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

AEROSPACE MATERIAL SPECIFICATION

AMS 5881

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Revised

ALLOY FORGINGS, 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)
Solution, Stabilized, and Precipitation Heat Treated

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant nickel alloy powder-metallurgy product in the form of 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 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 2808 - Identification, Forgings
AMS 5856 - 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

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

Printed in U.S.A.

3. TECHNICAL REQUIREMENTS:

3.1 Material: Forgings shall be produced from AMS 5856 billets or preforms, forged by a suitable process or processes to the required shape.

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
Sulphur	--	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: Solution, stabilization, and precipitation heat treated.

3.4 Heat Treatment: Shall be 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 ±15°F (±8.3°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: Forgings shall conform to the following requirements:

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 forgings 4.0 in. (102 mm) and under in nominal cross-section; tensile property requirements for forgings 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 forgings 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 1, 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 1, 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 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: Forgings 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. Forgings shall have substantially uniform macrostructure and grain flow.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of forgings 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 forgings conform to the requirements of this specification.

4.2 Classification of Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine control tests.

4.2.1 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.

4.3.1 A lot shall be all forgings produced from one lot of billets or preforms in one continuous production run and presented for vendor's inspection at one time.

4.3.2 A heat treat batch shall be all forgings from any lot heat treated in one furnace load. When specified, if a heat treat batch is not heat treated completely as one unit, separate heat treat batches shall be designated for solution heat treatment, stabilization heat treatment, and precipitation heat treatment.

4.4 Approval: Approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports:

4.5.1 The vendor of forgings shall furnish with each shipment three copies of a report of the results of tests for chemical composition of each lot in the shipment and 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, heat treat batch number, part number, quantity of forgings, powder lot number, and the size and source of stock used to make the forgings.

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 forgings, part number, and quantity. When forgings for making parts are produced or purchased by the parts vendor, that vendor shall inspect each lot of forgings to determine conformance to the requirements of this specification, and shall include in the report a statement that the forgings conform, or shall include copies of laboratory reports showing the results of tests to determine conformance.