



Designation: A1014/A1014M – 10

Standard Specification for Precipitation-Hardening Bolting (UNS N07718) for High Temperature Service¹

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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This specification covers precipitation hardening bolting (UNS N07718) 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](#)

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.

[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 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*—Alloy shall be multiple melted using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode

³ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three 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

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 [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*—Material shall be heated to a temperature of 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, 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 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 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 **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 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 **A370** and shall conform to the tensile strength shown in **Table 2**. The minimum full size breaking strength (lbf) [Kn] for individual sizes shall be as follows:

$$T_s = UTS \times A_s \quad (1)$$

where:

T_s = tensile strength,

UTS = tensile strength specified in **Table 2**, and

A_s = stress area, square inches [square millimetres], as shown in ASME B1.1 or calculated as follows:

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

where:

D = nominal thread size, and

n = the number of threads per inch.

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

where:

D = Nominal thread size, and

P = Thread pitch, mm.]

8. Metallography

8.1 *Microstructure*—The microstructure 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 **E112** 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 **A962/A962M** 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.

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 + Tantalum	4.75–5.50 ...
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.