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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 5890B

Issued 7-1-76
Revised 10-1-88

Superseding AMS 5890A

NICKEL BARS, FORGINGS, AND EXTRUSIONS, CORROSION AND HEAT RESISTANT
Thoria Dispersion Strengthened
$2.2ThO_2$
Stress-Relieved

UNS N03260

1. SCOPE:

1.1 Form: This specification covers thoria-dispersion-strengthened nickel in the form of bars, forgings, extrusions, and stock for forging or extruding.

1.2 Application: Primarily for parts required to operate in the range 1800° - 2400°F (982° - 1316°C) but a protective coating is required for operation at such temperatures. Fusion welding of structural members is not recommended but the product can be brazed and resistance welded satisfactorily.

1.3 Products covered by this specification are radioactive. Applicable rules and regulations pertaining to handling of radioactive material should be observed.

1.4 Safety - Hazardous Materials: While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibilty of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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 2261 - Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
MAM 2261 - Tolerances, Metric, Nickel, Nickel Alloy, and Cobalt Alloy Bars and Forging Stock
AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel Alloys and Cobalt 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
AMS 2375 - Control of Forgings Requiring First Article Approval
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 American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E8M - Tension Testing of Metallic Materials (Metric)
ASTM E21 - Elevated Temperature Tension Tests 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 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, Ø determined by wet chemical methods in accordance with ASTM E354, by spectrochemical methods, or by other analytical methods acceptable to purchaser; the method of determining thoria (ThO_2) shall be as agreed upon by purchaser and vendor:

	min	max
Thoria	1.80	2.60
Carbon	--	0.02
Sulfur	--	0.0025
Chromium	--	0.05
Cobalt	--	0.20
Titanium	--	0.05
Iron	--	0.05
Copper	--	0.15
Nickel	remainder	

3.1.1 Check Analysis: Composition variations shall meet the requirements of AMS 2269 except that chromium, titanium, and iron shall each vary not more than 0.001 over maximum; permissible variation for thoria shall be 0.01 under minimum or over maximum.

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

3.2.1 Bars: Hot and/or cold worked and stress-relieved.

3.2.2 Forgings and Extrusions: Stress-relieved.

3.2.3 Stock for Forging or Extruding: As ordered by the forging or extrusion manufacturer.

3.3 Stress-Relieving: Bars, forgings, and extrusions shall be stress-relieved Ø by heating in vacuum, argon, or hydrogen to a temperature within the range 2000° - 2200°F (1093° - 1204°C), holding at selected temperature within +25°F (+14°C) for not less than 1 hour, and cooling in vacuum, argon, or hydrogen to 500°F (260°C) or lower.

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

3.4.1 Bars, Forgings, and Extrusions:

3.4.1.1 Tensile Properties: Shall be as follows, determined in either the longitudinal or transverse direction except that testing in the transverse direction applies only to product from which a tensile specimen not less than 2.50 inches (63.5 mm) in length can be obtained. Testing in the longitudinal direction is not required on product tested in the transverse direction.

3.4.1.1.1 At Room Temperature: Shall be as follows, determined in accordance with ASTM E8 or ASTM E8M using a strain rate of 0.003 - 0.007 inch/inch/minute (0.003 - 0.007 mm/mm/minute) through the 0.6% offset and a cross-head speed of 0.03 - 0.07 inch (0.8 - 1.8 mm) per minute from the 0.6% offset to rupture:

Tensile Strength, minimum	57,000 psi (393 MPa)
Yield Strength at 0.2% Offset, minimum	42,000 psi (290 MPa)
Elongation in 4D, minimum	15%
Reduction of Area, minimum	50%

3.4.1.1.2 At 2000°F (1093°C): Shall be as specified in Table I, determined in accordance with ASTM E21 on specimens heated to 2000°F + 10 (1093°C + 6), held at heat for 10 - 30 minutes before testing, and tested at 2000°F + 10 (1093°C + 6) using a crosshead speed of 0.03 - 0.07 inch (0.8 - 1.8 mm)/minute.

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, minimum	Yield Strength at 0.2% Offset psi, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
0.500 to 0.750, incl	15,000	13,500	2	5
Over 0.750 to 1.250, incl	12,000	11,500	2	5

TABLE I (SI)

Nominal Diameter or Distance Between Parallel Sides Millimetres	Tensile Strength MPa, minimum	Yield Strength at 0.2% Offset MPa, minimum	Elongation in 4D %, minimum	Reduction of Area %, minimum
12.70 to 19.05, incl	103	93	2	5
Over 19.05 to 31.75, incl	83	79	2	5

3.4.1.1.2.1 Tensile property requirements at 2000°F (1093°C) for product under 0.500 inch (12.70 mm) or over 1.250 inches (31.75 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2 Stress-Rupture Properties at 2000°F (1093°C): Shall be as follows; testing of notched and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E292 and of smooth specimens in accordance with ASTM E139:

3.4.1.2.1 Ø A standard cylindrical combination smooth-and-notched specimen conforming to ASTM E292 maintained at 2000°F + 10 (1093°C + 6) while a load sufficient to produce the initial axial stress specified below is applied continuously, shall not rupture in less than 20 hours. The test shall be continued to rupture without change of load. Rupture shall occur in the smooth section and elongation and reduction of area of this section, measured at room temperature, shall be reported.

Nominal Diameter or Distance Between Parallel Sides		Initial Axial Stress	
Inches	Millimetres	psi	MPa
0.500 to 0.750, incl	12.70 to 19.05, incl	8000	55
Over 0.750 to 1.250, incl	Over 19.05 to 31.75, incl	7000	48

3.4.1.2.1.1 Ø Initial axial stress for product under 0.500 inch (12.70 mm) or over 1.250 inches (31.75 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2.2 Ø 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 3.4.1.2.1. The smooth specimen shall not rupture in less than 20 hours and elongation and reduction of area, measured at room temperature, shall be reported. The notched specimen shall not rupture in less time than the companion smooth specimen but need not be tested to rupture.

3.4.1.2.3 The tests of 3.4.1.2.1 and 3.4.1.2.2 may be conducted using a load higher than required to produce the applicable initial stress specified in 3.4.1.2.1 but load shall not be changed while test is in progress. Time to rupture and rupture location requirements shall be as specified in 3.4.1.2.1. The elongation and reduction of area after rupture, measured at room temperature, shall be reported.

3.4.1.2.4 When permitted by purchaser, the tests of 3.4.1.2.1 and 3.4.1.2.2 may be conducted using incremental loading. In such case, the load required to produce the applicable initial stress specified in 3.4.1.2.1 shall be maintained to rupture or for 20 hours, whichever occurs first. After the 20 hours and at intervals thereafter, the stress shall be increased in increments of 1000 psi (7 MPa). Time to rupture and rupture location shall be as specified in 3.4.1.2.1 and 3.4.1.2.2. The elongation and reduction of area, measured at room temperature, shall be reported.

3.4.2 Stock for Forging or Extruding: When a sample of stock is forged or extruded to a test coupon and stress-relieved as in 3.3, specimens taken from the stress-relieved coupon shall conform to the requirements of 3.4.1.1 and 3.4.1.2. If specimens taken from the stock after stress-relieving 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 or extruded coupon.

3.4.3 Structure: The product shall have a substantially uniform structure essentially free from porosity, determined by macroscopic or microscopic examination. Standards for acceptance shall be as agreed upon by purchaser and vendor.

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 Mars, gouges, scratches, pits, and similar imperfections which reduce dimensions of the product below the minimum allowable by the specified tolerances are not acceptable; such imperfections, if more than 0.005 inch (0.13 mm) deep but not of such depth that their removal would reduce dimensions below the minimum, will be permitted provided the number is not more than 5 per square foot (54/m^2). Superficial scratches, individual pits, and roughened areas which appear under magnification as a scattering of pits will be acceptable if they are less than 0.0005 inch (0.013 mm) deep; the number of such imperfections is not restricted. The product shall be free of contamination as determined by visual inspection; differences in reflectivity shall not be considered evidence of contamination.

3.6 Sizes: Except when exact lengths or multiples of exact lengths are ordered, bars and extrusions will be acceptable in 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 and extrusions weighing over 25 pounds per foot (37 kg/m), short lengths down to 2 feet (610 mm) may be supplied.

3.7 Tolerances: Shall conform to the following:

3.7.1 Bars and Forging Stock: All applicable requirements of AMS 2261 or MAM 2261.

3.7.2 Extrusions: As specified on the extrusion drawing or as agreed upon by purchaser and vendor.

3.7.3 Extruding Stock: As agreed upon by purchaser and vendor.

4. QUALITY ASSURANCE PROVISION:

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 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 powder lot or product lot as applicable.

4.2.1.1 Composition (3.1), structure (3.4.3), and surface condition (3.5.1) of the product.

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

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

4.2.2 Periodic Tests: Tests of stock for forging or extruding to determine ability to develop required properties (3.4.2) 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, Extrusions, and Stock For Extruding: AMS 2371.

4.3.2 Forgings and Forging Stock: AMS 2374.

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, forgings, and extrusions shall furnish with each shipment a report showing the results of tests for chemical composition of each powder lot and the results of tests on each product lot to determine conformance to the acceptance test requirements of this specification. This report shall include the purchase order number, powder lot number, AMS 5890B, size, and quantity. If forgings are supplied, the part number and the size and manufacturing source of stock used to make the forgings shall also be included.

4.5.2 Ø The vendor of stock for forging or extruding shall furnish with each shipment a report showing the results of tests for chemical composition of each powder lot. This report shall include the purchase order number, lot number, AMS 5890B, size, and quantity.