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StandardSpecification for Precipitation-Hardening Bolting (UNS N07718) for High Temperature Service[1]

This standard is issued under the fixed designation A1014/A1014M; 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.

1. Scope*

1.1 This specification covers precipitation hardening bolting material (UNS N07718) and bolting components for high temperature service. See Specification A962/A962M for the definition of "bolting."

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 only apply when specified individually in the purchase order or contract.

1.4 This specification is expressed in both inch-pound and in SI units. However, unless the purchase order or contract specifies the applicable M 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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

B637 Specification for Precipitation-Hardening and Cold Worked Nickel Alloy Bars, Forgings, and Forging Stock for Moderate or High Temperature Service

B880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys and Cobalt Alloys

E112 Test Methods for Determining Average Grain Size

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

2.2 *ASME Standards:*[3]

B1.1 Screw Threads

2.3 *SAE Standards:*[4]

AS 7467 Bolts And Screws, Nickel Alloy, UNS N07718 Tensile Strength 185 KSI [1275 MPa] Stress Rupture Rated Procurement Specification

3. Ordering Information

3.1 *Ordering*—It shall be the responsibility of the purchaser to specify all requirements that are necessary for product under this specification including any supplementary ones and those included in the ordering information required by Specification A962/A962M.

4. Common Requirements

4.1 *Common Requirements*—Bolting material and bolting components furnished to this specification shall conform to Specification A962/A962M, including any supplementary requirements indicated on the purchase order. Failure to comply with Specification A962/A962M constitutes non-conformance with this specification. If the requirements of this specification conflict with those of Specification A962/A962M, then the requirements of this specification shall prevail.

5. Manufacture

5.1 *Melting Process*—Bolting material alloy shall be multiple-melted using consumable electrode practice in the

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloysand 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 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.

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

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

remelt cycle or shall be induction melted under vacuum. If consumable electrode re-melting is not performed in vacuum, electrodes produced by vacuum induction melting shall be used.

5.2 *Heat Treatment:*

5.2.1 *Solution Treatment*—Bolting material shall be solution heat treated at a temperature within the range of 1725 to 1850 °F [940 to 1010 °C], held at the selected temperature for a time commensurate with cross-sectional thickness, and cooled at a rate equivalent to an air cool or faster.

5.2.1.1 *Temperature Variation*—Solution treating temperatures shall be controlled in the range of ± 25 °F [± 14 °C].

5.2.2 *Precipitation Heat Treatment*—Bolting material shall be heated to 1325 °F [720 °C], held at temperature for eight hours minimum, furnace cooled to 1150 °F [620 °C] at 100 °F [55 °C] per hour, held at temperature for eight hours, and cooled to room temperature. Alternatively, bolting material may be furnace cooled to 1150 °F [620 °C] at any rate provided the time at 1150 °F [620 °C] is adjusted so the total precipitation heat treatment time is 18 hours minimum.

5.2.2.1 *Temperature Variation*—Precipitation treatment temperatures and cooling rates shall be controlled in the range of ± 15 °F [± 8 °C].

5.3 *Straightening*—When straightening is necessary it shall be done after solution treating and prior to aging. Straightening after aging is prohibited.

5.4 *Threads*—Threads shall be formed by rolling in one pass after oxides have been removed from the area to be threaded.

5.5 *Dimensions and Tolerances, Bolting*—Fully heat treated bolting material shall meet the dimensional requirements of Specification B637 for UNS N07718.

6. Chemical Composition

6.1 *Remelt Ingots*—The chemical analyses of each remelted ingot used for bolting material shall conform to the requirements for chemical composition prescribed in Table 1.

TABLE 1 Chemical Requirements

Element	UNS N07718 (Formerly Grade 718)
Carbon, max.	0.08
Manganese, max.	0.35
Silicon, max.	0.35
Phosphorus, max.	0.015
Sulfur, max.	0.015
Chromium	17.0–21.0
Cobalt, max.[A]	1.0
Molybdenum	2.80–3.30
Columbium +	4.75–5.50
Tantalum	. . .
Titanium	0.65–1.15
Aluminum	0.20–0.80
Boron, max.	0.006
Iron[B]	Remainder
Copper, max.	0.30
Nickel[C]	50.0–55.0

[A] If determined.
[B] Determined arithmetically by difference.
[C] Nickel + Cobalt.

6.2 *Product Analysis*—If a product (check) analysis is performed by the purchaser, the bolting material shall conform to the product (check) analysis variations prescribed in Specification B880.

7. Mechanical Properties

7.1 *Tensile and Hardness*—All testing shall be performed after aging. The test specimens shall meet the requirements of Table 2.

7.2 *Stress Rupture*—Stress rupture testing shall be conducted in accordance with Table 2 using a combination test bar in accordance with Test Methods E292. Rupture must occur in the smooth section of each test specimen.

7.3 *Headed Bolting Components*—In addition to 7.1 and 7.2, headed bolting components such as bolts, studs, or screws with a body length three times the diameter of the component or longer shall be subjected to full size tensile test in accordance with Annex A3 of Test Methods and Definitions A370 and shall conform to the tensile strength shown in Table 2. The minimum full size breaking strength (lbf) for individual sizes shall be as follows:

$$Ts = UTS \times As \quad (1)$$

where:

Ts = tensile strength,
UTS = tensile strength specified in Table 2, and
As = stress area, square inches [square millimetres], as shown in ASME B1.1 or calculated as follows:

$$As = 0.785\,(D - (0.974/n))^2 \quad (2)$$

where:

D = nominal thread size, and
n = the number of threads per inch.

$$[As = 0.785\,(D - 0.9382P)^2] \quad (3)$$

[where:

D = Nominal thread size, and
P = Thread pitch, mm.]

8. Metallography

8.1 *Microstructure*—The microstructure of the bolting material shall be free of freckles, white spots, and Laves phases.

TABLE 2 Mechanical Properties

Tensile and Hardness	
Tensile strength, min, ksi [Mpa]	185 [1275]
Yield Strength, min, ksi, [Mpa] 0.2 % offset	150 [1035]
Elongation in 2 in., or 50 mm (or 4D) min %	12
Reduction of area, min, %	15
Hardness, Brinell	331–444
Stress Rupture Requirements	
Temperature, °F [°C]	1200 [650]
Stress, ksi [Mpa]	100 [690]
Hours, min	23
Elongation in 2 in., or 50 mm (or 4D), min %	5
Elevated Tensile Requirements	
Temperature, °F [°C]	1200 [650]
Tensile strength, min, ksi [Mpa]	145 [1000]
Yield Strength, min, ksi, [Mpa] 0.2 % offset	125 [860]
Elongation in 2 in., or 50 mm (or 4D) min %	12
Reduction of area, min, %	15