Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5339A
Superseding AMS 5339

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STEEL CASTINGS, INVESTMENT, MARAGING
17Ni - 10Co - 4.6Mo - 0.30Ti - 0.06Al

1. SCOPE:

1.1 Form: This specification covers a maraging steel in the form of investment castings.

1.2 Application: Primarily for parts of intricate design requiring ultra-high strength at temperatures up to 600° F (316° 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., 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2635 - Radiographic Inspection
AMS 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection

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

ASTM A370 - Mechanical Testing of Steel Products
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

2.3.1 Federal Standards: Federal Test Method 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 E353, 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
Manganese	--	0.10
Silicon	--	0.10
Phosphorus	--	0.010
Sulfur	--	0.010
Nickel	16.00	17.50
Cobalt	9.50	11.00
Molybdenum	4.40	4.80
Titanium	0.15	0.45
Aluminum	0.02	0.10
Iron	remainder	

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3.2 Condition: Homogenized, overaged, and solution heat treated.

3.3 Casting: 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. A master heat is refined metal of a single furnace charge or metal blended as in 3.3.1. 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.

3.3.1 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 in the blend does not exceed 10,000 lb (4540 kg). Ingot and pig may be blended together, shot may be blended, but shot shall not be blended with ingot or pig. 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 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.

3.4.2 Tensile Test Specimens: Shall be cast from remelted metal from each master heat except when Ø castings are poured directly from a master heat, in which case 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 A370 with 0.250 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 0.250 in. (6.35 mm) diameter. Center gating may be used. When requested, representative test specimens shall be supplied to the purchaser for confirmatory evaluation.

3.5 Heat Treatment: Castings and tensile test specimens shall be heat treated as follows:

3.5.1 Homogenization Heat Treatment:

3.5.1.1 Maximum Section Thickness up to 1 In. (25 mm), Excl: Heat to 1800° F ± 25 (982.2° C ± 14), hold at heat for not less than 4 hr, and cool in air to room temperature.

3.5.1.2 Maximum Section Thickness 1 to 2 In. (25 to 51 mm), Excl: Heat to 2100° F ± 25 (1148.9° C ± 14), hold at heat for not less than 4 hr, and cool to room temperature.

3.5.2 Overaging Heat Treatment: Heat to 1100° F ± 25 (593.3° C ± 14), hold at heat for not less than 4 hr, and cool in air to room temperature.

3.5.3 Solution Heat Treatment: Heat to 1500° F ± 25 (815.6° C ± 14), hold at heat for 1 hr per inch (25 mm) of section thickness but in no case less than 1 hr, and cool in air.

3.6 Properties: Castings and representative test specimens shall conform to the following requirements as Ø applicable; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.6.1 Hardness As Solution Heat Treated: Shall be not higher than 36 HRC or equivalent.

3.6.2 Tensile Properties After Maraging:

3.6.2.1 Separately-Cast Test Specimens: Tensile test specimens produced in accordance with 3.4.2, heat treated as in 3.5, heated to 900°F ± 25 (482.2°C ± 14), held at heat for not less than 3 hr, and air cooled to room temperature, shall conform to the following requirements:

Tensile Strength, min	240,000 psi (1655 MPa)
Yield Strength at 0.2% Offset, min	220,000 psi (1517 MPa)
Elongation in 4D, min	6%
Reduction of Area, min	20%

3.6.2.2 Specimens Machined from Castings: When specified on the drawing or when agreed upon by purchaser and vendor, tensile test specimens machined from castings heat treated as in 3.5, heated to 900°F ± 25 (482.2°C ± 14), held at heat for not less than 3 hr, and cooled in air to room temperature shall conform to the following requirements:

	Designated Area
Tensile Strength, min	240,000 psi (1655 MPa)
Yield Strength at 0.2% Offset, min	220,000 psi (1517 MPa)
Elongation in 4D, min	5%
Reduction of Area, min	20%

	Any Other Area
Tensile Strength, min	210,000 psi (1448 MPa)
Yield Strength at 0.2% Offset, min	180,000 psi (1241 MPa)
Elongation in 4D, min	4%
Reduction of Area, min	10%

3.7 Quality:

3.7.1 Ø 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.

3.7.2 Castings shall be produced under radiographic control, unless otherwise specified. 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 ensure maintenance of satisfactory quality.

3.7.3 Ø When specified, castings shall be subject to magnetic particle inspection in accordance with AMS 2640 or fluorescent penetrant inspection in accordance with AMS 2645.

3.7.4 Ø Radiographic, magnetic particle, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor.

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

3.7.5.1 Ø When permitted in writing by purchaser, defects in castings may be removed and the castings repaired by welding provided the weld area has properties comparable to those of the parent metal. Repair welds shall be subjected to the same inspection procedures and acceptance standards required of the casting and the weld repair area shall be suitably identified to facilitate inspection. The repair welding shall be performed prior to any heat treatment and nondestructive testing specified herein.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The vendor of castings 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 the castings 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 acceptance or 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 Three tensile test specimens in accordance with 3.4.2 from each master heat, when requested.

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

4.3.4 One casting from each master heat when properties of specimens machined from castings are required.

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
Mold pre-heating temperature, pouring temperature, or both (variations of ± 25° F (±14° C) from established limits are permissible)
Solidification rate and subsequent cooling procedures
Cleaning operations
Methods of routine inspection
Repair procedures

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.