

**AEROSPACE
MATERIAL
SPECIFICATION**

Submitted for recognition as an American National Standard

SAE AMS 5401A

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Superseding AMS 5401

ALLOY CASTINGS, INVESTMENT, CORROSION AND HEAT RESISTANT
62Ni - 21.5Cr - 9.0Mo - 3.6(Cb+Ta)
Vacuum Melted, Vacuum Cast
As Cast

UNS N06625

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 requiring moderate strength up to 1600°F (870°C) and excellent oxidation and corrosion 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 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 2268 - Chemical Check Analysis Limits, Cast Nickel and Nickel Alloys
AMS 2280 - Trace Element Control, Nickel Alloy Castings
AMS 2350 - Standards and Test Methods
AMS 2360 - Room Temperature Tensile Properties of Castings
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 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 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 or by spectrographic or other analytical methods approved by purchaser:

	min	max
Carbon	--	0.10
Manganese	--	0.50
Silicon	--	0.50
Phosphorus	--	0.015
Sulfur	--	0.015
Chromium	20.00 - 23.00	
Molybdenum	8.00 - 10.00	
Columbium + Tantalum	3.15 - 4.15	
Titanium (3.1.3)	--	0.40
Aluminum (3.1.3)	--	0.40
Cobalt	--	1.00
Iron	--	5.00
Copper	--	0.30
Nickel	remainder	

- 3.1.1 Shall be present but not in excess of maximum content specified.
- 3.1.2 Trace element limits shall meet the requirements of AMS 2280-1 unless trace element limits conforming to AMS 2280-2 are specified by purchaser.
- 3.1.3 Check Analysis: Composition variations shall meet the requirements of AMS 2268.
- 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.

- 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 15,000 lb (6800 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.
- 3.4.2 Tensile Specimens: Separately-cast 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.
- 3.4.2.1 When permitted by purchaser, integrally-cast coupons may be used for evaluating acceptance of castings in lieu of separately-cast specimens. Type and location of integrally-cast specimens shall be as agreed upon by purchaser and vendor.
- 3.5 Properties: Castings, integrally-cast coupons, and representative tensile specimens 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 on integrally-cast coupons or separately-cast tensile specimens or, when specified by purchaser or agreed upon by purchaser and vendor, on specimens cut from castings:

Tensile Strength, min	85,000 psi (590 MPa)
Yield Strength at 0.2% Offset, min	45,000 psi (310 MPa)
Elongation in 4D, min	25%

- 3.5.1.1 When tensile properties other than those specified in 3.5.1 are required of specimens cut from castings, tensile specimens conforming to ASTM E8 shall be machined, from locations indicated on the drawing, from a casting or castings selected at random from each lot. Property requirements for such specimens shall be as specified on the drawing or as agreed upon by purchaser and vendor and may be defined as specified in AMS 2360.

3.6 Quality:

- 3.6.1 Castings, 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 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.
- 3.6.2 Castings shall be produced under radiographic control. 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 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 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 test 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
Ø 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 properties of specimens cut from castings shall be determined only when specified by purchaser or when representative separately-cast specimens or integrally-cast coupons are not available. Tensile properties of separately-cast specimens or integrally-cast coupons need not be determined when such 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, 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 and presented for vendor's inspection at one time.
- 4.3.1 One or more chemical analysis specimens in accordance with 3.4.1 from each master heat or a casting from each lot.
- 4.3.2 Three separately-cast tensile specimens in accordance with 3.4.2 from each master heat or three or more integrally-cast coupons except when purchaser requires tensile properties of specimens cut from castings.
- 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 test 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.

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, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.2.1 Control factors for producing specimens and castings include, but are not limited to, the following:

Type of furnace and its capacity
Type and size of furnace charge
Vacuum level
Mold refractory formulation
Mold back-up material
Gating practices
Mold preheat and metal pouring temperatures; variations of $\pm 25^{\circ}\text{F}$ ($+ 15^{\circ}\text{C}$) from established limits are permissible
Solidification and cooling procedures
Cleaning operations
Methods of inspection

4.4.2.1.1 Any of the above process control factors for which parameters are considered proprietary by the vendor may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.5 Reports:

4.5.1 The vendor of castings shall furnish with each shipment a report showing the results of tests for chemical composition of at least one casting, or of a specimen as in 3.4.1 cast in a mold with parts, from each master heat represented and the results of tests on each lot to determine conformance to the other technical requirements of this specification. When properties of specimens cut from castings are specified, the report shall include the results of tests to determine conformance to such requirements. This report shall include the purchase order number, master heat number, code symbol, or both, AMS 5401A, part number, and quantity from each master heat.