1.5 \text{ mm}$).

10.2 Fold or roll up the specimen to a size convenient to place on the balance pan and weigh, recording the weight in grams to the nearest 1 mg.

11. Calculation

11.1 Calculate the yield as follows:

$$X = 1800/W$$

$$Y = 907.2/W$$

where:

X = weight (yield) m/kg,

Y = weight (yield), yd/lb, and

W = specimen weight, g.

12. Report

12.1 Report the following information:

12.1.1 Description of the material tested, for example, type, class, manufacturer, or other pertinent data,

12.1.2 Procedure used, and

12.1.3 Average yield in yards per pound for the three specimens.

13. Precision and Bias

13.1 *Precision*—The precision of this test method has not been determined.

13.2 *Bias*—This procedure has no bias because the value of yield is defined in terms of this test method.

**BREAKING STRENGTH AND KNOT
STRENGTH OR KNOT SLIP
RESISTANCE**

14. Terminology

14.1 *Descriptions of Terms Specific to This Standard:*

14.1.1 *breaking strength, n*—the applied force required to rupture a specimen in a tension test made under prescribed conditions.

14.1.2 *knot strength, n*—the applied force required to rupture a firmly tied square knot made in a test specimen.

14.1.3 *knot slip resistance, n*—the applied force exerted that causes the square knot to pull out before rupture when making the knot strength test as described herein.

15. Significance and Use

15.1 Breaking strength and knot strength or knot slip resistance are of importance for measuring suitability of lacing twines and tapes which in use are subjected to direct tensile stresses such as longitudinal pull in harnessing and to stresses in service. Knot strength or knot slip resistance is an indication of the maximum pull which the lacing will withstand, while breaking strength is a measure of the tensile stress which the material can withstand during application or in service. The results of these tests are useful in acceptance testing, product control, research, or referee testing.

16. Apparatus

16.1 Tests shall be made using a constant-rate-of-traverse testing machine conforming to the requirements of Specification D 76. Drum or capstan (Calloway) jaws shall be used. The distance between the contact points of the drums or capstans shall be adjusted to $10 \pm 0.5 \text{ in.}$ ($250 \pm 13 \text{ mm}$).

17. Procedure

17.1 *Breaking Strength*—Cut full-section specimens at least 20 in. (510 mm) long from the twine or tape. Align the specimens in the jaws and traverse the movable jaw at a speed of $12 \pm 0.5 \text{ in./min}$ ($300 \pm 13 \text{ mm/min}$) until the specimens break. Record the results of five tests, disregarding any tests where specimens break within 0.5 in. (13 mm) of the jaw contact.

17.2 *Knot Strength or Knot Slip Resistance*—Cut a specimen of at least 24 in. (600 mm) in length into two equal lengths and firmly tie together in a square knot. Trim one end of each length adjacently engaged to within $0.5 \pm 0.1 \text{ in.}$ ($13 \pm 2 \text{ mm}$) of the knot, leaving about 6 in. (150 mm) of the other end for attachment to the jaws of the tension testing machine. Align the knotted specimen in the jaws so that the knot is centrally located between the jaws and traverse the movable jaw at a rate of $12 \pm 0.5 \text{ in./min}$ ($300 \pm 13 \text{ mm/min}$) until the specimen either breaks at the knot or the knot slips out. Record the results of five tests, noting whether breakage or slippage occurs, and disregarding any tests where specimens break within 0.5 in. of the jaw contact.

17.3 Record failures caused by pulling out of the knot as knot slippage. If knot slippage is obtained on only one of the five tests, test an additional specimen. If knot breakage is then obtained, discard the reading corresponding to knot slippage.

18. Report

18.1 Report the following information:

18.1.1 Description of the material tested, for example, type, class, size, manufacturer, or other pertinent data,

18.1.2 Maximum, minimum, and average breaking strength expressed in pounds-force (or newtons),

18.1.3 If all acceptable specimens fail by rupture, the maximum, minimum, and average knot strength expressed in pounds-force, (or newtons), and

18.1.4 If knot slippage occurs on two or more specimens, the maximum, minimum, and average knot slip resistance expressed in pounds-force (or newtons).

 D 2443
19. Precision and Bias

19.1 *Precision*—The precision of this test method has not been determined.

19.2 *Bias*—This procedure has no bias because the value of knot strength or knot slippage is defined in terms of this test method.

VOLATILE CONTENT**20. Scope**

20.1 This test method covers a procedure for determining moisture and other volatile content of lacing twines and tapes. It is applicable to synthetic or natural fiber materials, whether or not they are coated or impregnated.

21. Significance and Use

21.1 This test method provides a basis for comparison of volatile contents of lacing twines and tapes and the coatings thereon. This information is useful where high volatile content is undesirable, for example, in hermetically sealed electronic systems. This method assumes that the moisture regained by material on reconditioning after testing is equal in amount to that lost during the test, and although this may not be necessarily true, particularly in the case of natural yarns, the method has been found to be reproducible and of significant value.

22. Apparatus

22.1 *Analytical Balance*, sensitive to 0.1 mg.

22.2 *Oven*, forced-circulation type.

22.3 *Desiccator*, charged with anhydrous calcium sulfate or equally efficient desiccant.

23. Test Specimens

23.1 At least three specimens, weighing between 0.5 and 0.6 g shall be tested.

24. Procedure

24.1 Place the specimen in a low-form weighing bottle of known weight and having a ground-glass cover to fit outside the neck (a bottle 50 mm in diameter and 30 mm high and of 30-mL capacity is suitable). Weigh and compute the specimen weight by difference, recording the weight in grams as W_1 .

24.2 Place the weighing bottle with cap ajar and containing the specimen in an oven at $105 \pm 1^\circ\text{C}$ for 72 h.

24.3 Refit the cover on the bottle, remove the bottle and specimen from the oven, and place in a desiccator until cooled to room temperature. Reweigh and compute the specimen weight by difference, recording this weight in grams as W_2 .

24.4 Expose the specimens in the weighing bottle with cap ajar to the atmosphere described in 4.1 for 40 h. Replace the cap and weigh, computing the specimen weight by difference and recording this weight in grams as W_3 .

25. Calculation

25.1 Calculate (1) total volatile content, (2) volatile content other than moisture, and (3) moisture content as follows:

$$V_t = [(W_1 - W_2)/W_2] \times 100 \quad (1)$$

$$V_s = [(W_1 - W_3)/W_3] \times 100 \quad (2)$$

$$V_m = V_t - V_s \quad (3)$$

where:

V_t = % volatile content (including moisture),

V_s = % volatile content (other than moisture),

V_m = % moisture content,

W_1 = weight of specimen untreated (as is), g,

W_2 = weight of specimen after treatment (dried), g, and

W_3 = weight of specimen reconditioned (regained), g.

26. Report

26.1 Report the following information:

26.1.1 Description of the material tested, for example, type, class, size, manufacturer, or other pertinent data, and

26.1.2 Percentage total volatile content, volatile content other than moisture, and moisture content for each specimen, expressed to the nearest 0.01 %, and the average contents for all specimens tested.

27. Precision and Bias

27.1 *Precision*—The precision of this test method has not been determined.

27.2 *Bias*—This procedure has no bias because the value of volatile content is defined in terms of this test method.

THICKNESS AND WIDTH OF LACING TAPES AND DIAMETER OF TWINES**28. Terminology**

28.1 *Definitions*:

28.1.1 The definitions of all terms employed in this test method shall be in accordance with Terminology D 123.

29. Significance and Use

29.1 Because of the necessity of limiting the pressure applied to a cable harness, these dimensions are important. Also, dimensions are needed in calculating other properties. Since this product is easily deformable, measurements are made while the tape or twine is subjected to a specified axial loading.

30. Apparatus

30.1 *Thickness (or Diameter)*—The apparatus used shall be that which is described in Method C of Test Methods D 374, except that the load shall be as described in the Thickness Section of Test Methods D 1000.

30.2 *Width*—The optical comparator used shall include a suitable reticle calibrated in 0.005 in. (0.100-mm) divisions and shall incorporate a magnifier capable of magnifying the scale sufficiently that the dimension to be measured can be estimated to 0.001 in. (0.025 mm). A 5× or 10× optical measuring device capable of being carried in a pocket is satisfactory.

30.3 Means shall be provided for applying a load as specified below to the specimen to be measured. The load shall be applied at least 5 in. (127 mm) from the point of thickness or width measurement on the specimen in such a manner that the area to be measured remains horizontal.

30.3.1 Tapes or twines with a rated breaking strength of less than 100 lbf (444.8 N) shall have a load of 4 to 6 % of the