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Superseding AMS5545E

Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate
54Ni – 19Cr – 11Co – 9.8Mo – 3.2Ti – 1.5Al – 0.006B
Vacuum Induction and Consumable Electrode Melted, Solution Heat Treated
Precipitation Heat Treatable
(Composition similar to UNS N07041)

RATIONALE

AMS5545F revises solution heat treatment (3.4) and bending (3.5.1.3) and results from 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, 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.

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

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<http://www.sae.org/technical/standards/AMS5545F>

- 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 A 480/A 480M Flat-Rolled Stainless and Heat-Resisting Steel 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 290 Bend Testing of Material for Ductility
- ASTM E 354 Chemical Analysis of High Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys
- ASTM E 384 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 E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser

TABLE 1 - COMPOSITION

Element	min	max
Carbon	--	0.12
Manganese	--	0.10
Silicon	--	0.50
Sulfur	--	0.015
Chromium	18.00	20.00
Cobalt	10.00	12.00
Molybdenum	9.00	10.50
Titanium	3.00	3.30
Aluminum	1.40	1.60
Boron (3.1.1)	0.0030	0.010
Iron	--	5.00
Copper	--	0.50
Nickel	remainder	

3.1.1 Boron may be less than 0.0030% by weight, determined on sheet and strip under 0.050 inch (1.27 mm) in nominal thickness, provided the specified requirement is met on stock prior to rolling into sheet or strip.

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 A 480/A 480M 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 rolled, solution heat treated, and descaled.

3.4 Solution Heat Treatment

3.4.1 Product 0.040 inch (1.016 mm) and above in thickness shall be solution heat treated by heating in a suitable atmosphere to $1975\text{ }^{\circ}\text{F} \pm 25$ ($1079\text{ }^{\circ}\text{C} \pm 14$), holding at heat for not less than 60 minutes per inch (25 mm) of nominal thickness, and cooling at a rate equivalent to a rapid air cool or faster. Pyrometry shall be in accordance with AMS2750.

3.4.2 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), to a temperature of $1975\text{ }^{\circ}\text{F} \pm 25$ ($1079\text{ }^{\circ}\text{C} \pm 14$), holding at temperature for a time commensurate with product thickness, and cooling at a rate equivalent to a rapid 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 $-60\text{ }^{\circ}\text{F}$ ($-50\text{ }^{\circ}\text{C}$) 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
Up to 0.015, incl	170	100	20
Over 0.015 to 0.115, incl	170	100	30
Over 0.115 to 0.1874, incl	180	115	30
Over 0.1874	195	140	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
Up to 0.38, incl	1172	689	20
Over 0.38 to 2.92, incl	1172	689	30
Over 2.92 to 4.760, incl	1241	793	30
Over 4.760	1344	965	30

3.5.1.2 Hardness

Shall be not higher than shown in Table 3, 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.

TABLE 3 - MAXIMUM HARDNESS REQUIREMENT

Nominal Thickness Inch	Nominal Thickness Millimeters	Hardness
Up to 0.040, incl	Up to 1.02, incl	75 HR15N
Over 0.040 to 0.070, incl	Over 1.02 to 1.78, incl	64 HRA
Over 0.070 to 0.1874, incl	Over 1.78 to 4.760, incl	30 HRC

3.5.1.3 Bending

Product shall have a test sample prepared nominally 0.750 inch (19.06 mm) in width, with its 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 4 times the nominal thickness of the product.

TABLE 4 - BENDING PARAMETERS

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
Up to 0.062, incl	Up to 1.57, incl	2
Over 0.062 to 0.125, incl	Over 1.57 to 3.18, incl	2.5
Over 0.125 to 0.1874, incl	Over 3.18 to 4.760, incl	3

3.5.1.4 Average Grain Size

Shall be ASTM No. 3 or finer, determined in accordance with ASTM E 112.

3.5.1.5 Microstructure

Metallographic examination shall disclose no significant alloy-depleted layer or other undesirable surface condition. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5.2 After Precipitation Heat Treatment

The product shall have the following properties after being precipitation heat treated by heating to 1400 °F ± 15 (760 °C ± 8), holding at heat for not less than 16 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 %
Up to 0.020, incl	160	120	6
Over 0.020	170	130	10

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 %
Up to 0.51, incl	1103	827	6
Over 0.51	1172	896	10

3.5.2.1.2 At 1400 °F (760 °C)

Shall be as specified in Table 6, determined in accordance with ASTM E 21 on specimens heated to 1400 °F ± 10 (760 °C ± 6), held at heat for not less than 20 minutes before testing, and tested at 1400 °F ± 10 (760 °C ± 6).

TABLE 6A - MINIMUM 1400 °F TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Thickness Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 2 Inches or 4D %
Up to 0.020, incl	130	110	3
Over 0.020	140	110	3

TABLE 6B - MINIMUM 760 °C TENSILE PROPERTIES, SI UNITS

Nominal Thickness Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 50.8 mm or 4D %
Up to 0.51, incl	896	758	3
Over 0.51	965	758	3