



Designation: **A416/A416M – 17a** A416/A416M – 18

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

This standard is issued under the fixed designation A416/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 U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification covers two grades of low-relaxation, seven-wire steel strand for use in prestressed concrete construction. Grade 250 [1725] and Grade 270 [1860] have minimum tensile strengths of 250 ksi [1725 MPa] and 270 ksi [1860 MPa], respectively, based on the nominal area of the strand.

1.2 A supplementary requirement (S1) is provided for use where bond strength testing of 0.600-in. [15.24-mm] diameter Grade 270 [1860] strand for applications in prestressed ground anchors is required by the purchaser. The supplementary requirement applies only when specified in the purchase order.

1.3 The text of this specification contains notes or footnotes, or both, that provide explanatory material. Such notes and footnotes do not contain any mandatory information.

1.4 This specification is applicable for orders in either inch-pound units (as Specification A416) or in SI units (as Specification A416M).

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. 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 specification.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

- 2.1 *ASTM Standards:*<sup>2</sup>
- A981/A981M Test Method for Evaluating Bond Strength for 0.600-in. [15.24-mm] Diameter Steel Prestressing Strand, Grade 270 [1860], Uncoated, Used in Prestressed Ground Anchors
  - A1061/A1061M Test Methods for Testing Multi-Wire Steel Prestressing Strand
- 2.2 *U.S. Military Standard:*<sup>3</sup>
- MIL-STD-129 Marking for Shipment and Storage
- 2.3 *U.S. Federal Standard:*<sup>3</sup>
- Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

## 3. Terminology

3.1 *Definition of Term Specific to This Specification:*

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

3.1.2 *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 wires.

<sup>1</sup> 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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<sup>2</sup> 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.

<sup>3</sup> Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

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

### 3.1.2.1 Discussion—

The direction of lay is either right-handed or left-handed.

3.1.3 strand splice, n—a production connection between two separate lengths of strand never intended to carry prestressing loads.

3.1.4 wire weld, n—a resistance butt-weld joining two separate lengths of wire after wire drawing and before the wire is formed into strand.

## 4. Ordering Information

4.1 Orders for low-relaxation seven-wire steel strand under this specification shall contain the following information:

- 4.1.1 Quantity (feet [metres]),
- 4.1.2 Nominal diameter of strand (inches [millimetres]),
- 4.1.3 Grade of strand, and
- 4.1.4 ASTM designation A416 [A416M] and year of issue.

4.2 The purchaser shall have the option to specify additional requirements, including but not limited to, the following:

- 4.2.1 Relaxation evidence for similarly dimensioned strand of the same grade (6.5.1),
- 4.2.2 Specially dimensioned strand (7.47.5),
- 4.2.3 Whether strand splices are permitted (8.1.1),
- 4.2.4 Weldless strand (8.18.2.2),
- 4.2.5 Requirements for outside inspection (11.1),
- 4.2.6 Load-elongation curve (13.2),
- 4.2.7 Packaging and package marking (Section 14),
- 4.2.8 Supplementary Requirement S1, and
- 4.2.9 Other special requirements, if any.

## 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.

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

NOTE 1—This product is a composite of seven wires and is produced only to meet the prescribed mechanical properties. The chemical composition 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 reelless pack. Traceability is based on identity of reels or reelless packs as maintained and reported by the manufacturer.

5.3 *Treatment*—After stranding, strand shall be subjected to a continuous thermal-mechanical treatment to produce the prescribed mechanical properties. Temper colors which result from the thermal-mechanical treatment are considered normal for the finished appearance of this strand.

## 6. Mechanical Property Requirements

6.1 Tests for mechanical properties shall be conducted in accordance with Test Methods A1061/A1061M.

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

**TABLE 1 Breaking Strength Requirements**

Nominal Diameter of Strand, in. [mm]	Minimum Breaking Strength of Strand, lbf [kN]	Steel Area of Strand, in. <sup>2</sup> [mm <sup>2</sup> ]	Weight [Mass] of Strand lb/1000 ft [kg/1000 m]
Grade 250 [1725]			
0.250 [6.4]	9 000 [40.0]	0.036 [23]	122 [182]
0.313 [7.9]	14 500 [64.5]	0.058 [37]	197 [294]
0.375 [9.5]	20 000 [89.0]	0.080 [52]	272 [405]
0.438 [11.1]	27 000 [120]	0.108 [69.7]	367 [548]
0.500 [12.7]	36 000 [160]	0.144 [92.9]	490 [730]
0.600 [15.2]	54 000 [240]	0.216 [139]	737 [1090]
Grade 270 [1860]			
0.375 [9.53]	23 000 [102]	0.085 [55]	290 [430]
0.438 [11.1]	31 000 [138]	0.115 [74.2]	390 [580]
0.500 [12.7]	41 300 [184]	0.153 [98.7]	520 [780]
0.520 [13.2]	45 000 [200]	0.167 [108]	570 [840]
0.563 [14.3]	51 700 [230]	0.192 [124]	650 [970]
0.600 [15.2]	58 600 [261]	0.217 [140]	740 [1100]
0.620 [15.7]	62 800 [279]	0.231 [150]	780 [1200]
0.700 [17.8]	79 400 [353]	0.294 [190]	1000 [1500]



**TABLE 2 Yield Strength Requirements**

Nominal Diameter of Strand in. [mm]	Initial Load, lbf [kN]	Minimum Load at 1.0 % Extension, lbf [kN]
Grade 250 [1725]		
0.250 [6.4]	900 [4.0]	8 100 [36.0]
0.313 [7.9]	1 450 [6.5]	13 050 [58.1]
0.375 [9.5]	2 000 [8.9]	18 000 [80.1]
0.438 [11.1]	2 700 [12.0]	24 300 [108.1]
0.500 [12.7]	3 600 [16.0]	32 400 [144.1]
0.600 [15.2]	5 400 [24.0]	48 600 [216.2]
Grade 270 [1860]		
0.375 [9.53]	2 300 [10.2]	20 700 [92.1]
0.438 [11.1]	3 100 [13.8]	27 900 [124.1]
0.500 [12.7]	4 130 [18.4]	37 170 [165.3]
0.520 [13.2]	4 500 [20.0]	40 500 [180.1]
0.563 [14.3]	5 170 [23.0]	46 530 [207.0]
0.600 [15.2]	5 860 [26.1]	52 740 [234.6]
0.620 [15.7]	6 280 [27.9]	56 520 [251.4]
0.700 [17.8]	7 940 [35.3]	71 500 [318.0]

**TABLE 3 Diameter Relation Between Center and Outer Wires**

Nominal Diameter of Strand, in. [mm]	Minimum Difference Between Center Wire Diameter and Diameter of Any Outer Wire, in. [mm]
Grade 250 [1725]	
0.250 [6.4]	0.001 [0.025]
0.313 [7.9]	0.0015 [0.038]
0.375 [9.5]	0.002 [0.051]
0.438 [11.1]	0.0025 [0.064]
0.500 [12.7]	0.003 [0.076]
0.600 [15.2]	0.004 [0.102]
Grade 270 [1860]	
0.375 [9.53]	0.002 [0.051]
0.438 [11.1]	0.0025 [0.064]
0.500 [12.7]	0.003 [0.076]
0.520 [13.2]	0.003 [0.076]
0.563 [14.3]	0.0035 [0.089]
0.600 [15.2]	0.004 [0.102]
0.620 [15.7]	0.004 [0.102]
0.700 [17.8]	0.0045 [0.114]

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6.3 *Yield Strength*—Yield strength in pounds [kN] shall be measured at 1.0 % extension under load. The minimum yield strength shall be 90 % 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 in./in. [0.0001 mm/mm] 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 24 in. [600 mm]. It shall be permissible to determine the total elongation value 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*—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 hours of testing.

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.

**7. Dimensions and Permissible Variations**

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

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 Lay length shall be between 12 and 16 times the nominal diameter of the strand.

7.4 *Permissible Variations in Diameter:*