SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

AMS 4942E

Issued JAN 1964
Revised JUN 2006

Superseding AMS 4942D

Titanium Tubing, Seamless
Annealed, 40.0 ksi (275 MPa) Yield Strength

(Composition similar to UNS R50400)

RATIONALE

AMS 4942E is a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers one grade of commercially-pure titanium in the form of seamless tubing.

1.2 Application

This tubing has been used typically for parts, such as fluid-conducting lines, requiring strength up to 400 °F (205 °C) and oxidation resistance up to 600 °F (315 °C), 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), or www.sae.org

AMS 2244	Tolerances, Titanium and Titanium Alloy Tubing
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2368	Sampling and Testing of Wrought Titanium Raw Material Except Forgings and Forging Stock
AMS 2809	Identification, Titanium Alloy Wrought Products
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys

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

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, or www.astm.org

ASTM E8	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	Standard Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys
ASTM E 2371	Standard Test Method for 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	
Iron	--	0.30	
Oxygen	--	0.25	
Carbon	--	0.10	
Nitrogen	--	0.03	(300 ppm)
Hydrogen (3.1.2)	--	0.015	(150 ppm)
Other Elements, each (3.1.1)	--	0.10	
Other Elements, total (3.1.1)	--	0.30	
Titanium	remainder		

3.1.1 Determination not required for routine acceptance.

3.1.2 Sample Size

When using ASTM E 1447 for hydrogen determination, size may be as large as 0.35 gram.

3.1.3 Check Analysis

Composition variations shall meet the applicable requirements of AMS 2249.

3.2 Melting Practice

Alloy shall be produced by electron beam cold hearth or plasma arc cold hearth melting practice, or shall be multiple melted with the final melting cycle under vacuum. When multiple melted, the first melt shall be made using 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 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

Cold reduced, annealed in accordance with AMS-H-81200, and descaled.

3.4 Properties

Tubing shall conform to the following requirements:

3.4.1 Tensile Properties

Shall be as specified in Table 2, determined in accordance with ASTM E 8 with the rate of strain maintained at 0.003 to 0.007 inch/inch/minute (0.003 to 0.007 mm/mm/minute) through the yield strength and then increased so as to produce failure in approximately one additional minute. When a dispute occurs between purchaser and vendor over the yield strength values, a referee test shall be performed on a machine having a strain rate pacer, using a rate of 0.005 inch/inch/minute (0.005 mm/mm/minute) through the yield strength and a minimum crosshead speed of 0.10 inch (2.5 mm) per minute above the yield strength.

TABLE 2 - TENSILE PROPERTIES

Property	Value
Tensile Strength	50.0 ksi (345 MPa) min
Yield Strength at 0.2% Offset	40.0 to 65.0 ksi (276 to 448 MPa)
Elongation in 2 inches (50.8 mm)	20% min

3.4.2 Flattening

3.4.2.1 Tubing with nominal wall thickness of 7 to 15% of the nominal OD shall withstand, without cracking on the OD surface, flattening sideways at room temperature under a load applied gradually until the outside dimension under load is equal to 7 times the nominal wall thickness.

3.4.2.1.1 If tubing does not pass the flattening test, a section of tube shall withstand, without cracking, bending at room temperature through an angle of 180 degrees around a diameter equal to 5 times the nominal wall thickness of the tubing. The axis of the bend shall be parallel to the axis of the tube and the inside of the tube shall be on the inside of the bend.

3.4.2.2 Tubing with nominal wall thickness less than 7% or greater than 15% of the nominal OD shall have flattening or bending properties as agreed upon by purchaser and vendor.

3.4.3 Flarability

Specimens as in 4.3.2.1 shall withstand flaring at room temperature, without formation of cracks or other visible defects, by being forced axially with steady pressure over a hardened and polished tapered steel pin having a 74-degree included angle to produce a flare having a permanent expanded OD not less than 1.30 times the original nominal OD.

3.4.4 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 (S) of 20.0 ksi (140 MPa) in the tubing wall. The hydrostatic pressure (P) shall be determined from Equation 1:

$$P = S \frac{D^2 - d^2}{D^2 + d^2}$$

where:

P = Test pressure in ksi (MPa)
S = 20.0 ksi (140 MPa) tensile stress
D = Nominal OD
d = Nominal ID

3.4.5 Surface Contamination

Tubing shall be free of any oxygen-rich layer, such as alpha case (See 8.2), or other surface contamination, determined by microscopic examination at not lower than 100X magnification or by other methods agreed upon by purchaser and vendor.

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 heavy scale or oxide, burrs, seams, tears, grooves, laminations, slivers, pits, and other imperfections detrimental to usage of the tubing. Surface imperfections such as handling marks, straightening marks, light mandrel and die marks, shallow pits, and scale pattern will not be considered injurious if the imperfections are removable within the tolerances specified for wall thickness but removal of such imperfections is not required.

3.6 Tolerances

Unless otherwise specified, tolerances shall conform to all applicable requirements of AMS 2244; standard tolerances for diameter and wall thickness shall apply.

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

Composition (3.1), tensile properties (3.4.1), flattening (3.4.2), pressure test (3.4.4), surface contamination (3.4.5), and tolerances (3.6) are acceptance tests and shall be performed on each heat or lot as applicable.

4.2.2 Periodic Tests

Flarability (3.4.3) 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 AMS 2368 and the following:

4.3.1 For Acceptance Tests

4.3.1.1 Flattening Tests and Pressure Tests

One or more samples from each lot.

4.3.1.1.1 Specimens for the alternate bend test of 3.4.2.1.1 shall be not less than 0.500 inch (12.50 mm) in length and shall embrace one-third to one-half the circumference of the tube. Cut edges of the specimen shall be smooth and free from burrs.

4.3.2 For Periodic Tests

As agreed upon by purchaser and vendor.