



Designation: **A320/A320M—14** **A320/A320M – 15**

## Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service<sup>1</sup>

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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*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 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  $-150\text{ }^{\circ}\text{F}$  [ $-101\text{ }^{\circ}\text{C}$ ], 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*:<sup>3</sup>

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

<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-320 in Section II of that Code.

<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

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, and Rivets (Metric) F0606\_F0606M

2.2 ASME Standards:<sup>4</sup>

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, 5.1.4, and 13.1.

### 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 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 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. 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

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

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:

| Diameter, in. [mm]               | Lot Size, lb [kg]                  |
|----------------------------------|------------------------------------|
| 1½ [30] and under                | 1500 [680] or fraction thereof     |
| Over 1½ [30] to 1¾ [45],<br>incl | 4500 [2040] or fraction<br>thereof |
| Over 1¾ [45] to 2½ [65],<br>incl | 6000 [2700] or fraction<br>thereof |
| Over 2½ [65]                     | 100 pieces or fraction thereof     |

6.1.2.3 *Full Size Specimens, Headed Fasteners*—Headed fasteners 1½ 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:

$$T_s = UTS \times A_s \quad (1)$$

where:

$T_s$  = Wedge tensile strength

UTS = Tensile strength specified in Table 1, and

$A_s$  = Stress area, square inches, as shown in ASME B1.1 or calculated as follows:

$$A_s = 0.785 (D - (0.974/n))^2 \quad (2)$$

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 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 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.

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.



TABLE 3 Chemical Requirements (Composition, %)⁴

| Ferritic Steels        |                                  |                                       |                               |                                       |                                 |                                       |  |                                       |  |                                       |                  |                                       |
|------------------------|----------------------------------|---------------------------------------|-------------------------------|---------------------------------------|---------------------------------|---------------------------------------|--|---------------------------------------|--|---------------------------------------|------------------|---------------------------------------|
| Type . . . . .         |                                  |                                       |                               |                                       |                                 |                                       |  |                                       |  |                                       |                  |                                       |
| Grade Symbol . . . . . | L7, L7M, L70                     | L7A, L71                              |                               | L7B, L72                              |                                 | L7C, L73                              |  | L43                                   |  | L1                                    |                  |                                       |
| Description . . .      | Chromium-Molybdenum <sup>B</sup> |                                       | Carbon-Molybdenum (AISI 4037) |                                       | Chromium-Molybdenum (AISI 4137) |                                       | Nickel-Chromium-Molybdenum (AISI 8740) |                                       | Nickel-Chromium-Molybdenum (AISI 4340) |                                       | Low-Carbon Boron |                                       |
|                        | Range, %                         | Product Variation, %<br>Over or Under | Range, %                      | Product Variation, %<br>Over or Under | Range, %                        | Product Variation, %<br>Over or Under | Range, %                               | Product Variation, %<br>Over or Under | Range, %                               | Product Variation, %<br>Over or Under | Range, %         | Product Variation, %<br>Over or Under |
| Carbon                 | 0.38–0.48 <sup>C</sup>           | 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      | ...                                   |

  

| Austenitic Steels, Classes 1, 1A, and 2 <sup>D</sup> |              |  |                                       |  |                                     |  |                                       |  |                                     |  |                                       |  |
|--|--------------|--|---------------------------------------|--|-------------------------------------|--|---------------------------------------|--|-------------------------------------|--|---------------------------------------|--|
| Type . . . . .                                       |              |  |                                       |  |                                     |  |                                       |  |                                     |  |                                       |  |
| Grade Symbol . . . . .                               | B8, B8A      |  |                                       |  |                                     |  | B8C, B8CA                             |  |                                     |  |                                       |  |
| UNS Designation . . . . .                            | S 30400(304) |  |                                       |  |                                     |  | S 34700(347)                          |  |                                     |  |                                       |  |
|  | Range, %     |  | Product Variation, %<br>Over or Under |  | Range, %                            |  | Product Variation, %<br>Over or Under |  | Range, %                            |  | Product Variation, %<br>Over or Under |  |
| Carbon, max  | 0.08         |  | 0.01 over                             |  | 0.08                                |  | 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                             |  |
| Phosphorus, max                                      | 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                            |  |
| Silicon, max   | 1.00         |  | 0.05 over                             |  | 1.00                                |  | 0.05 over                             |  | 1.00                                |  | 0.05 over                             |  |
| Nickel   | 8.0–11.0     |  | 0.15                                  |  | 9.0–12.0                            |  | 0.15                                  |  | 9.0–12.0                            |  | 0.15                                  |  |
| Chromium   | 18.0–20.0    |  | 0.20                                  |  | 17.0–19.0                           |  | 0.20                                  |  | 17.0–19.0                           |  | 0.20                                  |  |
| Columbium + Tantalum                                 | ...          |  | ...                                   |  | 10 × carbon content, min. –1.10 max |  | ...                                   |  | 10 × carbon content, min. –1.10 max |  | 0.05 under                            |  |

  

| Austenitic Steels, Classes 1, 1A, and 2 <sup>D</sup> |               |                                       |            |                                       |           |                                       |              |                                       |            |                                       |            |                                       |
|--|---------------|---------------------------------------|------------|---------------------------------------|-----------|---------------------------------------|--------------|---------------------------------------|------------|---------------------------------------|------------|---------------------------------------|
| Type . . . . .                                       |               |                                       |            |                                       |           |                                       |              |                                       |            |                                       |            |                                       |
| Grade Symbol . . . . .                               | B8T, B8TA     |                                       |            | B8P, B8PA                             |           |                                       | B8F, B8FA    |                                       |            | B8M, B8MA                             |            |                                       |
| UNS Designation . . . . .                            | S 32100(321)  |                                       |            | S 30500                               |           |                                       | S 30300(303) |                                       |            | S 30323(303Se)                        |            |                                       |
|  | Range, %      | Product Variation, %<br>Over or Under | Range, %   | Product Variation, %<br>Over or Under | Range, %  | Product Variation, %<br>Over or Under | Range, %     | Product Variation, %<br>Over or Under | Range, %   | Product Variation, %<br>Over or Under | Range, %   | Product Variation, %<br>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                             | 0.15       | 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                             | 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                            | 0.20       | 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 | 0.010 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                             | 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  | 0.10                                  | 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                                  | 16.0–18.0  | 0.20                                  |
| Molybdenum   | ...           | ...                                   | ...        | ...                                   | ...       | ...                                   | ...          | ...                                   | 2.00–3.00  | ...                                   | 2.00–3.00  | 0.10                                  |
| Selenium   | ...           | ...                                   | ...        | ...                                   | ...       | ...                                   | 0.15–0.35    | 0.03 under                            | ...        | ...                                   | ...        | ...                                   |
| Titanium   | 5 × (C+N) min | 0.05 under                            | ...        | ...                                   | ...       | ...                                   | ...          | ...                                   | ...        | ...                                   | ...        | ...                                   |
| Nitrogen   | 0.10, max     | 0.01                                  | ...        | ...                                   | ...       | ...                                   | ...          | ...                                   | ...        | ...                                   | ...        | ...                                   |

  

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