~~Designation:A 453/A453M–99~~ Designation: A 453/A 453M – 00

An American National Standard

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.

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]

~~A370Test Methods and Definitions for Mechanical Testing of Steel Products~~

~~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]

~~E30Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron~~

~~E59Practice for Sampling Steel and Iron for Determination of Chemical Composition~~

~~E~~ 139 Practice for Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

~~2.2 *ANSI Standards:*~~

~~B1.1Unified Screw Threads~~

~~B18.2.1 Square and Hex Bolts and Screws Including Hex Cap Screws and Lag Screws~~

~~B18.2.2 Square and Hex Nuts~~

~~B18.3Hexagon Socket and Spline Socket Screws~~

~~2.3 *AIAG Standard:*~~

~~B-5 02.00 Primary Metals Identification Tag Application Standard~~ [4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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[1] This specification is under the jurisdiction of ASTM Committee ~~A-1~~ 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.

Current edition approved March 10, ~~1999.~~2000. Published May ~~1999.~~2000. Originally published as A 453 – 61 T. Last previous edition ~~A453/A453M–96ε1~~. A 453/A 453M – 99.

[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 01.03.~~, Vol 03.01.

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),

4.1.2 Type of material (bars, bolts, nuts, etc.),

4.1.3 Grade and class,

4.1.4 Method of finishing (see ~~5.2~~6.1),

4.1.5 Type of thread desired (see ~~5.2.2~~6.1.1),

4.1.6 Alternative test method option (see 7.2.4.3),

~~4.1.7Bolt shape option, if any (see 8.2),~~

~~4.1.8Thread option, if any (see 8.3),~~

~~4.1.9Test method for surface quality, if any (see 10),~~

~~4.1.10Test location option, if any (see 11),~~

~~4.1.11Rejection option, if any (see 12.1), and~~

~~4.1.12If stress-rupture testing is not required (see~~

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

~~5.1*Melting Process*:~~

~~5.1.1The material shall be made by one or more of the following processes: electric-furnace, induction furnace, or consumable-electrode practice.~~

~~5.1.2Vacuum, protective atmospheres, or protective slags may be used during melting or pouring of the heat.~~

~~5.2~~

6.1 *Finishing Process*:

~~5.2.1The product shall be hot finished or cold finished (ground, rough turned or cold drawn) as specified on the purchase order.~~

~~5.2.2~~

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.

~~5.3~~

TABLE ~~2~~ 1 ~~L~~ Continuous Heat-Treatment Charge Sizes

Diameter, in. [mm]	~~Max~~Wei~~mum Log~~ht ~~Size~~, lb [kg]
~~1½ [38] and under~~	~~200 [90]~~
~~Over 1½ [38] to 1¾ [44], incl~~	~~300 [140]~~
To 1¾ [44]	3000 [1400]
~~Over 1¾ [44] to 2½ [63], incl~~	~~600 [270]~~
Over 1¾ [44] to 2½ [63]	6000 [2700]
~~Over 2½ [63]~~	~~20 pieces~~
Over 2½ [63]	12000 [5400]

TABLE 9 2 Permissible Variati Lons int Size of Cold-Finished Bars

SpecDified Size, in. [amm]	Permissible Variations from Specified Sizer, in. [mm]A	
	Over	Under
	Maximum Lot Sizer	Under, lb [kg]
Over½ to 1[13 to 25],excl	0.002 [0.05]	
1½ [38] and under	200 [90]	
	0.002 [0.05]	
Over 1½ [38] to 1¾ [44], incl	300 [140]	
1¾ to 1½ [25 to38], excl	0.0025 [0.06]	0.0025 [0.06]
Over 1¾ [44] to 2½ [63], incl	6]	00 [270]
1½ to 4[38 to 100], inclB	0.003 [0.08]	0.003 [0.08]
Over 2½ [63]	20.003 [0.08]	0.003 [0.08] pieces

A When it is necessary to heat treat or heat treat and pickle after cold finishing, because of special hardness or mechanical property requirements, the permissible variations are generally double those shown in the table.

B For size tolerances of sizes over 4 in. [100 mm], the manufacturer should be consulted.

6.2 *Heat Treatment*—Each grade and class shall be heat treated as prescribed in Table 3.

6.Chemical Composition

6.1*Heat Analysis*—An analysis of each heat of steel shall be made by the manufacturer to determine the percentages of the elements specified in Table 4 . This analysis shall be made from a test sample taken during the pouring of the heat. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Table 4.

6.1.1Steels with added lead shall not be used.

6.2*Product Analysis*:

6.2.1A product analysis may be made by the purchaser from tension samples representing the bolting material.

6.2.2Samples for chemical analysis, except for spectro-chemical analysis, shall be taken in accordance with Practice E59. The chemical composition thus determined shall conform to the requirements for product analysis variation as specified in Table 4.

6.2.3A product analysis shall be made by the manufacturer of bar stock made from vacuum-arc remelted steel.

TABLE 3 Heat Treatment RequirementsA

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
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
	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
	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
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
	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
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
	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
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
	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

A 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, %~~	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~~ 0.001 over	...	...
Copper	...	...	0.50 max	0.03 over

–	~~Grade 662~~		~~Grade 665~~	
	Grade 662		Grade 665	
UNS Number	S66220		S66545	
~~Content, %~~ –		~~Product Analysis, Variation Over or Under, %~~	~~Content, %~~	~~Product Analysis Variation, Over or Under, %~~
–	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~~ 0.001 over	0.01–0.07	0.005

[A] ~~Or columbium plus tantalum.~~

~~6.3*Methods of Analysis*—For referee purposes, Test Methods E30 shall be used.~~

7. Mechanical Properties

7.1 *Tension Test*:

7.1.1 *Requirements*~~—The material shall conform to the room-temperature tensile in each heat-treatment charge (see 3).~~ —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 3).

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

~~7.1.2.4Tension tests are not required on finished parts that are fabricated from heat-treated bars furnished in accordance with the requirements of this specification and tested in accordance with 7.1.2.1, provided they are not given a subsequent heat treatment.~~

~~7.1.3*Test Location and Orientation*— Specimens shall be taken in accordance with Test Methods and Definitions A370, Annex A1, from the bar stock used to make the product.~~

~~7.1.4*Test Methods*:~~