Designation: A 931 – 96 (Reapproved 2008)

Standard Test Method for Tension Testing of Wire Ropes and Strand[1]

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.

1.3 *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.

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

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

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 totalling 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*—the ultimate load at which a tensile failure occurs in the sample of wire rope being tested.

3.2.5.1 *Discussion*—The term *breaking strength* 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 *independent wire rope core (IWRC)*—a wire rope used as the core of a larger wire rope.

3.2.16 *inner wires*—all wires of a strand except the outer or cover wires.

[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.

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3.2.17 *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 *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 *socket*—generic name for a type of wire rope fitting.

3.2.22 *strand*—a plurality of round or shaped wires helically laid about a center.

3.2.23 *wire rope*—strands helically laid around a core.

3.2.24 *wire strand core (WSC)*—a wire strand used as the core of a wire rope.

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.

5.2 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 1⅛ 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*)).

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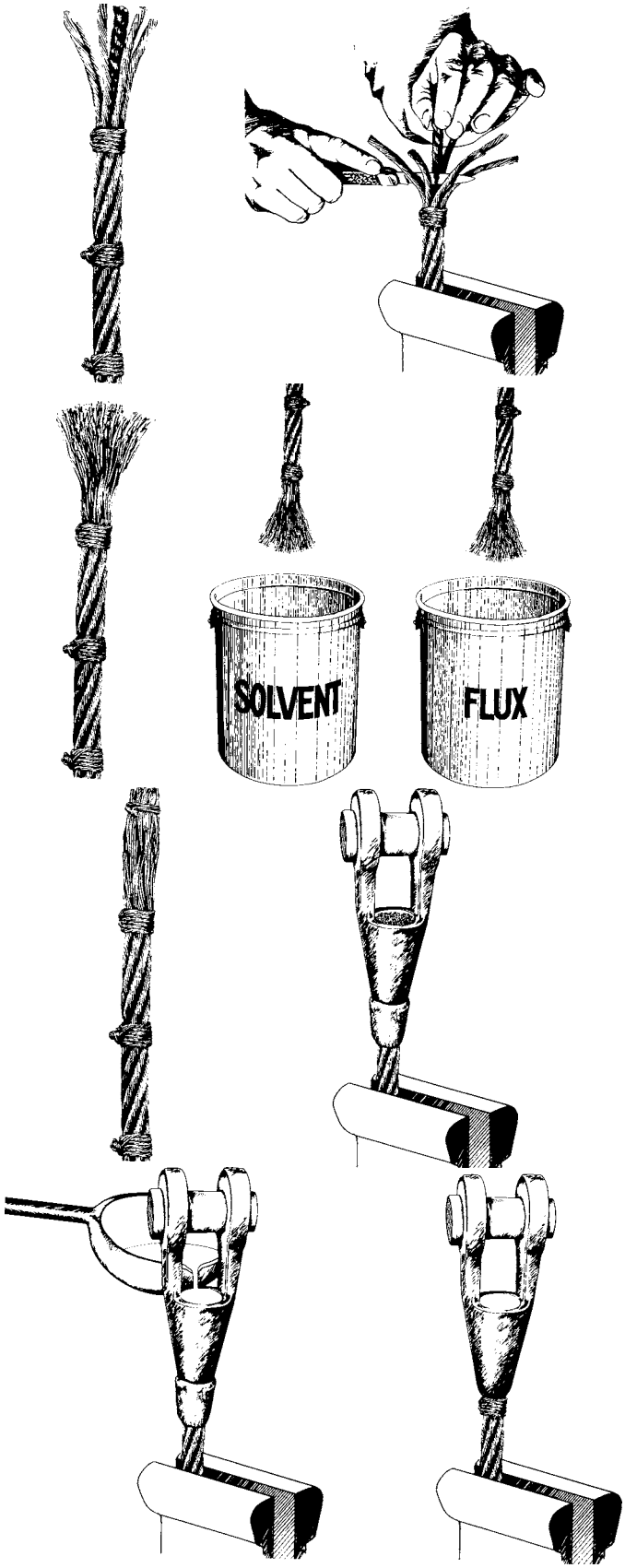


FIG. 1 Wire Rope for Socketing

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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 trichlorethane. **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 such time as the wires have dried thoroughly (see Fig. 1(*e*)).

7.3.4 *Close Rope Ends and Place Socket*—Use clean wire to compress the broomed-out rope end into a tight bundle that will permit the socket to be slipped on easily over the wires (see Fig. 1(*f*)). Before placing the socket on the rope, make certain that the socket itself is clean and heated to 200°F (93°C) to 400°F (204°C). This heating is necessary in order to dispel any residual moisture, and to prevent the zinc from cooling prematurely. **Warning:** Never heat a socket after it is placed on the rope. To do so may cause heat damage to the rope.

7.3.4.1 After the socket is on the rope end, the wires should be distributed evenly in the socket basket so that zinc can surround each wire. Use extreme care in aligning the socket with the rope's centerline, and in making certain that there is a minimum vertical length of rope, extending from the socket, that is equal to that specified in 6.3.

7.3.4.2 Seal the socket base with fire clay or putty, but make certain that this material does not penetrate into the socket base. Should this occur, it would prevent the zinc from penetrating the full length of the socket basket, thereby creating a void that would collect moisture after the socket is placed in service.

7.3.5 *Pour the Zinc*—The zinc used should meet Specification B 6 Grade (1) High Grade. Pour the zinc at a temperature of 950 to 970°F (510 to 521°C) (see Fig. 1(*h*)); make allowances for cooling if the zinc pot is more than 25 ft. from the socket. **Warning:** Do not heat zinc above 1200°F (649°C) or its bonding properties will be lost, and heat damage will occur to the rope. The zinc temperature may be measured with a portable pyrometer or a Tempilstik. Remove all dross before pouring. Pour the zinc in one continuous stream until it reaches the basket top and all wire ends are covered; there should be no "capping" of the socket.

7.3.6 *Remove Serving*—Remove the serving band from the socket base; check to make certain that the zinc has penetrated to the socket base (see Fig. 1(*i*)).

7.3.7 *Lubricate the Rope*—Apply wire rope lubricant to the rope at the socket base and on any rope section where the original lubricant may have been removed.

8. Thermo-Set Socketing

8.1 Before proceeding with a thermo-set resin socketing procedure, check manufacturer's instructions carefully. Give particular attention to selecting sockets that have been specifically designed for resin socketing.

8.2 *Acceptable Resin Types*—Commercially-available resin properties vary considerably. Hence, it is important to refer to the individual manufacturer's instructions before using any one type. General rules cannot, of course, be established.

8.3 When properly formulated, most thermo-e resins are acceptable for socketing. These formulations, when mixed, form a pourable material that will harden at ambient temperatures, or upon the application of moderate heat. No open flame or molten metal hazards exist with resin socketing since heat-curing, when necessary, requires a relatively low temperature 250 to 300°F (121 to 149°C) obtainable by electric resistance heating.

8.4 Tests have demonstrated that satisfactory wire rope socketing performance can be obtained with resins.

9. Procedure

9.1 Take measurements on the sample to determine the actual rope diameter and sample length between sockets before loading on the test machine.

NOTE 1—Rope diameter should be measured properly to determine the actual diameter. (See Fig. 2 for the correct method.) An incorrect measurement is possible and should be avoided. (See Fig. 3 for the method to avoid.)

9.2 After the sample is placed in the test machine, complete the zeroing before testing begins for accurate results. Start applying the load to the sample. The maximum rate of loading should be 0.032 in. per minute (0.032 mm per min) for each in.

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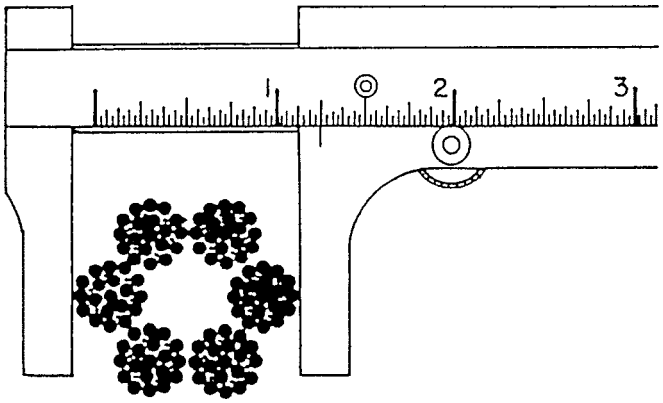


FIG. 2 Correct Measurement

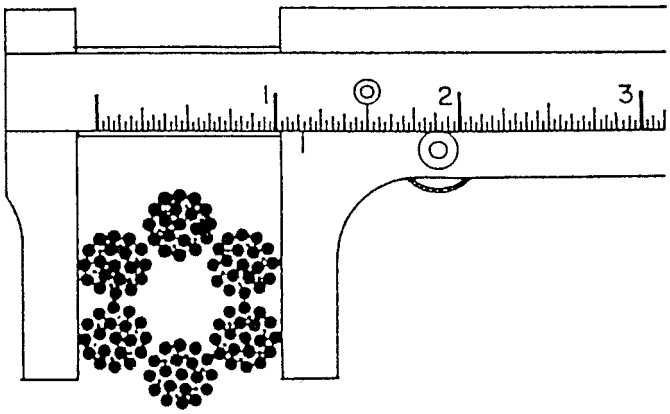


FIG. 3 Incorrect Measurement

(mm) of test gauge length when the rate is under the operator control (a typical test gauge length is 60 in. (1524 mm). Apply the load until a reduction from a maximum reading. This reduction will normally be accompanied by a noise when wires and strand break. Wire and lubricant will be thrown from the sample if not contained. **Warning:** Safety in tensile testing of wire rope should be a major concern for the operator of the test machine, observers and the surroundings. Uncontained wires, during testing, can impact and penetrate objects at a great distance. Adequate safety shields directly around the sample, as well as around the operator and observers, should be used at a minimum.

9.3 Final tensile test results are normally measured in pounds and can be compared with specifications for wire rope in the applicable documents, customer specifications, or manufacturer's specifications. A sample test form is included for documentation of the data.

10. Precision and Bias

10.1 The primary intent of testing wire ropes and strand is to ensure that the wire rope or strand will meet the specified acceptance strength. Sometimes yield strength, elongation, or modulus of elasticity is required or desired. In the case of galvanized strand tested to meet the requirements in Specifications A 586 and A 603, the procedures for determining percent elongation and modulus of elasticity and gauge lengths are specified in Specifications A 586 and A 603.

10.1.1 When yield strength is needed, the methods defined in Test Methods E 8 are recommended.

10.2 Retesting will be required if samples do not meet 97½ % of the nominal strength, if slippage occurs in the wires in the end attachments, or if a break is within one rope diameter of the end attachment. The variation in socketing proficiency can produce different breaking strengths on multiple tests of the same length of rope.

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

10.4 *Bias*—The bias of this test method includes quantitative estimates of the uncertainties of the dimensional measuring devices, the calibrations of testing equipment and the skill of the operators. At this time, the statements on bias should be limited to documented performance of particular laboratories.

11. Keywords

11.1 socket; thermo-set resin; wire rope

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