Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5606A
Superseding AMS 5606
Issued 11-15-71
Revised 7-16-79

ALLOY SHEET, STRIP, AND PLATE, CORROSION AND HEAT RESISTANT UNS N09706

41.5Ni - 16Cr - 37Fe - 2.9Cb - 1.8Ti
Consumable Electrode or Vacuum Induction Melted
1750°F (955°C) Solution Heat Treated

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 (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2262 - Tolerances, Nickel, Nickel-Base, and Cobalt-Base 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 Alloys, Wrought Products Except Forgings

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 - Estimating the Average Grain Size of Metals
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 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 E354, 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	--	0.06
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 in an atmosphere yielding a bright finish or solution heat treated and descaled to produce a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish; standards for acceptance shall be as agreed upon by purchaser and vendor.

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

3.3 Heat Treatment: The product shall be solution heat treated to conform to 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	896	552	30
Over 4.75	965	621	30

3.4.1.2 Hardness: Should be not higher than shown below, 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		
Inches	(Millimetres)	Hardness
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		
Inch	(Millimetres)	Bend Factor
Up to 0.050, incl	(Up to 1.27, incl)	1
Over 0.050 to 0.187, incl	(Over 1.27 to 4.75, incl)	2

3.4.1.3.1 Ø 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		
Inches	(Millimetres)	Grain Size
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 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), the 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.

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

Tensile Strength, min	170,000 psi (1172 MPa)
Yield Strength at 0.2% Offset, min	135,000 psi (931 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 (649°C): A tensile test specimen, maintained at 1200°F ± 3 (649°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	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	Stress MPa	Elongation in 50 mm or 4D %, min
Up to 0.38, incl	655	--
Over 0.38 to 0.64, incl	655	3
Over 0.64	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 (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.4.2.3.