



AEROSPACE MATERIAL SPECIFICATION

AMS 5865

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

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Revised

NICKEL SHEET AND STRIP, CORROSION AND HEAT RESISTANT Thoria Dispersion Strengthened 2.2ThO₂

1. SCOPE:

1.1 Form: This specification covers thoria-dispersion-strengthened nickel in the form of sheet and strip.

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 2262 - Tolerances, Nickel, Nickel-Base, and Cobalt-Base Alloy Sheet, Strip, and Plate
- 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

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 E290 - Semi-Guided Bend Test for Ductility of Metallic 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.

2.3.2 Military Standards:

MIL-STD-163 - Steel Mill Products, Preparation for Shipment and Storage

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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 (ThO₂) 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:** Cold-rolled, stress-relieved, descaled, and leveled.

3.3 **Stress-Relieving:** The product 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 **Tensile Properties:**

3.4.1.1 **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 crosshead 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	60,000 psi (414 MPa)
Yield Strength at 0.2% Offset, min	40,000 psi (276 MPa)
Elongation in 1 in. (25.4 mm), min	10%

3.4.1.2 **At 2000°F (1093.3°C):** Shall be as follows, 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.).

Tensile Strength, min	12,000 psi (82.7 MPa)
Yield Strength at 0.2% Offset, min	9,500 psi (65.5 MPa)
Elongation in 1 in. (25.4 mm), min	2%

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

3.4.3 Bending: Product 0.020 to 0.250 in. (0.51 to 6.35 mm), incl, in nominal thickness shall withstand, without cracking when examined at 10X magnification, bending in accordance with ASTM E290 through an angle of 105 deg (1.83 rad) around a diameter equal to the bend factor times the nominal thickness of the product with axis of bend parallel to the direction of rolling.

Nominal Thickness		Bend Factor
Inch	(Millimetres)	
0.020 to 0.125, incl	(0.51 to 3.18, incl)	2
Over 0.125 to 0.250, incl	(Over 3.18 to 6.35, incl)	3

3.4.3.1 Bending requirements for product less than 0.020 in. (0.51 mm) in nominal thickness shall be as agreed upon by purchaser and vendor.

3.4.4 Stress-Rupture Properties at 2000°F (1093.3°C): A tensile test specimen, maintained at 2000°F ± 3 (1093.3°C ± 1.7) while a load sufficient to produce an initial axial stress of 5,500 psi (37.0 MPa) is applied continuously, shall not rupture in less than 20 hours. The test shall be continued to rupture without change of load. The elongation in 1 in. (25.4 mm) after rupture, measured at room temperature, shall be reported. Test shall be conducted in accordance with ASTM E139.

3.4.4.1 The test of 3.4.4 may be conducted using a load higher than required to produce an initial axial stress of 5,500 psi (37.9 MPa) but load shall not be changed while test is in progress. Time to rupture requirement shall be as specified in 3.4.4. The elongation in 1 in. (25.4 mm) after rupture, measured at room temperature, shall be reported.

3.4.4.2 When permitted by purchaser, the test of 3.4.4 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 5,500 psi (37.9 MPa) 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 requirement shall be as specified in 3.4.4. The elongation in 1 in. (25.4 mm), measured at room temperature, shall be reported.

3.4.5 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 the thickness of the product below the minimum allowable by the thickness tolerance will not be permitted; such imperfections, if more than 0.0005 in. (0.013 mm) deep but not of such depth that their removal would reduce thickness below the minimum, will be permitted provided the number is not more than 5 per sq ft (54/m²). 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 Tolerances: Unless otherwise specified, tolerances shall conform to all applicable requirements of AMS 2262 except that the deviation from flat shall not exceed 6%, determined as in 3.6.1.

- 3.6.1 The deviation from flat shall be determined from the expression $100H/L$ where H is equal to the maximum distance between a flat surface and the highest surface of the product and L is the distance between the highest point of the product and the nearest point of contact of the product with the flat surface. A general bow in the product which can be eliminated by slight pressure without the ends coiling or an "oil-can" effect resulting will be acceptable.

4. QUALITY ASSURANCE PROVISIONS:

- 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 4.4. 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 of Tests: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests.
- 4.3 Sampling: Shall be in accordance with AMS 2371 and the following:
- 4.3.1 Tensile and stress-rupture test specimens from widths 5 in. (127 mm) and over shall be taken with the axis of the specimen perpendicular to the direction of rolling; for widths less than 5 in. (127 mm), specimens shall be taken with the axis parallel to the direction of rolling.
- 4.4 Reports:
- 4.4.1 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 thickness from each powder lot to determine conformance to the other technical 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.
- 4.4.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a 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.
- 4.5 Resampling and Retesting: Shall be in accordance with AMS 2371.

5. PREPARATION FOR DELIVERY:

- 5.1 Identification: Each sheet and strip shall be marked on one face, in the respective location indicated below, with AMS 5865, powder lot number, manufacturer's identification, and nominal thickness. The characters shall be of such size as to be clearly legible, shall be applied using a suitable marking fluid, and shall be removable in hot alkaline cleaning solution without rubbing. The markings shall have no deleterious effect on the product or its performance and shall be sufficiently stable to withstand normal handling.
- 5.1.1 Flat Strip 6 In. (152 mm) and Under in Width: Shall be marked in one or more lengthwise rows of characters recurring at intervals not greater than 3 ft (914 mm).
- 5.1.2 Flat Sheet and Flat Strip Over 6 In. (152 mm) in Width: Shall be marked in lengthwise rows of characters recurring at intervals not greater than 3 ft (914 mm), the rows being spaced not more than 6 in. (152 mm) apart and alternately staggered.