Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5890

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Revised

NICKEL BARS, FORGINGS, AND EXTRUSIONS, CORROSION AND HEAT RESISTANT
Thoria Dispersion Strengthened
2.2ThO_2

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 temperature range 1800° - 2400°F (982° - 1317°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. Products covered by this specification are radioactive. Applicable rules and regulations pertaining to handling of radioactive material should be observed.

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) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2261 - Tolerances, Nickel, Nickel Base, and Cobalt Base Alloy Bars and Forging Stock
AMS 2269 - Chemical Check Analysis Limits, Wrought Nickel and Nickel Base Alloys
AMS 2350 - Standards and Test Methods
AMS 2371 - Quality Assurance Sampling of Corrosion and Heat Resistant Alloys, Wrought Products Except Forgings
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 E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
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-Base Alloys

2.3 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

Printed in U.S.A.

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, 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 approved analytical methods; 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 max; permissible variation for thoria shall be 0.01 under min 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 by heating to 2000° - 2200°F (1093.3° - 1204.4°C) in vacuum, argon, or hydrogen, holding at heat for not less than 1 hr, and cooling to below 500°F (260°C) in vacuum, argon, or hydrogen.

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

3.4.1 Bars, Forgings, and Extrusions:

3.4.1.1 Tensile Properties:

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

Tensile Strength, min	57,000 psi (393 MPa)
Yield Strength at 0.2% Offset, min	42,000 psi (290 MPa)
Elongation in 1 in. (25.4 mm) or 4D, min	15%
Reduction of Area (round specimens), min	50%

3.4.1.1.2 At 2000°F (1093.3°C): Shall be as specified in Table I, determined in accordance with ASTM E21 on specimens heated to 2000°F ± 5 (1093.3°C ± 2.8), held at 2000°F ± 5 (1093.3°C ± 2.8) for not less than 10 min. before testing, and tested at 2000°F ± 5 (1093.3°C ± 2.8) using a crosshead speed of 0.03 - 0.07 in. per min. (0.8 - 1.8 mm/min.)

TABLE I

Nominal Diameter or Distance Between Parallel Sides Inches	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 1 in. or 4D %, min	Reduction of Area %, min
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, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 25.4 mm or 4D %, min	Reduction of Area %, min
12.70 to 19.05, incl	103	93.1	2	5
Over 19.05 to 31.75, incl	82.7	79.3	2	5

3.4.1.1.2.1 Tensile properties at 2000°F ± 5 (1093.3°C) for product less than 0.500 in. (12.70 mm) or over 1.250 in. (31.75 mm) in nominal diameter or distance between parallel sides shall be as agreed upon by purchaser and vendor.

3.4.1.2 Hardness: Shall be not lower than 75 HRB or equivalent, determined in accordance with ASTM E18.

3.4.1.3 Stress-Rupture Properties at 2000°F (1093.3°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:

3.4.1.3.1 A combination smooth-and-notched test specimen machined to the dimensions shown in Fig. 1 and Table II, maintained at 2000°F ± 3 (1093.3°C ± 1.7) 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	(55.2)
Over 0.750 to 1.250, incl	(Over 19.05 to 31.75, incl)	7000	(48.3)

3.4.1.3.2 As an alternate procedure, separate smooth and notched test 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 20 hr 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.

3.4.1.3.3 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 the applicable initial stress specified in 3.4.1.3.1 but load shall not be changed while test is in progress. Time to rupture and rupture location requirements shall be as specified in 3.4.1.3.1. The elongation in 1 in. (25.4 mm) and reduction area after rupture, measured at room temperature shall be reported.

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 the applicable initial stress specified in 3.4.1.3.1 shall be maintained to rupture or for 20 hr, whichever occurs first. After the 20 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 1000 psi (6.9 MPa). Time to rupture and rupture location shall be as specified in 3.4.1.3.1 and 3.4.1.3.2. 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, 3.4.1.2, and 3.4.1.3. If specimens taken from the stock after stress-relieving as in 3.3 conform to the requirements of 3.4.1.1, 3.4.1.2, and 3.4.1.3, 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 the 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 product.

3.5.1 Surface Condition: Mars, gouges, scratches, pits, and similar imperfections which reduce dimensions of the product below the minimum allowable by the specified tolerances will not be permitted; such imperfections, if more than 0.005 in. (0.013 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 sq ft (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 in. (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 will 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 mill lengths of 6 - 24 ft (1.8 - 7.3 m) but not more than 25% of any shipment shall be supplied in lengths of 6 - 9 ft (1.8 - 2.7 m) except that for bars and extrusions weighing over 25 lb per ft (37.2 kg/m), short lengths down to 2 ft (610 mm) may be supplied.

3.7 Tolerances: Unless otherwise specified, tolerances shall conform to the following:

3.7.1 Bars and Forging Stock: All applicable requirements of AMS 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 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 perform such confirmatory testing as he deems necessary to ensure that the product conforms to the requirements of this specification.

4.2 Classification Tests:

4.2.1 Acceptance Tests: The following are classified as acceptance tests:

4.2.1.1 Tests of the product to determine conformance to composition (3.1) and structure (3.4.3) requirements.

4.2.1.2 Tests of bars, forgings, and extrusions to determine conformance to tensile property (3.4.1.1), hardness (3.4.1.2), and stress-rupture (3.4.1.3) requirements.

4.2.1.3 Tests of bars and extrusions to determine conformance to surface condition (3.5.1.) and tolerance (3.7) requirements.

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.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 For direct U.S. Military procurement of forgings, substantiation test data and, when requested, preproduction test 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 and Extrusions: AMS 2371.

4.3.2 Forgings and Stock for Forging or Extruding: 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 the product shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of each powder lot and the results of tests on each size from each powder lot to determine conformance to the acceptance test requirements of this specification. This report shall include the purchase order number, powder lot number, material specification number, size, and quantity from each powder lot. 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 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of report showing the purchase order number, material specification number, 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 a statement that the material conforms, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented and no additional testing shall be permitted. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification: The product shall be identified as follows:

5.1.1 Bars, Rods, Tubes, and Shapes: In accordance with AMS 2806.

5.1.2 Forgings: In accordance with AMS 2808.

5.1.3 Stock for Forging or Extruding: 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 to ensure carrier acceptance and safe transportation to the point of 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 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 in all quotations and when acknowledging purchase orders.

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

8. NOTES:

8.1 For direct U.S. Military procurement, purchase documents should specify the following:

Title, number, and date of this specification
Form and size or part number of product desired
Quantity of product desired
Acceptance standards for structure
Applicable level of packaging (See 5.2.2).