AEROSPACE MATERIAL SPECIFICATION

AMS5950™	REV. D
Issued 1996-01 Revised 2020-12 Superseding AMS5950C	

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)

RATIONALE

AMS5950D add requriements for continuous furnaces (3.4), prohibits unauthorized exceptions (3.8), reports (4.4.3), and identification (5.1.1), notes (8.7), allows prior revisions (8.6), and results from a Five-Year Review and update of this specification.

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 (see 8.8).

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.

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/AMS5950D/

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
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
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
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 A480/A480M	Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM E3	Preparation of Metallographic Specimens
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 Test of Materials for Ductility
ASTM E354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
ASTM E384	Microindentation 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 E354, 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 AMS2269.

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 comparable to the following commercial corrosion-resistant steel finishes as described in ASTM A480, ASTM A480M, AS4194, and 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

The product shall be heat treated as follows; pyrometry shall be in accordance with AMS2750.

3.4.1 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.

3.4.2 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

Product 0.080 inch (2.03 mm) and under in nominal thickness shall conform to the following requirements. Property requirements for product greater than 0.080 inch (2.03 mm) shall be agreed upon between purchaser and producer.

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.

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 %, 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, determined in accordance with ASTM E18 or equivalent (see 8.3); 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 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 be tested in accordance with ASTM E290 using a sample prepared nominally 0.75 inch (19.0 mm) in width with its axis of bending parallel to the direction of rolling and shall withstand without cracking when bending through an angle of 180 degrees around a diameter equal to three times the nominal thickness of the product. In case of dispute, the results of tests using the guided bend test of ASTM E290 shall govern.

3.5.1.4 Average Grain Size

Shall be ASTM No. 10 or finer, determined in accordance with ASTM E112.

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 E3 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 °F (718 °C ± 8 °C), holding at heat for 8 hours ± 0.5 hour, cooling at 100 °F ± 15 °F (56 °C ± 8 °C) degrees per hour to 1150 °F ± 15 °F (621 °C ± 8 °C), holding at 1150 °F ± 15 °F (621 °C ± 8 °C) for 8 hours ± 0.5 hour, and cooling in air. Instead of the 100 °F ± 15 °F (56 °C ± 8 °C) degrees per hour cooling rate to 1150 °F ± 15 °F (621 °C ± 8 °C), product may be furnace cooled 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 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 °F (954 °C ± 14 °C), holding at heat for 60 minutes ± 5 minutes, 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 E8/E8M.

Table 3A - 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 %
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 E21 on specimens heated to 1200 °F ± 5 °F (649 °C ± 3 °C), held at heat for not less than 20 minutes before testing, and tested at 1200 °F ± 5 °F (649 °C ± 3 °C).

Table 4A - Minimum 1200 °F (649 °C) tensile properties, inch/pound units

Nominal Thickness Inches	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, determined in accordance with ASTM E18 or equivalent (see 8.3); 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 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 °F (649 °C ± 2 °C) 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 E139.

Table 5A - Stress-rupture properties, inch/pound units

Nominal OD Inches	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 hours, minimum, 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.

3.5.3 Mechanical property requirements for product outside the size range covered by Tables 2 to 5 (or 1.1) shall be agreed upon between purchaser and producer and reported per 4.4.3.

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.

3.8 Exceptions

Any exception shall be authorized by purchaser and reported as in 4.4.3.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

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

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 the country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations) and following results of tests and relevant information:

4.4.1 For each heat:

Composition.

4.4.2 For each lot:

As solution heat treated:

Tensile properties
Hardness
Bending property
Average grain size
Microstructure