NOTICE: This standard has either been superseded and replaced by a new version or withdrawn.
Contact ASTM International (www.astm.org) for the latest information

Designation: F 593 – 02$^{\epsilon 2}$

Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs[1]

This standard is issued under the fixed designation F 593; 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.

ε[1] NOTE—Table 2 was editorially corrected in February 2004.
ε[2] NOTE—Section 4.2 was editorially corrected in October 2004.

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 twelve austenitic, two ferritic, four martensitic, and one precipitation hardening.

Group	Alloys[A]	Condition[B]
1	304, 305, 384, 304 L, 18-9LW, 302HQ[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.
[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 F 594. Unless otherwise specified, all nuts used on these fasteners shall conform to the requirements of Specification F 594, 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.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
A 276 Specification for Stainless Steel Bars and Shapes
A 342/A 342M Test Methods for Permeability of Feebly Magnetic Materials
A 380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
A 493 Specification for Stainless Steel Wire and Wire Rods for Cold Heading and Cold Forging
A 555/A 555M Specification for General Requirements for Stainless Steel Wire and Wire Rods
A 564/A 564M Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
A 582/A 582M Specification for Free-Machining Stainless Steel Bars
A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
A 967 Specification for Chemical Passivation Treatments for Stainless Steel Parts
D 3951 Practice for Commercial Packaging
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
F 594 Specification for Stainless Steel Nuts
F 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets
F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

2.2 *ASME Standards:*[3]

B1.1 Unified Inch Screw Threads

[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.

Current edition approved April 10, 2002. Published May 2002. Originally published as F 593 – 78. Last previous edition F 593 – 01.

[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.

[3] Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States.

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

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 A 276, A 493, A 564/A 564M, and A 582/A 582M 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.

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, XM1, 18-9LW, and 302HQ)*:

5.1.1 *Condition A*—When Condition A is specified, the austenitic alloys shall be heated to 1900 ± 50°F (1038 ± 28°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 ± 50°F (788 ± 28°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 ± 50°F (1010 ± 28°C) sufficient for austenitization, held for at least ½ 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.

iTeh Standards (https://standards.iteh.ai) Document Preview

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[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 appropriate, subject to the Product Analysis Tolerance in Specifications A 484/A 484M and A 555/A 555M.

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 *D* or longer
Over 0.75	3 *D* 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

iTeh Standards
(https://standards.iteh.ai)
Document Preview

TABLE 1 Chemical Requirements

https://standards.iteh.ai/catalog/standards/sist/2950e36d-2957-4ba9-9887-544ba18e7e94/astm-f593-02e2

Alloy Group	UNS Designation	Alloy	Composition, % maximum except as shown									
			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	. . .	. . .
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 5× 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 × 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.

TABLE 2 Mechanical Property Requirements[A]

Stainless Alloy Group	Condition[B]	Alloy Mechanical Property Marking	Nominal Diameter, in.	Full-Size Tests			Machined Specimen Tests		
				Tensile Strength ksi[C]	Yield Strength, ksi[D,C]	Rockwell Hardness	Tensile Strength ksi[C]	Yield Strength, ksi[D,C]	Elongation in 4 *D*, %
Austenitic Alloys									
1 (303, 304, 304 L, 305, 384, XM1, 18-9LW, 302HQ, 303Se)	AF	F593A	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593B	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593C	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593D	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593A	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593B	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593C	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593D	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
2 (316, 316L)	AF	F593E	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593F	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593G	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593H	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593E	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593F	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593G	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593H	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
3 (321, 347)	AF	F593J	¼ to 1½ , incl	65 to 85	20	B85 max	60	20	40
	A	F593K	¼ to 1½ , incl	75 to 100	30	B65 to 95	70	30	30
	CW1	F593L	¼ to ⅝ , incl	100 to 150	65	B95 to C32	95	60	20
	CW2	F593M	¾ to 1½ , incl	85 to 140	45	B80 to C32	80	40	25
	SH1	F593J	¼ to ⅝ , incl	120 to 160	95	C24 to C36	115	90	12
	SH2	F593K	¾ to 1, incl	110 to 150	75	C20 to C32	105	70	15
	SH3	F593L	1⅛ to 1¼ , incl	100 to 140	60	B95 to C30	95	55	20
	SH4	F593M	1⅜ to 1½ , incl	95 to 130	45	B90 to C28	90	40	28
Ferritic Alloys									
4 (430, 430F)	AF	F593X	¼ to 1½ , incl	55 to 75	30	B85 max	50	25	. . .
	A	F593N	¼ to 1½ , incl	55 to 75	30	B85 max	50	25	. . .
	CW1	F593V	¼ to ⅝ , incl	60 to 105	40	B75 to 98	55	35	. . .
	CW2	F593W	¾ to 1½ , incl	55 to 100	30	B65 to 95	50	25	. . .
Martensitic Alloys									
5 (410, 416, 416Se)	H	F593P	¼ to 1½ , incl	110 to 140	90	C20 to 30	110	90	18
	HT	F593R	¼ to 1½ , incl	160 to 190	120	C34 to 45	160	120	12
6 (431)	H	F593S	¼ to 1½ , incl	125 to 150	100	C25 to 32	125	100	15
	HT	F593T	¼ to 1½ , incl	180 to 220	140	C40 to 48	180	140	10
Precipitation Hardening Alloys									
7 (630)	AH	F593U	¼ to 1½ , incl	135 to 170	105	C28 to 38	135	105	16

[A] Minimum values except where shown as maximum or as a range.

[B] Legend of conditions:
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 specified properties.

[C] The yield and tensile strength values for full-size products shall be computed by dividing the yield and maximum tensile load values by the stress area for the product size and thread series determined in accordance with Test Methods F 606 (see Table 4).

[D] Yield strength is the stress at which an offset of 0.2 % gage length occurs.

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 F 606 and Table 4); have insufficient threads for tension; or have drilled or undersized heads, drilled or reduced bodies, and so forth, that are weaker than the thread section, shall not be subject to tension tests but

iTeh Standards (https://standards.iteh.ai) Document Preview
ASTM F593-02e2
https://standards.iteh.ai/catalog/standards/sist/...-astm-f593-02e2