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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

# AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6544B

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An American National Standard

Superseding AMS 6544A

## PLATE, MARAGING STEEL
## 2.0Cr - 10Ni - 8.0Co - 1.0Mo (0.10 - 0.14C)
## Double Vacuum Melted, Solution Heat Treated

UNS K91970

1. SCOPE:

1.1 Form:

This specification covers a maraging steel in the form of rolled or forged plate.

1.2 Application:

This product has been used typically for heat treated parts requiring a combination of high strength, toughness, and weldability, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2242 Tolerances, Corrosion & Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
MAM 2242 Tolerances, Metric, Corrosion & Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
AMS 2248 Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

2.1 SAE Publications (Continued):

AMS 2370 Quality Assurance Sampling and Testing of Carbon and Low-Alloy Steel, Wrought Products and Forging Stock
AMS 2630 Ultrasonic Inspection, Product Over 0.5 Inch (12.5 mm) Thick
AMS 2807 Identification, Carbon and Low-Alloy Steels, Corrosion and Heat Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 370 Mechanical Testing of Steel Products
ASTM A 604 Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E 353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 399 Plane-Strain Fracture Toughness of Metallic Materials

2.3. U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

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Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

| Element | min | max |
|---|---|---|
| Carbon | 0.10 | 0.14 |
| Manganese | 0.05 | 0.25 |
| Silicon | -- | 0.10 |
| Phosphorus | -- | 0.010 |
| Sulfur | -- | 0.006 |
| Chromium | 1.80 | 2.20 |
| Nickel | 9.50 | 10.50 |
| Cobalt | 7.50 | 8.50 |
| Molybdenum | 0.90 | 1.10 |
| Titanium | -- | 0.015 |
| Aluminum | -- | 0.025 |
| Oxygen | -- | 0.0025 (25 ppm) |
| Nitrogen | -- | 0.0075 (75 ppm) |

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2248. No variation over maximum is permitted for oxygen and nitrogen.

3.2 Condition:

Plate shall be supplied in the following condition:

3.2.1 Rolled Plate: Hot rolled, solution heat treated, and descaled.

3.2.2 Forged Plate: Hot finished, solution heat treated, and descaled.

3.3 Heat Treatment:

Plate shall be solution heat treated as in 3.4.1 or 3.4.2, as applicable, holding at heat for sufficient time to ensure complete transformation, and quenching in agitated water sufficiently cool (See 8.2) to develop the properties specified herein.

3.3.1 Plate 2.0 Inches (51 mm) and Under in Nominal Thickness: Shall be solution heat treated by heating in air to 1525 °F ± 25 (829 °C ± 14) and quenching.

3.3.2 Plate Over 2.0 Inches (51 mm) in Nominal Thickness: Shall be solution heat treated by heating in air to 1650 °F ± 25 (899 °C ± 14), quenching, reheating to 1525 °F ± 25 (829 °C ± 14), and quenching.

3.4 Properties:

Plate shall conform to the following requirements; hardness, tensile, and impact testing shall be performed in accordance with ASTM A 370:

3.4.1 As Solution Heat Treated:

3.4.1.1 Hardness: Shall be not lower than 42 HRC, or equivalent.

3.4.1.2 Macrostructure: Visual examination of transverse sections from slabs, billets, or suitable rerolled product, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 36 square inches (232 $cm^2$) and under in nominal cross-sectional area shall be no worse than the macrographs of ASTM A 604 shown in Table 2. Macrostructure standards for product over 36 square inches (232 $cm^2$) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor.

TABLE 2 - Macrostructure

| Class | Condition | Severity |
|---|---|---|
| 1 | Freckles | B |
| 2 | White Spots | C |
| 3 | Radial Segregation | C |
| 4 | Ring Pattern | D |

3.4.2 After Aging: Plate shall meet the requirements of 3.5.2.1, 3.5.2.2, and 3.5.2.3 after being aged by heating to 950 °F ± 10 (510 °C ± 6), holding at heat for not less than 5 hours for sections 2.0 inches (51 mm) and under in nominal thickness and for 10 hours + 0.5, -0, for thicker sections, and cooling in air.

3.4.2.1 Tensile Properties: Shall be as shown in Table 3.

TABLE 3A - Minimum Tensile Properties

| Nominal Thickness Inches | Tensile Strength ksi | Yield Strength at 0.2% Offset ksi | Elongation in 4D % | Reduction of Area % |
|---|---|---|---|---|
| 0.375 to 2.000, incl | 190 | 180 | 14 | 62 |
| Over 2.000 to 4.000, incl | 190 | 175 | 15 | 60 |
| Over 4.000 to 8.000, incl | 190 | 170 | 15 | 50 |

TABLE 3B - Minimum Tensile Properties, SI

| Nominal Thickness Millimeters | Tensile Strength MPa | Yield Strength at 0.2% Offset MPa | Elongation in 4D % | Reduction of Area % |
|---|---|---|---|---|
| 9.52 to 50.80, incl | 1310 | 1241 | 14 | 62 |
| Over 50.80 to 101.60, incl | 1310 | 1207 | 15 | 60 |
| Over 101.60 to 203.20, incl | 1310 | 1172 | 15 | 50 |

3.4.2.1.2 Tensile properties for plate under 0.375 inch (9.52 mm) or over 8.000 inches (203.20 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.2.2 Impact Strength: Shall be as shown in Table 4.

TABLE 4A - Impact Strength

| Nominal Thickness Inches | Charpy V-Notch at 0°F Foot Pounds |
|---|---|
| 0.500 to 2.000, incl | 60 |
| Over 2.000 to 4.000, incl | 45 |
| Over 4.000 to 8.000, incl | 40 |

TABLE 4B - Impact Strength, SI

| Nominal Thickness Millimeters | Charpy V-Notch at -18°C J |
|---|---|
| 12.70 to 50.80, incl | 81 |
| Over 50.80 to 101.60, incl | 61 |
| Over 101.60 to 203.20, incl | 54 |

3.4.2.2.1 Impact strength for plate under 0.500 inch (12.70 mm) or over 8.00 inches (203.20 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.2.3 Fracture Toughness: Shall be not lower than 175 ksi inch (192 MPa m), determined in either the longitudinal or transverse direction in accordance with ASTM E 399 using the compact tension specimen. Fracture toughness requirements do not apply to plate under 0.500 inch (12.70 mm) in nominal thickness.

3.4.2.3.1 Fracture toughness testing in the longitudinal direction is not required on plate tested in the transverse direction.

3.5 Quality:

3.5.1 Steel shall be multiple melted using vacuum induction melting plus consumable electrode vacuum remelting.

3.5.2 Plate, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.5.3 All plate 0.50 inch (12.7 mm) and over in nominal thickness shall be ultrasonically inspected in accordance with AMS 2630 and shall meet Class AA quality requirements as defined therein. Hot-finished surfaces shall be suitably prepared prior to ultrasonic inspection.

3.6 Tolerances:

Shall conform to all applicable requirements of AMS 2242 or MAM 2242; for sizes not covered therein, tolerances shall be as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

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The vendor of plate shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the plate conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for composition (3.1), hardness (3.4.1.1), macrostructure (3.4.1.2), tensile properties (3.4.2.1), impact strength (3.4.2.2), ultrasonic inspection (3.5.3), and tolerances (3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests for fracture toughness (3.4.2.3) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

Shall be in accordance with the following: