# AEROSPACE MATERIAL SPECIFICATION

| AMS5545™ | REV. H |
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Superseding AMS5545G

# Nickel Alloy, Corrosion- and Heat-Resistant, Sheet, Strip, and Plate
# 54Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti - 1.5Al - 0.006B (Rene 41)
# Vacuum Induction and Consumable Electrode Melted, Solution Heat Treated
# Precipitation Heat Treatable
# (Composition similar to UNS N07041)

RATIONALE

AMS5545H is the result of a Five-Year Review and update of the specification. The revision adds the common material name to the Title, revises composition testing and reporting (see3.1 and 3.1.2), updates the controlling sheet finish specification (see 3.3.1), adds controls to strain rate during tensile testing (see 3.5.1.1.2 and 3.5.2.1.1.2), adds frequency of hardness testing in the solution heat treated condition (see 4.2.2), and updates exceptions information (see 8.5).

## 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 +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

AMS2283 Composition Testing Methods for Nickel- and Cobalt-Based 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**
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**For more information on this standard, visit**
https://www.sae.org/standards/content/AMS5545H

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 General Requirements for 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 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 Microindentation Hardness of Materials

2.3 Definitions

Terms used in AMS are defined in AS7766.

3. TECHNICAL REQUIREMENTS

3.1 Composition

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 | -- | 0.12 |
| 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 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.

3.1.3 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 rolled, solution heat treated, and descaled.

3.4 Solution Heat Treatment

Pyrometry shall be in accordance with AMS2750.

3.4.1 Except as specified in 3.4.1.1, product shall be solution heat treated by heating in a suitable atmosphere to 1975 °F ± 25 °F (1079 °C ± 14 °C), holding at the selected temperature 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.

3.4.1.1 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 other requirements of this specification.

3.4.1.2 For product 0.010 inch (0.25 mm) and under in nominal thickness, a dew point of -60 °F (-50 °C) or lower is recommended 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 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 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 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 |



3.5.1.1.1 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 supplier's certification of test shall indicate the thickness at which the room temperature tensile test was performed.

3.5.1.1.2 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.

3.5.1.2 Hardness

Hardness shall be not higher than shown in Table 3, or equivalent (see 8.2), determined in accordance with ASTM E18; for thin gauges, 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.

***Table 3 - Maximum hardness requirement***

| Nominal Thickness Inches | 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 E290 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 Inches | 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 Property requirements for product outside of the range covered by Table 3 or 4 shall be agreed upon between the purchaser and producer.

3.5.1.5 Average Grain Size

Average grain size shall be ASTM No. 3 or finer, determined in accordance with ASTM E112.

3.5.1.6 Microstructure

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

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 1400 °F ± 15 °F (760 °C ± 8 °C), 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 – Response to Heat Treatment

3.5.2.1.1 At Room Temperature

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

***Table 5A - Minimum room temperature tensile properties – response to heat treatment, 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 – response to heat treatment, SI units***

| Nominal Thickness Millimeters | Tensile Strength MPa | Yield Strength at 0.2% Offset MPa | Elongation in 50 mm or 4D % |
|---|---|---|---|
| Up to 0.51, incl | 1103 | 827 | 6 |
| Over 0.51 | 1172 | 896 | 10 |

3.5.2.1.1.1 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 supplier's certification of test shall indicate the thickness at which the room temperature tensile test was performed.

3.5.2.1.1.2 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.

3.5.2.1.2 At 1400 °F (760 °C)

Shall be as specified in Table 6, determined in accordance with ASTM E21 on specimens heated to 1400 °F ± 10 °F (760 °C ± 6 °C), held at heat for not less than 20 minutes before testing, and tested at 1400 °F ± 10 °F (760 °C ± 6 °C).

***Table 6A - Minimum 1400 °F tensile properties – response to heat treatment, 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 – response to heat treatment, SI units***

| Nominal Thickness Millimeters | Tensile Strength MPa | Yield Strength at 0.2% Offset MPa | Elongation in 50 mm or 4D % |
|---|---|---|---|
| Up to 0.51, incl | 896 | 758 | 3 |
| Over 0.51 | 965 | 758 | 3 |

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 supplier's certification of test shall indicate the thickness at which the elevated temperature tensile test was performed.

3.5.2.2 Hardness – Response to Heat Treatment

Shall be not lower than 35 HRC, or equivalent (see 8.2), determined in accordance with ASTM E18; for thin gauges 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.

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

3.7 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.

3.8 Tolerances

Tolerances shall conform to all applicable requirements of AMS2262.

3.9 Production, distribution, and procurement of metal stock shall comply with AS6279. After production and certification to the specified requirements, cutting in a plane perpendicular to the short transverse dimension is permitted.

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

Sampling and testing shall be in accordance with AMS2371.

4.3.1 If using an alternate size as in 3.5.1.1.1, 3.5.2.1.1.1, or 3.5.2.1.2.1, samples for these three tests shall be taken from the same alternate size from the same master coil and heat.

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.