SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS6408 | REV. D

Issued 1989-01
Revised 2013-01

Superseding AMS6408C

Steel, Hotwork Tool, Bars and Forgings
5.25Cr – 1.5Mo – 1.0V (0.35-0.45C) (H-13)
Electroslag Remelted (ESR) or Consumable Electrode Vacuum Arc Remelted (VAR)
Annealed

(Composition similar to UNS T20813)

RATIONALE

AMS6408D is a five year review and update of this specification.

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.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this document 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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http://www.sae.org/technical/standards/AMS6408D

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.

AMS2251 Tolerances, Low-Alloy Steel Bars

AMS2259 Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels

AMS2300 Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure

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

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

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

AMS2808 Identification, Forgings

ARP1110 Minimizing Stress Corrosion Cracking in Heat Treatable Wrought Low-Alloy and Martensitic Corrosion-Resistant Steels

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 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 Knoop and Vickers 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 AMS2259.

3.2 Melting Practice

Steel shall be multiple melted using either electroslag remelting (ESR) practice or consumable electrode vacuum arc remelting (VAR) practice as the final melting process.

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

Bars shall not be cut from plate. (Also see 4.4.2.)

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 of Each Heat

No specimen shall exceed the limits shown in Table 3, determined in accordance with ASTM E 45, Method D.

3.4.2.1 A rateable field is defined as one that 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.

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	a	1	a	1	a	1	3	1
Total Rateable Fields, Frequency, maximum	b	1	b	1	b	1	8	1

a - Combined A+B+C, not more than 3 fields
b - Combined A+B+C, not more than 8 fields

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 when 3.4.3.1 or 3.4.3.2 is not applicable shall be not greater than shown in Table 4.

TABLE 4A - MAXIMUM DEPTH OF 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 DEPTH OF 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

Extracted 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 that has been 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 of Bars and Forgings

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 AMS2300.

3.5.2 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.

3.5.3 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 machined, ground, turned, or polished surface.

3.6 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

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) and grain flow of forgings (3.5.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.