



AEROSPACE MATERIAL SPECIFICATION

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

AMS 5355C

Superseding AMS 5355B

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STEEL CASTINGS, INVESTMENT, CORROSION RESISTANT
16Cr - 4.1Ni - 0.28(Cb+Ta) - 3.2Cu

1. SCOPE:

1.1 Form: This specification covers a corrosion-resistant steel in the form of investment castings.

1.2 Application: Primarily for parts requiring good corrosion resistance and strength up to 600° F (315° C). Certain processing procedures and service conditions may cause this material to be subject to stress-corrosion cracking; ARP 1110 recommends practices to minimize such conditions on wrought products. Where stress-corrosion is considered to be a factor, precipitation heat treatment should be performed at temperatures not lower than 1000° F (538° 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) and Aerospace Recommended Practices (ARP) 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

2.1.2 Aerospace Recommended Practices:

ARP 1110 - Minimizing Stress Corrosion Cracking in Heat Treatable Wrought Low Alloy and Martensitic Corrosion Resistant Steels

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

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 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."

2.3.2 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 approved analytical methods:

	min	max
Carbon	--	0.06
Manganese	--	0.70
Silicon	0.50	- 1.00
Phosphorus	--	0.04
Sulfur	--	0.03
Chromium	15.50	- 16.70
Nickel	3.60	- 4.60
Columbium + Tantalum	0.15	- 0.40
Copper	2.80	- 3.50
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 (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 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 Heat Treatment: Castings and separately-cast tensile test specimens shall be heat treated as follows; castings and specimens may be given a homogenization heat treatment prior to solution treatment or may be given two solution heat treatments when permitted by purchaser, and shall be so treated when specified by purchaser:

3.5.1 Homogenization Heat Treatment: Heat to $2100^{\circ}\text{F} \pm 25$ ($1150^{\circ}\text{C} \pm 15$), hold at heat for not less than 90 min., and cool as required to below 70°F (20°C).

3.5.2 Solution Heat Treatment: Heat to $1900^{\circ}\text{F} \pm 25$ ($1038^{\circ}\text{C} \pm 15$), hold at heat for 1 hr per inch (25 mm) of section thickness but not less than 30 min., and cool as required to below 70°F (20°C).

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 Heat Treated:

3.6.1.1 Hardness: Shall be not higher than 36 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 following properties for that particular condition. Tensile and hardness 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
H900	$900^{\circ}\text{F} \pm 10$ ($482^{\circ}\text{C} \pm 6$)	90 min. ± 15
H925	$925^{\circ}\text{F} \pm 10$ ($496^{\circ}\text{C} \pm 6$)	90 min. ± 15
H1000	$1000^{\circ}\text{F} \pm 10$ ($538^{\circ}\text{C} \pm 6$)	90 min. ± 15
H1100	$1100^{\circ}\text{F} \pm 10$ ($593^{\circ}\text{C} \pm 6$)	90 min. ± 15

3.6.2.1 Separately-Cast Specimens:

3.6.2.1.1 Tensile Properties: Shall be as shown in Table II.

TABLE II

Condition	Tensile Strength psi, min	Yield Strength at 0.2% Offset psi, min	Elongation in 1 in. or 4D %, min	Reduction of Area %, min
H900	180,000	160,000	6	15
H925	180,000	150,000	6	15
H1000	150,000	130,000	8	20
H1100	130,000	120,000	8	15

TABLE II (SI)

Condition	Tensile Strength MPa, min	Yield Strength at 0.2% Offset MPa, min	Elongation in 25.4 mm or 4D %, min	Reduction of Area %, min
H900	1241	1103	6	15
H925	1241	1034	6	15
H1000	1034	896	8	20
H1100	896	827	8	15

- 3.6.2.1.2 Hardness: Should be not lower than shown in Table III for the corresponding precipitation heat treated condition, but the specimens shall not be rejected on the basis of hardness if the tensile property requirements are met for the condition tested.

TABLE III

Condition	Hardness HRC, min
H900	40
H925	40
H1000	34
H1100	32

3.6.2.2 Castings:

- 3.6.2.2.1 Tensile Properties: 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 selected at random from each master heat. 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.

- Ø 3.6.2.2.2 Hardness: Shall be as shown in Table III.

3.7 Quality:

- 3.7.1 Castings, as received by the 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 subject 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: Tests to determine conformance to the following requirements are classified as acceptance tests:

Ø 4.2.1.1 Composition (3.1).

Ø 4.2.1.2 Hardness of castings as solution heat treated (3.6.1.1).

4.2.1.3 Tensile properties of separately-cast test specimens (3.6.2.1.1) in the H925 condition, except when 4.2.1.4 applies.

4.2.1.4 Tensile properties of specimens cut from castings when specified or otherwise agreed upon (3.6.2.2.1).

Ø 4.2.1.5 Hardness of separately-cast specimens (3.6.2.1.2) in the H925 condition.

Ø 4.2.1.6 Hardness of castings (3.6.2.2.2).

Ø 4.2.1.7 Quality of castings (3.7).

4.2.2 Periodic Tests: Tests to determine conformance to the following requirements are classified as periodic tests:

4.2.2.1 Tensile properties of separately-cast test specimens (3.6.2.1.1) after precipitation heat treatment at temperatures other than 925° F (496° C).

4.2.2.2 Hardness of separately-cast test specimens (3.6.2.1.2) and of castings (3.6.2.2.1) after precipitation heat treatment at temperatures other than 925° F (496° C).

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

4.2.3.1 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:

Ø 4.3.1 Two chemical analysis specimens in accordance with 3.4.1 and/or a casting from each master heat.

Ø 4.3.2 Three tensile test specimens in accordance with 3.4.2 from each master heat, when requested.

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