



AEROSPACE MATERIAL SPECIFICATION

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

AMS 5357

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Revised

STEEL CASTINGS, INVESTMENT, CORROSION RESISTANT
15Cr - 4.6Ni - 0.22(Cb + Ta) - 2.8Cu
Solution Heat Treated

1. SCOPE:

- 1.1 Form: This specification covers a corrosion-resistant steel in the form of investment castings.
- 1.2 Application: Primarily for parts which will be machined in the solution heat treated condition and which require good corrosion resistance and strength up to 600° F (315°C) after precipitation heat treatment.

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, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2360 - Room Temperature Tensile Properties of Castings
AMS 2635 - Radiographic Inspection
AMS 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection
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

- 2.3 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

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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 No. 112, or by other approved analytical methods:

	min	max
Carbon	--	0.05
Manganese	--	0.60
Silicon	0.50 -	1.00
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	14.00 -	15.50
Nickel	4.20 -	5.00
Columbium + Tantalum	0.15 -	0.30
Copper	2.50 -	3.20
Nitrogen	--	0.05

- 3.2 Condition: 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 blended does not exceed 10,000 lb (4,540 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 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. (6.35 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.

- 3.5 Solution Heat Treatment: Castings and representative tensile test specimens shall be solution heat treated by heating to $1900^{\circ}\text{F} \pm 25$ ($1038^{\circ}\text{C} \pm 15$), holding at heat for 60 min. per inch (25 mm) of maximum cross-section, and cooling to below 90°F (32°C) at a rate equivalent to air cool or faster. Double solution heat treatment is acceptable.

3.6 Properties: Castings and representative tensile test specimens produced in accordance with 3.4.2 shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.6.1 As Solution Treated:

3.6.1.1 Hardness: Shall be not higher than 31 HRC or equivalent.

3.6.2 After Precipitation Heat Treatment: Castings and separately-cast specimens, when precipitation heat treated to a particular condition in accordance with the corresponding temperatures and times shown in Table I and cooled in air, shall have the properties specified in 3.6.2.1 for that particular condition. Tensile tests shall be made in only one precipitation heat treated condition. Unless otherwise specified, the precipitation heat treated testing condition shall be H925.

TABLE I

Condition	Temperature	Time
H925	925° F $\pm$ 10 (496° C $\pm$ 6)	90 min. $\pm$ 15
H935	935° F $\pm$ 10 (502° C $\pm$ 6)	4 hr $\pm$ 0.25
H1000	1000° F $\pm$ 10 (538° C $\pm$ 6)	4 hr $\pm$ 0.25
H1100	1100° F $\pm$ 10 (593° C $\pm$ 6)	4 hr $\pm$ 0.25

3.6.2.1 Tensile Properties: Conformance to the requirements of 3.6.2.1.1 shall be used as basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.2.1.2 apply:

3.6.2.1.1 Separately-Cast Specimens: Shall be as shown in Table II.

TABLE II

Condition	Tensile Strength psi, min.	Yield Strength at 0.2% Offset psi, min	Elongation in 4D %, min	Reduction of Area %, min
H925	180,000	160,000	6	15
H935	170,000	150,000	7	16
H1000	150,000	130,000	8	18
H1100	130,000	120,000	8	20

TABLE II (SI)

Condition	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 4D %, min	Reduction of Area %, min
H925	1241	1103	6	15
H935	1172	1034	7	16
H1000	1034	896	8	18
H1100	896	827	8	20

3.6.2.1.2 Castings: When specified on the drawing or when agreed upon by purchaser and vendor, tensile test specimens conforming to ASTM A370 shall be machined from castings as in 4.3.4. 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.

3.7 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. Metallic shot or grit shall not be used for final cleaning, unless otherwise permitted.
- 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, 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 provided the weld repair 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 castings. Weld repair areas shall be suitably marked to facilitate inspection. 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 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 conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed to represent each lot.
 - 4.2.1.1 Tensile properties of specimens cut from castings shall be determined only when specified by purchaser or when separately-cast specimens are not available. Tensile properties of separately-cast specimens are not available. Tensile properties of separately-cast specimens need not be determined when tensile 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 on the first-article shipment of a casting to a purchaser, when a change in material or processing requires reapproval, or when purchaser deems confirmatory testing is 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:

- 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.
- 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 day's pour of each master heat 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 specimens are not specified, not less than two tensile test specimens, one from the thickest section and one from the thinnest section, shall be cut from a casting or castings from each day's pour of each master heat.
 - 4.3.4.1 When size of castings or other factors preclude sampling as in 4.3.4, the type and frequency of testing shall be as agreed upon by purchaser and vendor.

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 parameters for 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 parameters for the control factors of processing, 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.
 - 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 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
 - Precipitation heat treatment time
 - Cleaning operations
 - Methods of routine inspection
 - 4.4.2.1.1 Any of the above control factors of processing 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.