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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5746E

Issued JUN 1960
Revised JUL 1989
Reaffirmed NOV 2000

Superseding AMS 5746D

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 (871°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 SAE publications 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

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2.1.1 (Continued):

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

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia PA 19103.

ASTM E8	Tension Testing of Metallic Materials
ASTM E8M	Tension Testing of Metallic Materials (Metric)
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 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 E353, by spectrochemical methods, or by other analytical methods acceptable to 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	
Lead	--	0.0005	(5 ppm)
Bismuth	--	0.00003	(0.3 ppm)
Selenium	--	0.0003	(3 ppm)
Iron	remainder		

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2248; no variations for lead, bismuth, and selenium are permitted.

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 treated as follows; pyrometry shall be in accordance with AMS 2750.

3.3.1 Solution: Heat to a temperature within the range 1850° - 1900°F (1010° - 1038°C), hold at the selected temperature within ±25°F (±14°C) for a time commensurate with cross-sectional thickness, and quench as required.

3.3.2 Precipitation: Heat to 1550°F ± 15 (843°C ± 8), hold at heat for 6 - 12 hours, air cool, heat to 1300°F ± 15 (704°C ± 8), hold at heat for 16 hours ± 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 or ASTM E8M.

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, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
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, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
Up to 19.0, incl	1310	862	12	15
Over 19.0	1310	862	10	12

3.4.1.1.2 Forgings:

Tensile Strength, minimum	175,000 psi (1207 MPa)
Yield Strength at 0.2% Offset, minimum	125,000 psi (862 MPa)
Elongation in 4D, minimum	8%
Reduction of Area, minimum	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 (649°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 standard, cylindrical, combination smooth-and-notched specimen conforming to ASTM E292, maintained at 1200°F ± 3 (649°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 hours 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 shown in ASTM E292, may be tested individually under the conditions of 3.4.1.3.1. The smooth specimen shall not rupture in less than 23 hours 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 hours, whichever occurs first. After the 48 hours and at intervals of 8 - 16 hours, preferably 8 - 10 hours, thereafter, the stress shall be increased in increments of 5,000 psi (34.5 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 Heading Stock: 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 produced by multiple melting 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 Forgings shall have substantially uniform macrostructure. Standards for acceptance shall be as agreed upon by purchase and vendor.

3.5.2.2 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 will be acceptable in mill lengths of 6 - 24 feet (1.8 - 7.3 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 feet (1.8 - 2.7 m) except that for bars weighing over 25 pounds per foot (37 kg/m), short lengths down to 2 feet (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: Test of forging stock (3.4.2) and of heading stock (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 and/or processing 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: 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 of this specification. This report shall include the purchase order number, lot number, AMS 5746E, 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 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 5746E, size, and quantity.

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.