SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS5334 | REV. H

Issued 1950-10
Revised 2007-08
Reaffirmed 2013-04

Superseding AMS5334G

Steel, Investment Castings
0.50Cr - 0.55Ni - 0.20Mo (0.25 - 0.35C) (SAE 8630 Mod)
Normalized and Tempered
(Composition similar to UNS J13042)

RATIONALE

AMS5334H has been reaffirmed to comply with the SAE five-year review policy.

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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS 2175	Casting, Classification and Inspection
AMS 2360	Room Temperature Tensile Properties of Castings
AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings
AMS-H-6875	Heat Treatment of Steel

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

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 1417	Liquid Penetrant Examination
ASTM E 1444	Magnetic Particle Examination
ASTM E 1742	Radiographic Examination

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 Melting 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. Melting of revert creates a new master heat.

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 modifications, such as 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

Castings shall be delivered in the normalized and tempered condition.

3.4 Test Specimens

Specimens shall be either separately-cast, integrally-cast (See 8.2.7), or machined from a casting, 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 analysis hardness 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 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 a casting (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 a casting are specified, specimen size and location shall be as agreed upon by purchaser and vendor (See 8.2.8 and 8.6).

3.4.5 Hardness Specimens for Response to Heat Treatment

May be a representative specimen or a casting.

3.5 Heat Treatment

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

3.5.1 Production Castings and Specimens

3.5.1.1 Normalize

Heat to a selected temperature in the range 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 Response to Heat Treatment

After heat treatment in accordance with 3.5.1, castings or specimens shall be heat treated as follows for subsequent testing to demonstrate response to heat treatment.

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 for each 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 a casting. Properties of integrally-cast specimens or specimens machined from a casting 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	5%
Reduction in Area	10%

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

3.7.1 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. Castings shall be free of cracks, laps, hot tears, and cold shuts, and shall be free of scale and other process-induced surface contamination which would obscure defects.

3.7.2 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.

3.7.2.1 Radiographic inspection shall be conducted in accordance with ASTM E 1742 or another method specified by purchaser.

3.7.3 When specified, castings shall be subjected to additional nondestructive testing as follows:

3.7.3.1 Fluorescent penetrant inspection in accordance with ASTM E 1417 or another method specified by purchaser.

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

3.7.4 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). AMS 2175 may be used to specify acceptance standards (casting grade) and frequency of inspection (casting class).

3.7.4.1 When acceptance standards are not specified, Grade C of AMS 2175 shall apply.

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 the performance of all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the castings conform to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), tensile properties (3.6.1), hardness (3.6.2.1 and 3.6.2.2), and the applicable requirements of quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests

Carburization/decarburization (3.6.3) and radiographic soundness (3.7.2) 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

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; if 3.4.2.1 applies, test frequency 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 specimen 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, two specimens from each lot shall be tested for conformance with 3.6.1.

4.3.3.3 For specimens machined from a casting, one casting 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 3.6.1.

4.3.3.3.1 When size and location of specimens are not shown, 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 a 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 3.6.1 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 source 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 using the methods, frequency, and acceptance standards specified by purchaser.

4.3.5 Unless otherwise specified by purchaser, one casting from each 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 as in 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 is 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 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 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 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 procedure
Replenishment and alloy addition procedures, if applicable
Time molten metal is in furnace
Solidification and cooling procedures
Cleaning operations (mechanical and chemical)
Welding procedure, if applicable
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 5334H, part number, quantity, and source and tempering temperature of tensile specimens.

4.6 Resampling and Retesting

If results of a valid test fail to meet specified requirements, except as in 4.3.4.1, two additional specimens in accordance with 4.3 from the same master heat, modified melt (See 3.2.3), or lot as applicable, shall be tested for each nonconforming characteristic. The results of each additional test, and the average of the results of all tests (original and retests), shall meet specified requirements; otherwise, the master heat or lot shall be rejected. Results of all tests shall be reported.

4.6.1 A test may be declared invalid if failure is due to specimen mispreparation, test equipment malfunction, improper test procedure, or the presence of random process defects, such as inclusions or gas holes, in a tensile specimen.