



Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand¹

This standard is issued under the fixed designation A882/A882M; 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 specification covers ASTM Specification **A416/A416M** low-relaxation Grade 250 and Grade 270 seven-wire prestressing steel strand with protective fusion-bonded epoxy coating applied by the electrostatic deposition method or other method that will meet the coating requirements in Section 8, and, except as allowed by 1.2, with the interstices of the seven wires filled with epoxy to minimize migration of corrosive media, either by capillary action or other hydrostatic forces.

NOTE 1—The manufacturer as identified throughout this specification is the coating applicator.

1.2 Upon special request by the purchaser, the interstices are left unfilled.

NOTE 2—Unfilled strand can corrode from the inside and its application for prestressing tendons in concrete or for rock and soil anchors is not recommended.

1.3 This specification is applicable for orders in either inch-pound units (as Specification A882) or SI units [as Specification A882M].

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.

2. Referenced Documents

2.1 ASTM Standards:²

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A416/A416M Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

B117 Practice for Operating Salt Spray (Fog) Apparatus

¹ This specification is 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.

D968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

G12 Test Method for Nondestructive Measurement of Film Thickness of Pipeline Coatings on Steel (Withdrawn 2013)³

G14 Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

G20 Test Method for Chemical Resistance of Pipeline Coatings

2.2 *Federal Highway Administration Report:*

FHWA-RD-74-18 Nonmetallic Coatings for Concrete Reinforcing Bars (February 1974)⁴

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *disbonding*—loss of adhesion between the fusion-bonded epoxy coating and the steel strand wires.

3.1.2 *fusion-bonded epoxy coating*—a product containing pigments, thermo-setting epoxy resins, cross-linking agents, and other substances, which is applied in the form of powder onto a clean, heated metallic substrate and fuses to form a continuous barrier coating.

3.1.3 *grit*—inert particles impregnated on the outer surface of the epoxy coating for improving bond with cement grout.

3.1.4 *holiday*—a discontinuity in the coating that is not discernible to a person with normal or corrected vision.

3.1.5 *patching material*—a liquid coating used to repair damaged or uncoated areas.

4. Ordering Information

4.1 The purchaser should specify:

4.1.1 Diameter, grade, and type of uncoated strand in accordance with Specification **A416/A416M** (latest edition).

4.1.2 Smooth or grit impregnated coating (see 7.3).

4.1.3 Quantity (in feet [metres]).

4.1.4 Requirements for certification (see A1.2.3).

4.1.5 Requirements for material samples (see 5.3).

4.1.6 Requirements for patching material (see 5.4).

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

⁴ Available from National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161, <http://www.ntis.gov>.

4.1.7 Number of pullout tests to be performed, if any.

NOTE 3—A typical ordering description for epoxy-coated strand is as follows: 84 000 feet [2560 m] of grit-impregnated epoxy-coated strand, ½-in. [12.7-mm] diameter, Grade 270 K low-relaxation on wooden reels to ASTM Specification A882 – [A882M –].

5. Materials

5.1 Prestressing steel strand to be coated shall meet the requirements of Specification **A416/A416M** as specified by the purchaser and shall be free of contaminants such as oil, grease, or paint.

5.1.1 Filled epoxy-coated strand shall have relaxation losses of not more than 6.5 % after 1,000 hours, when initially loaded to 70 % of the specified minimum breaking strength of the strand when tested under conditions of Specification **A416/A416M**.

5.2 The coating material shall meet the requirements listed in **Annex A1** of this specification. The coating material shall be of organic composition except for the pigment, or grit if applicable, which may be inorganic if used.

5.2.1 If specified in the order, a written certification shall be furnished to the purchaser that properly identifies the number of each batch of coating material used in the order, material, quantity represented, date of manufacture, name and address of manufacturer, a statement that the supplied coating material meets the requirements of **Annex A1**, and a statement that the coating material used in each batch is the same material as that which was qualified under the requirements of **Annex A1**.

5.3 If specified in the order, a representative 8-oz [0.23-kg] sample of coating material shall be packaged in an airtight container and identified by batch number, and supplied to the purchaser.

5.4 If specified in the order, patching material compatible with the coating material and inert in concrete, and meeting the requirements of **Annex A1** shall be supplied to the purchaser.

6. Surface Preparation

6.1 The surface of the steel strand to be coated shall be cleaned chemically or by another method that will impart the same cleanliness to ensure that the coated strand meets the requirements of Section 8.

7. Application of Coating

7.1 The coating shall be applied to the cleaned surface as soon as possible after cleaning and before reoxidation of the surface discernible to the unaided eye occurs. However, in no case shall application of the coating be delayed more than 10 min after cleaning, unless otherwise permitted by the purchaser.

7.2 The coating shall be applied by the electrostatic deposition method, or other method that will meet the coating requirements in Section 8, and fully cured in accordance with the recommendations of the manufacturer of the coating material.

7.3 The coating may be smooth or grit-impregnated.

7.3.1 Inert particles (grit) shall be impregnated into the surface of the coating when grit-impregnated strand is ordered.

Such particles shall not cause the coating to fail the requirements of Section 8. The particles shall be inert in concrete and non-reactive with concrete additives and soluble salts.

7.3.2 The epoxy on the surface of grit-impregnated strand shall be capable of reaching a temperature of 150°F [66°C] without reducing the transfer of prestress by bond from the strand to the surrounding concrete. (**Warning**—At temperatures above 165°F [74°C], currently available epoxy begins to soften and lose its ability to transfer load from strand to concrete by bond. At 200°F [93°C] practically all transfer capacity will be lost.)

8. Requirements for Coated Strands

8.1 Thickness of Coating:

8.1.1 The coating thickness after curing shall be 15 to 45 mils [380 to 1140 µm].

8.1.2 The thickness of the coating film shall be determined using a magnetic gauge or other method. The gauge shall be used and calibrated in accordance with the manufacturer's recommendations and Section 5 of Test Method **G12**, except that in 5.2.1 of Test Method **G12**, the foil shall be placed on the surface of the bare strand instead of the steel plate. The gauge shall be capable of measuring the coating thickness of a coated wire of circular cross-section with a diameter in the range of 0.1 to 0.3 in. [2.5 to 7.5 mm]. The allowable error on a single measurement of the coating thickness on the coated crown of an outer wire of the strand shall be ±5 %.

8.1.3 The coating thickness shall be measured on the crown of each of the six outer wires at least every 2000 ft [600 m] of continuous strand. The average of the coating thickness measurements for each set of six outer wires shall be supplied to the purchaser upon request. Records of inspection during manufacture shall also be made available when requested.

8.2 Continuity of Coating:

8.2.1 After application of the coating, a continuous in-line holiday detection procedure shall be employed using an aqueous electrolyte and a holiday detector with a minimum voltage setting of 67.5 V DC, following the procedure furnished by its manufacturer. The approximate location of holidays shall be recorded using automatic devices or markings on the strand for later patching.

8.2.2 The coated strand shall only be required to meet the holiday requirements of this specification with the in-line holiday detector, but shall not be required to pass holiday inspection performed on stationary strand for residence times exceeding 3 seconds.

8.2.3 During the continuous holiday detection procedure, coated strand containing more than two holidays per hundred feet [30 m] shall be rejected and corrective action for the epoxy-coating process shall be instituted. Coated strand with two holidays or less per hundred feet [30 metres] shall be patched in accordance with the patching material manufacturer's recommendation. Patching of holidays shall be performed such that the total of the thicknesses of the coating and the patch does not exceed 1.1 mm [45 mils].

NOTE 4—Hand-held holiday detector checks should be performed regularly to verify the accuracy of the in-line system.

8.3 Adhesion of Coating:

8.3.1 The adhesion and shear strength of the coating shall be evaluated by bending a sample from a finished reel of coated strand 180° around a mandrel diameter equal to 32 times the nominal diameter of the strand. Test specimens shall be at thermal equilibrium between 68 and 86°F [20 and 30°C].

8.3.2 No cracking or disbonding of the coating shall be visible to the unaided eye on the outside radius of the bent strand. Evidence of cracking or disbonding of the coating shall be considered cause for rejection of the coated strand represented by the bend test sample. Retests shall be conducted in accordance with 10.1.

8.3.3 Fracture of the steel wire or strand in the bend test for adhesion of coating shall not be considered as an adhesion failure of the coating, and another specimen from the same production shift may be substituted.

8.3.4 The adhesion of coating shall also be evaluated by a tension test in accordance with Section 6 of Specification **A416/A416M**. The coated strand shall satisfy the requirements for breaking strength, yield strength (1 % extension), and ultimate elongation described in Specification **A416/A416M**. No cracks visible to the unaided eye shall occur in the coating up to an elongation of 1 % (yield strength).

8.3.5 Sample length for the bend test shall be at least 5 ft, 0 in. long [1500 mm]. Sample length for the tension test shall follow the requirements of Test Methods and Definitions **A370**.

8.4 Bond with Concrete or Grout:

8.4.1 Pull-out tests shall be conducted on grit-impregnated coated strand to ensure proper bond properties. Pull-out specimens shall be cast in concrete cylinders with dimensions shown in **Table 1**. The untensioned strand shall be embedded concentrically along the longitudinal axis of the specimen. The minimum force at 0.001 in. [0.025 mm] slip shall be applied as shown in **Fig. 1**, by a hydraulic or mechanical jack when concrete reaches a compressive strength between 4000 and 5000 psi [30 and 35 MPa], and measured with a calibrated load indicator at a slip of 0.001 in. [0.025 mm]. A dial gage shall be used at the unloaded end to indicate slip. Minimum force at 0.001 in. [0.025 mm] slip shall be at least equal to or greater than the values shown in **Table 1**.

9. Number of Tests

9.1 Three pullout tests shall be performed annually as a minimum or repeated when a process change is made that could decrease the bond capacity of the epoxy-coated strand. The purchaser shall have the right to request additional pullout tests to be performed on the lot of epoxy-coated strand ordered.

TABLE 1 Requirements for Pull-Out Tests

Strand Diameter		Cylinder Diameter		Embedment Length		Minimum Force at 0.001 in. [0.025 mm] Slip	
in.	mm	in.	mm	in.	mm	lbf	kN
1/4 (0.250)	6.35	6	152	8.5	216	1700	7.56
5/16 (0.313)	7.94	6	152	8.0	203	1960	8.72
3/8 (0.375)	9.53	6	152	7.5	190	2210	9.83
7/16 (0.438)	11.11	6	152	6.5	165	2230	9.92
1/2 (0.500)	12.70	6	152	6.0	152	2350	10.45
(0.600)	15.25	6	152	5.5	140	2590	11.52

10. Retests

10.1 If the specimen for coating thickness, continuity, adhesion of coating, and pull-out tests fail to meet the specified requirements, two retest samples adjacent to the first sample from the same reel shall be conducted for each failed test. If the results of both retests meet the specified requirements, the reels represented by the samples shall be accepted.

11. Inspection

11.1 The inspector representing the purchaser shall have free entry while work on the contract of the purchaser is being performed. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be conducted so there is no unnecessary interference with the manufacturer's operation.

12. Rejection

12.1 Except as specified in 10.1, coated strand reels represented by test samples that do not meet the requirements of this specification shall be rejected.

12.2 A reel of coated strand that is rejected for thickness or continuity of coating shall be accepted if the non-conforming sections are removed and the remaining material meets the coating requirements of this specification.

13. Certification

13.1 If outside inspection is waived, a manufacturer's certification that the material has been tested in accordance with and meets the requirements of this specification shall be the basis of acceptance of the material. The certification shall include the specification number, year-date of issue, and revision letter, if any.

13.2 The manufacturer shall, when requested in the order, furnish a representative load-elongation curve for each size and grade of strand shipped and a copy of the manufacturer's quality control tests.

14. Handling and Identification

14.1 All strapping bands shall be padded or suitable banding shall be used to prevent damage to the coating. All reels of coated strand shall be handled in such a manner as not to damage the coating on the strand.

14.2 Coating damage due to handling shall be repaired in accordance with the recommendation of the manufacturer of patching material. The repaired coating shall conform to the requirements of Section 8 of this specification.

14.3 The reel number shall be maintained throughout the fabrication and coating process to the point of shipment for traceability.

15. Keywords

15.1 coating requirements; corrosion resistance; epoxy coating; prestressed concrete; steel wire; strand (tendons)

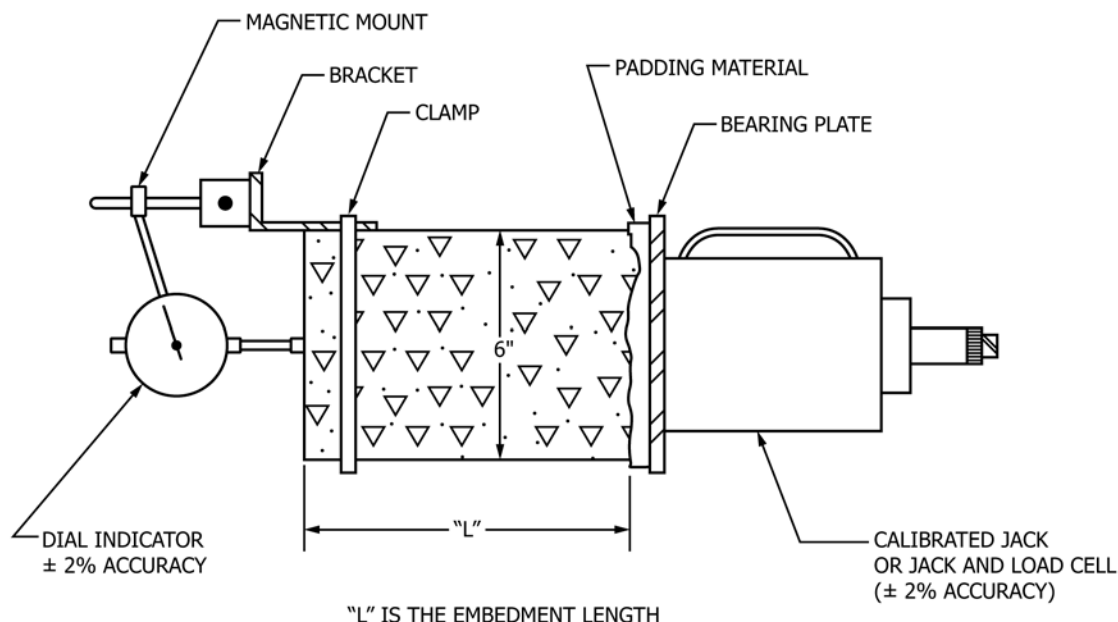


FIG. 1 Recommended Arrangement for Pull-Out Testing

ANNEX

(Mandatory Information)

A1. PREQUALIFICATION REQUIREMENTS FOR ORGANIC COATINGS

A1.1 Coating Requirements

A1.1.1 Chemical Resistance—The chemical resistance of coatings shall be evaluated in accordance with Test Method **G20** by immersing coated strands in each of the following: Distilled water, a 3 M aqueous solution of CaCl_2 , a 3 M aqueous solution of NaOH, and a solution saturated with $\text{Ca}(\text{OH})_2$. Specimens without holidays and specimens with intentional holes drilled through the coating 0.25 in. [6.35 mm] in diameter shall be tested. The temperature of the test solutions shall be $24 \pm 2^\circ\text{C}$. Minimum test time shall be 45 days. The coating must not blister, soften, lose bond, or develop holidays during this period. The intentionally-made holes shall exhibit no undercutting during the 45-day period.

A1.1.2 Chloride Permeability—The chloride permeability characteristics of the films of cured coatings having the minimum thickness as proposed for use shall be measured by the methods outlined in FHWA-RD-74-18. The test shall be performed at $24 \pm 2^\circ\text{C}$ for 45 days. The cumulative concentration of chloride ions permeating through the film shall be less than 1×10^{-4} M.

A1.1.3 Abrasion Resistance—The resistance of the strand coating to abrasion shall be determined by the falling sand method of Test Methods **D968** adapted for testing coated

strand. The volume of sand required to remove 10 mils (0.25 mm) of coating shall be greater than 1000 litres.

A1.1.4 Impact Test—The resistance of strand coating to mechanical damage shall be determined by the falling weight test. A test apparatus similar to that described in Test Method **G14** shall be used along with a 4-lb. [1.8 kg] tup. Impact shall occur on the crown areas on the coated strand. The test shall be performed at room temperature. With an impact of 80 in.-lb. [9 N·m], no shattering, cracking, or bond loss of the coating shall occur except at the impact area; that is, the area permanently deformed by the tup.

A1.1.5 Salt Spray (Fog) Test—Coated strand specimens shall be tensioned to 70 % of the minimum ultimate tensile strength and exposed to salt fog for 3000 h in accordance with Practice **B117**. Care shall be taken to protect the end anchorages used from salt fog or corrosion so as not to influence the test results. Observations for signs of corrosion shall be made and recorded every 250 h. After 3000 h of exposure, no evidence of rust shall be present, and the specimens shall be holiday-free.

A1.1.6 Elevated Temperature Test:

A1.1.6.1 Fabrication of Test Specimen:

(1) Pretension the coated strand to 75 % of its specified minimum breaking strength and anchor it in the form. Add shims under anchor if needed to return to 75 % of minimum breaking strength after anchor seating loss.

(2) Attach 10 thermocouples to the strand in pairs at a distance from end of 6 in. [0.15 m], 2 ft [0.61 m], 4 ft [1.22 m], 6 ft [1.83 m], and 7 ft 6 in. [2.29 m]. Place pairs with one on each side of strand.

(3) Cast concrete around the pretensioned strand to make a square concrete bar 8-ft [2.44-m] long with the strand at the center of the concrete cross section. Refer to **Table A1.1** for concrete cross section dimensions. Use moist cure, heat cure, or steam cure.

(4) Release strand from anchors by gentle release or flame cut when concrete strength reaches approximately 4000 psi [27.58 MPa] (see **Note A1.1**). Do not release if temperature in concrete around strand exceeds 150°F [65.5°C].

NOTE A1.1—Strength of concrete at time of test will not affect test results as long as it is at least 4000 psi [27.58 MPa].

A1.1.6.2 Test Procedures:

(1) Trim ends of strand so that motion of strand into concrete can be measured with a Linear Variable Differential Transformer (LVDT) or similar device.

(2) Mount specimen in heating chamber, connect thermocouples that are placed in the concrete at the surface of the strand, and mount the LVDT at each end.

(3) Apply heat so that temperature measured by thermocouples around strand increases as steadily as possible. Rate of increase should be between 1.0°F/min [0.5°C/min] and 2.5°F/min [1.4°C/min]. Increase rate as steadily and uniformly as possible along the square concrete bar.

(4) At intervals of approximately 7°F [3.8°C], record temperature and simultaneous readings of both LVDTs.

(5) Continue heating to at least 190°F [88°C].

(6) For each temperature recorded, plot average of the two LVDT readings against corresponding temperature. The temperature at which this plot crosses the 0.01-in. [0.25-mm] line is the temperature rating of the strand being tested for comparison to the requirements of **7.3.2**.

A1.2 Acceptance Testing

A1.2.1 Testing Agency—Acceptance tests shall be performed by an agency acceptable to the purchaser and manufacturer.

A1.2.2 Tests for chemical resistance, chloride permeability, abrasion resistance, impact resistance, and salt spray shall be conducted as specified in **A1.1**, whenever the coating formulation or supplier is changed.

A1.2.3 Certification—Reports summarizing the results of all tests and bearing the signature of the testing laboratory shall be furnished to the manufacturer.

TABLE A1.1 Cross-Section Dimensions of 8-ft [2.44-m] Long Square Concrete Bar

Strand Diameter, in. [mm]	Bar Cross Section, in. [mm]
3/8 [9.53]	3 1/2 × 3 1/2 [89 × 89]
7/16 [11.11]	4 1/2 × 4 1/2 [114 × 114]
1/2 [12.70]	4 1/2 × 4 1/2 [114 × 114]
0.600 [15.24]	5 1/2 × 5 1/2 [140 × 140]

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