



AEROSPACE MATERIAL

AMS 5856

Society of Automotive Engineers, Inc. SPECIFICATION

400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

Issued 9-15-75
Revised

ALLOY BILLETS AND PREFORMS, CORROSION AND HEAT RESISTANT
59.5Ni - 12Cr - 10Co - 3.0Mo - 6.0W - 3.0Ti - 1.5Ta - 4.5Al - 0.015B - 0.10Zr (0.30 - 0.35C)
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 for forgings.
- 1.2 Application: Primarily for parts requiring high strength up to 1500°F or 815°C and corrosion and oxidation resistance up to approximately 1700°F or 925°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) 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.

AMS 2261 - Tolerances, Nickel, Nickel Base, and Cobalt Base Bars and Forging Stock
AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel and Nickel Base Alloys
AMS 2350 - Standards and Test Methods
AMS 2375 - Approval and Control of Critical Forgings
AMS 2630 - Ultrasonic Inspection
AMS 5855 - Alloy Powder, Corrosion and Heat Resistant, 59.5Ni - 12Cr - 10Co - 3.0Mo - 6.0W - 3.0Ti - 1.5Ta - 4.5Al - 0.015B - 0.10Zr (0.30 - 0.35C)

- 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

- 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:

SAE Technical Board rules provide that: "All technical reports, including standards and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 3.1 Material: Billets and preforms shall be produced by consolidation of AMS 5855 powder by a suitable process to produce a product meeting the requirements specified herein.
- 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, except that oxygen and nitrogen shall be determined by Leco Gas Analyzer, or by other approved analytical methods:

	min	max
Carbon	0.30	0.35
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	11.50	12.50
Cobalt	9.50	10.50
Molybdenum	2.50	3.50
Tungsten	5.50	6.50
Titanium	2.75	3.25
Tantalum	1.00	2.00
Aluminum	4.20	4.80
Boron	0.01	0.02
Zirconium	0.05	0.15
Oxygen	--	0.010 (100 ppm)
Nitrogen	--	0.005 (50 ppm)
Iron	--	1.00
Lead	--	0.0002 (2 ppm)
Bismuth	--	0.00005 (0.5 ppm)
Nickel	remainder	

- 3.2.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269; check analysis limits for zirconium shall be 0.01 under min or over maximum.
- 3.3 Condition: As ordered by the forging manufacturer.
- 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 2175° - 2225°F (1190.6° - 1218.3°C), hold at the selected temperature within $\pm 15^\circ\text{F}$ ($\pm 8.3^\circ\text{C}$) for 2 hr ± 0.3 , and quench in oil.
- 3.4.2 Stabilization Heat Treatment: Heat to 2050°F ± 15 (1121.1°C ± 8.3), hold at heat for 2 hr ± 0.3 , and cool in air to below 700°F or 370°C.
- 3.4.3 Precipitation Heat Treatment: Heat to 1300°F ± 15 (704.4°C ± 8.3), hold at heat for 12 hr ± 0.5 , cool in air to below 700°F or 370°C, reheat to 1500°F ± 15 (815.6°C ± 8.3), hold at heat for 8 hr ± 0.5 , and cool in air.
- 3.5 Properties: When specified, a sample billet or preform shall be 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 3.5.1 through 3.5.5. If specimens taken from billets or preforms after heat treatment as in 3.4 conform to the requirements of 3.5.1 through 3.5.5, the tests shall be accepted as equivalent to tests of a forged coupon.
- 3.5.1 Grain Size: Shall be predominantly recrystallized grains of 1 or finer with no segregation of coarse or fine areas, determined by comparison of a polished and etched specimen with the chart in ASTM E112.

3.5.2 Tensile Properties: Shall be as follows for forged coupons or billets or preforms 4.0 in. (102 mm) and under in nominal cross-section; tensile property requirements for billets or preforms over 4.0 in. (102 mm) in nominal cross-section shall be as agreed upon by purchaser and vendor.

3.5.2.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	190,000 psi (1310 MPa)
Yield Strength at 0.2% Offset, min	140,000 psi (965 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	10%
Reduction of Area, min	12%

3.5.2.2 At 1500°F (815.6°C): Shall be as follows, determined in accordance with ASTM E21 on specimens heated to 1500°F ± 10 (815.6°C ± 5.6), held at 1500°F ± 10 (815.6°C ± 5.6) for 30 min. before testing, and tested at 1500°F ± 10 (815.6°C ± 5.6) 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 2 in. (50.8 mm) or 4D, min	10%
Reduction of Area, min	12%

3.5.3 Hardness: Should be 321 - 414 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 are met.

3.5.4 Stress-Rupture Properties at 1500°F (815.6°C): Shall be as follows; testing of notched specimens and of combination smooth-and-notched specimens shall be in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.5.4.1 A combination smooth-and-notched test specimen machined to the dimensions shown in Fig. 1 and Table I, maintained at 1500°F ± 3 (815.6°C ± 1.7) while a load sufficient to produce an initial axial stress of 80,000 psi (552 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. After the 23 hr, if rupture occurs in the notch, the smooth section shall, by suitable means, be continued to rupture or a separate smooth specimen shall be tested to rupture under the above conditions. Elongation of the smooth section after rupture, measured at room temperature, shall be not less than 5% in 4D.

3.5.4.2 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 3.5.4.1. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. The notched specimen shall not rupture in less than 23 hr but need not be tested to rupture.

3.5.4.3 The tests of 3.5.4.1 and 3.5.4.2 may be conducted using a load higher than required to produce an initial axial stress of 80,000 psi (552 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.5.4.1.

3.5.4.4 When permitted by purchaser, the tests of 3.5.4.1 and 3.5.4.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 80,000 psi (552 MPa) shall be used to rupture or for 23 hr, whichever occurs first. After the 23 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 and elongation requirements shall be as specified in 3.5.4.1.

3.5.5 Creep Test at 1400°F (760°C): A smooth tensile test specimen shall be maintained at 1400°F + 3 (760°C + 1.7) while a load sufficient to produce an initial axial stress of 70,000 psi (482 MPa) is applied continuously for 100 hr or until 0.2% plastic strain is produced, whichever is longer. The plastic strain after 100 hr and the time to 0.1% and 0.2% 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 shall be uniform in quality and condition, clean, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication of parts. Preforms shall have substantially uniform macrostructure and grain flow.

3.6.1 Billets and preforms shall be ultrasonically inspected 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 Tests: Tests to determine conformance to composition (3.1), ultrasonic (3.6.1), tolerance (3.7), and, when specified, property (3.5) requirements are classified as acceptance tests.

4.2.2 Periodic Tests: Tests to determine conformance to property (3.5) requirements are classified as periodic tests unless purchaser specifies that such tests are acceptance tests.

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

4.2.3.1 For direct U.S. Military procurement, preproduction test material and supporting test data shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be as agreed upon by purchaser and vendor except 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 and preforms shall in no way relieve the billet or preform vendor of responsibility for continued performance to all purchase order requirements.
- 4.4.2 The vendor shall establish for each size of billet and for preforms of each configuration the 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 control factors of processing, vendor shall submit for reapproval a statement of the proposed changes in materials or processing and, when requested, sample revised product. No production product incorporating the revised operations shall 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, grain flow, or working of the metal
 - 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 considered proprietary by the vendor may be assigned a code designation. Each variation in such factors shall be assigned a modified code designation. The vendor shall maintain complete records of all proprietary processes and factors.
- 4.5 Reports:
- 4.5.1 The vendor of the product shall furnish with each shipment three copies of a report of the results of tests for chemical composition of each lot of product in the shipment 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, material specification number, lot 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: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY: