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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6543C

Issued SEP 1975
Revised OCT 2001

Superseding AMS 6543B

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

(Composition similar to UNS K91970)

1. SCOPE:

1.1 Form:

This specification covers a premium aircraft-quality maraging steel in the form of bars 0.50 inch (12.7 mm) and over in nominal diameter or least distance between parallel sides, forgings, and forging stock.

1.2 Application:

These products have 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 canceled 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.

AMS 2248	Chemical Check Analysis Limits, Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
AMS 2251	Tolerances, Low-Alloy Steel Bars
MAM 2251	Tolerances, Metric, Low-Alloy Steel Bars
AMS 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 (Continued):

AMS 2372	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
AMS 2630	Inspection, Ultrasonic, Product Over 0.5 Inch (12.7 mm) Thick
AMS 2750	Pyrometry
AMS 2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
AMS 2808	Identification, Forgings
AS1182	Standard Machining Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

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

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	--	0.04
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 is permitted for oxygen and nitrogen.

3.2 Melting Practice:

Shall be multiple melted using vacuum induction melting followed by vacuum consumable electrode remelting.

3.3 Condition:

The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A 370:

3.3.1 Bars and Forgings: Hot finished, solution heat treated, and descaled, having hardness not lower than 42 HRC, or equivalent (See 8.2).

3.3.2 Forging Stock: As ordered by the forging manufacturer.

3.4 Heat Treatment:

Bars and forgings 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 8.3) to develop the mechanical properties specified herein. Pyrometry shall be in accordance with AMS 2750.

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

3.4.2 Product Over 2.0 Inches (51 mm) in Nominal Section 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.

3.5 Properties:

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

3.5.1 Bars and Forgings:

3.5.1.1 As Solution Heat Treated:

3.5.1.1.1 Macrostructure: Visual examination of transverse full cross-sections from bars, forgings, and forging stock, 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 ASTMA 604 shown in Table 2.

TABLE 2 - Macrostructure Limits

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

3.5.1.2 After Maraging: Bars and forgings shall meet the requirements of 3.5.1.2.1, 3.5.1.2.2, and 3.5.1.2.3 after being aged by heating within the range 900 to 950 °F (482 to 510 °C), holding at the selected temperature within ±10 °F (±6 °C) for not less than 5 hours, and cooling in air.

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

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

Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %	Reduction of Area %
0.500 to 2.000, incl	190	180	12	60
Over 2.000 to 4.000, incl	190	175	12	60
Over 4.000 to 8.000, incl	190	170	10	50

TABLE 3B - Minimum Tensile Properties, SI Units

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %	Reduction of Area %
12.70 to 50.80, incl	1310	1241	12	60
Over 50.80 to 101.60, incl	1310	1207	12	60
Over 101.60 to 203.20, incl	1310	1172	10	50

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

TABLE 4A - Impact Strength, Inch/Pound Units

Nominal Diameter or Least Distance Between Parallel Sides Inches	Charpy V-Notch at 0 °F foot-pounds
0.500 to 2.000, incl	60
Over 2.000 to 4.000, incl	50
Over 4.000 to 8.000, incl	40

TABLE 4B - Impact Strength, SI Units

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Charpy V-Notch at -18 °C Joules
12.70 to 50.80, incl	81.3
Over 50.80 to 101.60, incl	67.8
Over 101.60 to 203.20, incl	54.2

3.5.1.2.3 Fracture Toughness When Specified: Acceptance criteria and method of test shall be as established by purchaser.

3.5.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.4 and 3.5.1.2, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.1.2.1 and 3.5.1.2.2. If specimens taken from the stock after heat treatment as in 3.4 and 3.5.1.2 conform to the requirements of 3.5.1.2.1 and 3.5.1.2.2, the tests shall be accepted as equivalent to tests of a forged coupon.

3.6 Quality:

The product, 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 Bars ordered hot rolled or cold drawn or ground, turned, or polished, shall, after removal of the standard machining allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surfaces.

3.6.2 All product shall be inspected ultrasonically 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.

3.6.3 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of reentrant grain flow.

3.7 Tolerances:

Bars shall conform to all applicable requirements of AMS 2251 or MAM 2251.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of the product 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 product conforms to specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for the following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1) and macrostructure (3.5.1.1.1) of each heat.

4.2.1.2 Hardness (3.3.1) and ultrasonic quality (3.6.2) of each lot of bars and forgings as solution heat treated.

4.2.1.3 Tensile properties (3.5.1.2.1) and impact strength (3.5.1.2.2) of each lot of bars and forgings after maraging.

4.2.1.4 Fracture toughness, when specified, (3.5.1.2.3) of each lot of bars and forgings after maraging.

4.2.1.5 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) to demonstrate ability to develop required properties and grain flow of die forgings (3.6.3) 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 as follows:

4.3.1 Bars and Forging Stock: In accordance with AMS 2370.

4.3.2 Forgings: In accordance AMS 2372.