AEROSPACE MATERIAL SPECIFICATION

AMS4957™	REV. H

Issued 1987-10
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Superseding AMS4957G

Titanium Alloy, Round Bar and Wire, 3Al - 8V - 6Cr - 4Mo - 4Zr, Consumable Electrode Melted, Solution Heat Treated and Cold Drawn

(Composition similar to UNS R58640)

RATIONALE

AMS4957H results from a Five-Year Review and update of this specification with changes to update standard language related to unauthorized exceptions (see 3.4.2.1.1 and 8.6), relocate Definitions (see 2.3), add standard note related to alpha case (see 8.4), and update Applicable Documents (see Section 2), Average Grain Size (see 3.4.1.3), size recommendation for nondestructive inspection methods (see 8.2), and Ordering Information (see 8.7).

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of round bar and wire 0.625 inch (15.88 mm) and under in nominal diameter or thickness (see 8.7).

1.2 Application

These products have been used typically for coil springs requiring high tensile strength and corrosion resistance, but usage is not limited to such applications.

1.3 Classification

Bars and wire shall be classified as follows:

Type 1 - Straight lengths; solution heat treated, cold drawn, straightened, and centerless ground or polished

Type 2 - Coil; solution heat treated and cold drawn

1.3.1 Either Type 1 or Type 2 may be supplied unless a specific type is ordered.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS4957H/

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 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

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

AMS2750 Pyrometry

AMS2809 Identification, Titanium and Titanium Alloy Wrought Products

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 E112 Determining Average Grain Size

ASTM E426 Electromagnetic (Eddy Current) Testing of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

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 E1417 Liquid Penetrant Testing

ASTM E1447 Determination of Hydrogen in Reactive Metals and Reactive Metal Alloys by Inert Gas Fusion with Detection by 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 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.

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
Vanadium	7.50	8.50
Chromium	5.50	6.50
Molybdenum	3.50	4.50
Zirconium	3.50	4.50
Aluminum	3.00	4.00
Iron	--	0.30
Oxygen	--	0.14
Palladium (see 3.1.1)	--	0.10
Carbon	--	0.05
Nitrogen	--	0.03
Hydrogen (see 3.1.2)	--	0.030 (300 ppm)
Yttrium (see 3.1.3)	--	0.005 (50 ppm)
Other Elements, each (see 3.1.3)	--	0.15
Other Elements, total (see 3.1.3)	--	0.40
Titanium	remainder	

3.1.1 Determination not required unless intentionally added.

3.1.2 To be determined on final product.

3.1.3 Determination not required for routine acceptance.

3.1.4 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 melting cycle(s) prior to the final melting cycle(s) shall be vacuum or shall be argon and/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 solution treated at 1450 to 1700 °F (790 to 925 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with the thickness and the heating equipment and procedure used, with a cooling rate equivalent to an air cool or faster, and cold drawn to reduce cross-sectional area by 20 to 35%. Pyrometry shall be in accordance with AMS2750.

3.3.1 Type 1

Straight lengths, after solution heat treatment and cold drawing, shall be straightened, centerless ground or polished, cleaned, and acid pickled. Cleaning plus acid pickling shall remove not less than 0.0005-inch (0.013-mm) metal from the surface.

3.3.2 Type 2

Coils, after solution heat treatment and cold drawing, shall be cleaned and acid pickled. Cleaning plus acid pickling shall remove not less than 0.0005-inch (0.013-mm) metal from the surface.

3.3.3 The product shall be furnished bare unless lubricant coating is specified. The lubricant used shall not contain chlorides or other substances deleterious to titanium and shall be suitable for use on automatic spring winding machines.

3.4 Properties

The product shall conform to the following requirements:

3.4.1 As Cold Drawn

3.4.1.1 Coiling

The product shall show uniform pitch when wound two coil minimum on an arbor having less than or equal to the diameter specified in Table 2. All surfaces of the coil test shall be visually inspected at 8 to 12X magnification for the existence of cracks and seams. The test piece shall be extended as required to allow inspection of the coils.

Table 2A - Diameter versus arbor diameter, inch/pound units

Nominal Diameter (D) Inches	Arbor Diameter Inches
Up to 0.125, incl	0.250
Over 0.125 to 0.187, incl	0.375
Over 0.187 to 0.250, incl	0.500
Over 0.250 to 0.312, incl	0.625
Over 0.312 to 0.375, incl	0.750
Over 0.375 to 0.435, incl	0.875
Over 0.435 to 0.500, incl	1.000
Over 0.500 to 0.560, incl	1.125
Over 0.560 to 0.625, incl	1.250

Table 2B - Diameter versus arbor diameter, SI units

Nominal Diameter (D) Millimeters	Arbor Diameter Millimeters
Up to 3.18, incl	6.35
Over 3.18 to 4.75, incl	9.53
Over 4.75 to 6.35, incl	12.70
Over 6.35 to 7.92, incl	15.88
Over 7.92 to 9.53, incl	19.05
Over 9.53 to 11.05, incl	22.23
Over 11.05 to 12.70, incl	25.40
Over 12.70 to 14.22, incl	28.58
Over 14.22 to 15.88, incl	31.75

3.4.1.2 Microstructure

The product shall be examined at 400X minimum magnification and determined to be uniform and free from defects and surface contamination, such as alpha case (see 8.4).

3.4.1.3 Average Grain Size

The product shall have an average grain size of ASTM No. 5 or finer, determined in accordance with ASTM E112. The test sample may be aged (decoration age) sufficiently to delineate grain boundaries.

3.4.2 After Aging

The product shall have the following properties after being aged by heating to a temperature within the range 900 to 1050 °F (482 to 566 °C), holding at the selected temperature within ±10 °F (±6 °C) for 6 to 12 hours, and cooling in air; pyrometry shall be in accordance with AMS2750:

3.4.2.1 Tensile Properties

Shall be as shown in Table 3, determined in accordance with ASTM E8/E8M, as applicable.

Table 3A - Tensile properties, inch/pound units

Nominal Diameter Inch	Tensile Strength ksi	Elongation in 4D %, Min	Reduction of Area %, Min
Up to 0.187, incl	190 to 210	10	20
Over 0.187 to 0.375, incl	185 to 205	10	20
Over 0.375 to 0.625, incl	180 to 200	8	20

Table 3B - Tensile properties, SI units

Nominal Diameter Millimeters	Tensile Strength MPa	Elongation in 4D %, Min	Reduction of Area %, Min
Up to 4.75, incl	1310 to 1448	10	20
Over 4.75 to 9.52, incl	1276 to 1413	10	20
Over 9.52 to 15.88, incl	1241 to 1379	8	20

3.4.2.1.1 Mechanical property requirements for product outside the range covered by 1.1 shall be agreed upon between the purchaser and producer and reported per 4.4.2 (see 8.7).

3.5 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.

3.5.1 Visual Inspection

The product shall have a smooth surface free from pits, seams, laps, cracks, ruptures, and abrasions; it shall be clean and free from kinks, twists, scrapes, splits, mechanical damage, and other imperfections. Coils shall have a uniform cast.

3.5.2 Nondestructive Testing of Type 1 Straight Lengths

All product shall be tested by ultrasonic inspection or electromagnetic (eddy current) inspection acceptable to the purchaser (see 8.2). Ultrasonic inspection shall be both longitudinal, in accordance with AMS2631, Class AA, and shear wave, as specified in 3.5.2.1. Electromagnetic inspection shall be performed by a technique equivalent to that in ASTM E426. After setup per AMS2631, Class AA, the alarm gate for longitudinal (internal) inspection shall be set no higher than 75% of the response from the reference standard. The noise level on the longitudinal test must be below 25%.

3.5.2.1 Ultrasonic Inspection of Type 1 Straight Lengths

Calibration of ultrasonic equipment shall be performed at the start of operations and at least once every 2 hours of continuous operation or when there is a change of equipment or loss of power. A calibration standard as in 3.5.2.1.1 shall be used for each bar size. The diameter of the calibration standard used shall be within 5% of the diameter of the product being tested. The arrangement of transducers shall be such that no cross-talk is encountered. Bar supporting equipment shall provide in-line stability for the complete length of each bar. The equipment shall be such that transducers functioning in a clockwise and counterclockwise direction (this is a two-channel circumferential shear requirement) may be separately gated and recorded. The pulse rate of the equipment shall provide 100% coverage at maximum bar rotational rates. The helix feed angle shall be such that at least two rejectable signals are produced for each 0.250 inch (6.35 mm), or fraction thereof, of notch length on consecutive powered turns of the calibration standard bar.

3.5.2.1.1 Calibration Standard

Notches shall be parallel to the bar axis with a maximum length of 0.500 inch (12.70 mm) and a maximum width of 0.010 inch (0.25 mm). Depth of notches shall be 0.004-inch (0.10-mm) maximum with signal amplitude and alarm gate set at 80% of full scale.

3.5.2.1.2 The placement of calibration notches in each standard shall be such that water-travel-distance, shear-angle, helix-angle, and equipment gain as established during calibration remain identical during production applications. Calibration notches may be produced by electrodischarge machining.

3.5.3 Nondestructive Testing of Type 2 Coiled Product

All product shall be nondestructively tested by electromagnetic (eddy current) inspection by a technique equivalent to that in ASTM E426. Sizes below 0.125-inch (3.18-mm) diameter may be tested at the closest practical intermediate size. Large-diameter product, furnished in coil form, that cannot be eddy current tested shall be free of cracks and ruptures detectable by liquid penetrant examination in accordance with ASTM E1417.

3.6 Tolerances

Shall be in accordance with AMS2241.

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

3.8 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.2.

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 specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (see 3.1), microstructure (see 3.4.1.2), average grain size (see 3.4.1.3), tensile properties after aging (see 3.4.2.1), nondestructive testing of Type 1 straight lengths (see 3.5.2), and nondestructive testing of Type 2 coil (see 3.5.3) are acceptance tests and shall be performed on each heat or lot as applicable.