Designation: A449 – 14

# 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 A449; 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 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| Type 2 | Withdrawn 2003 |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 F1789 unless otherwise defined in this specification.

1.5 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

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]

A563 Specification for Carbon and Alloy Steel Nuts

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

B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

F436 Specification for Hardened Steel Washers

F606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

F788/F788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series

F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F1789 Terminology for F16 Mechanical Fasteners

F2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

G101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

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 B18 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,

[1] This specification is under the jurisdiction of ASTM Committee F16 on Fastenersand 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.

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

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

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 A449–XX, each with one finished hex nut ASTM A563, Grade DH. Each component mechanically zinc coated in accordance with B695, Class 5, Type II.

3.2 *Suitable Nuts and Washers:*

3.2.1 Suitable nuts are covered in Specification A563. 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 1 ½ in., plain (or with a coating of sufficient 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 A563, 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 F436, Type 1 or Specification F436, Type 3. Washers for A449 Type 3 fasteners shall conform to Specification F436 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 F2329.

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 55 of Specification B695.

5.1.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F2329, or a mechanically deposited zinc coating in accordance with Specification B695, Class 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 A563 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 manufacturer. See Guide G101 for methods 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 A751.

**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 | 0.15–0.30 | 0.13–0.32 |
| **Element** | **Boron 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** | **Alloy 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** | **Alloy Boron 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.

## 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 large diameter 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 nominal length of 2¼ D and longer, and sizes 1⅛ to 1½ in. inclusive having a nominal length of 3D and longer shall be wedge tested full size. Bolts of these sizes with heads other than hex or square shall be axially tested full size. All screws and bolts of these sizes shall conform to the proof load or alternative proof load requirements, and minimum tensile load requirements in Tables 4 and 5.

7.2.2 Bolts larger than 1½ in. diameter, other than those excepted in 7.2.3, shall preferably be wedge 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. 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 Bolt with diameters of 1.00 in. and smaller having a nominal 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 Table 4 or Table 5. Bolts with diameters of 1.00 in. and smaller having a nominal length shorter than 2D, and those with diameters above 1.00 in. having a nominal length shorter than 3D, which cannot be axially tensile tested shall be qualified on the basis of hardness.

7.2.4 Studs with nominal lengths of 5D 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. Studs with nominal lengths less than 5D shall be qualified on the basis of hardness. When equipment for full size testing is not available, machined specimens shall be tested and shall conform to the tensile requirements in Table 6.

7.2.4.1 When the length of a stud makes full-size testing impractical, it is permissible for manufacturers to test a full-sized section cut from the longer stud. Such sections shall conform to the tensile and proof load or alternate proof load specified in Table 5 and 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.

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 A563, 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:

**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 |
| Silicon: | | | | | | |
| 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.

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

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

D = Nominal diameter or thread size

| Nominal Diameter, in. | Oversize Limit, in.[A] | |
|---|---|---|
| | Hot-Dip Zinc | Mechanical Zinc |
| ¼ | 0.016 | 0.012 |
| 5⁄16, 3⁄8 | 0.017 | 0.012 |
| 7⁄16, ½ | 0.018 | 0.012 |
| 9⁄16, 5⁄8,3⁄4 | 0.020 | 0.013 |
| 7⁄8 | 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 F788/F788M.

## 10. Number of Tests and Retests

10.1 *Testing Responsibility:*

10.1.1 Each lot shall be tested by the manufacturer prior to shipment in accordance with the lot identification control quality assurance plan in 10.2 – 10.5.

10.1.2 When fasteners are furnished by a source other than the manufacturer, the responsible party as defined in 15.1 shall be responsible for assuring all tests have been performed and the fasteners comply with the requirements of this specification (see 4.3).

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

| 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 |

10.2 *Purpose of Lot Inspection*—The purpose of a lot inspection program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that secondary processors, distributors, and purchasers maintain the identification and integrity of each lot until the product is installed.

10.3 *Lot Processing*—All fasteners shall be processed in accordance with a lot identification-control quality assurance plan. The manufacturer, secondary processors, and distributors shall identify and maintain the integrity of each lot from raw material selection through all operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

10.4 *Lot Definition:*

10.4.1 *Standard Lot*—A lot shall be a quantity of uniquely identified fasteners of the same nominal size and length produced consecutively at the initial operation from a single mill heat of material and processed at one time, by the same processor in the same manner so that statistical sampling is valid. The identity of the lot and lot integrity shall be maintained throughout all subsequent operations and packaging.

10.5 *Number of Tests*—The minimum number of tests from each lot for the tests specified below shall be as follows:

| Tests | Number of Tests in Accordance With |
|---|---|
| Hardness, tensile strength, proof load | Guide F1470 |
| Coating weight/thickness | The referenced coating specification[A] |
| Surface discontinuities | Specification F788/F788M |
| Dimensions and thread fit | ASME B18.2.1 |

[A] Guide F1470 if the coating specification does not specify a testing frequency.

## 11. Test Methods

11.1 Tensile, proof load, and hardness tests shall be conducted in accordance with Test Methods F606.

11.2 Tensile strength for hex cap screws and hex and square bolts shall be determined using the wedge or axial tension testing method of full size product method or the machined test

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

| 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 |

specimens method depending on size and length as specified in 7.2.1 – 7.2.6. Bolts with heads other than hex or square shall be axially tested.

11.3 Studs shall be tested by the axial tension method as described in the second paragraph of axial tension testing of full size products in the Test Methods section of Test Methods F606.

11.4 Proof load shall be determined using Method 1, length measurement, or Method 2, yield strength, at the option of the manufacturer.

## 12. Inspection

12.1 If the inspection described in 12.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

12.2 The purchaser's representative shall have free entry to all parts of the manufacturer's works or supplier's place of business that concern the manufacture or supply of the fasteners. The manufacturer shall afford the purchaser's representative all reasonable facilities to satisfy him that the fasteners are being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the manufacturer's works or supplier's place of business.

## 13. Rejection and Rehearing

13.1 Disposition of nonconforming fasteners shall be in accordance with the section on Disposition of Nonconforming Lots of Guide F1470.

## 14. Certification

14.1 When specified on the purchase order, the manufacturer or supplier, whichever is the responsible party as defined in Section 15, shall furnish the purchaser test reports which include the following:

14.1.1 Heat analysis, heat number, and a statement certifying that heats having the elements listed in 6.4 intentionally added were not used to produce the fasteners,

14.1.2 Results of hardness, tensile, and proof load tests,

14.1.3 Zinc coating measured coating weight/thickness for coated fasteners,

14.1.4 Statement of compliance with dimensional and thread fit requirements,

14.1.5 Lot number and purchase order number,

14.1.6 Complete mailing address of responsible party, and

14.1.7 Title and signature of the individual assigned certification responsibility by the company officers.

14.2 Failure to include all the required information on the test report shall be cause for rejection.

## 15. Responsibility

15.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

## 16. Product Marking

16.1 *Manufacturers Identification*—All hex cap screws and bolts and one end of studs ⅜ in. and larger, and whenever

feasible studs smaller than ⅜ in., shall be marked by the manufacturer with a unique identifier to identify the manufacturer or private label distributor, as appropriate.

16.2 *Type Identification:*

16.2.1 Type 1 hex cap screws and bolts and one end of Type 1 studs ⅜ in. and larger, and whenever feasible studs smaller than ⅜ in., shall be marked "A449."

16.2.2 All Type 3 hex cap screws, blots, and studs shall be marked to indicate that they are produced from weathering steel. Heads of type 3 hex cap screws and bolts shall be marked "A449" underlined. Type 3 studs ⅜ in. and larger, and whenever feasible studs smaller than ⅜ in., shall be marked "A449" underlined on at least one end. Studs under ⅜ in. not marked "A449" underlined, shall be marked with the use of additional marks to indicate that they are produced from weathering steel.

16.3 *Marking Location and Methods:*

16.3.1 All markings shall be located on the top of a hex cap screw and bolt heads and on one end of studs and shall be either raised or depressed at the manufacturer's option.

16.3.2 Type and manufacturer's or private label distributor's identification shall be separate and distinct. The two identifications shall preferably be in different locations and, when on the same level, shall be separated by at least two spaces.

16.4 *Acceptance Criteria*—Fasteners which are not marked in accordance with these provisions shall be considered nonconforming and subject to rejection.

## 17. Packaging and Package Marking

17.1 *Packaging:*

17.1.1 Unless otherwise specified, packaging shall be in accordance with manufacturers practice.

17.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

17.2 *Package Marking:*

17.2.1 Each shipping unit shall include or be plainly marked with the following information:

17.2.1.1 ASTM designation and type,

17.2.1.2 Size,

17.2.1.3 Name and brand or trademark of the manufacturer,

17.2.1.4 Number of pieces,

17.2.1.5 Lot number,

17.2.1.6 Purchase order number, and

17.2.1.7 Country of origin.

## 18. Keywords

18.1 bolts; carbon steel; hex cap screws; steel; studs

## SUPPLEMENTARY REQUIREMENTS

### S1. Marking

S1.1 Studs that are continuously threaded with the same class of thread shall be marked on each end with the marking required by Section 16.

S1.2 Marking small sizes (customarily less than 0.375 in.) may not be practical. Consult the producer for the minimum size that can be marked.

## SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue, (A449 – 10), that may impact the use of this standard.

*(1) Revised*—11.2 to limit acceptable fractures to threads only, in alignment with Test Methods F606.
*(2) Revised*—several parts of 7.2 and Table 3, Table 4, and Table 5 to clarify tensile testing requirements.

*(3) Deleted*—Practice D3951 from 17.1.1.