Society of Automotive Engineers, Inc.
TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AEROSPACE MATERIAL SPECIFICATION

AMS 5331C
Superseding AMS 5331B
Issued 7-15-63
Revised 11-15-72

STEEL CASTINGS, SAND
0.80Cr - 1.8Ni - 0.35Mo (0.38 - 0.46C) (SAE 4340)

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 which require heat treatment to minimum yield strengths up to 180,000 psi (1241 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 Society of Automotive Engineers, Inc., Two Pennsylvania Plaza, New York, New York 10001.

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 2804 - Identification, Castings

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 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

2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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 approved analytical methods:

	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: Annealed.

3.3 Casting: A melt shall be the metal poured from a single furnace charge of 7000 lb (3178 kg) or less.

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. Composition of specimens shall conform to 3.1.

3.4.2 Tensile Test 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. Test 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 test specimens shall be part of the melt which is used for the castings.

3.5 Annealing: Castings and representative test specimens shall be annealed by heating to 1550 F ± 25 (843.3 C ± 14) in an atmosphere neutral to the specified carbon range, holding at heat for not less than 1 hr, and cooling as required.

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

3.6.1 Castings As Annealed:

3.6.1.1 Hardness: Shall be not higher than 286 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. (0.51 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 test specimens produced in accordance with 3.4.2 and castings, annealed as in 3.5, and hardened by heating to 1500 F ± 25 (815.6 C ± 14), holding at heat for not less than 30 min., and quenching in oil, and then double tempered by heating to 800 F ± 15 (426.7 C ± 8.3), holding at heat for 2 hr ± 15 min. and air cooled after each tempering operation, shall be capable of meeting the following requirements:

3.6.2.1 Tensile Properties of Test Specimens:

Tensile Strength, min	200,000 psi (1379 MPa)
Yield Strength at 0.2% Offset, min	180,000 psi (1241 MPa)
Elongation in 2 in. (50.8 mm) or 4D, min	5%

3.6.2.2 Properties of 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 test specimens conforming to ASTM A370 shall be machined from castings selected at random from the shipment. Size and location 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 shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to fabrication or to performance of parts. Castings shall have smooth surfaces and shall be well cleaned.

3.7.2 Castings shall be produced under radiographic control, unless otherwise specified. This 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 Radiographic and other quality standards shall be as agreed upon by purchaser and vendor.

3.7.4 Castings shall not be repaired by peening, plugging, or impregnating without written permission from purchaser.

3.7.5 When permitted in writing by purchaser, defects in castings may be removed and 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 casting and the weld repair area shall be suitably identified to facilitate inspection. The 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 assure 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 composition (3.1), hardness of castings as annealed (3.6.1.1), and carbon content (3.6.1.2) requirements are classified as acceptance or routine control tests.

4.2.2 Qualification Tests: Tests to determine conformance to properties after hardening and tempering (3.6.2) requirements are classified as qualification or periodic control tests.

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 melt.

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

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

4.3.4 When properties are required from specimens machined from castings after hardening and tempering, one casting from each melt.

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 for production of sample castings of each part number 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 control factors of processing which could affect quality or properties of the castings, vendor shall submit for reapproval a detailed statement of the revised operations and, when requested, sample castings. No production castings incorporating the revised operations shall 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 and its capacity
Size of furnace charge
Furnace atmosphere
Fluxing or deoxidation procedure
Pouring temperature (variation of ± 50 F (± 28 C) from established temperature limits is permissible)
Solidification rate and subsequent cooling procedures
Cleaning operations
Methods of routine inspection

4.4.2.1.1 Any of the above control factors of processing considered proprietary by the vendor may be assigned a code designation. Each variation in such factors shall be assigned a modified code designation.

4.5 Reports:

4.5.1 The vendor of castings shall furnish with each shipment three copies of a report of the results of tests for chemical composition of each melt represented and a statement that the castings conform to the technical requirements of this specification. When properties of test specimens cut from castings are specified, the report shall include the results of tests to determine conformance to such requirements. This report shall include the purchase order number, melt number, material specification number and its revision letter, part number, and quantity from each melt.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, material specification number and its revision letter, contractor or other direct supplier of castings, part number, and quantity. When castings for making parts are produced or purchased by the parts vendor, that vendor shall inspect castings from each melt represented to determine conformance to the requirements of this specification, and shall include in the report a statement that the castings conform, or shall include copies of laboratory reports showing the results of tests to determine conformance.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the castings may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the castings represented and no additional testing shall be permitted. Results of all tests shall be reported.