SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS5890 | REV. E

Issued 1976-07
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Revised 2009-07

Superseding AMS5890D

Nickel, Corrosion and Heat-Resistant, Bars, Forgings, and Extrusions
Thoria Dispersion Strengthened
2.2ThO_2
Stress-Relieved

(Composition similar to UNS N03260)

RATIONALE

AMS5890E revises stress rupture (3.4.1.2.4) requirements and is a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers thoria-dispersion-strengthened nickel powder metallurgy product in the form of bars, forgings, extrusions, and stock for forging or extruding.

1.2 Application

These products have been used typically for parts required to operate in the range 1800 to 2400 °F (982 to 1316 °C), but usage is not limited to such applications. 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 responsibility 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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS5890E

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2261	Tolerances, Nickel, Nickel Alloy, and Cobalt Alloy Bars, Rods, and Wire
AMS2269	Chemical Check Analysis Limits, Nickel, Nickel Alloys and Cobalt Alloys
AMS2371	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steels and Alloys, Wrought Products and Forging Stock
AMS2374	Quality Assurance Sampling and Testing, Corrosion and Heat-Resistant Steel and Alloy Forgings
AMS2806	Identification, Bars, Wire, Mechanical Tubing, and Extrusions, Carbon and Alloy Steels and Corrosion and Heat-Resistant Steels and Alloys
AMS2808	Identification, Forgings

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 8/E 8M	Tension Testing of Metallic Materials
ASTM E 21	Elevated Temperature Tension Tests of Metallic Materials
ASTM E 139	Conducting Creep, Creep-Rupture, and Stress-Rupture Tests of Metallic Materials
ASTM E 292	Conducting Time-for-Rupture Notch Tension Tests of Materials
ASTM E 354	Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt Alloys

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 354, by spectrochemical methods, or by other analytical methods acceptable to purchaser; the method of determining thoria (ThO_2) shall be acceptable to purchaser.

TABLE 1 - COMPOSITION

Element	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 applicable requirements of AMS2269 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 by heating in vacuum, argon, or hydrogen to a temperature within the range 2000 to 2200 °F (1093 to 1204 °C), holding at the selected temperature within ±25 °F (±14 °C) for not less than one 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 shown in Table 2, determined in accordance with ASTM E 8/E 8M using a strain rate of 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/minute) through the 0.6% offset and a cross-head speed of 0.03 to 0.07 inch per minute (0.08 to 1.8 mm/minute) from the 0.6% offset to rupture:

TABLE 2 - MINIMUM ROOM TEMPERATURE TENSILE PROPERTIES

Tensile Strength	57 ksi (393 MPa)
Yield Strength at 0.2% Offset	42.0 ksi (290 MPa)
Elongation in 4D	15%
Reduction of Area	50%

3.4.1.1.2 At 2000 °F (1 093 °C)

Shall be shown in Table 3, determined in accordance with ASTM E 21 on specimens heated to 2000 °F ± 10 (1093 °C ± 6), held at heat for 10 to 30 minutes before testing, and tested at 2000 °F ± 10 (1093 °C ± 6) using a crosshead speed of 0.03 to 0.07 inch per minute (0.08 to 1.8 mm/minute).

TABLE 3A - MINIMUM ELEVATED TEMPERATURE TENSILE PROPERTIES, INCH/POUND UNITS

Nominal Diameter or Least Distance Between Parallel Sides Inches	Tensile Strength ksi	Yield Strength at 0.2% Offset ksi	Elongation in 4D %	Reduction of Area %
0.500 to 0.750, incl	15.0	13.5	2	5
Over 0.750 to 1.250, incl	12.0	11.5	2	5

TABLE 3B - MINIMUM ELEVATED TEMPERATURE TENSILE PROPERTIES, SI UNITS

Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Tensile Strength MPa	Yield Strength at 0.2% Offset MPa	Elongation in 4D %	Reduction of Area %
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 least distance between parallel sides shall be agreed upon by purchaser and vendor.

3.4.1.2 Stress-Rupture Properties at 2000 °F (1093 °C)

Shall be shown in Table 4; testing of notched and of combination smooth-and-notched specimens shall be performed in accordance with ASTM E 292 and of smooth specimens in accordance with ASTM E 139:

3.4.1.2.1 A standard cylindrical combination smooth-notched specimen conforming to ASTM E 292, maintained at 2000 °F ± 10 (1093 °C ± 6) while a load sufficient to produce the initial axial stress specified in Table 4 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.

TABLE 4 - STRESS RUPTURE PROPERTIES

Nominal Diameter or Least Distance Between Parallel Sides Inches	Nominal Diameter or Least Distance Between Parallel Sides Millimeters	Initial Axial Stress ksi	Initial Axial Stress MPa
0.500 to 0.750, incl	12.70 to 19.05, incl	8.0	55
Over 0.750 to 1.250, incl	Over 19.05 to 31.75, incl	7.0	48

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

3.4.1.2.2 As an alternative 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 E 292, 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 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 of 8 hours minimum, thereafter, the stress shall be increased in increments of 1.0 ksi (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 Structure

The product shall have a substantially uniform structure essentially free from porosity, determined by macroscopic or microscopic examination. Standards for acceptance shall be acceptable to purchaser.

3.4.3 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.

3.5 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. 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 five per square foot (0.09 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) in depth; the number of such imperfections is not restricted. The product shall be free of contamination, determined by visual inspection; differences in reflectivity shall not be considered evidence of contamination.

3.6 Tolerances

Shall be as follows:

3.6.1 Bars

In accordance with AMS2261.

3.6.2 Extrusions

As specified on the extrusion drawing or agreed upon by purchaser and vendor.

3.6.3 Stock for Forging or Extruding

As agreed upon by purchaser and vendor.

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

The following requirements are acceptance tests and shall be performed on each powder lot or product lot as applicable.

4.2.1.1 Composition (3.1) of each powder lot.

4.2.1.2 Structure (3.4.2) and surface condition (3.5.1) of the product.

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

4.2.1.4 Tolerances (3.6) of bars and extrusions.

4.2.2 Periodic Tests

Stock for forging or extruding (3.4.3) to determine ability to develop required properties are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.3 Sampling and Testing:

Shall be as follows:

4.3.1 Bars, Extrusions, and Stock For Forging or Extruding

In accordance with AMS2371.

4.3.2 Forgings

In accordance with AMS2374.

4.4 Reports

The vendor of the product shall furnish with each shipment a report showing the results of tests for composition of each powder lot and for tensile properties, and stress rupture properties of each product lot, and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, powder lot number, AMS5890E, size, and quantity. If forgings are supplied, the size and manufacturing source of stock used to make the forgings shall also be included.

4.5 Resampling and Retesting

Shall be as follows:

4.5.1 Bars, Extrusions, and Stock for Forging or Extruding

In accordance with AMS2371.