



**Designation: A 416/A416M – 99**

## **Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete<sup>1</sup>**

This standard is issued under the fixed designation A 416/A416M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

### **1. Scope**

1.1 This specification covers two types and two grades of seven-wire, uncoated steel strand for use in pretensioned and post-tensioned prestressed concrete construction. The two types of strand are low-relaxation and stress-relieved (normal-relaxation). Low-relaxation strand shall be regarded as the standard type. Stress-relieved (normal-relaxation) strand will not be furnished unless specifically ordered, or by arrangement between purchaser and supplier. Grade 1725 [250] and Grade 1860 [270] have minimum ultimate strengths of 1725 MPa [250 ksi] and 1860 MPa [270 ksi], respectively, based on the nominal area of the strand.

1.2 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.3 The supplementary requirements in S1 shall be specified for 15.2-mm (0.6-in.) diameter uncoated seven-wire steel strand if needed for applications in prestressed ground anchors.

### **2. Referenced Documents**

#### **2.1 ASTM Standards:**

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products<sup>2</sup>

A 981 Test Method for Evaluating Bond Strength for 15.2 mm (0.6 in.) Diameter Prestressing Steel Strand, Grade 270, Uncoated, Used in Prestressed Ground Anchors<sup>3</sup>

E 328 Methods for Stress-Relaxation Tests for Materials and Structures<sup>4</sup>

#### **2.2 U.S. Military Standards:**

MIL-STD-129 Marking for Shipment and Storage<sup>5</sup>

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage<sup>5</sup>

#### **2.3 U.S. Federal Standard:**

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)<sup>5</sup>

### **3. Terminology**

#### **3.1 Definitions of Terms Specific to This Standard:**

3.1.1 *strand, n*—a group of wires having a center wire enclosed tightly by six helically placed outer wires with uniform pitch of not less than 12 and not more than 16 times the nominal diameter of the strand.

3.2 *Discussion*—The direction of lay may be either right- or left-hand, however, strands of different lays should not be spliced together.

### **4. Ordering Information**

4.1 Orders for seven-wire low-relaxation or stress-relieved (normal-relaxation) strand under this specification should include the following information:

4.1.1 Quantity (meters [feet]),

4.1.2 Diameter of strand,

4.1.3 Grade of strand,

4.1.4 Type of strand,

4.1.5 Packaging,

4.1.6 ASTM designation and year of issue, and

4.1.7 Special requirements, if any.

NOTE 1—A typical ordering description is as follows: 25 600 m [84 000 ft], 13 mm [0.5 in.], Grade 1860 [270] low-relaxation strand, in 3600-m [12 000-ft] reelless packs to ASTM A 416/A 416M—\_\_\_\_\_.

### **5. Materials and Manufacture**

5.1 *Base Metal*—The base metal shall be carbon steel of such quality that when drawn to wire, fabricated into strand, and then thermally treated, shall have the properties and characteristics prescribed in this specification.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 01.03.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.04.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>5</sup> Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094.

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5.2 *Wire*—The wire from which the strand is to be fabricated shall be round and have a dry-drawn finish.

NOTE 2—This product is a composite of seven wires and is produced to mechanical properties only. The chemistry of all wires or any individual wire is not pertinent to this application, and heat identity is not necessarily maintained. It is possible that wire from more than one heat may be used in the manufacture of a reel or pack. Traceability is based on pack identity as maintained and reported by the manufacturer.

5.3 *Treatment*—After stranding, low-relaxation strand shall be subjected to a continuous thermal-mechanical treatment to produce the prescribed mechanical properties. For stress-relieved (normal-relaxation) strand, only thermal treatment is necessary. Temper colors which result from the stress-relieving operation are considered normal for the finished appearance of this strand.

## 6. Mechanical Properties

6.1 Methods of testing for mechanical properties are described in Annex A7 of Test Methods and Definitions A 370. Low-relaxation strand shall also be tested as prescribed in Methods E 328.

6.2 *Breaking Strength*—The breaking strength of the finished strand shall conform to the requirements prescribed in Table 1.

6.3 *Yield Strength*—Yield strength in kN [pounds] is measured at 1 % extension under load. The minimum yield strength shall be 90 % for low-relaxation strand and 85 % for stress-relieved (normal-relaxation) strand of the breaking strength listed in Table 1. Initial loads for the test and minimum yield strengths are listed in Table 2.

6.3.1 The extension under load shall be measured by an extensometer calibrated with the smallest division not larger than 0.0001 mm/mm [0.0001 in./in.] of gage length.

6.4 *Elongation*—The total elongation under load shall not be less than 3.5 % using a gage length of not less than 600 mm [24 in.]. In practice the total elongation value may be determined by adding to the 1.0 % yield extension the percent extension or movement between the jaws gripping the strand after yield determination. The percent is calculated on the new base length of jaw-to-jaw distance.

6.5 *Relaxation Properties*—Low-relaxation strand shall have relaxation losses of not more than 2.5 % when initially loaded to 70 % of specified minimum breaking strength or not

more than 3.5 % when loaded to 80 % of specified minimum breaking strength of the strand after 1000 h tested under the conditions listed in 6.5.1 through 6.5.7.

6.5.1 If required, relaxation evidence shall be provided from the manufacturer's records of tests on similarly dimensioned strand of the same grade.

6.5.2 The temperature of the test piece shall be maintained at  $20 \pm 2^\circ\text{C}$  [ $68 \pm 3.5^\circ\text{F}$ ].

6.5.3 The test piece shall not be subjected to loading prior to the relaxation test.

6.5.4 The initial load shall be applied uniformly over a period of not less than 3 min and not more than 5 min, and the gage length shall be maintained constant; load relaxation readings shall commence 1 min after application of the total load.

6.5.5 Over-stressing of the test sample during the loading operation shall not be permitted.

6.5.6 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.

6.5.7 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.

## 7. Dimensions and Permissible Variations

7.1 The size of the finished strand shall be expressed as the nominal diameter of the strand in millimetres [inches].

7.2 The diameter of the center wire of any strand shall be larger than the diameter of any outer wire in accordance with Table 3.

7.3 *Permissible Variations in Diameter:*

7.3.1 All Grade 1725 [250] strand shall conform to a size tolerance of  $\pm 0.40$  mm [ $\pm 0.016$  in.] from the nominal diameter measured across the crowns of the wires.

7.3.2 All Grade 1860 [270] strand shall conform to a size tolerance of  $+0.65, -0.15$  mm [ $+0.026, -0.006$  in.] from the nominal diameter measured across the crowns of the wire.

7.3.3 Variation in cross-sectional area and in unit stress resulting therefrom shall not be cause for rejection provided

**TABLE 1 Breaking Strength Requirements**

Strand Designation No.	Diameter of Strand, mm [in.]	Minimum Breaking Strength of Strand, kN [lbf]	Steel Area of Strand, mm <sup>2</sup> [in. <sup>2</sup> ]	Weight of Strand kg/1000 m [lb/1000 ft]
Grade 1725 [250]				
6	6.4 [0.250]	40.0 [9 000]	23.2 [0.036]	182 [122]
8	7.9 [0.313]	64.5 [14 500]	37.4 [0.058]	294 [197]
9	9.5 [0.375]	89.0 [20 000]	51.6 [0.080]	405 [272]
11	11.1 [0.438]	120.1 [27 000]	69.7 [0.108]	548 [367]
13	12.7 [0.500]	160.1 [36 000]	92.9 [0.144]	730 [490]
15	15.2 [0.600]	240.2 [54 000]	139.4 [0.216]	1094 [737]
Grade 1860 [270]				
9	9.53 [0.375]	102.3 [23 000]	54.8 [0.085]	432 [290]
11	11.11 [0.438]	137.9 [31 000]	74.2 [0.115]	582 [390]
13	12.70 [0.500]	183.7 [41 300]	98.7 [0.153]	775 [520]
15	15.24 [0.600]	260.7 [58 600]	140.0 [0.217]	1102 [740]