

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard



AMS 6488F

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Superseding AMS 6488E

Steel, Bars and Forgings
5.0Cr - 1.3Mo - 0.5V - (0.38 - 0.43C)

UNS T20811

1. SCOPE:

1.1 Form:

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

1.2 Application:

These products have been used typically for parts requiring through hardening to a minimum hardness of 50 HRC in section thicknesses up to 12 inches (305 mm) with a combination of high strength, fatigue resistance, ductility, and thermal stability for operation in the range of -100 to +1000 °F (-73 to +538 °C), but usage is not limited to such applications.

- 1.2.1 Certain design and processing procedures may cause these products to become susceptible to stress-corrosion cracking after heat treatment; ARP1110 recommends practices to minimize such conditions.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

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

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2.1 (Continued):

MAM 2300	Premium Aircraft-Quality Steel, Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
AMS 2310	Qualification Sampling 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 2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
AMS 2808	Identification, Forgings
ARP1110	Minimizing Stress-Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys
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 Drive, 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 112	Determining the Average Grain Size
ASTM E 350	Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

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 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Carbon	0.38	0.43
Manganese	0.20	0.40
Silicon	0.80	1.00
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	4.75	5.25
Molybdenum	1.20	1.40
Vanadium	0.40	0.60
Nickel	--	0.25
Copper	--	0.35

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

3.1.2 In event of questionable or conflicting results, wet chemical analysis shall govern.

3.2 Condition:

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

3.2.1 Bars:

3.2.1.1 Bars 0.500 inch (12.70 mm) and Under in Nominal Diameter or Distance Between Parallel Sides: Annealed or cold finished having tensile strength not higher than 135 ksi (931 MPa) or equivalent hardness (See 8.2).

3.2.1.2 Bars Over 0.500 inch (12.70 mm) in Nominal Diameter or Distance Between Parallel Sides: Hot finished and annealed or annealed and cold finished having hardness not higher than 311 HB, or equivalent (See 8.3).

3.2.2 Forgings: Annealed having hardness not higher than 283 HB, or equivalent (See 8.3).

3.2.3 Forging Stock: As ordered by the forging manufacturer.

3.3 Properties:

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

- 3.3.1 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 cm²) 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	A
2	White Spots	B
3	Radial Segregation	B
4	Ring Pattern	B

- 3.3.2 Decarburization:

- 3.3.2.1 Bars ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.
- 3.3.2.2 Allowable decarburization of bars and billets ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
- 3.3.2.3 Decarburization of bars to which 3.3.2.1 or 3.3.2.2 is not applicable shall be not greater than shown in Table 3.

TABLE 3A - Maximum Depth of Decarburization, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Depth of Decarburization Inch
Up to 0.375, incl	0.010
Over 0.375 to 0.500, incl	0.015
Over 0.500 to 0.625, incl	0.020
Over 0.625 to 1.000, incl	0.025
Over 1.000 to 2.000, incl	0.035
Over 2.000 to 3.000, incl	0.048
Over 3.000 to 4.000, incl	0.062
Over 4.000 to 5.000, incl	0.094
Over 5.000	0.125

TABLE 3B - Maximum Depth of Decarburization, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters		Depth of Decarburization Millimeters
Up to	9.52, incl	0.25
Over	9.52 to 12.70, incl	0.38
Over	12.70 to 15.88, incl	0.51
Over	15.88 to 25.40, incl	0.64
Over	25.40 to 50.80, incl	0.89
Over	50.80 to 76.20, incl	1.22
Over	76.20 to 101.60, incl	1.57
Over	101.60 to 127.00, incl	2.39
Over	127.00	3.18

3.3.2.4 Decarburization shall be measured by the microscopic method or by HR30N scale or equivalent hardness testing method on hardened but untempered specimens protected during heat treatment to prevent changes in surface carbon content. Depth of decarburization, measured by a hardness method, is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness. Such measurements shall be far enough away from any adjacent surface to be uninfluenced by decarburization thereon. In event of questionable or conflicting results, the governing rejection criterion for depth of decarburization shall be microhardness testing and specifically that reading at which there is not more than 20 points Knoop, or equivalent, decrease in hardness from the core hardness.

3.3.2.4.1 When determining the depth of decarburization, it is permissible to disregard local areas provided the decarburization of such areas does not exceed the limits of Table 3 by more than 0.005 inch (0.13 mm) and the width is 0.065 inch (1.65 mm) or less.

3.3.3 Response to Heat Treatment: Specimens shall conform to the following requirements after being austenitized by heating to $1850^{\circ}\text{F} \pm 25$ ($1010^{\circ}\text{C} \pm 14$), holding at heat for 15 to 45 minutes, and cooling in air to room temperature and tempered three times by heating to a temperature not lower than 1000°F (538°C), holding at heat for 2 to 3 hours, and cooling in air. Grain size specimens need not be tempered.

3.3.3.1 Tensile Properties:

3.3.3.1.1 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	260 ksi (1793 MPa)
Yield Strength at 0.2% Offset	215 ksi (1482 MPa)
Elongation in 4D	8%
Reduction of Area	30%

- 3.3.3.1.2 Transverse: Shall be as shown in Table 5, determined on specimens selected and prepared in accordance with AMS 2310. Transverse requirements are applicable only to product sufficiently large to yield tensile specimens not less than 4.50 inches (114.3 mm) in length.

TABLE 5 - Minimum Transverse Tensile Properties

Property	Value
Tensile Strength	260 ksi (1793 MPa)
Yield Strength at 0.2% Offset	215 ksi (1482 MPa)
Reduction of Area	
Individual Value	6%
Average Value	15%

- 3.3.3.2 Hardness: Shall be 50 to 56 HRC, or equivalent (See 8.3). Product shall not be rejected on the basis of hardness if the tensile properties of 3.3.3.1, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness, are acceptable.
- 3.3.3.3 Average Grain Size: Shall conform to 3.3.3.3.1 or 3.3.3.3.2, determined in accordance with ASTM E 112 on specimens which are optionally heated to 1850 °F ± 15 (1010 °C ± 8), held at heat for 15 to 45 minutes, quenched to 1320 °F ± 10 (716 °C ± 6), held at 1320 °F (716 °C) for 30 minutes, and air cooled, polished, and examined.
- 3.3.3.3.1 Bars and Forgings 2.50 Inches (63.5 mm) and Under in Nominal Diameter or Least Distance Between Parallel Sides: Shall be ASTM No. 7 or finer (See 8.4).
- 3.3.3.3.2 Bars and Forgings Over 2.50 Inches (63.5 mm) in Nominal Diameter or Least Distance Between Parallel Sides: Shall be ASTM No. 5 or finer (See 8.4).

3.4 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.

- 3.4.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300, except vacuum arc melting is not required.
- 3.4.2 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 surfaces.
- 3.4.3 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 re-entrant grain flow.

3.5 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:

Except as stated in 3.3.3.1.1, all technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

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.