Designation: A706/A706M – 16

Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement[1]

This standard is issued under the fixed designation A706/A706M; 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.

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

1. Scope*

1.1 *General*—This specification covers deformed and plain low-alloy steel bars in cut lengths and coils for concrete reinforcement intended for applications where restrictive mechanical properties and chemical composition are required for compatibility with controlled tensile property applications or to enhance weldability. The standard sizes and dimensions of deformed bars and their number designations are given in Table 1.

1.2 *Grade*—Bars are of two minimum yield strength levels: namely, 60 000 psi [420 MPa] and 80 000 psi [550 MPa], designated as Grade 60 [420] and Grade 80 [550], respectively.

1.3 Plain bars, in sizes up to and including 2½ in. [63.5 mm] in diameter in coils or cut lengths, when ordered, shall be furnished under this specification. For ductility properties (elongation and bending), test provisions of the nearest smaller nominal diameter deformed bar size shall apply. Requirements providing for deformations and marking shall not be applicable.

1.4 *Controlled Tensile Properties*—This specification limits tensile properties (Table 2) to provide the desired yield/tensile properties for controlled tensile property applications.

1.5 *Welding*—This specification limits chemical composition (6.2) and carbon equivalent (6.4) to enhance the weldability of the material. When this steel is to be welded, a welding procedure suitable for the chemical composition and intended use or service should be used. The use of the latest edition of AWS D1.4/D1.4M is recommended. The AWS D1.4/D1.4M Welding Code describes the proper selection of the filler metals, preheat/interpass temperatures, as well as, performance and procedure qualification requirements.

1.6 Requirements for alternate bar sizes are presented in Annex A1. The requirements in Annex A1 only apply when specified by the purchaser (see 4.2.5).

1.7 The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes, excluding those in tables, shall not be considered as requirements of this specification.

1.8 This specification is applicable for orders in either inch-pound units (Specification A706) or in SI units [Specification A706M].

1.9 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 this specification.

1.10 *This specification 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 specification 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]

A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A510/A510M Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel

A615/A615M Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

A700 Guide for Packaging, Marking, and Loading Methods for Steel Products for Shipment

A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

[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.

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

TABLE 1 Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

Bar Designation No.	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions[A]			Deformation Requirements, in. [mm]		
		Diameter, in. [mm]	Cross-Sectional Area in.^{2} [mm^2]	Perimeter, in. [mm]	Maximum Average Spacing	Minimum Average Height	Maximum Gap (Chord of 12.5 % of Nominal Perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	1.043 [1.552]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	1.502 [2.235]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	2.044 [3.042]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	3.400 [5.060]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	4.303 [6.404]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	5.313 [7.907]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

[A] The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

TABLE 2 Tensile Requirements

	Grade 60 [420]	Grade 80 [550]
Tensile strength, min, psi [MPa]	80 000 [550][A]	100 000 [690][A]
Yield strength, min, psi [MPa]	60 000 [420]	80 000 [550]
Yield strength, max, psi [MPa]	78 000 [540]	98 000 [675]
Elongation in 8 in. [200 mm], min, %		
Bar Designation Nos.		
3, 4, 5, 6 [10, 13, 16, 19]	14	12
7, 8, 9, 10, 11 [22, 25, 29, 32, 36]	12	12
14, 18 [43, 57]	10	10

[A] Tensile strength shall not be less than 1.25 times the actual yield strength.

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E290 Test Methods for Bend Testing of Material for Ductility

2.2 *AWS Standard:*[3]

AWS D1.4/D1.4M Structural Welding Code—Reinforcing Steel

2.3 *U.S. Military Standard:*[4]

MIL-STD-129 Marking for Shipment and Storage

2.4 *U.S. Federal Standard:*[4]

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

3. Terminology

3.1 *Definitions of Terms Specific to This Specification:*

3.1.1 *deformations, n*—transverse protrusions on a deformed bar.

3.1.2 *deformed bar, n*—steel bar with protrusions; a bar that is intended for use as reinforcement in reinforced concrete and related construction.

3.1.2.1 *Discussion*—The surface of the bar is provided with lugs or protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The lugs or protrusions conform to the provisions of this specification.

3.1.3 *plain bar, n*—steel bar without protrusions.

3.1.4 *rib, n*—longitudinal protrusion on a deformed bar.

4. Ordering Information

4.1 Orders for low-alloy steel bars for concrete reinforcement under this specification shall contain the following information:

4.1.1 Quantity (weight) [mass],

4.1.2 Deformed or plain,

4.1.3 Bar designation number (size) of deformed bars, or nominal diameter (size) of plain bars,

4.1.4 Cut lengths or coils,

4.1.5 Grade, and

4.1.6 ASTM designation 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 Requirements for inspection (17.1),

4.2.2 Special package marking requirements (20.2),

4.2.3 Require bars in each bundle to be supplied from a single heat (16.1),

4.2.4 Other special requirements, if any, and

4.2.5 Optional requirements of Annex A1, if applicable.

5. Material and Manufacture

5.1 The bars shall be processed from properly identified heats of mold-cast or strand-cast steel. The steel shall be made by any commercially accepted process.

6. Chemical Composition

6.1 The chemical analysis of each heat shall be determined in accordance with Test Methods, Practices, and Terminology A751. The manufacturer shall make the analysis on test samples taken preferably during the pouring of the heat. The percentages of carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, molybdenum, and vanadium shall be determined.

6.2 The chemical composition as shown by heat analysis shall be limited by the following:

Element	max, %
Carbon	0.30
Manganese	1.50
Phosphorus	0.035
Sulfur	0.045
Silicon	0.50

[3] Available from American Welding Society (AWS), 8669 NW 36 Street, #130, Miami, FL 33166-6672, http://www.aws.org.

[4] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

6.3 Choice and use of alloying elements, combined with carbon, phosphorus, and sulfur to produce the mechanical properties prescribed in Table 2 and Table 3, shall be made by the manufacturer. Elements commonly used include manganese, silicon, copper, nickel, chromium, molybdenum, vanadium, columbium, titanium, and zirconium.

6.4 The heat analysis shall be such as to provide a carbon equivalent (C.E.) not exceeding 0.55 % as calculated by the following formula:

$$C.E. = \%C + \frac{\%\,Mn}{6} + \frac{\%\,Cu}{40} + \frac{\%\,Ni}{20} + \frac{\%\,Cr}{10} - \frac{\%\,Mo}{50} - \frac{\%\,V}{10} \quad (1)$$

6.5 *Product (Check) Verification Analysis*—A product check analysis made by the purchaser shall not exceed the following percentages:

Element	max, %
Carbon	0.33 %
Manganese	1.56 %
Phosphorus	0.043 %
Sulfur	0.053 %
Silicon	0.55 %

7. Requirements for Deformations

7.1 Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size, shape, and pattern.

7.2 The deformations shall be placed with respect to the axis of the bar so that the included angle is not less than 45°. Where the line of deformations forms an included angle with the axis of the bar from 45 to 70°, inclusive, the deformations shall reverse alternately in direction on each side, or those on one side shall be reversed in direction from those on the opposite side. Where the line of deformation is over 70°, a reversal in direction shall not be required.

7.3 The average spacing or distance between deformations on each side of the bar shall not exceed 7/10 of the nominal diameter of the bar.

7.4 The overall length of deformations shall be such that the gap (measured as a chord) between the ends of the deformations shall not exceed 12.5 % of the nominal perimeter of the bar. Where the ends terminate in a rib, the width of the rib shall be considered as the gap between these ends. The summation of the gaps shall not exceed 25 % of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.1416 times the nominal diameter.

7.5 The spacing, height, and gap of deformations shall conform to the requirements prescribed in Table 1.

TABLE 3 Bend Test Requirements

Bar Designation No.	Pin Diameter for 180° Bend Tests	
	Grade 60 [420]	Grade 80 [550]
3, 4, 5 [10, 13, 16]	3*d* [A]	3½ *d* [A]
6, 7, 8 [19, 22, 25]	4*d*	5*d*
9, 10, 11 [29, 32, 36]	6*d*	7*d*
14, 18 [43, 57]	8*d*	9*d*

[A] *d* = nominal diameter of specimen.

8. Measurements of Deformations

8.1 The average spacing of deformations shall be determined by measuring the length of a minimum of 10 spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space. Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers.

8.2 The average height of deformations shall be determined from measurements made on not less than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

8.3 Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot (see Note 1) tested that typical deformation height, gap, or spacing do not conform to the minimum requirements prescribed in Section 7. No rejection shall be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

NOTE 1—As used within the intent of 8.3, the term "lot" shall mean all the bars of one bar size and pattern of deformations contained in an individual shipping release or shipping order.

9. Tensile Requirements

9.1 The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 2.

9.2 The yield point or yield strength shall be determined by one of the following methods:

9.2.1 The yield point shall be determined by the drop of the beam or halt in the gauge of the tensile testing machine, where the steel tested has a sharp-kneed or well-defined yield point.

9.2.2 Where the steel does not have a well-defined yield point, the yield strength shall be determined by the offset method (0.2 % offset) as described in Test Methods and Definitions A370.

9.3 When material is furnished in coils, the test specimen shall be taken from the coil and straightened prior to placing it in the jaws of the tensile testing machine. (See Note 2.)

NOTE 2—Straighten the test specimen to avoid formation of local sharp bends and to minimize cold work. Insufficient straightening prior to attaching the extensometer can result in lower-than-actual yield strength readings.

9.3.1 Test specimens taken from post-fabricated material shall not be used to determine conformance to this specification. (See Note 3.)

NOTE 3—Multiple bending distortion from mechanical straightening and fabricating machines can lead to excessive cold work, resulting in higher yield strengths, lower elongation values, and a loss of deformation height.

9.4 The percentage of elongation shall be as prescribed in Table 2.