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400 COMMONWEALTH DRIVE WARRENDALE PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 6544A
Superseding AMS 6544

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

1. SCOPE:

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

1.2 Application: Primarily for heat treated parts requiring high strength, toughness, and weldability.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2242 - Tolerances, Corrosion & Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
MAM 2242 - Tolerances, Metric & 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
AMS 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock
AMS 2630 - Ultrasonic Inspection, Product Over 0.5 in. (12.5 mm) Thick

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E353, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	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 max 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 3.3.1 or 3.3.2, 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 In. (50 mm) and Under in Nominal Thickness: Shall be solution heat treated by heating in air to 1525°F ± 25 (830°C ± 15) and quenching.

3.3.2 Plate Over 2.0 In. (50 mm) in Nominal Thickness: Shall be solution heat treated by heating in air to 1650°F ± 25 (900°C ± 15), quenching, reheating to 1525°F ± 25 (830°C ± 15), and quenching.

3.4 Properties: Plate shall conform to the following requirements; hardness, tensile, and impact testing shall be performed in accordance with ASTM A370:

3.4.1 As Solution Heat Treated:

3.4.1.1 Hardness: Shall be not lower than 42 HRC or equivalent.
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3.4.1.2 Macrostructure: Visual examination of transverse sections as in 4.3.1.1 from slabs, billets, or suitable rerolled product, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macro-
ø structure, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections for product 36 sq in. (230 cm^2) and under in nominal cross-sectional area shall be no worse than the following macrographs of ASTM A604. Macrostructure standards for product over 36 sq in. (230 cm^2) in nominal cross-sectional area shall be as agreed upon by purchaser and vendor.

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 3.4.2.1, 3.4.2.2, and 3.4.2.3 after being aged by heating to 950°F ± 10 (510°C ± 5), holding at heat for not less than 5 hr for sections 2.0 in. (50 mm) and under in nominal thickness and for 10 hr + 0.5, -0, for thicker sections, and cooling in air.

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

TABLE I

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
0.375 to 2.000, incl	190,000	180,000	14	62
Over 2.000 to 4.000, incl	190,000	175,000	15	60
Over 4.000 to 8.000, incl	190,000	170,000	15	50

TABLE I (SI)

Nominal Thickness Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
9.50 to 50.00, incl	1310	1240	14	62
Over 50.00 to 100.00, incl	1310	1205	15	60
Over 100.00 to 200.00, incl	1310	1170	15	50

3.4.2.1.2 Tensile properties for plate under 0.375 in. (9.50 mm) or over 8.000 in. (200.00 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 II.

TABLE II

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

TABLE II (SI)

Nominal Thickness Millimetres	Charpy V-Notch at 0°F J
12.50 to 50.00, incl	81
Over 50.00 to 100.00, incl	61
Over 100.00 to 200.00, incl	54

3.4.2.2.1 Impact strength for plate under 0.500 in. (12.50 mm) or over 8.00 in. (200.00 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.2.3 Fracture Toughness: Shall be not lower than 175,000 psi$\sqrt{in.}$ (190 MPa$\sqrt{m}$), determined in either the longitudinal or transverse direction in accordance with ASTM E399 using the compact tension specimen. Fracture toughness requirements do not apply to plate under 0.500 in. (12.50 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 vacuum consumable electrode 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 in. (12.5 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: Unless otherwise specified, tolerances shall conform to the 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: The vendor of plate shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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 to determine conformance to requirements 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 classified as acceptance tests and shall be performed on each heat or lot as applicable.

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

4.3 Sampling: Shall be in accordance with the following:

4.3.1 For Acceptance Tests: Shall be in accordance with AMS 2370. Each plate 0.50 in. (12.5 mm) and over in nominal thickness shall be subjected to ultrasonic inspection.

4.3.1.1 Samples for macrostructure (3.4.1.2) testing shall be full cross-sectional specimens obtained from the finished slab or billet or suitable rerolled product representing the top and bottom of each ingot.

4.3.2 For Periodic Tests: As agreed upon by purchaser and vendor.

4.4 Reports:

4.4.1 The vendor of plate shall furnish with each shipment a report showing the results of tests for chemical composition and macrostructure of each heat, Ø for hardness, tensile, and impact properties of each lot, for ultrasonic soundness of each plate and, when performed, results of tests for fracture toughness. This report shall include the purchase order number, heat number, AMS 6544A, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 6544A, contractor or other direct supplier of plate, part number, and quantity. When plate for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of plate to determine conformance to the requirements of this specification and shall include in the report either a statement that the plate conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Plate shall be identified as in 5.1.1 unless marking as in 5.1.2 is specified. The characters shall be of such size as to be legible, shall be applied using a suitable marking fluid, and shall be removable in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the plate or its performance and shall be sufficiently stable to withstand normal handling. The markings shall be applied parallel to the longitudinal material direction or parallel to the final rolling direction.