



Designation: A1014/A1014M – 16 (Reapproved 2021)

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 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.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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. Referenced Documents

2.1 ASTM Standards:²

[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

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

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 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**.

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

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	...
Aluminum	0.65–1.15
Boron, max.	0.20–0.80
Iron ^B	0.006
Copper, max.	Remainder
Nickel ^C	0.30
	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., 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

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 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:

$$T_s = UTS \times A_s \tag{1}$$

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:

$$A_s = 0.785(D - (0.974/n))^2 \tag{2}$$

where:

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

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

[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. Threads of bolting components 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 non-crystallized grains.

8.2 *Macrostructure*—Bolting components 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 of bolting material.

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 bolting components with a body length less than three times the diameter of the component, a separately forged test bar may be used for tensile and stress rupture testing provided it is heat-treated with the components. Separately forged bars shall be approximately the same diameter as the headed bolting component they represent.

9.3 *Grain Size*—One test per lot.

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

9.5 *Headed Bolting Components*—One tensile test per lot.

10. Bolting Quality, Condition, and Finish

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

10.2 *Bolting Components*—Multiple laps on thread flanks are prohibited. Seams, laps, notches, slivers, or oxide scale in the root area of threads are prohibited. Cracks are prohibited.

11. Product Marking

11.1 *Marking*—Bolting components shall be marked with “718” and the manufacturer’s identification symbol.

12. Certification

12.1 *Report*—In addition to the requirements of A962/A962M, certification shall include the solution treatment cycle time and temperature and the aging cycle time(s) and temperature(s).

13. Keywords

13.1 bolting; bolting materials; bolting components; Inconel 718; nickel alloy; precipitation hardening; temperature service application – high

SUPPLEMENTARY REQUIREMENTS

These requirements do not apply unless specified in the purchase order and in the Ordering Information, in which event the specified tests shall be made before shipment of the product.

S1. Protective Atmosphere

S1.1 Heat treatment shall be performed under suitable protective atmosphere.

S2. Cleaning

S2.1 Bolting components shall be cleaned with nitric acid as stated in AS 7467

S3. Fillet Rolling

S3.1 The fillet area of the head of bolts, screws, or studs shall be rolled.

S4. Forged Heads

S4.1 Heads for bolts, screws, or studs shall be forged.

S5. Marking

S5.1 Marking on bolting components shall include heat lot identification.

S6. Thread Rolling

S6.1 Thread rolling shall be performed before precipitation heat treatment.