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# Standard Specification for Stainless Steel and Nickel Alloy Bolts, Hex Cap Screws, and Studs, for Heat Resistance and High Temperature Applications<sup>1</sup>

This standard is issued under the fixed designation F2281; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification covers the chemical and mechanical requirements for stainless steel and nickel alloy bolts, hex cap screws, and studs, 1/4 in. diameter and larger, intended for use at temperatures up to 1800°F (982°C), and in applications where resistance to heat and the effects of high temperature are to be considered. See [Appendix X1](#) for Service Application. A wide variety of materials are covered in this specification which can be used at high temperatures as a function of the specific alloy properties, as well as environmental requirements including corrosive environments.

1.2 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.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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:<sup>2</sup>

[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](#)  
[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](#)  
[B637 Specification for Precipitation-Hardening and Cold Worked Nickel Alloy Bars, Forgings, and Forging Stock for Moderate or High Temperature Service](#)  
[B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys](#)  
[D3951 Practice for Commercial Packaging](#)  
[E21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials](#)  
[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)  
[E76 Test Methods for Chemical Analysis of Nickel-Copper Alloys \(Withdrawn 2003\)<sup>3</sup>](#)  
[E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials](#)  
[E292 Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials](#)  
[E353 Test Methods for Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys](#)  
[E354 Test Methods for Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys](#)

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

**F606/F606M** Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets  
**F788/F788M** Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series  
**F1470** Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

2.2 *ASME Standards:*

**B1.1** Unified Inch Screw Threads<sup>4</sup>

**B18.2.1** Square and Hex Bolts and Screws, (Inch Series)<sup>4</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *heat resistance*—extent to which a material retains useful properties as measured during exposure of the material to a specified temperature and environment for a specified time.

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *high temperature*—defined solely for the purpose of this document as a range in temperature from 500°F (260°C) to 1800°F (982°C). Materials listed as high temperature alloys are designed to maintain their anticipated strength and characteristics within this range.

### 4. Classification

4.1 Three types of material, see **Appendix X1** for service application, are covered in this specification and are classified into the following:

4.1.1 *Type I*—Heat resisting alloys for continuous service applications:

4.1.1.1 *Class A*—Austenitic grades:

Alloy Grade	UNS Designation
304	S30400
304L	S30403
316	S31600
316L	S31603

4.1.1.2 *Class B*—Martensitic grades:

Alloy Grade	UNS Designation
410	S41000
416	S41600
431	S43100

4.1.1.3 *Class C*—Ferritic grades:

Alloy Grade	UNS Designation
430	S43000
430F	S43020

4.1.2 *Type II*—Heat resisting alloys for continuous and intermittent service applications:

Alloy Grade	UNS Designation
309	S30900
310	S31000
321	S32100
330	N08330
347	S34700

4.1.3 *Type III*—High temperature alloys for continuous and intermittent service applications:

4.1.3.1 *Class A*—Nickel based alloy:

Alloy Grade	UNS Designation
600	N06600
601	N06601

4.1.3.2 *Class B*—Precipitation hardened alloy:

Alloy Grade	UNS Designation
660	S66286

4.1.3.3 *Class C*—Precipitation hardened alloy:

Alloy Grade	UNS Designation
718	N07718

### 5. Ordering Information

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

5.1.1 ASTM designation and year date. When year date is not specified, the latest issue shall be invoked;

5.1.2 Quantity (number of pieces of each item),

5.1.3 Item name (that is, bolt, hex cap screw, or stud),

5.1.4 Size (nominal diameter, threads per inch, length),

5.1.5 Type, class, and alloy grade (see 4.1), and

5.1.6 Condition (see 6.2.3).

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

5.2.1 Forming (see 6.2.1),

5.2.2 Thread type (see 6.2.2),

5.2.3 Corrosion tests (see 13.1.2.1),

5.2.4 Finish (see 11.3),

5.2.5 Test reports (see 19.2), and

5.2.6 Supplementary Requirements, if any, to be specified on the order (see S1 through S8).

### 6. Materials and Manufacture

#### 6.1 Material:

6.1.1 Specifications **A276**, **A484/A484M**, **A493**, **A564/A564M**, **A582/A582M**, **B637** are noted for information only as suitable sources of material for the manufacture of bolts, hex cap screws, and studs to this specification.

6.1.2 The bolts, hex cap screws, and studs shall be manufactured from material having a chemical composition conforming to the requirements listed in **Table 1** and capable of developing the mechanical property requirements listed in **Table 2** for the finished fastener.

6.1.3 Various grades of material having unique heat resisting or high temperature characteristics are specified in this specification. A guide to their application is listed in **Appendix X1** to assist in the selection of the fastener material.

6.1.4 The form and condition of the raw material shall be at the option of the manufacturer but shall be such that the finished fastener conforms to all the specified requirements.

#### 6.2 Manufacture:

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

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

6.2.3 *Condition*—The fasteners shall be furnished in one of the following conditions and shall be agreed upon between the manufacturer and the purchaser at the time of the inquiry and order.

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

**TABLE 1 Chemical Requirements**

Composition, % maximum except as shown										
Alloy	Carbon	Mang.	Phos.	Sulfur	Silicon	Chromium	Nickel	Copper	Moly	Other
Type I, Class A, Heat Resisting Austenitic Grades										
304	0.08	2.00	0.045	0.030	1.00	18.0/20.0	8.0/10.5	1.00		
304L	0.03	2.00	0.045	0.030	1.00	18.0/20.0	8.0/12.0	1.00		
316	0.08	2.00	0.045	0.030	1.00	16.0/18.0	10.0/14.0		2.00/3.00	
316L	0.03	2.00	0.045	0.030	1.00	16.0/18.0	10.0/14.0		2.00/3.00	
Type I, Class B, Heat Resisting Martensitic Grades										
410	0.15	1.00	0.040	0.030	1.00	11.5/13.5				
416	0.15	1.25	0.060	0.15 min	1.00	12.0/14.0			0.60	
431	0.20	1.00	0.040	0.030	1.00	15.0/17.0	1.25/2.50			
Type I, Class C, Heat Resisting Ferritic Grades										
430	0.12	1.00	0.040	0.030	1.00	16.0/18.0				
430F	0.12	1.25	0.060	0.15 min	1.00	16.0/18.0			0.60	
Type II, Heat Resisting Austenitic Grades										
309	0.20	2.00	0.045	0.030	1.00	22.0/24.0	12.0/15.0			
310	0.25	2.00	0.045	0.030	1.50	24.0/26.0	19.0/22.0			
321	0.08	2.00	0.045	0.030	1.00	17.0/19.0	9.0/12.0			Ti5xCmin
330	0.08	2.00	0.030	0.030	0.75/1.50	17.0/20.0	34.0/37.0			
347	0.08	2.00	0.045	0.030	1.00	17.0/19.0	9.0/13.0			Cb + Ta10 × Cmin
Type III, Class A, High Temperature, Nickel Alloy Grades										
600	0.10	1.00		0.015	0.50	14.0/17.0	72.0 min	0.50		Fe 6.0/10.0
601	0.10	1.00		0.015	0.50	21.0/25.0	58.0/63.0	1.00		Al 1.0/1.7 Fe remainder
Type III, Class B, High Temperature, Precipitation Hardened Grade										
660	0.08	2.00	0.040	0.030	1.00	13.5/16.0	24.0/27.0		1.00/1.75	Ti 1.90/2.30 V 0.10/0.50 Al 0.35 max B 0.003/0.010 Fe remainder
Type III, Class C, High Temperature, Precipitation Hardened Grade										
718	0.08	0.35	0.015	0.015	0.35	17.0/21.0	50.0/55.0	0.30	2.80/3.30	Ti 0.65/1.15 Co 1.00 max Al 0.20/0.80 B 0.006 max Cb + Ta 4.75/5.50 Fe remainder

Type	Class	Condition
I	A	A, CWA, HWA
I	B	H, HT
I	C	A, CWA, HWA
II	...	A, CWA, HWA
III	A	A, CWA, HWA
III	B	AH1, AH2 or AH3
III	C	AH4
Condition		
A		Machined from annealed or solution-annealed stock thus retaining the properties of the original material
CWA		Cold formed from annealed or solution-annealed stock and then re-annealed
HWA		Hot formed from annealed or solution-annealed stock and then re-annealed
H		Hardened and tempered at 1050°F (565°C) minimum
HT		Hardened and tempered at 525°F (274°C) minimum
AH1		Solution treated at 1850°F (1010°C) and precipitation hardened (aging)
AH2		Solution treated at 1700°F (927°C) and precipitation hardened (aging)
AH3		Solution treated at 1850°F (1010°C) and double aged
AH4		Solution treated at 1725°F (941°C) to 1850°F (1010°C) and precipitation hardened (aging)

**6.2.4 Heat Treatment:**

6.2.4.1 *Condition A—(Austenitic Alloys Type I Class A and Type II)*, shall be heated to 1850 to 1950°F (1010 to 1066°C), held for a sufficient time, then cooled at a rate sufficient to prevent the precipitation of carbides and to provide the specified properties.

6.2.4.2 *Condition A—(Ferritic Alloys Type I Class C)*, shall be heated to 1400 to 1500°F (760 to 816°C), held for a sufficient time, and then air cooled to provide the specified properties.

6.2.4.3 *Condition A—(Nickel Alloy Type III Class A)*, shall be heated to 1600° to 1800°F (871 to 982°C), held for 10 to 15 min, and either water quenched or air cooled.

6.2.4.4 *Condition CWA—(Austenitic Alloys Type I Class A and Type II)*, shall be cold formed from annealed or solution annealed stock and then re-annealed or re-solution annealed in accordance with 6.2.4.1 after all cold working (including heading and threading) has been completed.

6.2.4.5 *Condition CWA—(Ferritic Alloys Type I Class C)*, shall be cold formed from annealed or solution annealed stock and then re-annealed or re-solution annealed in accordance