SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6408B

Issued JAN 1989
Reaffirmed SEP 2000
Revised JAN 2004
Superseding AMS 6408A

Steel, Hotwork Tool, Bars and Forgings 5.25Cr - 1.5Mo - 1.0V (0.35-0.45C) Electroslag Remelted (ESR) or Consumable Electrode Vacuum Arc Remelted (VAR) Annealed

(Composition similar to 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:

These products have been used typically 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, 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.

1.3 Classification:

Steel covered by this specification is classified by melting practice as follows:

Type 1 - Multiple melted using electroslag (ESR) process in the final melting cycle.
Type 2 - Multiple melted using consumable electrode vacuum arc (VAR) practice in the remelt cycle.

1.3.1 Unless a specific type is ordered, either type may be supplied.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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SAE WEB ADDRESS: **http://www.sae.org**

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2251	Tolerances, Low-Alloy Steel Bars
AMS 2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2300	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure
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 Heat Treatable Wrought Low-Alloy and Martensitic Corrosion-Resistant Steels
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 or 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 45	Determining the Inclusion Content of Steels
ASTM E 112	Determining Average Grain Size
ASTM E 350	Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E 384	Microindentation Hardness of 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 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	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 Melting Practice:

Steel shall be multiple melted using either electroslag or consumable electrode vacuum arc practice for the remelt cycle.

3.3 Condition:

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

3.3.1 Bars:

3.3.1.1 Bars 0.500 Inch (12.70 mm) and Under in Nominal Diameter or Least Distance Between Parallel Sides: Cold finished and annealed having hardness not higher than 262 HB, or equivalent (see 8.2).

3.3.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Least Distance Between Parallel Sides: Hot or cold finished and annealed having hardness not higher than 235 HB, or equivalent (See 8.2).

3.3.2 Forgings: Annealed having hardness not higher than 217 HB, or equivalent (See 8.2).

3.3.3 Forging Stock: As ordered by the forging manufacturer.

3.4 Properties:

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

3.4.1 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 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

3.4.2 Micro-Inclusion Rating: No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method D.

TABLE 3 - Micro-Inclusion Rating Limits

	A Thin	A Heavy	B Thin	B Heavy	C Thin	C Heavy	D Thin	D 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

3.4.2.1 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 I-r, ASTM E 45 (See 8.3).

3.4.3 Decarburization:

3.4.3.1 Bars ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

3.4.3.2 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.

3.4.3.3 Decarburization of bars to which 3.4.3.1 or 3.4.3.2 is not applicable shall be not greater than shown in Table 4.

TABLE 4A - Maximum Decarburization, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Total 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 4B - Maximum Decarburization, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Total 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

3.4.3.4 Decarburization shall be measured by the metallographic method, by the HR30N scale hardness testing method, or by a traverse method using microhardness testing in accordance with ASTM E 384. The hardness method(s) shall be conducted on a hardened but untempered specimen 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 on the adjacent surface. In case of dispute, the depth of decarburization determined using the microhardness traverse method shall govern.

3.4.3.4.1 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.

3.4.4 Response to Heat Treatment: Specimens as in 3.4.4.1 shall conform to the following requirements after being austenitized by heating to 1850 °F ± 25 (1010 °C ± 14), holding at heat for 15 to 45 minutes, cooling to room temperature at a rate equivalent to air cooling, and double tempered by heating to a temperature not lower than 1100 °F (593 °C), holding at heat for 2 to 3 hours, and cooling in air.

3.4.4.1 Longitudinal Tensile Properties: The requirements shown in Table 5 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 and forged to 25 square inches (161 cm^2) in cross-sectional area prior to heat treatment as in 3.4.4.

TABLE 5 - Minimum Tensile Properties

Requirement	Value
Tensile Strength	205 ksi (1413 MPa)
Yield Strength at 0.2% Offset	180 ksi (1241 MPa)
Elongation in 4D	8%
Reduction of Area	20%

3.4.4.2 Hardness: Shall be 44 to 50 HRC, or equivalent (See 8.2).

3.4.4.3 Average Grain Size: Shall be as follows, determined in accordance with ASTM E 112:

3.4.4.3.1 Bars and Forgings Up to 2.50 Inches (63.5 mm) in Nominal Diameter, Distance Between Parallel Sides, or Cross-Sectional Dimension: Shall be ASTM No. 7 or finer.

3.4.4.3.2 Bars and Forgings Over 2.50 Inches (63.5 mm) in Nominal Diameter, Distance Between Parallel Sides, or Cross-Sectional Dimension: Shall be ASTM No. 5 or finer.

3.5 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.

3.5.1 Steel shall be premium aircraft-quality conforming to AMS 2300.

3.5.2 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.

3.5.3 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 Tolerances:

Bars shall conform to all applicable requirements of AMS 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: Composition (3.1), condition (3.3), macrostructure (3.4.1), micro-inclusion rating (3.4.2), response to heat treatment (3.4.4), average grain size (3.4.4.3), and tolerances (3.6), are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Frequency-severity cleanliness rating (3.5.1) 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:

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 the product shall furnish with each shipment a report showing the results of tests for composition, macrostructure, and micro-inclusion rating, of each heat, and for the average grain size, tensile properties, and hardness after heat treatment 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, AMS 6408B, size, and quantity. If forgings are supplied, 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.

4.5.2 Forgings: In accordance with AMS 2372.