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Standard Test Methods for Testing Multi-Wire Steel Strand[1]

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1. Scope

1.1 These test methods describe procedures for testing the mechanical as well as relaxation properties of multi-wire steel strand.

1.2 These test methods are intended for use in evaluating specific strand properties prescribed in specifications for multi-wire steel strand, but they do not quantify acceptance criteria specified in the applicable specification for the strand being tested.

1.3 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.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

E4 Practices for Force Verification of Testing Machines

E83 Practice for Verification and Classification of Extensometer Systems

E328 Test Methods for Stress Relaxation for Materials and Structures

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *free span, n*—the distance between the gripping jaws occupied by the length of strand to be tested in which the strand is not contacted or detrimentally influenced by the gripping system.

3.1.2 *length of lay, n*—the axial distance required to make one complete revolution of any wire of a strand.

3.1.3 *strand, n*—two or more steel wires wound together in a helical form.

4. Significance and Use

4.1 The mechanical properties of the strand are determined by a test in which fracture of the specimen occurs in the free span between the jaws of the testing machine.

4.2 Mechanical properties of the strand will be negatively affected if proper care is not taken to prevent damage such as severe bending, abrasion, or nicking of the strand during sampling.

4.3 Premature failure of the test specimens may result if there is appreciable notching, cutting, or bending of the specimen by the gripping devices of the testing machine.

4.4 Errors in testing will result if the wires constituting the strand are not loaded uniformly.

4.5 The mechanical properties of the strand will be materially affected by excessive heating during specimen collection or preparation.

4.6 Gripping difficulties will be minimized by following the suggested methods of gripping described in Section 7.

5. Apparatus

5.1 Tensile test machine calibrated in accordance with Practices E4.

5.2 Class B-1 extensometer as described in Practice E83.

5.3 Class D extensometer as described in Practice E83.

6. Sampling

6.1 Unless otherwise specified in the material standard, test specimens shall be taken from the finished product prior to packaging. The number of test specimen(s) shall be taken as specified in the applicable specification for the material strand being tested.

[1] These test methods are under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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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.

7. Gripping Devices

7.1 Due to inherent physical characteristics of individual testing machines, it is not practical to recommend a universal gripping procedure that is suitable for all testing machines. Therefore, it is necessary to determine which of the methods of gripping described in 7.1.1-7.1.5 is most suitable for the testing equipment available. The gripping devices shall be designed such that during testing the load is distributed along the entire length of the grips. The effective gripping length as a minimum shall be equal to the length of lay of the strand.

7.1.1 *Standard V-Grips with Serrated Teeth (Note 1).*

7.1.2 *Standard V-Grips with Serrated Teeth (Note 1), Using Cushioning Material*—In this method, material is placed between the grips and the specimen to minimize the notching effect of the teeth. Materials that have been used include, but are not limited to lead foil, aluminum foil, carborundum cloth, and brass shims. The type and thickness of material required is dependent on the shape, condition, and coarseness of the teeth.

7.1.3 *Special Grips with Smooth, Semi-Cylindrical Grooves (Note 2)*—The grips can be used as is or in conjunction with an abrasive slurry applied to the grooves of the grips and the gripped portion of the specimen to prevent slippage. The slurry consists of abrasive such as Grade 3-F aluminum oxide and a carrier such as water or glycerin.

7.1.4 *Dead-End Eye Splices*—These devices are available in sizes designed to fit each size of strand to be tested.

7.1.5 *Chucking Devices*—Use of chucking devices of the type generally used for applying tension to strands in casting beds is not recommended for testing purposes.

NOTE 1—The number of teeth should be 15 to 30 per inch [25 mm].

NOTE 2—The radius of curvature of the grooves should be approximately the same as the radius of the strand being tested. To prevent the two grips from closing tightly when the specimen is in place, the groove should be located 1⁄32 in. [0.79 mm] above the flat face of the grip.

8. Speed of Testing

8.1 The speed of testing shall not be greater than that at which load and strain readings can be made accurately. Refer to speed of testing in Test Methods A370 on Testing Apparatus and Operations.

9. Test Procedures

9.1 *Yield Strength*—Use a Class B-1 extensometer (Note 3) as described in Practice E83. Apply an initial load of 10 % of the required minimum breaking strength to the specimen, attach the extensometer and adjust it to a reading of 0.1 % of gage length. Increase the load until the extensometer indicates an extension of 1 %. Record the load for this extension as the yield strength. The extensometer may be removed from the specimen after the yield strength has been determined. Data acquisition software is available that allows automatic collection of yield strength data. (See Note 4.)

9.2 *Elongation*—Use a Class D extensometer (Note 3) as described in Practice E83, having a gage length of not less than 24 in. [600 mm] (Note 3). Apply an initial load of 10 % of the required minimum breaking strength to the specimen. Attach the extensometer and adjust it to a zero reading. Increase the load until the extensometer indicates an elongation value equal to or greater than the minimum specified in the applicable specification. It is not necessary to determine the total percent elongation at maximum force.

9.2.1 In practice, the total percent elongation at maximum force may be determined by measuring the movement between the gripping jaws using a linear dial gage or a linear precision ruler. After the yield strength is achieved loading is stopped and the extensometer removed. The distance between the gripping jaws is measured. Loading is then continued until failure of one or more wires. The distance between the jaws is again measured. The total percent elongation is calculated as a percentage of the change in the jaw-to-jaw distance and adding this value to the value obtained by the extensometer. In any case, the total elongation value is determined when one or more wires fail during the test. (See Note 5.)

9.3 *Breaking Strength*—Continue loading to determine the maximum load at which one or more wires of the strand are fractured. Record this load as the breaking strength of the strand. (See Note 6.)

NOTE 3—The yield-strength extensometer and the elongation extensometer may be the same instrument or two separate instruments. It is advisable to use two separate instruments since the more sensitive yield-strength extensometer, which could be damaged when the strand fractures, may be removed following the determination of yield strength. The elongation extensometer may be constructed with less sensitive parts or be constructed in such a way that minimal damage would result if fracture occurs while the extensometer is attached to the specimen.

NOTE 4—*Automatic Yield Strength Data Collection*—Computerized data collection systems can be set to replicate the yield strength test method defined in 9.1. When using a computerized system, the strain is automatically set to 0.1 % of gage length at 10 % load even if the extensometer is attached to the specimen prior to the initial load. As additional load is applied, the computer will project a line connecting two specified load points along the proportional length of the stress-strain curve back to the strain axis (*x*-axis). Given the consistent elastic modulus inherent in PC strand, this line will intercept the stress (load) and strain axes at the zero-point for both. The 1 % elongation under load (EUL) point is identified by adding 1 % strain to the projected zero-point. This 1 % strain value is then paired with the corresponding stress (or load) to identify the 1 % EUL yield strength.

NOTE 5—Material for which specimens break outside the extensometer or in the jaws while measuring yield strength or elongation and yet meet the minimum specified values is considered to meet the mechanical property requirements for yield strength and elongation of the applicable specification, regardless of the gripping method used. Test of specimens that break outside of the extensometer gage length or in the gripping jaws and do not meet the minimum specified values is an invalid test. The results are to be discarded and the test repeated on a new specimen. Material for which specimens break within the extensometer gage length or outside the gripping jaws and do not meet the minimum specified values is subject to retest as provided in the section on Rejection and Retesting in the applicable specification.

NOTE 6—Material for which specimens break in the gripping jaws while measuring breaking load and yet meet the minimum specified values are considered as meeting the mechanical property requirement for breaking load of the product specification, regardless of gripping method used. Test of specimens that break in the gripping jaws and do not meet the minimum specified values is an invalid test. The results are to be discarded and the test shall be repeated on a new specimen. Material for which specimens break outside the gripping jaws and do not meet the minimum specified values are subject to retesting as provided in the section on Rejection and Retesting in the applicable specification.

9.4 *Relaxation Properties*—In addition to the general test procedures described in Test Methods E328, Test Method A, the following specific procedures for testing steel strand shall be followed:

9.4.1 The temperature of the test specimen shall be maintained at 68 ± 3.5°F [20 ± 2°C].

9.4.2 The test specimen shall not be subjected to loading prior to the relaxation test.

9.4.3 The initial load shall be applied uniformly over a period of not less than 3 min and not more than 5 min. The gage length shall be maintained constant.

9.4.4 Load-relaxation readings shall commence 1 min after application of the total load.

9.4.5 Over-stressing of the test specimen during the loading operation shall not be permitted.

9.4.6 The duration of the test shall be 1000 h or a shorter period of at least 200 h, provided it can be shown by records that an extrapolation of the shorter period test results to 1000 h will provide similar relaxation values as the full 1000 h test.

9.4.7 The test gage length shall be at least 60 times the nominal diameter. If this gage length exceeds the capacity of the extensometer or testing machine, then it is permitted to substitute a gage length of 40 times the nominal strand diameter.

10. Report

10.1 A report shall be prepared with the following information included as a minimum:

10.1.1 Strand size and grade,

10.1.2 Manufacturer of strand,

10.1.3 Date of test,

10.1.4 Test Number, and

10.1.5 Mechanical properties determined in accordance with applicable specification.

11. Precision and Bias

11.1 No statement is made on the precision and bias of these test methods since the test results indicate only whether there is conformance to given criteria and no generally accepted method for determining precision of these test methods is currently available. General guidelines provided herein for the specimens, instrumentation, and procedures make the results intractable to calculation of meaningful values by statistical analysis for precision at this time.

11.2 *Bias*—Since there is no accepted reference material suitable for determining the bias in this test method, no statement on bias is made.

12. Keywords

12.1 multi-wire steel strand; strand-gripping devices; strand properties