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400 Commonwealth Dr., Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 6408

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STEEL BARS AND FORGINGS, HOTWORK, TOOL
5.2Cr - 1.5Mo - 1.0V (0.35-0.45C)
Electroslag Remelted (ESR) or Consumable Electrode Vacuum Arc Remelted (VAR)
Annealed

UNS T20813

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: Primarily for hotwork tooling or for parts requiring a steel capable of through-hardening to a minimum hardness of 50 HRC in section thicknesses up to 12 inches (305 mm) with relatively high levels of strength, fatigue resistance, ductility, and thermal stability for use in service from -100° to +1000°F (-73° to 538°C) and where such parts may require welding.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Standards shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Materials Specifications:

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 2350 - Standards and Test Methods
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock
AMS 2372 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Forgings and Forging Stock

2.1.1 Aerospace Materials Specifications: (Continued)

AMS 2375 - Control of Forgings Requiring First Article Approval
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

2.1.2 Aerospace Standards:

AS1182 - Standard Machining Allowance, Aircraft Quality and Premium Quality Steel Products

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets
ASTM E45 - Determining the Inclusion Content of Steels
ASTM E112 - Determining Average Grain Size
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

3.1 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E350, by spectrochemical methods, or by other analytical methods acceptable to purchaser:

	min	max
Carbon	0.35	0.45
Manganese	0.20	0.50
Silicon	0.85	1.20
Phosphorus	--	0.020
Sulfur	--	0.008
Chromium	5.00	5.50
Molybdenum	1.20	1.75
Vanadium	0.85	1.20

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

3.2 Condition: The product shall be supplied in the following condition; hardness and tensile strength shall be determined in accordance with ASTM A370. Pyrometry shall be in accordance with AMS 2750.

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: Cold finished and annealed having hardness not higher than 262 HB, or equivalent.

3.2.1.1 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Distance Between Parallel Sides: Hot or cold finished and annealed having hardness not higher than 235 HB, or equivalent.

3.2.2 Forgings: Annealed having hardness not higher than 217 HB, or equivalent.

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 A370:

3.3.1 Inclusion Rating: Shall be as follows:

3.3.1.1 Macrostructure: Visual examination of transverse sections as in 4.3.3 from bars, billets, and forging stock, etched in accordance with ASTM A604, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the following macrographs of ASTM A604:

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

3.3.1.2 Micro-Inclusion Rating: No specimen as in 4.3.4 shall exceed the following limits, determined in accordance with ASTM E45, Method D:

	A		B		C		D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Worst Field Severity	1.5	1.0	1.5	1.0	1.5	1.0	2.0	1.0
Worst Field Frequency, maximum	*	1	*	1	*	1	3	1
Total Rateable Fields, Frequency, maximum	**	1	**	1	**	1	8	1

* Combined A+B+C, not more than 3 fields.
** Combined A+B+C, not more than 8 fields.

3.3.1.2.1 A rateable field is defined as one which has a Type A, B, C, or D inclusion rating of at least No. 1.0 thin or heavy in accordance with the Jernkontoret chart, Plate III, ASTM E45.

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 I.

TABLE I

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 I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Depth of Decarburization Millimetres
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 Rockwell Superficial 30-N 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, when 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 any decarburization or lack of decarburization theron.

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 above limits 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 as in 3.3.3.1 shall conform to the following requirements after being austenitized by heating to 1850°F ± 25 (1010°C ± 14), holding at heat for 15 - 45 minutes, cooling in air to room temperature and double tempering by heating to a temperature not lower than 1100°F (593°C), holding at heat for 2 - 3 hours, and cooling in air.

3.3.3.1 Longitudinal Tensile Properties: These requirements apply to specimens taken from bars and forging stock 25 square inches (161 cm^2) and under in cross-sectional area, from forgings with axis approximately parallel to the forging flow lines, and to specimens from coupons of stock over 25 square inches (161 cm^2) in cross-sectional area forged to 25 square inches (161 cm^2) in cross-sectional area prior to heat treatment as in 3.3.3.

Tensile Strength, minimum	205,000 psi (1413 MPa)
Yield Strength at 0.2% Offset, minimum	180,000 psi (1241 MPa)
Elongation in 4D, minimum	8%
Reduction of Area, minimum	20%

3.3.3.2 Hardness: Should be 44 - 50 HRC, or equivalent, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.3.1 are met.

3.3.3.3 Grain Size: Shall be as follows, determined in accordance with ASTM E112:

3.3.3.3.1 Bars and Forgings Up to 2.50 Inches (63.5 mm) in Nominal Diameter, Distance Between Parallel Sides, or Cross-Sectional Dimension: Predominantly 7 or finer with occasional grains as large as 5 permissible.

3.3.3.3.2 Bars and Forgings Over 2.50 Inches (63.5 mm) in Nominal Diameter, Distance Between Parallel Sides, or Cross-Sectional Dimension: Predominantly 5 or finer with occasional grains as large as 3 permissible.

3.4 Quality:

3.4.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300; it shall be multiple melted using either electroslag remelting or consumable electrode vacuum arc remelting practice for the remelt cycle.

3.4.2 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.

3.4.2.1 Bars ordered ground, turned, or polished shall be free from seams, laps, tears, and cracks open to the ground, turned, or polished surface.

3.4.2.2 Product ordered to surface conditions other than ground, turned, or polished shall, after removal of the standard machining allowance, be free from seams, laps, tears, cracks and other defects exposed to the machined surfaces. Standard machining allowance shall be in accordance with AS 1182.

3.4.2.3 Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4.2.4 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 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars will be acceptable in mill lengths of 6 - 20 feet (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).

3.6 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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material and/or processing requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling: Shall be in accordance with the following; a heat shall be the electroslag or consumable electrode vacuum arc remelted ingots produced from steel originally melted as a single furnace charge.

4.3.1 Bars: AMS 2370.