



# Standard Specification for High-Temperature Bolting Materials, with Expansion Coefficients Comparable to Austenitic Stainless Steels<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

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<sup>ε1</sup> NOTE—4.1.3 and 8.1 were editorially corrected August 2001.

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## 1. Scope

1.1 This specification<sup>2</sup> 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<sup>3</sup>](#)

A 437/A 437M [Specification for Alloy-Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service<sup>3</sup>](#)

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<sup>3</sup>](#)

E 139 [Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials<sup>4</sup>](#)

## 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.

## 4. Ordering Information

4.1 The inquiry and order shall indicate the following:

4.1.1 Quantity (weight or number of pieces),

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<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 Valves, Fittings, Bolting, and Flanges for High and Subatmospheric Temperatures.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code Applications see related Specification SA-453 in Section II of that Code.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.01.

**TABLE 1 Continuous Heat-Treatment Charge Sizes**

Diameter, in. [mm]	Weight, lb [kg]
To 1¼ [44]	3000 [1400]
Over 1¼ [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 1¼ [44], incl	300 [140]
Over 1¼ [44] to 2½ [63], incl	600 [270]
Over 2½ [63]	20 pieces

- 4.1.2 Type of material (bars, bolts, nuts, etc.),  
4.1.3 ~~Grade and class,~~  
4.1.3 Grade and class (see Table 4),  
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. 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 3.

**TABLE 3 Heat Treatment Requirements<sup>A</sup>**

Grade	Class	Solution Treatment	Hardening Treatment
660	A	1650 ± 25°F [900 ± 14°C], hold 2 h, min, and liquid quench	1325 ± 25°F [720 ± 14°C], hold 16 h, air cool
	B	1800 ± 25°F [980 ± 14°C], hold 1 h, min, and liquid quench	1325 ± 25°F [720 ± 14°C], hold 16 h, air cool
	C	1800 ± 25°F [980 ± 14°C], hold 1 h min, and oil quench	1425 ± 25°F [775 ± 14°C] hold 16 h, air cool 1200 ± 25°F [650 ± 14°C] hold 16 h, air cool
651	A		hot-cold worked at 1200°F [650°C] min with 15 % min reduction in cross-sectional area, stress-relief anneal at 1200°F [650°C] min or 4 h, min
	B		hot-cold worked at 1200°F [650°C] min with 15 % min reduction of cross-sectional area, stress-relief anneal at 1350°F [730°C] min for 4 h, min
662	A	1800 ± 25°F [980 ± 14°C], hold 2 h, liquid quench	1350 to 1400°F [730 to 760°C], hold 20 h, furnace cool to 1200 ± 25°F [650 ± 14°C], hold 20 h, air cool
	B	1950 ± 25°F [1065 ± 14°C], hold 2 h, liquid quench	1350 to 1400°F [730 to 760°C], hold 20 h, furnace cool to 1200 ± 25°F [650 ± 14°C], hold 20 h, air cool
665	A	1800 ± 25°F [980 ± 14°C], hold 3 h, liquid quench	1350 to 1400°F [730 to 760°C], hold 20 h, furnace cool to 1200 ± 25°F [650 ± 14°C], hold 20 h, air cool
	B	2000 ± 25°F [1095 ± 14°C], hold 3 h, liquid quench	1350 to 1400°F [730 to 760°C], hold 20 h, furnace cool to 1200 ± 25°F [650 ± 14°C], hold 20 h, air cool

<sup>A</sup> Times refer to the minimum time material is required to be at temperature.

**TABLE 4 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 <sup>A</sup>	...	...		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

<sup>A</sup> Or columbium plus tantalum.

## 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.

**TABLE 5 Mechanical Property Requirements**

Grade	Class	Tensile Strength, min		Yield Strength (0.2 % Offset), min		Elongation in 4× Diam <sup>A</sup> , min, %	Reduction of Area, min, %	Brinell Hardness Number	Approximate Rockwell Hardness, B and C	
		ksi	MPa	ksi	MPa				min	max
660	A, B, and C	130	895	85	585	15	18	248–341	99 HRB <sup>B</sup>	37 HRC
651	A	100	690	70 <sup>C</sup>	485	18	35	217–277	95 HRB	29 HRC
				60 <sup>D</sup>	415					
662	B	95	655	60 <sup>C</sup>	415	18	35	212–269	93 HRB	28 HRC <sup>E</sup>
				50 <sup>D</sup>	345					
				85	585					
665	A	130	895	85	585	15	18	255–321	100 HRB <sup>B</sup>	35 HRC <sup>E</sup>
	B	125	860	80	550	15	18	248–321	99 HRB	35 HRC
665	A	170	1170	120	830	12	15	311–388	32 HRC	41 HRC

<sup>A</sup> See Fig. 6 of Test Methods and Definitions A 370.

<sup>B</sup> Conversion numbers taken from Test Methods and Definitions A 370, Table 3D.

<sup>C</sup> Material sizes 3 in. [76 mm] and under in diameter.

<sup>D</sup> Material sizes over 3 in. [76 mm] in diameter.

<sup>E</sup> Conversion numbers taken from Specification A 193/A 193M, Table 2 (austenitic steels); others by interpolation.