



AEROSPACE MATERIAL

Society of Automotive Engineers, Inc. SPECIFICATION

TWO PENNSYLVANIA PLAZA, NEW YORK, N.Y. 10001

AMS 5333A

Superseding AMS 5333

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STEEL CASTINGS, INVESTMENT
0.50Cr - 0.55Ni - 0.20Mo (0.11 - 0.17C) (SAE 8615)

1. SCOPE:

- 1.1 Form: This specification covers a low-alloy steel in the form of investment castings.
- 1.2 Application: Primarily for small parts of intricate design which may require surface hardening by carburizing.

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

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM E8 - Tension Testing of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness
of Metallic Materials
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon
Electrical Steel, Ingot Iron, and Wrought Iron

- 2.3 Government Publications: Available from Superintendent of Documents, Government Printing Office, Washington, D. C. 20402.

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 | 0.11 | 0.17 |
| Manganese | 0.65 | 1.00 |
| Silicon | 0.50 | 1.00 |
| Phosphorus | -- | 0.04 |
| Sulfur | -- | 0.04 |
| Chromium | 0.35 | 0.65 |
| Nickel | 0.35 | 0.75 |
| Molybdenum | 0.15 | 0.35 |
| Copper | -- | 0.35 |

3.2 Condition: Normalized, unless otherwise ordered.

3.3 Casting: Castings shall be poured either from remelted metal from a master heat or master heat lot 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. 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 to form a master heat lot 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 master heat lot 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.

3.4 Master Heat Qualification: Each master heat and master heat lot 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 or master heat lot 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 or master heat lot 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. Composition of specimens shall conform to 3.1.

3.4.2 Tensile Test Specimens: Shall be cast from remelted metal from each master heat or master heat lot 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 E8 with 0.25 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 0.25 in. (6.35 mm) diameter. Center gating may be used. When requested, representative test specimens shall be supplied to the purchaser for confirmatory evaluation. Tensile test specimens shall conform to the requirements of 3.5.1.

3.5 Properties:

3.5.1 Properties of Separately Cast Test Specimens: Test specimens, produced in accordance with 3.4.2 and normalized in the same manner as castings, shall conform to the following requirements:

3.5.1.1 Tensile Properties: Shall be as follows, determined in accordance with ASTM E8.

| | |
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| Tensile Strength, min | 90,000 psi (621 MN/m ²) |
| Yield Strength at 0.2% Offset, min | 65,000 psi (448 MN/m ²) |
| Elongation in 2 in. (50.8 mm) or 4D, min | 18% |

3.5.1.2 Hardness: Not lower than 90 HRB or equivalent, determined in accordance with ASTM E18.

3.5.2 Properties of Castings:

- 3.5.2.1 Hardness: Castings, as normalized, shall have hardness not higher than 95 HRB or equivalent, determined in accordance with ASTM E18.
- 3.5.2.2 Tensile Properties: When specified on the drawing or when agreed upon by purchaser and vendor, tensile test specimens conforming to ASTM E8 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.

3.6 Quality:

- 3.6.1 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.
- 3.6.2 When castings are broken for fracture test, the fracture shall have uniform color and be substantially free from oxides and other defects.
- 3.6.3 Unless otherwise specified, castings shall be produced under radiographic control. 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.
- 3.6.4 Radiographic and other quality standards shall be as agreed upon by purchaser and vendor.
- 3.6.5 Castings shall not be repaired by plugging, welding, or other methods without written permission from purchaser.

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The vendor 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 material conforms 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 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 or master heat lot.
 - 4.3.2 Three tensile test specimens in accordance with 3.4.2 from each master heat or master heat lot.
 - 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, a casting shall be selected at random from each master heat or master heat 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.

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
Variations of more than ± 25 F (± 14 C) in mold
pre-heating temperature, pouring temperature,
or both
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 at least one casting, or of a specimen as in 3.4.1 cast in a mold with parts, from each master heat or master heat lot represented and the results of tests on each master heat or master heat lot to determine conformance to the other 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, master heat or master heat lot number (and code symbol if used), material specification number and its revision letter, part number, and quantity from each master heat or master heat lot.

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 master heat or master heat lot 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 testing of 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 master heat in the case of qualification test specimens, or of the castings in that shipment in the case of tests on castings or specimens cut from castings and no additional testing shall be permitted. Results of all tests shall be reported.