SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

AMS 5403B

Issued JAN 1984
Noncurrent NOV 1995
Reaf. Noncur. JAN 2002
Cancelled JUL 2007

Superseding AMS 5403A

Alloy Castings, Investment, Corrosion and Heat Resistant
60Ni - 14Cr - 9.5Co - 4.0Mo - 4.0W - 5.0Ti - 3.0Al - 0.015B - 0.06Zr
Vacuum Melted, Vacuum Cast

RATIONALE

AMS 5403A has been designated Cancelled because survey of aerospace users and producers determined that this product is not produced to this specification.

CANCELLATION NOTICE

This specification has been declared "CANCELLED" by the Aerospace Materials Division, SAE, as of July, 2007. By this action, this document will remain listed in the Numerical Section of the Index of Aerospace Material Specifications, indicating that it has been "CANCELLED".

Cancelled specifications are available from SAE.

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400 Commonwealth Drive, Warrendale, PA 15096-0001

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NONCURRENT NOTICE

This specification has been declared “NONCURRENT” by the Aerospace Materials Division, SAE, as of November 1995. It is recommended, therefore, that this specification not be specified for new designs.

“NONCURRENT” refers to those materials which have previously been widely used and which may be required on some existing designs in the future. The Aerospace Materials Division, however, does not recommend these as standard materials for future use in new designs. Each of these “NONCURRENT” specifications is available.

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1. SCOPE:

1.1 Form:

This specification covers a corrosion and heat resistant nickel alloy in the form of investment castings.

1.2 Application:

Primarily for parts, such as turbine blades, requiring high strength and oxidation resistance up to 2000°F (1095°C).

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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specification:

AMS 2280	Trace Element Control, Nickel Alloy Castings
AMS 2350	Standards and Test Methods
AMS 2635	Radiographic Inspection
AMS 2645	Fluorescent Penetrant Inspection
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings

2.2 ASTM Publications:

Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103.

ASTM A567	Iron, Cobalt, and Nickel-Base Alloy Castings for High Strength at Elevated Temperatures
ASTM E8	Tension Testing 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 E192	Reference Radiographs of Investment Steel Castings for Aerospace Applications
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 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

2.3.2 Military Standards:

MIL-STD-794 Parts and Equipment, Procedures for Packaging and Packing of

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 analytical methods approved by purchaser:

	min	max
Carbon	0.15	0.19
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.015
Sulfur	--	0.0075
Chromium	13.70	14.30
Cobalt	9.00	10.00
Molybdenum	3.70	4.30
Tungsten	3.70	4.30
Molybdenum + Tungsten	7.70	--
Titanium	4.80	5.20
Aluminum	2.80	3.20
Boron	0.01	0.02
Zirconium	0.02	0.10
Columbium	--	0.10
Tantalum	--	0.10
Iron	--	0.35
Copper	--	0.10
Vanadium	--	0.10
Hafnium	--	0.10
Magnesium	--	0.01
Nickel	remainder	

3.1.1 Trace element analysis shall meet the requirements of AMS 2280-2 except that thallium shall be 0.0001% (1 ppm) max and silver shall be 0.0005% (5 ppm) maximum.

3.1.2 Alloy shall have an average electron-vacancy number not larger than 2.32, determined in accordance with ASTM A567 with the following modifications:

3.1.2.1 The boride composition shall be $[Mo_{0.5}, Ti_{0.15}, Cr_{0.25}, Ni_{0.10}]_3 B_2$.

3.1.2.2 The formula for the carbide formed with the second half of the carbon shall be $Cr_{21} (Mo_x W_{1-x})_2 C_6$.

3.2 Condition:

As cast.

3.3 Casting:

3.3.1 The metal for casting shall be melted and poured under vacuum without loss of vacuum between melting and pouring.

3.3.2 Castings shall be poured either from remelted metal from a master heat or directly from a master heat. In either case, metal for casting shall be qualified as in 3.4.

3.3.2.1 A master heat is refined metal of a single furnace charge melted and cast into ingot or pig under vacuum. Gates, sprues, risers, and rejected castings shall be used only in preparation of master heats; they shall not be remelted directly, without refining, for pouring of castings.

3.4 Master Heat Qualification:

Each master heat shall be qualified by evaluation of chemical analysis and tensile specimens conforming to 3.4.1 and 3.4.2, respectively. A master heat may be considered conditionally qualified if vendor's test results show conformance to all applicable requirements of this specification. However, except when purchaser waives confirmatory testing, final qualification shall be based on purchaser's test results. Conditional qualification of a master heat shall not be construed as a guarantee of acceptance of castings poured therefrom.

3.4.1 Chemical Analysis Specimens: Shall be of any convenient size, shape, and form for vendor's tests. When chemical analysis specimens are required by purchaser, specimens shall be cast to a size, shape, and form agreed upon by purchaser and vendor.

3.4.2 Tensile Specimens: Shall be cast from remelted metal from each master heat except when castings are poured directly from a master heat, in which case the tensile specimens shall also be poured directly from the master heat. Specimens shall be of standard proportions in accordance with ASTM E8 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section. They shall be cast to size or shall be cast over-size and subsequently machined to 0.250 in. (6.25 mm) diameter. Center gating may be used. Grain size of specimens shall be 0.015 to 0.062 in. (0.38 to 1.55 mm).

3.5 Heat Treatment:

When solution and precipitation heat treatments are specified, castings and representative tensile specimens produced in accordance with 3.4.2 shall be heat treated as follows; nitrogen shall not be used as a protective atmosphere in either the heating or holding operations:

3.5.1.1 Solution Heat Treatment:

Heat to 2200°F ± 25 (1205°C ± 15) in vacuum, hold at heat for 2 hr ± 0.25 and cool in vacuum or inert atmosphere to 2000°F (1095°C) or lower within 10 minutes. Cooling to room temperature is optional.

3.5.1.2 First Precipitation Heat Treatment: Heat to 2000°F ± 25 (1095°C ± 15) in vacuum, hold at heat for 4 hr ± 0.25 and cool in vacuum or inert atmosphere to 1200°F (650°C) or lower within 60 minutes. Cooling to room temperature is optional.

3.5.1.3 Second Precipitation Heat Treatment (Coating Cycle): Heat to 1925°F ± 25 (1050°C ± 15) in vacuum, hydrogen, or inert atmosphere, hold at heat for 4 hr ± 0.25, and furnace cool in vacuum, hydrogen, or inert atmosphere to 1200°F (650°C) or lower within 15 to 60 minutes. Cooling to room temperature is optional.

3.5.1.4 Third Precipitation Heat Treatment: Heat to 1500°F ± 25 (845°C ± 15) in vacuum or inert atmosphere, hold at heat for 16 hr ± 0.5, and cool to room temperature.

3.6 Properties:

Castings and representative tensile specimens produced in accordance with 3.4.2 and heat treated as in 3.5 shall conform to the following requirements:

3.6.1 Tensile Properties at 1600°F (870°C): Shall be as follows, determined in accordance with ASTM E21 on specimens heated to 1600°F ± 5 (870°C ± 3), held at heat for 20 - 50 min. before testing, and tested at 1600°F ± 5 (870°C ± 3):

Tensile Strength, min	90,000 psi (620 MPa)
Yield Strength at 0.2% Offset, min	60,000 psi (415 MPa)
Reduction of Area, min	15%

3.6.2 Stress-Rupture Properties at 1800°F (980°C): A tensile specimen maintained at 1800°F ± 3 (980°C ± 2) while a load sufficient to produce an initial axial stress of 27,500 psi (190 MPa) is applied continuously, shall not rupture in less than 23 hours. The test shall be continued to rupture without change of load. Reduction of area after rupture, measured at room temperature, shall be not less than 5%. Test shall be performed in accordance with ASTM E139.

3.6.2.1 The test of 3.6.2 may be conducted using a load higher than required to produce an initial axial stress of 27,500 psi (190 MPa) but load shall not be changed while test is in progress. Time to rupture and reduction of area requirements shall be as specified in 3.6.2.

3.6.2.2 When permitted by purchaser, the test of 3.6.2 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 27,500 psi (190 MPa) shall be used to rupture or for 23 hr, whichever occurs first. After the 23 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 2,500 psi (17 MPa). Time to rupture and reduction of area requirements shall be as specified in 3.6.2.

3.7 Quality:

3.7.1 Castings, as received by 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 castings.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned. Metallic shot or grit shall not be used for final cleaning, unless otherwise permitted by purchaser.

3.7.2 Castings shall be produced under radiographic control, unless otherwise specified. This control shall consist of radiographic examination of castings in accordance with AMS 2635 until proper foundry technique, which will produce castings free from harmful internal imperfections, is established for each part number and of production castings as necessary to ensure maintenance of satisfactory quality.

3.7.3 When specified, castings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645.

3.7.4 Radiographic, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E192 may be used to define radiographic acceptance standards.

3.7.5 Castings shall not be repaired by peening, plugging, welding, or other methods without written permission from purchaser.

3.7.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings repaired by welding in accordance with AMS 2694.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of castings 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 castings conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Except as specified in 4.2.1.1, tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed to represent each master heat or lot as applicable.

4.2.1.1 Tensile and stress-rupture properties of specimens cut from castings shall be determined only when specified by purchaser or when representative separately-cast specimens or specimens cut from attached coupons are not available. Tensile and stress-rupture properties of separately-cast specimens or of specimens cut from attached coupons need not be determined when tensile and stress rupture properties of specimens cut from castings are determined.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.2.1 For direct U.S. Military procurement, substantiating test data, and when requested, preproduction test material 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; a lot shall be all castings of the same part number poured from the same master heat in a period of eight consecutive hours, solution and precipitation heat treated in the same furnace loads, and presented for vendor's inspection at one time:

4.3.1 Two chemical analysis specimens in accordance with 3.4.1 from each master heat or a casting from each melt.

4.3.2 Six tensile specimens in accordance with 3.4.2 from each lot, three specimens each for tensile testing and stress-rupture testing, except when tensile specimens cut from castings are specified.

4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.

4.3.4 One or more castings from each lot when properties of specimens machined from castings are required. Size, location, and number of specimens machined from castings shall be as specified on the drawing or as agreed upon by purchaser and vendor. When size, location, and number of specimens are not specified, not less than four tensile specimens, two from the thickest section and two from the thinnest section, shall be cut from a casting or castings from each lot.

4.4 Approval:

4.4.1 Sample castings from new or reworked master patterns and the casting procedure shall be approved by purchaser before castings for production use are supplied, unless such approval be waived by purchaser.