AEROSPACE MATERIAL SPECIFICATION

AMS5951™	REV. B

Issued 2010-12
Revised 2023-06

Superseding AMS5951A

(R) Nickel Alloy, Corrosion- and Heat-Resistant, Sheet, Strip, and Plate
57Ni - 20Cr - 10Co - 8.5Mo - 2.1Ti - 1.5Al - 0.005B
Vacuum Induction and Consumable Electrode Melted, Solution Heat Treated
Precipitation Heat Treatable
(Composition similar to UNS N07208)

RATIONALE

AMS5951B is the result of a Five-Year Review and update of the specification. The revision increases the allowable thickness (see 1.1 and throughout), revises composition specification and reporting (see 3.1 and 3.1.1), updates the solution heat treatment (see 3.4.1 and 3.4.2), adds option for continuous heat treatment (see 3.4.3), limits Table 2 testing requirements, updates Table 4 grain size based on thickness, adds mechanical properties for thicker sections (see Table 5 and Table 6), adds strain rate controls for tensile tests (see 3.5.1.1.1 and 3.5.2.1.1), prohibits unauthorized exceptions (see 3.5.3, 3.8, 4.4.4, 5.1.1, and 8.5), and allows prior revisions (see 8.4).

1. SCOPE

1.1 Form

This specification covers a corrosion- and heat-resistant nickel-based alloy in the form of sheet, strip, and plate 0.020 to 2.25 inches (0.50 to 57.2 mm) in thickness.

1.2 Application

These products have been used typically for parts requiring high strength up to 1600 °F (871 °C) and oxidation resistance up to 1800 °F (982 °C), 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.

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

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AMS5951B/

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

AS4194 Sheet and Strip Surface Finish Nomenclature

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 B906 Flat-Rolled Nickel and Nickel Alloys Plate, Sheet, and Strip

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E18 Rockwell Hardness of Metallic Materials

ASTM E21 Elevated Temperature Tension Tests 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 Testing of Material for Ductility

ASTM E384 Knoop and Vickers Hardness of Materials

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 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	0.04	0.08
Manganese	--	0.3
Silicon	--	0.15
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	18.5	20.5
Cobalt	9.0	11.0
Molybdenum	8.0	9.0
Tungsten	--	0.5
Columbium (Niobium)	--	0.2
Titanium	1.90	2.30
Tantalum	--	0.1
Aluminum	1.38	1.65
Boron	0.003	0.010
Iron	--	1.5
Copper	--	0.1
Zirconium	--	0.020
Nickel	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 multiple melted using vacuum induction followed by consumable electrode practice in the remelt cycle.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Sheet and Strip

Hot or cold rolled, solution heat treated, and, unless solution heat treatment is performed in an atmosphere yielding a bright finish, descaled having a surface appearance in accordance with ASTM B906 and AS4194 comparable to 3.3.1.1 or 3.3.1.2 as applicable.

3.3.1.1 Sheet

No. 2D finish.

3.3.1.2 Strip

No. 1 strip finish.

3.3.2 Plate

Hot or cold rolled, solution heat treated, and, unless solution heat treatment is performed in an atmosphere yielding a bright finish, descaled.

3.4 Solution Heat Treatment

3.4.1 Product 0.040 inch (1.106 mm) and above in thickness shall be solution heat treated by heating in a suitable atmosphere within the range of 2000 to 2100 °F (1093 to 1149 °C), holding at the selected temperature ±25 °F (±15 °C) for a time commensurate with the thickness, and cooling at a rate equivalent to air cool or faster. Pyrometry shall be in accordance with AMS2750.

3.4.2 For product under 0.040 inch (1.016 mm) in thickness, process parameters (e.g., furnace temperature set points, heat input, travel rate, etc.) shall be established by the material producer and validated by testing of product to specified requirements. It is recommended that the product be solution heat treated by heating in a suitable protective atmosphere, preferably in hydrogen or argon (see 3.4.2.1) or in vacuum (10-4 torr or less), within the range of 2000 to 2100 °F (1093 to 1149 °C), holding at the selected temperature ±25 °F (±15 °C) for a time commensurate with the thickness, and cooling at a rate equivalent to air cool or faster. Pyrometry shall be in accordance with AMS2750.

3.4.2.1 For product 0.010 inch (0.25 mm) and under in nominal thickness, a dew point of -60 °F (-50 °C) or lower is preferable when using hydrogen or argon atmosphere (see 3.5.3).

3.4.3 Continuous Heat Treatment

When continuous heat treating 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 material 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

Shall be as shown in Table 2, determined in accordance with ASTM E8/E8M and 3.5.1.1.1.

3.5.1.1.1 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 in/in and 0.5 in/in (0.05 mm/mm 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 in/in/min and 0.5 in/in/min (0.05 mm/mm/min and 0.5 mm/mm/min). The requirement for compliance becomes effective for material produced 1 year after the publication date of this specification.

Table 2A - Tensile properties, inch/pound units[1]

Nominal Thickness Inches	Tensile Strength ksi, Max	Yield Strength at 0.2% Offset ksi, Max	Elongation in 2 Inches or 4D %, Min
0.020 to 0.1874, incl	150	75	30
Over 0.1874 to 0.375, incl	150	100	30

[1] The solution heat-treated tensile requirements assure cold formability. Testing above 0.375 inch is not required

Table 2B - Tensile properties, SI units[1]

Nominal Thickness Millimeters	Tensile Strength MPa, Max	Yield Strength at 0.2% Offset MPa, Max	Elongation in 50 mm or 4D %, Min
0.51 to 4.760, incl	1034	517	30
Over 4.760 to 9.52, incl	1034	689	30

[1] The solution heat-treated tensile requirements assure cold formability. Testing above 9.52 mm is not required

3.5.1.2 Hardness

Shall be not higher than 30 HRC, or equivalent (see 8.2), determined in accordance with ASTM E18; for thin gages, where superficial hardness testing is impractical, microhardness testing in accordance with ASTM E384 may be used. Product shall not be rejected on the basis of hardness if the tensile property requirements 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.

3.5.1.3 Bending

Product 0.1874 inch (4.760 mm) and under in thickness shall be tested using a sample nominally 0.75 inch (19.0 mm) in width, with the axis of bending parallel to the direction of rolling, and shall withstand, without cracking, bending in accordance with ASTM E290 through an angle of 180 degrees around a diameter equal to the bend factor shown in Table 3 times the nominal thickness of the product. In case of dispute, the guided bend test of ASTM E290 shall apply.

Table 3 - Bending parameters

Nominal Thickness Inches	Nominal Thickness Millimeters	Bend Factor
0.020 to 0.050, incl	0.51 to 3.18, incl	1.5
Over 0.050 to 0.1874, incl	Over 3.18 to 4.760, incl	2

3.5.1.4 Average Grain Size

Shall be as shown in Table 4, determined in accordance with ASTM E112.

Table 4 - Average grain size

Nominal Thickness Inches	Nominal Thickness Millimeters	ASTM Grain Size Number
0.020 to 0.1874, incl	0.51 to 4.760, incl	3.0 or finer
Over 0.1874 to 2.000, incl	Over 4.760 to 50.80, incl	2.0 or finer
Over 2.000 to 2.250, incl	Over 50.80 to 57.20, incl	1.0 or finer

3.5.2 Response to Precipitation Heat Treatment

Samples from the product shall have the following properties after being precipitation heat treated by heating to 1850 °F ± 15 °F (1010 °C ± 8 °C), holding at heat for 2 hours and cooling at a rate equivalent to cooling in air, followed by heating to 1450 °F ± 15 °F (788 °C ± 8 °C), holding at heat for not less than 8 hours, and cooling at a rate equivalent to cooling in air.

3.5.2.1 Tensile Properties

3.5.2.1.1 At Room Temperature

Shall be as shown in Table 5, determined in accordance with ASTM E8/E8M and 3.5.1.1.1.

Table 5A - Minimum room temperature tensile properties, inch/pound units

Nominal Thickness Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
0.020 to 1.00, incl	150	85	20
Over 1.00 to 2.25, incl	155	90	20

Table 5B - Minimum room temperature tensile properties, SI units

Nominal Thickness Millimeters	Tensile Strength Mpa	Yield Strength at 0.2% Offset Mpa	Elongation in 50 mm or 4D %, Min
0.51 to 25.4, incl	1034	586	20
Over 25.4 to 57.2. incl	1069	620	20

3.5.2.2 Hardness

Shall be not lower than 24 HRC, or equivalent (see 8.2), determined in accordance with ASTM E18; for thin gages where superficial hardness testing is impractical, microhardness testing in accordance with ASTM E384 may be used. Product shall not be rejected on the basis of hardness if the tensile property requirements of 3.5.2.1.1 are acceptable, determined on specimens taken from the same sample as that with nonconforming hardness or from another sample with similar nonconforming hardness.

3.5.2.3 Stress-Rupture Properties at 1700 °F (927 °C)

A tensile specimen, maintained at 1700 °F ± 3 °F (927 °C ± 2 °C) while a load sufficient to produce an initial axial stress of 13 ksi (89 MPa) is applied continuously, shall be in accordance with Table 6. Tests shall be conducted in accordance with ASTM E139.

Table 6A - Stress-rupture parameters and limits, inch/pound units

Nominal Thickness Inches	Hours to Rupture, Min	Elongation in 2 Inches or 4D %, Min
0.020 to 0.1874, incl	25	5
Over 0.1874 to 2.250, incl	50	10

Table 6B - Stress-rupture parameters and limits, SI units

Nominal Thickness Millimeters	Hours to Rupture, Min	Elongation in 50 mm or 4D %, Min
0.51 to 4.760, incl	25	5
Over 4.760 to 57.20, incl	50	10

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 of 13 ksi (89 MPa) 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.

3.5.3 Property requirements for product outside the range listed in 1.1 shall be agreed upon between the purchaser and producer and reported per 4.4.4.

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

Shall conform to all applicable requirements of AMS2262.

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.4

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer'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.

4.2 Classification of Tests

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.3 Sampling and Testing

Shall be in accordance with AMS2371.

4.4 Reports

The producer of the product shall furnish with each shipment a report showing the producer’s name and country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations) and the following results of tests and relevant information.

4.4.1 For Each Heat

Composition.

4.4.2 For Each Lot

4.4.2.1 As Solution Heat Treated

Tensile properties
Hardness
Bending properties
Average grain size