

SPECIFICATION FOR STAINLESS AND ALLOY-STEEL TURBINE-TYPE BOLTING SPECIALLY HEAT TREATED FOR HIGH-TEMPERATURE SERVICE



SA-437/SA-437M



(23)

(Identical with ASTM Specification A437/A437M-15(2021).)

Specification for Stainless and Alloy-Steel Turbine-Type Bolting Specially Heat Treated for High-Temperature Service

1. Scope

1.1 This specification covers stainless and alloy-steel bolting material and bolting components specially heat treated for high-temperature service, such as steam turbine, gas turbine, and similar uses. See Specification A962/A962M for the definition of bolting. This material requires special processing and should not be used in general-purpose applications. Bolting furnished as bars shall be hot wrought and may be further processed by centerless grinding or by cold drawing.

1.2 The high-temperature properties of the bolting materials and components covered by this specification are dependent upon special heat treatment, which is required. Although the high-temperature properties are not specified, they are implied by control of the chemistry, heat treatment, and room-temperature properties of the bolting material.

1.3 Three levels of bolting strength are covered, designated Grades B4B, B4C, and B4D.

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

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

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

1.7 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each

system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:

- A962/A962M Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range
- E292 Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials
- E112 Test Methods for Determining Average Grain Size

3. Ordering Information

3.1 It shall be the responsibility of the purchaser to specify all requirements necessary for product under this specification. Such requirements to be considered include, but are not limited to, the following:

- 3.1.1 Specification designation, grade, issue date, and revision letter,
- 3.1.2 Quantity (weight or number of pieces),
- 3.1.3 Description (bars, bolts, nuts, etc.),
- 3.1.4 Dimensions,
- 3.1.5 Finish, and
- 3.1.6 Impact testing of nuts, if required (see Section 8).

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 (Grade B4D only), marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification A962/A962M constitutes nonconformance with this specification. In case of conflict between this specification and Specification A962/A962M, this specification shall prevail.

5. Heat Treatment

5.1 Grades B4B and B4C shall be heated to a temperature range of 1875 to 1925 °F [1025 to 1050 °C] and liquid quenched to below 600 °F [316 °C]. The material Grades B4B and B4C shall then be uniformly reheated for tempering at a tempering temperature at least 100 °F [55 °C] higher than the proposed operating temperature but not less than 1150 °F [620 °C], then air or furnace cooled to room temperature. The material shall be at the tempering temperature for a minimum of 2 h. Double tempering may be used to enhance properties.

5.2 Grade B4D shall be heated to a temperature range of 1700 to 1750 °F [925 to 954 °C] and oil quenched. The material shall then be uniformly reheated or tempered at a temperature of 1200 °F [650 °C] minimum, followed by air or furnace cooling to room temperature.

5.3 Stress relieving treatment of the bar material is required after any stretcher, roller, or rotary-straightening or cold-finishing operations performed after heat treatment for mechanical properties. Local gaging or press straightening to correct camber limitations in excess of ¼ in. in any 5 ft [6 mm in any 1.5 m] shall be followed by a stress relieving heat treatment. The minimum stress relieving temperature shall be 100 °F [55 °C] below the minimum tempering temperature as shown in 5.1 for Grades B4B and B4C or in 5.2 for Grade B4D.

6. Chemical Composition

6.1 Bolting material shall conform to the requirements as to chemical composition specified in Table 1.

TABLE 1 Chemical Requirements^A

Element	Grades B4B, B4C ^B		Grade B4D	
	Range, %	Product Variation, % Over or Under	Range, %	Product Variation, % Over or Under
Carbon	0.20–0.25	0.02	0.36–0.44	0.02
Manganese	0.50–1.00	0.03	0.45–0.70	0.03
Phosphorus, max	0.025	0.005 over	0.04	0.005 over
Sulfur, max	0.025	0.005 over	0.04	0.005 over
Silicon	0.20–0.50	0.05	0.20–0.35	0.02
Nickel	0.50–1.00	0.03	...	...
Chromium	11.0–12.5	0.15	0.80–1.15	0.05
Molybdenum	0.90–1.25	0.05	0.50–0.65	0.03
Vanadium	0.20–0.30	0.03	0.25–0.35	0.03
Tungsten	0.90–1.25	0.05	...	...
Aluminum, max ^C	0.05	...	0.015	...
Titanium, max	0.05	...	...	...
Tin, max	0.04	...	...	...

^A Steel to which lead has been added shall not be used.

^B UNS S42200.

^C Total, Soluble + Insoluble

7. Tensile Requirements

7.1 Bolting material shall conform to the requirements as to tensile properties prescribed in Table 2 at room temperature after heat treatment.

7.2 The longitudinal axis of the test specimen shall be parallel to the direction of rolling.

8. Impact Requirements

8.1 Grades B4B, B4C, and B4D shall conform to the requirements as to impact properties prescribed in Table 3 at room temperature after heat treatment.

9. Hardness Tests

9.1 Grades B4B, B4C, and B4D shall conform to the requirements as to hardness as prescribed in Table 4 and Table 5 at room temperature after heat treatment.

10. Nuts

10.1 When specified by the purchaser, nuts shall be subject to the impact and tension requirements of this specification. The tests shall be made on test specimens taken from the bar or plate used in the manufacture of the nuts.

11. Threads

11.1 All threads shall be formed after heat treatment.

12. Nondestructive Inspection

12.1 Each bar or forged blank of starting material shall be subjected to NDE following final heat treatment. The method used shall be either the Eddy Current (EC), the Magnetic Particle (MPI) (wet or dry), the Liquid Penetrant (LPI), the Ultrasonic (UT), or the Visual Testing (VT), at the option of the producer. For LPI or MPI, linear indications (those indications longer than ¼ in. [1.5 mm] with a length greater than three times their width) are unacceptable. For UT or ET, reject levels for linear indications shall be based on the alarm response from a surface notch with a maximum depth of 0.012 in. [0.30 mm] in a calibration bar. Product being subjected to VT shall be pickled prior to inspection. VT indications longer than ¼ in. [3.2 mm] are prohibited.

13. Certification

13.1 Certification is required. See Specification A962/A962M.

TABLE 2 Tensile Requirements

Grade	Diameter, in. [mm]	Tensile Strength, min, ksi [MPa]	Yield Strength (0.2 % offset) min, ksi [MPa]	Elongation Reduction	
				in 2 in. or 50 mm, min, %	of Area, min, %
B4B	...	145 [1000]	105 [720]	13	30
B4C	...	115 [790]	85 [585]	18	50
B4D	2½ [65] and under	125 [860]	105 [720]	18	50
		110 [760]	95 [655]	17	45
		100 [690]	85 [585]	16	45

TABLE 3 Impact Requirements

Grade	Minimum Impact Value, ft-lbf [J]
B4B	10 [14]
B4C	25 [34]
B4D ^A	25 [34]

^A For bars over 5-in. [127-mm] diameter only.

TABLE 4 Hardness Requirements for Bolts and Studs

Grade	Brinell Hardness Number, max
B4B	331
B4C	277
B4D	302

14. Product Marking

14.1 Use the grade symbol shown in Table 4. See Specification A962/A962M.

TABLE 5 Hardness Requirements for Nuts and Washers

Grade	Brinell Hardness Number	Rockwell Hardness Number
B4B	293–341	C 31–37
B4C	229–277	C 21–29
B4D	263–311	C 27–33

15. Keywords

15.1 bolts—steel; chromium alloy steel; bolting components—steel; marking on bolting components; nuts—steel; stainless steel; steel bars—alloy; steel bolting material; temperature service applications—high; turbine materials

SUPPLEMENTARY REQUIREMENTS

One or more of the following supplementary requirements shall be applied only when specified by the purchaser in the inquiry, contract, or order; in which event the specified tests shall be made before shipment of the product.

S1. Non-Destructive Examination

S1.1 NDE is required following all machining and threading. The acceptance criteria of 12.1 shall apply.

S2. Stress Rupture Testing—Grade B4B

S2.1 Stress rupture testing shall be conducted at 1200 °F [650 °C] and 26 000 psi [180 MPa] using a combination test bar in accordance with Test Methods E292. Rupture shall occur in the smooth section of each test specimen. The test may be

discontinued after 25 h provided the certification so notes. Stress rupture testing is not required on bars less than ½ in. [12.7 mm] in diameter or thickness.

S3. Grain Size—Grades B4B and B4C

S3.1 The average grain size shall be 4 or finer. The maximum size of individual grains, distributed at random, shall be a 2. When the average grain size is 5 or finer, only the average size need be reported. Grain size determination shall be performed in accordance with Test Methods E112.