Designation: F593 – 13a

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

This standard is issued under the fixed designation F593; 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 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 thirteen 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, 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.

1.5 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.*

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 Feebly 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
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

[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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[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**

F606 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

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.

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

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

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[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 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:

TABLE 1 Chemical Requirements

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	. . .	. . .		
5	S41623	416Se	0.15	1.25	0.060	0.060	1.00	12.0 to 14.0			0.60 max[A]	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 F606 (see Table 4).

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

TABLE 3 Mechanical Test Requirements for Bolts and Studs[A]

Item	Nominal Length		Tensile Load, lbf	Full-Size Tests				Machined Specimen Tests		
	Diameters ¾ in. and Less	Diameters Over ¾ in.		Wedge Tensile Strength	Axial Tensile Strength	Yield Strength	Rockwell Hardness	Tensile Strength	Yield Strength	Elongation
Square and hex bolts and hex cap screws	less than 2¼*D*	less than 3*D*	all	Option A	[B]	[B]	Option C	[B]	[B]	[B]
	2¼*D* and longer	3*D* and longer	120 000 max	mandatory	[B]	mandatory	[B]	[B]	[B]	[B]
			over 120 000	Option A	[B]	Option A	[B]	Option B	Option B	Option B
Studs and other bolts	less than 2¼*D*	less than 3*D*	all	[B]	Option A	[B]	Option C	[B]	[B]	[B]
	2¼ *D* and longer	3*D* and longer	120 000 max	[B]	mandatory	mandatory	[B]	[B]	[B]	[B]
			over 120 000	[B]	Option A	Option A	[B]	Option B	Option B	Option B
Specials[C]	all	all	all	[B]	[B]	[B]	mandatory	[B]	[B]	[B]

[A] Where options are given, all the tests under an option shall be performed. Option A, Option B, and Option C indicates manufacturer may perform all Option A (full-size), all Option B (machined specimen), or all Option C tests whichever is preferred. Option A tests should be made whenever feasible.
[B] Tests that are not mandatory.
[C] Special fasteners are those fasteners with special configurations including drilled heads, reduced body, etc., that are weaker than the threaded section. Special fasteners having full-size heads shall be tested as specified for studs and other bolts.

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 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 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

TABLE 4 Tensile Stress Areas and Threads per Inch

Nominal Size, in. (*D*)	Coarse Threads–UNC		Fine Threads-UNF		Thread Series–8 UN	
	Threads/in.	Stress Area[A], in.^{2}	Threads/in.	Stress Area[A], in.^{2}	Threads/in.	Stress Area[A], in.^{2}
¼ (0.250)	20	0.0318	28	0.0364	. . .	. . .
5⁄16 (0.3125)	18	0.0524	24	0.0580	. . .	. . .
3⁄8 (0.375)	16	0.0775	24	0.0878	. . .	. . .
7⁄16 (0.4375)	14	0.1063	20	0.1187	. . .	. . .
½ (0.500)	13	0.1419	20	0.1599	. . .	. . .
9⁄16 (0.5625)	12	0.1820	18	0.2030	. . .	. . .
5⁄8 (0.625)	11	0.2260	18	0.2560	. . .	. . .
¾ (0.750)	10	0.3340	16	0.3730	. . .	. . .
7⁄8 (0.875)	9	0.4620	14	0.5090	. . .	. . .
1.000	8	0.6060	12	0.6630	. . .	. . .
1⅛ (1.125)	7	0.7630	12	0.8560	8	0.790
1¼ (1.250)	7	0.9690	12	1.0730	8	1.000
1⅜ (1.375)	6	1.1550	12	1.3150	8	1.233
1½ (1.500)	6	1.4050	12	1.5810	8	1.492

[A] Tensile stress areas are computed using the following formula:

$$A_s = 0.7854\left[D - \frac{0.9743}{n}\right]^2$$

where:

A_s = tensile stress area, in.^{2},
D = nominal size (basic major diameter), in., and
n = number of threads per inch.

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 workmanlike 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 suitable raw material and manufactured by properly controlled practices to maintain resistance to corrosion. When corrosion tests are required, Supplementary Requirement S7 must be specified in the inquiry and order, except as noted in 12.1.2.2.

12.1.2.2 Products that have been hot worked shall be solution annealed and tested to determine freedom from precipitated carbides. Not less than one corrosion test shall be made from each lot. Corrosion tests shall be performed in accordance with Practice A262, Practices A or E as applicable.

12.2 *Retests:*

12.2.1 When tested in accordance with the required sampling plan, a lot shall be subject to rejection if any of the test specimens fail to meet the applicable test requirements.

12.2.2 If the failure of a test specimen is due to improper preparation of the specimen or to incorrect testing technique, the specimen shall be discarded and another specimen substituted.

13. Significance of Numerical Limits

13.1 For the purposes of determining compliance with the specified limits for properties listed in this specification, an observed value or calculated value shall be rounded in accordance with Practice E29.

14. Test Specimens

14.1 *Chemical Tests*—When required, samples for chemical analysis shall be taken by drilling, sawing, milling, turning, clipping, or other such methods capable of producing representative samples.

14.2 *Mechanical Tests:*

14.2.1 Specimens shall be full size or machined in accordance with 7.2 through 7.4. Machined specimens, when required, shall be machined from the fastener in accordance with Test Methods F606.

14.2.2 The hardness shall be determined on the finished fastener in accordance with Test Methods F606.

14.3 *Corrosion Resistance*—Test specimens shall be prepared in accordance with Practices A262.

15. Test Methods

15.1 *Chemical Analysis*—The chemical composition shall be determined in accordance with Test Methods A751.

15.1.1 The fastener manufacturer may accept the chemical analysis of each heat of raw material purchased and reported on the raw material certification furnished by the raw material producer. The fastener manufacturer is not required to do any further chemical analysis testing provided that precise heat lot traceability has been maintained throughout the manufacturing process on each lot of fasteners produced and delivered

15.2 *Mechanical Tests:*

15.2.1 When full-size tests are to be performed, the yield strength and wedge tensile strength or axial tensile strength, as required by Section 7, shall be determined on each sample in accordance with the appropriate methods of Test Methods F606.

15.2.2 Full-size bolts and hex cap screws subject to tension tests shall be tested using a wedge under the head. The wedge shall be 10° for bolts 0.750-in. nominal diameter and less and 6° for bolts over 0.750-in. diameter.

15.2.3 When machined specimen tests are necessary (see Section 7), the yield strength, tensile strength, and elongation shall be determined on each sample in accordance with Test Methods F606.

15.2.4 The hardness shall be determined in accordance with Test Methods F606. A minimum of two readings shall be made on each sample, each of which shall conform to the specified requirements.

15.3 *Corrosion Resistance*—When specified on the purchase order or inquiry, corrosion tests to determine freedom from precipitated carbides shall be performed in accordance with Practice A262, Practice A or E as applicable.

16. Rejection and Rehearing

16.1 Unless otherwise specified, any rejection based on tests specified herein and made by the purchaser shall be reported to the manufacturer within 30 working days from the receipt of the product by the purchaser.

17. Certification and Test Reports

17.1 *Certificate of Compliance*—Unless otherwise specified in the purchase order, the manufacturer shall furnish certification that the product was manufactured and tested in accordance with this specification and the customer's order and conforms to all specified requirements.

17.2 *Test Reports*—When specified on the order, the manufacturer shall furnish a test report showing the chemical analysis of the fasteners and the results of the last completed set of mechanical tests for each lot of fasteners in the shipment.

17.3 All certification shall indicate the purchase order number and the applicable requirements of Section 3.

18. Product Marking

18.1 *Individual Products*—All products except studs ⅜ in. in diameter and smaller shall be marked with a symbol identifying the manufacturer. In addition, they shall be marked with the alloy/mechanical property marking in accordance with Table 2. The manufacturer may at his option add the specific stainless alloy designation from Table 1. However, marking of the stainless alloy designation does not signify compliance with this specification. The marking shall be raised or depressed at the option of the manufacturer.

19. Packaging and Package Marking

19.1 *Packaging:*

19.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D3951.

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

19.2 *Package Marking*—Each shipping unit shall include or be plainly marked with the following:

19.2.1 ASTM specification,
19.2.2 Alloy number,
19.2.3 Alloy/mechanical property marking,
19.2.4 Size,
19.2.5 Name and brand or trademark of manufacturer,
19.2.6 Number of pieces,
19.2.7 Country of origin,
19.2.8 Date of manufacture,
19.2.9 Purchase order number, and
19.2.10 Lot number, if applicable.

20. Keywords

20.1 bolts; general use; hex cap screws; stainless; studs

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry and order (see Section 3). Supplementary requirements shall in no way negate any requirement of the specification itself.

S1. Shipment Lot Testing

S1.1 When Supplementary Requirement S1 is specified on the order, the manufacturer shall make sample tests on the individual lots for shipment to ensure that the product conforms to the specified requirements.

S1.2 The manufacturer shall make an analysis of a randomly selected finished fastener from each lot of product to be shipped. Heat or lot control shall be maintained. The analysis of the starting material from which the fasteners have been manufactured may be reported in place of the product analysis.

S1.3 The manufacturer shall perform mechanical property tests in accordance with this specification and Guide F1470 on the individual lots for shipment.

S1.4 The manufacturer shall furnish a test report for each lot in the shipment showing the actual results of the chemical analysis and mechanical property tests performed in accordance with Supplementary Requirement S1.

S2. Additional Tests

S2.1 When additional tests of mechanical properties are desired by the purchaser, the test(s) shall be made as agreed upon between the manufacturer and the purchaser at the time of the inquiry or order.

S3. Source Inspection

S3.1 When Supplementary Requirement S3 is specified on the inquiry and order, the product shall be subject to inspection by the purchaser at the place of manufacture prior to shipment. The manufacturer shall afford the inspector all reasonable facilities to satisfy that the product is being furnished in accordance with this specification. All inspections and tests shall be so conducted so as not to interfere unnecessarily with the operations of the manufacturer.

S4. Alloy Control

S4.1 When Supplementary Requirement S4 is specified on the inquiry and order, the manufacturer shall supply that alloy specified by the customer on his order with no group substitutions permitted without the written permission of the purchaser.

S5. Heat Control

S5.1 When Supplementary Requirement S5 is specified on the inquiry or order, the manufacturer shall control the product by heat analysis and identify the finished product in each shipment by the actual heat number.

S5.2 When Supplementary Requirement S5 is specified on the inquiry and order, Supplementary Requirements S1 and S4 shall be considered automatically invoked with the addition that the heat analysis shall be reported to the purchaser on the test reports.

S6. Permeability

S6.1 When Supplementary Requirement S6 is specified on the inquiry and order, the permeability of bolts, hex cap screws, and studs of Alloy Groups 1, 2, and 3 in Conditions A or AF shall not exceed 1.5 at 100 oersteds when determined in accordance with Test Methods A342/A342M.

S7. Corrosion Resistance Tests

S7.1 When Supplementary Requirement S7 is specified on the inquiry and order, corrosion test(s) shall be performed as agreed upon between the manufacturer and the purchaser at the time of the inquiry or order.

S8. Passivation

S8.1 When Supplementary Requirement S8 is specified on the inquiry or order, the finished product shall be passivated in accordance with Practice A380 or Specification A967 at the option of the manufacturer.

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (F593 – 13) that may impact the use of this standard. (Approved December 1, 2013.)

(1) Updated 1.2 to the the appropriate number of austenitic alloys currently in the standard.

(2) Updated Table 3 for the appropriate option for the full-size test requirements.

Committee F16 has identified the location of selected changes to this standard since the last issue (F593 – 02(2008)$^{\varepsilon 1}$) that may impact the use of this standard.

(1) Clarified wording in 1.2, footnote C.