Designation: A320/A320M – 21a

Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service[1]

This standard is issued under the fixed designation A320/A320M; 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[2] covers alloy steel bolting materials and bolting components for pressure vessels, valves, flanges, and fittings for low-temperature service. See Specification A962/A962M for the definition of bolting. The bars shall be hot-wrought and may be further processed by centerless grinding or by cold drawing. Austenitic stainless steel may be solution annealed or annealed 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 both ferritic and austenitic steels designated L7, B8, etc. Selection will depend on design, service conditions, mechanical properties, and low-temperature characteristics. The mechanical requirements of Table 1 indicate the diameters for which the minimum mechanical properties apply to the various grades and classes, and Table 2 stipulates the requirements for Charpy impact energy absorption. The manufacturer should determine that the material can conform to these requirements before parts are manufactured. For example, when Grade L43 is specified to meet the Table 2 impact energy values at −150 °F [−101 °C], additional restrictions (such as procuring a steel with lower P and S contents than might normally be supplied) in the chemical composition for AISI 4340 are likely to be required.

NOTE 1—The committee formulating this specification has included several grades of material 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. Users should note that hardenability of some of the grades mentioned may restrict the maximum size at which the required mechanical properties are obtainable.

1.3 The following referenced general requirements are indispensable for application of this specification: Specification A962/A962M.

1.4 Nuts for use with bolting are covered in Section 10 and the nut material shall be impact tested.

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 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. 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:*[3]

A194/A194M Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

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

E566 Practice for Electromagnetic (Eddy Current/Magnetic Induction) Sorting of Ferrous Metals

[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-320 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.

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

TABLE 1 Mechanical Requirements

Class and Grade, Diameter, in. [mm]	Heat Treatment	Minimum Tempering Temperature, °F [°C]	Tensile Strength, min, ksi [MPa]	Yield Strength, min, ksi [MPa] (0.2 % offset)	Elongation in 2 in. or 50 mm, min, %	Reduction of Area, min, %	Hardness, max
		Ferritic Steels					
L7, L7A, L7B, L7C, L70, L71, L72, L73			125	105	16	50	321 HBW or 35 HRC
2½ [65] and under[A]	quenched and tempered	1100 [593]	[860]	[725]			
L43			125	105	16	50	321 HBW or 35 HRC
4 [100] and under[A]	quenched and tempered	1100 [593]	[860]	[725]			
L7M			100	80	18	50	235 HBW[B] or 99 HRB
2½ [65] and under[A]	quenched and tempered	1150 [620]	[690]	[550]			
L1 1 [25] and under[A]	quenched and tempered		125 [860]	105 [725]	16	50	. . .
		Austenitic Steels[C]					
Class 1: B8, B8C, B8M, B8P, B8F, B8T, B8LN, B8MLN, all diameters	carbide solution treated		75 [515]	30 [205]	30	50	223 HBW[D] or 96 HRB
Class 1A: B8A, B8CA, B8MA, B8PA, B8FA, B8TA, B8LNA, B8MLNA, all diameters	carbide solution treated in the finished condition		75 [515]	30 [205]	30	50	192 HBW or 90 HRB
Class 2: B8, B8C, B8P, B8F, B8T:	carbide solution treated and strain hardened						
¾ [20] and under			125 [860]	100 [690]	12	35	321 HBW or 35 HRC
over ¾ to 1 [20 to 25], incl			115 [795]	80 [550]	15	35	321 HBW or 35 HRC
over 1 to 1¼ [25 to 32], incl			105 [725]	65 [450]	20	35	321 HBW or 35 HRC
over 1¼ to 1½ [32 to 40], incl[A]			100 [690]	50 [345]	28	45	321 HBW or 35 HRC
Class 2: B8M:	carbide solution treated and strain hardened						
¾ [20] and under			110 [760]	95 [655]	15	45	321 HBW or 35 HRC
over ¾ to 1 [20 to 25], incl			100 [690]	80 [550]	20	45	321 HBW or 35 HRC
over 1 to 1¼ [25 to 32], incl			95 [655]	65 [450]	25	45	321 HBW or 35 HRC
over 1¼ to 1½ [32 to 40], incl[A]			90 [620]	50 [345]	30	45	321 HBW or 35 HRC

[A] These upper diameter limits were established on the basis that these were the largest sizes commonly available that consistently met specification property limits. They are not intended as absolute limits beyond which bolting materials could no longer be certified to the specification.
[B] To meet the tensile requirements, the Brinell hardness shall not be less than 200 HBW or 93 HRB.
[C] Class 1 products are made from solution-treated material. Class 1A products are solution treated in the finished condition for corrosion resistance; heat treatment is critical for enhancing this physical property and meeting the mechanical property requirements. Class 2 products are made from solution-treated material that has been strain hardened. Austenitic steels in the strain-hardened condition may not show uniform properties throughout the cross section, particularly in sizes over ¾ in. [20 mm] in diameter.
[D] For sizes ¾ in. [20 mm] in diameter and smaller, a maximum hardness of 241 HBW (100 HRB) is permitted.

TABLE 2 Impact Test Temperatures and Properties

Grade	Test Temperature		CVN Specimen Section Size, mm	Min Average Impact Toughness of Three Test Specimens, ft-lbf [J]	Min Impact Value of a Single Specimen of Set of Three, ft-lbf [J]
	°F	°C			
L7M, L70, L71, L72, L73	–100	–73	10 × 10	20 [27]	15 [20]
			10 × 7.5	16 [22]	12 [16]
L7, L7A, L7B, L7C, L43	–150	–101	10 × 10	20 [27]	15 [20]
			10 × 7.5	16 [22]	12 [16]
L1	–100	–73	10 × 10	40 [54]	30 [41]
			10 × 7.5	32 [44]	24 [32]

F436/F436M Specification for Hardened Steel Washers Inch and Metric Dimensions

F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

2.2 *ASME Standards:*[4]

B1.1 Screw Threads

B18.21.1 Washers: Helical Spring-Lock, Tooth Lock, and Plain Washers (Inch Series)

3. Ordering Information

3.1 It is the purchaser's responsibility to specify in the purchase order all information necessary to purchase the needed materials. Examples of such information include, but are not limited to, the following:

3.1.1 Quantity and size,

3.1.2 Heat-treated condition, that is, for the austenitic stainless steels, solution-treated (Class 1); solution-treated after finishing (Class 1A); and annealed and strain-hardened (Class 2),

3.1.3 Description of items required (bars, bolts, screws, or studs),

3.1.4 Nuts and washers, if required by the purchaser, in accordance with Section 10, and

3.1.5 Special requirements, in accordance with 5.1.1, 5.1.3, 5.1.4, and 13.1.

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 (carbon and 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 the requirements in this specification and Specification A962/A962M, this specification shall prevail.

5. Materials and Manufacture

5.1 *Heat Treatment:*

5.1.1 Bolting materials shall be allowed to cool to room temperature after rolling or forging. Grades L7, L7A, L7B, L7C, L7M, L43, L1, L70, L71, L72, and L73 shall be reheated to above the upper critical temperature and liquid quenched and tempered. Grades B8, B8C, B8M, B8T, B8F, B8P, B8LN, and B8MLN shall receive a carbide solution treatment. Products made from such material are described as Class 1. This shall consist of holding the bolting material for a sufficient time at a temperature at which the chromium carbide will go into solution and then cooling in air or in a liquid medium at a rate sufficient to prevent reprecipitation of the carbide. Bolting material thus treated is described as Class 1. If specified in the purchase order, bolting material shall be solution treated in the finished condition and shall be described as Class 1A.

5.1.2 Use of water quenching is prohibited for any ferritic grade when heat treatment is performed after heading or threading.

5.1.3 When increased mechanical properties are desired, austenitic bolting shall be solution annealed and strain hardened if specified in the purchase order; material so treated is identified as Class 2.

5.1.4 If scale-free bright finish is required, this shall be specified in the purchase order.

5.1.5 For L7M bolting, the final heat treatment, which may be the tempering or stress-relieving operation conducted at 1150 °F [620 °C] minimum, shall be done after machining or rolling of the threads and any type of cutting.

6. Mechanical Requirements

6.1 *Tensile Properties:*

6.1.1 Bolting material as represented by the tension specimens shall conform to the requirements as to tensile properties prescribed in Table 1 at room temperature after heat treatment (see 5.1.1). Alternatively, Class 2 Strain Hardened Headed Bolting Components shall be tested full size after strain hardening to determine tensile strength and yield strength and shall conform to the requirements prescribed in Table 1. Should the results of full size tests conflict with results of tension specimen tests, full size test results shall prevail.

6.1.2 *Number of Tests:*

6.1.2.1 For heat-treated bars, one tension test and one impact test consisting of three specimens shall be made for each diameter of each heat represented in each tempering charge. When heat treated without interruption in continuous furnaces, the material in a lot shall be the same heat, same prior condition, same size, and subjected to the same heat treatment. Not fewer than two tensile tests and two impact tests are required for each lot containing 20 000 lbs [9000 kg] or less. Every additional 10 000 lbs [4500 kg] or fraction thereof requires an additional tensile test and impact test.

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

6.1.2.2 For studs, bolts, screws, etc., one tension test and one set of three impact specimens shall be made for each diameter of each heat involved in the lot. Each lot shall consist of the following:

Diameter, in. [mm]	Lot Size, lb [kg]
1⅛ [30] and under	1500 [680] or fraction thereof
Over 1⅛ [30] to 1¾ [45], incl	4500 [2040] or fraction thereof
Over 1¾ [45] to 2½ [65], incl	6000 [2700] or fraction thereof
Over 2½ [65]	100 pieces or fraction thereof

6.1.2.3 *Full Size Specimens, Headed Bolting Components*—Headed bolts or screws 1 ½ in. in body diameter and smaller, with body length three times the diameter or longer, and that are produced by upsetting or forging (hot or cold) shall be subjected to full size testing in accordance with 6.1.3. This testing shall be in addition to tensile testing as specified in 6.1.1. Wedge tensile testing shall be limited to product with socket head cap screw, hexagon, square, hex flange, or twelve point flange heads. The lot size shall be shown in 6.1.2.2. Failure shall occur in the body or threaded section with no failure, or indications of failure, such as cracks, at the junction of the head and shank. Wedge tensile testing is not required for flat countersunk head or socket button products.

6.1.3 *Full Size Bolting Components, Wedge Tensile Testing*—When applicable, see 6.1.2.3. Headed components shall be wedge tested full size. The minimum full size load applied (lbf or kN) for individual sizes shall be as follows:

$$W = T_s \times A_t \quad (1)$$

where:

W = minimum wedge tensile load without fracture,
T_s = tensile strength specified in ksi or MPa in Tables 2 and 3, and
A_t = stress area of the thread section, square inches or square millimetres, as shown in the Cone Proof Load Tables in Specification A962/A962M.

6.2 *Impact Properties:*

6.2.1 *Requirements:*

6.2.1.1 Impact tests are required for the grades shown in Table 3. Class 1, 1A, and 2 austenitic steels for temperatures above –325 °F [–200 °C]; Class 1 and 1A austenitic Grades B8, B8A, B8P, B8PA, B8C, B8CA, B8LN, and B8LNA above –425 °F [–255 °C]; and ferritic or austenitic bolting ½ in. [12.5 mm] and smaller, are exempt from impact testing, unless Supplementary Requirement S1 is specified in the purchase order (see 1.4). All other material furnished under this specification shall be tested. Material of Grades L7, L7A, L7B, L7C, L7M, L43, L70, L71, L72, and L73 shall show a minimum impact energy absorption of 20 ft · lbf [27 J] and of Grade L1 a minimum impact energy absorption of 40 ft · lbf [54 J] at the specified test temperature.

6.2.1.2 The temperature of the coolant used for chilling the test specimens shall be controlled within ±2 °F [1 °C]. Test temperatures for ferritic grades are listed in Table 2. Exceptions to this requirement are permissible, and the impact tests may be made at specified temperatures different than those shown in Table 2, provided the test temperature is at least as low as the intended service temperature and the bolting is suitably marked to identify the reported test temperature. When impact testing is required for austenitic grades, test criteria shall be agreed upon between the supplier and purchaser.

6.2.1.3 The impact test requirements for standard and subsize Charpy V-notch (CVN) test specimens are prescribed in Table 2. If the material is impact tested at a temperature lower than the specified test temperature with impact energy absorption results equal to or greater than the specified required impact energy absorption for that product, the material can be considered suitable for the specified test temperature.

NOTE 2—As an example, the purchase order or contract requires an L-grade bolt to have an average 15 ft-lbs at –50 °F. If the Charpy V-notch testing indicates that the bolting material passes at –100 °F and if it also meets other mechanical property or other environmental resistance requirements, it is permissible or suitable for use if that specified temperature reflects the minimum anticipated temperature range to which that the product or application will be subjected.

6.2.2 *Number of Tests:*

6.2.2.1 The test requirements for heat-treated bars are given in 6.1.2.1.

6.2.2.2 For test requirements on studs, bolts, screws, etc., see 6.1.2.2.

6.2.2.3 Impact tests are not required to be made on heat-treated bars, bolts, screws, studs, and stud bolts ½ in. [12.5 mm] and under in diameter.

6.2.3 *Test Specimens*—For sections 1 in. [25 mm] or less in diameter, test specimens shall be taken at the axis; for sections over 1 in. [25 mm] in diameter, midway between the axis and the surface.

6.3 *Hardness Requirements:*

6.3.1 The hardness shall conform to the requirements prescribed in Table 1. Hardness testing shall be performed in accordance with either Specification A962/A962M or with Test Methods F606/F606M.

6.3.2 The maximum hardness of Grade L7M shall be 235 HBW or 99 HRB. Minimum hardness shall not be less than 200 HBW or 93 HRB. Conformance to this hardness shall be ensured by testing each bolt or stud by Brinell or Rockwell B methods in accordance with 6.3.1.

6.3.2.1 The use of 100 % electromagnetic testing for hardness as an alternative to 100 % indentation hardness testing is permissible when qualified by sampling using indentation hardness testing. Each lot tested for hardness electromagnetically shall be 100 % examined in accordance with Practice E566. Following electromagnetic testing for hardness, a random sample of a minimum of 100 pieces in each purchase lot (as defined in 6.1.2.2) shall be tested by indentation hardness methods. All samples must meet hardness requirements to permit acceptance of the lot. If any one sample is outside of the specified maximum or minimum hardness, the lot shall be rejected and either reprocessed and resampled, or tested 100 % by indentation hardness methods.

6.3.2.2 In the event a controversy exists relative to minimum strength, tension tests shall prevail over hardness readings. Products which have been tested and found acceptable shall have a line under the grade symbol.

TABLE 3 Chemical Requirements (Composition, %)[A]

Type	Ferritic Steels											
Grade Symbol	L7, L7M, L70		L7A, L71		L7B, L72		L7C, L73		L43		L1	
Description . . .	Chromium-Molybdenum[B]		Carbon-Molybdenum (AISI 4037)		Chromium-Molybdenum (AISI 4137)		Nickel-Chromium-Molybdenum (AISI 8740)		Nickel-Chromium-Molybdenum (AISI 4340)		Low-Carbon Boron	
	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under
Carbon	0.38–0.48[C]	0.02	0.35–0.40	0.02	0.35–0.40	0.02	0.38–0.43	0.02	0.38–0.43	0.02	0.17–0.24	0.01
Manganese	0.75–1.00	0.04	0.70–0.90	0.03	0.70–0.90	0.03	0.75–1.00	0.04	0.60–0.85	0.03	0.70–1.40	0.04
Phosphorus, max	0.035	0.005 over	0.035	0.005 over	0.035	0.005 over	0.035	0.005 over	0.035	0.005 over	0.035	0.005 over
Sulfur, max	0.040	0.005 over	0.040	0.005 over	0.040	0.005 over	0.040	0.005 over	0.040	0.005 over	0.050	0.005 over
Silicon	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.30	0.02
Nickel	. . .	. . .	. . .	. . .	. . .	. . .	0.40–0.70	0.03	1.65–2.00	0.05	. . .	. . .
Chromium	0.80–1.10	0.05	. . .	. . .	0.80–1.10	0.05	0.40–0.60	0.03	0.70–0.90	0.03	. . .	. . .
Molybdenum	0.15–0.25	0.02	0.20–0.30	0.02	0.15–0.25	0.02	0.20–0.30	0.02	0.20–0.30	0.02	. . .	. . .
Boron	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.001–0.003	. . .

Type	Austenitic Steels, Classes 1, 1A, and 2[D]			
Grade Symbol	B8, B8A		B8C, B8CA	
UNS Designation.	S 30400(304)		S 34700(347)	
	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under
Carbon, max	0.08	0.01 over	0.08	0.01 over
Manganese, max	2.00	0.04 over	2.00	0.04 over
Phosphorus, max	0.045	0.010 over	0.045	0.010 over
Sulfur, max	0.030	0.005 over	0.030	0.005 over
Silicon, max	1.00	0.05 over	1.00	0.05 over
Nickel	8.0–11.0	0.15	9.0–12.0	0.15
Chromium	18.0–20.0	0.20	17.0–19.0	0.20
Niobium[E] + Tantalum	. . .	. . .	10 × carbon content, min. –1.10 max	0.05 under

Type.	Austenitic Steels, Classes 1, 1A, and 2[D]									
Grade Symbol	B8T, B8TA		B8P, B8PA		B8F, B8FA				B8M, B8MA	
UNS Designation	S 32100(321)		S 30500		S 30300(303)		S 30323(303Se)		S 31600(316)	
	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under
Carbon, max	0.08	0.01 over	0.12	0.01 over	0.15	0.01 over	0.15	0.01 over	0.08	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	2.00	0.04 over
Phosphorus, max	0.045	0.010 over	0.045	0.010 over	0.20	0.010 over	0.20	0.010 over	0.045	0.010 over
Sulfur	0.030, max	0.005 over	0.030, max	0.005 over	0.15, min	0.020	0.06, max	0.010 over	0.030, max	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	1.00	0.05 over
Nickel	9.0–12.0	0.15	11–13.0	0.15	8.0–10.0	0.10	8.0–10.0	0.10	10.0–14.0	0.15
Chromium	17.0–19.0	0.20	17.0–19.0	0.20	17.0–19.0	0.20	17.0–19.0	0.20	16.0–18.0	0.20
Molybdenum	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2.00–3.00	0.10
Selenium	. . .	. . .	. . .	. . .	. . .	. . .	0.15–0.35	0.03 under	. . .	. . .
Titanium	5 × (C+N) min -0.7 max	0.05 under	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Nitrogen	0.10, max	0.01	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

Type	Austenitic Steels, Classes 1 and 1A			
Grade Symbol	B8LN, B8LNA		B8MLN, B8MLNA	
UNS Designation	S 30453		S 31653	
	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under
Carbon, max	0.030	0.005 over	0.030	0.005 over
Manganese, max	2.00	0.04 over	2.00	0.04 over