Designation: D6320/D6320M – 24

Standard Test Methods for Single Filament Hose Reinforcing Wire Made from Steel[1]

This standard is issued under the fixed designation D6320/D6320M; 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 testing of single filament steel wires that are used to reinforce hose products. By agreement, these test methods may be applied to similar filaments used for reinforcing other rubber products.

1.2 These test methods describe test procedures only and do not establish specifications or tolerances.

1.3 These test methods cover the determinations of the mechanical properties listed below:

Property	Section
Breaking force (strength)	7 – 14
Yield strength	7 – 14
Elongation	7 – 14
Knot strength	15 – 21
Torsion resistance	22 – 29
Reverse bend	30 – 37
Wrap	38 – 44
Diameter	45 – 51

1.4 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.

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

1.6 *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

D2969 Test Methods for Steel Tire Cords (Withdrawn 2023)[3]

D4848 Terminology Related to Force, Deformation and Related Properties of Textiles

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

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.

3.1.1.1 The following terms are relevant to this standard: hose reinforcing wire, torsion resistance, yield strength.

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

3.1.2.1 The following terms are relevant to this standard: breaking force and elongation.

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

4. Summary of Test Method

4.1 A summary of the directions prescribed for determination of specific properties of hose reinforcing wire is stated in the appropriate sections of the specific test methods that follow.

5. Significance and Use

5.1 The procedures for the determination of properties of single-filament hose reinforcing wire made from steel are considered satisfactory for acceptance testing of commercial shipments of this product because the procedures are the best available and have been used extensively in the trade.

5.1.1 In the case of a dispute arising from differences in reported test results when using these test methods for acceptance testing of commercial shipments, the purchaser 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.

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

supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for investigation of bias. As a minimum, two parties should take a group of test specimens which are as homogeneous as possible and which are from a lot of material of the type in question. The test specimens then should be randomly assigned in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared by using an appropriate statistical test and an acceptable probability level chosen by the two parties before testing is begun. If a bias is found, either its cause must be determined and corrected or the purchaser and supplier must agree to interpret future test results with consideration to the known bias.

6. Sampling

6.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of reels, coils, spools, or other shipping units of wire directed in an applicable material specification or other agreement between purchaser and supplier. Consider reels, coils, spools, or other shipping units of wire to be the primary sampling units.

NOTE 1—A realistic specification or other agreement between the purchaser and the supplier requires taking into account the variability between and within primary sampling units, to provide a sampling plan which at the specified level of the property of interest has a meaningful producer's risk and acceptable quality level.

6.2 *Laboratory Sample*—Use the primary sampling units in the lot sample as a laboratory sample.

6.3 *Test Specimens*— For each test procedure, take the number of lengths of hose reinforcing wire of the specified lengths from each laboratory sample as directed in the test procedure.

BREAKING FORCE, YIELD STRENGTH, AND ELONGATION

7. Scope

7.1 This test method covers the measurement of breaking force, yield strength, and elongation of single filament steel reinforcing wire in a tensile test.

8. Summary of Test Method

8.1 The specimen is clamped in a tensile testing machine and increasing forces applied until the specimen breaks. The change in force is measured versus the increase in separation of the specimen clamps to form a force-extension curve. Breaking force is read directly from the curve and is expressed in newtons (pounds - force). Elongation at break is the extension at break divided by the original specimen length times 100. Yield strength the intersection of the force-extension curve with a line at 0.2 % offset, is read from the force-extension curve and is expressed in newtons (pounds - force). Current tensile test machines may have the capability for calculating elongation and yield strength using a programmed computer.

9. Significance and Use

9.1 The load bearing ability of a reinforced rubber product such as a steel reinforced hydraulic hose is related to the strength of the single-filament wire used as the reinforcing material. The breaking force and yield strength are used in engineering calculations when designing this type of reinforced product.

9.2 Elongation of hose reinforcing wire is taken into consideration in the design and engineering of hoses because of its effect on uniformity and dimensional stability during service.

10. Apparatus

10.1 *Tensile Testing Machine,* constant rate of extension (CRE) type tensile testing machine of such capacity that the maximum force required to fracture the wire shall not exceed 90 % nor be less than 10 % of the selected force measurement range. The specifications and methods of calibration and verification shall conform to Specification D76.

10.2 In some laboratories, the output of CRE type of tensile testing machine is connected with electronic recording and computing equipment that may be programmed to calculate and print the results for each of the force - extension properties, optional.

10.3 Extensometer, any device that can be attached to the specimen and that permits recording of the specimen extension during loading, optional.

10.4 Grips, of such design that failure of the specimen does not occur at the gripping point, and slippage of the specimen within the jaws (grips) is prevented.

11. Procedure

11.1 Select a proper force-scale range on the tensile testing machine based on the estimated breaking force of the specimen being tested.

11.2 If specified, tensile testing may be carried out after aging for 1 h ± 5 min at 150 °C ± 5°C [300 °F ± 9 °F].

11.3 Set the crosshead speed at 25 mm/min. [1.0 in./min.] and recorder chart speed at 250 mm/min. [10 in./min.]

11.4 Adjust the distance between the grips of the tensile machine, nip to nip, to a gage length of 500 mm, ± 0.5 %.

11.5 Secure the specimen in the upper grip sufficiently to prevent slippage during testing. While keeping the specimen straight and taut, place and secure the other end in the lower grip.

11.6 Apply a force of no greater than 1 *N* [0.2 lbf] on the clamped specimen to take out any residual slack before initiating the test. This will be considered the zero-reference point for elongation calculations. The pre-tension force should depends on tested samples. only one setting 1 N cannot guarantee all kind of HRW samples keep straight condition especially for big diameter of HRW. Apply a pretension of maximum 1 % of nominal break force of filament to keep the specimen taut.

11.7 Start the testing machine and record the force-extension curve generated.

11.7.1 If the specimen fractures at, or within, 5 mm [0.2 in.] of the gripping point, discard the result and test another specimen. If such jaw breaks continue to occur, insert a jaw liner, such as an abrasive cloth, between the gripping surface and the specimen in a manner that the liner extends beyond the grip edge where it comes in contact with the specimen.

11.8 Conduct this test procedure on two specimens from each laboratory sampling unit.

11.9 *Breaking Force*— Read the maximum force from the force-extension curve.

11.10 *Elongation*—Determine the total elongation at break point from the force-extension curve.

11.11 *Yield Strength*— Determine the yield strength by the 0.2 % offset method.

11.11.1 On the force-extension curve (see Fig. 1) that has been generated (see 11.7), lay off Om equal to the specified value of the offset (0.2 % elongation): draw mn parallel to OA and locate *r*. This intersection of mn with the force-extension curve corresponds to force *R*, that is the yield strength. Should the force-extension curve exhibit an initial nonlinear portion, extrapolate from the straight line portion to the base line. This intersection is point 0 used in this section.

12. Calculation

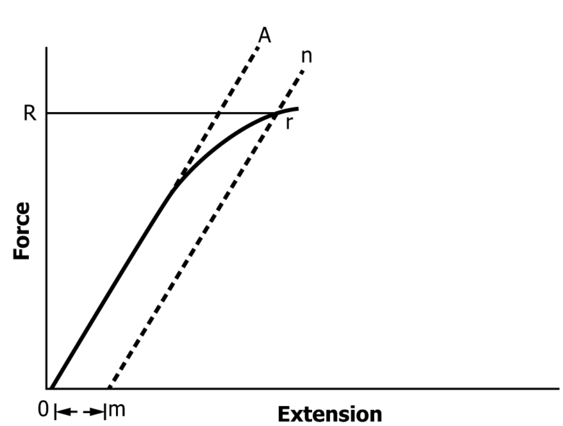
12.1 *Break Strength*— Calculate the average breaking force for each laboratory sampling unit to the nearest 1 *N* [0.2 lbf], and record this value as breaking strength.

12.2 *Elongation at Break:*

12.2.1 Calculate the elongation at break for each specimen from the force-extension curve to the nearest 0.1 %. Should the force-extension curve exhibit an initial nonlinear portion, extrapolate from the straight line portion of the curve to the base line. This intersection is the point of origin for the elongation determination. The extension from this point to the force at the point of rupture is the total elongation.

12.2.2 Calculate the average elongation at break for each laboratory sampling unit.

12.3 *Yield Strength*— Calculate the average yield strength from each laboratory sampling unit as directed in Section 11.11.1 to the nearest 1 *N* [0.2 lbf[.



0m = Specified Offset

FIG. 1 Force-Extension Curve for Determination of Yield Strength by the Offset Method

13. Report

13.1 State that the tests were performed as directed in these test methods (D6320) for breaking strength, elongation at break and yield strength. Describe the material or product tested.

13.2 Report the following information:

13.2.1 The test results of each specimen and the laboratory sample average. Calculate and report any other data agreed to between the purchaser and the supplier,

13.2.2 Type of tensile test machine, machine number (if applicable), and rate of extension,

13.2.3 Whether specimens were heat aged or not,

13.2.4 Any deviation from the standard test procedure, and

13.2.5 Date of test and operator.

14. Precision and Bias

14.1 *Precision*—0.30 mm HT [high tensile: 2750 MN/m^2 to 3050 MN/m^2] brass plated hose wire was tested. The single operator repeatability standard deviation for breaking force has been determined to be 8.24*N*. The single operator repeatability standard deviation for yield strength has been determined to be 5.24 *N*. The single operator repeatability standard deviation for elongation has been determined to be 0.14 %. The reproducibility of this test method is being determined and will be available before 2005.

14.2 *Bias*—The tensile property procedures of these test methods have no bias, because these properties can be defined only in terms of a test method.

KNOT STRENGTH

15. Scope

15.1 This section describes the test procedure to determine the knot test characteristic of hydraulic hose wire with a diameter less than or equal to 0.82 mm [0.032 in.]. In practice, the knot test is most suitable for wires less than 0.50 mm [0.020 in.].

15.2 *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.*

16. Significance and Use

16.1 Complex stress and strain conditions sensitive to variation in materials occur in wire specimens during knot strength testing. The knot strength test is a useful tool in assessing wire ductility as defective wire lowers knot strength.

17. Apparatus

17.1 *Tensile Test Machine,* CRE-type and grips as described in Section 10. Electronic recording and computing equipment is optional.

18. Procedure

18.1 Select a proper force-scale range on the tensile testing machine based upon the estimated breaking force of the specimen being tested.

18.2 If specified, the knot strength test may be carried out after aging for 1 h ± 5 min at 150 °C ± 5 °C [300 °F ± 9 °F].

18.3 Adjust the distance between the grips of the tensile testing machine, nip to nip, to a gage length of 250 mm [10 in.] ± 0.5 %.

18.4 Form a simple loop (overhand) knot in the middle zone of the test piece as shown in Fig. 2.

18.5 Center the knot between the grips. Secure one end of the specimen in the upper grip sufficiently to prevent slippage during testing. While keeping the specimen taut, place and secure the other end in the lower grip.

18.6 After setting the crosshead speed at 25 mm/min [1 in./min] and the recorder chart at 25 mm/min. [1 in./min], start the testing machine and record the force-extension curve generated.

18.7 When the knotted diameter reaches about 5 mm [0.2 in.], change the crosshead speed to 10 mm/min [0.4 in./min.] and load to fracture.

18.8 If the specimen fractures at or within 5 mm [0.2 in.] of the gripping point, discard the result and test another specimen. If such jaw breaks continue to occur, see 11.7.1 for techniques to minimize the occurrence of such failures.

18.9 Conduct this test procedure on two specimens from each laboratory sampling unit.

18.10 Determine the breaking strength sample average of the wire (F_m) as in Section 12.

19. Calculation

19.1 *Knot Breaking Strength*—Read the maximum force (F_{kn}) for each knotted wire from the force-extension charts to the nearest 1 *N* [0.2 lbf].

19.2 *Knot Strength Ratio*—Calculate the knot strength ratio for each specimen using Eq 1.

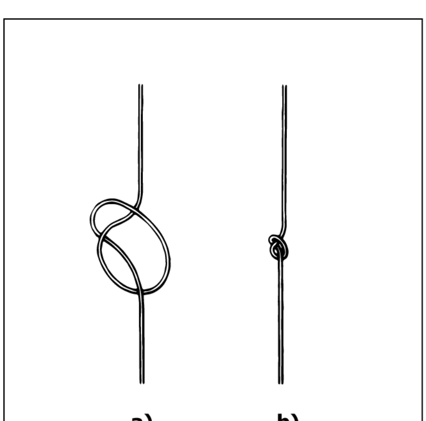


FIG. 2 Overhand Knot, (a) As Tied and (b) As Tightened During the Test

$$Kn = 100\, F_{kn}/F_m \quad (1)$$

where:

Kn = knot strength ratio, %
F_{kn} = knot breaking strength, *N* [lbf], and
F_m = breaking strength of the wire, *N* [lbf].

20. Report

20.1 State that the tests were performed as directed in this test methods (D6320). Describe the material or product tested and report the following:

20.1.1 The individual knot strength ratio values are reported for each specimen. Calculate and report any other data agreed to between the purchaser and the supplier,

20.1.2 Date of test and operator,

20.1.3 Type of tensile test machine, machine number (if applicable), and rate of extension, and

20.1.4 Any deviation from the standard test procedure.

21. Precision and Bias

21.1 *Precision*—0.30 mm HT [high tensile: 2750 MN/m^2 to 3050 MN/m^2] brass plated hose wire was tested. The single operator repeatability standard deviation for knot strength has been determined to be 3.85*N*. The reproducibility of this test method is being determined and will be available before 2005.

21.2 *Bias*—The procedure of the test method has no bias, since this property can be defined only in terms of a test method.

TORSION RESISTANCE

22. Scope

22.1 This test method covers the determination of wire ductility by twisting a wire to failure.

23. Summary of Test Method

23.1 Single filament of wire is tested in torsion by holding one end of the wire fixed while rotating the other.

24. Significance and Use

24.1 Complex stress and strain conditions sensitive to variation in materials occur in wire specimens during torsion testing. The torsion test is a useful tool in assessing wire ductility under torsional loading. Defective wire lowers torsion resistance.

25. Apparatus

25.1 *Torsion Test Machine,* with automatic drive, that allows a single filament of wire under light tension to be tested in torsion, with a counter which is provided which registers the number of wire revolutions to wire fracture.

26. Procedure

26.1 Cut the test specimens to the appropriate lengths to obtain the proper gage length between chuck or edges.

26.2 If specified, the torsion resistance test may be carried out after aging for 1 h ± 5 min at 150 °C ± 5 °C [300 °F ± 9 °F].