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Standard Test Method for Tension Testing of Wire Ropes and Strand¹

This standard is issued under the fixed designation A 931; 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 tension testing of wire ropes and strand at room temperature, specifically to determine the minimum acceptance strength or nominal strength, yield strength, elongation, and modulus of elasticity.~~

~~1.2 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.*~~

1.1 This test method covers the tension testing of wire ropes and strand at room temperature, specifically to determine the measured breaking force, yield strength, elongation, and modulus of elasticity. Methods described in this standard are not intended for other purposes.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 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 precautionary statements are given in 7.3.2, 7.3.4, 7.3.5, and 9.2. Specific precautionary statements are given in Note 1 and Note 2.

2. Referenced Documents

2.1 ASTM Standards:²

A 586 Specification for Zinc-Coated Parallel and Helical Steel Wire Structural Strand

A 603 Specification for Zinc-Coated Steel Structural Wire Rope ~~B6~~ Specification for Zinc

A 1023/A 1023M Specification for Stranded Carbon Steel Wire Ropes for General Purposes

B 6 Specification for Zinc

E 4 Practices for Force Verification of Testing Machines

E 6 Terminology Relating to Methods of Mechanical Testing

E 8 Test Methods for Tension Testing of Metallic Materials

2.2 ISO Standard³

ISO 17558 Specification for Steel Wire Ropes – Socketing Procedures – Molten Metal and Resin Socketing

3. Terminology

3.1 The terminology relating to tensile testing in Terminology E 6 applies to this test method. In addition, the following definitions for wire rope will apply:

3.2 Definitions:

3.2.1 *abrasion*—frictional surface wear on the wires of a wire rope.

3.2.2 *aggregate area*—see *area, metallic*.

3.2.3 *aggregate strength*—the strength derived by ~~totaling~~totaling the individual breaking strengths of the elements of the strand or rope. This strength does not give recognition to the reduction in strength resulting from the angularity of the elements in the rope, or other factors that may affect efficiency.

3.2.4 *area, metallic*—sum of the cross-sectional areas of all wires either in a wire rope or in a strand.

3.2.5 *breaking strength*~~force~~—the ~~ultimate~~maximum load at which a tensile failure occurs in the sample of wire rope being tested.

¹ This test method is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.03 on Steel Rod and Wire.

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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 Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

*A Summary of Changes section appears at the end of this standard.

- 3.2.5.1 *Discussion*—The term ~~breaking strength~~ breaking force is synonymous with actual strength.
- 3.2.6 *cable*—a term loosely applied to wire rope, wire strand, and electrical conductors.
- 3.2.7 *center*—the axial member of a strand about which the wires are laid.
- 3.2.8 *classification*—group or family designation based on wire rope constructions with common strengths and weights listed under the broad designation.
- 3.2.9 *construction*—geometric design description of the wire rope’s cross section. This includes the number of strands, the number of wires per strand, and the pattern of wire arrangement in each strand.
- 3.2.10 *core*—the axial member of a wire rope about which the strands are laid.
- 3.2.11 *fiber core*—cord or rope of vegetable or synthetic fiber used as the core of a rope.
- 3.2.12 *galvanized rope*—~~wire rope made up of galvanized wire.~~
- 3.2.13 *galvanized strand*—~~strand made up of galvanized wire.~~
- 3.2.14 *grade*—wire rope or strand classification by strength or type of material, that is, Class 3, Type 302 stainless, phosphor bronze, etc. It does not apply to strength of the individual wires used to manufacture the rope or strand.
- 3.2.15
- 3.2.13 *independent wire rope core (IWRC)*—a wire rope used as the core of a larger wire rope.
- 3.2.16
- 3.2.14 *inner wires*—all wires of a strand except the outer or cover wires.
- 3.2.17
- 3.2.15 *lay*—(a) the manner in which the wires in a strand or the strands in a rope are helically laid, or (b) the distance measured parallel to the axis of the rope (or strand) in which a strand (or wire) makes one complete helical convolution about the core (or center). In this connection, lay is also referred to as *lay length* or *pitch*.
- 3.2.18 *minimum acceptance strength*—~~that strength that is 2½% lower than the catalog or nominal strength. This tolerance is used to offset variables that occur during sample preparation and actual physical test of a wire rope.~~
- 3.2.19 *pitch*.
- 3.2.16 *minimum breaking force*—specified value that the breaking force must meet or exceed in a prescribed test.
- 3.2.17 *modulus of elasticity*—the slope of the elastic portion of the stress-strain curve. The ratio of stress to corresponding strain below the proportional limit. This value is generally taken between 20 and 50% of the nominal strength.
- 3.2.20 *nominal strength*—the published (catalog) strength calculated by a standard procedure that is accepted by the wire rope industry. The wire rope manufacturer designs wire rope to this strength, and the user should consider this strength when making design calculations.
- 3.2.21—the slope of the elastic portion of the stress-strain curve. The ratio of stress to corresponding strain below the proportional limit. This value is generally taken between 20 and 50 % of the minimum breaking force.
- 3.2.18 *socket*—generic name for a type of wire rope fitting.
- 3.2.22
- 3.2.19 *strand*—a plurality of round or shaped wires helically laid about a center.
- 3.2.23
- 3.2.20 *wire rope*—strands helically laid around a core.
- 3.2.24
- 3.2.21 *wire strand core (WSC)*—a wire strand used as the core of a wire rope.
- 3.2.22 *zinc-coated (galvanized) rope*—wire rope made up of zinc coated (galvanized) wire.
- 3.2.23 *zinc coated (galvanized) strand*—strand made up of zinc-coated (galvanized) wire.

4. Significance and Use

- 4.1 Wire rope tests are generally to be performed on new rope. The use of wire rope in any application can reduce individual wire strengths due to abrasion and nicking that will result in the wire rope strength being reduced. Damage to the outer wires will also lower the maximum strength achieved during tension testing.
- 4.2 The modulus of elasticity of wire rope is not considered to be a standard requirement at this time. The determination of this material property requires specialized equipment and techniques.
- 4.3 Rope to be tested should be thoroughly examined to verify that no external wire damage is present. If present, it should be noted. When possible, a new undamaged sample should be obtained for testing.
- 4.4 End attachments and their installation can directly affect breaking strength achieved during testing. Any attachment that can be used to directly achieve the required rope breaking strength can be used. Standard testing with a poured socket, using zinc, white metal or thermoset resin, has been considered the most efficient. Proficiency in attachment of any fitting can have a direct effect on the final test results.

5. Interferences

- 5.1 Visual examination of the sample for any damage to outer wires should be done. If any damage is evident, the sample should not be used. The purpose of this test method is to verify the nominal or maximum strength the wire rope or strand can achieve.

5.1 Visual examination of the sample for any damage to outer wires should be done. If any damage is evident, the sample should not be used.

5.2 Measurement of the rope or strand sample is necessary to document the size, length between end attachments, and length of lay of the rope if necessary. Further details regarding this will be discussed in test results.

5.3 The length of test specimen shall not be less than 3 ft, (0.91 m) between sockets for wire ropes up to 1 in. (25.4 mm) diameter, inclusive, and not less than 5 ft (1.52 m) between sockets for wire ropes 1 1/8 in. (28.6 mm) to 3 in. (77 mm) diameter. On wire ropes larger than 3 in. (77 mm), the clear length of the test specimen shall be at least 20 times the rope diameter.

6. Apparatus

6.1 *Testing Machines*—Machines used for tension testing shall conform to the requirements of Practices E 4. The loads used in determining tensile strength and yield strength shall be within loading range of the tensile machine as defined in Practices E 4.

6.2 Gripping Devices:

6.2.1 *General*—Various types of gripping devices may be used to transmit the measured load applied by the testing machine to test specimens. To ensure axial tensile stress within the gauge length, the axis of the test specimen should coincide with the center line of the heads of the machine. Any departure from this requirement may introduce bending stresses that are not included in the usual stress computation.

6.2.2 *Wedge Grips*—Testing machines usually are equipped with wedge grips. These wedge grips generally furnish a satisfactory means of gripping long specimens of ductile metal. If, however, for any reason, one grip of a pair advances farther than the other as the grips tighten, an undesirable bending stress may be introduced. When liners are used behind the wedges, they must be of the same thickness and their faces must be flat and parallel. For best results, the wedges should be supported over their entire lengths by the heads of the testing machine. This requires that liners of several thicknesses be available to cover the range of specimen thickness. For proper gripping, it is desirable that the entire length of the serrated face of each wedge be in contact with the specimen. Specially-designed round-shaped grips may have to be used for testing rope or strand. It is essential that all wires in the rope or strand are uniformly gripped when the load is applied.

6.2.3 *Conical Grips*—Conical grips are constructed so that when they are fitted together, a conical-shaped cavity exists which will hold a cone socket wire rope or strand and attachment (fitting).

7. Sample Preparation and Preparation of End Attachments

7.1 Poured sockets are considered to be the most efficient and should be used due to their ability to distribute the load evenly in the wire rope when installed properly. Procedures for the proper installation of poured end attachments can be found in socketing procedures.

7.2 Other end attachments such as grips may be used provided the required loading is achieved.

7.3 Sample Preparation Procedures:

7.3.1 Socketing

Zinc-Poured Socketing:

7.3.1.1 *Measuring the Rope Ends to be Socketed*—The rope end should be of sufficient length so that the ends of the unlaid wires (from the strands) will be at the top of the socket basket (see Fig. 1(a)).

7.3.1.2 *Apply Serving at Base of Socket*—Apply a tight wire serving band at the point where the socket base will be for a length of two rope diameters (see Fig. 1(b) and 1(c)).

7.3.1.3 *Broom Out Strand Wires*—Unlay and straighten the individual rope strands and spread them evenly so that they form an included angle of approximately 60°. Unlay the wires of each individual strand for the full length of the rope end, being careful not to disturb or change the lay of the wires and strands under the serving band. Unlay the wires of an independent wire rope core in the same manner. A fiber core should be cut out and removed as close to the serving band as possible (see Fig. 1(c)).

7.3.2 *Clean the Broomed-Out Ends*—A suggested cleaning solvent for this step is SC-5 methyl chloroform. It is also known under the names chlorothane VG and 1-1-1 trichloroethane. **Warning:** Breathing the vapor of this solvent is harmful; it should only be used in a well-ventilated area. Be sure to follow the solvent manufacturer's instructions, and carefully observe all instructions printed on the label. Some non-chlorinated solvents are adequate and are preferable if available.

7.3.2.1 Swish the broomed-out rope end in the solvent, then brush vigorously to remove all grease and dirt, making certain that the wires are clean to the very bottom close to the serving band (see Fig. 1(d)). Additionally, a solution of muriatic acid may also be used. If, however, acid is used, the broomed-out ends should be rinsed in a solution of bicarbonate of soda so as to neutralize any acid that may remain on the rope. Care should be exercised to prevent acid from entering the core; this is particularly important if the rope has a fiber core. Where it is feasible, the best and preferred cleaning method for rope ends prior to socketing is ultrasonic cleaning. After this cleaning step, place the broomed-out end upright in a vise allowing it to remain until all solvent has evaporated and the wires are dry.

7.3.2.2 Solvent should never be permitted to remain on the rope or on the serving band since it will run down the wires when the rope is removed from the vise.

7.3.3 *Dip the Broomed-Out Rope Ends in Flux*—Prepare a hot solution of zinc-ammonium chloride flux comparable to Zaclon K. Use a concentration of 1 lb. (453.6 g) of zinc-ammonium chloride to 1 gal (3.774 L) of water, maintain this at a temperature of 180°F (82°C) to 200°F (93°C). Swish the broomed-out end in the flux solution, then place the rope end upright in the vise until