SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS6543 REV. E

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Superseding AMS6543D

Steel, Bars and Forgings
2.0Cr - 10Ni - 8.0Co - 1.0Mo (0.10 - 0.14C) (HY-180)
Double Vacuum Melted
Solution Heat Treated, Marage Hardenable

(Composition similar to UNS K91970)

RATIONALE

AMS6543E results from a Five Year Review and update of this specification.

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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2248 Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

AMS2251 Tolerances, Low-Alloy Steel Bars

AMS2370 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (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/AMS6543E

AMS2372 Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings

AMS2630 Inspection, Ultrasonic, Product Over 0.5 Inch (12.7 mm) Thick

AMS2750 Pyrometry

AMS2806 Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys

AMS2808 Identification, Forgings

AS1182 Standard Stock Removal Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, 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

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 AMS2248. 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

Bar shall not be cut from plate.

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

3.3.2 Forgings

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

3.3.3 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 AMS2750.

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 shall be no worse than the macrographs of ASTM A 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 Response to Heat Treatment (Maraging) for Bars and Forgings

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 maraged 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

3.5.1.2.1 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

3.5.1.2.2 Fracture Toughness When Specified

Acceptance criteria and method of test shall be as established by purchaser.

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 stock removal allowance in accordance with AS1182, be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

3.6.2 All product shall be inspected ultrasonically in accordance with AMS2630 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 that 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 AMS2251.

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) of each lot of bars and forgings as solution heat treated.

4.2.1.3 Ultrasonic quality (3.6.2) of each bar and forging as solution heat treated.

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

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

4.2.1.6 Tolerances (3.7) of bars.

4.2.2 Periodic Tests

The test for grain flow of die forgings (3.6.3) 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

4.3.1 Bars and Forging Stock

In accordance with AMS2370.

4.3.2 Forgings

In accordance AMS2372.

4.4 Reports

4.4.1 The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for composition and macrostructure of each heat and for condition of each lot and ultrasonic quality of each piece as solution heat treated, and for tensile and impact properties after maraging of each lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS6543E, product form and size (and/or part number if applicable), and quantity. If forgings are supplied, the size and melt source of stock used to make the forgings shall also be included.

4.4.2 Report the nominal metallurgically worked cross sectional size and the cut size, if different (See 3.3.1).

4.4.3 The vendor of forging stock shall furnish with each shipment a report showing the results of tests for composition, and macrostructure for each heat and the results of any additional property requirements imposed by 8.6. This report shall include the purchase order number, heat number, AMS6543E, size and quantity.

4.5 Resampling and Retesting

4.5.1 Bars and Forging Stock

In accordance with AMS2370.