

AEROSPACE
MATERIAL
SPECIFICATION

AMS 5339B
Superseding AMS 5339A

Issued 11-1-69
Revised 10-1-82

UNS J93010

STEEL CASTINGS, INVESTMENT, MARAGING
17Ni - 10Co - 4.6Mo - 0.3Ti - 0.06Al
Homogenized, Overaged, and Solution Heat Treated

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 up to 600°F (315°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 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2694 - Repair Welding of Aerospace Castings
AMS 2804 - Identification, Castings

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

ASTM A370 - Mechanical Testing of Steel Products
ASTM E192 - Reference Radiographs of Investment Steel Castings for
Aerospace Applications
ASTM E353 - Chemical Analysis of Stainless, Heat-Resisting, Maraging,
and Other Similar Chromium-Nickel-Iron Alloys

SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade or their use by governmental agencies is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

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 E353, 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	--	0.03
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

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.

3.3.1 A master heat is refined metal of a single furnace charge or metal blended as in 3.3.2. 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 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 (4500 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 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 A370 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 Homogenization Heat Treatment:
- 3.5.1.1 Maximum Section Thickness up to 1 In. (25 mm), Excl: Heat to $1800^{\circ}\text{F} \pm 25$ ($980^{\circ}\text{C} \pm 15$), 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 50 mm), Excl: Heat to $2100^{\circ}\text{F} \pm 25$ ($1150^{\circ}\text{C} \pm 15$), hold at heat for not less than 4 hr, and cool in air to room temperature.
- 3.5.1.3 Maximum Section Thickness 2 In. (50 mm) and Over: As agreed upon by purchaser and vendor.
- 3.5.2 Overaging Heat Treatment: Heat to $1100^{\circ}\text{F} \pm 25$ ($595^{\circ}\text{C} \pm 15$), hold at heat for not less than 4 hr, and cool in air to room temperature.
- 3.5.3 Solution Heat Treatment: Heat to $1500^{\circ}\text{F} \pm 25$ ($815^{\circ}\text{C} \pm 15$), 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 tensile specimens shall conform to the following requirements as applicable; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.6.1 Hardness As Solution Heat Treated: Not higher than 36 HRC or equivalent.

3.6.2 Tensile Properties After Maraging: Tensile specimens heat treated as in 3.5, shall have the following properties after being maraged by heating to $900^{\circ}\text{F} \pm 25$ ($480^{\circ}\text{C} \pm 15$), holding at heat for not less than 3 hr, and cooling in air to room temperature:

3.6.2.1 Separately-Cast Specimens:

Ø

Tensile Strength, min	240,000 psi (1655 MPa)
Yield Strength at 0.2% Offset, min	220,000 psi (1515 MPa)
Elongation in 4D, min	5%
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 specimens shall be machined from locations indicated on the drawing from castings selected at random to represent the lot. If designated location is not defined, tensile properties specified for areas other than designated apply.

Ø

3.6.2.2.1 Designated Areas:

Ø

Tensile Strength, min	240,000 psi (1655 MPa)
Yield Strength at 0.2% Offset, min	220,000 psi (1515 MPa)
Elongation in 4D, min	5%
Reduction of Area, min	20%

3.6.2.2.2 Areas Other Than Designated:

Tensile Strength, min	210,000 psi (1450 MPa)
Yield Strength at 0.2% Offset, min	180,000 psi (1240 MPa)
Elongation in 4D, min	4%
Reduction of Area, min	10%

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.

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 magnetic particle inspection in accordance with AMS 2640 and/or to fluorescent penetrant inspection in accordance with AMS 2645.
- 3.7.4 Radiographic, magnetic particle, 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, impregnating, or other methods without written permission from purchaser.
- 3.7.5.1 When permitted in writing by purchaser, defects in castings may be 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 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: Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and as preproduction tests and shall be performed on each master heat or lot as applicable, 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.
- 4.2.1 Tensile properties of separately-cast specimens need not be determined when tensile properties of specimens cut from castings are determined.
- 4.2.2 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 poured from a single master heat, heat treated together as a batch, 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 Three tensile specimens in accordance with 3.4.2 from each master heat.
- 4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.

- 4.3.4 When purchaser specifies that properties of specimens machined from castings apply, not less than two specimens shall be machined from a casting or castings from each lot. Specimens shall be of standard proportions conforming to ASTM A370 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section. If location and number of specimens are not shown on the drawing, not less than two specimens, one from the thickest section and one 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 control factors of processing 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 control factors of processing, vendor shall submit for reapproval a statement of the proposed changes and, when requested, sample test specimens, 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 test specimens and castings include, but are not limited to, the following:

Type of furnace and its capacity
Type and size of furnace charge
Time molten metal is in furnace
Furnace atmosphere
Fluxing or deoxidation procedure
Number of ladles used in pour
Mold refractory formulation
Mold back-up material
Gating practices
Mold preheat and pouring temperatures, (variations of $\pm 25^{\circ}\text{F}$ ($\pm 15^{\circ}\text{C}$) from established limits are permissible)
Solidification and cooling procedures
Heat treatment cycles
Cleaning operations
Methods of inspection