Designation: A 638/A 638M – 00 (Reapproved 2004)

Standard Specification for Precipitation Hardening Iron Base Superalloy Bars, Forgings, and Forging Stock for High-Temperature Service[1]

This standard is issued under the fixed designation A 638/A 638M; 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[2] covers hot-finished or cold-finished precipitation hardening iron base superalloy bars, forgings, and forging stock for high-temperature service. The mechanical properties of these alloys are developed by suitable solution treating and precipitation hardening treatments.

1.2 Two grades of iron base alloy are covered. Selection will depend upon design, service conditions, mechanical properties, and elevated temperature characteristics.

1.3 The values stated in either inch-pound units or SI (metric) units are to be regarded separately as standards; within the text and tables, the SI units are shown in [brackets]. The values stated in each system are not exact equivalents; therefore, each system must be used independent of the other. Combining values from the two systems may result in nonconformance with the specification.

1.4 Unless the order specifies an "M" designation, the material shall be furnished to inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 484/A 484M Specification for General Requirements for Stainless Steel Bars, Billets and Forgings

A 751 Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[4]

E 527 Practice for Numbering Metals and Alloys (UNS)

3. Ordering Information

3.1 It is the responsibility of the purchaser to specify all requirements that are necessary for material ordered under this specification. Such requirements may include, but are not limited to, the following:

3.1.1 Quantity (weight or number of pieces),

3.1.2 Name of material (precipitation hardening iron base superalloy),

3.1.3 Form (bars, forgings, and forging stock),

3.1.4 Dimensions (in the case of rough or finished forgings the order shall be accompanied by a print or drawing or otherwise adequately described as to the shape and dimension),

3.1.5 Grade designation (Table 1),

3.1.6 Condition (Section 5),

3.1.7 Finish (Section 3),

3.1.8 Mechanical requirements (Section 8),

3.1.9 ASTM designation, and

3.1.10 Special requirements.

4. General Requirements

4.1 In addition to the requirements of this specification, all requirements of the current edition of Specification A 484/A 484M shall apply. Failure to comply with the general requirements of Specification A 484/A 484M constitutes nonconformance with this specification.

5. Condition

5.1 The product forms covered in this specification may be furnished in one of the following conditions:

5.1.1 Hot-finished,

5.1.2 Solution treated (Grade 660 only—Type 1 or Type 2 solution treatment as specified),

5.1.3 Solution and precipitation treated (Grade 660 only—Type 1 or Type 2 solution treatment as specified), or

5.1.4 Other as specified.

6. Heat Treatment

6.1 Samples cut from bars, forgings, or a sample forged from the forging stock shall conform to the mechanical properties of Table 1 and Table 2 when heat treated as prescribed in Table 3.

6.2 When a sample cut from the forging stock and heat treated as prescribed in Table 2 conforms to the properties in Tables 3 and 4, it shall be accepted as equivalent to a forged coupon.

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[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 A01.17 on Flat-Rolled and Wrought Stainless Steel.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-638 in Section II of that Code.

[3] 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.

[4] Withdrawn.

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TABLE 1 Mechanical Property Requirements

	Grade 660	Grade 662 (bars)	Grade 662 (forgings)[A]
Heat treatment[B]	solution + precipitation harden	solution + precipitation harden	solution + precipitation harden
Tensile strength, min:			
psi	130 000	130 000	125 000
[MPa]	[895]	[895]	[860]
Yield strength (0.2 % offset), min:			
psi	85 000	85 000	80 000
[MPa]	[585]	[585]	[550]
Elongation in 4D min, %	15	15	15
Reduction of area min, %	18	18	18
Brinell hardness	248 min	248 min	248 min

[A] The elongation of tensile specimens machined tangentially from near the center of large disk forgings over 50 in.^{2} [320 cm^2] in cross section may be as low as 10 %. The reduction of area may be as low as 12 %.
[B] Refer to Table 3 of heat treatment.

TABLE 2 Stress-Rupture Requirements

Grade	Heat Treatment[A]	Test Temperature		Stress		Minimum Hours[B]	Minimum Elongation, %
		°F	[°C]	psi	[MPa]		
660	solution + precipitation harden	1200	[650]	65 000	[450]	23	3
662	solution + precipitation harden	1200	[650]	60 000	[415]	15	3

[A] Refer to Table 3 for details of heat treatment.
[B] Test specimens meeting minimum requirements may be overloaded to produce rupture in a reasonable and practical time period.

TABLE 3 Heat Treatment

Grade	Solution Treatment	Precipitation Hardening Treatment[A]
660	Type 1 1650 ± 25°F [900 ± 15°C], hold 2 hr, oil or water quench	1300 to 1400°F [705 to 760°C], hold 16 h, air cool or furnace cool
660	Type 2 1800 ± 25°F [980 ± 15°C], hold 1 h, oil or water quench	1300 to 1400°F [705 to 760°C], hold 16 h, air cool or furnace cool
662	1750 to 1900°F [955 to 1040°C] hold 1 h, min, oil or water quench	1250 to 1400°F [675 to 760°C], hold 5 h, min, slow cooling in 5 h, min to 1200 ± 15°F [650 ± 10°C], hold 20 h, min, air cool or furnace cool

[A] Times refer to the minimum time material is required to be at temperature.

7. Chemical Composition

7.1 The steel shall conform to the requirements for chemical composition specified in Table 4.

7.2 Methods and practices relating to chemical analysis required by this specification shall be in accordance with Test Methods, Practices, and Terminology A 751, except that for remelt material, product analysis tolerances may be used to determine conformance to this specification.

7.3 For referee purposes, Test Methods E 30 shall be used.

7.4 Methods and practices relating to chemical analysis required by this specification shall be in accordance with Test Methods, Practices, and Definitions A 751, except that for remelt material, product analysis tolerances may be used to determine conformance to this specification.

8. Mechanical Properties

8.1 The material shall conform to the mechanical property requirements specified in Table 1 after heat treatment as described in Table 3.

8.2 The material shall meet the requirements as to stress-rupture properties specified in Table 2 at the test temperature indicated after heat treatment as described in Table 3.

8.3 When specified in the ordering information (3.1.8), material may be ordered without stress-rupture testing. Material not stress-rupture tested shall be permanently stamped NR (See Section 10).

9. Metallurgical Properties

9.1 When specified, the grain size shall be 1 or finer.

10. Product Marking

10.1 Unless otherwise specified on the purchase order, each bundle shall be properly tagged with metal tags showing the purchase order number, heat number, name of alloy (or grade), *"NR" when material has not been stress-rupture tested*, specification number, and size.

10.1.1 Bars 1 in. [25 mm] and over in diameter, or 1 in. [25 mm] and over in thickness between parallel sides, shall be stamped with the heat number, *and if not stress-rupture tested, with the letters "NR"* within approximately 2 in. [50 mm] of one end. Smaller sizes shall be boxed or bundled and identified with metal tags as described in 10.1.

10.1.2 Forgings shall be identified as agreed upon between the seller and the purchaser.

11. Keywords

11.1 precipitation hardening superalloy steel; superalloy steel bars; superalloy steel billets; superalloy steel forgings; temperature service applications—high

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TABLE 4 Chemical Requirements

	Grade 660 (UNS S 66286)[A]		Grade 662 (UNS S 66220)[A]	
	Ladle Analysis Range, %	Check Analysis Over or Under	Ladle Analysis Range, %	Check Analysis Over or Under
Carbon	0.08 max	0.01 over	0.08 max	0.01 over
Manganese	2.00 max	0.04 over	1.50 max	0.04
Silicon	1.00 max	0.05 over	1.00 max	0.05
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
Chromium	13.50–16.00	0.20	12.00–15.00	0.15
Nickel	24.00–27.00	0.20	24.00–28.00	0.20
Molybdenum	1.00–1.50	0.05	2.50–3.50	0.10
Titanium	1.90–2.35	0.05	1.55–2.00	0.05
Copper	...	...	0.50 max	0.03 over
Aluminum	0.35 max	0.05 over	0.35 max	0.05 over
Vanadium	0.10–0.50	0.03	...	...
Boron	0.0010–0.010	0.0004 under 0.001 over	0.0010–0.010	0.0004 under 0.001 over

[A] New designation established in accordance with Practice E 527 and SAE J 1086.

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