

AEROSPACE MATERIAL SPECIFICATION

SAE AMS4957

REV. E

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Superseding AMS4957D

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

AMS4957E results from a Five Year Review and update of this specification.

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.

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 follow:

Type 1 - Straight lengths; Solution heat treated, cold drawn, straightened and centerless ground

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.

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.

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2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 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 and Billet
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products

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 E 8 / E 8M Tension Testing of Metallic Materials

ASTM E 112 Determining Average Grain Size

ASTM E 426 Electromagnetic (Eddy Current) Testing of Seamless and Welded Tubular Products, Austenitic Stainless Steel and Similar Alloys

ASTM E 1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique

ASTM E 1417 Liquid Penetrant Testing

ASTM E 1447 Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

ASTM E 1941 Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

ASTM E 2371 Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

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 E 1941, hydrogen in accordance with ASTM E 1447, oxygen and nitrogen in accordance with ASTM E 1409, and other elements in accordance with ASTM E 2371. 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 (3.1.2)	--	0.10
Carbon	--	0.05
Nitrogen	--	0.03
Hydrogen (3.1.1, 3.1.3)	--	0.030 (300 ppm)
Yttrium (3.1.4)	--	0.005 (50 ppm)
Other Elements, each (3.1.4)	--	0.15
Other Elements, total (3.1.4)	--	0.40
Titanium	remainder	

3.1.1 When ASTM E 1447 is used for hydrogen determination, sample size may be as large as 0.35 gram.

3.1.2 Determination not required unless intentionally added.

3.1.3 To be determined on final product.

3.1.4 Determination not required for routine acceptance.

3.1.5 Check Analysis

Composition variations shall meet the applicable requirements of AMS2249.

3.2 Melting Practice

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

3.2.1.1 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.

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

3.3 Condition

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, 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 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

Product shall show uniform pitch when wound 2 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 VS ARBOR DIAMETER, INCH/POUND UNITS

Nominal Diameter (D) Inch	Arbor Diameter Inch
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 VS 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

Product shall be examined at 400X minimum magnification and determined to be uniform and free from defects and surface contamination such as alpha case.

3.4.1.3 Average Grain Size

Product shall have an average grain size of ASTM No. 5 or finer, determined in accordance with ASTM E 112. For sizes 0.500 inch (12.7 mm) and above, occasional fields having an average grain size of ASTM No. 4 are permissible. The test sample shall 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 E 8 / E 8M, 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

3.5 Quality

The product, 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 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 (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 E 426. The noise amplitude, during inspection of bars, shall be not greater than 10% below the alarm gate height or 25% of full scale, whichever is less.

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 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 length of 0.250 inch $\pm$ 0.002 to 0.500 inch $\pm$ 0.002 (6.35 mm $\pm$ 0.05 to 12.70 mm $\pm$ 0.05) and a maximum width of 0.003 inch (0.08 mm). Depth of notches shall be 0.002 inch (0.05 mm) maximum with signal amplitude and alarm gate set at 50% of full scale. Alternatively, deeper notches may be used, up to 0.004 inch (0.10 mm), providing that the signal amplitude and alarm gate are set so as to produce a rejectable signal from a 0.002 inch (0.05 mm) deep defect in production bars.

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 E 426. 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, which cannot be eddy current tested shall be free of cracks and ruptures detectable by liquid penetrant examination in accordance with ASTM E 1417.

3.6 Tolerances

Shall be in accordance with AMS2241.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of the product shall supply all samples for vendor's tests and shall be responsible for the performance of all required tests. 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 (3.1) microstructure (3.4.1.2), average grain size (3.4.1.3), tensile properties after aging (3.4.2.1), nondestructive testing of Type 1 straight lengths (3.5.2), and nondestructive testing of Type 2 coil (3.5.3) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Coiling (3.4.1.1) and fluorescent penetrant testing of large diameter product furnished in coil form (3.5.3) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.