



Designation: A193/A193M – 24

# Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications<sup>1</sup>

This standard is issued under the fixed designation A193/A193M; 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.

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

## 1. Scope\*

1.1 This specification<sup>2</sup> covers alloy and stainless steel bolting materials and bolting components for pressure vessels, valves, flanges, and fittings for high temperature or high pressure service, or other special purpose applications. See Specification [A962/A962M](#) for the definition of bolting. Bars and wire shall be hot-wrought and may be further processed by centerless grinding or by cold drawing. Austenitic stainless steel may be carbide solution treated or carbide solution treated and strain-hardened. When strain hardened austenitic stainless steel is ordered, the purchaser should take special care to ensure that [Appendix X1](#) is thoroughly understood.

1.2 Several grades are covered, including ferritic steels and austenitic stainless steels designated B5, B8, and so forth. Selection will depend upon design, service conditions, mechanical properties, and high temperature characteristics.

1.3 The following referenced general requirements are indispensable for application of this specification: Specification [A962/A962M](#).

NOTE 1—The committee formulating this specification has included several steel types that have been rather extensively used for the present purpose. Other compositions will be considered for inclusion by the committee from time to time as the need becomes apparent.

NOTE 2—For grades of alloy-steel bolting suitable for use at the lower range of high temperature applications, reference should be made to Specification [A354](#).

NOTE 3—For grades of alloy-steel bolting suitable for use in low temperature applications, reference should be made to Specification [A320/A320M](#).

1.4 Nuts for use with bolting are covered in Section [13](#).

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee [A01](#) on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee [A01.22](#) on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-193 in Section II of that Code.

1.5 Supplementary Requirements are provided for use at the option of the purchaser. The supplementary requirements shall apply only when specified in the purchase order or contract.

1.6 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order or contract specifies the applicable *M* specification designation (SI units), the inch-pound units shall apply.

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.8 *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>3</sup>

[A153/A153M](#) Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

[A194/A194M](#) Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

[A320/A320M](#) Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service

[A354](#) Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

[A788/A788M](#) Specification for Steel Forgings, General Requirements

<sup>3</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.

\*A Summary of Changes section appears at the end of this standard

- A962/A962M** Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range
- B633** Specification for Electrodeposited Coatings of Zinc on Iron and Steel
- B695** Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
- B696** Specification for Coatings of Cadmium Mechanically Deposited
- B766** Specification for Electrodeposited Coatings of Cadmium
- E18** Test Methods for Rockwell Hardness of Metallic Materials
- E21** Test Methods for Elevated Temperature Tension Tests of Metallic Materials
- E112** Test Methods for Determining Average Grain Size
- E139** Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
- E150** Recommended Practice for Conducting Creep and Creep-Rupture Tension Tests of Metallic Materials Under Conditions of Rapid Heating and Short Times (Withdrawn 1984)<sup>4</sup>
- E151** Recommended Practice for Tension Tests of Metallic Materials at Elevated Temperatures with Rapid Heating and Conventional or Rapid Strain Rates (Withdrawn 1984)<sup>4</sup>
- E292** Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials
- E328** Test Methods for Stress Relaxation for Materials and Structures
- E566** Practice for Electromagnetic (Eddy Current/Magnetic Induction) Sorting of Ferrous Metals
- E709** Guide for Magnetic Particle Testing
- F606/F606M** Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- F1940** Test Method for Process Control Verification to Prevent Hydrogen Embrittlement in Plated or Coated Fasteners
- F1941/F1941M** Specification for Electrodeposited Coatings on Mechanical Fasteners, Inch and Metric
- F2329/F2329M** Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

## 2.2 ASME Standards:<sup>5</sup>

- B18.2.1** Square and Hex Bolts and Screws
- B18.2.3.3M** Metric Heavy Hex Screws
- B18.3** Hexagon Socket and Spline Socket Screws

## 2.3 AIAG Standards:<sup>6</sup>

- AIAG B-5 02.00** Primary Metals Identification Tag Application Standard

## 2.4 ISO Standards:<sup>7</sup>

- ISO 4762** Hexagon Socket Head Cap Screws

## 3. General Requirements and Ordering Information

3.1 The inquiry and orders shall include the following, as required, to describe the desired bolting material or bolting components adequately:

3.1.1 Heat-treated condition (that is carbide solution treated (Class 1), carbide solution treated after finishing (Class 1A), and carbide solution treated and strain-hardened (Classes 2, 2B and 2C), for the austenitic stainless steels; Classes 1B and 1C apply to the carbide solution-treated nitrogen-bearing stainless steels; Class 1D applies to bolting material that is carbide solution treated by cooling rapidly from the rolling temperature),

3.1.2 Description of items required (that is, bars, bolts, screws, or studs),

3.1.3 Nuts, if required by purchaser, in accordance with 13.1,

3.1.4 Supplementary requirements, if any, and

3.1.5 Special requirements, in accordance with 6.1.5.1, 6.2.6, 8.1, and 13.1.

3.2 *Coatings*—Coatings are prohibited unless specified by the purchaser (See Supplementary Requirements S13 and S14). When coated bolting components are ordered the purchaser should take special care to ensure that **Appendix X2** is thoroughly understood.

## 4. Common Requirements

4.1 Bolting materials and bolting components supplied to this specification shall conform to the requirements of Specification **A962/A962M**. These requirements include test methods, finish, thread dimensions, macroetch (alloy steels only), marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification **A962/A962M** constitutes nonconformance with this specification. In case of conflict between this specification and Specification **A962/A962M**, this specification shall prevail.

## 5. Manufacture (Process)

5.1 *Melting*—See Specification **A962/A962M** for requirements.

5.2 *Quality*—See Specification **A962/A962M** for requirements.

## 6. Heat Treatment

### 6.1 Ferritic Steels:

6.1.1 Ferritic steels shall be allowed to cool to a temperature below the cooling transformation range immediately after rolling or forging. Bolting materials shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a *quenching charge*), quenched in a liquid medium under substantially uniform conditions for

<sup>4</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>5</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

<sup>6</sup> Available from Automotive Industry Action Group (AIAG), 26200 Lahser Rd., Suite 200, Southfield, MI 48033, <http://www.aiag.org>.

<sup>7</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

**TABLE 1 Chemical Requirements (Composition, percent)<sup>A</sup>**

Ferritic Steels															
Description and UNS Designation	Class	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Copper	Niobium <sup>F</sup>	Titanium	Vanadium	Aluminum	Nitrogen
Grade B5 5 % Chromium		0.10 min	1.00	0.040	0.030	1.00	4.0–6.0	...	0.40–0.65	...	...	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.01	0.03	0.005	0.005	0.05	0.10	...	0.05	...	...	...	...	...	...
B6, B6X 12 % Chromium (410), S41000		0.08–0.15	1.00	0.040	0.030	1.00	11.5–13.5	...	...	...	...	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.01 over	0.03	0.005	0.005	0.05	0.15	...	...	...	...	...	...	...	...
B7, B7M Chromium-Molybdenum <sup>C</sup>		0.38–0.48 <sup>D</sup>	0.75–1.00	0.035	0.040	0.15–0.35	0.80–1.10	...	0.15–0.25	...	...	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.02	0.04	0.005	0.005	0.02	0.05	...	0.02	...	...	...	...	...	...
B16 Chromium-Molybdenum-Vanadium		0.36–0.47	0.45–0.70	0.035	0.040	0.15–0.35	0.80–1.15	...	0.50–0.65	...	...	...	0.25–0.35	0.015 <sup>E</sup>	...
Product Analysis Variation <sup>B</sup>		0.02	0.03	0.005	0.005	0.02	0.05	...	0.03	...	...	...	0.03	...	...
Austenitic Steels															
Description and UNS Designation	Classes	Carbon	Manganese	Phosphorous	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Copper	Niobium <sup>F</sup>	Titanium	Vanadium	Aluminum	Nitrogen
Grade B8, B8A 304, S30400	1, 1A, 1D, 2	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.01	0.04	0.010	0.005	0.05	0.20	0.15	...	...	...	...	...	...	...
B8C, B8CA 347, S34700	1, 1A, 1D, 2	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	10 × C to 1.10	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.01	0.04	0.010	0.005	0.05	0.20	0.15	...	...	0.05 under	...	...	...	...
B8M, B8MA, B8M2, B8M3 316, S31600	1, 1A, 1D, 2	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–14.0	2.00–3.00	...	...	...	...	...	...
Product Analysis Variation <sup>B</sup>		0.01	0.04	0.010	0.005	0.05	0.20	0.15	0.10	...	...	...	...	...	...



TABLE 1 Continued

B8F, B8PA	S30500	1, 1A, 1D, 2	0.12	2.00	0.045	0.030	1.00	17.0–19.0	11.0–13.0	...	...	...	...	...
Product Analysis Variation <sup>B</sup>			0.01	0.04	0.010	0.005	0.05	0.20	0.15	...	...	...	...	...
B8N, B8NA	304N, S30451	1A, 1B, 1D, 2	0.08	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	0.10–0.16
Product Analysis Variation <sup>B</sup>			0.01	0.04	0.010	0.005	0.05	0.20	0.15	...	...	...	...	0.01
B8MN, B8MNA	316N, S31651	1A, 1B, 1D, 2	0.08	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	...	...	...	0.10–0.16
Product Analysis Variation <sup>B</sup>			0.01	0.04	0.010	0.005	0.05	0.20	0.15	0.10	...	...	...	0.01
B8MLCuN, B8MLCuNA	S31254	1A, 1B, 1D, 2	0.020	1.00	0.030	0.010	0.80	19.5–20.5	17.5–18.5	6.0–6.5	0.50–1.00	...	...	0.18–0.25
Product Analysis Variation <sup>B</sup>			0.005	0.03	0.005	0.002	0.05	0.20	0.15	0.10	...	...	...	0.02
B8T, B8TA	321, S32100	1, 1A, 2	0.08	2.00	0.045	0.030	1.00	17.0–19.0	9.0–12.0	...	...	...	5 x (C + N) to 0.70	0.10
Product Analysis Variation <sup>B</sup>			0.01	0.04	0.010	0.005	0.05	0.20	0.15	...	...	...	0.05 under	...
B8R, B8RA	S20910	1C, 1D	0.06	4.0–6.0	0.045	0.030	1.00	20.5–23.5	11.5–13.5	1.50–3.00	...	0.10–0.30	...	0.20–0.40
Product Analysis Variation <sup>B</sup>			0.01	0.05	0.005	0.005	0.05	0.25	0.15	0.10	...	0.05	...	0.02
B8S, B8SA	S21800	1C, 1D	0.10	7.0–9.0	0.060	0.030	3.5–4.5	16.0–18.0	8.0–9.0	...	...	...	...	0.08–0.18
Product Analysis Variation <sup>B</sup>			0.01	0.06	0.005	0.005	0.15	0.20	0.10	...	...	...	...	0.01
B8LN, B8LNA	S30453	1, 1A, 1D	0.030	2.00	0.045	0.030	1.00	18.0–20.0	8.0–11.0	...	...	...	...	0.10–0.16
Product Analysis Variation <sup>B</sup>			0.005	0.04	0.010	0.005	0.05	0.20	0.15	...	...	...	...	0.01



TABLE 1 Continued

B8MLN, B8MLNA	S31653	1, 1A, 1D	0.030	2.00	0.045	0.030	1.00	16.0–18.0	10.0–13.0	2.00–3.00	...	...	...	0.10–0.16
Product Analysis Variation <sup>B</sup>			0.005	0.04	0.010	0.005	0.05	0.20	0.15	0.10	...	...	...	0.01
B8CLN, B8CLNA	347LN, S34751	1, 1A, 1D	0.005– 0.020	2.00	0.045	0.030	1.00	17.0–19.0	9.0–13.0	...	...	0.20–0.50; 15 x carbon content, min	...	0.06–0.10
Product Analysis Variation <sup>B</sup>			0.002 under, 0.005 over	0.04	0.01	0.005	0.05	0.20	0.15	...	...	0.05	...	0.01
B8CLNCu B8CLNCu BA	S34752 <sup>G</sup>	1, 1A, 1D	0.005– 0.02	2.00	0.035	0.010	0.60	17.0–19.0	10.0–13.0	0.20–1.20	2.50–3.50	0.20–0.50; 15 x carbon content, min	...	0.06–0.12
Product Analysis Variation			0.002 under, 0.005 over	0.04	0.01	0.005	0.05	0.20	0.15	0.15	0.15	0.05	...	0.01
B8ML4CuN, B8ML4CuNA	S31730	1, 1A, 1D	0.030	2.00	0.040	0.010	1.00	17.0–19.0	15.0–16.5	3.0–4.0	4.0–5.0	...	...	0.045
Product Analysis Variation <sup>B</sup>			0.005	0.04	0.005	0.002	0.05	0.20	0.15	0.10	0.15	...	...	0.01

<sup>A</sup>Values are maximums unless a range or a minimum is indicated. Where ellipses appear in this table, there is no requirement and the element need not be determined or reported. The intentional addition of Bi, Se, Te, and Pb is not permitted.

<sup>B</sup>Product Analysis—Individual determinations sometimes vary from the specified limits as shown in the tables. The several determinations of any individual element in a heat may not vary both above and below the specified range. Product variation limits are over for maximums, over or under for ranges, and under for minimums, unless otherwise indicated.

<sup>C</sup>Typical steel compositions used for this grade include 4140, 4142, 4145, 4140H, 4142H, and 4145H.

<sup>D</sup>For bar sizes over 3½ in. [90 mm], inclusive, the carbon content may be 0.50 % max. For the B7M grade, a minimum carbon of 0.28 % is permitted, provided that the required tensile properties are met in the section sizes involved, the use of AISI 4130 or 4130H is allowed.

<sup>E</sup>Total of soluble and insoluble.

<sup>F</sup>Columbium and Niobium are alternate names for element 41 in the Periodic Table of the Elements.

<sup>G</sup>For S34752 – Boron content shall be 0.001–0.005 for both heat and product analysis.

each quenching charge, and tempered. The minimum tempering temperature shall be as specified in **Tables 2 and 3**.

**TABLE 2 Mechanical Requirements — Inch Products**

Grade	Diameter, in.	Minimum Tempering Temperature, °F	Tensile Strength, min, ksi	Yield Strength, min, 0.2 % offset, ksi	Elongation in 4D, min, %	Reduction of Area, min, %	Hardness, max
<b>Ferritic Steels</b>							
B5 4 to 6 % chromium	up to 4, incl	1100	100	80	16	50	...
B6 13 % chromium	up to 4, incl	1100	110	85	15	50	...
B6X 13 % chromium	up to 4, incl	1100	90	70	16	50	26 HRC
B7 Chromium-molybdenum	2½ and under	1100	125	105	16	50	321 HBW or 35 HRC
	over 2½ to 4	1100	115	95	16	50	321 HBW or 35 HRC
	over 4 to 7	1100	100	75	18	50	321 HBW or 35 HRC
B7M <sup>A</sup> Chromium-molybdenum	4 and under	1150	100	80	18	50	235 HBW or 99 HRB
	over 4 to 7	1150	100	75	18	50	235 HBW or 99 HRB
B16 Chromium-molybdenum-vanadium	2½ and under	1200	125	105	18	50	321 HBW or 35 HRC
	over 2½ to 4	1200	110	95	17	45	321 HBW or 35 HRC
	over 4 to 8	1200	100	85	16	45	321 HBW or 35 HRC
Grade, Diameter, in.	Heat Treatment <sup>B</sup>	Tensile Strength, min, ksi	Yield Strength, min, 0.2 % offset, ksi	Elongation in 4 D, min %	Reduction of Area, min %	Hardness, max	
<b>Austenitic Steels</b>							
Classes 1 and 1D; B8, B8M, B8P, B8LN, B8MLN, B8CLN, all diameters	carbide solution treated	75	30	30	50	223 HBW or 96 HRB <sup>C</sup>	
Classes 1 and 1D; B8, B8CLNCuB, all diameters	carbide solution treated	75	30	35	50	223 HBW or 96 HRB <sup>C</sup>	
Classes 1 and 1D: B8ML4CuN, all diameters	carbide solution treated	70	25	35	50	90 HRB	
Class 1: B8C, B8T, all diameters	carbide solution treated	75	30	30	50	223 HBW or 96HRB <sup>C</sup>	
Class 1A: B8A, B8CA, B8CLNA, B8MA, B8PA, B8TA, B8LNA, B8MLNA, B8NA, B8MNA, B8MLCuNA, all diameters	carbide solution treated in the finished condition	75	30	30	50	192 HBW or 90 HRB	
Class 1A: B8ML4CuNA, all diameters	carbide solution treated	70	25	35	50	90 HRB	
Classes 1B and 1D: B8N, B8MN, B8MLCuN, all diameters	carbide solution treated	80	35	30	40	223 HBW or 96 HRB <sup>C</sup>	
Classes 1C and 1D: B8R, all diameters	carbide solution treated	100	55	35	55	271 HBW or 28 HRC	
Class 1C: B8RA, all diameters	carbide solution treated in the finished condition	100	55	35	55	271 HBW or 28 HRC	
Classes 1C and 1D: B8S, all diameters	carbide solution treated	95	50	35	55	271 HBW or 28 HRC	
Classes 1C: B8SA, all diameters	carbide solution treated in the finished condition	95	50	35	55	271 HBW or 28 HRC	
Class 2: B8, B8C, B8P, B8T, B8N, <sup>D</sup> ¾ and under over ¾ to 1, incl	carbide solution treated and strain hardened	125	100	12	35	321 HBW or 35 HRC	
		115	80	15	35	321 HBW or 35 HRC	
		105	65	20	35	321 HBW or 35 HRC	
over 1 to 1¼, incl							