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Standard Specification for Precipitation-Hardening Bolting Material (UNS N07718) for High Temperature Service[1]

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1. Scope*

1.1 This specification covers a precipitation hardening bolting material (UNS N07718) for high temperature service.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

B 637 Specification for Precipitation-Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High-Temperature Service

B 880 Specification for General Requirements for Chemical Check Analysis Limits for Nickel, Nickel Alloys, and Cobalt Alloys

E 112 Test Methods for Determining the Average Grain Size

E 292 Test Methods for Conducting Time-For-Rupture Notch Tension Tests of Materials

2.2 *ANSI Standards:*

B1.1 Screw Threads[3]

2.3 *SAE Standards:*

AS 7467 Bolts And Screws, Nickel Alloy, UNS N07718 Tensile Strength 185 KSI Stress Rupture Rated Procurement Specification[4]

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 A 962/A 962M.

4. Common Requirements

4.1 *Common Requirements*—Product furnished to this specification shall conform to Specification A 962/A 962M, including any supplementary requirements indicated on the purchase order. Failure to comply with Specification A 962/A 962M constitutes non-conformance with this specification. If the requirements of this specification conflict with those of Specification A 962/A 962M, then the requirements of this specification shall prevail.

5. Manufacture

5.1 *Melting Process*—Alloy shall be multiple melted using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode remelting is not performed in vacuum, electrodes produced by vacuum induction melting shall be used.

5.2 *Heat Treatment*:

5.2.1 *Solution Treatment*—Material shall be solution heat treated at a temperature within the range of 1725 to 1850°F (941 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*—Material shall be heated to a temperature of 1325°F (718°C), held at temperature for eight hours minimum, furnace cooled to 1150°F (621°C) at 100°F (56°C) per hour, held at temperature for eight hours, and cooled to room temperature. Alternatively, material may be furnace cooled to 1150°F (621°C) at any rate provided the time at 1150°F (621°C) is adjusted so the total precipitation heat treatment time is 18 hours minimum.

[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 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 form American National Standards Institute, 11 W. 42 nd St., 13th Floor, New York, NY 10036.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

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

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 Material*—Fully heat treated bolting material shall meet the dimensional requirements of Specification B 637 for UNS N07718.

6. Chemical Composition

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

6.2 *Product Analysis*—If a product (check) analysis is performed by the purchaser, the material shall conform to the product (check) analysis variations prescribed in Specification B 880.

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 E 292. Rupture must occur in the smooth section of each test specimen.

7.3 *Headed Fasteners*—In addition to 7.1 and 7.2, headed fasteners with body length three times the diameter or longer shall be subjected to full size tensile test in accordance with Annex A3 of Test Methods and Definitions A 370 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:

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

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.

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., 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., min %	12
Reduction of area, min, %	15

where:
Ts = tensile strength,
UTS = tensile strength specified in Table 2, and
As = stress area, square inches, as shown in ANSI 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.

8. Metallography

8.1 *Microstructure*—The microstructure shall be free of freckles, white spots, and Laves phases. Threads may show evidence of cold working as a result of rolling. The average grain size shall be determined in accordance with Test Methods E 112 and found to be ASTM No 5 or finer. Up to 20 % of the structure may have a grain size as large as a No. 3 due to the presence of noncrystallized grains.

8.2 *Macrostructure*—Fasteners produced from forgings shall exhibit continuous flow lines in the threads and in any shank to head or fillet and/or bearing surface areas.

9. Number of Tests

9.1 *Chemistry*—One test per remelt ingot.

9.2 *Mechanical Properties*—The number of tests shall be in accordance with Specification A 962/A 962M except that for stress rupture one test shall be run per lot. For headed fasteners with a body length less than three times the diameter a separately forged test bar may be used for tensile and stress rupture testing provided it is heat-treated with the parts. Separately forged bars shall be approximately the same diameter as the headed fastener they represent.

9.3 *Grain Size*—One test per lot.

9.4 *Flow Lines*—One test per lot on forged fasteners after final machining.

9.5 *Headed Fasteners*—One tensile test per lot.

10. Workmanship

10.1 *Bolting Material*—Shall be uniform in quality and condition, smooth, commercially straight or flat, and free of injurious imperfections.