

**AEROSPACE
MATERIAL
SPECIFICATION**

AMS 5391C
Superseding AMS 5391B

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ALLOY CASTINGS, INVESTMENT, CORROSION AND HEAT RESISTANT
73Ni - 13Cr - 4.5Mo - 2.3(Cb+Ta) - 0.75Ti - 6.0Al - 0.010B - 0.10Zr
Vacuum Melted
As Cast

UNS N07713

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 up to 1800°F (980°C) 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 Specifications:

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

REAFFIRMED

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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 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	0.08	0.20
Manganese	--	0.25
Silicon	--	0.50
Sulfur	--	0.015
Chromium	12.00	14.00
Molybdenum	3.80	5.20
Columbium + Tantalum	1.80	2.80
Titanium	0.50	1.00
Aluminum	5.50	6.50
Boron	0.005	0.015
Zirconium	0.05	0.15
Cobalt (3.1.1)	--	1.00
Iron	--	2.50
Copper	--	0.50
Nickel + Cobalt	remainder	

3.1.1 Determination not required for routine acceptance.

3.2 Condition: As cast.

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. When permitted by purchaser, protective atmosphere may be used in lieu of vacuum for pouring of castings.

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 Properties: Specimens from castings and representative tensile specimens
Ø produced in accordance with 3.4.2 shall conform to the following requirements:

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

Tensile Strength, min	110,000 (760 MPa)
Yield Strength at 0.2% Offset, min	100,000 (690 MPa)
Elongation in 4D, min	3%

3.5.2 Hardness: Should be 30 - 42 HRC, or equivalent, determined in accordance
Ø with ASTM E18, but castings shall not be rejected on the basis of hardness if the tensile property requirements of 3.5.1 are met.

3.5.3 Stress-Rupture Properties at 1800°F (980°C): Tensile specimens, maintained at 1800°F $\pm$ 3 (980°C $\pm$ 2) while a load sufficient to produce an initial axial stress of 22,000 psi (150 MPa) is applied continuously shall not rupture in less than 30 hours. The test shall be continued to rupture without change of load. Elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. Test shall be performed in accordance with ASTM E139.

3.5.3.1 The test of 3.5.3 may be conducted using a load higher than required to produce an initial axial stress of 22,000 psi (150 MPa) but load shall not be changed while test is in progress. Time to rupture and elongation requirements shall be as specified in 3.5.3.

3.5.3.2 When permitted by purchaser, the test of 3.5.3 may be conducted using incremental loading. In such case, the load required to produce an initial axial stress of 22,000 psi (150 MPa) shall be used to rupture or for 30 hr, whichever occurs first. After the 30 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 3.5.3.

3.6 Quality:

3.6.1 Castings, as received by purchaser, shall be uniform in quality and
Ø condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the castings.

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

- 3.6.2 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.
- 3.6.3 When specified, castings shall be subjected to fluorescent penetrant inspection in accordance with AMS 2645.
- 3.6.4 Radiographic, fluorescent penetrant, and other quality standards shall be
Ø as agreed upon by purchaser and vendor. ASTM E192 may be used to define radiographic acceptance standards.
- 3.6.5 Castings shall not be repaired by peening, plugging, welding, or other methods without written permission from purchaser.
- 3.6.5.1 When permitted in writing by purchaser, defects in castings may be
Ø 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
Ø 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: Tests to determine conformance to all technical
Ø 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
Ø shall be determined only when specified by purchaser or when separately-cast specimens are not available. Tensile and stress-rupture properties of separately-cast specimens need not be determined when such properties are determined on specimens cut from castings.
- 4.2.2 Preproduction Tests: Tests to determine conformance to all technical
Ø 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 eight consecutive hours and presented for vendor's inspection at one time:

4.3.1 Two chemical analysis specimens in accordance with 3.4.1 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, except when properties of specimens cut from castings are required.

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 master heat when tensile and stress-rupture 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 master heat.

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.

4.4.2 Vendor shall establish separately for tensile specimens used for master heat qualification and for production of sample castings of each part number parameters for the process control factors which will produce tensile specimens meeting master heat qualification requirements and acceptable castings; these shall constitute the approved casting procedures and shall be used for producing subsequent master heat qualification specimens and production castings. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, sample test specimens, castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.