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AEROSPACE MATERIAL SPECIFICATION

AMS 4985A
Superseding AMS 4985

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TITANIUM ALLOY CASTINGS, INVESTMENT OR RAMMED GRAPHITE
6Al - 4V
Annealed

1. SCOPE:

1.1 Form: This specification covers a titanium alloy in the form of investment or rammed graphite castings.

1.2 Applications: Primarily for parts of intricate design requiring relatively good strength-to-weight ratio and good toughness and corrosion resistance.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) 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 2635 - Radiographic 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 E8 - Tension Testing of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E120 - Chemical Analysis of Titanium and Titanium Alloys

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 151 - Metals; Test Methods

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 E120, by spectrographic methods in accordance with Federal Test Method Standard No. 151, Method 112, or by other analytical methods approved by purchaser:

	min	max	
Aluminum	5.50 -	6.75	
Vanadium	3.50 -	4.50	
Iron	--	0.30	
Oxygen	--	0.20	
Carbon	--	0.10	
Nitrogen	--	0.05	(500 ppm)
Hydrogen	--	0.015	(150 ppm)
Yttrium	--	0.005	(50 ppm)
Residual Elements, each (3.1.1)	--	0.10	
Residual Elements, total (3.1.1)	--	0.40	
Titanium	remainder		

3.1.1 Determination not required for routine acceptance.

3.2 Condition: Annealed.

3.3 Casting:

3.3.1 The metal for castings shall be melted and poured under vacuum without loss of vacuum between melting and pouring.

3.3.2 Castings shall be poured only from a master heat qualified as in 3.4.
ø Solidification of the master heat into pigs or ingots before melting for pouring castings is optional.

3.3.2.1 A master heat shall consist of metal which has been consumable electrode
ø melted under vacuum. The electrode shall be made from metal conforming to 3.1 which has been previously consumable electrode melted. The electrode shall not include any sponge or chips or any welds contaminated with tungsten. It may include cleaned foundry scrap (gates, sprues, risers, and rejected castings) provided it is from previously qualified master heats.

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 for vendor's tests; when chemical analysis specimens are required by purchaser, specimens shall be cast to a size, shape, and form agreed upon by purchaser and vendor.

3.4.2 Tensile Specimens: Integral or 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 E8 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section. Specimens shall be cast to size or shall be cast oversize and subsequently machined to 0.250 in. (6.25 mm) diameter.

3.5 Heat Treatment: Castings and representative tensile specimens shall be annealed by heating in vacuum or a controlled atmosphere to a temperature within the range 1300° - 1550°F (705° - 845°C), holding at the selected temperature within ±25°F (±15°C) for 2 - 4 hr, cooling in the furnace to below 1000°F (540°C), and cooling in air to room temperature.

3.6 Properties: Castings, specimens cut from attached coupons, and representative tensile specimens produced in accordance with 3.4.2 shall conform to the following requirements; conformance to the requirements of 3.6.1.1 shall be used for acceptance except when purchaser specifies that requirements of 3.6.1.2 apply:

3.6.1 Tensile Properties: Shall be as specified in 3.6.1.1 or 3.6.1.2, determined in accordance with ASTM E8 with the rate of strain maintained at 0.003 - 0.007 in./in. per min. (0.003 - 0.007 mm/mm per min.) through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer, using a rate of 0.005 in./in. per min. (0.005 mm/mm per min.) through the yield strength and a minimum cross head speed of 0.10 in. (2.5 mm) per min. above the yield strength.

3.6.1.1 Separately-Cast Specimens or Specimens Cut From Attached Coupons:

Tensile Strength, min	130,000 psi (895 MPa)
Yield Strength at 0.2% Offset, min	120,000 psi (825 MPa)
Elongation in 4D, min	6%

3.6.1.2 Specimens Cut From Castings:

3.6.1.2.1 Designated Areas:

Tensile Strength, min	130,000 psi (895 MPa)
Yield Strength at 0.2% Offset, min	120,000 psi (825 MPa)
Elongation in 4D, min	6%

3.6.1.2.2 Non-Designated Areas:

Tensile Strength, min	125,000 psi (860 MPa)
Yield Strength at 0.2% Offset, min	108,000 psi (745 MPa)
Elongation in 4D, min	4.5%

3.6.2 Hardness of Castings: Shall be not higher than 39 HRC, or equivalent, determined in accordance with ASTM E18.

3.6.3 Surface Contamination: Castings shall be free of any oxygen-rich layer, such as alpha case, any carbon-rich layer, or other surface contamination.

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 internal and external imperfections detrimental to usage of the castings.

3.7.1.1 Castings shall have smooth surfaces and shall be well cleaned. Metallic shot or grit shall not be used for final cleaning, unless otherwise permitted by purchaser.

3.7.2 Castings shall be produced under radiographic control, unless otherwise specified. 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 fluorescent penetrant inspection in accordance with AMS 2645.

3.7.4 Radiographic, fluorescent penetrant, and other quality standards shall be as agreed upon by purchaser and vendor.

3.7.5 Castings shall not be repaired by peening, plugging, welding, 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 to represent 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 representative separately-cast specimens or specimens cut from attached coupons are not available. Tensile properties of separately-cast specimens or of specimens from attached coupons 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 or 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, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be in accordance with the following; a lot shall be all Ø castings of the same part number poured from the same master heat in not longer than eight consecutive hours, annealed in the same heat treat batch, and presented for vendor's inspection at one time:

4.3.1 Two chemical analysis specimens in accordance with 3.4.1 or a casting from each master heat except that for hydrogen determinations one sample from each lot, obtained after thermal and chemical processing is completed.

4.3.2 Three separately-cast tensile specimens in accordance with 3.4.2 from each master heat except when tensile specimens are permitted to be obtained from attached coupons as in 4.3.3.

4.3.3 One attached coupon, when specified or permitted by purchaser, obtained from each of three castings or clusters of castings selected at random from each lot. Coupons shall be of a size and shape and located on castings as specified on the part drawing or as agreed upon by purchaser and vendor. Specimens conforming to ASTM E8 with 0.250 in. (6.25 mm) diameter at the reduced parallel gage section shall be machined from each coupon.

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

4.3.5 One or more castings from each lot when tensile properties of specimens cut from castings are required. Specimens shall conform to ASTM E8 and shall be either 0.250 in. (6.25 mm) diameter at the reduced parallel gage section, sub-size specimens proportional to the standard, or standard sheet-type specimens. For determining conformance to the requirements of 3.6.1.2, if specimen locations are not specified on the drawing or by purchaser, not less than four tensile specimens, two from the thickest section and two from the thinnest section, shall be cut from a casting or castings from each lot.

4.3.6 For determining conformance to quality requirements, sampling shall be as agreed upon by purchaser and vendor.

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 parameters for the process control factors, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, sample test specimens, 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:

Size of furnace crucible
Master heat metal source
Vacuum level
Mold refractory formulation
Mold back-up material
Gating practices
Mold preheat and pouring temperatures (variations of ±25°F (±15°C) from established limits are permissible)
Solidification and cooling procedures
Annealing heat treatment cycles
Hot isostatic processing procedures, when specified
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.

4.5 Reports:

4.5.1 The vendor of castings shall furnish with each shipment three copies of a report showing the results of tests for chemical composition of at least one casting, or of specimens as in 3.4.1 cast in a mold with parts, from each master heat represented and the results of tests for tensile properties of separately-cast specimens, of specimens cut from attached coupons when permitted, or of specimens cut from castings representing each lot, and the results of tests for hydrogen content and hardness of castings from each lot, and stating that the castings conform to the quality requirements of this specification. This report shall include the purchase order number, master heat number or code symbol, AMS 4985A, part number, and quantity from each master heat.

4.5.2 The vendor of finished or semi-finished parts shall furnish with each shipment three copies of a report showing the purchase order number, AMS 4985A, contractor or other direct supplier of castings, part number, and quantity. When castings for making parts are produced or purchased by the parts vendor, that vendor shall inspect castings from each master heat represented to determine conformance to the requirements of this specification and shall include in the report either a statement that the castings conform or copies of laboratory reports showing the results of tests to determine conformance.