AEROSPACE MATERIAL SPECIFICATION

AMS4922	REV. C

Issued 1990-10
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Reaffirmed 2012-02

Superseding AMS4922B

Titanium Alloy, Seamless, Hydraulic Tubing
15V - 3.0Cr - 3.0Al - 3.0Sn
Cold Worked and Precipitation Heat Treated
(Composition similar to UNS R58153)

RATIONALE

AMS4922C has been reaffirmed to comply with the SAE five-year review policy.

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of seamless tubing.

1.2 Application

This tubing has been used typically for parts, such as high-pressure hydraulic lines, requiring high strength and oxidation resistance up to 550 °F (288 °C) and weldability, but usage is not limited to such applications.

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 724-776-4970 (outside USA), www.sae.org.

AMS2244	Tolerances, Titanium and Titanium Alloy Tubing
AMS2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS2634	Ultrasonic Inspection, Thin Wall Metal Tubing
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products
AS33611	Tube Bend Radii

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS4922C

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

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

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

2.3 ASME Publications

Available from American Society of Mechanical Engineers, 22 Law Drive, P.O. Box 2900, Fairfield, NJ 07007, 2300, Tel: 973-882-1170, www.asme.org.

ASME B46.1 Surface Texture

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	14.0	16.0
Chromium	2.5	3.5
Aluminum	2.5	3.5
Tin	2.5	3.5
Iron	--	0.25
Carbon	--	0.05
Oxygen	--	0.13
Nitrogen	--	0.050 (500 ppm)
Hydrogen	--	0.015 (150 ppm)
Other Elements, each (3.1.1)	--	0.10
Other Elements, total (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. Melting cycle(s) prior to the final melting cycle shall be made using vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice(s). The final melting cycle shall be made under vacuum using vacuum arc remelting (VAR) practice with no alloy additions permitted.

3.2.1 The atmosphere for nonconsumable electrode melting 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 and Heat Treatment

Cold worked and precipitation heat treated by heating to a temperature within the range 900 to 1250 °F (482 to 677 °C) and holding at the selected temperature within ±25 °F (±14 °C) for not less than 2 hours. Pyrometry shall be in accordance with AMS2750.

3.4 Properties

Tubing shall conform to the following requirements:

3.4.1 Tensile Properties

Shall be as shown in Table 2, determined in accordance with ASTM E 8 / E 8M with the rate of strain set at 0.005 inch/inch/minute (0.005 mm/mm/minute) and maintained within a tolerance of ± 0.002 inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

TABLE 2 - MINIMUM TENSILE PROPERTIES

Property	Value
Tensile Strength	135 ksi (931 MPa)
Yield Strength at 0.2% Offset	125 ksi (862 MPa)
Elongation in 2 Inches (50.8 mm)	
Nominal Wall Thickness	
Up to 0.020 Inch (0.51 mm), incl	10%
Over 0.020 Inch (0.51 mm)	12%

3.4.2 Pressure Testing

Tubing shall show no bulges, leaks, pin holes, cracks, or other defects when subjected to an internal hydrostatic pressure (P) sufficient to cause a tensile stress equal to 125 ksi (862 MPa) in the tubing wall, except that a diametric permanent set of 0.002 inch/inch (0.002 mm/mm) of diameter is acceptable. The hydrostatic pressure (P) shall be determined from Equation 1, but shall not exceed 20 ksi (138 MPa):

$$P = S\frac{D^2 - d^2}{D^2 + d^2} \quad \text{(Eq. 1)}$$

where:

P = Test pressure in ksi (MPa)

S = 125 ksi (862 MPa)

D = Nominal OD

d = Nominal ID

3.4.3 Bending

Tubing shall not develop cracks, tears, breaks, or other flaws when bent 180 degrees around a suitable die having a centerline radius equal to three times the nominal OD of the tubing. A solid rod or ball-type retractable mandrel inserted to the tangent of the bend, or an appropriate tube filler, shall be used to support the inside of the tube during bending to restrict flattening to a value that does not exceed 5% of the nominal OD of the tube. Flattening shall be determined in accordance with AS33611.

3.4.4 Flattening

The inside and outside surfaces of tubing shall show no cracks, tears, breaks, opened die marks, or opened polishing marks when a full section of the tube is flattened between parallel plates under a load applied gradually and perpendicularly to the longitudinal axis until the distance between the plates is not greater than values shown in Table 3. After examination of the outside surfaces, the samples shall be split longitudinally and the inside surfaces examined. Examination of tube surfaces shall be at 5 to 10X magnification.

TABLE 3 - FLATTENING TEST

Outside Diameter to Wall Thickness Ratio OD/t	Distance Between Plates (t = Wall Thickness)
Up to 12, incl	Not Required
Over 12 to 16, incl	12t
Over 16 to 30, incl	15t
Over 30 to 50, incl	17t

3.4.4.1 Alternate Flattening

When specified, sample(s) shall be sectioned longitudinally along the tube diameter and flattened between parallel plates until the distance between the plates is equal to the wall thickness of the tube sample. The inside and outside surfaces of tubing shall show no cracks, tears, breaks, opened die marks, or polishing marks.

3.4.5 Microstructure

Shall be predominantly a cold-worked, precipitated beta structure with dispersed, fine alpha precipitate. Tubing shall be free of alpha case (8.2) or other surface contamination, determined by microscopic examination at not less than 200X magnification, ammonium bifluoride etch inspection (3.4.5.1), microhardness testing, or other method acceptable to purchaser.

3.4.5.1 Ammonium Bifluoride Etch Inspection

A sample of tubing shall be etched with a solution of 18 grams ammonium bifluoride in a liter of distilled water. White or gray areas indicate alpha case.

3.4.5.2 Microstructural Hardness Differential

A surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E 384 on the Knoop scale using a 200 gram load, is evidence of unacceptable surface contamination.

3.5 Quality

Tubing, as received by purchaser, shall be uniform in quality and condition and shall have a finish conforming to the best practice for high quality aircraft tubing. It shall be smooth and free from scale or oxide, burrs, seams, tears, grooves, laminations, slivers, pits, and other imperfections detrimental to usage of the tubing.

3.5.1 Each tube shall be ultrasonically inspected in accordance with AMS2634, Class AA, for ID, OD, and subsurface imperfections of all types and orientation (longitudinal and transverse).

3.5.2 Surface Condition

3.5.2.1 OD Surface

Shall show a uniformly acid-pickled surface finish; not less than 0.001 inch (0.025 mm) of metal shall have been chemically removed from the wall thickness as a finishing operation. Belt polishing or buffing of the OD surface with a grit size of 400 or finer is permissible prior to the pickling operation. Centerless grinding or other mechanical operations are not acceptable.

3.5.2.2 ID Surface

Shall show a uniform matte finish, produced by abrasive blasting with grit not larger than 100 mesh (150 µm) followed by forced-flow, acid pickle to remove not less than 0.0005 inch (0.013 mm) of metal from the wall thickness.

3.5.2.3 Surface Texture

Shall be not greater than 63 microinches (1.6 µm) on the ID and be not greater than 32 microinches (0.8 µm) on the OD, determined in accordance with ASME B46.1.

3.5.2.4 Surface Cleanliness

Tubing shall be free from grease and other foreign matter. Metallic flakes or particles shall not be collected by a clean, white cloth drawn through the length of the bore of a test sample. Discoloration of the cloth, without the presence of flakes or particles, is acceptable.

3.6 Tolerances

Shall conform to all applicable requirements of the following:

3.6.1 Diameter

Shall be as specified in Table 4; tolerances shown include ovality.

TABLE 4A - OUTER DIAMETER, TOLERANCES, INCH/POUND UNITS

Nominal OD Inches	Tolerance Inch plus	Tolerance Inch minus
Over 0.093 to 0.188, incl	0.002	0.000
Over 0.188 to 0.500, incl	0.003	0.000
Over 0.500 to 1.000, incl	0.004	0.000
Over 1.000 to 1.500, incl	0.004	0.001
Over 1.500 to 2.000, incl	0.005	0.001

TABLE 4B - OUTER DIAMETER, TOLERANCES, SI UNITS

Nominal OD Millimeters	Tolerance Millimeter plus	Tolerance Millimeter minus
Over 2.36 to 4.78, incl	0.05	0.00
Over 4.78 to 12.70, incl	0.08	0.00
Over 12.70 to 25.40, incl	0.10	0.00
Over 25.40 to 38.10, incl	0.10	0.025
Over 38.10 to 50.80, incl	0.13	0.025

3.6.2 Wall Thickness

All tubing 1.500 inches (38.10 mm) and under in nominal OD shall not vary more than +10%, -5%; Tubing over 1.500 inches (38.10 mm) in nominal OD shall not vary more than ±10%.

3.6.3 Length and Straightness

Shall conform to AMS2244.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of tubing 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 tubing conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

All technical requirements, except pressure testing (3.4.2), are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Pressure testing (3.4.2) is a periodic test 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 tubing of the same nominal size from the same ingot, same processing, and finishing operations and precipitation heat treated in the same furnace charge.

4.3.1 Composition

One sample from each lot of tubing for hydrogen, oxygen, and nitrogen determinations shall be obtained after thermal and chemical processing is completed. An ingot analysis obtained from the alloy producer may be utilized to substantiate other requirements.

4.3.2 Tensile Properties

One sample from each 1000 feet (305 m) or three samples from each lot, whichever is greater.

4.3.3 Bending

Two samples from each lot.

4.3.4 Flattening

One sample from each 135 feet (41 m) of tubing or 10 samples from each lot, whichever is less. Each sample shall be not less than 2 inches (51 mm) long, cut in half with the cuts parallel to the axis of the tube.