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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 Department of Defense.

1. Scope*

1.1 This specification[2] covers alloy steel bolting 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.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

E566 Practice for Electromagnetic (Eddy-Current) Sorting of Ferrous Metals

F436 Specification for Hardened Steel Washers

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

[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.**

2.2 *ASME Standards:*[4]
B1.1 Screw Threads
B18.22.1 Plain Washers

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, 5.1.2, 5.1.3, and 12.1.

4. Common Requirements

4.1 Bolting 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.

4.2 For L7M bolting, the final heat treatment, which may be the tempering operation if conducted at 1150 °F [620 °C] minimum, shall be done after machining and forming operations, including thread rolling and any type of cutting.

5. Materials and Manufacture

5.1 *Heat Treatment*:

5.1.1 Bolting 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 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. Material thus treated is described as Class 1. If specified in the purchase order, material shall be solution treated in the finished condition; material so treated is described as Class 1A.

5.1.2 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.

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

5.1.4 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 The 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 Fasteners 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. In the continuous type treatment, a charge shall be defined as 6000 lb [2700 kg].~~ 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.

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:

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

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 Fasteners*—Headed fasteners 1 ½ in. in body diameter and smaller, with body length three times the diameter or longer, and which 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. The lot size shall be shown in 6.1.2.2. Failure shall occur in the body or threaded sections with no failure, or indications of failure, such as cracks, at the junction of the head and shank.

6.1.3 *Full Size Fasteners, Wedge Tensile Testing*—When applicable, see 6.1.2.3. Headed fasteners shall be wedge tested full size in accordance with Annex A3 of Test Methods and Definitions A370 and shall conform to the tensile strength shown in Table 1. The minimum full size breaking strength (lbf) for individual sizes shall be as follows:

$$Ts = UTS \times As \quad (1)$$

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where:
Ts = Wedge tensile strength
UTS = Tensile strength specified in Table 1, and
As = Stress area, square inches, as shown in ASME B1.1 or calculated as follows:

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where:
D = Nominal thread size, and
n = The number of threads per inch.

6.2 *Impact Properties*:

6.2.1 *Requirements*:

6.2.1.1 ~~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 test temperature when tested by the procedure specified in the applicable portions of Sections 19 to 28 of Test Methods and Definitions A370. The temperature of the coolant used for chilling the test specimens shall be controlled within ±3 °F [1.5 °C]. Impact tests are not required for carbide solution treated or strain hardened Grades B8, B8F, B8P, B8M, B8T, B8LN, and B8MLN for temperatures above −325 °F [−200 °C]; for carbide solution treated Grades B8, B8P, B8C, and B8LN above −425 °F [−255 °C]; for all ferritic and austenitic steel grades of bolting½ in. [12.5 mm] and smaller in diameter. All other material furnished under this specification shall be tested. Test temperatures for ferritic grades are listed in~~ 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 test temperature when tested by the procedure specified in the applicable portions of Sections 19 to 28 of Test Methods and Definitions A370. The temperature of the coolant used for chilling the test specimens shall be controlled within ±3 °F [1.5 °C]. Test temperatures for ferritic grades are listed in Table 4. Exceptions to this requirement are permissible, and the impact tests may be made at specified temperatures different than those shown in ~~Table 3~~Table 4, 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.

6.2.1.2 The impact test requirements for standard and subsize Charpy test specimens are prescribed in Table 2.

6.2.2 *Number of Tests*:

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

TABLE ~~3~~ 4 Recommended Test Temperature for Stock Parts

Grade	Test Temperature	
	°F	°C
L7M, L70, L71, L72, L73	−100	−73
L7, L7A, L7B, L7C	−150	−101
L43	−150	−101
L1	−100	−73

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 HB or 35 HRC~~
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 HB or 35 HRC~~
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 HB[B] or 99 HRB~~
L7M			100	80	18	50	235 HBW[B] or 99 HRB
2½ [65] and under[A]	quenched and tempered	1150 [620]	[690]	[550]			
L1			125	105	16	50	. . .
1 [25] and under[A]	quenched and tempered		[860]	[725]			
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 HB[D] or 96 HRB~~
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 HB or 90 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 HB or 35 HRC~~
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~~	~~30~~	~~321 HB or 35 HRC~~
over ¾ to 1 [20 to 25], incl			115 [795]	80 [550]	15	30	321 HBW or 35 HRC
~~over 1 to 1¼ [25 to 32], incl~~			~~105 [725]~~	~~65 [450]~~	~~20~~	~~35~~	~~321 HB 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 HB 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 HB or 35 HRC~~
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 HB or 35 HRC~~
over ¾ to 1 [20 to 25], incl			100 [690]	80 [550]	20	45	321 HBW or 35 HRC

TABLE 2 Impact Energy Absorption Requirements

Size of Specimen, mm	Minimum Impact Value Required for Average of Each Set of Three Specimens, ft·lbf [J]	Minimum Impact Value Permitted for One Specimen Only of a Set, ft·lbf [J]
All Grades Except L1[A]		
10 by 10	20 [27]	15 [20]
10 by 7.5	16 [22]	12 [16]
Grade L1		
10 by 10	40 [54]	30 [41]
10 by 7.5	32 [44]	24 [32]

[A] See 6.2.1.1 for permitted exemptions.

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.

6.3.2 The maximum hardness of Grade L7M shall be 235 HBW or 99 HRB (conversion in accordance with Table Number 2B of Test Methods and Definitions A370). 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.

7. Chemical Composition

7.1 Each alloy shall conform to the chemical composition requirements prescribed in ~~Table 4~~Table 3.

8. Workmanship, Finish, and Appearance

8.1 Bolts, screws, studs, and stud bolts shall be pointed and shall have a workmanlike finish.

9. Retests

9.1 If the results of the mechanical tests of any test lot do not conform to the requirements specified, the manufacturer may retreat such lot not more than twice, in which case two additional tension tests and one additional impact test consisting of three specimens shall be made from such lot, all of which shall conform to the requirements specified.

10. Nuts and Washers

10.1 Bolts, studs, and stud bolts of Grades L7, L7A, L7B, L7C, L43, L1, L70, L71, L72, and L73 shall be equipped with ferritic alloy nuts conforming to Grade 4 or Grade 7 of Specification A194/A194M or a grade of steel similar to the studs. Grade 7M nuts at a hardness not exceeding 235 HBW (or equivalent) shall be used with Grade L7M bolts, studs, and stud bolts. All nut materials, including those which may be supplied under Specification A194/A194M, shall be subject to the impact requirements of this specification in the following manner: impact tests shall be made on test specimens taken from the bar or plate from the heat of steel used for manufacturing the nuts, and heat treated with the nut blanks.

10.2 Bolts, studs, and stud bolts of Grades B8, B8C, B8T, B8P, B8F, B8M, B8LN, and B8MLN shall be equipped with austenitic alloy nuts conforming to Grades 8, 8C, 8T, 8F, 8M, 8LN, and 8MLN for Specification A194/A194M. Impact tests are not required for Grades 8F, 8M, 8T, and 8MLN for temperatures above −325 °F [−200 °C] and for Grades 8, 8P, 8C, and 8LN above −425 °F [−255 °C].

10.3 If the purchaser requires nuts with a Charpy impact energy absorption of not less than 20 ft · lbf [27 J] at temperatures below −150 °F [−100 °C], he may require that the nuts conform to Grades 8, 8C, 8M, 8P, 8T, 8F, 8LN, or 8MLN of Specification A194/A194M.

10.4 Washers for use with ferritic steel bolting shall conform to Specification F436.

10.5 Washers for use with austenitic steel bolting shall be made of austenitic steel as agreed upon between the manufacturer and purchaser.

10.6 Washer dimensions shall be in accordance with requirements of ASME B18.22.1, unless otherwise specified in the purchase order.

11. Threads

11.1 Where practical, all threads shall be formed after heat treatment. Class 1A, Grades B8A, B8CA, B8MA, B8PA, B8FA, B8TA, B8LNA, and B8MLNA are to be solution-treated in the finished condition.

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

Type	Ferritic Steels											
Grade	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	. . .