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AEROSPACE MATERIAL SPECIFICATION

AMS 5334D
Superseding AMS 5334C

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STEEL CASTINGS, INVESTMENT
0.50Cr - 0.55Ni - 0.20Mo (0.25 - 0.35C) (SAE 8630 Mod)
Normalized and Tempered

UNS J13042

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 requiring heat treatment to minimum tensile strengths up to 150,000 psi (1035 MPa).

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications 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 Application
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron

REAFFIRMED
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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 Specifications:

MIL-H-6875 - Heat Treatment of Steels, Process for

2.3.3 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	0.60	0.95
Silicon	--	1.00
Phosphorus	--	0.04
Sulfur	--	0.04
Chromium	0.35	0.65
Nickel	0.35	0.75
Molybdenum	0.15	0.30
Copper	--	0.35

3.2 Condition: 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 Ø 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 15,000 lb (6300 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 Ø 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), in an atmosphere neutral to the specified carbon range, holding at heat for not less than 1 hr, and cooling at a rate equivalent to that obtained in still air and shall be tempered at not lower than 500°F (425°C). Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6875.

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 and Tempered:

3.6.1.1 Hardness: Not higher than 99 HRB or equivalent. Ø

3.6.1.2 Carburization or Decarburization: The carbon content shall be within the Ø limits of 3.1 throughout the casting except that within 0.003 in. (0.08 mm) of the surface the carbon content may be lower than specified in 3.1.

3.6.2 After Hardening and Tempering: Tensile specimens produced in accordance with 3.4.2 and castings shall meet the requirements of 3.6.2.1 and 3.6.2.2 when 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 tempered by heating to 825°F ± 15 (440°C ± 10), holding at heat for 1 hr per in. (25 mm) of cross section but not less than 1 hr, and cooling in air.

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%

3.6.2.2 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 as in 4.3.4 conforming to ASTM A370 shall be machined from locations indicated on the drawing from castings selected at random to represent the lot. 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 Ø condition, sound, and free from foreign materials and from imperfections detrimental to the 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. 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, to fluorescent penetrant inspection in accordance with AMS 2645, or to both.

3.7.4 Radiographic, magnetic particle, fluorescent penetrant, and other quality Ø 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, Ø or other methods without written permission from purchaser.

3.7.5.1 When permitted in writing by purchaser, defects in castings may be Ø 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 Ø 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 Ø requirements of this specification are classified as acceptance tests and as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, on each master heat or lot as applicable, when a change in material or processing, or both, 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 Ø 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 Ø castings poured from a single master heat, normalized and tempered together as a batch, and presented for vendor's inspection at one time:

4.3.1 At least one chemical analysis specimens in accordance with 3.4.1 from Ø each master heat or a casting from each lot.

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 One or more castings from each lot when properties of specimens machined Ø 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 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 process control factors which will produce tensile specimens meeting master heat qualification requirements and acceptable castings; these shall constitute the approved casting procedure and shall be used for producing subsequent master heat qualification specimens and production castings. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.

4.4.2.1 Ø Control factors for producing test specimens and castings include, but are not limited to, the following:

Type of furnace and its capacity
Size and type of furnace charge
Time molten metal is in furnace
Furnace atmosphere
Fluxing or deoxidation procedure
Number of ladles used in pour
Mold refractory formulation
Gating practices
Mold preheat and metal pouring temperatures (variations of ±25°F (±15°C) from established limits are permissible)
Solidification and cooling procedures
Normalizing and tempering cycles
Cleaning operations
Methods of inspection

4.4.2.1.1 Any of the above process control factors 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.

4.5 Reports: