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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 5331D
Superseding AMS 5331C

Issued 7-15-63
Revised 10-1-82

UNS J24060

STEEL CASTINGS, SAND
0.82Cr - 1.8Ni - 0.35Mo (0.38 - 0.46C) (SAE 4340)
Normalized and Tempered

1. SCOPE:

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

1.2 Application: Primarily for cast parts requiring heat treatment to minimum yield strengths up to 180,000 psi (1240 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 (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 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 E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E446 - Reference Radiographs for Steel Castings Up to 2 In. (51 mm) in Thickness

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	0.38	0.46
Manganese	0.60	1.00
Silicon	0.50	0.90
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.65	1.00
Nickel	1.65	2.00
Molybdenum	0.30	0.45
Copper	--	0.35

3.2 Condition: Normalized and tempered.

3.3 Casting: A melt shall be the metal poured from a single furnace charge. A lot shall be all castings poured from a single melt, heat treated in the same furnace load, and presented for vendor's inspection at one time.

3.4 Test Specimens:

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 attached to castings if practicable or shall be standard keel blocks conforming to ASTM A370, unless purchaser permits use of cast-to-size specimens. Specimens shall be cast with each melt of metal for castings and, when requested, shall be supplied with the castings. Keel blocks shall be cast in molds made of suitable core sand, shall be poured directly after pouring the castings, and shall be kept in the mold until black. Metal for the specimens shall be part of the melt which is used for the castings.

3.5 Heat Treatment: Castings and representative tensile specimens shall be normalized by heating to 1600° - 1700°F (870° - 925°C) in an atmosphere Ø neutral to the specified carbon range, holding at heat for not less than 1 hr per inch (25 mm) of maximum cross-section, and cooling in air to room temperature and tempered by heating to not lower than 1100°F (595°C), holding at heat for not less than 1 hr, and cooling in air.

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:
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3.6.1.1 Hardness: Shall be not higher than 285 HB or equivalent.

3.6.1.2 Carburization or Decarburization: The carbon content shall be within the limits of 3.1 throughout the casting except that within 0.020 in. (0.50 mm) of the surface or 10% of wall thickness, whichever is smaller, the carbon content may be lower than specified in 3.1.

3.6.2 After Hardening and Tempering: Tensile specimens produced in accordance Ø with 3.4.2 and castings normalized and tempered as in 3.5 shall meet the following requirements after being hardened by heating to 1500°F ± 25 (815°C ± 15), holding at heat for not less than 30 min., and quenching in oil, and double tempered by heating to 800°F ± 15 (425°C ± 8), holding at heat for 2 hr ± 0.25 and air cooled after each tempering operation:

3.6.2.1 Tensile Properties of Separately-Cast Specimens:

Tensile Strength, min	200,000 psi (1380 MPa)
Yield Strength at 0.2% Offset, min	180,000 psi (1240 MPa)
Elongation in 4D, min	5%

3.6.2.2 Castings:

3.6.2.2.1 Hardness: Shall be 44 - 49 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 castings selected at random from each 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 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 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 ø inspection in accordance with AMS 2640 and/or 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 E446 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.

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 ø 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: Tests to determine conformance to requirements for ø composition (3.1) and for hardness (3.6.1.1), and carbon content (3.6.1.2) of castings as normalized and tempered are classified as acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for ø properties of separetely-cast specimens, and of castings when specified, after hardening and tempering (3.6.2) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests ø and shall be performed 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.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when Ø 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 from each melt and/or a casting from each lot.

4.3.2 Three tensile specimens in accordance with 3.4.2 from each melt, when requested.

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 after hardening and tempering are required. 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 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 for production of sample castings of each part number parameters for the control factors of processing which will produce acceptable castings; these shall constitute the approved casting procedure and shall be used for producing 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 castings include, but are not limited to, the following:

Type of furnace
Furnace atmosphere
Fluxing or deoxidation procedure
Gating and risering practices
Pouring temperature (variation of ± 50°F (± 30°C) from the established limit is permissible)
Solidification and cooling procedures
Normalizing and tempering cycles
Cleaning operations
Methods of inspection