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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6526E

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Superseding AMS 6526D

Steel, Bars, Forgings, Tubing, and Rings
1.0Cr - 7.5Ni - 4.5Co - 1.0Mo - 0.09V (0.29 - 0.34C)
Consumable Electrode Vacuum Melted, Annealed

(Composition similar to UNS K91283)

1. SCOPE:

1.1 Form:

This specification covers a premium aircraft-quality, high-strength, low-alloy steel in the form of bars, forgings, mechanical tubing, flash welded rings, and stock for forging or flash welded rings.

1.2 Application:

These products have been used typically for parts requiring through hardening to high strength levels and where such parts may require welding during fabrication, but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; 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 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.

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

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 (Continued):

AMS 2259	Chemical Check Analysis Limits, Wrought Low-Alloy and Carbon Steels
AMS 2300	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure
MAM 2300	Steel Cleanliness, Premium 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 2750	Pyrometry
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 7496	Rings, Flash Welded, Carbon and Low-Alloy Steels
ARP1110	Minimizing Stress Corrosion Cracking in Wrought Forms of Steels and Corrosion Resistant Steels and Alloys
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 or 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 Steel
ASTM E 112	Determining Average Grain Size
ASTM E 353	Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys
ASTM E 384	Microindentation Hardness of Materials
ASTM E 399	Plane-Strain Fracture Toughness of Metallic 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 353, by spectrochemical methods, or by other analytical methods acceptable to purchaser.

TABLE 1 - Composition

Element	min	max
Carbon	0.29	0.34
Manganese	0.10	0.35
Silicon	--	0.20
Phosphorus	--	0.010
Sulfur	--	0.010
Chromium	0.90	1.10
Nickel	7.00	8.00
Cobalt	4.25	4.75
Molybdenum	0.90	1.10
Vanadium	0.06	0.12
Copper	--	0.35

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

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 Least Distance Between Parallel Sides: Annealed and cold finished having tensile strength not higher than 165 ksi (1138 MPa) or equivalent hardness (See 8.2).

3.3.1.2 Bars Over 0.500 Inch (12.70 mm) in Nominal Diameter or Least Distance Between Parallel Sides and Forgings, Flash Welded Rings, and Mechanical Tubing: Hot finished, annealed, and descaled having hardness not higher than 341 HB, or equivalent (See 8.3).

3.3.2 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS 7496.

3.3.3 Stock for Forging or Flash Welded Rings: As ordered by the forging or flash welded ring manufacturer.

3.4 Heat Treatment:

Bars, forgings, mechanical tubing, and flash welded rings shall be duplex annealed by heating to 1250 °F ± 25 (677 °C ± 14), holding at heat for 4 hours ± 0.25, cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool, reheating to 1150 °F ± 25 (621 °C ± 14), holding at heat for 4 hours ± 0.25, and cooling to room temperature in air or other atmosphere at a rate equivalent to an air cool. Pyrometry shall be in accordance with AMS 2750.

3.5 Properties:

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

3.5.1 Macrostructure: Visual examination of transverse full cross-sections from bars, billets, tube rounds, and stock for forging or flash welded rings, 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	A
3	Radial Segregation	B
4	Ring Pattern	B

3.5.2 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 Limits

Type	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	1.5	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

3.5.2.1 A rateable field is defined as one which has a type A, B, C, or D inclusion rating of at least 1.0 thin or heavy in accordance with the Jernkontoret Chart, Plate III, ASTM E 45.

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

3.5.4 Decarburization:

3.5.4.1 Bars, tubing, and flash welded rings ordered ground, turned, or polished shall be free from decarburization on the ground, turned, or polished surfaces.

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

3.5.4.3 Decarburization of bars and flash welded rings to which 3.5.4.1 or 3.5.4.2 is not applicable shall be not greater than shown in Table 4.

TABLE 4A - Maximum 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	0.012
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 5.000, incl	0.045

TABLE 4B - Maximum 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	0.30
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 127.00, incl	1.14

3.5.4.4 Decarburization of tubing to which 3.5.4.1 or 3.5.4.2 is not applicable shall be not greater than shown in Table 5.

TABLE 5A - 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 5B - Maximum Decarburization, SI Units

Nominal Wall Thickness Millimeters	Total Depth ID Millimeter	Total Depth OD Millimeters
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

3.5.4.5 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.

3.5.4.5.1 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.

3.5.5 Response to Heat Treatment: Specimens taken from bars, forgings, mechanical tubing, and parent metal of flash welded rings, heat treated as in 3.5.5.1, shall conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3. Product need not be annealed as in 3.3 before heat treatment to determine conformance to these requirements.

3.5.5.1 Heat Treatment:

3.5.5.1.1 Normalizing: Heat to 1675 °F ± 25 (913 °C ± 14), hold at heat for not less than 1 hour per inch (25 mm) of maximum section thickness, and cool at a rate equivalent to air cooling to room temperature.

3.5.5.1.2 Hardening: Heat to 1550 °F ± 25 (843 °C ± 14), hold at heat for 1 hour per inch (25 mm) of maximum section thickness but not less than 1 hour, quench sections 4.0 inches (102 mm) and under in nominal thickness into room temperature oil or water and sections over 4.0 inches (102 mm) in nominal thickness into room temperature oil. Cool to -100 °F ± 10 (-73 °C ± 6), within 2 hours after quenching, hold at -100 °F ± 10 (-73 °C ± 6) for not less than 2 hours, and warm in air to room temperature.

3.5.5.1.3 Tempering: Heat to 1000 °F ± 10 (538 °C ± 6), hold at heat for not less than 2 hours, cool to below 125 °F (52 °C), reheat to 1000 °F ± 10 (538 °C ± 6), hold at heat for not less than 2 hours, and cool in air to room temperature.

3.5.5.2 Tensile Properties: Shall be as shown in Table 6.

TABLE 6 - Minimum Tensile Properties

Property	Value
Tensile Strength	220 ksi (1517 MPa)
Yield Strength at 0.2% Offset	190 ksi (1310 MPa)
Elongation in 4D	10%
Reduction of Area	40%

3.5.5.3 Fracture Toughness: Fracture toughness, when specified, shall be not less than 90.0 ksi $\sqrt{\text{inch}}$ (99 MPa $\sqrt{\text{m}}$) K_{IC} or K_Q, determined in accordance with ASTM E 399 on any product from which a specimen of a standardized ASTM E 399 orientation can be extracted having dimensions not less than 1.50 inches (38.1 mm) in section thickness and not less than 4.00 inches (101.6 mm) in width.

3.5.6 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.5.5.1, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3. If specimens taken from the stock after heat treatment as in 3.5.5.1 conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.6.1 Forging stock from a heat meeting the requirements of 3.5.6 in one size need not be retested for use in a smaller size.

3.5.7 Stock for Flash Welded Rings: Specimens taken from stock after heat treatment as in 3.5.5.1 shall conform to the requirements of 3.5.5.2 and, when specified, 3.5.5.3.

3.6 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.

3.6.1 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.

3.6.2 Bars, tubing, and flash welded rings 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.

3.6.3 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.

3.7 Tolerances:

Shall be as follows:

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

3.7.2 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: The following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (3.1), macrostructure (3.5.1), and micro-inclusion rating (3.5.2) of each heat.