SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

AMS 5404B

Issued JAN 1983
Noncurrent NOV 1995
Reaf. Noncur. JAN 2002
Cancelled APR 2007

Superseding AMS 5404A

Alloy Castings, Investment, Corrosion and Heat Resistant
59Ni - 12.6Cr - 9.0Co - 1.9Mo - 4.2W - 4.0Ti - 4.2Ta - 3.4Al - 0.015B - 0.10Zr - 0.90Hf
Vacuum Melted, Vacuum Cast
Solution and Precipitation Heat Treated

RATIONALE

AMS 5404 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 April, 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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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5404A

Issued JAN 1983
Noncurrent NOV 1995
Reaf. Noncur. JAN 2002

Superseding AMS 5404

Alloy Castings, Investment, Corrosion and Heat Resistant 59Ni - 12.6Cr - 9.0Co - 1.9Mo - 4.2W - 4.0Ti - 4.2Ta - 3.4Al - 0.015B - 0.10Zr - 0.90Hf Vacuum Melted, Vacuum Cast Solution and Precipitation Heat Treated

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 1800°F (980°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 Specifications:

AMS 2350	Standards and Test Methods
AMS 2635	Radiographic Inspection
AMS 2645	Fluorescent Penetrant Inspection
AMS 2804	Identification, Castings

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 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-Base 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	0.07	0.20
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	12.20	13.00
Cobalt	8.50	9.50
Molybdenum	1.70	2.10
Tungsten	3.85	4.50
Titanium	3.85	4.15
Tantalum	3.85	4.50
Aluminum	3.20	3.60
Aluminum + Titanium	7.30	7.70
Boron	0.010	0.020
Zirconium	0.05	0.14
Hafnium	0.75	1.05
Columbium	--	0.10
Iron	--	0.50
Nickel	remainder	

3.2 Condition:

Solution and precipitation heat treated.

3.3 Casting:

3.3.1 The metal for castings 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 or is metal blended as in 3.3.2.2 and 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.

3.3.2.2 Unless prohibited by purchaser, metal from two or more master heats may be blended provided that the composition of each master heat to be blended is within the limits of 3.1 and that the total weight of metal blended does not exceed 10,000 lb (4500 kg). When two or more master heats are blended, the resultant blend shall be considered a master heat.

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 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 oversize and subsequently machined to 0.250 in. (6.25 mm) diameter. Center gating may be used.

3.5 Heat Treatment:

Castings and representative tensile specimens shall be heat treated as follows:

3.5.1 Solution Heat Treatment:

Heat to 2050°F ± 25 (1120°C ± 15) in an inert atmosphere or vacuum, hold at heat for 2 hr ± 0.25, and cool in air or in an inert atmosphere at a rate equivalent to air cool or faster.

3.5.2 Precipitation Heat Treatment: Heat to 1550°F ± 25 (845°C ± 15), hold at heat for 4 hr ± 0.5, and air cool, reheat to 1400°F ± 25 (760°C ± 15), hold at heat for 16 hr ± 0.5, and air cool to room temperature.

3.6 Properties:

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

3.6.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8:

Tensile Strength, min	130,000 psi (895 MPa)
Yield Strength at 0.2% Offset, min	125,000 psi (860 MPa)
Elongation in 4D, min	3%

3.6.2 Stress-Rupture Properties at 1700°F (925°C): A tensile specimen, maintained at 1700°F ± 3 (925°C ± 2) while at a load sufficient to produce an initial axial stress of 41,000 psi (285 MPa) is applied continuously, shall not rupture in less than 35 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than 6% in 4D. 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 41,000 psi (285 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation 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 41,000 psi (285 MPa) shall be used to rupture or for 35 hr, whichever occurs first. After the 35 hr and at intervals of 8 - 16 hr, preferably 8 - 10 hr, thereafter, the stress shall be increased in increments of 5000 psi (35 MPa). Time to rupture and elongation requirements shall be as specified in 3.6.2.

3.6.3 Grain Size: Shall be essentially equiaxed and uniform throughout the casting and shall not exceed 0.25 in. (6.25 mm) in any dimension. Columner grains up to 0.500 in. (12.5 mm) shall be acceptable when agreed upon by purchaser and vendor.

3.6.4 Surface Imperfections:

3.6.4.1 Intergranular Attack and Intercarbide Attack: Shall not be permitted on any finished casting.

3.6.4.2 Surface Oxides and Alloy Depletion: Shall be permitted provided the depth of penetration does not exceed 0.0010 in. (0.025 mm). Isolated areas of these conditions are permitted to a depth of 0.0020 in. (0.050 mm).

3.6.4.3 Extraneous Nonmetallics: Shall be permitted in isolated areas provided the depth of penetration from the surface does not exceed 0.0020 in. (0.050 mm).

3.6.5 Microstructure: Shall be uniform and essentially free of blocky primary eta phase when viewed at 100X magnification except a maximum of 5% blocky primary eta phase per field 0.0394 in. (1.00 mm) in diameter shall be permitted in thick sections (greater than 0.5 in. (12.5 mm)). In any case, the blocky primary eta phase shall not be large enough to form a continuous network between interdendritic areas in more than two adjacent fields of view. The method of sample preparation and analysis shall be as agreed upon by purchaser and vendor.

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.

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 on 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 are not available. Tensile and stress-rupture properties of separately-cast specimens 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 and/or processing 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 not longer than 8 consecutive hours and presented for vendor's inspection at one time:

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

4.3.2 Six tensile specimens in accordance with 3.4.2 from each master heat, three specimens each for tensile testing and stress-rupture testing, when requested.

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