Designation: A 970/A 970M – 04a

Standard Specification for Headed Bars for Concrete Reinforcement [1]

This standard is issued under the fixed designation A 970/A 970M; 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.

1. Scope*

1.1 This specification covers deformed and plain low-alloy steel reinforcing bars in cut lengths, with head(s) attached to one or both ends, for concrete reinforcement. Attachment shall be accomplished through welding or forging of heads onto the bar ends, by internal threads in the head mating to threads on the bar end or by a separate threaded nut to secure the head to the bar. Heads shall be forge formed, machined from bar stock, or cut from plate.

NOTE 1—This specification is applicable for headed bars produced with welded, threaded, or forged heads and used for reinforcement of concrete structures. The requirements of this specification are not applicable to headed bars where the attachment of the head is accomplished by alternate means.

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

1.3 *Controlled Mechanical Properties and Performance Requirements*—This specification by use of tensile and bend tests and the specified minimum performance levels in Sections 7 and 8 provides the required performance properties for these assemblies.

1.4 *Welding, Threading, and Forging*:

1.4.1 Welding of heads to the reinforcing steel shall be approached with care. A welding procedure conforming to ANSI/AWS D1.4 shall be used for all required production welding of the head to the bar, except for friction welding that shall conform to ANSI/AWS C6.1.

1.4.2 *Forging*—Integrally forged headed bars where the heads are produced by deforming the bar ends in a hot forging process also are acceptable.

1.4.3 *Threading*—It shall be permissable to attach the head(s) to the reinforcing bar utilizing straight or tapered internal threads within the head or by securing the head to the threaded bar end with a separate internally threaded nut.

1.4.4 *Low-Alloy Steel Bars*—Low-alloy steel reinforcing bars conforming to Specification A 706/A 706M shall be used to manufacture welded headed bars. Specification A 706/A 706M limits chemical composition and carbon equivalence to enhance weldablity of the material.

1.4.5 Reinforcing bar material conforming to A 615/A 615M or A 706/A 706M is acceptable for the production of threaded or forged headed bars.

1.4.6 Other types of steel reinforcing bars shall be permitted: (1) providing they conform to the dimensional and weight requirements of the reinforcement as specified in 1.4.4 or 1.4.5, as applicable, and (2) when specified and agreed upon by the purchaser and the manufacturer and only when the suitability of the head and bar materials for the welding, threading, or forging process specified is demonstrated through successful application of the requirements for testing and frequency of testing in Sections 7 and 8 of this specification.

1.4.7 All reinforcing bars shall conform to the mechanical performance requirements of this specification.

1.5 This specification is applicable for orders in either SI or inch-pound units.

1.6 The values stated in either inch-pound units or SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification. The inch-pound units shall apply unless the "M" designation of this specification is specified in the order.

1.7 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 29/A 29M Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements for

A 36/A 36M Specification for Carbon Structural Steel

A 108 Specification for Steel Bars, Carbon, Cold Finished, Standard Quality

[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.**

A 304 Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements
A 370 Test Methods and Definitions for Mechanical Testing of Steel Products
A 572/A 572M Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steels
A 615/A 615M Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
A 700 Practices for Packaging, Marking and Loading Methods for Steel Products for Domestic Shipment
A 706/A 706M Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.2 *ANSI Standards*

B1.1 Unified Screw Threads
B1.13 Screw Threads

2.3 *ANSI/AWS Standards:*

ANSI/AWS C6.1 Recommended Practices for Friction Welding[3]
ANSI/AWS D1.4 Structural Welding Code - Reinforcing Steel[3]

2.4 *U.S. Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[4]
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage[4]

2.5 *U.S. Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *forged headed bar*—a steel bar used in the reinforcement of concrete that has the head(s) integrally forged to one or both ends.

3.1.2 *head*—a round, elliptical, or rectangular shape employed to anchor a steel bar in concrete.

3.1.3 *welded headed bar*—a steel bar used in the reinforcement of concrete that has the head(s) welded to one or both ends.

3.1.4 *threaded head bar*—a steel bar used in the reinforcement of concrete that has the head(s) attached to one or both ends utilizing tapered or straight threads internal to the head or by a separate internally threaded nut securing the head to the threaded bar end.

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,

4.1.2 Name of product: welded or forged headed bars for the reinforcement of concrete,

4.1.3 Bar material specification,

4.1.4 Bar size,

4.1.5 Deformed or plain bars,

4.1.6 Head geometry, including thickness, height, width, and cross-sectional area,

4.1.7 Head material specification,

4.1.8 Type of head attachment.

4.1.9 Number of heads per bar length,

4.1.10 Length of bar assembly,

4.1.11 Packaging, and

4.1.12 ASTM designation and year of issue.

NOTE 2—A typical example of an ordering description is as follows: 200 Mg [220 tons] welded headed reinforcing bars for concrete reinforcement, Size No. 25 [No. 8] in 18 m [60 ft] lengths in secured lifts, conforming to Specification A 970/A 970M. Two heads per bar assembly shall be provided and shall be attached by welding. Heads shall be cut from plate material conforming to Specification A 36/A 36M plate and shall be 75 mm [3 in.] square. Certified mill test reports are required. Manufacturer shall provide certified copies of manufacturing test report as required in 14.2 of this specification.

5. Material and Manufacture

5.1 The reinforcing bars shall be rolled from properly identified heats of mold cast or strand cast steel using the open-hearth, basic-oxygen, or electric-furnace process.

5.2 Heads shall be formed, machined, or cut from properly identified heats of mold cast or strand cast steel using the open-hearth, basic oxygen, or electric-furnace process.

5.3 The head shall be dimensioned to be capable of resisting the nominal tensile strength of the reinforcing bar when the welded, threaded, or forged headed reinforcing bar is embedded in concrete. The determination of the head dimensions, as defined in Fig. 1, shall be in accordance with good engineering practice and established methods, including test reports, calculations or both. The head dimensions shall be provided by the purchaser in the order. Head dimensions shall define the head geometry including thickness,height, and width of the head. Alternate head dimensions supplied by the manufacturer shall be permitted if agreed to in advance by the purchaser. The manufacturer furnishes documentation to the purchaser in the form of calculations or test reports, or both, that confirms the suitability of alternate head dimensions for the intended application.

5.4 *Threading*

5.4.1 Bars with heads attached utilizing tapered or straight threads shall have threads placed either internally in the head to mate with external threads on the bar surface or utilizing a separate accompanying internally threaded nut to secure the head to the threaded bar end. Threads shall conform to the Unified Screw Thread series, either coarse or fine, according to ANSI B1.1 and ANSI B1.13. Use of other thread specifications or standards at the option of the manufacturer shall be permitted if agreed to by the purchaser.

5.4.2 Care shall be exercised to account for out-of-roundness in the rolled reinforcing bar in the production of the threads, so that the minimum thread dimensions are maintained around the full circumference of the bar.

[3] Available from American Welding Society, P.O. Box 351040, 550 N.W. LeJeune Rd., Miami, FL 33126.

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

5.4.3 It shall be permissable to hot- or cold-roll, or machine cut, threads into the surface of the bar and heads at the option of the manufacturer.

6. Chemical Composition

6.1 An analysis of each heat of steel for bar and heads shall be made by the manufacturer from test samples taken during the pouring of heats. The percentage of carbon, manganese, phosphorus, sulfur, silicon, copper, nickel, chromium, molybdenum, and vanadium shall be determined. Carbon equivalent (CE) shall be determined using the CE formula in Specification A 706/A 706M.

6.2 *Bars*—The chemical composition of bars shall conform to the requirements for low-alloy steel bars produced under Specification A 706/A 706M or other steel specification approved by the purchaser for welded headed bars, or threaded headed bars with the head(s) attached through straight or tapered threads. Forged headed bars with the heads integrally forged onto the bars shall have bars with chemical composition conforming to the requirements of Specifications A 615/A 615M or A 706/A 706M, or other steel specification approved by the purchaser for threaded or forged headed bars.

6.3 *Heads*—The chemical composition of heads for welded headed bars shall conform to one of the following steel specifications: Specification A 29/A 29M, A 36/A 36M, A 108, A 304, A 572/A 572M, A 706/A 706M, or other steel specifications approved by the purchaser.

7. Mechanical Test and Performance Requirements

7.1 Welded, threaded, or forged headed bars shall be subjected to mechanical tests to verify production method and product quality prior to manufacture. Mechanical testing also shall be performed at intervals during production. All tests shall be performed on test specimens at a temperature not less than 16°C [60°F].

7.2 *Tensile Tests*:

7.2.1 Tensile testing of the headed bar assembly shall be performed accordance with the requirements described in Test Methods and Definitions A 370. Failure shall be defined as partial or total fracture of the bar, the head, or the head-to-bar connection.

7.2.2 *Specimen Preparation*—Tensile test specimens shall be the full cross-section of the bar as rolled with a head attached to one end of the reinforcing bar. The minimum length of the test specimen shall be the greater of 250 mm [10 in.] or ten times the diameter of the bar. A specimen with a head welded, threaded, or forged to one end shall be placed in the testing machine with the head supported by a steel plate or other fixture to prevent movement and bending of the head. The fixture shall be placed concentrically with the longitudinal axis of the reinforcing bar directly against the flat inner surface of the head. The fixture shall provide clearance between the head support and the head-to-bar connection. Provisions shall be made for clearance between the support and any weld or forming material on the reinforcing bar-to-head connection. The free end of the bar, without a head attached, shall be gripped by the test machine.

7.3 *Tensile Requirements*:

7.3.1 *Tensile Strength*—The test specimen performance for welded, threaded, or forged headed bars shall conform to the requirements for tensile properties presented in Table 1.

7.3.2 *Yield Strength*—The test specimen performance for welded, threaded, or forged headed bars shall conform to the requirements for yield strength presented in Table 1.

7.3.3 *Acceptance Criteria*—In addition to meeting the strength requirements of Table 1, no observed partial or total fracture of the head or the bar-head connection shall be permitted; the failure shall be observed to occur in the parent reinforcing bar material a minimum of one bar diameter from the head-to-bar connection. Failure of the head or the head-to-bar connection within the attachment region is unacceptable and shall be cause for rejection.

7.4 *Yield Point Determination*:

7.4.1 *Procedure*—The yield point or yield strength of the bar itself shall be determined by one of the following methods:

7.4.1.1 The yield point shall be determined by a drop of the beam or halt in the gage of the testing machine.

7.4.1.2 When the bar material tested does not have a well-defined yield point, the yield strength shall be determined at extension under load using an autographic diagram method or an extensometer as described in 14.1.2 and 14.1.3 of Test Methods and Definitions A 370. The extension under load shall be 0.35 % strain.

7.5 *Bend Test Requirements*:

7.5.1 Welded or forged headed bars shall be subject to bend testing.

7.5.2 *Procedure*—The test specimen shall be bent around a suitable mandrel to an angle of at least 90° with no observed partial or total fracture of the head, the bar, or the head-to-bar connection.

7.5.3 *Bend Test Mandrel*—The mandrel shall be placed so as to directly bend the welded or forged region. The required mandrel dimensions for bend testing are prescribed in Table 2. The centerline of the bend test mandrel shall be placed at the intersection of the reinforcing bar and the weld or forged region, as shown in Fig. 1.

7.5.4 *Specimen Preparation*—Bend test specimens shall be the full cross-section of the bar as rolled with a head attached to one end of the reinforcing bar. For welded or forged heads directly attached to the end of the reinforcing bar where the head interferes with placement of the bend test mandrel, sufficient head material and any excess material associated

TABLE 1 Tensile Requirements SI Units [Inch-Pound Units]

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

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

TABLE 2 Bend Test Requirements, SI Units [Inch-Pound Units]

Bar Designation	Mandrel Diameter
10, 13 and 16 [3, 4 and 5]	3d[A]
19, 22 and 25 [6, 7 and 8]	4d
29, 32 and 36 [9, 10 and 11]	6d
43 and 57 [14 and 18]	8d

[A] d = nominal diameter of bar

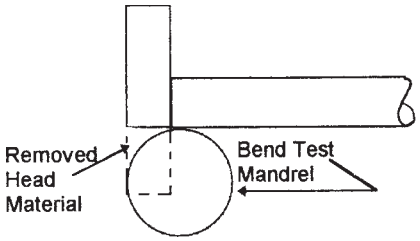

FIG. 1 Bend Test Specimen Mandrel Configuration

with the welding or forging process shall be removed along one edge of the reinforcing bar to provide a flat surface on the specimen for the bend mandrel. This preparation shall ensure that the contact point of the bend mandrel is directly at the base of the reinforcing bar diameter as shown in Fig. 1. For welded or forged headed bars where the head does not interfere with the positioning of the bend test mandrel, no specimen preparation shall be performed.

7.6 *Wedge Test Requirements*

7.6.1 Wedge testing shall be used in place of bend testing for threaded head bars. Wedge testing involves tension testing with a wedge and shall be substituted in place of the bend testing for headed barrs required in 8.

7.6.2 *Procedure*—The bar-head assembly shall be tension tested with a 10° wedge placed under the head in conformance to the requirements of specification A 370, subsection 3.2.1.5. The assembly shall be pulled to failure. No observed partial or total fracture of the head, bar, or the bar-head connection shall be permitted; failure shall be observed to occur in the reinforcing bar material a minimum of one-half bar diameter from the connection. The ultimate tensile strength obtained in this test shall meet or exceed the requirements of Table 3 [Table 4].

7.6.3 *Specimen Preparation*—Wedge test specimens shall be the full section of the bar as rolled with a head attached to one end of the reinforcing bar. The 10° wedge shall be configured and placed under the head as required in Fig. A3.2 of Specification A 370.

8. Frequency of Testing

8.1 *Number of Tests*:

8.1.1 *Pre-Production*—Prior to production, a testing program shall be undertaken that includes two bend or wedge tests and two tensile tests. The tests shall be repeated for each combination of head and bar material specification, grade or type, and welding, threading, or forging process.

8.1.2 *Production*—It shall be permissible to use either the tensile test prescribed in 7.3, the bend test prescribed in 7.5, or the wedge test in 7.6 for threaded headed bars to verify the production method and product quality. A minimum of two tests shall be conducted during the production shift or period. One test at the start and one test at the end of each 8-h shift or less than 8-h production period or at random intervals during the production period shall be conducted.

TABLE 3 Nominal Head Dimensions, SI Units

NOTE 1—The table provides nominal dimensions for heads covered by this specification to provide anchorage of the welded headed bar in concrete.

NOTE 2—The nominal head dimensions given in Table 3 are calculated to ensure that shear or bending forces do not cause premature failure of the head or crushing failure of the concrete under the head. These calculations are based on concrete compressive strength of 30 MPa and reinforcing steel with a yield strength of 420 MPa.

NOTE 3—The head thickness is measured parallel to the reinforcing bar longitudinal axis and the head width is measured perpendicular to the reinforcing bar axis. The cross-sectional area of the head is the projected area measured perpendicular to the axis of the bar.

NOTE 4—Research and experience with headed bars in Europe, Canada, and the United States have shown that a head area of approximately ten times the nominal bar area, or a head diameter of three times the nominal bar diameter, is necessary to anchor the bar with the head *only*, while not crushing the concrete under the head.

Standard Bar Designation Number	Nominal Head Dimensions		
	Minimum thickness, mm	Minimun cross sectional area, mm^2	Minimum width, mm
10	10	710	19
13	11	1 290	22
16	12	2 000	25
19	14	2 840	35
22	16	3 870	37
25	16	5 100	40
29	18	6 450	43
32	20	8 200	51
36	22	9 700	55
43	32	14 500	65
57	40	25 800	80

8.1.2.1 In the event different heats of head or bar material or both within the same material specification are used to produce welded, threaded, or forged headed bars during a production run, a minimum of two tensile tests in accordance with 7.3 or two bend tests in accordance with 7.5 shall be conducted to verify the production method, product quality, and welding, forging, or threading quality or weldability of the heats of materials prior to continuing production.

8.2 *Retests*:

8.2.1 *Pre-Production*—Any identified procedural or performance deficiencies shall be corrected and pre-production testing repeated until the tensile and bend test results meet the performance requirements of this specification.

8.2.2 *Production*—When partial or total fracture(s) of the bend, wedge, or tensile test specimens occur(s) in the weld, thread, or forging region, the production lot shall be rejected and no retest shall be allowed.

8.2.2.1 If the result of a tension test fails to meet the specified minimum strength requirements of 7.3.3 then a retest shall be allowed. Two specimens taken at random from the production lot shall be tested during a retest. Both specimens shall pass the tension test requirements of Section 7 or the production lot shall be rejected.