Designation: A706/A706M – 22a

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 three minimum yield strength levels: namely, 60 000 psi [420 MPa], 80 000 psi [550 MPa], and 100 000 psi [690 MPa] designated as Grade 60 [420], Grade 80 [550], and Grade 100 [690], 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.

NOTE 1—As a result of the 117 000 psi minimum tensile strength for Grade 100 [690], users of this specification should be aware that ACI 318 Type 1 mechanical splice requirements of 125 % of specified yield strength requirements in tension and compression, found in many acceptance criteria, may result in an invalid mechanical splice qualification or verification test when the tensile strength of the bar is between 117 000 psi and 125 000 psi.

1.6 Annex A2 describes the methods for determination of uniform elongation (El_u). Annex A2 is mandatory when Supplementary Requirement S1 is specified by the purchaser (see 4.2.6).

1.7 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).

1.8 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.

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

1.10 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.

1.11 *This standard 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 standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.12 *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.*

[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.

Current edition approved Dec. 1, 2022. Published February 2023. Originally approved in 1974. Last previous edition approved in 2022 as A706/A706M – 22. DOI: 10.1520/A0706_A0706M-22A.

***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]	Grade 100 [690]
Tensile strength, min, psi [MPa]	80 000 [550]	100 000 [690]	117 000 [805]
Yield strength, min, psi [MPa]	60 000 [420]	80 000 [550]	100 000 [690]
Yield strength, max, psi [MPa]	78 000 [540]	98 000 [675]	118 000 [815]
Ratio of actual tensile strength to actual yield strength, min	1.25	1.25	1.17
Elongation in 8 in. [200 mm], min, %			
Bar Designation Nos.			
3, 4, 5, 6 [10, 13, 16, 19]	14	12	10
7, 8, 9, 10, 11 [22, 25, 29, 32, 36]	12	12	10
14, 18 [43, 57]	10	10	10

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 and Practices for Chemical Analysis of Steel Products

E8/E8M Test Methods for Tension Testing of Metallic Materials

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)

2.5 *ACI Building Code:*[5]

ACI Code-318 Building Code Requirements for Structural Concrete and Commentary

2.6 *Canadian Standards Association:*[6]

G30.18 Carbon steel bars for concrete reinforcement

2.7 *ISO Standards:*[7]

ISO 15630–1 Steel for the reinforcement and prestressing of concrete – Test methods – Part 1: Reinforcing bars, rods and wire

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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.

[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.

[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.

[5] Available from American Concrete Institute, 38800 Country Club Dr., Farmington Hills, MI, 48331-3439, http://www.concrete.org.

[6] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

[7] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

3.1.4 *plastic component of uniform elongation, El [%], n*—the measurement of plastic strain taken remote from the break to avoid localized necking of the bar, used for the determination of uniform elongation (see Annex A2).

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

3.1.6 *uniform elongation, El_u [%]*—the elongation determined at the maximum force sustained by the test piece just prior to necking or fracture, or both (see Test Methods E8/E8M).

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.

4.2.6 Supplementary requirements, 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

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.

TABLE 3 Bend Test Requirements

Bar Designation No.	Pin Diameter for 180° Bend Tests		
	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
3, 4, 5 [10, 13, 16]	3*d* [A]	3½ *d* [A]	3½ *d*
6, 7, 8 [19, 22, 25]	4*d*	5*d*	5*d*
9, 10, 11 [29, 32, 36]	6*d*	7*d*	7*d*
14, 18 [43, 57]	8*d*	9*d*	9*d*

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

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:

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

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.

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 2) 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. 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 3.)

NOTE 3—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 4.)

NOTE 4—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.

10. Bending Requirements

10.1 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 specimen shall be straightened prior to placing it in the bend tester.

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

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

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

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

10.3 It shall be permissible to use other methods of bend testing as described in Test Methods E290, such as placing a specimen across two round bearings free to rotate and applying the bending force with a fixed rounded-tip mandrel conforming to the specified bend radius, allowing the bar to pass through with sufficient clearance. When failures occur under other methods of bend resistance, retests shall be permitted under the bend-test method prescribed in 10.2.

11. Permissible Variation in Weight [Mass]

11.1 Deformed reinforcing bars shall be evaluated on the basis of nominal weight [mass]. The weight [mass] determined using the measured weight [mass] of the test specimen and rounding in accordance with Practice E29, 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.

11.2 Weight [mass] variation for plain bars shall be computed on the basis of permissible variation in diameter. For plain bars smaller than ⅜ in. [9.5 mm] in diameter, use Specification A510/A510M. For larger plain bars up to and including 2½ in. [63.5 mm] in diameter, use Specification A6/A6M.

12. Finish

12.1 The bars shall be free of detrimental surface imperfections.

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

12.3 Surface imperfections or flaws other than those specified in 12.2 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 5—Deformed reinforcing bars intended for epoxy coating applications should have surfaces with a minimum of sharp edges to achieve proper coverage. Particular attention should be given to bar marks and deformations where coating difficulties are prone to occur.

NOTE 6—Deformed reinforcing bars destined to be mechanically-spliced or butt-spliced by welding may require a certain degree of roundness in order for the splices to adequately achieve strength requirements.

13. Number of Tests

13.1 One tension test and one bend test shall be made of each bar size rolled from each heat.

13.2 One set of dimensional property tests including bar weight [mass] and spacing, height, and gap of deformations shall be made of each bar size rolled from each heat.

14. Retests

14.1 If the results of an original tension test 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 strength, or within two percentage units of the required elongation or uniform elongation, a retest shall be permitted on two random specimens for each original tension test specimen failure from the lot. Both retest specimens shall meet the requirements of this specification.

14.2 If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in 14.4.2 and 14.4.3, 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].

14.3 If a weight [mass] test fails for reasons other than flaws in the specimen as described in 14.4.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

14.4 If the original test or any of the random retests fails because of any reasons listed in 14.4.1, 14.4.2, or 14.4.3, the test shall be considered an invalid test:

14.4.1 The elongation property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle half of the gage length, as indicated by scribe marks on the specimen before testing;

NOTE 7—Marking specimens with multiple scribe or punch marks can reduce the occurrence of fracture outside or near these marks and the need for declaring the test invalid.

14.4.2 Mechanical reasons such as failure of testing equipment or improper specimen preparation; and

14.4.3 Flaws are detected in a test specimen, either before or during the performance of the test.

14.5 The original results from 14.4.1, 14.4.2, or 14.4.3 shall be discarded and the test shall be repeated on a new specimen from the same lot.

15. Test Specimens

15.1 All mechanical tests shall be conducted in accordance with Test Methods and Definitions A370. In case of any conflict between the requirements in this specification and the requirements of Test Methods and Definitions A370, the requirements in this specification shall prevail.

15.2 Tension test specimens shall be the full section of the bar as rolled. Unit stress determinations for yield and tensile strength shall be based on the nominal bar area.

15.2.1 Tension test specimens shall be long enough to provide for an 8-in. [200-mm] gage length, a distance of at least two bar diameters between each gage mark and the grips.

NOTE 8—It is recommended that sufficient additional length of the test specimen be provided to fill the grips completely, leaving some excess length protruding beyond each grip. The grips should be shimmed so that no more than ½ in. [13 mm] of a grip protrudes from the head of the tensile testing machine.

15.2.2 *Gage Marks*—The 8-in. [200-mm] gage length shall be marked on the specimen using a preset 8-in. [200-mm] punch or, alternately, may be punch marked every 2 in. [50 mm]) along the 8-in. [200-mm] gage length, on one of the longitudinal ribs, if present, or in the clear spaces between transverse deformations. Punch marks shall not be placed on a transverse deformation.

NOTE 9—Light punch marks are desirable because deep marks severely indent the bar and may affect the results.

15.3 Bend test specimens shall be the full section of the bar as rolled.

16. Test Reports

16.1 When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's heat or test identification number. Unless otherwise specified, it shall be permissible for the manufacturer to make a full-size bundle at the end of a heat by adding bars from a consecutively rolled heat of the same nominal chemical composition. The manufacturer shall identify a bundle consisting of bars from two heats with the identification number of the first heat rolled or identify both heats. The manufacturer shall maintain records of the heats contained in each bundle.

16.1.1 Chemical analysis including the percentages of carbon, manganese, phosphorous, sulfur, silicon, copper, nickel, chromium, molybdenum, and vanadium.

16.1.2 Carbon equivalent in accordance with 6.4.

16.1.3 Tensile properties.

16.1.4 Bend test results.

16.1.5 Uniform elongation, if applicable.

16.1.6 Compliance with Supplementary Requirements S1, if applicable, shall be stated on the Material Test Report.

16.2 A Material Test Report, Certificate of Inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document shall meet the requirements of the invoked ASTM standard(s) and conform to any EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 10—The industry definition invoked here is: EDI is the computer to computer exchange of business information in a standard format such as ANSI ASC X12.

17. Inspection

17.1 Inspection of the low-alloy steel reinforcing bars shall be agreed upon between the purchaser and the manufacturer as part of the purchase order or contract.

18. Rejection and Rehearing

18.1 Any rejection based on testing undertaken by the purchaser shall be promptly reported to the manufacturer.

18.2 Samples tested that represent rejected material shall be preserved for two weeks from the date rejection is reported to the manufacturer. In case of dissatisfaction with the results of the tests, the manufacturer shall have the right to make claim for a rehearing within that time.

19. Marking

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

19.1.1 Compliance with Supplementary Requirements S1, if applicable, shall be indicated on the tag.

19.2 Each manufacturer shall identify the symbols of their marking system.

19.3 All bars produced to this specification, except plain bars, which shall be tagged for grade, 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:

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

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

19.3.3 *Type of Steel*—Letter *W* indicating that the bar was produced to this specification.

19.3.3.1 Bars that meet the requirements of this specification shall be considered as satisfying all requirements of the corresponding size and grade of Specification A615/A615M.

19.3.4 *Minimum Yield Strength Designation*—For Grade 60 [420] bars, 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. For Grade 80 [550] bars, the marking shall be either the number 80 [6] or three continuous longitudinal lines through at least five spaces. For Grade 100 [690] bars, either the number 100 [7] or four continuous lines through at least five deformation spaces, or the letter C.

19.3.5 It shall be permissible to substitute a metric size bar of Grade 420 for the corresponding inch-pound size bar of Grade 60, a metric size bar of Grade 550 for the corresponding inch-pound size bar of Grade 80, and a metric size bar of Grade 690 for the corresponding inch-pound size bar of Grade 100.

20. Packaging and Package Marking

20.1 Packaging, marking, and loading for shipment shall be in accordance with Practices A700.

20.2 When specified in the purchase order or contract, and for direct procurement by or direct shipment to the U.S. Government, marking for shipment, in addition to requirements specified in the purchase order or contract, shall be in accordance with MIL-STD-129 for military agencies and with Fed. Std. No. 123 for civil agencies.

21. Keywords

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

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified individually by the purchaser in the purchase order or contract.

NOTE S1.1—Supplementary requirements S1 were determined to be essential additions to this specification when the bars produced to this specification are used in earthquake resistant structures. These provisions were added in the ACI 318 Structural Concrete Building Code in the 2019 revision as additional requirements to this specification and are included herein at the request of ACI 318 Structural Concrete Building Code – Main Committee.

S1. Additional Requirements for Bars Used in Earthquake Resistant Structures

S1.1 The radius (r) at the base of the deformations shall be at least 1.5 times the height (h) of the deformations. Conformance shall be assessed by measurements on newly machined rolls or by the radius of the tools used to form the deformations. Conformance shall not be assessed by measurements taken from the as rolled bar or job-site samples.

S1.1.1 Unless otherwise specified in the purchase order or contract, the supplier will describe the means of determining and documenting compliance with S1.1.

NOTE S1.2—Control of the radius at the root of the deformation by roll or tooling shape is necessary due to the inability to routinely obtain this measurement on the finished bar during production. Controlling the radius at the root of the deformation by measurements taken on the roll or tooling helps provide improved low cycle fatigue performance by avoiding the sharp notch at the root of the deformation. It is accepted that the radius at the root of the deformation will change during rolling due to natural roll wear. While there is no guarantee that the same radius will be exhibited on the finished bar, this additional provision is preferable when compared to

TABLE S1.1 Additional Tensile Requirements

Uniform Elongation (El_u) min, % in 4 in. [100 mm]	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
Bar Designation Nos.			
10 [32] and smaller	9	7	6
11 [36] and larger	6	6	6

having no restriction on this property.

S1.2 *Uniform Elongation*—Bars shall conform to the uniform elongation requirements in Table S1.1.

ANNEXES

(Mandatory Information)

A1. ALTERNATE BAR SIZES

A1.1 The following requirements shall apply only when specified in the purchase order or contract. When specified, the following Table A1.1, Table A1.2, and Table A1.3 replace Table 1, Table 2, and Table 3, respectively.

TABLE A1.1 Deformed Bar Designations, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

Bar Designation No.[A]	Nominal Weight, lb/ft[B] [Nominal Mass, kg/m][C]	Nominal Dimensions[D]			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)
10	0.414 [0.617]	0.394 [10.0]	0.12 [79]	1.237 [31.4]	0.276 [7.0]	0.016 [0.40]	0.151 [3.8]
12	0.597 [0.888]	0.472 [12.0]	0.18 [113]	1.484 [37.7]	0.331 [8.4]	0.019 [0.48]	0.181 [4.6]
16	1.061 [1.578]	0.630 [16.0]	0.31 [201]	1.979 [50.3]	0.441 [11.2]	0.028 [0.72]	0.241 [6.1]
20	1.657 [2.466]	0.787 [20.0]	0.49 [314]	2.474 [62.8]	0.551 [14.0]	0.039 [1.00]	0.301 [7.7]
25	2.589 [3.853]	0.984 [25.0]	0.76 [491]	3.092 [78.5]	0.689 [17.5]	0.049 [1.25]	0.377 [9.6]
28	3.248 [4.834]	1.102 [28.0]	0.95 [616]	3.463 [88.0]	0.772 [19.6]	0.055 [1.40]	0.422 [10.7]
32	4.242 [6.313]	1.260 [32.0]	1.25 [804]	3.958 [100.5]	0.882 [22.4]	0.063 [1.06]	0.482 [12.2]
36	5.369 [7.990]	1.417 [36.0]	1.58 [1018]	4.453 [113.1]	0.992 [25.2]	0.071 [1.80]	0.542 [13.8]
40	6.629 [9.865]	1.575 [40.0]	1.95 [1257]	4.947 [125.7]	1.102 [28.0]	0.79 [2.00]	0.603 [15.3]
50	10.36 [15.41]	1.969 [50.0]	3.04 [1963]	6.184 [157.1]	1.378 [35.0]	0.098 [2.50]	0.753 [19.1]
60	14.91 [22.20]	2.362 [60.0]	4.38 [2827]	7.421 [188.5]	1.654 [42.0]	0.106 [2.70]	0.904 [23.0]

[A] The bar designations are based on the number of millimetres of the nominal diameter of the bar.
[B] The assumed weight of a cubic foot of steel is 490 lb/ft^3 in accordance with Specification A6/A6M.
[C] The assumed mass of a cubic metre of steel is 7850 kg/m^3 in accordance with Specification A6/A6M.
[D] 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 A1.2 Tensile Requirements

	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
Tensile strength, min, psi [MPa]	80 000 [550]	100 000 [690]	117 000 [805]
Yield strength, min, psi [MPa]	60 000 [420]	80 000 [550]	100 000 [690]
Yield strength, max, psi [MPa]	78 000 [540]	98 000 [675]	118 000 [815]
Ratio of actual tensile strength to actual yield strength, min	1.25	1.25	1.17
Elongation in 8 in. [200 mm], min, %			
Bar Designation No.			
10, 12, 16, 20	14	12	10
25, 28, 32, 36	12	12	10
40, 50, 60	10	10	10

TABLE A1.3 Bend Test Requirements

Bar Designation No.	Pin Diameter for 180° Bend Tests		
	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
10, 12, 16	3*d* [A]	3½ *d* [A]	3½ *d*
20, 25	4*d*	5*d*	5*d*
28, 32, 36	6*d*	7*d*	7*d*
40, 50, 60	8*d*	9*d*	9*d* [B]

[A] *d* = nominal diameter of specimen.
[B] Bend Testing of Grade 100 [690] Nos. 40, 50 and 60 shall be subject to agreement between purchaser and manufacturer.

A2. DETERMINATION OF UNIFORM ELONGATION

A2.1 Uniform elongation (El_u) shall be determined by using an extensometer in accordance with the uniform elongation method in Test Methods E8/E8M, or by the manual method described in A2.2.

A2.1.1 In case of dispute, the manual method shall take precedence.

A2.2 *Manual Method for Determination of Uniform Elongation*:

NOTE A2.1—Uniform elongation is the sum of the plastic strain, measured remote from the break (excluding the necked region), and the elastic strain calculated from the tensile strength and Young's Modulus. The Manual Method described herein was adapted from CSA G30.18 and from ISO 15630-1.

A2.2.1 Multiple 2 in. [50 mm] gage marks shall be scribed on the bar prior to tensile testing (also described in 15.2.2).

A2.2.1.1 It shall be permissible to scribe gage marks more frequently than 2 in. [50 mm] intervals as long as the final measurements are based on an original gage length (b_0) of 4 in. [100 mm].

NOTE A2.2—Examples of alternate permissible gage mark intervals: 1 in. [25 mm] or 0.5 in. [12.5 mm] intervals that are permitted.

A2.2.2 The plastic component of uniform elongation (El) shall be determined using measurements taken on the bar after fracture on a 4 in. [100 mm] gage length (b), remote from the necked region. See Fig. A2.1.

A2.2.3 There shall be a minimum distance (r_1) of 1 in. [25 mm] between the gripped region and the gage measurement (b).

A2.2.4 There shall be a minimum distance (r_2) of 2 in. [50 mm] from the fracture to the gage measurement (b).

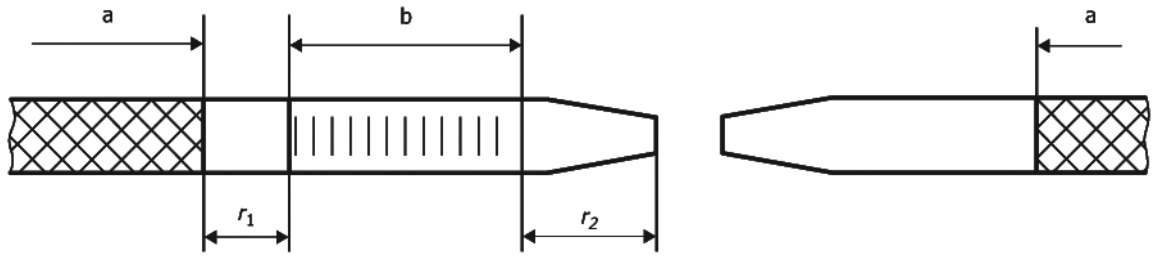
A2.2.5 El shall be calculated from the following formula:

$$El[\%] = \frac{b - b_0}{b_0} \times 100\ \% \qquad (A2.1)$$

A2.2.5.1 This determination of El shall be considered invalid if the distance (r_1) between the grips and the gage measurement is less than 1 in. [25 mm] or if the distance (r_2) between the break and the gage measurement is less than 2 in. [50 mm]. See Fig. A2.1.

A2.2.6 El_u shall be calculated from the following formula, where Young's Modulus of steel is 29 000 Ksi [200 GPa]:

$$El_u[\%] = El[\%] + \left(\frac{\text{Actual Tensile Strength}}{\text{Young's Modulus}}\right) \times 100\ \% \qquad (A2.2)$$



where:

a = gripped area,
b = gage measurement after fracture,
b_0 = original gage measurement (4 in. [100 mm]),
r_1 = distance between grips and gage length, and
r_2 = distance between fracture and gage mark.

FIG. A2.1 Determination of Plastic Component of Uniform Elongation Remote From The Break (EI)

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A706/A706M – 22) that may impact the use of this standard. (Approved Dec. 1, 2022.)

(1) Revised 1.2.
(2) Added Note 1 in 1.5. Renumbered all other notes.
(3) Added footnote 5 to 2.5.
(4) Revised Table 2 and deleted footnote A from Table 2.
(5) Added 1.6, renumbered the remainder of Section 1.
(6) Added reference to Test Methods E8/E8M in Section 2.
(7) Added reference to ACI 318 in Section 2.
(8) Added 3.1.6.
(9) Added 4.2.6.
(10) Revised Table 3 and added footnote B.
(11) Revised 14.1.
(12) Added 16.1.5.
(13) Added 16.1.6.
(14) Added 19.1.1.
(15) Revised 19.3.5.
(16) Added Supplementary Requirements S1 and S2.
(17) Revised Table A1.2 and deleted footnote A from Table A1.2.
(18) Revised Table A1.3 and added footnote B to Table A1.3.
(19) Added Annex A2.

Committee A01 has identified the location of selected changes to this standard since the last issue (A706/A706M – 16) that may impact the use of this standard. (Approved July 1, 2022.)

(1) Revised 19.3.3 and added new 19.3.3.1.