SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6544C

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Superseding AMS 6544B

Maraging Steel, Plate
2.0Cr - 10Ni - 8.0Co - 1.0Mo (0.10 - 0.14C)
Double Vacuum Melted, Solution Heat Treated

(Composition similar to UNS K91971)

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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2242	Tolerances, Corrosion & Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
AMS 2248	Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2370	Quality Assurance Sampling and Testing, 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

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS6544C

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or www.astm.org.

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

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

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 Melting Practice:

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

3.3 Condition:

Plate shall be supplied in the following condition:

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

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

3.4 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.

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

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

3.5 Properties:

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

3.5.1 As Solution Heat Treated:

3.5.1.1 Hardness: Shall be not lower than 42 HRC, or equivalent (See 8.3).

3.5.1.2 Macrostructure: Visual examination of transverse full cross 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.

TABLE 2 – Macrostructure Limits

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

3.5.2 After Aging: Specimens from 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 at a rate equivalent to air cooling.

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

TABLE 3A - Minimum Tensile Properties, Inch/Pound Units

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 Units

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

3.5.2.2 Impact Strength: Shall be as shown in Table 4 when tested in the longitudinal direction. Product meeting the requirements of Table 4 when tested in the transverse direction need not be tested in the longitudinal direction.

TABLE 4A - Impact Strength, Inch/Pound Units

Nominal Thickness Inches	Charpy V-Notch at 0 °F Foot Pounds
0.500 to 2.000, incl	65
Over 2.000 to 4.000, incl	45
Over 4.000 to 8.000, incl	40

TABLE 4B - Impact Strength, SI Units

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

3.5.2.3 Fracture Toughness: Shall be not lower than 175 ksi $\sqrt{\text{inch}}$ (192 MPa $\sqrt{\text{m}}$), determined in either the longitudinal (T-L) or transverse (L-T) 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.

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

3.6 Quality:

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.

3.6.1 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.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2242.

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the plate conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Composition (3.1), hardness (3.5.1.1), macrostructure (3.5.1.2), tensile properties (3.5.2.1), impact strength (3.5.2.2), ultrasonic inspection (3.6.1), and tolerances (3.7) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Fracture toughness (3.5.2.3) is a periodic test 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 AMS 2370.

4.4 Reports:

The vendor of plate shall furnish with each shipment a report showing the results of tests for composition and macrostructure of each heat, hardness, tensile, and impact properties of each lot, ultrasonic soundness of each plate and, when performed, results of tests for fracture toughness, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS 6544C, size, and quantity.

4.5 Resampling and Retesting:

Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be in accordance with AMS 2807.

5.2 Protective Treatment:

Plate shall be protected from corrosion prior to shipment.

5.3 Packaging:

Plate shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the plate to ensure carrier acceptance and safe delivery.

6. ACKNOWLEDGMENT:

A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Plate not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of a specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revision. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.