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Designation: **A 449 – 004**

Standard Specification for Quenched and Tempered Steel Bolts and Studs¹

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 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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1. Scope*

1.1 This specification² covers the chemical and mechanical requirements for two types of quenched and tempered steel bolts and studs for general applications where high strength is required.

1.2 The two types of bolts covered in this specification are:

1.2.1 *Type 1*—Medium-carbon steel bolts and studs furnished in nominal diameters of ¼ to 3 in., inclusive.

1.2.2 *Type 2*—Low-carbon martensite or medium-carbon martensite steel bolts and studs furnished in nominal diameters of ¼ to 1 in., inclusive.

1.3 The bolts and studs shall be ~~Type-1; 1, Type-2; or, 2,~~ or Type 1 or 2 at manufacturer's option², as specified by the purchaser. When a type is not specified, Type 1 shall be furnished. When elevated temperature applications are involved, Type 1 shall be specified by the purchaser on the order.

1.4 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 ⁴
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

⁴ 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.

1.5 Unless otherwise specified, washers ordered with bolts shall be furnished to the requirements of Specification F 436.

1.6 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.

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

2. Referenced Documents

2.1 *ASTM Standards:*³

A 153/A 153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A 563 Specification for Carbon 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, and Rivets

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

F 1789

2.2 *ANSI/ASME Standards:*

B 1.1 Unified Screw Threads

B 18.2.1 Square and Hex Bolts and Screws

B 18.24.1 Part Identifying Number (PIN) Code System⁴

2.3 *Military Standard:*

MIL-STD-105 Single Sampling Plan for Normal Inspection⁵

3. Ordering Information

3.1 Orders for bolts and studs (including nuts and accessories) under this specification shall include the following:

3.1.1 ASTM designation and year of issue.

3.1.2 Type required, that is, ~~Type-1; 1, Type-2; 2,~~ or Type 1 or 2 at manufacturer's option (see 1.3).

3.1.3 Name of product (that is, bolt or stud).

3.1.4 Quantities (number of pieces by size (including nuts)).

3.1.5 Bolt size and length.

3.1.6 *Washers*—Specific quantity and size (separate from bolts).

3.1.7 *Hot Dip or Mechanically Deposited Zinc Coatings*—For hot dip or mechanically deposited zinc coatings covered by 5.1 and requiring overtapped nuts, specify the zinc coating process required, that is, hot dip, mechanically deposited, or no preference (see 5.1).

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*, Vol 01.06, volume information, refer to the standard's Document Summary page on the ASTM website.

Annual Book

⁴ Available from American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990. *Annual Book of ASTM Standards*, Vol 01.03.

⁵ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

- 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 Specify if certified test reports are required (see 10.2).
- 3.1.11 Specify additional testing (see 10.3) or special requirements.
- 3.1.12 Any special requirements.
- 3.1.13 For establishment of a part identifying system, see ASME B18.24.1.

4. Materials and Manufacture

- 4.1 Steel for bolts and studs shall be made by the open-hearth, basic-oxygen, or electric-furnace process.
- 4.2 Type 2 bolts and studs shall be made from fully killed fine-grain steel.
- 4.3 The bolts and studs shall be heat treated by quenching in a liquid medium from above the transformation temperature and then tempering by reheating to a temperature of not less than 800°F (425°C).
- 4.4 Threads of bolts and studs shall be rolled, cut, or ground.

5. Protective Coatings

5.1 *Zinc, Hot Dip and Mechanically Deposited Requiring Overtapped 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 Class C of Specification A 153.
- 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 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 A 153, Class C, or a mechanically deposited zinc coating in accordance with Specification B 695, Class 50. 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.
- 5.1.5 Type 2 bolts and studs shall be zinc coated by the mechanical-deposition process only.

NOTE 1—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 Coatings other than specified in 5.1 shall be as specified by the purchaser on the purchase order.
- 5.2.2 When other coatings are specified, the complete specification for the coating shall be included as part of the purchase order.

6. Chemical Composition

- 6.1 The bolts and studs shall conform to the chemical composition specified in Table 1 for the type specified.
- 6.2 Product analyses may be made by the purchaser from finished material representing each lot. The chemical composition thus determined shall conform to the requirements prescribed for product analysis in Table 1.

TABLE 1 Chemical Requirements for Type 1 and Type 2 Bolts and Studs

Element	Composition, %	
	Type 1	Type 2
Carbon:		
Heat analysis	0.28–0.55	0.15–0.38
Product analysis	0.25–0.58	0.13–0.41
Manganese, min:		
Heat analysis	0.60	0.70
Product analysis	0.57	0.67
Phosphorus, max:		
Heat analysis	0.040	0.040
Product analysis	0.048	0.048
Sulfur, max:		
Heat analysis	0.050	0.050
Product analysis	0.058	0.058
Boron, min:		
Heat analysis	...	0.0005
Product analysis	...	0.0005

6.3 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

6.4 Chemical analyses shall be performed in accordance with Test Methods A 751.

7. Mechanical Properties

7.1 Bolts and studs shall not exceed the maximum hardness specified in Table 2.

7.2 Bolts less than three diameter in length and studs less than four diameter in length shall have hardness values not less than the minimum nor more than the maximum limits required by Table 2. This hardness testing is the only mechanical testing requirement for these bolts or studs.

7.3 Bolts and studs other than those excepted in 7.2 shall be subjected to tension tests as specified in 7.4 and 7.5.

7.4 Bolts and studs 1½ in. in diameter or less, other than those excepted in 7.2, shall be tested full size and shall conform to the tensile strength and either the proof load or yield strength requirements specified in Tables 3 and 4.

7.5 Bolts and studs larger than 1½ in. in diameter, other than those excepted in 7.2, shall preferably be tested full size and when so tested, shall conform to the tensile strength and either the proof load or yield strength requirements specified in Tables 3 and 4, respectively. When equipment of sufficient capacity for full-size testing is not available, or when the length of the bolt or stud makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements of Table 5. In the event that bolts are tested by both full size and by the machined test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

7.6 For bolts and studs on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence over low readings of hardness tests.

8. Dimensions

8.1 Unless otherwise specified, the bolts shall be Hex Cap Screw (Finished Hexagon Head) with dimensions conforming to the latest issue of ANSI B18.2.1.

8.2 Studs shall have dimensions conforming to those specified by the purchaser.

8.3 Unless otherwise specified, uncoated threads shall be Coarse Thread Series as specified in the latest issue of ANSI B1.1, and shall have Class 2A tolerances.

8.4 Bolts and studs hot dip or mechanically zinc coated (see 5.1).

8.4.1 Unless otherwise specified, bolts to be used with nuts or tapped holes that have been tapped oversize, in accordance with Specification A 563, shall have Class 2A threads before hot-dip or mechanically deposited zinc coating. After zinc coating, the maximum limit of pitch and major diameter may exceed the Class 2A limit by the following amount:

Diameter, in.	Oversize Limit, in. (mm) ^A
¼	0.016
⅜, ½	0.017
⅝, ¾	0.018
⅞ to 1, incl	0.020
1	0.022
1 to 1¼, incl	0.024
1½, 1¾	0.027
1¾ to 3, incl	0.050

^A These values are the same as the overlapping required for zinc-coated nuts in Specification A 563.

8.4.2 The gaging limit for bolts shall be verified during manufacture or use by assembly of a nut tapped as nearly as practical to the amount oversize shown above. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance, gage tolerance plus) is to be used. Assembly of the gage, or the nut described above, must be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, are to be performed at the frequency and quality described in Table 6.

8.5 *Electroplated Bolts and Studs*—Unless otherwise specified, threads prior to plating shall conform to ANSI/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 The bolts and studs shall be commercially smooth and free of burrs, laps, seams, cracks, and other injurious material or manufacturing defects which would make them unsuitable for the intended application.

TABLE 2 Hardness Requirements

Bolt or Stud Diameter, in.	Hardness	
	Brinell Hardness Number	Rockwell C
¼ to 1, incl	255 to 321	25 to 34
Over 1 to 1½, incl	223 to 285	19 to 30
Over 1½ to 3, incl	183 to 235	...

TABLE 3 Tensile Requirements for Coarse-Thread Full-Size Bolts and Studs

Bolt or Stud Diameter, in.	Threads per inch ^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
1/4	20	0.0318	3 800	2 700	2 900
5/16	18	0.0524	6 300	4 450	4 800
3/8	16	0.0775	9 300	6 600	7 100
7/16	14	0.1063	12 750	9 050	9 800
1/2	13	0.1419	17 050	12 050	13 050
9/16	12	0.182	21 850	15 450	16 750
5/8	11	0.226	27 100	19 200	20 800
3/4	10	0.334	40 100	28 400	30 700
7/8	9	0.462	55 450	39 250	42 500
1	8	0.606	72 700	51 500	55 750
1 1/8	7	0.763	80 100	56 450	61 800
1 1/4	7	0.969	101 700	71 700	78 500
1 3/8	6	1.155	121 300	85 450	93 550
1 1/2	6	1.405	147 500	104 000	113 800
1 3/4	5	1.90	171 000	104 500	110 200
2	4 1/2	2.50	225 000	137 500	145 000
2 1/4	4 1/2	3.25	292 500	178 750	188 500
2 1/2	4	4.00	360 000	220 000	232 000
2 3/4	4	4.93	443 700	271 150	286 000
3	4	5.97	537 300	328 350	346 200

^A For 8 threads per inch sizes 1 1/8 to 1 1/2 in., inclusive, stresses of 105 000 psi (725 MPa), 74 000 psi (510 MPa), and 81 000 psi (560 MPa) shall be used for calculating the values in columns 4, 5, and 6 respectively.

^B Stress area is calculated as follows:

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

where:

A_s = stress area,

D = nominal diameter, and

n = threads per inch.

^C Values tabulated are based on the following:

Bolt Size, in.	Column 4, psi (MPa)	Column 5, psi (MPa)	Column 6, psi (MPa)
1/4 to 1, incl	120 000 (825)	85 000 (585)	92 000 (635)
1 1/8 to 1 1/2, incl	105 000 (725)	74 000 (510)	81 000 (560)
1 3/4 to 3, incl	90 000 (620)	55 000 (380)	58 000 (400)

9.2 Surface discontinuity limits shall be in accordance with Specification F 788/F 788M.

10. Number of Tests and Retests

10.1 The requirements of this specification shall be met in continuous mass production for stock, and the manufacturer shall make sample inspections to ensure that the product conforms to the specified requirements. Additional tests of individual shipments of material are not ordinarily contemplated. Individual heats of steel are not identified in the finished product.

10.2 When specified in the order, the manufacturer shall furnish a test report certified to be the last completed set of mechanical tests for each stock size in each shipment.

10.3 When testing on a lot basis is specified on the purchase order, a lot, for purposes of selecting test samples, shall consist of all material of one type, that is, bolts or studs having the same nominal diameter and length offered for inspection at one time. From each lot, the number of tests for each specified property shall be as follows:

Number of Pieces in Lot	Number of Samples
800 and less	1
Over 800 to 8 000, incl	2
Over 8 000 to 22 000, incl	3
Over 22 000	5

10.4 Should any sample fail to meet the requirements of a specified test, double the original number of samples from the same lot shall be retested for the requirement(s) in which it failed. All the additional samples shall conform to the specification or the lot shall be rejected.

10.5 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

TABLE 4 Tensile Requirements for Fine-Thread Full-Size Bolts and Studs

Bolt or Stud Diameter, in.	Threads per inch	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
1/4	28	0.0364	4 350	3 100	3 500
5/16	24	0.0580	6 950	4 950	5 350
3/8	24	0.0878	10 550	7 450	8 100
7/16	20	0.1187	14 500	10 100	10 900
1/2	20	0.1599	19 200	13 600	14 700
9/16	18	0.203	24 350	17 250	18 700
5/8	18	0.256	30 700	21 750	23 500
3/4	16	0.373	44 750	31 700	34 300
7/8	14	0.509	61 100	43 250	46 800
1	12	0.663	79 550	56 350	61 000
1 1/8	12	0.856	89 900	63 350	69 350
1 1/4	12	1.073	112 650	79 400	86 900
1 3/8	12	1.315	138 100	97 300	106 500
1 1/2	12	1.581	166 000	117 000	128 000

^A See footnote B in Table 3.

^B See footnote C in Table 3.

TABLE 5 Tensile Requirements for Specimens Machined from Bolts and Studs

Bolt or Stud Diameter, in.	Tensile Strength, min, psi (MPa)	Yield Strength, min, psi (MPa)	Elongation in 4 D, min, %	Reduction of Area, min, %
1/4 to 1, incl	120 000 (825)	92 000 (635)	14	35
Over 1 to 1 1/2, incl	105 000 (725)	81 000 (560)	14	35
Over 1 1/2 to 3, incl	90 000 (620)	58 000 (400)	14	35

TABLE 6 Sample Sizes and Acceptance Numbers for Inspection of Hot-Dip or Mechanically Deposited Zinc-Coated Threads

Lot Size	Sample Size ^{A,B}	Acceptance Number ^A
2 to 90	13	1
91 to 150	20	2
151 to 280	32	3
281 to 500	50	5
501 to 1 200	80	7
1 201 to 3 200	125	10
3 201 to 10 000	200	14
10 001 and over	315	21

^A Sample sizes of acceptance numbers are extracted from "Single Sampling Plan for Normal Inspection," Table IIA, MIL-STD-105.

^B Inspect all bolts in the lot if the lot size is less than the sample size.

11. Test Methods

11.1 Tests shall be conducted in accordance with Test Methods F 606.

11.2 The wedge test shall be applicable only to square and hexagon head bolts.

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, Test Methods section of Test Methods F 606.

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 inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is 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 works.

13. Responsibility

13.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser and certifies that the fastener was manufactured, sampled, tested and inspected in accordance with this specification and meets all of its requirements.

14. Rejection and Rehearing

14.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

15. Product Marking

15.1 *Manufacturers Identification*—All bolt heads and one end of studs shall be marked with a unique identifier by the manufacturer to identify the manufacturer or private label distributor, as appropriate.

15.2 *Type Identification*—In addition to the requirements in 15.1, all bolt heads and one end of studs $\frac{3}{8}$ in. and larger, and whenever feasible studs less than $\frac{3}{8}$ in., shall be marked to identify the Type as follows:

Type	Marking
1	3 radial lines 120° apart
2	3 radial lines 60° apart

15.3 *Marking Method and Location*—All markings shall be located on the top of the bolt head or stud end and may be either raised or depressed, at the option of the manufacturer.

15.4 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. Packaging and Package Marking

16.1 *Packaging:*

16.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

16.1.2 When zinc-coated nuts are included on the same order as zinc coated bolts, the bolts and nuts shall be shipped in the same container.

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

16.2 *Package Marking:*

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

16.2.1.1 ASTM designation and type,

16.2.1.2 Size,

16.2.1.3 Name and brand or trademark of the manufacturer,

16.2.1.4 Number of pieces,

16.2.1.5 Purchase order number, and

16.2.1.6 Country of origin.

17. Keywords

17.1 bolts; carbon steel; 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 15.

S1.2 Marking small sizes (customarily less than 0.375 in. (9.525 mm)) may not be practical. Consult the producer for the minimum size that can be marked.

SUMMARY OF CHANGES

This section identifies

Committee F16 has identified the location of selected changes to this standard that have been incorporated since the 93 issue. For the convenience of the user, Committee F16 has highlighted those changes last issue, A 449-00, that may impact the use of this standard. This section may also include descriptions of the changes or reasons for the changes, or both.

(1) Added 3.1.13, providing for optional use of ASME B18.24.1, Part Identifying Number (PIN) Code System. (Approved Jan. 1, 2004.)

(I) Added Section 1.7 that references Terminology F 1789.

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