Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5852

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Revised

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

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 Aerospace Material Specifications (AMS) and Aerospace Recommended Practices (ARP) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2261 - Tolerances, Nickel, Nickel Base, and Cobalt Base 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
AMS 5851 - Alloy Powder, Corrosion and Heat Resistant, 55Ni - 15Cr - 17Co - 5.0Mo - 3.5Ti - 4.0Al - 0.025B

2.1.2 Aerospace Recommended Practices:

ARP 1313 - Determination of Trace Elements in High Temperature Alloys

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E21 - Elevated Temperature Tension Tests of Metallic Materials
ASTM E112 - Estimating the Average Grain Size of Metals
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-Base Alloys

Printed in U.S.A.

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

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 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 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 spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other approved analytical methods 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	--	0.00005 (0.5 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 ±15°F (±8°C) for 4 hr ± 0.25, and cool at a rate equivalent to air cool or faster.

3.4.2 Stabilization Heat Treatment: Heat to 1600°F ± 15 (871°C ± 8), hold at heat for 8 hr ± 0.5, and cool to room temperature at a rate equivalent to an air cool; reheat to 1800°F ± 15 (982°C ± 8), hold at heat for 4 hr ± 0.25, and cool at a rate equivalent to an air cool.

3.4.3 Precipitation Heat Treatment: Heat to 1200°F ± (649°C ± 8), hold at heat for 24 hr ± 0.5, and air cool to room temperature; reheat to 1400°F ± 15 (760°C ± 8), hold at heat for 8 hr ± 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 sq in. (32 cm^2) 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 hr ± 0.25, and cooled to room temperature. Specimens approximately 0.5 sq in. (3 cm^2) 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 in. (102 mm) and under in nominal cross-section; tensile property requirements for product over 4.0 in. (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:

Tensile Strength, min	195,000 psi (1345 MPa)
Yield Strength at 0.2% Offset, min	140,000 psi (965 MPa)
Elongation in 4D, min	16%
Reduction of Area, min	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 30 min. before testing, and tested at 1400°F ± 10 (760°C ± 6) at a strain rate of 0.003 - 0.007 in. per in. per min. (0.003 - 0.007 mm/mm/min.) to the yield strength and a rate of 0.03 - 0.07 in. per in. per min. (0.03 - 0.07 mm/mm/min.) above the yield strength:

Tensile Strength, min	150,000 psi (1034 MPa)
Yield Strength at 0.2% Offset, min	125,000 psi (862 MPa)
Elongation in 4D, min	20%
Reduction of Area, min	30%

3.5.2.3 Hardness: Should be 313 - 403 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; testing of notched specimens shall be in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.5.2.4.1 A combination smooth-and-notched test specimen machined to the dimensions shown in Fig. 1 and Table I, maintained at 1400°F ± 3 (816°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 test specimens, machined from adjacent sections of the same piece with gage sections conforming to the respective dimensions of Table I, may be tested individually under the conditions of 3.5.2.4.1. The smooth specimen shall not rupture in less than 15 hr 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 hr, whichever occurs first. After the 15 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr 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 test 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 hr or until 0.1% plastic strain is produced, whichever is longer. The plastic strain after 110 hr 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 by purchaser and vendor. Tests shall be conducted in accordance with ASTM E139.

3.6 Quality: The product, as received by the purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the product. Preforms shall have substantially uniform macrostructure.

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

3.7 Tolerances: Unless otherwise specified, tolerances for billets shall conform to all applicable requirements of AMS 2261.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of the product shall supply all samples 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 perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Test: Tests to determine conformance to composition (3.2), microstructure (3.5.1.1), thermally induced porosity (3.5.1.2), ultrasonic (3.6.1), tolerance (3.7), and, when specified, properties after heat treatment (3.5.2) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to properties after heat treatment (3.5.2) requirements are classified as periodic tests unless purchaser specifies that such tests are acceptance tests.

4.2.3 Qualification Tests: Tests to determine conformance to all technical requirements of this specification are classified as qualification tests.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, qualification test material shall be submitted to the cognizant qualification agency as directed by the procuring activity, the contracting officer, or the 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 compactions of powder into billets or preforms shall be approved by purchaser before billets or preforms for production use are supplied, unless such approval be waived. Approval of preproduction billets or preforms shall in no way relieve the vendor of responsiblity 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 the parameters for control factors of processing 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 control factors of processing, vendor shall submit for reapproval a statement of the proposed changes in material and 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

4.4.2.1.1 Any of the above control factors of processing for which the parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in parameters of such factors shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and parameters.

4.5 Reports:

4.5.1 The vendor of the product shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each lot and, when specified, the results of tests to determine conformance to the other technical requirements of this specification. This report shall include the purchase order number, lot number, material specification number, size of billet or part number of preform, quantity, and the source and lot number of powder used to make the billets or preforms.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number, contractor or other direct supplier of material, part number, and quantity. When material for making parts is produced or purchased by the parts vendor, that vendor shall inspect each lot of material to determine conformance to the requirements of this specification, and shall include in the report a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: Shall be in accordance with AMS 2374.

5. PREPARATION FOR DELIVERY:

5.1 Identification: Shall be as agreed upon by purchaser and vendor.

5.2 Packaging:

5.2.1 The product shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of these products to ensure carrier acceptance and safe delivery. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.2.2 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-163, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.2.1 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS: Material not conforming to this specification or to authorized modifications will be subject to rejection.