



Designation: F593 – 17

Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs¹

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This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers the requirements for stainless steel bolts, hex cap screws, and studs 0.25 to 1.50 in., inclusive, in nominal diameter in a number of alloys in common use and intended for service applications requiring general corrosion resistance.

1.2 Seven groups of stainless steel alloys are covered, including fourteen austenitic, two ferritic, four martensitic, and one precipitation hardening.

Group	Alloys ^A	Condition ^B
1	304, 305, 384, 304 L, 18-9LW, 302HQ, 304J3 ^D	(CW) cold worked ^C
2	316, 316 L	(CW) cold worked ^C
3	321, 347	(CW) cold worked ^C
4	430 ^E	(CW) cold worked ^C
5	410 ^F	(H) hardened and tempered
6	431	(H) hardened and tempered
7	630	(AH) age hardened

^A Unless otherwise specified on the inquiry and order, the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer (see 6.1).

^B See 4.2 for options.

^C Sizes 0.75 in. and larger may be hot worked and solution annealed, provided the bolts comply with the cold worked (CW) mechanical property requirements.

^D When approved by the purchaser, Alloys 303, 303Se, or XM1 may be furnished.

^E When approved by the purchaser, Alloy 430F may be furnished.

^F When approved by the purchaser, Alloys 416 or 416Se may be furnished.

1.3 Supplementary requirements of an optional nature are provided, applicable only when agreed upon between the manufacturer and the purchaser at the time of the inquiry and order.

1.4 Suitable nuts for use with bolts, hex cap screws, and studs included in this specification are covered by Specification F594. Unless otherwise specified, all nuts used on these fasteners shall conform to the requirements of Specification F594, shall be of the same alloy group, and shall have a specified minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener.

¹ This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.04 on Nonferrous Fasteners.

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1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

- A262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
- A276 Specification for Stainless Steel Bars and Shapes
- A342/A342M Test Methods for Permeability of Weakly Magnetic Materials
- A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
- A484/A484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
- A493 Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
- A555/A555M Specification for General Requirements for Stainless Steel Wire and Wire Rods
- A564/A564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
- A582/A582M Specification for Free-Machining Stainless Steel Bars
- A751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

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

- [A967 Specification for Chemical Passivation Treatments for Stainless Steel Parts](#)
- [D3951 Practice for Commercial Packaging](#)
- [E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)
- [F594 Specification for Stainless Steel Nuts](#)
- [F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets](#)
- [F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection](#)

2.2 ASME Standards:³

B1.1 Unified Inch Screw Threads

B18.2.1 Square and Hex Bolts and Screws, Including Hex Cap Screws

2.3 JIS Standard:⁴

JIS G4309 Stainless Steel Wires

3. Ordering Information

3.1 Orders for bolts, hex cap screws, and studs under this specification shall include the following:

- 3.1.1 Quantity (number of pieces of each item and size),
- 3.1.2 Name of item (bolt, hex cap screw, stud, etc.),
- 3.1.3 Size (nominal diameter, threads per inch, length; see Section 9),
- 3.1.4 Alloy group number (see 6.1), and
- 3.1.5 Condition (see 4.2).

3.2 Orders for bolts, hex cap screws, and studs under this specification may include the following optional requirements:

- 3.2.1 Forming (see 4.1.2),
- 3.2.2 Rolled or cut threads (see 4.1.3),
- 3.2.3 Composition (see 6.2),
- 3.2.4 Corrosion Resistance (see 8.1),
- 3.2.5 Finish (see 10.3),
- 3.2.6 Rejection (see 16.1), and
- 3.2.7 Test report (see 17.2).

3.2.8 Supplementary requirements, if any, to be specified on the order (see S1 through S8), and

3.2.9 ASTM specification and year of issue. When year of issue is not specified, fasteners shall be furnished to the latest issue.

NOTE 1—*Example* 10 000 pieces, Hex Cap Screw, 0.250 in. -20×3.00 in., Alloy Group 1, Condition CW, Furnish Test Report, Supplementary Requirement S3.

4. Manufacture

4.1 Manufacture:

4.1.1 Specifications [A276](#), [A493](#), [A564/A564M](#), and [A582/A582M](#) are noted for information only as suitable sources of material for the manufacture of bolts, hex cap screws, and studs to this specification.

4.1.2 *Forming*—Unless otherwise specified, the fasteners shall be cold formed, hot formed, or machined from suitable material at the option of the manufacturer.

³ Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, <http://www.global.ihs.com>.

⁴ Available from Japanese Industrial Standards Committee (JIS) 1-3-1 Kasumigasaki, Chiyoda-ku, Tokyo 100-8901, Japan. <http://www.jisc.go.jp>

4.1.3 *Threads*—Unless otherwise specified, the threads shall be rolled or cut at the option of the manufacturer.

4.2 *Condition*—The fasteners shall be furnished in the following conditions, unless specified to be furnished in one of the optional conditions:

Alloy Group	Condition Furnished Unless Otherwise Specified	Optional Conditions (must be specified)
1, 2, 3	CW	AF, A, SH
4	CW	A
5	H	HT
6	H	HT
7	AH	none

- A—Machined from annealed or solution-annealed stock thus retaining the properties of the original material; or hot-formed and solution annealed.
- AF—Headed and rolled from annealed stock and then reannealed.
- AH—Solution-annealed and age-hardened after forming.
- CW—Headed and rolled from annealed stock thus acquiring a degree of cold work. Sizes 0.75 in. and larger may be hot-worked and solution-annealed.
- H—Hardened and tempered at 1050°F (565°C) minimum.
- HT—Hardened and tempered at 525°F (274°C) minimum.
- SH—Machined from strain-hardened stock or cold-worked to develop the specific properties.

5. Heat Treatment

5.1 *Alloy Groups 1, 2, and 3 (Austenitic Alloys 303, 303Se, 304, 304 L, 305, 316, 316 L, 321, 347, 384, XMI, 18-9LW, 302HQ, and 304J3):*

5.1.1 *Condition A*—When Condition A is specified, the austenitic alloys shall be heated to $1900 \pm 50^\circ\text{F}$ ($1038 \pm 28^\circ\text{C}$), at which time the chromium carbide will go into the solution, be held for a sufficient time, and then be cooled at a rate sufficient to prevent precipitation of the carbide and to provide the specified properties.

5.1.2 *Condition CW*—When Condition CW is specified, the austenitic alloys shall be annealed in accordance with 5.1.1, generally by the raw material manufacturer and then cold worked to develop the specified properties.

5.1.3 *Condition AF*—When Condition AF is specified, the austenitic alloys shall be annealed in accordance with 5.1.1 after all cold working (including heading and threading) has been completed.

5.2 *Alloy Group 4 (Ferritic Alloys 430 and 430F):*

5.2.1 *Condition A*—The ferritic alloys shall be heated to a temperature of $1450 \pm 50^\circ\text{F}$ ($788 \pm 28^\circ\text{C}$), held for an appropriate time, and then air cooled to provide the specified properties.

5.2.2 *Condition CW*—When Condition CW is specified, the ferritic alloys shall be annealed in accordance with 5.2.1, generally by the raw material manufacturer and then cold worked to develop the specified properties.

5.2.3 *Condition AF*—When Condition AF is specified, the ferritic alloys shall be annealed in accordance with 5.2.1 after all cold working (including heading and threading) has been completed.

5.3 *Alloy Group 5 (Martensitic Alloys 410, 416, and 416Se):*

5.3.1 *Condition H*—When Condition H is specified, the Martensitic Alloys 410, 416, and 416Se shall be hardened and tempered by heating to $1850 \pm 50^\circ\text{F}$ ($1010 \pm 28^\circ\text{C}$) sufficient for austenitization, held for at least $\frac{1}{2}$ h and rapid air- or

oil-quenched, and then reheating to 1050°F (565°C) minimum for at least 1 h and air cooled to provide the specified properties.

5.3.2 *Condition HT*—When Condition HT is specified, the Martensitic Alloys 410, 416, and 416Se shall be hardened and tempered by heating to 1850 ± 50°F (1010 ± 28°C) sufficient for austenitization, held for at least ½ h and rapid air- or oil-quenched, and then reheating to 525°F (274°C) minimum for at least 1 h and air cooled to provide the specified properties.

5.4 *Alloy Group 6 (Martensitic Alloy 431):*

5.4.1 *Conditions H and HT*—Martensitic Alloy 431 shall be hardened and tempered in accordance with 5.3.1 and 5.3.2 as applicable.

5.5 *Alloy Group 7 (Precipitation Hardening Alloy 630):*

5.5.1 *Condition AH*—Precipitation Hardening Alloy 630 shall be solution annealed and aged by heating to 1900 ± 25°F (1038 ± 14°C) for at least ½ h and rapid air- or oil-quenched to 80°F (27°C) maximum, then reheating to a temperature of 1150 ± 15°F (621 ± 8°C) for 4 h and air cooled to provide the specified properties.

6. Chemical Composition

6.1 *Alloy Groups*—It is the intent of this specification that fasteners shall be ordered by alloy group numbers, which include alloys considered to be chemically equivalent for general purpose use. The alloy groupings are shown as follows. The purchaser has the option of ordering a specific alloy, in stead of an alloy group number, as permitted in 6.2.2.

Alloy Group	Alloys
1	304, 304 L, 305, 384, 18-9LW, 302HQ, 304J3 ^A
2	316, 316 L
3	321, 347
4	430 ^B
5	410 ^C
6	431
7	630

^A When approved by the purchaser, Alloys 303, 303Se, or XM1 may be furnished.

^B When approved by the purchaser, Alloy 430F may be furnished.

^C When approved by the purchaser, Alloys 416 or 416Se may be furnished.

6.2 *Chemical Composition Limits:*

6.2.1 *Ordering by Alloy Group*—Unless otherwise specified on the inquiry and order (see Supplementary Requirement S4), the choice of an alloy from within a group shall be at the discretion of the fastener manufacturer as required by his method of fastener fabrication and material availability. The specific alloy used by the fastener manufacturer shall be clearly identified on any certification required by the order and shall have a chemical composition conforming to the requirements of Table 1 for the specific alloy.

6.2.2 *Ordering by Specific Alloy*—When ordered by a specific alloy number, the fasteners shall conform to the chemical composition limits of Table 1 for the specific alloy.

6.3 *Product Analysis:*

6.3.1 When performed, product analysis to determine chemical composition shall be performed on at least one fully manufactured finished fastener representing each lot. The chemical composition thus determined shall conform to the requirements of Table 1 for the specified alloy or alloy group as

TABLE 1 Chemical Requirements

Alloy Group	UNS Designation	Alloy	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Copper	Molybdenum	Others
Austenitic Alloys												
1	S30300	303	0.15	2.00	0.20	0.15 min	1.00	17.0 to 19.0	8.0 to 10.0	...	0.60 max ^A	...
1	S30323	303 Se	0.15	2.00	0.20	0.060	1.00	17.0 to 19.0	8.0 to 10.0	...	...	Se 0.15 min
1	S30400	304	0.08	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 10.5	1.00	...	...
1	S30403	304 L	0.03	2.00	0.045	0.030	1.00	18.0 to 20.0	8.0 to 12.0	1.00	...	...
1	S30500	305	0.12	2.00	0.045	0.030	1.00	17.0 to 19.0	10.5 to 13.0	1.00	...	...
1	S38400	384	0.08	2.00	0.045	0.030	1.00	15.0 to 17.0	17.0 to 19.0	...	0.50 max ^A	...
1	S20300	XM1	0.08	5.0 to 6.5	0.040	0.18 to 0.35	1.00	16.0 to 18.0	5.0 to 6.5	1.75 to 2.25	...	...
1	S30430	18-9LW	0.10	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0	...	...
1	S30433	302HQ	0.03	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.0	3.0 to 4.0	...	...
1	...	304J3 ^B	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	8.0 to 10.5	1.00 to 3.00	...	...
2	S31600	316	0.08	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	...	2.00 to 3.00	...
2	S31603	316 L	0.03	2.00	0.045	0.030	1.00	16.0 to 18.0	10.0 to 14.0	...	2.00 to 3.00	...
3	S32100	321	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 12.0	...	...	Ti 5x C min
3	S34700	347	0.08	2.00	0.045	0.030	1.00	17.0 to 19.0	9.0 to 13.0	...	...	Cb+Ta 10 x C min
Ferritic Alloys												
4	S43000	430	0.12	1.00	0.040	0.030	1.00	16.0 to 18.0	...	...	...	...
4	S43020	430F	0.12	1.25	0.060	0.15 min	1.00	16.0 to 18.0	...	...	0.60 max ^A	...
Martensitic Alloys												
5	S41000	410	0.15	1.00	0.040	0.030	1.00	11.5 to 13.5	...	...	...	...
5	S41600	416	0.15	1.25	0.060	0.15 min	1.00	12.0 to 14.0	...	...	0.60 max ^A	...
5	S41623	416Se	0.15	1.25	0.060	0.060	1.00	12.0 to 14.0	...	...	...	Se 0.15 min
6	S43100	431	0.20	1.00	0.040	0.030	1.00	15.0 to 17.0	1.25 to 2.50	...	...	...
Precipitation Hardening Alloy												
7	S17400	630	0.07	1.00	0.040	0.030	1.00	15.0 to 17.5	3.0 to 5.0	3.0 to 5.0	...	Cb+Ta 0.15–0.45

^A At manufacturer's option, determined only when intentionally added.

^B 304J3 from JIS Standard G4309.

appropriate, subject to the Product Analysis Tolerance in Specifications **A484/A484M** and **A555/A555M**.

6.3.2 In the event of discrepancy, a referee chemical analysis of samples from each lot shall be made in accordance with **14.1**.

7. Mechanical Properties

7.1 The finished fasteners shall meet the applicable mechanical property and test requirements of **Table 2** and **Table 3** as appropriate for the specified alloy group and condition and shall be tested for conformance to the mechanical property requirements as specified herein.

7.2 Fasteners having a nominal thread diameter-length combination as follows:

Thread Diameter, in.	Thread Length, in.
0.75 or less	2.25 <i>D</i> or longer
Over 0.75	3 <i>D</i> or longer

and a breaking load of 120 000 lbf (535 kN) or less shall be tested full size and shall meet the full-size tensile (minimum and maximum) and yield strength requirements in **Table 2** for the specified alloy.

7.3 Fasteners having a nominal thread diameter-length combination in accordance with **7.2** and a breaking load exceeding 120 000 lbf (535 kN) shall be tested full-size and shall meet the full size tensile (minimum and maximum) and yield strength properties in **Table 2**. When equipment of sufficient capacity for such tests is not available, or if excessive length of the fasteners makes full-size testing impractical, use of standard or round specimens that meet the “machined specimen test tensile properties” in **Table 2** is permitted. In the event of discrepancy or dispute between test results obtained from full-size finished fasteners and standard or round specimens, the referee method shall be tests performed on full-size finished fasteners.

7.4 Fasteners that are too short (lengths less than that specified in **7.2** (see Test Methods **F606/F606M** and **Table 4**); have insufficient threads for tension; or have drilled or under-sized heads, drilled or reduced bodies, and so forth, that are weaker than the thread section, shall not be subject to tension tests but shall conform to the hardness (minimum and maximum) requirements of **Table 2**.

8. Corrosion Resistance

8.1 Carbide Precipitation:

8.1.1 Rod, bar, and wire in the austenitic Alloy Groups 1, 2, and 3, except the free-machining grades, 303 and 303Se, used to make fasteners in accordance with this specification shall be capable of passing the test for susceptibility to intergranular corrosion as specified in Practice E of Practices **A262**.

8.1.2 As stated in Practice **A262**, samples may be subjected to the faster and more severe screening test in accordance with Practice A. Failing Practice A, specimens shall be tested in accordance with Practice E and be considered satisfactory if passing Practice E.

9. Dimensions

9.1 Bolts and Hex Cap Screws:

9.1.1 Unless otherwise specified, the dimensions shall be in accordance with the requirements of ASME B18.2.1 for hex cap screws (finished hex bolts).

9.1.2 When specified, the dimensions of bolts shall be in accordance with the requirements of ASME B18.2.1 (type as specified), or such other dimensions shall be specified.

9.2 *Studs*—Dimensions of studs including double-end clamping and double-end interference shall be as specified by the purchaser.

9.3 *Threads*—Unless otherwise specified, the bolts, cap screws, and studs shall have Class 2A threads in accordance with ASME B1.1.

9.4 *Points*—Unless otherwise specified, the points shall be flat and chamfered or rounded, at the option of the manufacturer.

10. Workmanship and Finish

10.1 *Workmanship*—The fasteners shall have a workman-like finish, free of injurious burrs, seams, laps, irregular surfaces, and other defects affecting serviceability.

10.2 *Cleaning and Descaling*—The fasteners shall be descaled or cleaned, or both, in accordance with Specification **A380**.

10.3 *Protective Finishes*—Unless otherwise specified, the fasteners shall be furnished without an additive chemical or metallic finish.

11. Sampling

11.1 A lot, for the purposes of selecting test specimens, shall consist of not more than 100 000 pieces offered for inspection at one time having the following common characteristics:

- 11.1.1 One type of item (that is, bolts, hex cap screws, studs, etc.),
- 11.1.2 Same alloy and condition,
- 11.1.3 One nominal diameter and thread series,
- 11.1.4 One nominal length,
- 11.1.5 Produced from one heat of material, and
- 11.1.6 Heat treated under the same conditions as to time and temperature.

12. Number of Tests and Retests

12.1 Number of Tests:

12.1.1 *Mechanical Tests*—The mechanical requirements of this specification shall be met in continuous mass production for stock. The manufacturer shall make sample inspections as specified below to ensure that the product conforms to the specified requirements. When tests of individual shipments are required, Supplementary Requirement S1 must be specified in the inquiry and order.

Number of Pieces in Lot	Number of Tests	Acceptance Criteria	
		Acceptance Number	Rejection Number
2 to 50	2	0	1
51 to 500	3	0	1
501 to 35 000	5	0	1
35 001 to 100 000	8	0	1

12.1.2 Corrosion Resistance Tests:

12.1.2.1 Unless otherwise specified, inspection for corrosion resistance shall be in accordance with the manufacturer’s standard quality control practices. No specific method of inspection is required, but the fasteners shall be produced from