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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 6523E

Issued NOV 1970
Revised APR 2001

Superseding AMS 6523D

Steel, Sheet, Strip, and Plate
0.75Cr - 9.0Ni - 4.5Co - 1.0Mo - 0.09V (0.17 - 0.23C)
Vacuum Consumable Electrode Melted, Annealed

(Composition similar to UNS K91472)

1. SCOPE:

1.1 Form:

This specification covers a premium aircraft-quality, low-alloy steel in the form of sheet, strip, and plate.

1.2 Application:

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

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.

AMS 2252	Tolerances, Low-Alloy Steel Sheet, Strip, and Plate
MAM 2252	Tolerances, Metric, Low-Alloy Steel Sheet, Strip, and Plate
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

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 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock
AMS 2750	Pyrometry
AMS 2759	Heat Treatment of Steel Parts, General Requirements
AMS 2807	Identification, Carbon and Low-Alloy Steels, Corrosion and Heat Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft 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 Average Grain Size
ASTM E 338	Sharp-Notch Tension Testing of High-Strength Sheet Materials
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

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	0.17	0.23
Manganese	0.20	0.40
Silicon	--	0.20
Phosphorus	--	0.010
Sulfur	--	0.010
Chromium	0.65	0.85
Nickel	8.50	9.50
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 vacuum consumable electrode practice in the remelt cycle.

3.3 Condition:

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

3.3.1 Sheet and Strip: Cold finished, bright or atmosphere annealed, and descaled if necessary; or hot rolled, annealed, and descaled having hardness not higher than 36 HRC, or equivalent (See 8.2).

3.3.2 Plate: Hot rolled, annealed, and descaled having hardness not higher than 36 HRC, or equivalent (See 8.2).

3.3.3 When normalized and tempered product is ordered, hardness shall be not higher than 40 HRC, or equivalent (See 8.2).

3.4 Heat Treatment:

Shall be as follows; pyrometry shall be in accordance with AMS 2750:

3.4.1 Annealing: Product shall be annealed by heating to 1250 °F ± 25 (677 °C ± 14), holding at heat for 4 hours ± 0.25, air cooling to room temperature, reheating to 1150 °F ± 25 (621 °C ± 14), holding at heat for 8 hours ± 0.25, and cooling in air to room temperature.

3.4.2 Normalizing: When specified by purchaser, product shall be normalized prior to annealing by heating to temperature, holding at heat for not less than one hour per inch (25 mm) of maximum thickness but not less than one hour, and cooling in air to room temperature.

3.5 Properties:

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

3.5.1 Macrostructure: Visual examination of full transverse cross-sections of finished slab or billet or suitable rerolled product, 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

Condition	Class	Severity
Freckles	1	A
White Spots	2	A
Radial Segregation	3	B
Ring Pattern	4	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 Rating Limits

	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, max	*	1	*	1	*	1	3	1
Total Rateable Fields Frequency, max	**	1	**	1	**	1	8	1

* Combined A+B+C, not more than 3 fields
** 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, of 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: Depending upon thickness of the product, decarburization may be measured by a HR30N hardness step test method, or by the microhardness traverse method. Additionally, the metallographic method shall be used, in part (See 3.5.4.4.1), to inspect product 0.025 to 0.250 inch (0.64 to 6.35 mm) thick, and it may be used to inspect product with thickness 0.375 inch (9.52 mm) and over.

3.5.4.1 In the case of dispute, the microhardness method, conducted in accordance with ASTM E 384, shall govern. The allowance for decarburization shall be that which would have been applicable had the step method been used (See 3.5.4.4.1 or 3.5.4.5.1, as applicable).

3.5.4.2 Specimens: Shall be full thickness of the product except that specimens from plate 0.250 inch (6.35 mm) and over in nominal thickness may be slices approximately 0.250 inch (6.35 mm) thick cut parallel to and preserving one original surface of the plate. Recommended minimum specimen size is 1 x 4 inches (25 x 102 mm). For product 0.025 to 0.250 inch (0.64 to 6.35 mm), a full cross section metallographic sample shall be prepared to inspect for presence of complete decarburization (ferrite).

3.5.4.3 Procedure: Specimens shall be hardened by austenitizing and quenching; preferably, they shall not be tempered but, if tempered, the tempering temperature shall be not higher than 300 °F (149 °C). During heat treatment, specimens shall be protected by suitable atmosphere or medium or by suitable plating to prevent carburization or further decarburization.

3.5.4.4 Product 0.025 to 0.250 inch (0.64 to 6.35 mm) Exclusive in Nominal Thickness: Protective plating, if used to prevent any decarburization during hardening, shall be removed, and a portion of the specimen shall be ground with copious coolant to prevent thermal or mechanical effects to a depth of 0.050 inch (1.27 mm) or one-half thickness, whichever is less.

3.5.4.4.1 Allowance: The product shall show no layer of complete decarburization (ferrite) determined metallographically at a magnification not exceeding 100X. It shall also be free from any partial decarburization to the extent that the difference in hardness between the original surface and the surface (depth) generated by grinding as in 3.5.4.4 shall not be greater than two units on the HRA scale, or equivalent (See 8.2). Also, refer to 3.5.4.1.

3.5.4.5 Product 0.250 to 0.375 inch (6.35 to 9.52 mm), Exclusive, in Nominal Thickness: Specimens shall be ground to remove 0.010 inch (0.25 mm) of metal to create a test reference surface, and a portion of the specimen shall be further ground to a depth of at least one-third the original thickness of the specimen.

3.5.4.5.1 Allowance: Shall be free from decarburization to the extent that the difference in hardness between the two prepared steps shall be not greater than three units on the HRA scale, or equivalent (See 8.2). Also, refer to 3.5.4.1.

3.5.4.6 Product 0.375 inch (9.52 mm) and Over in Nominal Thickness:

3.5.4.6.1 Allowance: The total depth of the decarburization, determined metallographically at a magnification not exceeding 100X, on the as-supplied plate, shall be not greater than shown in Table 4. Also, refer to 3.5.4.1. The depth of decarburization shall be that which is defined as the perpendicular distance from the surface to the depth under that surface below which there is no further increase in hardness.

TABLE 4A - Maximum Decarburization, Inch/Pound Units

Nominal Thickness Inches	Total Depth of Decarburization Inch
0.375 to 0.500, incl	0.015
Over 0.500 to 1.000, incl	0.025
Over 1.000 to 2.000, incl	0.035

TABLE 4B - Maximum Decarburization, SI Units

Nominal Thickness Millimeters	Total Depth of Decarburization Millimeter
9.52 to 12.70, incl	0.38
Over 12.70 to 25.40, incl	0.64
Over 25.40 to 50.80, incl	0.89

3.5.5 Properties After Normalizing, Hardening, Sub-Zero Cooling, and Double Tempering Heat Treatment: Product shall meet the following properties after being normalized by heating to 1650 °F ± 25 (899 °C ± 14), holding at heat for one hour per inch (25 mm) of maximum cross-section, and cooling in air to room temperature; hardened by heating to 1525 °F ± 25 (829 °C ± 14), holding at heat for one hour per inch (25 mm) of maximum cross-section but not less than one hour, and quenching in oil or water; cooling to -100 °F ± 10 (-73 °C ± 6) within two hours, holding at -100 °F ± 10 (-73 °C ± 6) for not less than two hours, warming to room temperature; and double tempered by heating to 1035 °F ± 15 (557 °C ± 8), holding at heat for two hours per inch (25 mm) of maximum cross-section but not less than two hours, cooling to approximately 125 °F (52 °C), reheating to 1035 °F ± 15 (557 °C ± 8), holding at heat for two hours per inch (25 mm) of maximum cross-section but not less than two hours, and cooling in air to room temperature. If the first temper cannot be performed within two hours of sub-zero treatment, snap temper the product at 350 to 450 °F (177 to 232 °C) for two hours per inch (25 mm) of thickness. Normalizing may be omitted if the product was supplied normalized or annealed. Heat treating equipment and controls shall be in accordance with AMS 2759.

3.5.5.1 Tensile Properties: Shall be as shown in Table 5.

TABLE 5A - Minimum Tensile Properties, Inch/Pound Units

Nominal Thickness Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %	Reduction of Area %
Up to 0.250, excl	190	175	5	45
0.250 and over	190	175	10	45

TABLE 5B - Minimum Tensile Properties, SI Units

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %	Reduction of Area %
Up to 6.35, excl	1310	1207	5	45
6.35 and over	1310	1207	10	45

3.5.5.2 Hardness: Shall be 41 to 46 HRC, or equivalent (See 8.2).

3.5.5.3 Fracture Toughness: When specified, product shall be subjected to fracture toughness testing. Sheet and strip shall be tested in accordance with ASTM E 338 and plate shall be tested in accordance with ASTM E 399. Results of tests on sheet and strip over four inches (102 mm) wide and plate under 1.50 inch (38.1 mm) in thickness shall be reported. Plate over 1.50 inch (38.1 mm) in thickness shall have fracture toughness not less than 120 ksi $\sqrt{\text{inch}}$ (132 MPa $\sqrt{\text{m}}$) in the longitudinal direction (L-T) and 110 ksi $\sqrt{\text{inch}}$ (121 MPa $\sqrt{\text{m}}$) in the long-transverse (T-L) direction.

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.

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2252 or MAM 2252.