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AEROSPACE MATERIAL SPECIFICATION

AMS 5882A
Superseding AMS 5882

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ALLOY FORGINGS, CORROSION AND HEAT RESISTANT 55Ni - 15Cr - 17Co - 5.0Mo - 3.5Ti - 4.0Al - 0.025B Solution, Stabilization, and Precipitation Heat Treated 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 forgings.

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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 2376 - Qualification, Approval, and Control of Premium-Quality Forgings, Alloy Steels and Heat-Treatable Corrosion and Heat Resistant Steels and Alloys
AMS 2808 - Identification, Forgings
AMS 5852 - 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

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 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 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: Forgings shall be forged, from AMS 5852 billets or preforms, 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, or by other analytical methods approved by 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	--	0.00005 (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.

3.4 Condition: Solution, stabilization, and precipitation heat treated.

3.5 Heat Treatment: Shall be as follows:

3.5.1 Solution Heat Treatment: Heat to a temperature within the range 1975° - 2075°F (1080° - 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.

3.5.2 Stabilization Heat Treatment: Heat to 1600°F ± 15 (870°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 (980°C ± 8), hold at heat for 4 hr ± 0.25, and cool at a rate equivalent to an air cool.

3.5.3 Precipitation Heat Treatment: Heat to 1200°F ± 15 (650°F ± 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 air cool to room temperature.

3.6 Properties: Forgings shall conform to the following requirements:

3.6.1 Microstructure: Shall show recrystallized grains and freedom from lack of cohesion along prior particle boundaries and shall be essentially free of voids and hollows, conforming to standards specified by purchaser; conformance shall be determined by microscopic examination at 100X or 400X magnification, or both, of specimens polished and etched in Kalling's reagent.

3.6.2 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.

3.6.3 Tensile Properties: Shall be as follows for forgings 4.0 in. (100 mm) and under in nominal thickness, determined in either the longitudinal or transverse direction except that testing in the transverse direction
Ø applies only to forgings from which a tensile specimen not less than 2.50 in. (62.5 mm) in length can be obtained; testing in the longitudinal direction is not required on forgings tested in the transverse direction. Tensile property requirements for forgings over 4.0 in. (100 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.6.3.1 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%

3.6.3.2 At 1400°F (760°C): Shall be as follows, determined in accordance with ASTM E21 on specimens heated to 1400°F ± 10 (760°C ± 5), held at heat for 20 to 30 min. before testing, and tested at 1400°F ± 10 (760°C ± 5):

Tensile Strength, min	150,000 psi (1035 MPa)
Yield Strength at 0.2% Offset, min	125,000 psi (860 MPa)
Elongation in 4D, min	20%
Reduction of Area, min	30%

3.6.4 Hardness: Should be 311 - 401 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 3.6.3.1 are met.

3.6.5 Stress-Rupture Properties at 1400°F (760°C): Shall be as follows; 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:

3.6.5.1 A combination smooth-and-notched specimen machined to the dimensions shown in Fig. 1 and Table I, maintained at 1400°F ± 3 (760°C ± 2) while a load sufficient to produce an initial axial stress of 85,000 psi (585 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.

3.6.5.2 As an alternate procedure, separate smooth and notched 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 3.6.5.1. 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.

3.6.5.3 The tests of 3.6.5.1 and 3.6.5.2 may be conducted using a load higher than required to produce an initial axial stress of 85,000 psi (585 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 3.6.5.1.

3.6.5.4 When permitted by purchaser, the tests of 3.6.5.1 and 3.6.5.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 85,000 psi (585 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 5,000 psi (35 MPa). Time to rupture, rupture location, and elongation requirements shall be as specified in 3.6.5.1.

3.6.6 Creep Properties at 1300°F (705°C): A smooth tensile specimen shall be maintained at 1300°F ± 3 (705°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 upon by purchaser and vendor. Tests shall be conducted in accordance with ASTM E139.

3.7 Quality: Forgings, as received by 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 forgings.

3.7.1 Forgings shall have substantially uniform macrostructure and grain flow. Ø Acceptance standards shall be as agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of forgings shall supply all samples for vendor's tests and shall be responsible for performing all Ø 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 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 tests and as Ø preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, on each lot, when a change in material or processing, or both, requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.1 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, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with AMS 2374.

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: Qualification, approval, and control of forgings shall be in accordance with AMS 2376, unless otherwise specified.

4.5 Reports:

4.5.1 The vendor of forgings shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each lot and the results of tests on each heat treat batch to determine conformance to the other technical requirements of this specification. This report shall include the purchase order number, lot number, AMS 5882A, 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, AMS 5882A, 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 either a statement that the forgings conform or 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 in accordance with AMS 2808.

5.2 Packaging:

5.2.1 Forgings 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 the forgings 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 and its revision letter in all quotations and when acknowledging purchase orders.

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

8. NOTES:

8.1 Marginal Indicia: The phi (Ø) symbol is used to indicate technical changes from the previous issue of this specification.

8.2 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Size or part number of forgings desired
Quantity of forgings desired
Acceptance standards for microstructure (See 3.6.1)
Acceptance standards for macrostructure and grain flow (See 3.7.1)
Applicable level of packaging (See 5.2.2)

8.3 Forgings meeting the requirements of this specification have been classified under Federal Standardization Area Symbol "FORG".

This specification is under the jurisdiction of AMS Committee "F".