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~~An American National Standard~~ Designation: A 453/A 453M – 02

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

This standard is issued under the fixed designation A 453/A 453M; 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.

~~ε[1] NOTE—4.1.3 and 8.1 were editorially corrected August 2001.~~

1. Scope*

1.1 This specification[2] covers four grades of bolting materials with nine classes of yield strength ranging from 50 to 120 ksi [345 to 827 MPa] for use in high-temperature service such as fasteners for pressure vessel and valve flanges. The material requires special processing and is not intended for general purpose applications. The term "bolting material," as used in this specification, covers rolled, forged, or hot-extruded bars; bolts, nuts, screws, washers, studs, and stud bolts. Headed bolts and rolled threads may be supplied.

NOTE 1—Other bolting materials are covered by Specification A 193/A 193M and Specification A 437/A 437M.

1.2 Supplementary Requirement S 1 of an optional nature is provided. This shall apply only when specified by the purchaser in the order.

1.3 This specification is expressed in both inch-pound units and in SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.4 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:*

A 193/A 193M Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service[3]

A 437/A 437M Specification for Alloy-Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service[3]

A 962/A 962M Specification for Steel Fasteners or Fastener Materials, or Both, Intended for Use at Any Temperature from Cryogenic to the Creep Range[3]

E 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bolting material*—this covers rolled, forged, or hot-extruded bars; bolts, nuts, screws, washers, studs, and stud bolts; and also includes those manufactured by upset heading or roll threading techniques.

3.1.2 *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.

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

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[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 Valves, Fittings, Bolting, and Flanges for High and Subatmospheric Temperatures.~~

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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] *Annual Book of ASTM Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 03.01.

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

TABLE 4 1 Chemontical Reqnuious Heat-Treatment Charge Sizes

GrDiade 660	Grade 651	
UNS NumberS66286	S63198	
UNS NumeterS66286	S63198	
-	Content, %	Product Analysis Variation, Over or Under, %
, in. [mm]	Went, %	Product Analysight, Over or Under, %
Carbon	0.08 max	0.01 over
To 1¾ [44]	3008 max	0 [1 over
Manganese	2.00 max	0.04
Over 1¾ [44] to 2½ [63]	600 max	0.04
Phosphorus	0.040 max	0.005 over
Over 2½ [63]	0.040 max	0.005 over
Sulfur	0.030 max	0.005 over
Silicon	1.00 max	0.05
Nickel	24.0–27.00.20	8.0–11.0
Nickel	2000.20	8.0–11.0
Molybdenum	1.00–1.50	0.05
Tungsten	...	...
Titanium	1.90–2.35	0.05
Columbium[A]	...	...
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 0001 over
Copper	...	...

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

[A] Or columbium plus tantalum.

4. Ordering Information

4.1 The inquiry and order shall indicate the following:
4.1.1 Quantity (weight or number of pieces),
4.1.2Type of material (bars, bolts, nuts, etc.),
4.1.3Grade and class (see Table 4),
4.1.2 Description of material (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 7.2.4.3),
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,
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 (see 7.2.1).

5. Common Requirements

5.1 Material and fasteners supplied to this specification shall conform to the requirements of Specification A 962/A 962M.

TABLE 3 2 Hea Lot Treatment Requ SirzementsA

GrDiadmeter, in. [mm]	ClMass	Solutximum Lon Treatment
660	A	1650±25°F [900 ± 14°C], hold 2 h, min, and liquid que
1½ [38] and under	A	1650±200 ± 14°C], hold 2 h, min, and liquid quenc
	B	1800 ± 25°F [980 ±14°C], hold 1 h, min, and liquid qu
Over 1½ [38] to 1¾ [44], incl	B	18300 [14°C], hold 1 h, min, and liquid quench
	C	1800 ± 25°F [980 ± 14°C], hold 1 h min, and oil que
Over 1¾ [44] to 2½ [63], incl	C	18600 [980 ± 14°C], hold 1 h min, and oil quench
651	A	
Over 2½ [63]	A	
	B	
662	A	1800± 25°F [980 ± 14°C], hold 2 h, liquid quench
	B	1950 ± 25°F [1065 ± 14°C], hold 2 h, liquid quenc
665	A	1800± 25°F [980 ± 14°C], hold 3 h, liquid quench
	B	2000 ± 25°F [1095 ± 14°C], hold 3 h, liquid quenc

[A]Times refer to the minimum time material is required to be at temperature.

These requirements include test methods, finish, thread dimensions, marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification A 962/A 962M constitutes nonconformance with this specification. In case of conflict between the requirements of this specification and Specification A 962/A 962M, this specification shall prevail.

6. Materials and Manufacture

6.1 *Finishing Process*:

6.1.1 Threads may be performed by machining or rolling. For Type 1 bolting, threading shall be performed after precipitation heat treatment. Types M1 and M2 bolting shall have machine cut threads. For Types 2 R1 and R2, bolting shall have rolled threads. Types R1 and M1 bolting, threading shall be threaded performed after precipitation heat treatment. Types R2 and M2 bolting shall be threaded after solution heat treatment 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 34.

7. Mechanical Properties

7.1 *Tension Test*:

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

7.1.2 *Number of Specimens*:

7.1.2.1 *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 3.1.2). 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.

7.1.2.2 *Finished Parts*—One tension test shall be made if the lot consists of parts of the same nominal diameter. If the lot consists of parts 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).

7.1.2.3 The diameter range shall be in increments of ½ in. [12.5 mm].

7.2 *Stress-Rupture Test*:

7.2.1 *Requirements*—The material shall conform to the stress-rupture requirements prescribed in Table 6 for design temperatures above 800°F [427°C]. Material not stress-rupture tested shall be permanently stamped NR.

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

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

7.2.4 *Test Method*:

7.2.4.1 The rupture test shall be performed in accordance with Practice E 139.

7.2.4.2 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.

TABLE 5 3 Mee Chanemical Property Requirements

Grade		Grade 660		Tensile St Gradength, 651
UNS Numinber		Yield Strength (0.662 % Offset), min		
ksi	MPa Content, %	k Product Analysis Variation, Over or Under, %	MPa Content, %	Elongation in 4× Diam[A], min, % Reduction of Are
660	A, B, and C	130	895	850.02
Carbon	0.08 max	0.01 over	0.28–0.35	0.02
Manganese	585	15	18	248–341
Manganese	2.00 max	0.04	0.75–1.50	0.04
	99 HRB[B]	37 HRC 0.005 over	0.040 max	0.005 over
Phosphorus	0.040 max	0.005 over	0.040 max	0.005 over
651	A	100	690	70C.005 over
Sulfur	0.030 max	0.005 over	0.030 max	0.005 over
Silicon	485	18	35	217–2770.05
Silicon	1.00 max	0.05	0.30–0.80	0.05
Nickel	95 HRB	29 HRC 0	8.0–11.0	0.15
Nickel	24.0–27.0	0.20	8.0–11.0	0.15
				60D.25
Chromium	13.5–16.0	0.20	18.0–21.0	0.25
Molybdenum	415			0.05
Molybdenum	1.00–1.50	0.05	1.00–1.75	0.05
Tungsten		...	1.00–1.75	0.05
Tungsten	...	...	1.00–1.75	0.05
	B	95	655	60.05 over
Titanium	1.90–2.35	0.05	0.10–0.35	0.05 over
Columbium[C]	415	18	35	212–2690.05
Columbium[A]	...	...	0.25–0.60	0.05
Aluminum	93 HRB	28 HRC[E] 0.05 over	...	...
Aluminum	0.35 max	0.05 over	...	...
				50[D] ...
Vanadium	0.10–0.50	0.03	...	...
Boron	345			
Boron	0.001–0.010	0.0004 under to	...	...
		0.001 over		
662	A	130	895	80.03 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, %
585	15	18	255–321	100 HRB[B] 1 over
Carbon	0.08 max	0.01 over	0.08 max	0.01 over
Manganese	0.40–1.00	0.03	5 HRC[E] 2.00	0.04
Manganese	0.40–1.00	0.03	1.25–2.00	0.04
	B	125	860	80.005 over
Phosphorus	0.040 max	0.005 over	0.040 max	0.005 over
Sulfur	550	15	18	248–3210.005 over
Sulfur	0.030 max	0.005 over	0.030 max	0.005 over
Silicon	99 HRB	35 HRC	0.10–0.80	0.05
Silicon	0.40–1.00	0.05	0.10–0.80	0.05
665	A	170	1170	120
Nickel	24.0–28.0	0.20	24.0–28.0	0.20
	830	12	15	311–3885
Chromium	12.0–15.0	0.15	12.0–15.0	0.15
Molybdenum	32 HRC	41 HRC 0	1.25–2.25	0.10
Molybdenum	2.0–3.5	0.10	1.25–2.25	0.10
	B	155	1070	120.05
Titanium	1.80–2.10	0.05	2.70–3.3	0.05
Aluminum	830	12	15	311–3880.05 over
Aluminum	0.35 max	0.05 over	0.25 max	0.05 over
Copper	32 HRC	0.03 over	0.25 max	0.03 over
Copper	0.50 max	0.03 over	0.25 max	0.03 over
Boron	0.001–0.010	0.0004 under to	0.01 HRC–0.07	0.005
Boron	0.001–0.010	0.0004 under to 0.001 over	0.01–0.07	0.005

[A] See Fig. 6 of Test Methods and Definitions A370.
[B] Conve Orsi con nlumbers taken from Test Methods and Definitions A370, Table 3D.
[C] Material sizes 3 in. [76 mm] and under in diameter.
[D] Materia pl sizes over 3 in. [76 mm] in diameter.
[E] Conversion numbers taken from Specification A193/A193M, Table 2 (austenitic steels); others by interpolation m.