

STEEL SHEET, STRIP, AND PLATE  
1.0Cr - 7.5Ni - 4.5Co - 1.0Mo - 0.09V (0.29 - 0.34C)  
Vacuum Consumable Electrode Melted, Annealed

UNS K91313

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: Primarily for parts, such as pressure vessels, requiring through-hardening to high strength levels and where such parts may require welding during fabrication.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 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 2350 - Standards and Test Methods  
AMS 2370 - Quality Assurance Sampling of Carbon and Low-Alloy Steels. Wrought Products Except Forgings and Forging Stock

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2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products

ASTM A604 - Macroetch Testing of Consumable Electrode Remelted Steel Bars and Billets

ASTM E45 - Determining the Inclusion Content of Steel

ASTM E112 - Determining Average Grain Size

ASTM E338 - Sharp-Notch Tension Testing of High-Strength Sheet Materials

ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

ASTM E399 - Plane-Strain Fracture Toughness of Metallic Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 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, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max
Carbon	0.29	0.34
Manganese	0.10	0.35
Silicon	--	0.20
Phosphorus	--	0.01
Sulfur	--	0.01
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 Condition: The product shall be supplied in the following condition; hardness shall be determined in accordance with ASTM A370:

- 3.2.1 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.
- 3.2.2 Plate: Hot rolled, annealed, and descaled having hardness not higher than 36 HRC or equivalent.
- 3.2.3 When normalized and tempered product is ordered, hardness shall be not higher than 40 HRC or equivalent.
- 3.3 Properties: The product shall conform to the following requirements; tensile testing shall be performed in accordance with ASTM A370:

3.3.1 Macrostructure: Visual examination of specimens as in 4.3.1, etched in accordance with ASTM A604 in hot hydrochloric acid (1:1) at 160° - 180°F (71° - 82°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 standards agreed upon by purchaser and vendor.

3.3.2 Micro-Inclusion Rating: No specimen as in 4.3.2 shall exceed the following limits, determined in accordance with ASTM E45, Method D:

Type	Inclusion Rating			
	A	B	C	D
Thin	2.0	1.5	1.5	1.5
Heavy	1.0	1.0	1.0	1.5

3.3.2.1 For types A, B, and C thin combined, there shall be not more than three fields of No. 2.0 A type or No. 1.5 B and C types and not more than five other lower rateable A, B, and C type thin fields per specimen. For type D thin, there shall be not more than five No. 1.5 thin fields. Any number of lower rateable D-type thin fields per specimen is permitted. There shall be not more than one field each of No. 1.0 type A, B, or C or three fields of type D heavy per specimen. In addition, the thickness of the D-type heavy shall not exceed 0.0005 in. (0.012 mm).

3.3.2.2 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 E45.

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

3.3.4 Decarburization:

3.3.4.1 Product Under 0.045 In. (1.15 mm) in Nominal Thickness: The method of test and the allowance shall be as agreed upon by purchaser and vendor.

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## 3.3.4.2 Product 0.045 to 0.375 In. (1.15 to 9.50 mm), Excl, in Nominal Thickness:

3.3.4.2.1 Specimens: Shall be the full thickness of the product except that specimens from plate 0.250 in. (6.25 mm) and over in nominal thickness shall be slices approximately 0.250 in. (6.25 mm) thick cut parallel to and preserving one original surface of the plate. Recommended specimen size is 1 x 4 in. (25 x 100 mm).

3.3.4.2.2 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°F (150°C). 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 in. (1.15 to 6.25 mm), excl, in nominal thickness and a portion of the specimen shall be ground to a depth of 0.050 in. (1.25 mm) or one-half thickness, whichever is less. Specimens from product 0.250 to 0.375 in. (6.25 to 9.50 mm), excl, in nominal thickness shall be ground to remove 0.020 in. (0.50 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.

## 3.3.4.2.3 Allowance:

3.3.4.2.3.1 Product 0.045 to 0.250 In. (1.15 to 6.25 mm), Excl, 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 3.3.4.2.2 shall be not greater than 2 units on the Rockwell "A" Scale.

3.3.4.2.3.2 Product 0.250 to 0.375 In. (6.25 to 9.50 mm), Excl, 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.

3.3.4.3 Product 0.375 In. (9.50 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 I.

TABLE I

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
Over 2.000	As agreed upon

TABLE I (SI)

Nominal Thickness Millimetres	Depth of Decarburization Millimetre
9.50 to 12.50, incl	0.38
Over 12.50 to 25.00, incl	0.62
Over 25.00 to 50.00, incl	0.88
Over 50.00	As agreed upon

3.3.5 Properties After Heat Treatment: Product shall meet the following requirements after being normalized by heating to 1650°F + 25 (900°C + 15), holding at heat for 1 hr per inch (25 mm) of maximum cross-section, and cooling in air to room temperature; hardened by heating to 1550°F + 25 (845°C + 15), holding at heat for 1 hr per inch (25 mm) of maximum cross-section but not less than 1 hr, and quenching in oil or water; cooling to -100°F + 10 (-75°C + 5), holding at -100°F + 10 (-75°C + 5) for not less than 2 hr, warming to room temperature; and double tempered by heating to 975°F + 15 (525°C + 8), holding at heat for 2 hr per inch (25 mm) of maximum cross-section but not less than 2 hr, cooling to approximately 125°F (50°C), reheating to 975°F + 15 (525°C + 8), holding at heat for 2 hr per inch (25 mm) of maximum cross-section but not less than 2 hr, and cooling in air to room temperature:

3.3.5.1 Tensile Properties: Shall be as specified in Table II.

TABLE II

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. or 4D %, min	Reduction of Area %, min
Up to 0.250, excl	220,000	185,000	6	--
0.250 and over	220,000	190,000	10	35

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TABLE II (SI)

Nominal Thickness Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 50 mm or 4D %, min	Reduction of Area %, min
Up to 6.25, excl	1515	1275	6	--
6.25 and over	1515	1310	10	35

3.3.5.2 Hardness: Should be not lower than 46 HRC, or equivalent, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.3.5.1 are met.

3.3.5.3 Fracture Toughness: When specified, the product shall be subjected to fracture toughness testing and the results reported. Sheet and strip  $\emptyset$  shall be tested in accordance with ASTM E338 and plate shall be tested in accordance with ASTM E399. Acceptance standards shall be as agreed upon by purchaser and vendor.

#### 3.4 Quality:

3.4.1 Steel shall be premium aircraft-quality conforming to AMS 2300 or MAM 2300. It shall be multiple melted using vacuum consumable electrode practice in the remelt cycle.

3.4.2 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.

3.5 Tolerances: Unless otherwise specified, tolerances shall conform to all applicable requirements of AMS 2252 or MAM 2252.

#### 4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all  $\emptyset$  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 product conforms to the requirements of this specification.

#### 4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for  $\emptyset$  composition (3.1), condition (3.2), macrostructure (3.3.1), micro-inclusion rating (3.3.2), grain size (3.3.3), decarburization (3.3.4), frequency-severity cleanliness rating (3.4.1), and tolerances (3.5) 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 response to heat treatment (3.3.5) 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; a heat shall be the consumable electrode remelted ingots produced from steel originally melted as a single furnace charge:

4.3.1 Samples for macrostructure (3.3.1) testing 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 ingots of each heat.

4.3.2 Samples for micro-inclusion rating (3.3.2) shall be obtained from the finished slab or billet or suitable rerolled product and shall consist of not less than four specimens representing the top and bottom of the first and last ingots 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 ingots from a heat yielding more than 10 ingots.

4.4 Reports:

4.4.1 The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition, macrostructure, micro-inclusion rating, grain size, and frequency-severity cleanliness rating of each heat and, when performed, to the periodic test requirements. This report shall include the purchase order number, heat number, AMS 6524B, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 6524B, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification and shall include in the report either a statement that the material conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: Shall be in accordance with AMS 2370.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as in 5.1.1 unless purchaser permits a method from 5.1.2.

5.1.1 Each sheet, strip, and plate shall be marked on one face, in the respective location indicated below, with AMS 6524B, heat number, manufacturer's identification, and nominal thickness. The characters shall be of such size as to be legible, shall be applied using a suitable