SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4957C

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Superseding AMS 4957B

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)

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.

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

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2241	Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Bars and Wire
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2631	Ultrasonic Inspection, Titanium and Titanium Alloy Bar and Billet
AMS 2750	Pyrometry
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 8M	Tension Testing of Metallic Materials (Metric)
ASTM E 112	Determining Average Grain Size
ASTM E 120	Chemical Analysis of Titanium and Titanium Alloys
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 in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
ASTM E 1417	Liquid Penetrant Examination
ASTM E 1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight shown in Table 1; oxygen shall be determined in accordance with ASTM E 1409, hydrogen in accordance with ASTM E 1447, and other elements by wet chemical methods in accordance with ASTM E 120, by spectrochemical methods, or by other analytical methods acceptable to 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)
Residual Elements, each (3.1.4)	--	0.15
Residual 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 requirements of AMS 2249.

3.2 Melting Practice:

3.2.1 Alloy shall be multiple melted. Melting cycle(s) prior to the final melting cycle shall be made using consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice(s). The final melting cycle shall be made under vacuum using consumable electrode practice with no alloy additions permitted.

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 in accordance with AMS-H-81200 with a cooling rate equivalent to an air cool or faster and cold drawn to reduce cross sectional area by 20 to 35%.

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 Wrapping: Product under 0.312 inch (7.92 mm) in nominal diameter shall withstand, without cracking, wrapping at room temperature one full turn around a diameter equal to the nominal diameter of the product. All surfaces shall be examined at 10X magnification and determined to be free of cracks and ruptures. Test specimens shall accompany shipment of product and be free of cracks and ruptures detectable by liquid penetrant examination in accordance with ASTM E 1417.

3.4.1.2 Coiling: Product shall be wound in a tightly closed coil, with a minimum of five complete turns on an arbor having a diameter as specified in Table 2. For sizes up to 0.1875 inch (4.762 mm), inclusive, the resultant coil shall be stretched to a permanent set of four times its wound length. Coils shall exhibit a uniform pitch with no splits or fractures.

TABLE 2A - Diameter vs. Arbor Diameter, Inch/Pound Units

Nominal Diameter (D) Inch	Arbor Diameter Inch
Up to 0.034, incl	0.102
Over 0.034 to 0.045, incl	0.145
Over 0.045 to 0.055, incl	0.212
Over 0.055 to 0.125, incl	0.250
Over 0.125 to 0.625, incl	2D

TABLE 2B - Diameter vs. Arbor Diameter, SI Units

Nominal Diameter (D) Millimeters					Arbor Diameter Millimeters
	Up	to	0.86,	incl	2.59
Over	0.86	to	1.14,	incl	3.68
Over	1.14	to	1.40,	incl	5.38
Over	1.40	to	3.18,	incl	6.35
Over	3.18	to	15.88,	incl	2D

3.4.1.3 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.

3.4.1.4 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 AMS 2750.

3.4.2.1 Tensile Properties: Shall be as shown in Table 3, determined in accordance with ASTM E 8 or ASTM 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 AMS 2631, 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 two 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 ± 0.002 to 0.500 inch ± 0.002 (6.35 mm ± 0.05 to 12.70 mm ± 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 AMS 2241.

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 the specified requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Composition (3.1), wrapping (3.4.1.1), microstructure (3.4.1.3), average grain size (3.4.1.4), 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 (3.4.1.2), fluorescent penetrant testing of all wrap test specimens (3.4.1.1) and 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.

4.3 Sampling and Testing:

Shall be in accordance with the following; a lot shall be all product of the same nominal size from the same heat processed at the same time.

4.3.1 Composition: One sample from the top and bottom of each heat except that for hydrogen determinations, one sample from each lot obtained after thermal and chemical processing is completed.

4.3.2 Wrapping, and Tensile Properties: Two samples from each lot.

4.3.3 Microstructure: One sample from each lot.

4.4 Reports:

The vendor of the product shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, average grain size, and tensile properties of each lot and stating that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS 4957C, size, quantity, and aging time and temperature.