



AEROSPACE MATERIAL SPECIFICATION

AMS5330™**REV. E**

Issued	1963-07
Revised	1987-10
Noncurrent	1998-02
Reaf. Nonc.	2013-04
Stabilized	2015-12

Superseding AMS5330D

Steel Castings, Investment
0.80Cr - 1.8Ni - 0.35Mo (0.38 - 0.46C) (SAE 4340 Modified)
Annealed

J24060

RATIONALE

AMS5330E is stabilized as the document is not in use.

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1. SCOPE:

1.1 Form:

This specification covers a low-alloy steel in the form of investment castings.

1.2 Application:

Primarily for parts of intricate design requiring tensile strengths up to 200,000 psi (1380 MPa) after hardening and tempering heat treatment.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications:

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

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2360 - Room Temperature Tensile Properties of Castings
AMS 2369 - Quality Assurance Sampling of Carbon and Low-Alloy Steel Castings
AMS 2635 - Radiographic Inspection
AMS 2640 - Magnetic Particle Inspection
AMS 2645 - Fluorescent Penetrant Inspection
AMS 2694 - Repair Welding of Aerospace Castings
AMS 2804 - Identification, Castings

2.2 ASTM Publications:

Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM E192 - Reference Radiographs of Investment Steel Castings for Aerospace Applications
ASTM E350 - Chemical Analysis of Carbon Steel, Low-Alloy Steel, Silicon, Electrical Steel, Ingot Iron, and Wrought Iron

2.3 U.S. Government Publications:

Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Specifications:

MIL-H-6875 - Heat Treatment of Steel, Process for

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the following percentages by weight, determined by wet chemical methods in accordance with ASTM E350 or by spectrochemical or other analytical methods approved by purchaser:

	min	max
Carbon	0.38	0.46
Manganese	0.60	1.00
Silicon	0.50	1.00
Phosphorus	--	0.025
Sulfur	--	0.025
Chromium	0.65	1.00
Nickel	1.65	2.00
Molybdenum	0.30	0.45
Copper	--	0.35

3.2 Condition:

Annealed.

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.

- 3.3.1 A master heat is refined metal of a single furnace charge or is metal blended as in 3.3.2. 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.
- 3.3.2 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 blended does not exceed 15,000 lb (6800 kg). 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 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 technical 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.
- 3.4.2 Tensile Specimens: Shall be cast from remelted metal from each master heat except when castings are poured directly from a master heat, specimens shall also be poured directly from the master heat. Specimens shall be of standard proportions in accordance with ASTM A370 with 0.250 in. (6.25 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. (6.25 mm) diameter. Center gating may be used.

3.5 Heat Treatment:

Castings and separately-cast tensile specimens shall be annealed by heating to $1550^{\circ}\text{F} \pm 25$ ($845^{\circ}\text{C} \pm 15$) in an atmosphere neutral to the specified carbon range, holding at heat for not less than 1 hr, and cooling as required. Furnace surveys and calibration of temperature controllers and recorders shall be in accordance with MIL-H-6875 or with a survey and calibration program certified by the vendor as meeting the intent of MIL-H-6875.

3.6 Properties:

Castings and separately-cast tensile specimens produced in accordance with 3.4.2 shall conform to the following requirements; hardness and tensile testing shall be performed in accordance with ASTM A370:

3.6.1 Castings As Annealed:

- 3.6.1.1 Hardness: Not higher than 30 HRC, or equivalent.

3.6.1.2 Carburation or Decarburation: 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: Castings and separately-cast tensile specimens produced in accordance with 3.4.2 shall conform to the requirements of 3.6.2.1 and 3.6.2.2 after being hardened by heating, in an atmosphere neutral to the carbon content, to 1500°F ± 25 (815°C ± 15), holding at heat for not less than 30 min., and quenching in oil, and double tempered by heating to a temperature not lower than 800°F (425°C), holding at heat for 2 hr ± 0.25, and cooling in air, reheating to a temperature not lower than 800°F (425°C), holding at heat for 2 hr ± 0.25, and cooling in air.

3.6.2.1 Separately-Cast Specimens:

3.6.2.1.1 Tensile Properties:

Tensile Strength, min	200,000 psi (1380 MPa)
Yield Strength at 0.2%, offset, min	180,000 psi (1240 MPa)
Elongation in 4D, min	5%

3.6.2.2 Castings:

3.6.2.2.1 Hardness: 44 - 49 HRC, or equivalent.

3.6.2.2.2 Tensile Properties: When specified on the drawing or when agreed upon by purchaser and vendor, tensile specimens conforming to ASTM A370 shall be machined from castings selected at random from each lot. Size, location, and number of such specimens and required properties shall be as shown on the drawing or as agreed upon by purchaser and vendor and may be defined as specified in AMS 2360.

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.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned.

3.7.2 Castings shall be produced under radiographic control. 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 subjected to magnetic particle inspection in accordance with AMS 2640, to fluorescent penetrant inspection in accordance with AMS 2645, or to both.

- 3.7.4 Radiographic, magnetic particle, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor. ASTM E192 may be used to define radiographic acceptance standards.
- 3.7.5 Castings shall not be repaired by peening, plugging, welding, impregnating, or other methods without written permission from purchaser.
- 3.7.5.1 When permitted in writing by purchaser, defects in castings may be removed and the castings repaired by welding in accordance with AMS 2694.

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. Results of such tests shall be reported to the purchaser as required by 4.5. 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: Except as specified in 4.2.1.1, tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each master heat or lot as applicable.
 - 4.2.1.1 Tensile properties of specimens cut from castings shall be determined only when specified by purchaser or when separately-cast specimens are not available. Tensile properties of separately-cast specimens need not be determined when tensile properties of specimens cut from castings are determined.
- 4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.
 - 4.2.2.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling:

Shall be in accordance with AMS 2369.

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 by purchaser.
- 4.4.2 Vendor shall establish separately for tensile specimens used for master heat qualification and for production of sample castings of each part number parameters for the process control factors which will produce tensile 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 the parameters for process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, test specimens, sample castings, or both. Production castings incorporating the revised operations shall not be shipped prior to receipt of reapproval.
- 4.4.2.1 Control factors for producing tensile specimens and castings include, but are not limited to, the following:
- Type of furnace and its capacity
 - Type and size of furnace charge
 - Time molten metal is in furnace
 - Furnace atmosphere
 - Fluxing or deoxidation procedure
 - Number of ladles used in pour
 - Mold refractory formulation
 - Mold back-up material
 - Gating practices
 - Mold preheating and metal pouring temperatures; variations of $\pm 25^{\circ}\text{F}$ ($\pm 15^{\circ}\text{C}$) from established limits are permissible
 - Solidification and cooling procedures
 - Heat treatment procedures
 - Cleaning operations
 - Methods of inspection
- 4.4.2.1.1 Any of the above process control factors 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.