Designation: A 706/A 706M – 00

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

This standard is issued under the fixed designation A 706/A 706M; 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 Department of Defense.

1. Scope

1.1 *General*—This specification covers deformed and plain low-alloy steel bars in cut lengths or 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. The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this specification.

1.2 *Grade*—Bars are of a single minimum yield strength level: namely, 60 000 psi [420 MPa], designated as Grade 60 [420].

1.3 Plain rounds, in sizes up to and including 2 in. [50.8 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.

1.4 *Controlled Tensile Properties*—This specification limits mechanical 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 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 ANSI/AWS D1.4 is recommended. This document describes the proper selection of the filler metals, preheat/interpass temperatures, as well as, performance and procedure qualification requirements.

1.6 This specification is applicable for orders in either inch-pound units (Specification A 706) or in SI units [Specification A 706M].

1.7 The values stated in either inch-pound units or SI units are to be regarded as standard. Within the text, the SI 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 this specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 6/A 6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Steel Piling[2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3]

A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel[3]

A 510M Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel (Metric)[3]

A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement[2]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment[4]

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products[2]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[5]

2.2 *ANSI/AWS Standard:*

AWS D1.4 Structural Welding Code—Reinforcing Steel[6]

2.3 *Government Standards:*

MIL-STD-129 Marking for Shipment and Storage[7]

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[7]

2.4 *U.S. Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

[1] 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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[2] *Annual Book of ASTM Standards*, Vol 01.04.

[3] *Annual Book of ASTM Standards*, Vol 01.03.

[4] *Annual Book of ASTM Standards*, Vol 01.05.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

[6] Available from the American Welding Society, P.O. Box 351040, 550 N.W. Le Jeune Rd., Miami, FL 33135.

[7] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

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

Bar Designation No.[A]	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions[B]			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] Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars [bar numbers approximate the number of millimetres of the nominal diameter of the bar].

[B] 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

Tensile strength, min, psi [MPa]	80 000 [550][A]
Yield strength, min, psi [MPa]	60 000 [420]
Yield strength, max, psi [MPa]	78 000 [540]
Elongation in 8 in. [203.2 mm], min, %	
Bar Designation Nos.	
3, 4, 5, 6 [10, 13, 16, 19]	14
7, 8, 9, 10, 11 [22, 25, 29, 32, 36]	12
14, 18 [43, 57]	10

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

3.1.1 *deformations*, *n*—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.

3.1.3 *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.

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

3.1.5 *rib*, *n*— longitudinal protrusions on a deformed bar.

4. Ordering Information

4.1 It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered to this specification. Such requirements shall include, but are not limited to, the following:

4.1.1 Quantity (weight) [mass],

4.1.2 Name of material (low-alloy steel deformed and plain bars for concrete reinforcement),

4.1.3 Size,

4.1.4 Cut lengths or coils,

4.1.5 Deformed or plain,

4.1.6 Packaging (see Section 17),

4.1.7 ASTM designation and year of issue, and

4.1.8 Certified mill test reports (if desired). (See Section 13.)

NOTE 1—A typical ordering description is as follows: 20 tons, low-alloy steel deformed bars for concrete reinforcement, No. 14, 60 ft 0 in. long, in secured lifts to Specification A 706 – ____. Certified mill test reports are required.

[19 tonnes, low-alloy steel deformed bars for concrete reinforcement, No. 25, 18.3 m long, in secured lifts to Specification A 706M – ____. Certified mill test reports are required.]

5. Material and Manufacture

5.1 The bars shall be processed from properly identified heats of mold cast or strand cast steel.

5.2 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace.

6. Chemical Composition

6.1 The chemical analysis of each heat shall be determined in accordance with Test Methods A 751. 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

6.3 Choice and use of alloying elements, combined with carbon, phosphorus, and sulfur to give 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:

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

TABLE 3 Bend Test Requirements

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

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

6.5 *Product (Check) Verification Analysis*—An analysis may be made by the purchaser from finished bars representing each heat of steel. The percentages thus determined shall not exceed the following:

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 between the ends of the deformations on opposite sides of the bar shall not exceed 12.5 % of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25 % of the nominal perimeter of the bar. Furthermore, the summation of gaps shall not exceed 25 % of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.14 times the nominal diameter.

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

8. Measurements of Deformations

8.1 The average spacing of deformations shall be determined by dividing a measured length of the bar specimen by the number of individual deformations and fractional parts of deformations on any one side of the bar specimens. A measured length of the bar specimen shall be considered the distance from a point on a deformation to a corresponding point on any other deformation on the same side of the bar. 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 4) 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 2—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. Mechanical Requirements

9.1 *Tensile Properties*:

9.1.1 The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 2. The yield strength or yield point shall be determined by one of the following methods:

9.1.1.1 Extension under load using an autographic diagram method or an extensometer as described in Test Methods and Definitions A 370. However, the extension under load shall be 0.0035 in./in. [0.0035 mm/mm] (0.35 %). When material is furnished in coils, the test sample shall be straightened prior to placing it in the jaws of the tensile machine (see Note 5). Straightening shall be done carefully to avoid the 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.

9.1.1.2 By the drop of the beam or halt in the gage of the testing machine, where the steel tested has a sharp-kneed or well-defined type of yield point.

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

NOTE 3—Straightening should be done carefully to avoid the 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.

9.2 *Bending Properties*:

9.2.1 The bend test specimen shall withstand being bent around a pin without cracking on the outside radius of the bent portion. The requirements for degree of bending and sizes of pins are prescribed in Table 3. When material is furnished in coils, the test sample shall be straightened prior to placing it in the bend tester.

9.2.2 The bend test shall be made on specimens of sufficient length to ensure free bending and with apparatus that provides:

9.2.2.1 Continuous and uniform application of force throughout the duration of the bending operation,

9.2.2.2 Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate,

9.2.2.3 Close wrapping of the specimen around the pin during the bending operation.

9.3 *Test Specimens*:

9.3.1 The tension test specimens shall be the full section of the bar as rolled. The unit stress determination shall be based on the nominal bar area.

9.3.2 The bend test specimens shall be the full section of the bar as rolled.

10. Permissible Variation in Weight [Mass]

10.1 Deformed reinforcing bars shall be evaluated on the basis of nominal weight [mass]. The weigh [mass] determined using the measured weight [mass] of the test specimen and rounding in accordance with Practice E 29, shall be at least

94% of the applicable weight [mass] per unit length prescribed in Table 1. In no case shall overweight [excess mass] of any deformed bar be cause for rejection. Weight [mass] variation for plain rounds shall be computed on the basis of permissible variation in diameter. For plain round bars smaller than ⅜ in. [9.5 mm], use Specification A 510 [Specification A 510M]. For larger bars up to and including 2 in. [50 mm], use Specification A 6/A 6M.

11. Finish

11.1 The bars shall be free of detrimental surface imperfections.

11.2 Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the weight, dimensions, cross-sectional area, and tensile properties of a hand wire brushed test specimen are not less than the requirements of this specification.

11.3 Surface imperfections or flaws other than those specified in 11.2 shall be considered detrimental when specimens containing such imperfections fail to conform to either tensile or bending requirements. Examples include, but are not limited to, laps, seams, scabs, slivers, cooling or casting cracks, and mill or guide marks.

NOTE 4—Reinforcing bar intended for epoxy coating applications should have surfaces with a minimum of sharp edges to achieve proper cover. Particular attention should be given to bar marks and deformations where coating difficulties are prone to occur.

NOTE 5—Deformed bars destined to be mechanically-spliced or butt-welded may require a certain degree of roundness in order for the splices to adequately achieve strength requirements.

12. Number of Tests and Retests

12.1 All mechanical tests shall be conducted in accordance with Test Methods and Definitions A 370 including Annex A9.

12.2 *Number of Tests*— One tension test and one bend test shall be made of each bar size rolled from a heat.

12.3 *Retests*:

12.3.1 If any tensile property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

12.3.2 If the results of an original tension specimen fail to meet the specified minimum requirements and are within 2000 psi [14 MPa] of the required tensile strength, within 1000 psi [7 MPa] of the required yield point, or within two percentage units of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. Both retest specimens shall meet the requirements of this specification.

12.3.3 If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in 12.3.5 and 12.3.6, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification. The retest shall be performed on test specimens that are at air temperature but not less than 60°F [16°C].

12.3.4 If a weight [mass] test fails for reasons other than flaws in the specimen as described in 12.3.6, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

12.3.5 If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it may be discarded and another specimen taken.

12.3.6 If flaws are detected in a test specimen, either before or during the performance of the test, it may be discarded and another specimen of the same size bar from the same heat substituted.

13. Test Reports

13.1 Report the following information on a per heat basis. Additional items may be reported as requested or desired.

13.1.1 Chemical analysis including carbon, manganese, phosphorous, sulfur, silicon, copper, nickel, chromium, molybdenum, and vanadium.

13.1.2 Carbon equivalent in accordance with 6.4.

13.1.3 Tensile properties.

13.1.4 Bend test.

14. Inspection

14.1 The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy the inspector that the material is being furnished in accordance with this specification. All tests (except product (check) analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted so as not to interfere unnecessarily with the operation of the works.

14.2 *For Government Procurement Only*—Except as otherwise specified in the contract, the contractor shall be responsible for the performance of all inspection and test requirements specified herein and shall be permitted to use one's own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification where such inspections are deemed neccesary to assure that material conforms to prescribed requirements.

15. Rejection

15.1 Unless otherwise specified, any rejection based on tests made in accordance with 6.5 shall be reported to the manufacturer within five working days from the receipt of samples by the purchaser.

16. Marking

16.1 When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's heat or test identification number.

16.2 Each manufacturer shall identify the symbols of his marking system.

16.3 All bars produced to this specification, except plain round bars, shall be identified by a distinguishing set of marks

legibly rolled onto the surface of one side of the bar to denote in the following order:

16.3.1 *Point of Origin*— Letter or symbol established as the manufacturer's mill designation.

16.3.2 *Size Designation*— Arabic number corresponding to bar designation number of Table 1.

16.3.3 *Type of Steel*— Letter *W* indicating that the bar was produced to this specification, or letters *W* and *S* indicating that the bar was produced to meet both Specifications A 615/A 615M and A 706/A 706M.

16.3.4 *Minimum Yield Designation*—The marking shall be either the number 60 [4] or a single continuous longitudinal line through at least five spaces offset from the center of the bar side.

16.3.5 It shall be permissible to substitute a metric size bar of Grade 420 for the corresponding inch-pound size bar of Grade 60.

17. Packaging

17.1 When specified in the purchase order, packaging shall be in accordance with Practices A 700.

17.2 *For Government Procurement Only*—When specified in the contract or order, and for direct procurement by or direct shipment to the United States, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

18. Keywords

18.1 alloy steel; concrete reinforcement; deformations (protrusions); steel bars