Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 5605

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Revised

ALLOY SHEET, STRIP, AND PLATE, CORROSION AND HEAT RESISTANT
Nickel Base - 16Cr - 37Fe - 2.9Cb - 1.8Ti
Consumable Electrode or Vacuum Induction Melted
1800 F (982.2 C) Solution Heat Treated

1. SCOPE:

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

1.2 Application: Primarily for parts requiring good machinability and high strength at room and cryogenic temperatures for short time use up to approximately 1000 F (538 C), particularly those 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., Two Pennsylvania Plaza, New York, New York 10001.

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 and Nickel Base 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, Pennsylvania 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E112 - Estimating Average Grain Size of Metals
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 Base Alloys

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

2.3.1 Federal Standards:

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

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 approved analytical methods:

	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 finish as close as possible to a 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 3.4.1.1, 3.4.1.2, 3.4.1.3, 3.4.1.4, and 3.4.2. 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 1750 - 1850 F (954.4 - 1010 C), holding at the selected temperature within ±25 F (±14 C) for a time commensurate with the thickness, 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	130,000	80,000	30
Over 0.187	140,000	90,000	30

TABLE I (SI)

Nominal Thickness Millimeters	Tensile Strength MN/m^2, max	Yield Strength at 0.2% Offset MN/m^2, max	Elongation in 50.8 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 in the following table 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	(Millimeters)	
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: The product shall withstand, without cracking, bending in accordance with ASTM E290 through an angle of 180 deg (3.14 rad) around a diameter equal to the bend factor times the nominal thickness of the material with axis of bend parallel to the direction of rolling.

Nominal Thickness		Bend Factor
Inch	(Millimeters)	
Up to 0.050, incl	(Up to 1.27, incl)	1
Over 0.050 to 0.187	(Over 1.27 to 4.75, incl)	2

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	(Millimeters)	
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 Precipitation Heat Treatment: The product shall conform to the following requirements after being precipitation heat treated by heating to 1350 F ± 15 (732.2 C ± 8.3), holding at heat for 8 hr, cooling at a rate of 100 F (55.6 C) per hr to 1150 F ± 15 (621.1 C ± 8.3), holding at 1150 F ± 15 (621.1 C ± 8.3) for 8 hr, and cooling in air. Instead of the 100 F (55.6 C) deg per hr cooling rate to 1150 F ± 15 (621.1 C ± 8.3), the furnace cooling may be at any rate provided the time at 1150 F ± 15 (621.1 C ± 8.3) is adjusted to give a total precipitation heat treatment time of 18 hours.

3.4.2.1 Tensile Properties at Room Temperature: Shall be as specified in Table II, determined in accordance with ASTM E8:

TABLE II

Nominal Thickness Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 2 in. or 4D %, min
Up to 0.187, incl	175,000	145,000	12
Over 0.187	170,000	140,000	12

TABLE II (SI)

Nominal Thickness Millimeters	Tensile Strength MN/m^2, min	Yield Strength at 0.2% Offset psi, min	Elongation in 50.8 mm or 4D %, min
Up to 4.75, incl	1207	1000	12
Over 4.75	1172	965	12

3.4.2.2 Hardness: Should be not lower than 34 HRC or equivalent determined in accordance with ASTM E18, but the product shall not be rejected on the basis of hardness if the tensile properties of 3.4.2.1 are met.

3.5 Quality: Material shall be multiple melted using consumable electrode practice in the remelt cycle or shall be induction melted under vacuum, unless otherwise permitted. If consumable electrode remelting is not performed in vacuum, electrodes which have been produced by vacuum induction melting shall be used. The product shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts.

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

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor shall supply all samples 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 perform such confirmatory testing as he deems necessary to assure 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 routine control tests.

4.3 Sampling: Shall be in accordance with AMS 2371 and the following:

4.3.1 Tensile test specimens from widths 9 in. (229 mm) and over shall be taken with the axis perpendicular to the direction of rolling; for widths less than 9 in. (229 mm), specimens shall be taken with the axis parallel to the direction of rolling.

4.4 Reports:

4.4.1 The vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition of each heat in the shipment and the results of tests on each thickness from each heat to determine conformance to the other requirements of this specification. This report shall include the purchase order number, heat number, material specification number, solution heat treatment temperature used, thickness, size, and quantity from each heat.

4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, 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 a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.5 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

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 5605, heat number, manufacturer's identification, and nominal thickness. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid, and shall be capable of being removed in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the material or its performance and shall be sufficiently stable to withstand normal handling.