~~Designation:A449–07a~~ Designation: A 449 – 07b

Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use[1]

This standard is issued under the fixed designation A 449; 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 This specification[2] covers quenched and tempered steel hex cap screws, bolts, and studs having a minimum tensile strength of 120 ksi for diameters 1.0 in. and smaller; 105 ksi for diameters over 1.0 in. to 1½ in.; and 90 ksi for diameters 1¾ in. to 3.0 in. inclusive. The term ″fasteners″ in this specification denotes hex cap screws, bolts, and studs.

1.2 The fasteners are intended for general engineering use.

1.3 The fasteners are furnished in diameters ¼ to 3.0 in. inclusive. They are designated by type denoting chemical composition as follows:

Type	Description
Type I	Plain carbon steel, carbon boron steel, alloy steel, or alloy boron steel
Type 2	Withdrawn 2003
Type 3	Weathering steel

1.4 Terms used in this specification are defined in Terminology F 1789 unless otherwise defined in this specification.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

1.6 *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:* [3]

A 563 Specification for Carbons and Alloy Steel Nuts

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

B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

D 3951 Practice for Commercial Packaging

F 436 Specification for Hardened Steel Washers

F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F 1789 Terminology for F16 Mechanical Fasteners

~~F1941Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads (UN/UNR))~~

F 2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

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[1] This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets and Washers.

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[2] For *ASME Boiler and Pressure Vessel Code* applications see related Specifications SA-449 in Section II of that Code.

[3] 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.**

2.2 *ASME Standards:*[4]
B 1.1 Unified Screw Threads
B 18.2.1 Square and Hex Bolts and Screws
B 18.24 Part Identifying Number (PIN) Code System Standard for B 18 Fastener Products

3. Ordering Information

3.1 Orders for fasteners under this specification shall include the following:
3.1.1 Quantity (number of pieces),
3.1.2 Size, including nominal diameter and length,
3.1.3 Name of product,
3.1.4 Type, that is, Type 1, or Type 3 as required,
3.1.5 ASTM designation and year of issue, and
3.1.6 Other components such as nuts and washers if required.
3.1.7 *Hot-Dip or Mechanically Deposited Zinc Coatings* —For hot-dip or mechanically deposited zinc coatings covered by 5.1 and requiring over-tapped nuts, specify the zinc coating process required, that is, hot-dip, mechanically deposited, or no preference (see 5.1).
3.1.8 *Other Coatings*—Specify other protective coating if required (see 5.2).
3.1.9 Specify if inspection at point of manufacture is required.
3.1.10 Test reports if required.
3.1.11 Supplementary or special requirements.
3.1.12 For establishment of a part identifying system, see ASME B18.24.

NOTE 1—A typical ordering description follows: 1000 pieces ⅛ in. diameter × 4.0 in. long hex cap screw, Type 1, ASTM A 449–XX, each with one finished hex nut ASTM A 563, Grade DH. Each component mechanically zinc coated in accordance with B 695, Class 5, Type II.

3.2 *Suitable Nuts and Washers*:
3.2.1 Suitable nuts are covered in Specification A 563. Unless otherwise specified, the grade and style of nut shall be as follows:

Fastener Size and Surface Finish	Nut Grade and Style[A]
¼ to 1½ in., plain (or with a coating of insufficient thickness to require over-tapped nuts)	B, hex
Over 1½ to 3 in., plain (or with a coating of insufficient thickness to require over-tapped nuts)	A, heavy hex
¼ to 3 in., zinc-coated (or with a coating thickness requiring over-tapped nuts)	DH, heavy hex
¼ to 3 in., Type 3	C3, DH3, heavy hex

[A] Nuts of other grades and styles having specified proof load stresses (Specification A 563, Table 3) greater than the specified grade and style of nut are suitable.

3.2.2 Unless otherwise specified, washers ordered with fasteners shall be furnished to the requirements of Specification F 436, Type 1 or Specification F 436, Type 3. Washers for A 449 Type 3 fasteners shall conform to Specification F 436 Type 3.

4. Materials and Manufacture

4.1 *Heat Treatment*:
4.1.1 Type 1 fasteners produced from medium carbon steel shall be quenched in a liquid medium from the austenitizing temperature.
4.1.2 Type 1 fasteners produced from medium carbon steel to which chromium, nickel, molybdenum, or boron were intentionally added, and Type 3 fasteners, shall be quenched in oil from the austenitizing temperature.
4.1.3 Type 1 and Type 3 fasteners, regardless of the steel used, shall be tempered by reheating to not less than 800°F.
4.2 *Threading*—Threads shall be rolled, cut, or ground.
4.3 *Secondary Processing*—If any processing which can affect the mechanical properties of the fasteners is performed after the initial testing, the fasteners shall be retested for all specified mechanical properties affected by the reprocessing.

5. Protective Coatings

5.1 *Zinc, Hot Dip, and Mechanically Deposited Requiring Over-tapped Nuts*:
5.1.1 When zinc-coated fasteners are required, the purchaser shall specify the zinc-coating process, such as, hot-dip, mechanically deposited, or no preference.
5.1.2 When hot dip is specified, the fasteners shall be zinc coated by the hot-dip process in accordance with the requirements of Specification F 2329.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, http://www.asme.org.

5.1.3 When mechanically deposited is specified, the fasteners shall be zinc coated by the mechanical deposition process in accordance with the requirements of Class ~~50~~55 of Specification B 695.

5.1.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F 2329, or a mechanically deposited zinc coating in accordance with Specification B 695, Class ~~50.~~55. Threaded components (bolts and nuts) shall be coated by the same zinc coating process, and the suppliers' option shall be limited to one process per item with no mixed processes in a lot.

NOTE 2—When the intended application requires that assembled tension exceeds 50 % of minimum bolt or stud proof load, an anti-galling lubricant may be needed. Application of such a lubricant to nuts and a test of the lubricant efficiency are provided in Supplementary Requirement S1 of Specification A 563 and should be specified when required.

5.2 *Other Coatings*:

5.2.1 When other coatings are required, the purchaser shall specify the coating specification, including the classification codes or grade numbers to identify the coating material, thickness, supplemental treatments, or other requirements to define the coating. The fasteners shall be coated in accordance with and conform to the specified coating specification.

5.2.2 When a specification does not apply, the purchaser shall specify the desired coating, coating thickness, supplemental treatments, or other requirements to define the coating.

6. Chemical Composition

6.1 Type 1 fasteners shall be plain carbon steel, carbon boron steel, alloy steel, or alloy boron steels, at the manufacturers option, conforming to the requirements in Table 1.

6.2 Type 3 fasteners shall be weathering steel and shall conform to one of the chemical compositions specified in Table 2. The selection of the chemical composition, A, B, C, D, E or F, shall be a the option of the manufacuturer. See Guide G 101 for methods

TABLE 1 Chemical Requirements for Type 1 Fasteners

Element	Carbon Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058
Silicon	0.015–0.30	0.13–0.32

Element	Carbon Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.040	0.048
Sulfur, max	0.050	0.058
Silicon	0.10–0.30	0.08–0.32
Boron	0.0005–0.003	0.0005–0.003

Element	Carbon Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Silicon	0.15–0.35	0.13–0.37
Alloying Elements	[A]	[A]

Element	Carbon Steel	
	Heat Analysis	Product Analysis
Carbon	0.30–0.52	0.28–0.55
Manganese, min	0.60	0.57
Phosphorus, max	0.035	0.040
Sulfur, max	0.040	0.045
Silicon	0.15–0.35	0.13–0.37
Boron	0.0005–0.003	0.0005–0.003
Alloying Elements	[A]	[A]

[A] Steel, as defined by the American Iron and Steel Institute, shall be considered to be alloy when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 %; silicon, 0.60 %; copper, 0.60 % or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

TABLE 2 Chemical Requirements for Type 3 Fasteners[A]

Element	Composition, %					
	Type 3 Fasteners[A]					
	A	B	C	D	E	F
Carbon:						
Heat analysis	0.33–0.40	0.38–0.48	0.15–0.25	0.15–0.25	0.20–0.25	0.20–0.25
Product analysis	0.31–0.42	0.36–0.50	0.14–0.25	0.14–0.25	0.18–0.27	0.19–0.25
Manganese:						
Heat analysis	0.90–1.20	0.70–0.90	0.80–1.35	0.40–1.20	0.60–1.00	0.90–1.20
Product analysis	0.86–1.24	0.67–0.93	0.76–1.39	0.36–1.24	0.56–1.04	0.86–1.24
Phosphrous:						
Heat analysis	0.035 max	0.06–0.12	0.035 max	0.035 max	0.035 max	0.035 max
Product analysis	0.040 max	0.06–0.125	0.040 max	0.040 max	0.040 max	0.040 max
Sulfur:						
Heat analysis	0.040 max	0.040 max	0.040 max	0.040 max	0.040 max	0.040 max
Product analysis	0.045 max	0.045 max	0.045 max	0.045 max	0.045 max	0.045 max
Silicone:						
Heat analysis	0.15–0.35	0.30–0.50	0.15–0.35	0.25–0.50	0.15–0.35	0.15–0.35
Product analysis	0.13–0.37	0.25–0.55	0.13–0.37	0.20–0.55	0.13–0.37	0.13–0.37
Copper:						
Heat analysis	0.25–0.45	0.20–0.40	0.20–0.50	0.30–0.50	0.30–0.60	0.20–0.40
Product analysis	0.22–0.48	0.17–0.43	0.17–0.53	0.27–0.53	0.27–0.53	0.17–0.43
Nickel:						
Heat analysis	0.25–0.45	0.50–0.80	0.25–0.50	0.50–0.80	0.30–0.60	0.20–0.40
Product analysis	0.22–0.48	0.47–0.83	0.22–0.53	0.47–0.83	0.27–0.63	0.17–0.43
Chromium:						
Heat analysis	0.45–0.65	0.50–0.75	0.30–0.50	0.50–1.00	0.60–0.90	0.45–0.65
Product analysis	0.42–0.68	0.47–0.83	0.27–0.53	0.45–1.05	0.55–0.95	0.42–0.68
Vanadium:						
Heat analysis	[B]	[B]	0.020 min	[B]	[B]	[B]
Product analysis	[B]	[B]	0.010 min	[B]	[B]	[B]
Molybdenum:						
Heat analysis	[B]	0.06 max	[B]	0.10 max	[B]	[B]
Product analysis	[B]	0.07 max	[B]	0.11 max	[B]	[B]
Titanium:						
Heat analysis	[B]	[B]	[B]	0.05 max	[B]	[B]
Product analysis	[B]	[B]	[B]	0.06 max	[B]	[B]

[A] A,B,C,D, E and F are classes of material used for Type 3 fasteners. Selection of a class shall be at the option of the bolt manufacturer.
[B] These elements are not specified or required.

of estimating the atmospheric corrosion resistance of low alloy steel.

6.3 Product analyses made on finished fasteners representing each lot shall conform to the product analysis requirements specified in Table 1 or Table 2, as applicable.

6.4 Heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for bolts. Compliance shall be based on certification that heats of steel having any of the listed elements intentionally added were not used to produce the bolts.

6.5 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A 751.

7. Mechanical Properties

7.1 *Hardness*—The fasteners shall conform to the hardness specified in Table 3. See Table 3, Note A.

7.2 *Tensile Properties*:

7.2.1 Except as permitted in 7.2.2 for long fasteners and 7.2.3 for short fasteners, hex cap screws and hex and square head bolts in sizes 1.00 in. and smaller having a length of 2¼ D and longer and sizes 1⅛ to 1½ in. inclusive having a length of 3D and longer shall be wedge tested full size. Bolts with heads other than hex or square shall be axially tested. Both wedge and axially tested hex cap screws and bolts shall conform to the proof load or alternative proof load, and minimum wedge tensile load in Tables 4 and 5, as applicable. The load applied during proof load testing shall be equal to or greater than the proof load in Table 4 or Table 5 as applicable.

TABLE 3 Hardness Requirements for Hex Cap Screws, Bolts, and Studs

Nominal Diameter, in.	Length, in.	Brinell		Rockwell C	
		Min	Max	Min	Max
¼ to 1, inclusive	Less than 2D[A]	253	319	25	34
	2D and over	. . .	319	. . .	34
Over 1 to 1½ , inclusive	Less than 3D[A]	223	286	19	30
	3D and over	. . .	286	. . .	30
Over 1½ to 3, inclusive	Less than 3D[A]	183	235	. . .	. . .
	3D and over	. . .	235	. . .	. . .

[A] Hex cap screws and bolts larger than 1.00 in. diameter and shorter than 3D and all studs shorter than 3D are subject only to minimum and maximum hardness.
D = Nominal diameter or thread size

TABLE 4 Tensile Load Requirements for Coarse-Thread Full-Size Hex Cap Screws, Bolts and Studs

Bolt or Stud Diameter, in.	Threads per in.[A]	Stress Area,[B] in.[2]	Tensile Load, min, lbf[C]	Proof Load, Length Measurement Method, lbf[C]	Alternative Proof Load, Yield Strength Method (0.2 % Offset), lbf[C]
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
¼	20	0.0318	3 800	2 700	2 900
5/16	18	0.0524	6 300	4 450	4 800
⅜	16	0.0775	9 300	6 600	7 100
7/16	14	0.1063	12 750	9 050	9 800
½	13	0.1419	17 050	12 050	13 050
9/16	12	0.182	21 850	15 450	16 750
⅝	11	0.226	27 100	19 200	20 800
¾	10	0.334	40 100	28 400	30 700
⅞	9	0.462	55 450	39 250	42 500
1	8	0.606	72 700	51 500	55 750
1⅛	7	0.763	80 100	56 450	61 800
1¼	7	0.969	101 700	71 700	78 500
1⅜	6	1.155	121 300	85 450	93 550
1½	6	1.405	147 500	104 000	113 800
1¾	5	1.90	171 000	104 500	110 200
2	4½	2.50	225 000	137 500	145 000
2¼	4½	3.25	292 500	178 750	188 500
2½	4	4.00	360 000	220 000	232 000
2¾	4	4.93	443 700	271 150	286 000
3	4	5.97	537 300	328 350	346 200

[A] For 8 threads per in., sizes 1⅛ to 1½ in., inclusive, stresses of 105 000 psi, 74 000 psi, and 81 000 psi shall be used for calculating the values in columns 4, 5, and 6 respectively.

[B] The stress area is taken from ASME B1.1 which uses the equation below to calculate the values:

$$A_s = 0.7854[D - (0.9743/n)]^2$$

where:
A_s = stress area,
D = nominal diameter, and
n = threads per in.

[C] Values tabulated are based on the following:

Bolt Size, in.	Column 4, psi	Column 5, psi	Column 6, psi
¼ to 1, incl.	120 000	85 000	92 000
1⅛ to 1½ , incl.	105 000	74 000	81 000
1¾ to 3, incl.	90 000	55 000	58 000

7.2.2 Hex cap screws and square head bolts larger than 1½ in. diameter, other than those excepted in 7.2.3, shall preferably be tested full size and when so tested shall conform to the tensile strength and either the specified proof load or yield strength requirements in Tables 4 and 5, as applicable. When equipment of sufficient capacity for full size testing is not available, or when the length of the bolt makes full size testing impractical, machined specimens shall be tested and shall conform to the requirements of Table 6.

7.2.3 Sizes 1.00 in. and smaller having a length shorter than 2¼ D down to 2D inclusive, which cannot be wedge tensile tested shall be axially tension tested full size and shall conform to the minimum tensile load and proof load or alternate proof load specified in Tables 4 and 5. Sizes 1.00 in. and smaller having a length shorter than 2D which cannot be axially tensile tested shall be qualified on the basis of hardness.

7.2.4 Studs 3D and longer shall be axially tension tested full size and shall conform to the tensile and proof load or alternate proof load specified in Table 4 and Table 5, as applicable. When equipment for full size testing is not available, or when the studs are too long for full size testing, machined specimens shall be tested and shall conform to the tensile requirements in Table 6.

7.2.5 If fasteners are subjected to both hardness and tensile tests, the tensile test results shall take precedence in the event of low hardness test results.

7.2.6 If fasteners are subjected to both full size and machined specimen tests, the full size test results shall take precedence if the results of the two methods differ.

8. Dimensions

8.1 *Head and Body*:

8.1.1 *Hex Cap Screws*—Unless otherwise specified, hex cap screws shall be furnished with dimensions conforming to ASME B18.2.1.

TABLE 5 Tensile Load Requirements for Fine-Thread Full-Size Hex Cap Screws, Bolts, and Studs

Bolt or Stud Diameter, in.	Threads per in.	Stress Area,[A] in.[2]	Tensile Load, min, lbf[B]	Proof Load, Length Measurement Method, lbf[B]	Alternative Proof Load, Yield Strength Method (0.2 % Offset), min, lbf[B]
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
¼	28	0.0364	4 350	3 100	3 500
5/16	24	0.0580	6 950	4 950	5 350
⅜	24	0.0878	10 550	7 450	8 100
7/16	20	0.1187	14 250	10 100	10 900
½	20	0.1599	19 200	13 600	14 700
9/16	18	0.203	24 350	17 250	18 700
⅝	18	0.256	30 700	21 750	23 500
¾	16	0.373	44 750	31 700	34 300
⅞	14	0.509	61 100	43 250	46 800
1	12	0.663	79 550	56 350	61 000
1⅛	12	0.856	89 900	63 350	69 350
1¼	12	1.073	112 650	79 400	86 900
1⅜	12	1.315	138 100	97 300	106 500
1½	12	1.581	166 000	117 000	128 000

[A] See footnote *B* in Table 4.
[B] See footnote *C* in Table 4.

TABLE 6 Tensile Strength Requirements for Specimens Machined from Hex Cap Screws, Bolts, and Studs

Nominal Diameter, in.	Tensile Strength, min, psi	Yield Strength, min, psi	Elongation in 4*D*, min, %	Reduction of Area, min, %
¼ to 1, incl.	120 000	92 000	14	35
Over 1 to 1½ , incl.	105 000	81 000	14	35
Over 1½ to 3, incl.	90 000	58 000	14	35

8.1.2 *Bolts*—When styles other than specified in 8.1.1 are required, they shall have dimensions conforming to those specified by the purchaser.

8.1.3 *Studs*—Studs shall have dimensions conforming to those specified by the purchaser.

8.2 *Threads*:

8.2.1 *Uncoated*—Unless otherwise specified, uncoated threads shall be the Unified Coarse Thread Series as specified in the latest issue of ASME B1.1, and shall have Class 2A tolerances.

8.2.2 *Coated*—Unless otherwise specified, zinc-coated bolts, to be used with zinc-coated nuts or tapped holes, which are tapped oversize in accordance with Specification A 563, shall have UNC Class 2A threads before hot-dip or mechanically deposited zinc-coating. After zinc coating, the pitch diameter and major diameter shall not exceed the Class 2A limits by more than the following amounts:

Nominal Diameter, in.	Oversize Limit, in.[A]	
	Hot-Dip Zinc	Mechanical Zinc
¼	0.016	0.012
5/16 , ⅜	0.017	0.012
7/16 , ½	0.018	0.012
9/16 , ⅝ ,¾	0.020	0.013
⅞	0.022	0.015
1.0 to 1¼	0.024	0.016
1⅜ , 1½	0.027	0.018
1¾ to 3.0, incl	0.050	0.033

[A] Hot-dip zinc nuts are tapped oversize after coating and mechanical zinc coated nuts are tapped oversize before coating.

8.2.3 Unless otherwise specified, fasteners electroplated or mechanically coated to 0.0005 in. or less, threads prior to plating shall conform to ASME B1.1 Class 2A and after plating shall not exceed the Class 3A maximum limits, that is, Class 2A plus the allowance.

9. Workmanship, Finish, and Appearance

9.1 Surface discontinuity limits, inspection, and evaluation shall be in accordance with Specification F 788/F 788M.