

Designation: A 193/A 193M-08b Designation: A193/A193M - 09

Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications¹

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 (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.

1. Scope*

- 1.1 This specification² covers alloy and stainless steel bolting material for pressure vessels, valves, flanges, and fittings for high temperature or high pressure service, or other special purpose applications. The term *bolting material* as used in this specification covers bars, bolts, screws, studs, stud bolts, and wire. Bars and wire shall be hot-wrought. The material 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 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 A 962/A 962MA962/A962M.
- Note 1—The committee formulating this specification has included fifteen 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 material suitable for use at the lower range of high temperature applications, reference should be made to Specification A 354A354.
- Note 3—For grades of alloy-steel bolting material suitable for use in low temperature applications, reference should be made to Specification A 320/A 320MA320/A320M.
 - 1.4 Nuts for use with this bolting material are covered in Section 14.
- 1.5 Supplementary Requirements S1 through S14 are provided for use when additional tests or inspection are desired. These shall apply only when specified in the purchase order. VI A 193/A 193M-09
- 1.6 This specification is expressed in both inch-pound units and in SI units. However, unless the order specifies the applicable *M* specification designation (SI units), the material shall be furnished to inch-pound units.
- 1.7 The values stated in either inch-pound units or SI units are to be regarded separately as standard. The values stated in each system <u>aremay</u> not <u>be</u> exact equivalents; therefore, each system <u>mustshall</u> be used independently of the other. Combining values from the two systems may result in non-conformance with the <u>specification.standard</u>. Within the text, the SI units are shown in brackets.

2. Referenced Documents

2.1 ASTM Standards:³

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

A194/A194M Specification for Carbon and Alloy 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

¹ 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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² For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-193 in Section II of that Code.

³ 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.



A962/A962M Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the

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 Times⁴

E151 Recommended Practice for Tension Tests of Metallic Materials at Elevated Temperatures Withwith Rapid Heating and Conventional or Rapid Strain Rates⁴

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) Sorting of Ferrous Metals

E709 Guide for Magnetic Particle Testing

EF606Practice for Strain-Controlled Fatigue Testing—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 Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads (UN/UNR))

F2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

2.2 ANSI Standards:5

B18.2.1 Square and Hex Bolts and Screws Teh Standards

B18.2.3.1M Metric Hex Cap Screws

B18.3 Hexagon Socket and Spline Socket Screws

B18.3.1M Metric Socket Head Cap Screws

2.3 AIAG Standard:⁶

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard

3. General Requirements and Ordering Information

- 3.1 The inquiry and orders shall include the following, as required, to describe the desired material adequately:
- 3.1.1 Heat-treated condition (that is, normalized and tempered, or quenched and tempered, for the ferritic materials, and 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 material 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 14.1,
 - 3.1.4 Supplementary requirements, if any, and
 - 3.1.5 Special requirements, in accordance with 7.1.5.1, 7.2.6, 9.1, 14.1, and 15.1.
- 3.2 Coatings—Coatings are prohibited unless specified by the purchaser (See Supplementary Requirements S13 and S14). When coated fasteners are ordered the purchaser should take special care to ensure that Appendix X2 is thoroughly understood.

4. Common Requirements

4.1 Material and fasteners supplied to this specification shall conform to the requirements of Specification A 962/A 962MA962/A962M. These requirements include test methods, finish, thread dimensions, marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification A 962/A 962/A 962/A 962/A constitutes nonconformance with this specification. In case of conflict between this specification and Specification A 962/A 962MA962/A962M, this specification shall prevail.

5. Manufacture (Process)

5.1 The steel shall be produced by any of the following processes: open-hearth, basic-oxygen, electric-furnace, or

⁴ Withdrawn.

⁴ Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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



vacuum-induction melting (VIM). The molten steel may be vacuum-treated prior to or during pouring of the ingot or strand casting. 5.2 *Quality*—See Specification A 962/A 962M—See Specification A 962/A 962M for requirements.

6. Discard

6.1 A sufficient discard shall be made to secure freedom from injurious piping and undue segregation.

7. Heat Treatment

7.1 Ferritic Steels

7.1.1 Ferritic steels shall be allowed to cool to a temperature below the cooling transformation range immediately after rolling or forging. Materials to be liquid quenched 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 each quenching charge, and tempered. Materials to be normalized and tempered or air-quenched and tempered shall be reheated to the proper temperature to refine the grain, cooled uniformly in air to a temperature below the transformation temperature range and tempered. The minimum tempering temperature shall be as specified in), quenched in a liquid medium under substantially uniform conditions for each quenching charge, and tempered. The minimum tempering temperature shall be as specified in Tables 2 and 3.

TABLE 1 Chemical Requirements (Composition, percent)^A

Type						Ferritic	Steels			
Grade			B5			В	B6 and B6X			
Description			5% Chromium			1.	12 % Chromium			
UNS Designation						S	S41000 (410)			
			Range	eh S	Product Variation, Over or Under ^B	rds ^P	ange	Product \ Over or \		
Carbon			0.10 min		0.01 under		.08–0.15	0.01 ove		
Manganese, max			1.00		0.03 over		.00	0.03 ove		
Phosphorus, max			0.040		0.005 over		.040	0.005 ove		
Sulfur, max			0.030		0.005 over		.030	0.005 ove		
Silicon			1.00 max		0.05 over		.00 max	0.05 ove	r	
Chromium			4.0-6.0		0.10		1.5–13.5	0.15		
Molybdenum			0.40-0.6	5	0.05					
Туре) Ferritic	Steels			
Grade			B7, B7M			 b_bfc2_(B	P_(B1671.95fbc0a/astm_a193_a193m_09			
Description	imo 8 siana	Chromium-Molybdenum ^C			C	Chromium-Molybdenum-Vanadium				
					Product Variation,			Product Variation,		
			Range Over or Unde			Range		Over or Under ^B		
Carbon		0.37–0.4					0.36-0.47		0.02	
Manganese		0.65–1.					0.45–0.70		0.03	
Phosphorus, max		0.035				0.035		0.005 over		
Sulfur, max				0.040 0.005 over		0.040		0.005 over		
Silicon		0.1			0.02		0.15–0.35		0.02	
Chromium		0.7		0.75–1.20 0.05		0.80–1.15		0.05		
Molybdenum	(0.15-0.25		0.02	0	0.50-0.65		0.03	
Vanadium						0	0.25-0.35		0.03	
Aluminum, max % ^E						0.015				
Туре				Αι	ustenitic Steels, ^F Clas	sses 1, 1A, 1E), and 2			
Grade	B8, B8A		B8C, B8CA		B8M, B8MA, B8M2, B8M3		B8P, B8PA			
UNS Designation	S30400 (304)			S34700 (347)		S31600 (3	S31600 (316)		S30500	
	Range	Product Variati Over or Under		Range	Product Variation, Over or Under ^B	Range	Product Variation, Over or Under ^B	Range	Product Variation Over or Under ^B	
Carbon, max	0.08	0.01 over		0.08	0.01 over	0.08	0.01 over	0.12	0.01 over	
Manganese, max	2.00	0.04 over		2.00	0.04 over	2.00	0.04 over	2.00	0.04 over	
Phosphorus, max	0.045	0.010 over		0.045	0.010 over	0.045	0.010 over	0.045	0.010 over	
Sulfur, max	0.030	0.005 over		0.030	0.005 over	0.030	0.005 over	0.030	0.005 over	
Silicon, max	1.00	0.05 over		1.00	0.05 over	1.00	0.05 over	1.00	0.05 over	
Chromium	18.0-20.0	0.20		17.0-19.0	0.20	16.0-18.0	0.20	17.0-19.0	0.20	
Nickel	8.0-11.0	0.15		9.0-12.0	0.15	10.0-14.0	0.15	11.0-13.0	0.15	
Molybdenum						2.00-3.00	0.10			
Columbium +				10 x carbon	0.05 under					
Columbian +										
tantalum				content, min						



TABLE 1 Continued

		IADLE	i Continuea					
Type		Austen	itic Steels, F Classes 1A	4, 1B, 1D, and 2	2			
Grade B8N, B8NA			B8MN, B8MNA		B8MLCuN,	B8MLCuN, B8MLCuNA		
UNS Designation	S30451 (304N)		S31651 (316N)	51 (316N)		S31254		
	Range	Product Variation, Over or Under ^B	Range	Product Va Over or Ur		Product Variation, Over or Under ^B		
Carbon, max	0.08	0.01 over	0.08	0.01 over	0.020	0.005 over		
Manganese, max	•		2.00		1.00	0.03 over		
Phosphorus, max	·		0.045	0.010 over		0.005 over		
Sulfur, max	0.030	0.005 over	0.030	0.005 over		0.002 over		
Silicon, max Chromium	1.00 18.0–20.0	0.05 over 0.20	1.00 16.0–18.0	0.05 over 0.20	0.80 19.5–20.5	0.05 over 0.20		
Nickel	8.0–11.0	0.20	10.0–16.0	0.20	17.5–18.5	0.20		
Molybdenum			2.00–3.00	0.10	6.0–6.5	0.10		
Nitrogen	•		0.10-0.16	0.01	0.18-0.22	0.02		
Copper		0.01			0.50-1.00			
Type				Austeni	tic Steels ^F , Classes 1, 1	A. and 2		
Grade				B8T, B8		,		
UNS Designation				S32100	(321)			
				Range		Product Variation, Over or Under ^B		
Carbon, max				0.08		0.01 over		
Manganese, max				2.00		0.04 over		
Phosphorus, max				0.045		0.010 over		
Sulfur, max				0.030		0.005 over 0.05 over		
Silicon, max Chromium				1.00 17.0–19	0	0.20		
Nickel				9.0–12.		0.20		
Titanium					- N) min, 0.70 max	0.05 under		
Nitrogen								
Туре		mttps./	Au	stenitic Steels ^F ,	Classes 1C and 1D			
Grade		B8R, B8RA	umont	Drow	B8S, B8SA			
UNS Designation		S20910	ument	IICA	S21800			
		Range	Product Vari Over or Und	,	Range	Product Variation, Over or Under ^B		
Carbon, max		0.06	0.01 over		0.10	0.01 over		
		04.0-6.0 dards/sis			7.0–9.07e7195fbc(
Phosphorus, max					0.060			
Sulfur, max		0.045	0.005 over			0.005 over		
Silicon		0.030	0.005 over		0.030	0.005 over 0.005 over		
Silicon Chromium		0.030 1.00 max	0.005 over 0.05 over		0.030 3.5–4.5	0.005 over 0.005 over 0.15		
Silicon Chromium Nickel		0.030	0.005 over		0.030	0.005 over 0.005 over		
Chromium		0.030 1.00 max 20.5–23.5	0.005 over 0.05 over 0.25		0.030 3.5–4.5 16.0–18.0	0.005 over 0.005 over 0.15 0.20		
Chromium Nickel Molybdenum Nitrogen		0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40	0.005 over 0.05 over 0.25 0.15 0.10 0.02		0.030 3.5–4.5 16.0–18.0 8.0–9.0	0.005 over 0.005 over 0.15 0.20 0.10		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05		0.030 3.5–4.5 16.0–18.0 8.0–9.0	0.005 over 0.005 over 0.15 0.20 0.10		
Chromium Nickel Molybdenum Nitrogen	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40	0.005 over 0.05 over 0.25 0.15 0.10 0.02		0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18	0.005 over 0.005 over 0.15 0.20 0.10 		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02		0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18	0.005 over 0.005 over 0.15 0.20 0.10 		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02		0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18	0.005 over 0.005 over 0.15 0.20 0.10 		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02		0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 	0.005 over 0.005 over 0.15 0.20 0.10 0.01		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA	0.005 over 0.005 over 0.15 0.20 0.10 		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA S30453 Range	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under ^B 0.005 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA \$30453 Range 0.030 2.00	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00	O.005 over O.005 over O.15 O.20 O.10 O.01 Product Variation, Over or Under ^B O.005 over O.04 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi Product Vari Over or Unc 0.005 over 0.04 over 0.010 over	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under ^B 0.005 over 0.04 over 0.010 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max Sulfur, max	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045 0.030	0.005 over 0.05 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Aust Product Vari Over or Unc 0.005 over 0.04 over 0.010 over 0.005 over	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045 0.030	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under 0.005 over 0.04 over 0.010 over 0.005 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max Sulfur, max Silicon	ım	0.030 1.00 max 20.5-23.5 11.5-13.5 1.50-3.00 0.20-0.40 0.10-0.30 0.10-0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045 0.030 1.00	0.005 over 0.05 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi Product Vari Over or Unc 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045 0.030 1.00	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under ^B 0.005 over 0.04 over 0.010 over 0.005 over 0.005 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max Sulfur, max Silicon Chromium	ım	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045 0.030 1.00 18.0–20.0	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi Product Vari Over or Unc 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over 0.20	tenitic Steels ^F , (0.030 3.5-4.5 16.0-18.0 8.0-9.0 0.08-0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045 0.030 1.00 16.0-18.0	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under ^B 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max Sulfur, max Silicon Chromium Nickel	im	0.030 1.00 max 20.5-23.5 11.5-13.5 1.50-3.00 0.20-0.40 0.10-0.30 0.10-0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045 0.030 1.00 18.0-20.0 8.0-11.0	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi Product Vari Over or Unc 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over 0.20 0.15	tenitic Steels ^F , (0.030 3.5–4.5 16.0–18.0 8.0–9.0 0.08–0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045 0.030 1.00 16.0–18.0 10.0–13.0	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Product Variation, Over or Under ^B 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over 0.20 0.15		
Chromium Nickel Molybdenum Nitrogen Columbium + tantalu Vanadium Type Grade UNS Designation Carbon, max Manganese Phosphorus, max Sulfur, max Silicon Chromium	im	0.030 1.00 max 20.5–23.5 11.5–13.5 1.50–3.00 0.20–0.40 0.10–0.30 0.10–0.30 B8LN, B8LNA S30453 Range 0.030 2.00 0.045 0.030 1.00 18.0–20.0	0.005 over 0.05 over 0.25 0.15 0.10 0.02 0.05 0.02 Ausi Product Vari Over or Unc 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over 0.20	tenitic Steels ^F , (0.030 3.5-4.5 16.0-18.0 8.0-9.0 0.08-0.18 Classes 1, 1A and 1D B8MLN, B8MLNA S31653 Range 0.030 2.00 0.045 0.030 1.00 16.0-18.0	0.005 over 0.005 over 0.15 0.20 0.10 0.01 Variation, Over or Under ^B 0.005 over 0.04 over 0.010 over 0.005 over 0.05 over 0.05 over		

^A The intentional addition of Bi, Se, Te, and Pb is not permitted.

^B Product analysis—Individual determinations sometimes vary from the specified limits on ranges 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.

^C Typical steel compositions used for this grade include 4140, 4142, 4145, 4140H, 4142H, and 4145H.

^D For bar sizes over 3½ in. [90 mm], inclusive, the carbon content may be 0.50 %, max. For the B7M grade, a minimum carbon content 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.

E Total of soluble and insoluble.

F Classes 1 and 1D are solution treated. Classes 1, 1B, and some 1C (B8R and B8S) products are made from solution treated material. Class 1A (B8A, B8CA, B8MA, B8PA, B8TA, B8LNA, B8MLNA, B8NA, and B8MNA) and some Class 1C (B9RA and B8SA) products are solution treated in the finished condition. Class 2 products are solution treated and strain hardened.

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TABLE 2 Mechanical Requirements — Inch Products

Grade	Diameter, in.	Minimum Tempering Temperature, °F Ferritic Steel	Tensile Strength, min, ksi	Yield Strength, min, 0.2 % offset, ksi	Elongation in 4D, min, %	Reduct of Are min,	ea, max
B5		remiic Steel	5				
4 to 6 % chromium	up to 4, incl	1100	100	80	16	50	
B6 13 % chromium B6X	up to 4, incl	1100	110	85	15	50	
13 % chromium B7	up to 4, incl	1100	90	70	16	50	26 HRC
Chromium-molybdenum	2½ and under	1100	125	105	16	50	321 HB or
	over 2½ to 4	1100	115	95	16	50	35 HRC 321 HB or
	over 4 to 7	1100	100	75	18	50	35 HRC 321 HB or
B7M ^A Chromium-molybdenum	4 and under	1150	100	80	18	50	35 HRC 235 HB or
	over 4 to 7	1150	100	75	18	50	99 HRB 235 BHN or 99 HRB
B16 Chromium-molybdenum-vanadium	21/2 and under	1200	125	105	18	50	321 HB or
Ciriomiam-molybaenam-vanadiam							35 HRC
	over 2½ to 4	1200	110	95	17	45	321 HB or 35 HRC
	over 4 to 8	1200	100	85	16	45	321 HB or 35 HRC
Grade, Diameter, in.	Heat Treatment ^B	5	Tensile Strength, min, ksi	Yield Strength, min, 0.2 % offset, ksi		duction Area, nin %	Hardness, max
Classes 1 and 1D; B8, B8M, B8P, 6	earbide colution treated	Austernite Ste	-75	30	30	50 :	223 HB ^C or 96 HRE
B8LN; Classes 1 and 1D; B8, B8M, B8P, of				30	30		223 HB or 96 HRB
B8LN, B8MLN, all diameters	AST		193M-09		_	_	
	carbide solution treated		a d5 490b-1	bfc2- 30 /e719	5fbc 30 a/ast	50 a 1 9	223 HB ^C or 96HRE
Class 1: B8C, B8T, all	carbide solution treated		75	<u>30</u>	<u>30</u>	<u>50</u>	223 HB or 96HRB
	carbide solution treated in the finished condition	I	75	30	30	50	192 HB or 90 HRB
Classes 1B and 1D: B8N, B8MN, e	carbide solution treated		-80	35	30	40	223 HB^C or 96 HRI
	carbide solution treated		80	<u>35</u>	30	<u>40</u>	223 HB or 96 HRB
	carbide solution treated		100	55	35	55	271 HB or 28 HRC
,	carbide solution treated in the finished condition	I	100	55	35	55	271 HB or 28 HRC
Classes 1C and 1D: B8S, all diameters	carbide solution treated		95	50	35	55	271 HB or 28 HRC
Classes 1C: B8SA,	carbide solution treated in the finished	I	95	50	35	55	271 HB or 28 HRC
Class 2: B8, B8C, B8P, B8T, and B8N, D	condition carbide solution treated and strain hardened		125	100	12	35	321 HB or 35 HRC
	carbide solution treated and strain hardened		125	100	<u>12</u>	<u>35</u>	321 HB or 35 HRC
over 3/4 to 1, incl over 1 to 11/4 , incl over 11/4 to 11/2 , incl			115 105 100	80 65 50	15 20 28	35 35 45	321 HB or 35 HRC 321 HB or 35 HRC 321 HB or 35 HRC