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AEROSPACE MATERIAL SPECIFICATION

AMS 5336C
Superseding AMS 5336B

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STEEL CASTINGS, INVESTMENT
0.95Cr - 0.20Mo (0.25 - 0.35C)
Normalized

1. SCOPE:

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

1.2 Application: Primarily for small structural parts of intricate design.

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 2360 - Room Temperature Tensile Properties of Castings
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 E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

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 E350, 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	0.25	0.35
Manganese	0.40	0.80
Silicon	--	1.00
Phosphorus	--	0.04
Sulfur	--	0.04
Chromium	0.80	1.10
Molybdenum	0.15	0.25
Nickel	--	0.25
Copper	--	0.25

3.2 Condition: Normalized or normalized and tempered.

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 is 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 (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 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 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 Ø normalized by heating to 1700° - 1750°F (925° - 955°C), holding at heat for not less than 1 hr, and cooling at a rate equivalent to that obtained in still air and, when tempering is required, shall be tempered at not lower than 800°F (425°C).

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

3.6.1 Castings as Normalized or Normalized and Tempered:

3.6.1.1 Hardness: Not higher than 30 HRC or equivalent.

3.6.1.2 Carburization or Decarburization: The carbon content shall be within Ø the limits of 3.1 throughout the casting except that within 0.020 in. (0.5 mm) of the surface or 10% of wall thickness, whichever is less, the carbon content may be lower than specified in 3.1 provided specified tensile properties are met after hardening and tempering as in 3.6.2.

3.6.2 After Hardening and Tempering: Tensile specimens produced in accordance with 3.4.2 and castings, normalized or normalized and tempered as in 3.5, shall meet the requirements of 3.6.2.1 and 3.6.2.2 after being hardened by heating, in an atmosphere neutral to the carbon content, to 1600°F ± 25 (870°C ± 15), holding at heat for not less than 30 min., and quenching in oil and double tempered by heating to 825°F ± 15 (400°C ± 8), holding at heat for 1 hr per inch (25 mm) of maximum cross-section but not less than 1 hr, cooling in air, reheating to 825°F ± 15 (400°C ± 8), holding at heat for 1 hr per inch (25 mm) of maximum cross-section but not less than 1 hr, and cooling in air. Conformance to the requirements of 3.6.2.1 shall be used as basis for acceptance of castings except when purchaser specifies that the requirements of 3.6.2.2 apply.

3.6.2.1 Separately-Cast Specimens:

3.6.2.1.1 Tensile Properties:

Tensile Strength, min	150,000 psi (1035 MPa)
Yield Strength at 0.2% offset, min	125,000 psi (860 MPa)
Elongation in 4D, min	5%
Reduction of Area, min	10%

3.6.2.1.2 Hardness: 32 - 38 HRC or equivalent.

3.6.2.2 Castings:

3.6.2.2.1 Hardness: 32 - 38 HRC or equivalent.

3.6.2.2.2 Tensile Properties: When specified on the drawing or when agreed upon by purchaser and vendor, tensile specimens conforming to ASTM A370 shall be machined from locations indicated on the drawing from castings selected at random to represent the lot. Size, location, and number 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.

3.7 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 Ø 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.

3.7.6 Ø 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: Ø 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:

4.2.1 Acceptance Tests: Ø Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be preformed on each master heat or lot as applicable.

4.2.2 Preproduction Tests: Ø 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 and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be 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; 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 representing each lot.

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 four specimens 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 specimen locations 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 ±25°F (±15°C) from established limits are permissible)
Solidification and cooling procedures
Normalizing and tempering heat treatment cycles
Cleaning operations
Methods of 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.