SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 5333E

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Superseding AMS 5333D

Steel, Investment Castings
0.50Cr - 0.55Ni - 0.25Mo (0.11 - 0.17C) (SAE 8615)
Normalized

(Composition similar to UNS J11442)

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 parts of intricate design which may require surface hardening by carburizing, 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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2694	Repair Welding of Aerospace Castings
AMS 2804	Identification, Castings
AMS-H-6875	Heat Treatment of Steel Raw Materials
AMS-STD-2175	Castings, Classification and Inspection of

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

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or http://www.astm.org.

ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
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	0.11	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

3.1.1 Vendor may test for any element not otherwise listed in Table 1 and include this analysis in the report of 4.5.1. Limits of acceptability may be specified by purchaser (See 8.2.3).

3.2 Melting Practice:

Castings 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 3.4.1) 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 (See 8.2.1) which defines the controls, test, and traceability criteria for castings. Control factors of 4.4.2.2 shall apply.

3.3 Condition:

Castings shall be delivered in the normalized condition.

3.4 Test Specimens:

3.4.1 Each master heat shall be qualified by evaluation of a chemical analysis specimen.

3.4.1.1 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 3.4.1 shall be acceptable to purchaser.

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

3.5 Heat Treatment:

Castings shall be heat treated in accordance with AMS-H-6875 except as specified in 3.5.1.

3.5.1 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.

3.6 Properties:

Castings shall conform to the following requirements:

3.6.1 Hardness of Castings: Shall be not higher than 90 HRB, or equivalent (See 8.3) determined in accordance with ASTM E 18:

3.6.2 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 other 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 other 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, fluorescent penetrant, magnetic particle, visual, and other inspection methods shall be as agreed upon by purchaser and vendor (See 8.2.7). AMS-STD-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-STD-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), hardness (3.6.1), and applicable requirements of quality (3.7) are acceptance tests and shall be performed as specified in 4.3.

4.2.2 Periodic Tests: Radiographic soundness (3.7.2) is a periodic test and shall be performed at a frequency selected by the 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 3.4.1.1 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 Castings shall be inspected in accordance with 3.7 to the methods, frequency, and acceptance standards specified by purchaser.

4.3.4 Unless otherwise specified by purchaser, one casting from each lot shall be tested for hardness to determine conformance with 3.6.1.

4.3.4.1 In the event of failure, the entire lot shall be 100% inspected or 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 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. 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 sample castings to purchaser for reapproval.

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

4.4.2.2 Control factors for producing castings include, but are not limited to, the factors shown below. Vendors procedures shall identify tolerances, ranges, and/or control limits, as applicable.

Composition of ceramic cores, if used
Arrangement and number of patterns in the mold
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

4.4.2.2 (Continued):

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.

4.4.2.2.1 Any of the control factors of 4.4.2.2 for which parameters are considered proprietary by the 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 vendors 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 5333E, part number, and quantity.

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 samples 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, or improper test procedure.

4.6.2 Unless otherwise authorized by purchaser, castings may be subjected to not more than one reheat treatment cycle of 3.5.1 in the event of hardness failure. Upon reheat treatment, castings shall be submitted for testing in accordance with 4.3.3 and 4.3.4.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Unless otherwise specified by purchaser, individual castings shall be identified in accordance with AMS 2804.