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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5334E

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Submitted for recognition as an American National Standard

Superseding AMS 5334D

(R) STEEL, INVESTMENT CASTINGS
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:

These castings have been used typically for small structural parts of intricate design requiring heat treatment to minimum tensile strengths up to 150 ksi (1034 MPa), but usage is not limited to such applications.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2360 Room Temperature Tensile Properties of Castings
AMS 2694 Repair Welding of Aerospace Castings
AMS 2804 Identification, Castings

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A 370	Mechanical Testing of Steel Products
ASTM E 350	Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon Electrical Steel, Ingot Iron, and Wrought Iron
ASTM E 1444	Magnetic Particle Examination

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-6875	Heat Treatment of Steel, Process for
MIL-STD-453	Inspection, Radiographic
MIL-STD-2073-1	DOD Materiel, Procedures for Development and Application of Packaging Requirements
MIL-STD-2175	Castings, Classification and Inspection of
MIL-STD-6866	Inspection, Liquid Penetrant

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Castings shall conform to the percentages by weight shown in Table 1, determined by wet chemical methods in accordance with ASTM E 350, by spectrochemical methods, or by other analytical methods acceptable to purchaser (See 8.2.1 and 8.2.2).

TABLE 1 - Composition

Element	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

3.1.1 Vendor may test for any element not otherwise listed in Table 1 and include this analysis in the report of 4.5. Limits of acceptability may be specified by purchaser (See 8.2.3).

3.2 Melt Practice:

Castings and specimens shall be poured at casting vendor's facility either from a melt (See 8.2.4) of a master heat or directly from a master heat (See 8.2.5).

3.2.1 Revert (gates, sprues, risers, and rejected castings) may be used only in the preparation of master heats; revert shall not be remelted directly without refining for pouring of castings.

3.2.2 Portions of two or more qualified master heats (See 3.4.2) may be melted together and poured into castings using a procedure authorized by purchaser (See 8.2.6).

3.2.3 If alloy additions or replenishments are made by the vendor at remelt, vendor shall have a written procedure acceptable to purchaser which defines the controls, test, and traceability criteria for both castings and separately-cast specimens. Control factors of 4.4.2.2 shall apply.

3.3 Condition:

Normalized and tempered.

3.4 Test Specimens:

Specimens shall be either separately-cast, integrally-cast (See 8.2.7), or machined from castings, and shall conform to 3.2.

3.4.1 If specimens are separately-cast, vendor shall have a written procedure acceptable to purchaser. Control factors of 4.4.2.2 shall apply.

3.4.2 Each master heat shall be qualified by evaluation of chemical and tensile specimens.

3.4.2.1 If alloy additions or replenishments are made at remelt as in 3.2.3, the frequency of sampling and testing used by the vendor for qualification to 3.4.2 shall be acceptable to purchaser.

3.4.2.2 The tensile qualification tests of 3.4.2 are not required if these tests are conducted using integrally-cast specimens (4.3.3.2) or specimens machined from castings (4.3.3.3).

3.4.3 Chemical Analysis Specimens: Shall be of any convenient size and shape.

3.4.4 Tensile Specimens: Shall be of standard proportions in accordance with ASTM A 370 with 0.250 inch (6.35 mm) diameter at the reduced parallel gage section.

3.4.4.1 Separately-cast and integrally-cast specimens may be either cast to size or cast oversize and subsequently machined to 0.250 inch (6.35 mm) diameter.

3.4.4.2 When integrally-cast specimens and specimens machined from castings are specified, specimen size and location shall be as agreed upon by purchaser and vendor. (See 8.2.8 and 8.5).

3.5 Heat Treatment:

Castings and representative tensile specimens shall be heat treated in accordance with MIL-H-6875 except as specified in 3.5.1 and 3.5.2.

3.5.1 Castings and Specimens:

3.5.1.1 Normalize: Heat to a selected temperature in the range of 1700 to 1750 °F (927 to 954 °C), in an atmosphere neutral to the specified carbon range, hold at heat for not less than one hour, and cool at a rate equivalent to that obtained in still air.

3.5.1.2 Temper: Heat to a temperature not lower than 500 °F (260 °C).

3.5.2 Castings and Specimens for Testing after Hardening and Tempering:

3.5.2.1 Harden: Heat to 1600 °F ± 25 (871 °C ± 14), in an atmosphere neutral to the specified carbon range, hold at heat for not less than 30 minutes, and quench in oil.

3.5.2.2 Temper: Heat to a temperature not lower than 800 °F (427 °C), hold at heat for one hour per inch (25 mm) of cross section but not less than one hour, and cool in air.

3.5.3 Tensile specimens used for master heat qualification may be heat treated separately from castings.

3.6 Properties:

Conformance shall be based upon testing separately-cast specimens unless purchaser specifies integrally-cast specimens or specimens machined from castings. Properties of integrally-cast specimens or specimens machined from castings shall be as specified by purchaser.

3.6.1 Room Temperature Tensile Properties: Shall be as shown in Table 2, determined in accordance with ASTM A 370, after heat treatment in accordance with 3.5.1 and 3.5.2. Properties other than those listed may be defined as specified in AMS 2360.

TABLE 2 - Minimum Tensile Properties

Property	Value
Tensile Strength	150 ksi (1034 MPa)
Yield Strength at 0.2% Offset	125 ksi (862 MPa)
Elongation in 4D	8%
Reduction in Area	20%

3.6.2 Hardness: Shall be as follows, determined in accordance with ASTM A 370:

3.6.2.1 Castings as Normalized and Tempered: Shall be not higher than 99 HRB, or equivalent (See 8.3).

3.6.2.2 Castings and Specimens as Hardened and Tempered: Shall be 32 to 38 HRC, or equivalent (See 8.3).

3.6.3 Carburization or Decarburization: The carbon content shall be within the limits of 3.1 throughout the casting except within 0.003 inch (0.08 mm) of the surface.

3.7 Quality:

Castings, as received by purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the castings.

3.7.1 Unless otherwise specified by purchaser, the following shall apply:

3.7.1.1 Castings shall be free of cracks, laps, hot tears, and cold shuts.

3.7.1.2 Castings shall be free of scale and other process-induced surface contamination which would obscure defects.

3.7.2 Acceptance standards for radiographic, magnetic particle, fluorescent penetrant, visual, and other inspection methods shall be as agreed upon by purchaser and vendor (See 8.2.8). MIL-STD-2175 may be used to specify acceptance standards (casting grade) and frequency of inspection (casting class).

3.7.2.1 When acceptance standards are not specified, Grade C of MIL-STD-2175 shall apply.

3.7.3 Castings shall be produced under radiographic control. This control shall consist of radiographic examination of each casting part number until foundry manufacturing controls, in accordance with 4.4.2, have been established. Additional radiography shall be conducted in accordance with the frequency of inspection specified by purchaser or as necessary to ensure continued maintenance of internal quality.

3.7.3.1 Radiographic inspection shall be conducted in accordance with MIL-STD-453 or other process method specified by purchaser.

3.7.4 When specified, additional nondestructive testing shall be performed as follows:

3.7.4.1 Fluorescent penetrant inspection in accordance with MIL-STD-6866 or other process method specified by purchaser.

3.7.4.2 Magnetic particle inspection in accordance with ASTM E 1444 or other process method specified by purchaser.

3.7.5 Castings shall not be peened, plugged, impregnated, or welded unless authorized by purchaser.

3.7.5.1 When authorized by purchaser, welding in accordance with AMS 2694 or other welding program acceptable to purchaser may be used.

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 required tests. 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 for composition (3.1), tensile properties (3.6.1), hardness (3.6.2.1 and 3.6.2.2), and quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests: Tests for radiographic soundness (3.7.3) are periodic tests and shall be performed at a frequency selected by vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed on sample castings (4.3.2), when a change in control factors occurs (4.4.2.2), and when purchaser deems confirmatory testing to be required.

4.3 Sampling and Testing:

The minimum testing performed by vendor shall be in accordance with the following:

4.3.1 One chemical analysis specimen or a casting from each master heat shall be tested for conformance with Table 1, unless 3.4.2.1 applies, in which case frequency of testing shall be acceptable to purchaser.

4.3.2 One preproduction casting in accordance with 4.4 shall be tested to the requirements of the casting drawing and to all technical requirements.

4.3.2.1 Dimensional inspection sample quantity shall be as specified by purchaser.

4.3.3 Tensile tests shall be conducted to determine conformance with Table 2. Sampling and test frequency is dependent upon the type and origin of specimen specified by purchaser (See 3.6) or selected by vendor (See 4.3.3.4). When 3.4.2.1 applies, test frequency shall be acceptable to purchaser.

4.3.3.1 For separately-cast specimens in the hardened and tempered condition of 3.5.2, one or more specimens from each master heat shall be tested for conformance with 3.6.1.

4.3.3.2 For integrally-cast specimens in the hardened and tempered condition of 3.5.2, at least two specimens from each lot shall be tested for conformance with 3.6.

4.3.3.3 For specimens machined from casting, one or more castings shall be randomly selected from each lot and tested in the hardened and tempered condition of 3.5.2 at locations shown on the engineering drawing for conformance with 3.6.

4.3.3.3.1 When size and location of specimens are not shown, at least two test specimens shall be tested, one from the thickest section and one from the thinnest section. Once established under 4.4.2.2, test locations may be changed only as agreed upon by purchaser and vendor.

4.3.3.4 When acceptable to purchaser, specimens machined from casting may be used in lieu of both separately-cast and integrally-cast specimens, and integrally-cast specimens may be used in lieu of separately-cast specimens. In each case, the resultant properties must conform to the requirements of 3.6 for separately-cast specimen requirements or to alternative requirements specified by purchaser (See 8.5).

4.3.3.4.1 When specimens are selected for test as in 4.3.3.4 from an origin other than that specified by purchaser, vendor shall include in the report of 4.5 a description of the origin of the specimen that was tested.

4.3.3.5 When casting size, section thickness, gating method, or other factors do not permit conformance with 4.3.3.2 or 4.3.3.3, sampling and testing shall be as agreed upon by purchaser and vendor.

4.3.4 Castings shall be inspected in accordance with 3.7 to the methods, frequency, and acceptance standards specified by purchaser.

4.3.5 Unless otherwise specified by purchaser, one casting per lot shall be tested for hardness to determine conformance with 3.6.2.1.

4.3.5.1 In the event of failure, the entire lot shall be 100% inspected or reheat treated in accordance with 4.6.2.

4.3.6 After heat treatment to 3.5.1 and 3.5.2, one casting, or a specimen representing the thickest section of the casting, from each master heat shall be tested for hardness to determine conformance with 3.6.2.2.

4.3.6.1 In event of failure, castings and specimens may be reheat treated in accordance with 4.6.2.

4.4 Approval:

4.4.1 Sample casting(s) from new or reworked master patterns produced under the casting procedure of 4.4.2 shall be approved by purchaser before castings for production use are supplied, unless such approval be waived by purchaser.

4.4.2 For each casting part number, vendor shall establish parameters for process control factors that will consistently produce castings and test specimens meeting the requirements of the casting drawing and this specification. These parameters shall constitute the approved casting procedure and shall be used for production of subsequent castings and test specimens. If necessary to make any change to these parameters, vendor shall submit a statement of the proposed changes for purchaser reapproval. When requested, vendor shall also submit test specimens, sample castings, or both to purchaser for reapproval.

4.4.2.1 Production castings produced prior to receipt of purchaser's approval shall be at vendor's risk.

4.4.2.2 Control factors for producing castings and separately-cast test specimens include, but are not limited to, the factors shown below. Vendor's procedures shall identify tolerances, ranges, and/or control limits, as applicable. Control factors for separately-cast test specimens must generally represent, but need not be identical to, those factors used for castings (See 3.2.3 and 3.4.1):

Composition of ceramic cores, if used
Arrangement and number of patterns in the mold including integrally-cast specimens, if applicable
Size, shape, and location of gates and risers
Mold refractory formulation
Grain refinement methods, if applicable
Mold backup material (weight, thickness, or number of dips)
Type of furnace, atmosphere, and charge for melting
Mold preheat and metal pouring temperatures
Fluxing or deoxidation procedures
Replenishment and alloy addition procedure, if applicable
Time that molten metal is in the furnace
Solidification and cooling procedures
Cleaning operations (mechanical and chemical)
Heat treatment
Straightening
Final inspection methods
Location of specimens machined from castings, if applicable

4.4.2.2.1 Any of the control factors of 4.4.2.2 for which parameters are considered proprietary by vendor may be assigned a code designation. Each variation in such parameters shall be assigned a modified code designation.

4.4.2.2.1.1 Unless otherwise agreed upon by purchaser and vendor, purchaser shall be entitled to review proprietary control factor details and coding at vendor's facility.

4.5 Reports:

The vendor of castings shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements. This report shall include the purchase order number, master heat identification, heat treat/lot identification, AMS 5334E, part number, quantity, and source and tempering temperature of tensile specimens.