

# AEROSPACE MATERIAL SPECIFICATION



AMS 5852C

Issued SEP 1977  
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Superseding AMS 5852B

Submitted for recognition as an American National Standard

NICKEL ALLOY, CORROSION AND HEAT RESISTANT, BILLETS AND PREFORMS  
55Ni - 15Cr - 17Co - 5.0Mo - 3.5Ti - 4.0Al - 0.0258  
Powder Metallurgy Product, Hot Isostatically Pressed

UNS N13017

This specification has been declared "NONCURRENT" by the Aerospace Materials Division, SAE, as of April 1994. It is recommended, therefore, that this specification not be specified for new designs.

This cover sheet should be attached to the "B" revision of the subject specification.

"NONCURRENT" refers to those materials which have previously been widely used and which may be required on some existing designs in the future. The Aerospace Materials Division, however, does not recommend these as standard materials for future use in new designs. Each of these "NONCURRENT" specifications is available from SAE upon request.

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400 Commonwealth Dr., Warrendale, PA 15096-0001

# AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5852B

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 Revised 7-1-89

Superseding AMS 5852A

ALLOY BILLETS AND PREFORMS, CORROSION AND HEAT RESISTANT  
 55Ni - 15Cr - 17Co - 5.0Mo - 3.5Ti - 4.0Al - 0.025B  
 Powder Metallurgy Product, Hot Isostatically Pressed

UNS N13047

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant nickel alloy powder-metallurgy product in the form of billets and preforms.

1.2 Application: Primarily for highly-stressed parts, such as rotating parts of gas turbine engines, requiring high strength and corrosion and oxidation resistance up to 1400°F (760°C).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2261 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock

MAM 2261 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock

AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt Alloys

AMS 2350 - Standards and Test Methods

AMS 2374 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Forgings and Forging Stock

AMS 2630 - Ultrasonic Inspection, Product Over 0.5 In. (12.5 mm) Thick

AMS 5851 - Alloy Powder, Corrosion and Heat Resistant, 55Ni - 15Cr - 17Co - 5.0Mo - 3.5Ti - 4.0Al - 0.025B, as Fabricated

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2.1.2 Aerospace Recommended Practices:

ARP1313 - Determination of Trace Elements in High Temperature Alloys

2.2 ASTM Publications: Available from ASTM, 1916 Race Street, Philadelphia, PA 19103.

- ASTM E8 - Tension Testing of Metallic Materials
- ASTM E8M - Tension Testing of Metallic Materials (Metric)
- ASTM E10 - Brinell 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 E292 - Conducting Time-For-Rupture Notch Tension Tests of Materials
- ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

3. TECHNICAL REQUIREMENTS:

- 3.1 Material: Billets and preforms shall be produced by compaction of AMS 5851 powder by hot isostatic pressing (HIP) to produce products meeting the requirements of 3.5 and 3.6.

- 3.2 Composition: Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E354, by spectrochemical methods, or by other analytical methods acceptable to purchaser except that lead and bismuth shall be determined in accordance with ARP 1313 and oxygen and nitrogen shall be determined by Leco gas analyzer or equivalent:

|            | min       | max     |           |
|------------|-----------|---------|-----------|
| Carbon     | 0.02      | - 0.06  |           |
| Manganese  | --        | 0.15    |           |
| Silicon    | --        | 0.20    |           |
| Phosphorus | --        | 0.015   |           |
| Sulfur     | --        | 0.015   |           |
| Chromium   | 14.00     | - 16.00 |           |
| Cobalt     | 16.00     | - 18.00 |           |
| Molybdenum | 4.50      | - 5.50  |           |
| Titanium   | 3.35      | - 3.65  |           |
| Aluminum   | 3.85      | - 4.15  |           |
| Boron      | 0.020     | - 0.030 |           |
| Tungsten   | --        | 0.05    |           |
| Iron       | --        | 0.50    |           |
| Copper     | --        | 0.10    |           |
| Zirconium  | --        | 0.06    |           |
| Lead       | --        | 0.0002  | (2 ppm)   |
| Bismuth    | --        | 0.00003 | (0.3 ppm) |
| Oxygen     | --        | 0.010   | (100 ppm) |
| Nitrogen   | --        | 0.0050  | (50 ppm)  |
| Nickel     | remainder |         |           |

- 3.2.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269; no variation over maximum will be permitted for lead, bismuth, oxygen, and nitrogen.
- 3.3 Condition: As hot isostatically pressed (HIP).
- 3.4 Heat Treatment: When specified, the product shall be heat treated as follows:
- 3.4.1 Solution Heat Treatment: Heat to a temperature within the range 1975° - 2075°F (1079° - 1135°C), hold at the selected temperature within  $\pm 15^\circ\text{F}$  ( $\pm 8^\circ\text{C}$ ) for 4 hours  $\pm 0.25$ , and cool at a rate equivalent to an air cool or faster.
- 3.4.2 Stabilization Heat Treatment: Heat to 1600°F  $\pm 15$  (871°C  $\pm 8$ ), hold at heat for 8 hours  $\pm 0.5$ , and cool to room temperature at a rate equivalent to an air cool; reheat to 1800°F  $\pm 15$  (982°C  $\pm 8$ ), hold at heat for 4 hours  $\pm 0.25$ , and cool at a rate equivalent to an air cool or faster.

3.4.3 Precipitation Heat Treatment: Heat to 1200°F ± 15 (649°C ± 8), hold at heat for 24 hours ± 0.5, and air cool to room temperature; reheat to 1400°F ± 15 (760°C ± 8), hold at heat for 8 hours ± 0.25, and cool in air.

3.5 Properties: The product shall conform to the following requirements:

3.5.1 As Hot Isostatically Pressed:

3.5.1.1 Microstructure: Shall show complete bonding between powder particles and shall meet standards agreed upon by purchaser and vendor for incipient melting, hollow powder particles, and nonmetallic inclusions, determined by microscopic examination of polished specimens etched in Kalling's reagent and examined at 100X magnification for bonding and at 400X magnification for incipient melting, hollow powder particles, and nonmetallic inclusions.

3.5.1.2 Thermally-Induced Porosity (TIP): Shall be no greater than permitted by standards agreed upon by purchaser and vendor, determined as follows:

3.5.1.2.1 A sample having one surface approximately 5 square inches (32 cm<sup>2</sup>) in area shall be heated in air to a temperature within the range 2200° - 2225°F (1204° - 1218°C), held at the selected temperature within ±15°F (±8°C) for 4 hours ± 0.25, and cooled to room temperature. Specimens approximately 0.5 square inch (3 cm<sup>2</sup>) in surface area shall be cut from the sample, polished, etched, and examined as in 3.5.1.1.

3.5.2 After Heat Treatment: When a billet or preform is forged to a test coupon and heat treated as in 3.4, specimens taken from the heat treated coupon shall conform to the requirements of 3.5.2.1 through 3.5.2.5. If specimens taken from the billets or preforms after heat treatment as in 3.4 conform to the requirements of 3.5.2.1 through 3.5.2.5, the tests shall be accepted as equivalent to tests of a forged coupon.

3.5.2.1 Grain Size: Predominantly 4 or finer with occasional grains as large as 1 permissible, determined by comparison of a polished and etched specimen with the chart in ASTM E112.

3.5.2.2 Tensile Properties: Shall be as follows for product 4.0 inches (102 mm) and under in nominal cross-section, determined in either the longitudinal or transverse direction except that testing in the transverse direction applies only to product from which a tensile specimen not less than 2.50 inches (63.5 mm) in length can be obtained; testing in the longitudinal direction is not required on product tested in the transverse direction. Tensile property requirements for product over 4.0 inches (102 mm) in nominal cross-section shall be as agreed upon by purchaser and vendor.

3.5.2.2.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM E8 or ASTM E8M:

|  |                        |
|--|------------------------|
| Tensile Strength, minimum              | 195,000 psi (1344 MPa) |
| Yield Strength at 0.2% Offset, minimum | 140,000 psi ( 965 MPa) |
| Elongation in 4D, minimum              | 16%                    |
| Reduction of Area, minimum             | 18%                    |

3.5.2.2.2 At 1400°F (760°C): Shall be as follows, determined in accordance with ASTM E21 on specimens heated to 1400°F ± 10 (760°C ± 6), held at heat for 20 to 30 minutes before testing, and tested at 1400°F ± 10 (760°C ± 6):

|  |                        |
|--|------------------------|
| Tensile Strength, minimum              | 150,000 psi (1034 MPa) |
| Yield Strength at 0.2% Offset, minimum | 125,000 psi ( 861 MPa) |
| Elongation in 4D, minimum              | 20%                    |
| Reduction of Area, minimum             | 30%                    |

3.5.2.3 Hardness: Should be 311 - 401 HB, or equivalent, determined in accordance with ASTM E10, but the product shall not be rejected on the basis of hardness if the tensile property requirements of 3.5.2.2.1 are met.

3.5.2.4 Stress-Rupture Properties at 1400°F (760°C): Shall be as follows;  
 Ø testing of notched specimens and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.5.2.4.1 A standard, cylindrical, combination smooth-and-notched specimen  
 Ø conforming to ASTM E292, maintained at 1400°F ± 3 (760°C ± 2) while a load sufficient to produce an initial axial stress of 85,000 psi (586 MPa) is applied continuously, shall not rupture in less than 15 hours. The test shall be continued to rupture without change of load. Rupture shall occur in the smooth section and elongation of this section after rupture, measured at room temperature, shall be not less than 12% in 4D.

3.5.2.4.2 As an alternate procedure, separate smooth and notched specimens,  
 Ø machined from adjacent sections of the same piece with gage sections conforming to the respective dimensions shown in ASTM E292, may be tested individually under the conditions of 3.5.2.4.1. The smooth specimen shall not rupture in less than 15 hours and elongation after rupture, measured at room temperature, shall be not less than 12% in 4D. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.5.2.4.3 The tests of 3.5.2.4.1 and 3.5.2.4.2 may be conducted using a load higher than required to produce an initial axial stress of 85,000 psi (586 MPa) but load shall not be changed while test is in progress. Time to rupture, rupture location, and elongation requirements shall be as specified in 3.5.2.4.1.

3.5.2.4.4 When permitted by purchaser, the tests of 3.5.2.4.1 and 3.5.2.4.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 85,000 psi (586 MPa) shall be used to rupture or for 15 hours, whichever occurs first. After the 15 hours and at intervals of 8 - 16 hours, preferably 8- 10 hours thereafter, the stress shall be increased in increments of 5000 psi (34.5 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.5.2.4.1.

3.5.2.5 Creep Properties at 1300°F (704°C): A smooth tensile specimen shall be maintained at 1300°F ± 3 (704°C ± 2) while a load sufficient to produce an initial axial stress of 74,000 psi (510 MPa) is applied continuously for 110 hours or until 0.1% plastic strain is produced, whichever is longer. The plastic strain after 110 hours and the time to 0.1% plastic strain shall be reported. Gage dimensions of specimens and techniques used to measure creep shall be as agreed upon by purchaser and vendor. Tests shall be conducted in accordance with ASTM E139.

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.

3.6.1 Preforms shall have substantially uniform macrostructure. Acceptance standards shall be as agreed upon by purchaser and vendor.

3.6.2 Billets and preforms shall be subjected to ultrasonic inspection in accordance with AMS 2630. Method of test and acceptance standards shall be as agreed upon by purchaser and vendor.

3.7 Tolerances: Billets shall conform to all applicable requirements of AMS 2261 or MAM 2261.

#### 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 performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the requirements of this specification.

#### 4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for composition (3.2), microstructure (3.5.1.1), thermally-induced porosity (3.5.1.2), ultrasonic soundness (3.6.2), tolerances (3.7), and, when specified, properties after heat treatment (3.5.2) are classified as acceptance tests and shall be performed on each lot.

- 4.2.2 Periodic Tests: Tests to determine conformance to requirements for properties after heat treatment (3.5.2) are classified as periodic tests, except when purchaser specifies that such tests are acceptance tests, and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.
- 4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of the product to a purchaser, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.
- 4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.
- 4.3 Sampling: Shall be in accordance with AMS 2374 and as specified in 4.3.1; a lot shall be all product produced from one powder lot in one continuous production run and presented for vendor's inspection at one time.
- 4.3.1 Each billet and preform shall be ultrasonically inspected.
- 4.4 Approval:
- 4.4.1 Preproduction billets or preforms of compacted powder shall be approved by purchaser before billets or preforms for production use are supplied, unless such approval be waived by purchaser. Approval of preproduction billets or preforms shall in no way relieve the vendor of responsibility for continued conformance to all purchase order requirements.
- 4.4.2 The vendor shall establish, for each size of billet and for preforms of each configuration, parameters for the process control factors which will yield products meeting the requirements of this specification. These shall constitute the approved manufacturing procedures for each product and shall be used for subsequent production of the product. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in material and/or processing and, when requested, sample product. Production billets or preforms incorporating the revised operations shall not be shipped prior to receipt of reapproval.
- 4.4.2.1 Control factors for producing the product include, but are not limited to, the following:
- Source of metallurgical powder
  - Type of compaction equipment
  - Processing sequence or number of operations, including thermal operations that would result in different cross-sectional structure
  - Protective atmosphere
  - Cleaning operations (e.g., chemical descaling or mechanical cleaning)
  - Inspection and testing