SAE The Engineering Society For Advancing Mobility Land Sea Air and Space

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 6528

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STEEL BARS
0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130)
Special Aircraft Quality Cleanliness
Normalized

UNS G41300

1. SCOPE:

1.1 Form: This specification covers a premium aircraft-quality, low-alloy steel in the form of bars.

1.2 Application: Primarily for parts required to meet stringent magnetic inspection criteria and having sections 0.50 in. (12.5 mm) and under in nominal thickness at time of heat treatment, requiring a through-hardening steel capable of developing hardness as high as 35 HRC when properly hardened and tempered and also parts of greater thickness but requiring proportionately lower hardness.

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 Material 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

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2.1.1 Aerospace Material Specifications (Cont'd.):

AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels, Wrought Products Except Forgings and Forging Stock
AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Heat and Corrosion Resistant Steels and Alloys

2.1.2 Aerospace Standards:

AS 1182 - 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 A255 - End-Quench Test for Hardenability of Steel
ASTM A370 - Mechanical Testing of Steel Products
ASTM E112 - Determining Average Grain Size
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E381 - Macroetch Testing, Inspection, and Rating Steel Products, Comprising Bars, Billets, Blooms, and Forgings

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 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	0.28	0.33
Manganese	0.40	0.60
Silicon	0.15	0.35
Phosphorus	--	0.015
Sulfur	--	0.008
Chromium	0.80	1.10
Molybdenum	0.15	0.25
Nickel	--	0.25
Copper	--	0.35

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

3.2 Condition:

3.2.1 Hot rolled and normalized at 1700°F ± 25 (925°C ± 15).

3.2.1.1 When specified, either a cold drawn or cold finished surface shall be furnished.

3.2.1.1.1 Cold finished surface shall be produced by turning, grinding, polishing, or burnishing, or a combination thereof; surface hardness shall be not more than 3 points HRC harder than hardness at mid-radius, determined in accordance with ASTM A370.

3.2.1.2 Cold finished surface may be furnished when cold drawn or hot rolled or no surface condition is specified.

3.2.1.3 Cold drawn surface may be furnished when hot rolled or no surface condition is specified.

3.3 Properties: Bars shall conform to the following requirements; hardness testing shall conform to ASTM A370:

3.3.1 Macrostructure: Visual examination of transverse sections as in 4.3.1 from bars and billets, etched in accordance with ASTM E381 in hot hydrochloric acid (1:1) at 160° - 180°F (70° - 80°C) for sufficient time to develop a well-defined macrostructure, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the following macrographs of ASTM E381:

Section Size		
Square Inches	Square Centimetres	Macrographs
Up to 36, incl	Up to 230, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 230 to 645, incl	S2 - R2 - C3
Over 100	Over 645	As agreed upon

3.3.2 Grain Size: Predominantly 5 or finer with occasional grains as large as 3 permissible, determined in accordance with ASTM E112.

3.3.3 Hardenability: Shall be J34=5 and J27=8 min, determined in accordance with ASTM A255 except that the normalizing temperature shall be 1700°F ± 10 (925°C ± 5).

3.3.4 Decarburization:

3.3.4.1 Bars ordered cold finished shall be free from decarburization.

3.3.4.2 Allowable decarburization of bars and billets ordered for redrawing or to specified microstructural requirements shall be as agreed upon by purchaser and vendor.

3.3.4.3 Decarburization of bars to which 3.3.4.1 or 3.3.4.2 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	0.012
Over 0.500 to 0.625, incl	0.014
Over 0.625 to 1.000, incl	0.017
Over 1.000 to 1.500, incl	0.020
Over 1.500 to 2.000, incl	0.025
Over 2.000 to 2.500, incl	0.030
Over 2.500 to 3.000, incl	0.035
Over 3.000 to 4.000, incl	0.045

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Depth of Decarburization Millimetres
Up to 9.50, incl	0.25
Over 9.50 to 12.50, incl	0.30
Over 12.50 to 15.50, incl	0.35
Over 15.50 to 25.00, incl	0.42
Over 25.00 to 37.50, incl	0.50
Over 37.50 to 50.00, incl	0.62
Over 50.00 to 62.50, incl	0.75
Over 62.50 to 75.00, incl	0.88
Over 75.00 to 100.00, incl	1.12

3.3.4.3.1 Limits for depth of decarburization of bars over 4.000 in. (100.00 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.3.4.4 Decarburization shall be measured by the microscopic method or by Rockwell Superficial 30-N scale, or equivalent, hardness testing method on hardened specimens, protected during heat treatment to prevent changes in surface carbon content. Specimens for microscopic examination shall be tempered; specimens for hardness testing shall be untempered. 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 thereon.

3.3.4.4.1 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 in. (0.12 mm) and the width is 0.065 in. (1.65 mm) or less.

3.4 Quality:

3.4.1 Steel shall conform to the cleanliness requirements of AMS 2300 or MAM 2300 (See 8.1). It need not conform to the melting practice requirements of AMS 2300 or MAM 2300.

3.4.2 Bars, 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 bars.

3.4.2.1 Bar, including those ordered cold drawn, 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.

3.4.2.2 Bars ordered cold finished shall be free from seams, laps, tears, and cracks.

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 ft (2 - 6 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 ft (3 m).

3.6 Tolerances: Hot rolled and cold drawn bars shall conform to AMS 2251 or MAM 2251; cold finished bars shall conform to Table II and Table III as applicable.

3.6.1 Diameter:

3.6.1.1 Coiled Bars:

TABLE II

Specified Diameter		Tolerances, Minus Only	
Inches	Millimetres	Inch	Millimetre
Up to 1.000, incl	Up to 25.00, incl	0.003	0.08

3.6.1.2 Straight Bars:

TABLE III

Specified Diameter		Tolerances, Minus Only	
Inches	Millimetres	Inch	Millimetre
Up to 1.500, incl	Up to 37.5, incl	0.004	0.10
Over 1.500 to 2.500, incl	Over 37.5 to 62.5, incl	0.005	0.12
Over 2.500 to 5.000, incl	Over 62.5 to 125.0, incl	0.006	0.15
Over 5.000 to 5.700, incl	Over 125.0 to 142.5, incl	0.008	0.20
Over 5.700 to 7.080, incl	Over 142.5 to 177.0, incl	0.016	0.40

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of bars 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 4.4. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the bars conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.1), macrostructure (3.3.1), grain size (3.3.2), hardenability (3.3.3), decarburization (3.3.4), and frequency-severity cleanliness rating (3.4.1) are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for cold finished surface hardness (3.2.1.1.1) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling: Shall be in accordance with AMS 2370 and the following:

4.3.1 Samples for macrostructure (3.3.1) testing shall be full cross-sectional specimens obtained from the finished billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingot of each heat or, in the case of multiple ingots poured simultaneously, the top and bottom of 10% of the ingots from each pouring plate.

4.3.2 Samples for frequency-severity cleanliness rating (3.4.1) shall conform to AMS 2300 or MAM 2300 except as follows:

4.3.2.1 When multiple ingots are poured simultaneously, i.e., no pouring sequence is identifiable, the samples shall be taken from semi-finished or finished product representing the top and bottom of at least 20% of the ingots (evenly distributed among bottom plates) with not less than one ingot from each bottom plate. If the ingot pattern is asymmetrical, the ingots samples shall include those most distant from the pouring sprue.