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SAE-AMS6523, "STEEL SHEET, STRIP, AND PLATE 0.75CR - 9.0NI- 4.5CO - 1.0MO - 0.09V (0.17 - 0.23C) VACUUM CONSUMABLE ELECTRODE MELTED, ANNEALED", was adopted on 17-MAR-89 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-ITAA, 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

SAE AMS 6523D

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Submitted for recognition as an American National Standard

Superseding AMS 6523C

STEEL, SHEET, STRIP, AND PLATE
0.75Cr - 9.0Ni - 4.5Co - 1.0Mo - 0.09V (0.17 - 0.23C)
Vacuum Consumable Electrode Melted, Annealed

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 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 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	Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure
MAM 2300	Premium Aircraft-Quality Steel Cleanliness, Magnetic Particle Inspection Procedure, Metric (SI) Measurement
AMS 2370	Quality Assurance Sampling and Testing, Carbon and Low-Alloy Steel Wrought Products and Forging Stock

2.1 (Continued)

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, 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 45 Determining the Inclusion Content of Steel
ASTM E 112 Determining the 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

2.3 U.S. Government Publications:

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

MIL-STD-1 63 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	0.17	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 Melt 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 ºF ± 25 (677 ºC ± 14), holding at heat for 4 hours ± 0.25, air cooling to room temperature, reheating to 1150 ºF ± 25 (621 ºC ± 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 1650 ºF ± 25 (899 ºC ± 14), 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 (R) Macrostructure: Visual examination of full cross-sectional specimens as in 4.3.1, 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 as in 4.3.2 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 (R) Average Grain Size: Shall be ASTM No. 5 or finer, determined in accordance with ASTM E 112 (See 8.3).

3.5.4 Decarburization:

3.5.4.1 Product 0.045 to 0.375 Inch (1.14 to 9.52 mm), Exclusive, in Nominal Thickness:

3.5.4.1.1 Specimens: Shall be the full thickness of the product except that specimens from plate 0.250 inch (6.35 mm) and over in nominal thickness shall be slices approximately 0.250 inch (6.35 mm) thick cut parallel to and preserving one original surface of the plate. Recommended specimen size is 1 x 4 inches (25 x 102 mm).

3.5.4.1.2 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 ºF (149 ºC). During heat treatment, specimens shall be protected by suitable atmosphere or medium or by suitable plating to prevent carburization or further decarburization. Protective plating, if used, shall then be removed from specimens of product 0.045 to 0.250 inch (1.14 to 6.35 mm), exclusive, in nominal thickness and a portion of the specimen shall be ground to a depth of 0.050 inch (1.27 mm) or one-half thickness, whichever is less. Specimens from product 0.250 to 0.375 inch (6.35 to 9.52 mm), exclusive, in nominal thickness shall be ground to remove 0.020 inch (0.51 mm) of metal from the original surface of the plate and a portion of the specimen shall be further ground to a depth of at least one-third the original thickness of the specimen. At least three Rockwell hardness readings shall be taken on each prepared step and each group of readings averaged.

3.5.4.1.3 Allowance:

3.5.4.1.3.1 Product 0.045 to 0.250 Inch (1.15 to 6.35 mm), Exclusive, in Nominal Thickness: The product shall show no layer of complete decarburization, determined microscopically at a magnification not exceeding 100X. It shall also be free from partial decarburization to the extent that the difference in hardness between the original surface and the portion ground as in 3.5.4.1.2 shall be not greater than 2 units on the Rockwell "A" Scale.

3.5.4.1.3.2 Product 0.250 to 0.375 Inch (6.35 to 9.52 mm), Exclusive, in Nominal Thickness: Shall be free from decarburization to the extent that the difference in hardness between the two prepared steps shall be not greater than 3 units on the Rockwell "A" Scale.

3.5.4.2 Product 0.375 Inch (9.52 mm) and Over in Nominal Thickness: The total decarburization, determined microscopically at a magnification not exceeding 100X on the as-supplied plate, shall be not greater than shown in Table 4.

TABLE 4A - Maximum Decarburization, Inch/Pound Units

Nominal Thickness Inches	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	Depth of Decarburization Millimeters
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 ºF ± 25 (899 ºC ± 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 ºF ± 25 (829 ºC ± 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 ºF ± 10 (-73 ºC ± 6) within two hours, holding at -100 ºF ± 10 (-73 ºC ± 6) for not less than two hours, warming to room temperature; and double tempered by heating to 1035 ºF ± 15 (557 ºC ± 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 ºF (52 ºC), reheating to 1035 ºF ± 15 (557 ºC ± 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 first temper cannot be performed within two hours of sub-zero treatment, snap temper at 350 to 450 ºF (177 to 232 ºC) 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 specified 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). (R)

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 in the longitudinal direction (L-T) not less than 120 ksi $\sqrt{\text{inch}}$ (132 MPa$\sqrt{\text{m}}$) 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.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:
(R)

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:

Tests for all technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling and Testing:
(R)

Shall be in accordance with AMS 2370 and the following:

4.3.1 Samples for macrostructure rating (3.5.1) shall be full cross-sectional specimens obtained from the finished slab or billet or suitable rerolled product representing the top and bottom of at least the first, middle, and last usable ingot of each heat. When ingot location is not available, the lot shall be sampled on at least one end of 10% of the slabs or billets.

4.3.2 Samples for micro-inclusion rating (3.5.2) shall be obtained from the finished slab or billet or suitably rerolled product and shall consist of not less than four specimens representing the top and bottom of the first and last ingot from a heat yielding 10 or fewer ingots or not less than six specimens representing the top and bottom of the first, middle, and last usable ingot from a heat yielding more than 10 ingots.