AEROSPACE MATERIAL SPECIFICATION

AMS6906™	REV. D
Issued 2004-01 Revised 2024-11 Superseding AMS6906C	

Titanium Alloy Bars, Forgings, and Forging Stock
6.0Al - 2.0Sn - 4.0Zr - 6.0Mo
Solution Heat Treated and Aged
(Composition similar to UNS R56260)

RATIONALE

AMS6906D results from a Five-Year Review and update of this specification with changes to clarify maximum cross-sectional area in Form (see 1.1) and Tensile Properties (see Table 2 and 3.5.1.1.7), update wording to prohibit unauthorized exceptions (see 3.5.1.1.5 and 8.5), relocate Definitions (see 2.3) and information on statistical analysis (see 3.5.1.1.6), and update Applicable Documents (see Section 2) and Ordering Information (see 8.6).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of bars up through 4.000 inches (101.60 mm) in nominal diameter or least distance between parallel sides, inclusive, and maximum cross-sectional area of 32 square inches (206.5 cm^2), forgings of thickness up through 4.000 inches (101.60 mm), inclusive, and maximum cross-sectional area of 32 square inches (206.5 cm^2), and stock for forging of any size (see 8.6).

1.2 Application

These products have been used typically for parts requiring high strength up to 1000 °F (538 °C), but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP982 recommends practices to minimize such conditions.

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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
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For more information on this standard, visit
https://www.sae.org/standards/content/AMS6906D/

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2241 Tolerances, Corrosion- and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

AMS2368 Sampling and Testing of Wrought Titanium Raw Material, Except Forgings and Forging Stock

AMS2631 Ultrasonic Inspection, Titanium and Titanium Alloy Bar, Billet, and Plate

AMS2643 Structural Examination of Titanium Alloys, Chemical Etch Inspection Procedure

AMS2750 Pyrometry

AMS2808 Identification, Forgings

AMS2809 Identification, Titanium and Titanium Alloy Wrought Products

ARP982 Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

AS1814 Terminology for Titanium Microstructures

AS6279 Standard Practice for Production, Distribution, and Procurement of Metal Stock

AS7766 Terms Used in Aerospace Metals Specifications

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 E8/E8M Tension Testing of Metallic Materials

ASTM E539 Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

ASTM E1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

ASTM E1447 Determination of Hydrogen in Reactive Metals and Reactive Metal Alloys by the Inert Gas Fusion Thermal Conductivity or Infrared Spectrometry

ASTM E1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E2371 Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)

ASTM E2994 Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

2.3 Definitions

Terms used in AMS are defined in AS7766.

2.3.1 Terminology relating to titanium microstructures is presented in AS1814.

3. TECHNICAL REQUIREMENTS

3.1 Composition

Shall conform to the percentages by weight shown in Table 1; carbon shall be determined in accordance with ASTM E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E539, ASTM E2371, or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max
Aluminum	5.50	6.50
Molybdenum	5.50	6.50
Zirconium	3.60	4.40
Tin	1.75	2.25
Iron	--	0.15
Oxygen	--	0.15
Carbon	--	0.04
Nitrogen	--	0.04 (400 ppm)
Hydrogen	--	0.0125 (125 ppm)
Yttrium (see 3.1.1)	--	0.005 (50 ppm)
Other Elements, each (see 3.1.1)	--	0.10
Other Elements, total (see 3.1.1)	--	0.40
Titanium	remainder	

3.1.1 Determination not required for routine acceptance.

3.1.2 Check Analysis

Composition variations shall meet the applicable requirements of AMS2249.

3.2 Melting Practice

Alloy shall be multiple melted. The first melt shall be made by vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final melt cycle.

3.2.1 The atmosphere for nonconsumable electrode melting shall be vacuum or shall be argon or helium at an absolute pressure not higher than 1000 mm of mercury.

3.2.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

3.3 Condition

The product shall be supplied in the following condition:

3.3.1 Bars

Hot finished with or without subsequent cold reduction, solution heat treated, aged, and descaled. A machined or ground surface is permitted unless prohibited by the purchaser. The product shall be processed to the final thickness/diameter by metallurgical working operations prior to any straightening, dimensional sizing, or surface finishing operations. Bar shall not be cut from plate.

3.3.2 Forgings

Solution heat treated, aged, and descaled.

3.3.3 Stock for Forging

As ordered by the forging manufacturer.

3.4 Heat Treatment

Bars and forgings shall be solution heat treated at 1500 to 1675 °F (816 to 913 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with section thickness and the heating equipment and procedure used, and water quenched (except that thin sections may be air cooled) and aged at 1050 to 1250 °F (566 to 677 °C), holding at the selected temperature within ±15 °F (±8 °C) for 4 to 8 hours. Pyrometry shall be in accordance with AMS2750.

3.5 Properties

The product shall conform to the following requirements:

3.5.1 Bars and Forgings

3.5.1.1 Tensile Properties

Shall be as specified in Table 2, determined in accordance with ASTM E8/E8M with the rate of strain set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (±0.002 mm/mm/min) through the 0.2% offset yield strain.

3.5.1.1.1 Tensile property requirements apply in both the longitudinal and transverse directions. Transverse tensile properties of Table 2 apply only to product that a test specimen not less than 2.50 inches (63.5 mm) in length can be obtained.

3.5.1.1.2 Specimens for the longitudinal requirements in Table 2 shall be taken with the axis of the specimen within 15 degrees of parallel to the grain flow.

3.5.1.1.3 Yield strength and reduction of area requirements do not apply to product under 0.125 inch (3.18 mm) in nominal diameter or least distance between parallel sides.

3.5.1.1.4 Values in brackets [ ] apply to the short-transverse direction for short-transverse dimensions of 3.00 inches or greater. When short-transverse properties are determined, long-transverse properties do not need to be determined.

Table 2 - Minimum tensile properties (see 3.5.1.1.6)

Nominal Diameter or Least Distance Between Parallel Sides Inches (Millimeters)	Maximum Cross-Sectional Area Square Inches (cm^2) (3.5.1.1.7)	Tensile Strength ksi (MPa)	Yield Strength at 0.2% Offset ksi (MPa)	Elongation in 2 Inches (50.8 mm) or 4D % (3.5.1.1.4)	Reduction of Area % (3.5.1.1.4)
Up to 2.50 (63.5), incl	32 (206.5)	170 (1172)	160 (1103)	10	20
Over 2.50 (63.5) to 3.00 (76.2), incl		165 (1138)	155 (1068)	8 [6]	15 [12]
Over 3.00 (76.2) to 4.00 (101.6), incl		160 (1103)	150 (1034)	8 [6]	15 [12]

3.5.1.1.5 Mechanical property requirements for product outside the size range covered by Table 2 shall be agreed upon between the purchaser and producer and reported per 4.4.3 (see 8.6).

3.5.1.1.6 Mechanical properties for the sizes listed in Table 2 were taken from MIL-T-9047 and have not been substantiated by AMS statistical procedures.

3.5.1.1.7 Maximum cross-sectional area of 32 square inches (206.5 cm^2) applies to all product sizes in Table 2.

3.5.1.2 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.1.2.1 or 3.5.1.2.2 (see 2.3.1).

3.5.1.2.1 Equiaxed and/or elongated primary alpha in a transformed beta matrix with no continuous network of alpha at prior beta grain boundaries.

3.5.1.2.2 Primary alpha in an aged transformed beta matrix.

3.5.1.2.3 A microstructure showing a continuous network of alpha in prior beta grain boundaries is not acceptable.

3.5.1.3 Surface Contamination

Except as specified in 3.5.1.3.1, the product shall be free of any oxygen-rich layer (see 8.2), such as alpha case, or other surface contamination, determined by microscopic examination at not lower than 400X magnification or by other method agreed upon by the purchaser and producer (see 8.6).

3.5.1.3.1 When permitted by the purchaser, product to be machined all over may have an oxygen-rich layer, provided such layer is removable within the machining allowance on the product.

3.5.1.4 Macrostructure

Product shall be uniform in quality and condition, homogenous, sound, and free from foreign materials and from internal imperfections detrimental to fabrication or performance of parts.

3.5.2 Stock for Forging

When a sample of stock is forged to a test coupon and heat treated as in 3.4, specimens taken from the heat-treated coupon shall conform to the requirements of 3.5.1.1. If specimens taken from the stock after heat treatment as in 3.4 conform to the requirements of 3.5.1.1, the tests shall be accepted as equivalent to tests of a forged coupon.

3.6 Quality

The product, as received by the purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from imperfections detrimental to usage of the product.

3.6.1 Ultrasonic Inspection

Product 0.500 to 1.500 inches (12.70 to 38.10 mm), inclusive, in nominal thickness, diameter, or least distance between parallel sides shall meet Class A1 requirements of AMS2631. Product over 1.500 inches (38.10 mm) in nominal thickness, diameter, or least distance between parallel sides shall meet Class A requirements of AMS2631.

3.7 Tolerances

Bars shall conform to all applicable requirements of AMS2241.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279.

3.9 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.3.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The producer of the product shall supply all samples for the producer's tests and shall be responsible for the performance of all required tests. The purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

The following requirements are acceptance tests and shall be performed on each heat or lot as applicable:

4.2.1.1 Composition (see 3.1) of each heat.

4.2.1.2 Hydrogen content (see 3.1), tensile properties (see 3.5.1.1), microstructure (see 3.5.1.2), surface contamination (see 3.5.1.3), and macrostructure (see 3.5.1.4) of each lot of bars and forgings.

4.2.1.3 Ultrasonic quality of each bar, forging, or forging stock as required by 3.6.1.

4.2.1.4 Tolerances (see 3.7) of bars.

4.2.2 Periodic Tests

Ability of stock for forging (see 3.5.2) to develop specified properties is a periodic test and shall be performed at a frequency selected by the producer unless frequency of testing is specified by the purchaser.

4.3 Sampling and Testing

Shall be in accordance with AMS2368 and as follows; a lot shall be all product of the same nominal size from the same heat processed at the same time:

4.3.1 For Acceptance Tests

4.3.1.1 Composition

At least one sample from each heat, except that for hydrogen determinations one sample from each lot obtained after all thermal and chemical processing is completed.

4.3.1.2 Tensile Properties

At least one sample from bars from each lot. The number, location, and orientation of samples from each lot of forgings shall be as agreed upon by the purchaser and producer (see 8.6).

4.3.1.3 Macrostructure

A specimen at least 0.5-inch (12.7-mm) long by full cross section from each end of the bars selected for sampling shall be macrostructurally examined for conformance to the quality requirements. Unless otherwise specified, macrostructural examination shall be performed in accordance with AMS2643. The number of bars selected for examination shall not be less than the amounts shown in Table 3.