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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5746D

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Superseding AMS 5746C

ALLOY BARS AND FORGINGS, CORROSION AND HEAT RESISTANT
15Cr - 45Ni - 4.1Mo - 4.1W - 3.0Ti - 1.0Al - 31Fe
Consumable Electrode Vacuum Melted
Solution and Precipitation Heat Treated UNS N09979

1. SCOPE:

1.1 Form: This specification covers a corrosion and heat resistant nickel alloy in the form of bars, forgings, and stock for forging or heading.

1.2 Application: Primarily for parts such as turbine rotors, shafts, blades, bolts, dowels, and fittings requiring high strength up to 1600°F (870°C) and oxidation resistance up to 1800°F (980°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.

2.1.1 Aerospace Material Specifications:

AMS 2241 - Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
MAM 2241 - Tolerances, Metric, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS 2248 - Chemical Check Analysis Limits, Wrought Corrosion and Heat Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys
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

2.1.1 (Continued):

AMS 2375 - Control of Forgings Requiring First Article Approval
AMS 2806 - Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Heat and Corrosion Resistant Steels and Alloys
AMS 2808 - Identification, Forgings

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 E139 - Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests of Materials
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron 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 Specifications:

MIL-H-6875 - Heat Treatment of Steel, Process for

2.3.2 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, Ø determined by wet chemical methods in accordance with ASTM E353 or by spectrochemical or other analytical methods approved by purchaser:

	min	max
Carbon	--	0.08
Manganese	--	0.75
Silicon	--	0.75
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	14.00	16.00
Nickel	42.00	48.00
Molybdenum	3.75	4.50
Tungsten	3.75	4.50
Titanium	2.70	3.30
Aluminum	0.75	1.30
Boron	0.008	0.016
Zirconium	--	0.050
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 and Forgings: Solution and precipitation heat treated.

3.2.2 Stock for Forging or Heading: As ordered by the forging or heading manufacturer.

3.3 Heat Treatment: Bars and forgings shall be solution and precipitation heat Ø treated as follows; furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6875:

3.3.1 Solution: Heat to a temperature within the range 1850° - 1900°F Ø (1010° - 1040°C), hold at the selected temperature within ±25°F (±15°C) for 1 - 4 hr, and quench as required.

3.3.2 Precipitation: Heat to 1550°F + 15 (840°C + 8), hold at heat for 6 - 12 hr, air cool, heat to 1300°F ± 15 (705°C ± 8), hold at heat for 16 hr ± 1, and air cool.

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

3.4.1 Bars and Forgings:

3.4.1.1 Tensile Properties: Shall be as specified in Table I and 3.4.1.1.2, determined in accordance with ASTM E8.

3.4.1.1.1 Bars:

TABLE I

Nominal Diameter or Equivalent Cross Section Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 0.75, incl	190,000	125,000	12	15
Over 0.75	190,000	125,000	10	12

TABLE I (SI)

Nominal Diameter or Equivalent Cross Section Millimetres	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
Up to 19.0, incl	1310	860	12	15
Over 19.0	1310	860	10	12

3.4.1.1.2 Forgings:

Tensile Strength, min	175,000 (1205 MPa)
Yield Strength at 0.2% Offset, min	125,000 (860 MPa)
Elongation in 4D, min	8%
Reduction of Area, min	10%

3.4.1.2 Hardness: Shall be 340 - 418 HB, or equivalent, determined in accordance with ASTM E10.

3.4.1.3 Stress-Rupture Properties at 1200°F (650°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:

3.4.1.3.1 A combination smooth and notched specimen machined to the dimensions shown in Fig. 1 and Table II, maintained at 1200°F ± 3 (650°C ± 2) while a load sufficient to produce an initial axial stress of 95,000 psi (655 MPa) is applied continuously, shall not rupture in less than 23 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 5% in 4D if the specimen ruptures in 48 hr or less and not less than 3% in 4D if the specimen ruptures in more than 48 hours.

3.4.1.3.2 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 II may be tested individually under the conditions of 3.4.1.3.1. The smooth specimen shall not rupture in less than 23 hr and elongation after rupture, measured at room temperature, shall be as specified in 3.4.1.3.1. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.3.3 The tests of 3.4.1.3.1 and 3.4.1.3.2 may be conducted using a load higher than required to produce an initial axial stress of 95,000 psi (655 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 3.4.1.3.1.

3.4.1.3.4 When permitted by purchaser, the tests of 3.4.1.3.1 and 3.4.1.3.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 95,000 psi (655 MPa) shall be used to rupture or for 48 hr, whichever occurs first. After the 48 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 3.4.1.3.1.

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 3.4.1.1.2, 3.4.1.2, and 3.4.1.3. If specimens taken from the stock after heat treatment as in 3.3 conform to the requirements of 3.4.1.1.2, 3.4.1.2, and 3.4.1.3, the tests shall be accepted as equivalent to tests of a forged coupon.

3.4.3 Stock for Heading: Specimens taken from the stock after heat treatment as in 3.3 shall conform to the requirements of 3.4.1.1.1, 3.4.1.2, and 3.4.1.3.

3.5 Quality:

3.5.1 Alloy shall be multiple melted using vacuum consumable electrode practice in the remelt cycle.

3.5.2 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.

3.5.2.1 Ø Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5.2.2 Ø Grain flow of die forgings, except in areas which contain flash-line end grain, shall follow the general contour of the forging, showing no evidence of re-entrant flow.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, straight bars will be acceptable in mill lengths of 6 - 24 ft (2 - 7.5 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 ft (2 - 3 m) except that for bars weighing over 25 lb per ft (37 kg/m), short lengths down to 2 ft (610 mm) may be supplied.

3.7 Tolerances: Bars shall conform to all applicable requirements of AMS 2241 or MAM 2241.

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 Tensile properties (3.4.1.1), hardness (3.4.1.2), and stress-rupture properties (3.4.1.3) of each lot of bars and forgings.

4.2.1.3 Tolerances (3.7) of bars.

4.2.2 Periodic Tests: Tests of forging stock (3.4.2) and of stock for heading (3.4.3) to demonstrate ability to develop required properties are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

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

4.3 Sampling: Shall be in accordance with the following:

4.3.1 Bars: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374 and the following:

4.3.2.1 Size, location, and number of specimens for tensile tests of disc forgings shall be as agreed upon by purchaser and vendor.

4.4 Approval: When specified, approval and control of forgings shall be in accordance with AMS 2375.

4.5 Reports:

4.5.1 The vendor of bars and forgings shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and the results of tests on each lot to determine conformance to the other acceptance test requirements and, when performed, to the periodic test requirements of this specification. This report shall include the purchase order number, heat number, AMS 5746D, size, and quantity. If forgings are supplied, the part number and the size and melt source of stock used to make the forgings shall also be included.

4.5.2 Ø The vendor of stock for forging or heading shall furnish with each shipment a report showing the results of tests for chemical composition of each heat. This report shall include the purchase order number, heat number, AMS 5746D, size, and quantity.

4.5.3 The vendor of finished or semi-finished parts shall furnish with each shipment a report showing the purchase order number, AMS 5746D, 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 either a statement that the material conforms or copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: Shall be in accordance with the following:

4.6.1 Bars and Heading Stock: AMS 2371.

4.6.2 Forgings and Forging Stock: AMS 2374.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Bars: In accordance with AMS 2806.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Stock for Forging or Heading: 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 the product 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: Material 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 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

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

Title, number, and date of this specification
Form and size or part number of product desired
Quantity of product desired
Standards for acceptance of forging macrostructure (See 3.5.2.1)
Applicable level of packaging (See 5.2.2)

8.4 Products meeting the requirements of this specification have been classified under Federal Supply Classification (FSC) 9510 and Federal Standardization Area Symbol "FORG".

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