Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 5377

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Revised

ALLOY CASTINGS, INVESTMENT, CORROSION AND HEAT RESISTANT
Nickel Base 12Cr - 4.5Mo - 2.0(Cb + Ta) - 0.70Ti - 6.0Al
Vacuum Melted

1. SCOPE:

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

1.2 Application: Primarily for parts such as turbine blades, buckets, and integral wheels requiring high strength up to 1800 F (982 C) and oxidation resistance up to 2000 F (1093 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 Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2360 - Room Temperature Tensile Properties of Castings
AMS 2362 - Stress-Rupture Properties of Castings
AMS 2635 - Radiographic Inspection

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E139 - Creep and Time-for-Rupture Tension Tests of Materials
ASTM E354 - Chemical Analysis of High-Temperature, Electrical, Magnetic, and Other Similar Iron, Nickel, and Cobalt-Base Alloys

2.3 Government Publications: Available from Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.

2.3.1 Federal Standards:

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

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 approved analytical methods.

	min		max
Carbon	0.03	-	0.07
Manganese	--		0.25
Silicon	--		0.50
Phosphorus	--		0.015
Sulfur	--		0.015
Chromium	11.75	-	12.25
Molybdenum	4.0	-	5.0
Columbium + Tantalum	1.75	-	2.25
Titanium	0.50	-	0.90
Aluminum	5.50	-	6.50
Boron	0.005	-	0.015
Zirconium	0.05	-	0.15
Iron	--		0.50
Copper	--		0.50
Nickel & Cobalt	remainder		
Cobalt (3.1.1)	--		1.0

3.1.1 Determination not required for routine acceptance.

3.2 Condition: As cast, unless otherwise specified.

3.3 Casting: Castings shall be poured either from remelted metal from a master heat or directly from a master heat. The metal for castings shall be melted and poured under vacuum without loss of vacuum between melting and pouring. In either case, metal for casting shall be qualified as in 3.4. 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. The total weight of metal in a master heat shall not exceed 10,000 lb (4540 kg).

3.4 Master Heat Qualification: Each master heat shall be qualified by evaluation of chemical analysis and tensile test 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. Composition of specimens shall conform to 3.1.

3.4.2 Tensile Test Specimens: Shall be cast from remelted metal from each master heat except that when castings are poured directly from a master heat, the tensile test specimens shall also be poured directly from the master heat. Tensile test specimens shall be of standard proportions in accordance with ASTM E8 with 0.25 in. (6.35 mm) diameter at the reduced parallel gage section. They shall be cast to size or shall be cast oversize and subsequently machined to 0.25 in. (6.35 mm) diameter. Center gating may be used. When requested, representative specimens shall be supplied to the purchaser for confirmatory evaluation. Tensile test specimens shall conform to the requirements of 3.5.1.

3.5 Properties:

3.5.1 Cast Test Specimens:

3.5.1.1 Tensile Properties: Unless otherwise agreed upon by purchaser and vendor, tensile test specimens produced in accordance with 3.4.2 and tested in accordance with ASTM E8 shall conform to the following requirements:

Tensile Strength, min	110,000 (758 MN/m^2)
Yield Strength at 0.2% Offset, min	100,000 (690 MN/m^2)
Elongation in 2 in. (50.8 mm) or 4D, min	5%
Reduction of Area min	8%

3.5.1.2 Hardness: Shall be 30 - 42 HRC or equivalent, determined in accordance with ASTM E18.

3.5.1.3 Stress-Rupture Test at 1800 F (982.2 C): Unless otherwise agreed upon by purchaser and vendor, tensile test specimens produced in accordance with 3.4.2 maintained at 1800 F ± 5 (982.2 C ± 2.8) while a load sufficient to produce an initial axial stress of 22,000 psi (151.7 MN/m^2) is applied continuously shall not rupture in less than 30 hours. The test shall be continued to rupture. Elongation after rupture, measured at room temperature, shall be not less than 5% in 4D. Tests shall be conducted in accordance with ASTM E139.

3.5.2 Castings:

3.5.2.1 Hardness: Shall be 30 - 42 HRC or equivalent, determined in accordance with ASTM E18.

3.5.2.2 Tensile Properties: When specified on the drawing or when agreed upon by purchaser and vendor, tensile test specimens conforming to ASTM E8 shall be machined from castings selected at random from the shipment. Size and location of such specimens and required properties shall be as shown on the drawing or as agreed upon by purchaser and vendor. Required properties may be defined as specified in AMS 2360.

3.5.2.3 Stress-Rupture Test at 1800 F (982.2 C): When specified on the drawing or when agreed upon by purchaser and vendor, stress-rupture test specimens shall be machined from castings selected at random from the shipment. Size and location of such specimens and stress-rupture properties required shall be as shown on the drawing or as agreed upon by purchaser and vendor. Required properties may be defined as specified in AMS 2362. Tests shall be conducted in accordance with AMS 2362.

3.6 Quality:

3.6.1 Castings shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts. Castings shall have smooth surfaces and shall be well cleaned. Unless otherwise specified, metallic shot or grit shall not be used for final cleaning.

3.6.2 When castings are broken for fracture test, the fracture shall have uniform color and be substantially free from oxides and other defects.

3.6.3 Unless otherwise specified, castings shall be produced under radiographic control. This 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 insure maintenance of satisfactory quality.

3.6.4 Inspection standards and procedures shall be as agreed upon by purchaser and vendor.

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

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor shall supply all samples 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 perform such confirmatory testing as he deems necessary to assure that material conform to the requirements of this specification.

4.2 Classification of Tests: Tests to determine conformance to all technical requirements of this specification are classified as routine control tests.

4.3 Sampling: Shall be in accordance with the following:

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 test specimens in accordance with 3.4.2 from each master heat, three specimens each for tensile and stress-rupture testing.

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

4.3.4 When properties are required from specimens machined from castings, a casting shall be selected at random 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.

4.4.2 Vendor shall establish separately for tensile test specimens used for master heat qualification and for production of sample castings of each part number the control factors of processing which will produce tensile test 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 control factors of processing which could affect quality or properties of the castings, vendor shall submit for reapproval a statement of the revised operations and, when requested, sample test specimens, castings, or both. No production castings incorporating the revised operations shall be shipped prior to receipt of reapproval.

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

Type of furnace and its capacity
Size of furnace charge
Furnace atmosphere
Fluxing or deoxidation procedure
Mold refractory formulation
Mold back-up material
Gating practices
Variations or more than ± 25 F (± 14 C) in mold preheating temperature, pouring temperature, or both
Solidification rate and subsequent cooling procedures
Cleaning Operations
Methods of routine inspection

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

4.5 Reports:

4.5.1 The vendor of castings shall furnish with each shipment three copies of a report of 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 master heat to determine conformance to the other technical requirements of this specification. When properties of test 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 (and code symbol if used), material specification number and its revision letter, part number, and quantity from each master heat.