

ADOPTION NOTICE

SAE-AMS6425, "STEEL BARS, FORGINGS, AND TUBING 1.4MN - 1.5SI - 0.30CR - 1.8NI - 0.40MO - (0.23 - 0.28C) CONSUMABLE ELECTRODE VACUUM MELTED", was adopted on 15-AUG-90 for use by the Department of Defense (DoD). Proposed changes by DoD activities must be submitted to the DoD Adopting Activity: Commander, Defense Supply Center Philadelphia, ATTN: DSCP-ILEA, 700 Robbins Avenue, Philadelphia, PA 19111-5096. Copies of this document may be purchased from the Society of Automotive Engineers 400 Commonwealth Drive Warrendale, Pennsylvania, United States, 15096-0001. <http://www.sae.org/>

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AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

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Superseding AMS 6425

STEEL, BARS, FORGINGS, AND TUBING
1.4Mn - 1.5Si - 0.30Cr - 1.8Ni - 0.40Mo (0.23 - 0.28C)
Consumable Electrode Vacuum Melted

UNS K32550

1. SCOPE:

1.1 Form:

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

1.2 Application:

These products have been used typically for parts requiring a through-hardening steel capable of developing a combination of high tensile strength, ductility, and fracture toughness, 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 2253 Tolerances, Carbon and Alloy Steel Tubing
MAM 2253 Tolerances, Metric, Carbon and Alloy Steel Tubing
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 and Testing 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
AS1182	Standard Machining Allowance, Aircraft-Quality and Premium Aircraft-Quality Steel Bars and Mechanical Tubing
ARP1110	Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

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
ASTM E 399	Plane-Strain Fracture Toughness of Metallic Materials

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

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	0.23	0.28
Manganese	1.20	1.50
Silico	1.30	1.70
Phosphorus	--	0.010
Sulfur	--	0.010
Chromium	0.20	0.40
Nickel	1.65	2.00
Molybdenum	0.35	0.45
Copper	--	0.35

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2259, except that check analysis limits for carbon shall apply to over maximum only.

3.2 Melting Practice:

Steel shall be multiple melted using consumable electrode vacuum practice in 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 Distance Between Parallel Sides: Cold finished having tensile strength not higher than 145 ksi (1000 MPa) or equivalent hardness (See 8.2).

3.3.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Distance Between Parallel Sides: (R) Hot finished, unless otherwise ordered, annealed if necessary, having hardness not higher than 293 HB, or equivalent. Bars ordered cold finished may have hardness as high as 311 HB, or equivalent (See 8.3).

3.3.2 Forgings: Normalized and tempered having hardness not higher than 311 HB, or equivalent (R) (See 8.3).

3.3.3 Mechanical Tubing: Cold finished, unless otherwise ordered, having hardness not higher than (R) 32 HRC, or equivalent. Tubing ordered hot finished and annealed shall have hardness not higher than 31 HRC, or equivalent (See 8.3).

3.3.4 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, tube rounds or tubes, and forging stock, etched in hot hydrochloric acid in accordance with ASTM A 604, shall show no pipe or cracks. Except as specified in 3.4.1.1, 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	A
3	Radial Segregation	B
4	Ring Pattern	B

- 3.4.1.1 (R) If purchaser permits tubes to be produced directly from ingots or large blooms, transverse sections may be taken from tubes rather than tube rounds. Macrostructure standards for such tubes shall be as agreed upon by purchaser and vendor.
- 3.4.2 (R) Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112 (See 8.4).
- 3.4.3 Decarburization:
- 3.4.3.1 Bars and tubing 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, billets, and tube rounds ordered for redrawing or forging or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.
- 3.4.3.3 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 3.

TABLE 3A - Maximum Decarburization, Bars, Inch/Pound Units

Nominal Diameter or Distance Between Parallel Sides Inches	Depth of Decarburization Inch
Up to 0.375, incl	0.015
Over 0.375 to 0.500, incl	0.017
Over 0.500 to 0.625, incl	0.019
Over 0.625 to 1.000, incl	0.022
Over 1.000 to 1.500, incl	0.025
Over 1.500 to 2.000, incl	0.030
Over 2.000 to 2.500, incl	0.035
Over 2.500 to 3.000, incl	0.040
Over 3.000 to 5.000, incl	0.045

TABLE 3B - Maximum Decarburization, Bars, SI Units

Nominal Diameter or Distance Between Parallel Sides Millimeters	Depth of Decarburization Millimeters
Up to 9.52, incl	0.38
Over 9.52 to 12.70, incl	0.43
Over 12.70 to 15.88, incl	0.48
Over 15.88 to 25.40, incl	0.56
Over 25.40 to 38.10, incl	0.64
Over 38.10 to 50.80, incl	0.76
Over 50.80 to 63.50, incl	0.89
Over 63.50 to 76.20, incl	1.02
Over 76.20 to 127.00, incl	1.14

3.4.3.4 Decarburization of tubing 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, Tubing, Inch/Pound Units

Nominal Wall Thickness Inches	Depth ID	Depth OD
	Inch	Inch
Up to 0.109, incl	0.008	0.015
Over 0.109 to 0.203, incl	0.010	0.020
Over 0.203 to 0.400, incl	0.012	0.025
Over 0.400 to 0.600, incl	0.015	0.030
Over 0.600 to 1.000, incl	0.017	0.035
Over 1.000	0.020	0.040

TABLE 4B - Maximum Decarburization, Tubing, SI Units

Nominal Wall Thickness Millimeters	Depth ID	Depth OD
	Millimeter	Millimeter
Up to 2.77, incl	0.20	0.38
Over 2.77 to 5.16, incl	0.25	0.51
Over 5.16 to 10.16, incl	0.30	0.64
Over 10.16 to 15.24, incl	0.38	0.76
Over 15.24 to 25.40, incl	0.43	0.89
Over 25.40	0.51	1.02

3.4.3.4 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, 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 thereon.

3.4.3.5.1 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.

3.4.4 Response to Heat Treatment: Specimens shall have the following properties after being (R) normalized by heating to 1725 °F ± 25 (941 °C ± 14), holding at heat for one hour per inch (25 mm) of maximum cross-section, and cooling in air, hardened by heating to 1600 °F ± 25 (871 °C ± 14), holding at heat for one hour per inch (25 mm) of maximum cross-section, and quenching in oil, and tempered by heating to 550 °F ± 10 (288 °C ± 6), holding at heat for two to three hours, and cooling in air to room temperature:

3.4.4.1 Longitudinal Tensile Properties: Shall be as specified in Table 5; testing in the longitudinal direction need not be performed on product tested in the transverse direction:

TABLE 5 - Minimum Longitudinal Tensile Properties

Property	Value
Tensile Strength	220 ksi (1517MPa)
Yield Strength at 0.2% Offset	185 ksi (1276 MPa)
Elongation in 4D	10%
Reduction of Area	30%

3.4.4.2 Transverse Tensile Properties: Shall be as shown in Table 6, determined on specimens selected and prepared in accordance with AMS 2310; transverse properties apply only to product from which tensile specimens not less than 2.50 inches (63.5 mm) in length can be taken.

TABLE 6A - Minimum Transverse Tensile Properties, Inch/Pound Units

Nominal Cross-Sectional Area Square Inches	Tensile Strength ksi	Yield Strength At 0.2% Offset ksi	Reduction of Area % Average	Reduction of Area % Individual
Up to 100, incl	220	185	30	25
Over 100 to 144, incl	220	185	25	20
Over 144 to 225, incl	220	185	20	15

TABLE 6B - Minimum Transverse Tensile Properties, SI Units

Nominal Cross-Sectional Area Square Centimeters	Tensile Strength MPa	Yield Strength At 0.2% Offset MPa	Reduction of Area % Average	Reduction of Area % Individual
Up to 645, incl	1517	1276	30	25
Over 645 to 929, incl	1517	1276	25	20
Over 929 to 1452, incl	1517	1276	20	15

3.4.4.3 Fracture Toughness: When specified, bars and/or forgings shall be subjected to fracture toughness testing as follows:

3.4.4.3.1 Bars: Shall be not lower than 100 ksi \sqrt{inch} (1110 MPa \sqrt{m}), K_{IC} or K_{Q} , determined in accordance with ASTM E 399 on specimens in the LS (preferred) or LT orientation from bars 1.50 inches (38.1 mm) and over in section thickness and 4.0 inches (102 mm) and over wide.

3.4.4.3.2 Forgings: Shall be not lower than 100 ksi \sqrt{inch} (110 MPa \sqrt{m}), K_{IC} or K_{Q} , determined in accordance with ASTM E 399 on specimens in TL orientation from forgings 1.50 inches (38.1 mm) and over in section thickness.

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 or MAM 2300 except that a maximum average frequency (F) rating of 0.10 and a maximum average severity (S) rating of 0.20 shall apply.

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 2251 or MAM 2251.

3.6.2 Mechanical Tubing: In accordance with AMS 2253 or MAM 2253.

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. 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: Composition (3.1), condition (3.3), macrostructure (3.4.1), average grain size (3.4.2), decarburization (3.4.3), response to heat treatment (3.4.4), fracture toughness when specified (3.4.4.3), quality (3.5), grain flow of die forgings (3.5.3), 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:

(R)

Shall be as follows:

4.3.1 Bars, Mechanical Tubing, and Forging Stock: In accordance with AMS 2370.

(R)

4.3.2 Forgings: In accordance with AMS 2372.

(R)