AEROSPACE MATERIAL SPECIFICATION

AMS5328™	REV. E

Issued 1936-07
Revised 1987-10
Noncurrent 1998-02
Reaf. Nonc. 2013-04
Stabilized 2017-08

Superseding AMS5328D

Steel Castings, Investment
0.80Cr - 1.8Ni - 0.35Mo (0.28 - 0.36C) (SAE 4330 Modified)
Annealed

J23260

RATIONALE

AMS5328E has been stabilized as mature technology.

STABILIZED NOTICE

AMS5328E has been declared "STABILIZED" by SAE AMS Carbon and Low Alloy Steels Committee E. This document will no longer be updated and may no longer represent standard industry practice. This document was stabilized because this document contains mature technology that is not expected to change and thus no further revisions are anticipated. Previously this document was reaffirmed non-current. The last technical update of this document occurred in August 1987. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to this specification; including exceptions listed on the certification.

NOTE: In many cases, the purchaser may represent a sub tier supplier and not the cognizant engineering organization.

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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 thin to moderately thick cross-section which require heat treatment to minimum tensile strengths up to 180,000 psi (1240 MPa).

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 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 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	0.28	0.36
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 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: Separately-cast tensile specimens shall be cast from remelted metal from each master heat except when castings are poured directly from a master heat, in which case the 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 representive separately-cast tensile specimens shall be annealed by heating to 1550°F ± 25 (845°C ± 15) in an atmosphere neutral to the specified carbon range, holding at heat for not less than 1 hr, and cooling as required.

3.6 Properties:

Castings and representative tensile specimens 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 Carburization or Decarburization: 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.

3.6.2 After Hardening and Tempering: Separately-cast tensile specimens, integrally-cast coupons, and castings shall meet the requirements of 3.6.2.1 and 3.6.2.2 as applicable when 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 750°F ± 15 (400°C ± 8), holding at heat for 2 hr ± 0.25, and cooling in air after each tempering operation.

3.6.2.1 Separately-Cast Specimens:

3.6.2.1.1 Tensile Properties:

Tensile Strength, min	180,000 psi (1240 MPa)
Yield Strength at 0.2%, offset, min	160,000 psi (1105 MPa)
Elongation in 4D, min	5%

3.6.2.2 Castings or Integrally-Cast Coupons:

3.6.2.2.1 Hardness: 40 - 45 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 locations indicated on the drawing from castings selected at random to represent the lot or from integrally-cast coupons. 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. Required properties 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:

Tests to determine conformance to all technical requirements of this specification are classified as acceptance tests and as preproduction tests and shall be performed prior to or on the first-article shipment of a casting to a purchaser, on each master heat or lot as applicable, when a change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.1 Tensile properties of separately-cast specimens need not be determined when tensile properties of specimens cut from castings are determined.

4.2.2 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 the following; a lot shall be all castings poured from a single master heat, heat treated together as a batch, and presented for vendor's inspection at one time:

4.3.1 Two chemical analysis specimens in accordance with 3.4.1 from each master heat or a casting from each lot.

4.3.2 Three separately-cast tensile specimens in accordance with 3.4.2 from each lot except when purchaser requires tensile properties of specimens machined from castings or from integrally-cast coupons.

4.3.3 Two preproduction castings in accordance with 4.4.1 of each part number.

4.3.4 When purchaser specifies that tensile properties of specimens machined from castings apply, not less than two specimens machined from a casting or castings from each lot. Specimens shall be of standard proportions conforming to ASTM A370 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section. If specimen locations are not shown on the drawing, not less than two specimens, one from the thickest section and one from the thinnest section, shall be cut from a casting or castings from each 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 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 procedure and shall be used for producing subsequent master heat qualification specimens and production castings. If necessary to make any change in parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes 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 test 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 preheat and metal pouring temperatures; variations of ±25°F (±15°C) from established limits are permissible
Solidification and cooling procedures
Annealing heat treatment cycles
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.