SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6478B

Issued MAY 1994
Revised OCT 2001
Cancelled SEP 2005
Superseding AMS 6478A

Steel, Bars and Forgings
3.1Cr - 11.5Ni - 13.5Co - 1.2Mo (0.21 - 0.25C)
Vacuum Melted, Annealed
Heat Treatable to 290 ksi (1999 MPa) Tensile Strength

(Composition similar to UNS K92580)

CANCELLATION NOTICE

This specification has been declared “CANCELLED” by the Aerospace Materials Division, SAE, as of September, 2005, and has been superseded by AMS 6532. The requirements of the latest issue of AMS 6532 shall be fulfilled whenever reference is made to the cancelled AMS 6478. By this action, this document will remain listed in the Numerical Section of the Index of Aerospace Material Specifications, noting that it has been superseded by AMS 6532.

Cancelled specifications are available from SAE.

TO PLACE A DOCUMENT ORDER:
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1. SCOPE:

1.1 Form:

This specification covers a premium aircraft-quality alloy steel in the form of bars, forgings, and forging stock.

1.2 Application:

These products have been used typically for parts requiring a combination of high strength, high toughness, and weldability, but usage is not limited to such applications. Product after heat treatment should attain a minimum tensile strength of 290 ksi (1999 MPa) and yield strength of 245 ksi (1689 MPa).

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 2251	Tolerances, Low-Alloy Steel Bars
MAM 2251	Tolerances, Metric, Low-Alloy Steel Bars
AMS 2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2300	Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
MAM 2300	Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
AMS 2310	Qualification Sampling and Testing of Steels, Transverse Tensile Properties
AMS 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel, Wrought Products and Forging Stock
AMS 2372	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Forgings
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	Macrotech Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E 45	Determining the Inclusion Content of Steel
ASTM E 112	Determining Average Grain Size
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	0.21	0.25
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.008
Sulfur	--	0.005
Phosphorus + Sulfur	--	0.010
Chromium	2.90	3.30
Nickel	11.00	12.00
Cobalt	13.00	14.00
Molybdenum	1.10	1.30
Titanium	--	0.015
Aluminum	--	0.015
Oxygen	--	0.0020 (20 ppm)
Nitrogen	--	0.0015 (15 ppm)

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2259.

3.2 Melting Practice:

Steel shall be multiple melted using vacuum induction melting followed by vacuum arc remelting.

3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Bars and Forgings: Annealed to a hardness not higher than 372 HB, or equivalent (See 8.2), determined in accordance with ASTM A 370, and descaled.

3.3.2 Forging Stock: As ordered by the forging manufacturer.

3.4 Heat Treatment:

Shall conform to the following:

3.4.1 Bars: Shall be annealed by heating to 1250 °F ± 25 (677 °C ± 14), holding at heat for not less than 16 hours, and cooling in air.

3.4.2 Forgings: Shall be normalized by heating to 1650 °F ± 25 (899 °C ± 14), holding at heat for 60 minutes ± 15, cooling in air to room temperature, and annealed by heating to 1250 °F ± 25 (677 °C ± 14), holding at heat for not less than eight hours, and forced-air cooling. Pyrometry shall be in accordance with AMS 2750.

3.5 Properties:

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

3.5.1 Macrostructure: Visual examination of transverse full cross-sections from bars, billets, 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 macrograph standards of ASTM A 604 shown in Table 2.

TABLE 2 - Macrostructure Standards

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

3.5.2 Micro-inclusion Rating: No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method A:

TABLE 3 - Micro-Inclusion Rating Limits

Type	A	B	C	D
Thin	1.5	1.5	1.5	1.5
Thick	1.0	1.0	1.0	1.0

3.5.3 Response to Heat Treatment:

3.5.3.1 Bars and Forgings: Test specimens cut from product 100 square inches (645 cm^2) and under in cross-sectional area that have been annealed as in 3.4 shall have the following properties after heating to 1625 °F ± 25 (885 °C ± 14), holding at heat for 60 to 75 minutes, and cooling at a rate equivalent to an air cool to ambient temperature, cooling to -100 °F ± 15 (-73 °C ± 8), holding at temperature for 60 minutes ± 5, warming at a rate equivalent to an air warm to room temperature, and aged by heating to 875 °F ± 10 (469 °C ± 6) (See 8.3), holding at heat for five to eight hours, and cooling at a rate equivalent to an air cool. Specimens over 1.25 inches (31.8 mm) thickness shall be oil quenched from 1625 °F ± 25 (885 °C ± 14).

3.5.3.1.1 Tensile Properties:

3.5.3.1.1.1 Longitudinal: Shall be as shown in Table 4; testing in the longitudinal direction need not be performed on product tested in the transverse direction.

TABLE 4 - Minimum Longitudinal Tensile Properties

Property	Value
Tensile Strength	290 ksi (1999 MPa)
Yield Strength at 0.2% Offset	245 ksi (1689 MPa)
Elongation in 4D	10%
Reduction of Area	50%

3.5.3.1.1.2 Transverse: Shall be as shown in Table 5, determined on specimens selected and prepared in accordance with AMS 2310. Transverse properties apply only to product from which tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

TABLE 5 - Minimum Transverse Tensile Properties

Property	Value
Tensile Strength	290 ksi (1999 MPa)
Yield Strength at 0.2% Offset	245 ksi (1689 MPa)
Elongation in 4D	8%
Reduction of Area	35%

3.5.3.1.2 Hardness: Shall be not lower than 54 HRC, or equivalent (See 8.2).

3.5.3.1.3 Toughness: Shall be not lower than 80 ksi $\sqrt{\text{inch}}$ (88 MPa $\sqrt{\text{m}}$) K_{IC}, determined in accordance with ASTM E 399 on specimens in the longitudinal LS or LR orientation from product 3.00 inches (76.2 mm) and over in nominal section thickness. If standard 1.00 inch (25.4 mm) thick specimens are not capable, due to section size, of yielding a valid K_{IC} value, a K_Q value not lower than 80 ksi $\sqrt{\text{inch}}$ (88 MPa $\sqrt{\text{m}}$) will be acceptable.

3.5.3.1.4 Average Grain Size: Shall be ASTM No. 8 or finer for product 100 square inches (645 cm^2) and under in cross-sectional area, determined in accordance with ASTM E 112.

3.5.3.2 Forging Stock: Stock, when heat treated as in 3.4 and 3.5.3.1, shall conform to the requirements of 3.5.3.1.1.1 and/or 3.5.3.1.1.2, 3.5.3.1.2, 3.5.3.1.3, and 3.5.3.1.4. Test specimens may be taken from the stock or from a sample of stock forged to a test 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 Steel shall be premium-aircraft quality conforming to AMS 2300 or MAM 2300, except that a maximum average frequency (F) rating of 0.10 and a maximum average severity (S) rating of 0.20 shall apply.

3.6.2 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 surface.

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), macrostructure (3.5.1), and micro-inclusion rating (3.5.2) of each heat.

4.2.1.2 Tensile properties (3.5.3.1.1.1 and/or 3.5.3.1.1.2), hardness (3.5.3.1.2), and average grain size (3.5.3.1.4) of each lot of bars and forgings after heat treatment.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests for the following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser:

4.2.2.1 Fracture toughness (3.5.3.1.3) of bars and forgings after heat treatment.

4.2.2.2 Ability of forging stock to develop required properties (3.5.3.2).

4.2.2.3 Frequency-severity cleanliness rating (3.6.1).

4.2.2.4 Grain flow of die forgings (3.6.3).

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 with AMS 2372.

4.4 Reports:

The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for chemical composition, microinclusion rating, and macrostructure of each heat and for tensile properties, hardness, and average grain size of each lot, the results of tests to determine conformance to the periodic test requirements, and stating that the product conforms to the other technical requirements. This report shall include the purchase order numbers, heat and lot numbers, AMS 6478A, size and quantity. When forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5 Resampling and Retesting:

Shall be as follows:

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