SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS5951

Issued 2010-12

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

AMS5951 is a new specification for a corrosion and heat-resistant nickel based alloy in the form of sheet, strip, and plate.

1. SCOPE

1.1 Form

This specification covers a corrosion and heat-resistant nickel based alloy in the form of sheet, strip, and plate.

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.

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

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS5951

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 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

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

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 B 906 Flat-Rolled Nickel and Nickel Alloys Plate, Sheet, and Strip

ASTM E 8/E 8M Tension Testing of Metallic Materials

ASTM E 18 Rockwell Hardness of Metallic Materials

ASTM E 21 Elevated Temperature Tension Tests of Metallic Materials

ASTM E 112 Determining Average Grain Size

ASTM E 139 Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials

ASTM E 290 Bend Testing of Material for Ductility

ASTM E 354 Chemical Analysis of HighTemperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

ASTM E 384 Knoop and Vickers Hardness of Materials

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight, shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to 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 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 B 906 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 2050 to 2150 °F (1121 to 1177 °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 2050 to 2150 °F (1121 to 1177 °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.

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 E 8/E 8M.

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
0.020 to 0.1874, incl	150	75	30
Over 0.1874 to 1.0	150	100	30

TABLE 2B - TENSILE PROPERTIES, SI UNITS

Nominal Thickness Millimeters	Tensile Strength MPa, max	Yield Strength at 0.2% Offset MPa, max	Elongation in 50.8 mm or 4D %, min
0.508 to 4.760, incl	1034	517	30
Over 4.760 to 25.4	1034	689	30

3.5.1.2 Hardness

Shall be not higher than 30 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18; for thin gages, where superficial hardness testing is impractical, microhardness testing in accordance with ASTM E 384 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 inches (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 E 290 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 E 290 shall apply.

TABLE 3 - BENDING PARAMETERS

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
0.020 to 0.050, incl	0.508 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 E 112.

TABLE 4 - BENDING PARAMETERS

Nominal Thickness Inch	Nominal Thickness Millimeters	ASTM Grain Size Number
0.020 to 0.1874, incl	0.508 to 4.760, incl	3 or finer
Over 0.1874 to 1.0, incl	Over 4.760 to 25.4	2.5 or finer

3.5.2 After Precipitation Heat Treatment

The product shall have the following properties after being precipitation heat treated by heating to 1850 °F ± 15 (1010 °C ± 8), holding at heat for 2 hours and cooling at a rate equivalent to cooling in air, followed by heating to 1450 °F ± 15 (788 °C ± 8), 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 E 8/E 8M.

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 1.0, incl	150	85	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 50.8 mm or 4D %, min
0.508 to 25.4, incl	1034	586	20

3.5.2.2 Hardness

Shall be not lower than 24 HRC, or equivalent (See 8.2), determined in accordance with ASTM E 18; for thin gages where superficial hardness testing is impractical, microhardness testing in accordance with ASTM 384 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 (927 °C ± 2) 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 E 139.

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 1.0	50	10

TABLE 6B - STRESS RUPTURE PARAMETERS AND LIMITS, SI UNITS

Nominal Thickness Millimeters	Hours to Rupture, min	Elongation in 50.8 mm or 4D %, min
0.508 to 4.760, incl	25	5
Over 4.760 to 25.4	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.

3.6 Quality

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.

3.7 Tolerances

Shall conform to all applicable requirements of AMS2262.

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 the performance of all required tests. 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 vendor of the product shall furnish with each shipment a report showing the following results of tests and relevant information