Designation: A453/A453M – 17 (Reapproved 2024)

Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels[1]

This standard is issued under the fixed designation A453/A453M; 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 five grades of bolting materials with twelve classes of yield strength ranging from 50 to 120 ksi [345 to 827 MPa] for use in high-temperature service for bolting components, such as bolts, screws, nuts, or studs, for pressure vessel and valve flanges. See Specification A962/A962M for the definition of bolting. The material requires special processing and is not intended for general purpose applications.

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

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

1.4 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.

1.5 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.

1.6 *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]

A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

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

E139 Test Methods for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

E292 Test Methods for Conducting Time-for-Rupture Notch Tension Tests of Materials

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *heat-treatment charge*—one heat of material heat treated in one batch. If a continuous operation is used, the weight processed as a heat-treatment charge shall not exceed the weights in Table 1.

3.1.2 *lot*—a lot shall consist of the quantities shown in Table 2.

4. Ordering Information

4.1 The inquiry and order shall indicate the following:

4.1.1 Quantity (weight or number of pieces),

4.1.2 Description of item (bars, bolts, nuts, etc.),

4.1.3 Grade and class (see Table 3),

4.1.4 Method of finishing (see 6.1),

4.1.5 Type of thread desired (see 6.1.1),

4.1.6 Alternative test method option (see 8.2.4.3),

4.1.7 Bolt shape option, if any,

4.1.8 Thread option, if any,

4.1.9 Test method for surface quality, if any,

[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-453 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.

TABLE 1 Continuous Heat-Treatment Charge Sizes

Diameter, in. [mm]	Weight, lb [kg]
To 1¾ [44]	3000 [1400]
Over 1¾ [44] to 2½ [63]	6000 [2700]
Over 2½ [63]	12000 [5400]

TABLE 2 Lot Sizes

Diameter, in. [mm]	Maximum Lot Size, lb [kg]
1½ [38] and under	200 [90]
Over 1½ [38] to 1¾ [44], incl	300 [140]
Over 1¾ [44] to 2½ [63], incl	600 [270]
Over 2½ [63]	20 pieces

4.1.10 Test location option, if any,

4.1.11 Rejection option, if any, and

4.1.12 If stress-rupture testing is not required, except for Grade 660 Class D and Grade 668 (see 8.2.1).

5. Common Requirements

5.1 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, 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 of this specification and Specification A962/A962M, this specification shall prevail.

6. Materials and Manufacture

6.1 *Finishing Process:*

6.1.1 Threads may be formed by machining or rolling. Threads may be formed after precipitation heat treatment or after solution anneal but prior to precipitation heat treatment. Type designations are as follows:

Type M1—threads formed by machining after precipitation heat treatment.

Type M2—threads formed by machining after solution anneal but prior to precipitation heat treatment.

Type R1—threads formed by rolling after precipitation heat treatment.

Type R2—threads formed by rolling after solution anneal but prior to precipitation heat treatment.

When not specified by the purchaser, the type supplied shall be the option of the manufacturer.

6.2 *Heat Treatment*—Each grade and class shall be heat treated as prescribed in Table 4.

7. Chemical Composition

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

8. Mechanical Properties

8.1 *Tension Test:*

8.1.1 *Requirements*—Bolting material in each heat-treatment charge shall conform to the room-temperature tensile requirements in Table 5.

8.1.2 *Number of Specimens:*

8.1.2.1 *Heat-Treated Bars*—When not more than two sizes of bars are heat treated in the same load, one tension test shall be made from each size in each heat of material in the heat-treatment charge (see 3.1.1). When more than two sizes of bars are treated in the same charge, one tension test shall be made from one bar of each of the two largest diameters from each heat of material in the heat-treating charge.

8.1.2.2 *Finished Bolting Components*—One tension test shall be made if the lot consists of parts of the same nominal diameter. If the lot consists of components of more than one nominal diameter, one tension test shall be made from each nominal diameter of each heat involved in the lot (see Section 3).

8.2 *Stress-Rupture Test:*

8.2.1 *Requirements*—Bolting material shall conform to the stress-rupture requirements prescribed in Table 6 for design temperatures above 800 °F [427 °C]. Bolting material not stress-rupture tested shall be permanently stamped NR. Grade 660 Class D and Grade 668 do not require stress-rupture and shall be stamped NR.

8.2.2 The number of specimens shall be the same as the required number of tension test specimens.

8.2.3 The test location and orientation shall be the same as that required for the tension test specimens.

8.2.4 *Test Method:*

8.2.4.1 The rupture test shall be performed in accordance with Practice E139.

NOTE 1—Fig. 1 is taken from Test Method E292. This is to facilitate detection of notch sensitivity. The specimen found in Practice E139 does not include a notch. The specimen in Fig. 1 is to be used only to determine if the material is notch sensitive. Actual testing is to Practice E139, not Test Method E292, so the additional test data required by Test Method E292 is not to be determined or reported.

8.2.4.2 A combination smooth and notched test specimen, machined to the dimensions prescribed in Fig. 1 and Table 7, shall be tested in accordance with the stress-rupture requirements prescribed in Table 6. The test shall be continued to rupture. The rupture shall occur in the smooth section of the bar.

8.2.4.3 As an alternative procedure and, when specifically approved by the purchaser, separate smooth and notched test specimens, machined from adjacent sections of the same piece, with gage sections conforming to the respective dimensions of Table 7, may be tested under the above conditions. The notched specimen need not be tested to rupture but shall not rupture in less time than the companion smooth specimen.

8.2.4.4 When the minimum specified time to rupture in Table 6 has been achieved, incremental loading may be used to accelerate the time to rupture. At intervals of 8 to 16 h, preferably 8 to 10 h, the stress shall be increased in increments of 5000 psi [34.5 MPa]. Rupture location, and elongation requirements shall be as prescribed in Table 6, 8.2.4.2, and 8.2.4.3.

8.3 *Hardness Test:*

8.3.1 *Requirements*—Bolting material shall conform to the room temperature hardness requirements prescribed in Table 5.

8.3.2 *Number of Tests:*

TABLE 3 Chemical Requirements

	Grade 660		Grade 651	
UNS Number	S66286		S63198	
	Content, %	Product Analysis Variation, Over or Under, %	Content, %	Product Analysis Variation, Over or Under, %
Carbon	0.08 max	0.01 over	0.28–0.35	0.02
Manganese	2.00 max	0.04	0.75–1.50	0.04
Phosphorus	0.040 max	0.005 over	0.040 max	0.005 over
Sulfur	0.030 max	0.005 over	0.030 max	0.005 over
Silicon	1.00 max	0.05	0.30–0.80	0.05
Nickel	24.0–27.0	0.20	8.0–11.0	0.15
Chromium	13.5–16.0	0.20	18.0–21.0	0.25
Molybdenum	1.00–1.50	0.05	1.00–1.75	0.05
Tungsten	...	...	1.00–1.75	0.05
Titanium	1.90–2.35	0.05	0.10–0.35	0.05 over
Columbium[A]	...	...	0.25–0.60	0.05
Aluminum	0.35 max	0.05 over	...	...
Vanadium	0.10–0.50	0.03	...	...
Boron	0.001–0.010	0.0004 under to 0.001 over	...	...
Copper	...	...	0.50 max	0.03 over

	Grade 662		Grade 665	
UNS Number	S66220		S66545	
	Content, %	Product Analysis, Variation Over or Under, %	Content, %	Product Analysis Variation, Over or Under, %
Carbon	0.08 max	0.01 over	0.08 max	0.01 over
Manganese	0.40–1.00	0.03	1.25–2.00	0.04
Phosphorus	0.040 max	0.005 over	0.040 max	0.005 over
Sulfur	0.030 max	0.005 over	0.030 max	0.005 over
Silicon	0.40–1.00	0.05	0.10–0.80	0.05
Nickel	24.0–28.0	0.20	24.0–28.0	0.20
Chromium	12.0–15.0	0.15	12.0–15.0	0.15
Molybdenum	2.0–3.5	0.10	1.25–2.25	0.10
Titanium	1.80–2.10	0.05	2.70–3.3	0.05
Aluminum	0.35 max	0.05 over	0.25 max	0.05 over
Copper	0.50 max	0.03 over	0.25 max	0.03 over
Boron	0.001–0.010	0.0004 under to 0.001 over	0.01–0.07	0.005

	Grade 668	
UNS Number	S66285	
	Content, %	Product Analysis, Variation Over or Under, %
Carbon	0.08 max	0.01 over
Manganese	2.00 max	0.04
Phosphorus	0.040 max	0.005 over
Sulfur	0.030 max	0.005 over
Silicon	1.00 max	0.05
Nickel	17.5 – 21.5	0.20
Chromium	13.5–16.0	0.20
Molybdenum	1.50 max	0.05
Tungsten	...	...
Titanium	2.2–2.8	0.05
Columbium[A]	...	...
Aluminum	0.50 max	0.05 over
Vanadium	0.50 max	0.03
Boron	0.001–0.010	0.0004 under to 0.001 over
Copper	...	...

[A] Or columbium plus tantalum.