SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5932

Issued NOV 1998

Submitted for recognition as an American National Standard

Steel, Corrosion and Heat Resistant, Bars, Forgings and Tubing
14.5Cr - 2.3Ni - 12.5Co - 4.0Mo - 0.60V - 0.03Cb
Premium Aircraft-Quality, Carburizing
Double Vacuum Melted

UNS S42640

1. SCOPE:

1.1 Form:

This specification covers a premium aircraft-quality corrosion and heat resistant steel in the form of bars, forgings, mechanical tubing, and forging stock.

1.2 Application:

These products have been used typically for critical carburized parts such as bearings, cams, shafts, gears, and bolts operating in a corrosive environment under heavy loads and high speeds at elevated temperatures, and subject to very rigid inspection standards, but usage is not limited to such applications.

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.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7161 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2241	Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
MAM 2241	Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS 2243	Tolerances, Corrosion and Heat Resistant Steel Tubing
MAM 2243	Tolerances, Metric, Corrosion and Heat Resistant Steel Tubing
AMS 2248	Chemical Check Analysis Limits, Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
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 2371	Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2374	Quality Assurance Sampling and Testing, Corrosion and Heat Resistant Steel and Alloy 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
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 45	Determining the Inclusion Content of Steel
ASTM E 112	Determining the Average Grain Size
ASTM E 353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

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	0.10	0.25
Manganese	-	1.0
Silicon	-	1.0
Phosphorus	-	0.020
Sulfur	-	0.010
Chromium	13.00	16.00
Nickel	1.75	2.75
Cobalt	11.00	14.00
Molybdenum	3.00	5.00
Vanadium	0.40	0.80
Columbium	0.01	0.05
Tungsten	-	0.25
Copper	-	0.10

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

3.2 Melting Practice:

Steel shall be double vacuum melted using vacuum induction melting followed by vacuum arc consumable electrode remelting practice.

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 having tensile strength not higher than 201 ksi (1386 MPa) or equivalent hardness (See 8.1).

3.3.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Least Distance Between Parallel Sides: Hot finished and annealed unless otherwise ordered, having hardness not higher than 388 HB, or equivalent (See 8.2). Bars ordered cold finished may have hardness as high as 401 HB, or equivalent.

3.3.2 Forgings: As ordered.

3.3.3 Mechanical Tubing: Cold finished, unless otherwise ordered, having hardness not higher than 401 HB, or equivalent (See 8.2). Tubing ordered hot finished and annealed shall have hardness not higher than 388 HB, or equivalent.

3.3.4 Forging Stock: As ordered by the forging manufacturer.

3.4 Properties:

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

3.4.1 Macrostructure: Visual examination of transverse sections from bars, billets, tube rounds, 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 macrographs of ASTM A 604 shown in Table 2.

TABLE 2 - Macrostructure Limits

Class	Condition	Severity
1	Freckles	A
2	White Spots	A
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	A	B	B	C	C	D	D
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Worst Field Severity	1.5	1.0	1.0	1.0	1.0	1.0	1.5	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 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 E 45.

3.4.3 Average Grain Size: Shall be ASTM No. 4 or finer, determined in accordance with ASTM E 112.

3.4.4 Response to Heat Treatment: Specimens, protected by suitable means or treated in a neutral atmosphere or neutral salt to minimize scaling and prevent either carburization or decarburization, shall have average hardness not lower than 45 HRC after being heated to 2000 to 2050 °F (1093 to 1121 °C) by any convenient means, held to equalize at temperature, oil quenched to 150 °F (66 °C) or lower, air cooled to room temperature, cooled to -110 °F (-79 °C) or lower, held at that temperature for not less than 1 hour, and tempered for 2 hours ± 0.25 at 900 to 975 °F (482 to 524 °C).

3.4.5 Decarburization:

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

3.4.5.2 Allowable decarburization of bars, billets, and tube rounds ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

3.4.5.3 Decarburization of bars to which 3.3.5.1 or 3.3.5.2 is not applicable shall be not greater than shown in Table 4.

TABLE 4A - Maximum Decarburization, Inch/Pound Units

Nominal Diameter or Least Distance Between Parallel Sides Inches	Depth of Decarburization Inch
Up to 0.500, incl	0.015
Over 0.500 to 1.000, incl	0.030
Over 1.000 to 2.000, incl	0.040
Over 2.000 to 3.000, incl	0.050
Over 3.000 to 4.000, incl	0.065
Over 4.000 to 5.000, incl	0.095

TABLE 4B - Maximum Decarburization, SI Units

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Depth of Decarburization Millimeters
Up to 12.70, incl	0.38
Over 12.70 to 25.40, incl	0.76
Over 25.40 to 50.80, incl	1.02
Over 50.80 to 76.20, incl	1.27
Over 76.20 to 101.60, incl	1.65
Over 101.60 to 127.00, incl	2.41

3.4.5.4 Decarburization of tubing to which 3.3.5.1 or 3.3.5.2 is not applicable shall be not greater than shown in Table 5.

TABLE 5A - Maximum Decarburization, Inch/Pound Units

Nominal Outside Diameter Inches	Depth of Decarburization Inch
Up to 1.000, incl	0.025
Over 1.000 to 2.000, incl	0.035
Over 2.000 to 3.000, incl	0.045
Over 3.000 to 4.000, incl	0.055
Over 4.000 to 5.000, incl	0.080

TABLE 5B - Maximum Decarburization, SI Units

Nominal Outside Diameter Millimeters	Depth of Decarburization Millimeters
Upto 25.40, incl	0.64
Over 25.40 to 50.80, incl	0.89
Over 50.80 to 76.20, incl	1.14
Over 76.20 to 101.60, incl	1.40
Over 101.60 to 127.00, incl	2.03

3.4.5.5 Decarburization shall be measured by the metallographic method, by HR 30N scale hardness testing method, or by the microhardness transverse method 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 decarburization on the adjacent surface. In case of dispute, the depth of decarburization determined using the microhardness transverse method shall govern.

3.4.5.5.1 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.

3.5 Quality:

The product, as received by the 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 or MAM 2300.

3.5.2 Bars and tubing 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.

3.5.3 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.

3.6 Tolerances:

Shall be as follows:

3.6.1 Bars: In accordance with AMS 2241 or MAM 2241.

3.6.2 Mechanical Tubing: In accordance with AMS 2243 or MAM 2243.

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), average grain size (3.4.3), response to heat treatment (3.4.4), decarburization (3.4.5), 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 die forgings (3.5.3) are periodic tests 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, Mechanical Tubing, and Forging Stock: In accordance with AMS 2371.

4.3.2 Forgings: In accordance with AMS 2374.

4.3.3 Samples for response to heat treatment (3.4.4) shall be as follows:

4.3.3.1 Specimens from bars shall be full cross-sections of the bar, ground on both faces normal to the axis so that length is 0.500 inch ± 0.010 (12.70 mm ± 0.25).

4.3.3.2 Specimens from mechanical tubing shall be full cross-sections of the tubing, shall have wall thickness not over 0.625 inch (15.88 mm) with wall thicknesses over 0.625 inch (15.88 mm) being turned to 0.625 inch ± 0.010 (15.88 mm ± 0.25), and shall be ground on both faces so that length is 0.500 inch ± 0.010 (12.70 mm ± 0.25).

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition, macrostructure, micro-inclusion rating, and response to heat treatment of each heat and for average grain size 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 5932, size, and quantity. If 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, Mechanical Tubing, and Forging Stock: In accordance with AMS 2371.

4.5.2 Forgings: In accordance with AMS 2374.