

AEROSPACE MATERIAL SPECIFICATION



AMS 4942D

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Superseding AMS 4942C

Titanium Tubing, Seamless Annealed, 40,000 psi (275 MPa) Yield Strength

UNS R50400

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2244	Tolerances, Titanium and Titanium Alloy Tubing
MAM 2244	Tolerances, Metric, 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

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2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E8	Tension Testing of Metallic Materials
ASTM E8M	Tension Testing of Metallic Materials, Metric
ASTM E120	Chemical Analysis of Titanium and Titanium Alloys
ASTM E 1409	Determination of Oxygen 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 Method

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Bldg. 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-H-81200 Heat Treatment of Titanium and Titanium Alloys

3. TECHNICAL REQUIREMENTS:

3.1 Composition:

Shall conform to the percentages by weight, shown in Table 1, determined by analytical methods in accordance with ASTM E120, ASTM E 1409, ASTM E 1447, by spectrochemical methods or by other analytical methods approved by 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)
Residual Elements, each (3.1.1)	--	0.10
Residual 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 requirements of AMS 2249.

3.2 Melting Practice:

Alloy shall be produced by electron beam melting practice or shall be multiple melted with the final melting cycle under vacuum. When multiple melted, the first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice.

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 MIL-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 or E 8M 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

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%

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:

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

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 or MAM 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.

4.3.2.1 Specimens for flarability (3.4.3) test shall be full tubes or sections cut from a tube. The end of the specimen to be flared shall be cut square with the cut end smooth and free from burrs but not rounded.

4.4 Reports:

The vendor of tubing shall furnish with each shipment a report showing the results of tests for chemical composition of each heat and for the hydrogen content, tensile properties, and surface contamination of each lot, and stating that the tubing conforms to the other technical requirements. This report shall include the purchase order number, heat number, lot number, AMS 4942D, size, and quantity from each heat.