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

AEROSPACE MATERIAL SPECIFICATION

AMS 5336B
Superseding AMS 5336A
Issued 7-1-57
Revised 12-1-73

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

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 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 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection

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:

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	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 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. A master heat is refined metal of a single furnace charge or metal blended as in 3.3.1. 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.

3.3.1 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 in the blend does not exceed 10,000 lb (4540 kg). Ingot and pig may be blended, 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 that when castings are poured directly from a master heat, the tensile test specimens shall also be poured directly from the master heat. Tensile test 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. When requested, representative test specimens shall be supplied to the purchaser for confirmatory evaluation.

3.5 Heat Treatment: Castings and tensile test specimens shall be normalized by heating to 1700° - 1750° F (926.7° - 954.4° C), 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 800° F (427° C).

3.6 Properties: Castings and representative test 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 30 HRC 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 0.003 in. (0.08 mm) of the surface the carbon content may be lower than specified in 3.1 provided all other specified properties are met.

3.6.2 After Hardening and Tempering: Tensile test specimens produced in accordance with 3.4.2 and castings, normalized and tempered as in 3.5, shall conform to 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 (871.1° C ± 14), holding at heat for not less than 30 min., and quenching in oil, and double tempered by heating to 825° F ± 15 (440.6° C ± 8.3), holding at heat for 1 hr per inch (25 mm) of cross section but not less than 1 hr, and cooling in air after each tempering operation.

3.6.2.1 Separately-Cast Test Specimens:

3.6.2.1.1 Tensile Properties:

Tensile Strength, min	150,000 psi (1034 MPa)
Yield Strength at 0.2% offset, min	125,000 psi (862 MPa)
Elongation in 1 in. (25.4 mm) or 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 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 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 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.

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

3.7.6 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 casting and the weld repair area shall be suitably marked 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: Tests to determine conformance to all technical requirements of this specification are classified as acceptance or routine 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 master heat.

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

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

4.3.4 When properties are required from specimens machined from castings, one casting from each master heat.

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 separately for tensile test specimens used for master heat qualification and for production of sample castings of each part number the control factors of processing which will produce tensile test 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 control factors of processing which could affect quality or properties of the castings, vendor shall submit for reapproval a statement of the revised operations and, when requested, sample test specimens, castings, or both. No production castings incorporating the revised operations shall 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
Size of furnace charge
Furnace atmosphere
Fluxing or deoxidation procedure
Mold refractory formulation
Mold back-up material
Gating practices
Mold preheating temperature and pouring temperature
(variations of ±25° F (±14° C) from established limits are 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.