



AEROSPACE MATERIAL SPECIFICATION

AMS5606™**REV. G**

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Revised 2024-09

Superseding AMS5606F

(R) Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate
41.5Ni - 16Cr - 37Fe - 2.9Cb (NB) - 1.8Ti
Consumable Electrode or Vacuum Induction Melted,
1750 °F (954 °C) Solution Heat Treated
(Composition similar to UNS N09706)

RATIONALE

AMS5606G is the result of a Five-Year Review and update of the specification. The revision updates composition testing and reporting (see 3.1 and 3.1.1), revises the finish requirements (see 3.3.1), adds continuous heat-treatment requirements (see 3.4.1), clarifies bending requirements (see 3.5.1.3), adds strain rate control during tensile testing (see 3.5.2.1.1), adds pyrometry controls (see 3.4 and 3.5.2), adds minimum thickness requirements and updates mechanical testing (see 3.5.1.1, 3.5.1.2, 3.5.2, 3.5.2.2, and 8.2), prohibits unauthorized exceptions (see 1.1, 3.5.3, 3.8, 4.4.1, and 8.5), and allows the use of prior revisions (see 8.4).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel alloy in the form of sheet, strip, and plate 1.000 inch (25.40 mm) and under in nominal thickness.

1.2 Application

These products have been used typically for parts requiring resistance to creep and stress rupture up to 1300 °F (704 °C), oxidation resistance up to 1800 °F (982 °C), and good machinability, particularly for those parts that are formed or welded and then heat treated to develop required properties, but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

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2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2262	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Sheet, Strip, and Plate
AMS2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys
AMS2283	Composition Testing Methods for Nickel- and Cobalt-Based Alloys
AMS2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2750	Pyrometry
AMS2807	Identification, Carbon and Low-Alloy Steels, Corrosion- and Heat-Resistant Steels and Alloys, Sheet, Strip, Plate, and Aircraft Tubing
AS7766	Terms Used in Aerospace Metals Specifications

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E18	Rockwell Hardness of Metallic Materials
ASTM E112	Determining Average Grain Size
ASTM E139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E140	Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
ASTM E290	Bend Test of Materials for Ductility

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Composition shall conform to the percentages by weight shown in Table 1, determined in accordance with AMS2283 or by other analytical methods acceptable to the purchaser.

Table 1 - Composition

Element	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 (Niobium)	2.50	3.30
Tantalum	--	0.05
Titanium	1.50	2.00
Aluminum	--	0.40
Boron	--	0.006
Copper	--	0.30
Iron	remainder	

3.1.1 The producer may test for any element not listed in Table 1 and include this analysis in the report of 4.4. Reporting of any element not listed in the composition table is not a basis for rejection unless limits of acceptability are specified by the purchaser.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2269.

3.2 Melting Practice

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 that have been produced by vacuum induction melting shall be used for remelting.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Sheet and Strip

Sheet and strip shall be hot or cold rolled, solution heat treated, and, unless solution heat treatment is performed in an atmosphere yielding a bright finish, descaled producing a uniform finish.

3.3.2 Plate

Plate shall be hot rolled, solution heat treated, and descaled.

3.4 Heat Treatment

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 of 1700 to 1800 °F (927 to 982 °C), holding at the selected temperature within ± 25 °F (± 14 °C) for a time commensurate with section thickness but not less than 5 minutes, and cooling at a rate equivalent to an air cool or faster. Pyrometry shall be in accordance with AMS2750.

3.4.1 Continuous Heat Treatment

When continuous annealing is used, process parameters (e.g., furnace temperature set points, heat input, travel rate, etc.) for continuous heat-treating lines shall be established by the producer and validated by testing of product to the requirements of 3.5.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 As Solution Heat Treated

3.5.1.1 Tensile Properties

Tensile properties shall be as specified in Table 2, determined in accordance with ASTM E8/E8M for product 0.005 inch (0.12 mm) and over.

Table 2A - Tensile properties, inch/pound units

Nominal Thickness Inches	Tensile Strength ksi, max	Yield Strength at 0.2% Offset ksi, max	Elongation in 2 Inches or 4D %, min
Up to 0.1875, excl	130	80	30
0.1875 and over	140	90	30

Table 2B - Tensile properties, SI units

Nominal Thickness Millimeters	Tensile Strength MPa, max	Yield Strength at 0.2% Offset MPa, max	Elongation in 50 mm or 4D %, min
Up to 4.762, excl	896	552	30
4.762 and over	965	621	30

3.5.1.2 Hardness

Hardness for product 0.005 and over shall be not higher than shown in Table 3, or equivalent (see 8.2), determined in accordance with ASTM E18. Product shall not be rejected on the basis of hardness if the tensile properties of 3.5.1.1 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

Table 3 - Maximum hardness

Nominal Thickness Inches	Nominal Thickness Millimeters	Hardness
Up to 0.1875, excl	Up to 4.762, excl	102 HRB
0.1875 and over	4.762 and over	25 HRC

3.5.1.3 Bending

Product 0.1874 inch (4.75 mm) and under in nominal thickness shall be transverse tested in accordance with ASTM E290. Testing shall be performed at room temperature. Bend requirements shall be in accordance with Table 4. When visually examined, the specimen shall exhibit no cracking. In case of dispute, the results of tests using the guided bend test of ASTM E290 shall govern.

Table 4 - Bending

Nominal Thickness Inches	Nominal Thickness Millimeters	Angle Degrees	Bend Radius ^(1, 2)
Up to 0.050, incl	Up to 1.27, incl	180	0.5t
Over 0.050 to 0.1874, incl	Over 1.27 to 4.762, incl	180	1t

⁽¹⁾ Bend radius is defined as a bend factor multiplied by the nominal thickness (t).

⁽²⁾ Prior versions of this specification may have specified a bend factor and a bend diameter in lieu of bend radius.

3.5.1.4 Average Grain Size

The average grain size shall be as shown in Table 5, determined in accordance with ASTM E112.

Table 5 - Average grain size

Nominal Thickness Inches	Nominal Thickness Millimeters	Grain Size
Up to 0.1875, excl 0.1875 and over	Up to 4.762, incl Over 4.762	5 or finer 4 or finer

3.5.2 Response to Stabilization and Precipitation Heat Treatment

Samples from product 0.010 to 1.000 inch (0.25 to 25.40 mm) in nominal thickness shall have the following properties after heat treatment:

- Stabilization heat treated by heating to 1550 °F ± 15 °F (843 °C ± 8 °C), holding at heat for 3 hours ± 0.25 hour, and cooling in air to room temperature.
- Precipitation heat treated by heating to 1325 °F ± 15 °F (718 °C ± 8 °C), holding at heat for 8 hours ± 0.25 hour, cooling at a rate of 100 °F (56 °C) per hour to 1150 °F ± 15 °F (621 °C ± 8 °C), holding at 1150 °F ± 15 °F (621 °C ± 8 °C) for 8 hours ± 0.25 hour, and cooling in air. Instead of the 100 °F (56 °C) per hour cooling rate to 1150 °F ± 15 °F (621 °C ± 8 °C), furnace cooling may be at any rate provided the time at 1150 °F ± 15 °F (621 °C ± 8 °C) is adjusted to give a total precipitation heat-treatment time of not less than 18 hours.

Pyrometry shall be in accordance with AMS2750.

3.5.2.1 Tensile Properties

Response to heat-treatment tensile properties shall be as specified in Table 6, determined in accordance with ASTM E8/E8M.

Table 6 - Minimum tensile properties - response to heat treatment

Property	Value
Tensile Strength	170 ksi (1172 MPa)
Yield Strength at 0.2% Offset	135 ksi (931 MPa)
Elongation in 2 Inches (50 mm) or 4D	12%

- Unless otherwise specified, the strain rate shall be set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (±0.002 mm/mm/min) through 0.2% offset yield strain. After the yield strain, the speed of the testing machine shall be set between 0.05 and 0.5 in/in (0.05 and 0.5 mm/mm) of the length of the reduced parallel section (or distance between the grips for specimens not having a reduced section) per minute. Alternatively, an extensometer and strain rate indicator may be used to set the strain rate between 0.05 and 0.5 in/in/min (0.05 and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

3.5.2.2 Hardness

Response to heat-treatment hardness shall be not lower than 30 HRC, or equivalent (see 8.2), determined in accordance with ASTM E18. Product shall not be rejected on the basis of hardness if the tensile properties of 3.5.2.1 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.2.3 Stress-Rupture Properties at 1200 °F (649 °C)

A tensile specimen, maintained at 1200 °F $\pm$ 3 °F (649 °C $\pm$ 2 °C) while a load sufficient to produce the initial axial stress specified in Table 7 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 7. Tests shall be conducted in accordance with ASTM E139.

Table 7A - Stress-rupture properties, inch/pound units

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

Table 7B - Stress-rupture properties, SI units

Nominal Thickness Millimeters	Initial Axial 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	689	3

3.5.2.3.1 The test of 3.5.2.3 may be conducted using a load higher than required to produce the initial axial stress specified in Table 7, but the load shall not be changed while the test is in progress. Time to rupture and elongation requirements shall be as specified in 3.5.2.3.

3.5.2.3.2 When permitted by the purchaser, the test of 3.5.2.3 may be conducted using incremental loading. In such case, the load required to produce the initial axial stress specified in Table 7 shall be maintained to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 hours, minimum, thereafter, the stress shall be increased in increments of 5.0 ksi (34.5 MPa). Time to rupture and elongation requirements shall be as specified in 3.5.2.3.

3.5.3 Mechanical properties for product outside the range specified in 1.1 shall be agreed upon between the purchaser and producer.

3.6 Quality

The product, as received by the purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.7 Tolerances

Tolerances shall conform to all applicable requirements of AMS2262.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.1

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The supplier of the product shall supply all samples for the supplier's tests and shall be responsible for the performance of all required tests. The purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.