SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5950A

Issued JAN 1996
Revised NOV 2002

Superseding AMS 5950

Nickel Alloy, Corrosion and Heat-Resistant, Sheet and Strip
52.5Ni - 19Cr - 3.0Mo - 5.0Cb - 0.90Ti - 0.50Al - 18Fe
Vacuum Induction and Consumable Electrode Melted
Solution Heat Treated, Precipitation Hardenable

(Composition similar to UNS N07719)

1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat-resistant nickel alloy in the form of sheet and strip 0.080 inch (2.03 mm) and under in nominal thickness.

1.2 Application:

These products have been used typically for parts requiring resistance to low-cycle fatigue, creep and stress-rupture up to 1300 °F (704 °C), and oxidation resistance up to 1800 °F (982 °C), particularly those parts which are superplastically or otherwise formed or welded and then heat treated to develop desired 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.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2262	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Sheet, Strip, and Plate
MAM 2262	Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Sheet, Strip, and Plate
AMS 2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys, and Cobalt Alloys

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

2.1 (Continued):

AMS 2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS 2807	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, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM A 480/A 480M	Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM E 3	Preparation of Metallographic Specimens
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 18	Rockwell Hardness and Rockwell Superficial 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	Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E 354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
ASTM E 384	Microhardness 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	--	0.05
Manganese	--	0.35
Silicon	--	0.35
Phosphorus	--	0.015
Sulfur	--	0.002
Chromium	17.00	21.00
Nickel	50.00	55.00
Molybdenum	2.80	3.30
Columbium	4.75	5.25
Titanium	0.65	1.15
Aluminum	0.20	0.80
Cobalt	--	1.00
Boron	--	0.006
Copper	--	0.30
Nitrogen	--	0.01
Iron	remainder	

3.1.1 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2269.

3.2 Melting Practice:

Alloy shall be multiple melted using vacuum induction melting followed by consumable electrode remelting.

3.3 Condition:

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 A 480/A 480M and AS4194 comparable to 3.3.1 or 3.3.2 as applicable, except that product 0.010 inch (0.25 mm) and under in nominal thickness shall have surface appearance comparable to a 2B finish.

3.3.1 Sheet No. 2D finish.

3.3.2 Strip: No. 1 strip finish.

3.4 Solution Heat Treatment:

No specific heat treating instructions are specified but it is recommended that the product be solution heat treated by heating in a suitable protective atmosphere, preferably in hydrogen or argon or in a vacuum at 10^{-4} Torr or less (See 8.2), to a temperature within the range 1700 to 1825 °F (927 to 996 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with product thickness, and cooling at a rate equivalent to an air cool or faster.

3.5 Properties:

Product 0.080 inch (2.03 mm) and under in nominal thickness 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 or ASTM E 8M.

TABLE 2A - Tensile Properties, Inch/Pound Units

Nominal Thickness Inch	Tensile Strength ksi, max	Yield Strength at 0.2% Offset ksi, max	Elongation in 2 Inches %, min
Up to 0.010, incl	185	155	report
Over 0.010 to 0.080, incl	185	155	20

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 %, min
Up to 0.25, incl	1276	1069	report
Over 0.25 to 2.03, incl	1276	1069	20

3.5.1.2 Hardness: Shall be not higher than 34 HRC, or equivalent (See 8.3), 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 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.

3.5.1.3 Bending: Product shall withstand, without cracking, bending at room temperature in accordance with ASTM E 290 through an angle of 180 degrees around a diameter equal to three times the nominal thickness of the product, with axis of bend parallel to the direction of rolling.

3.5.1.4 Average Grain Size: Shall be ASTM No. 10 or finer, determined in accordance with ASTM E 112.

3.5.1.5 Surface Microstructure: Metallographic examination on an unetched and an etched specimen cross-section of product 0.080 inch (2.03 mm) and under in nominal thickness, shall disclose no alloy depleted surface layer (See 8.4.1), intergranular attack, or other detrimental surface conditions greater than 0.0005 inch (0.013 mm) for product 0.060 inch (1.52 mm) and under in nominal thickness, or greater than 0.001 inch (0.025 mm) for product over 0.060 to 0.080 inch (1.52 to 2.03 mm) in nominal thickness. Each specimen shall be prepared according to ASTM E 3 and evaluated at 500X magnification.

3.5.2 After Precipitation Heat Treatment: The product shall have the following properties after being precipitation heat treated by heating to 1325 °F ± 15 (718 °C ± 8), holding at heat for 8 hours ± 0.5, cooling at 100 °F ± 15 (56 °C ± 8) degrees per hour to 1150 °F ± 15 (621 °C ± 8), holding at 1150 °F ± 15 (621 °C ± 8) for 8 hours ± 0.5, and cooling in air. Instead of the 100 F ± 15 (56 C ± 8) degrees per hour cooling rate to 1150 °F ± 15 (621 °C ± 8), product may be furnace cooled at any rate provided the time at 1150 °F ± 15 (621 °C ± 8), is adjusted to give a total precipitation heat treatment time of 18 hours. The product shall also meet the requirements of 3.5.2.1, 3.5.2.2, and 3.5.2.3 after being re-solution heat treated by heating to 1750 °F ± 25 (954 °C ± 14), holding at heat for 60 minutes ± 5, and cooling at a rate equivalent to an air cool or faster and precipitation heat treated as above.

3.5.2.1 Tensile Properties:

3.5.2.1.1 At Room Temperature: Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM E 8M.

TABLE 3A - Minimum Room Temperature Tensile Properties, Inch/Pound Units

Nominal Thickness Inch	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches %
Up to 0.010, incl	180	148	report
Over 0.010 to 0.080, incl	180	148	12

TABLE 3B - 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 %
Up to 0.25, incl	1241	1020	report
Over 0.25 to 2.03, incl	1241	1020	12

3.5.2.1.2 At 1200 °F (649 °C): Shall be as shown in Table 4, determined in accordance with ASTM E 21 on specimens heated to 1200 °F ± 5 (649 °C ± 3), held at heat for not less than 20 minutes before testing, and tested at 1200 °F ± 5 (649 °C ± 3).

TABLE 4A - Minimum 1200 °F (649 °C) Tensile Properties, Inch/Pound Units

Nominal Thickness Inch	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches %
Up to 0.025, incl	140	115	5
Over 0.025 to 0.080, incl	145	120	5

TABLE 4B - Minimum 1200°F (649 °C) Tensile Properties, SI Units

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm %
Up to 0.64, incl	965	793	5
Over 0.64 to 2.03, incl	1000	827	5

3.5.2.1.2.1 For product 0.010 inch (0.25 mm) and under in nominal thickness, properties may be established using a sample up to 0.025 inch (0.64 mm) in nominal thickness from the same master coil and heat. The report of 4.4 shall indicate the thickness at which the elevated temperature tensile test was performed.

3.5.2.2 Hardness: Shall be not lower than 36 HRC, or equivalent (See 8.3), 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 properties 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 1200 °F (649 °C): A tensile specimen, maintained at 1200 °F ± 3 (649 °C ± 2) while a load sufficient to produce the initial axial stress specified in Table 5 or higher stress 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 not less than shown in Table 5. Tests shall be conducted in accordance with ASTM E 139.

TABLE 5A - Stress-Rupture Properties, Inch/Pound Units

Nominal OD Inch	Initial Axial Stress, ksi	Elongation % in 2 Inches
Up to 0.015, incl	95.0	--
Over 0.015 to 0.025, incl	95.0	4
Over 0.025 to 0.080, incl	100	4

TABLE 5B - Stress-Rupture Properties, SI Units

Nominal OD Millimeters	Initial Axial Stress, MPa	Elongation % in 50.8 mm
Up to 0.38, incl	655	--
Over 0.38 to 0.64, incl	655	4
Over 0.64 to 2.03, incl	689	4

3.5.2.3.1 For product 0.010 inch (0.25 mm) and under in nominal thickness, stress-rupture properties may be established using a sample up to 0.025 inch (0.64 mm) in nominal thickness from the same master coil and heat. The report of 4.4 shall indicate the thickness at which the stress-rupture test was performed.

3.5.2.3.2 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 5 or higher stress shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 to 16 hours, preferably 8 to 10 hours, thereafter, the stress shall be increased in increments of 5.0 ksi (34 MPa). 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 AMS 2262 or MAM 2262.

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:

4.2.1 Acceptance Tests: The following requirements are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Tensile properties (3.5.1.1), hardness (3.5.1.2), bending (3.5.1.3), average grain size (3.5.1.4), and microstructure (3.5.1.5) of each lot as solution heat treated.

4.2.1.3 Room temperature tensile properties (3.5.2.1.1) and hardness (3.5.2.2) of each lot after precipitation heat treatment.

4.2.1.4 Tolerances (3.7) of each lot.

4.2.2 Periodic Tests: The following requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.2.1 Tensile properties at 1200 °F (649 °C) (3.5.2.1.2) and stress-rupture properties (3.5.2.3) after precipitation heat treatment.

4.2.2.2 Tensile properties (3.5.2.1.1 and 3.5.2.1.2), hardness (3.5.2.2), and stress-rupture properties (3.5.2.3) after re-solution and precipitation heat treatment as in 3.5.2.