

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

SAE AMS 5606B

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Superseding AMS 5606A

ALLOY SHEET, STRIP, AND PLATE, CORROSION AND HEAT RESISTANT

41.5Ni - 16Cr - 37Fe - 2.9Cb - 1.8Ti

Consumable Electrode or Vacuum Induction Melted

1750°F (955°C) Solution Heat Treated

UNS N09706

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant nickel alloy in the form of sheet, strip, and plate.

1.2 Application: Primarily for parts requiring resistance to creep and stress-rupture up to 1300°F (705°C), oxidation resistance up to 1800°F (980°C), and good machinability, particularly for those parts which are formed or welded and then heat treated to develop required properties.

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 2262 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Sheet, Strip, and Plate

MAM 2262 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Sheet, Strip, and Plate

AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys

AMS 2350 - Standards and Test Methods

AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, 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 E8 - Tension Testing of Metallic Materials
- ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
- ASTM E112 - Determining Average Grain Size
- ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
- ASTM E290 - Semi-Guided Bend Test for Ductility of Metallic Materials
- ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

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

2.3.1 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 E354 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	--	0.06
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.020
Sulfur	--	0.015
Chromium	14.50 -	17.50
Nickel	39.00 -	44.00
Columbium + Tantalum	2.50 -	3.30
Titanium	1.50 -	2.00
Aluminum	--	0.40
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269.

3.2 Condition: The product shall be supplied in the following condition:

3.2.1 Sheet and Strip: Cold rolled, solution heat treated, and, unless solution heat treatment is performed in an atmosphere yielding a bright finish, descaled having a surface appearance comparable to the following corrosion-resistant steel finishes as applicable:

3.2.1.1 Sheet: No. 2D finish.

3.2.1.2 Strip: No. 1 strip finish.

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3.2.2 Plate: Hot rolled, solution heat treated, and descaled.

3.3 Heat Treatment: The product shall be solution heat treated to meet the requirements of 3.4. No specific solution heat treatment is specified but it is recommended that the product be solution heat treated by heating in a suitable protective atmosphere to a temperature within the range 1700° - 1800°F (930° - 980°C), holding at the selected temperature within +25°F (+15°C) for a time commensurate with section thickness but not less than 5 min., and cooling at a rate equivalent to air cool or faster.

3.4 Properties: The product shall conform to the following requirements:

3.4.1 As Solution Heat Treated:

3.4.1.1 Tensile Properties: Shall be as specified in Table I, determined in accordance with ASTM E8.

TABLE I

Nominal Thickness Inches	Tensile Strength psi, max	Yield Strength at 0.2% Offset psi, max	Elongation in 2 in. or 4D %, min
Up to 0.187, incl	130,000	80,000	30
Over 0.187	140,000	90,000	30

TABLE I (SI)

Nominal Thickness Millimetres	Tensile Strength MPa, max	Yield Strength at 0.2% Offset MPa, max	Elongation in 50 mm or 4D %, min
Up to 4.75, incl	895	550	30
Over 4.75	965	620	30

3.4.1.2 Hardness: Should be not higher than the following, or equivalent, determined in accordance with ASTM E18 but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.1.1 are met:

Nominal Thickness		Hardness
Inches	Millimetres	
Up to 0.187, incl	Up to 4.75, incl	102 HRB
Over 0.187	Over 4.75	25 HRC

- 3.4.1.3 **Bending:** Product 0.187 in. (4.75 mm) and under in nominal thickness shall withstand, without cracking, bending in accordance with ASTM E290 through an angle of 180 deg around a diameter equal to the bend factor times the nominal thickness of the product with axis of bend parallel to the direction of rolling.

Nominal Thickness		Bend Factor
Inches	Millimetres	
Up to 0.050, incl	Up to 1.25, incl	1
Over 0.050 to 0.187, incl	Over 1.25 to 4.75, incl	2

- 3.4.1.3.1 Bending requirements for product over 0.187 in. (4.75 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

- 3.4.1.4 **Grain Size:** Shall be as follows, determined by comparison of a polished and etched specimen with the chart in ASTM E112:

Nominal Thickness		Grain Size
Inches	Millimetres	
Up to 0.187, incl	Up to 4.75, incl	Predominantly 5 or finer
Over 0.187	Over 4.75	Predominantly 4 or finer

- 3.4.2 **After Stabilization and Precipitation Heat Treatment:** The product, 0.010 - 1.000 in. (0.25 - 25.00 mm) in thickness, shall have the following properties after being stabilization heat treated by heating to 1550°F + 15 (845°C + 8), holding at heat for 3 hr + 0.25, and cooling in air to room temperature and precipitation heat treated by heating to 1325°F + 15 (720°C + 8), holding at heat for 8 hr + 0.25, cooling at a rate of 100 F (55 C) deg per hr to 1150°F + 15 (620°C + 8), holding at 1150°F + 15 (620°C + 8) for 8 hr + 0.25, and cooling in air. Instead of the 100 F (55 C) deg per hr cooling rate to 1150°F + 15 (620°C + 8), furnace cooling may be at any rate provided the time at 1150°F + 15 (620°C + 8) is adjusted to give a total precipitation heat treatment time of not less than 18 hours. Properties of product over 1.000 in. (25.00 mm) or under 0.010 in. (0.25 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

- 3.4.2.1 **Tensile Properties:** Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	170,000 psi (1170 MPa)
Yield Strength at 0.2% Offset, min	135,000 psi (930 MPa)
Elongation in 2 in. (50 mm) or 4D, min	12%

- 3.4.2.2 **Hardness:** Should be not lower than 30 HRC, or equivalent, determined in accordance with ASTM E18 but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.4.2.1 are met.

- 3.4.2.3 Stress-Rupture Properties at 1200°F (650°C): A tensile specimen, maintained at 1200°F + 3 (650°C + 2) while a load sufficient to produce the initial axial stress specified in Table II is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be as specified in Table II. Tests shall be conducted in accordance with ASTM E139.

TABLE II

Nominal Thickness Inches	Initial Axial Stress psi	Elongation in 2 in. or 4D %, min
Up to 0.015, incl	95,000	-
Over 0.015 to 0.025, incl	95,000	3
Over 0.025	100,000	3

TABLE II (SI)

Nominal Thickness Millimetres	Initial Axial Stress MPa	Elongation in 50 mm or 4D %, min
Up to 0.38, incl	655	-
Over 0.38 to 0.62, incl	655	3
Over 0.62	690	3

- 3.4.2.3.1 The test of 3.4.2.3 may be conducted using a load higher than required to produce the initial axial stress specified in Table II but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.4.2.3.
- 3.4.2.3.2 When permitted by purchaser, the test of 3.4.2.3 may be conducted using incremental loading. In such case, the load required to produce the initial axial stress specified in Table II shall be maintained to rupture or for 23 hr, whichever occurs first. After the 23 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter the stress shall be increased in increments of 5000 psi (35 MPa). Time to rupture and elongation requirements shall be as specified in 3.4.2.3.

3.5 Quality:

- 3.5.1 Alloy shall be produced by multiple melting using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used for remelting.
- 3.5.2 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.

3.6 Tolerances: Shall conform to all applicable requirements of AMS 2262 or MAM 2262.

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 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: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling: Shall be in accordance with AMS 2371; when consumable electrode remelted alloy is supplied, a heat shall be the consumable electrode remelted ingots produced from alloy originally melted as a single furnace charge.

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 of each heat and the results of tests on each lot to determine conformance to the other technical requirements of this specification. This report shall include the purchase order number, heat number, AMS 5606B, solution heat treatment temperature used, size, and quantity.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 5606B, 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 2371.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Each sheet, strip, and plate shall be marked on one face, in the respective location indicated below, with AMS 5606B, 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 marking fluid, and shall be removable in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the product or its performance and shall be sufficiently stable to withstand normal handling.