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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6409B

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Superseding AMS 6409A

Steel, Bars, Forgings, and Tubing
0.80Cr - 1.8Ni - 0.25Mo (0.38 - 0.43C) (SAE 4340)
Special Aircraft Quality Cleanliness
Normalized and Tempered

(Composition similar to UNS G43406)

1. SCOPE:

1.1 Form:

This specification covers a 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 required to meet stringent magnetic particle inspection criteria, having sections 3.5inches (89 mm) and under in nominal thickness at time of heat treatment, and requiring a through-hardening steel capable of developing a minimum hardness of 40HRC when properly hardened and tempered and also for parts of greater thickness but requiring proportionately lower hardness, 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.

1.2.2 These products are not recommended for use in parts heat treated to a maximum tensile strength over 220 ksi (1517 MPa) or where the high transverse properties of vacuum-arc-remelted or electroslag remelted steel are required (See 8.2).

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

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 or www.sae.org.

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 2304	Steel Cleanliness, Special Aircraft-Quality, Magnetic Particle Inspection Procedure
MAM 2304	Steel Cleanliness, Special Aircraft-Quality, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
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 2759/1	Heat Treatment of Carbon and Low-Alloy Steel Parts, Minimum Tensile Strength below 220 ksi (1517 MPa)
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
AMS-H-6875	Heat Treatment of Steel, Process for
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, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM A 255	Determining Hardenability of Steel
ASTM A 370	Mechanical Testing of Steel Products
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 381	Macroetch Testing Steel Bars, Billets, Blooms, and Forgings
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	0.38	0.43
Manganese	0.65	0.85
Silicon	0.15	0.35
Phosphorus	--	0.015
Sulfur	--	0.008
Chromium	0.70	0.90
Nickel	1.65	2.00
Molybdenum	0.20	0.30
Copper	--	0.35

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

3.2 Condition:

The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A 370:

3.2.1 Bars: Normalized at 1650 °F ± 25 (899 °C ± 14) and tempered, having hardness at mid-radius not higher than 269 HB, or equivalent (See 8.3). Bars shall have a turned, ground, polished, or burnished surface; surface hardness shall be not more than 3 points HRC harder than mid-radius hardness.

3.2.1.1 Hot finished or cold drawn surface may be specified; however, when hot finished or cold drawn is specified, bars with a turned, ground, polished, or burnished surface hardness not more than 3 points HRC harder than mid-radius hardness as in 3.2.1 may be furnished.

3.2.2 Forgings: Normalized and tempered in accordance with AMS-H-6875 having hardness not higher than 269 HB, or equivalent (See 8.3).

3.2.3 Mechanical Tubing: Normalized and tempered having hardness not higher than 269 HB, or equivalent (See 8.3). Tubing 1.0 inch (25 mm) and under in nominal OD shall be cold reduced; larger sizes shall be hot rolled.

3.2.4 Forging Stock: As ordered by the forging manufacturer.

3.3 Properties:

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

3.3.1 Macrostructure: Visual examination of transverse full cross-sections from bars, billets, tube rounds, and forging stock, etched in hot hydrochloric acid in accordance with ASTM E 381, shall show no pipe or cracks. Porosity, segregation, inclusions, and other imperfections shall be no worse than the macrographs of ASTM E 381 shown in Table 2.

TABLE 2 - Macrostructure Limits

Cross-Sectional Area Square Inches	Cross-Sectional Area Square Centimeters	Macrographs
Up to 36, incl	Up to 232, incl	S2 - R1 - C2
Over 36 to 100, incl	Over 232 to 645, incl	S2 - R2 - C3

3.3.2 Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112.

3.3.3 Hardenability: Shall be J11/16 inch (17.5 mm) = 53 HRC minimum and J20/16 inch (31.7 mm) = 50 HRC minimum (See 8.4), determined in accordance with ASTM A 255 on the standard end-quench specimen; the specimen shall be normalized at 1600°F ± 10 (871 °C ± 6) and austenitized at 1550 °F ± 10 (843 °C ± 6).

3.3.4 Decarburization:

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

3.3.4.2 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.

3.3.4.3 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 3.

TABLE 3A - Maximum Decarburization, Inch/Pound Units

Nominal Thickness 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	0.012
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 3B - Maximum Decarburization, SI Units

Nominal Thickness 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	0.30
Over 12.70 to 15.88, incl	0.36
Over 15.88 to 25.40, incl	0.43
Over 25.40 to 38.10, incl	0.51
Over 38.10 to 50.80, incl	0.64
Over 50.80 to 63.50, incl	0.76
Over 63.50 to 76.20, incl	0.89
Over 76.20 to 101.60, incl	1.14

3.3.4.4 Decarburization of mechanical tubing shall be not greater than shown in Table 4.

TABLE 4A - Maximum Decarburization, Inch/Pound Units

Nominal Wall Thickness Inches	Total Depth ID Inch	Total Depth OD 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, SI Units

Nominal Wall Thickness Millimeters	Total Depth ID Millimeter	Total Depth OD 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

3.3.4.5 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.

3.3.4.5.1 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.

3.3.5 Tensile Properties: After being heat treated in accordance with AMS 2759/1 to an ultimate tensile strength range of 180 to 200 ksi (1241 to 1379MPa), product shall have a transverse reduction of area not lower than 15% (See 4.3).

3.4 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.

3.4.1 Steel shall be special aircraft-quality conforming to AMS 2304 or MAM 2304.

3.4.2 Bars and mechanical 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 surface.

3.4.3 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 reentrant grain flow.

3.5 Tolerances:

Shall be as follows:

3.5.1 Bars: In accordance with AMS 2251 or MAM 2251.

3.5.2 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 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 (3.2), macrostructure (3.3.1), average grain size (3.3.2), hardenability (3.3.3), decarburization (3.3.4), frequency-severity cleanliness rating (3.4.1), and tolerances (3.5) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tensile properties after heat treatment (3.3.5) and grain flow of die forgings (3.4.3) 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 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, hardenability, and frequency-severity rating of each heat, and for the 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 6409B, 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, Mechanical Tubing, and Forging Stock: In accordance with AMS 2370 except that resampling for cleanliness shall conform to 4.5.3.

4.5.2 Forgings: In accordance with AMS 2372 except that resampling for cleanliness shall conform to 4.5.3.

4.5.3 Cleanliness: If any specimen fails to meet the specified frequency-severity cleanliness requirements, the entire heat shall be rejected or resampling and retesting shall be performed as follows:

4.5.3.1 Nonconforming Ingot(s): Reject or take additional discard, resample, and retest.

4.5.3.2 Ingot(s) Not Originally Sampled: Sample and test material from the respective nonconforming position(s), i.e., top or bottom, of two additional ingots for each nonconforming ingot. The ingots selected for additional samples shall be from locations in the pouring plate pattern closest to the nonconforming ingot(s).

4.5.3.3 If the nonconforming ingot(s) fail(s) the retest, repeat 4.5.3.1.

4.5.3.4 If all ingots sampled as in 4.5.3.2 meet the frequency-severity cleanliness requirements, the heat, except for original nonconforming ingot(s), is acceptable.

4.5.3.5 If any of the ingots sampled as in 4.5.3.2 fail to meet the frequency-severity cleanliness requirements, the heat shall be rejected or each ingot shall be tested at the nonconforming position(s) and acceptance of each ingot shall be based on the tests thereon.

4.5.3.6 All steel supplied to this specification shall be either from ingots which successfully met the frequency-severity cleanliness requirements, top and bottom, or from ingots and positions represented by successfully tested ingots.