

ALLOY BARS, FORGINGS, AND RINGS, CORROSION AND HEAT RESISTANT
21Cr - 20Ni - 20Co - 3.0Mo - 2.5W - 1.0(Cb+Ta) - 0.15N - 31Fe
Solution and Precipitation Heat Treated

UNS R30155

1. SCOPE:

- 1.1 Form: This specification covers a corrosion and heat resistant iron-chromium-nickel-cobalt alloy in the form of bars, wire, forgings, flash welded rings, and stock for forging, flash welded rings, or heading.
- 1.2 Application: Primarily for parts, such as turbine rotors, shafts, blades, and bolts, requiring high strength up to 1350°F (732°C) and oxidation resistance up to 1800°F (982°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 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.

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2.1.1 Aerospace Material Specifications:

- AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys.
- AMS 2261 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
- AMS 2261 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
- AMS 2350 - Standards and Test Methods
- AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Wrought Products Except Forgings and Forging Stock
- AMS 2374 - Quality Assurance Sampling of Corrosion and Heat Resistant Steels and Alloys, Forgings and Forging Stock
- AMS 2375 - Control of Forgings Requiring First Article Approval
- AMS 2750 - Pyrometry
- AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat Resistant Steels and Alloys
- AMS 2808 - Identification, Forgings
- AMS 7490 - Rings, Flash Welded, Corrosion and Heat Resistant Austenitic Steels and Austenitic-Type Alloys

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

- ASTM E10 - Brinell Hardness of Metallic Materials
- ASTM E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic 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 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:

	min	max
Carbon	0.08	0.16
Manganese	1.00	2.00
Silicon	--	1.00
Phosphorus	--	0.040
Sulfur	--	0.030
Chromium	20.00	22.50
Nickel	19.00	21.00
Cobalt	18.50	21.00
Molybdenum	2.50	3.50
Tungsten	2.00	3.00
Columbium + Tantalum	0.75	1.25
Nitrogen	0.10	0.20
Iron	remainder	

- 3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248.

- 3.2 Condition: The product shall be supplied in the following condition.

- 3.2.1 Bars, Wire, Forgings, and Flash Welded Rings: Solution and precipitation heat treated and descaled.

- 3.2.1.1 Flash welded rings shall not be supplied unless specified or permitted on purchaser's part drawing. When supplied, rings shall be manufactured in accordance with AMS 7490.

- 3.2.2 Stock for Forging, Flash Welded Rings, or Heading: As ordered by the forging, flash welded ring, or heading manufacturer.

- 3.3 Heat Treatment: Bars, wire, forgings, and flash welded rings shall be solution heat treated by heating to $2150^{\circ}\text{F} \pm 25$ ($1177^{\circ}\text{C} \pm 14$), holding at heat for not less than 60 minutes, and quenching in water and precipitation heat treated by heating to $1500^{\circ}\text{F} \pm 25$ ($816^{\circ}\text{C} \pm 14$), holding at heat for not less than 4 hours and cooling in air. Pyrometry shall be in accordance with AMS 2750.

- 3.4 Properties: The product shall conform to the following requirements:

- 3.4.1 Bars, Wire, Forgings, and Flash Welded Rings:

- 3.4.1.1 Hardness: Shall be 192 - 241 HB, or equivalent, determined in accordance with ASTM E10.

- 3.4.1.2 Stress-Rupture Properties at 1350°F (732°C): A tensile specimen, maintained at $1350^{\circ}\text{F} + 3$ ($732^{\circ}\text{C} + 2$) while a load sufficient to produce an initial axial stress of 32,000 psi (221 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than 10% in 4D. Tests shall be conducted in accordance with ASTM E139.
- 3.4.1.2.1 The test of 3.4.1.2 may be conducted using a load higher than required to produce an initial axial stress of 32,000 psi (221 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.4.1.2.
- 3.4.1.2.2 When permitted by purchaser, the test of 3.4.1.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 32,000 psi (221 MPa) shall be used to rupture or for 23 hours, whichever occurs first. After the 23 hours and at intervals of 8 - 16 hours, preferably 8-10 hours thereafter, the stress shall be increased in increments of 2000 psi (14 MPa). Elongation requirements shall be as specified in 3.4.1.2.
- 3.4.2 Forging Stock: When a sample of stock is forged to a test coupon and heat treated as in 3.3, specimens taken from the heat treated coupon shall conform to the requirements of 3.4.1.1 and 3.4.1.2. If specimens taken from the stock after heat treatment as in 3.3 conform to the requirements of 3.4.1.1 and 3.4.1.2, the tests shall be accepted as equivalent to tests of a forged coupon.
- 3.4.3 Stock for Flash Welded Rings or Heading: Specimens taken from the stock after heat treatment as in 3.3 shall conform to the requirements of 3.4.1.1 and 3.4.1.2.
- 3.5 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.
- 3.5.1 Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by purchaser and vendor.
- 3.5.2 Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forgings showing no evidence of re-entrant grain flow.
- 3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars and wire will be acceptable in mill lengths of 6 - 20 feet (1.8 - 6.1 m) but not more than 10% of any shipment shall be supplied in lengths shorter than 10 feet (3 m).
- 3.7 Tolerances: Bars, wire, and forging stock 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 the following requirements are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.1.1 Composition (3.1) of each heat.

4.2.1.2 Hardness (3.4.1.1) of each lot of bars, wire, forgings, and flash welded rings.

4.2.1.3 Tolerances (3.7) of bars, wire, and forging stock.

4.2.2 Periodic Tests: Tests to determine conformance to the following requirements are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.2.1 Stress-rupture properties (3.4.1.2) of bars, wire, forgings, and flash welded rings.

4.2.2.2 Ability of forging stock (3.4.2) and stock for flash welded rings or heading (3.4.3) to develop required properties.

4.2.3 Preproduction Tests: Tests of forgings to determine conformance to all applicable technical requirements of this specification when AMS 2375 is specified are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a forging to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiating test data and, when requested, preproduction forgings 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 the following:

4.3.1 Bars, Wire, Flash Welded Rings, and Stock for Flash Welded Rings or Heading: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374.