SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4940

Issued APR 2003

Titanium Sheet, Strip, and Plate
Commercially Pure
Annealed, 25.0 ksi (172 MPa) Yield Strength

(Composition similar to UNS R50550)

1. SCOPE:

1.1 Form:

This specification covers one grade of commercially-pure titanium in the form of sheet, strip, and plate.

1.2 Application:

This material has been used typically for parts requiring the properties of titanium and good formability but not high strength, but usage is not limited to such applications.

1.3 Classification:

Product melted to this specification shall be produced by one of the following melting methods:

Type 1 - Multiple melted using consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice with the final melting cycle under vacuum.
Type 2 - Electron beam melted

Unless a specific type is ordered, either type of melting practice may be supplied.

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.

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 2242	Tolerances, Corrosion and Heat Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate
AMS 2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS 2750	Pyrometry
AMS 2809	Identification, Titanium and Titanium Alloy Wrought Products

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 290	Bend Testing of Material for Ductility
ASTM E 384	Microindentation Hardness of Materials
ASTM E 1409	Determination of Oxygen in Titanium and Titanium Alloys by the Inert Gas Fusion Method
ASTM E 1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Technique

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
Iron	--	0.20
Oxygen	--	0.15
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen (3.1.3)	--	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 Check Analysis: Composition variations shall meet the applicable requirements of AMS 2249.

3.1.3 Sample size, when using ASTM E 1447, may be as large as 0.35 gram.

3.2 Melting Practice:

3.2.1 Alloy shall be produced by electron beam melting 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. The subsequent melt or melts shall be made using consumable electrode practice.

3.2.1.1 The atmosphere for consumable electrode melting shall be vacuum or shall be argon and/or helium at an absolute pressure not higher than 1000 mm of mercury.

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

3.3 Condition:

The product shall be supplied in the following condition:

3.3.1 Sheet and Strip: Hot rolled with or without subsequent cold reduction, annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 2D finish (See 8.3).

3.3.2 Plate: Hot rolled, annealed, descaled, and flattened, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish (See 8.3).

3.4 Annealing:

The product shall be annealed by heating to a temperature within the range 1200 to 1500 °F (649 to 816 °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, and cooling as required to produce product capable of meeting requirements of 3.5. Pyrometry shall be in accordance with AMS 2750.

3.5 Properties:

The product shall conform to the following requirements:

3.5.1 Tensile Properties: Shall be in accordance with Table 2 for product 1.000 inch (25.40 mm) and under in nominal thickness, determined in accordance with ASTM E 8 or ASTM 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 test 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, minimum	35.0 ksi (241 MPa)
Yield Strength at 0.2% Offset	25.0 to 45 ksi (172 to 310 MPa)
Elongation in 2 Inches (50.8 mm) or 4D, minimum	24%

3.5.1.1 Elongation requirement applies only to product 0.025 inch (0.64 mm) and over in nominal thickness.

3.5.2 Bending: Product under 0.1875 inch (4.762 mm) in nominal thickness, shall have a test sample prepared nominally 0.750 inch (19.06 mm) in width, with its axis of bending parallel to the direction of rolling. The sample shall be bend tested in conformance with the guided bend test defined in ASTM E 290 through an angle of 105 degrees. The test fixture supports shall have a contact radius 0.010 minimum, and the plunger shall have a diameter equal to the bend factor shown in Table 3 times the nominal thickness. Examination of the bent sample shall show no evidence of cracking when examined at 15 to 25 X magnification.

TABLE 3 - Bend Factors

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
Up to 0.070	Up to 1.78	3
Over 0.070 to 0.1875	Over 1.78 to 4.762	4

3.5.3 Average Grain Size: Shall be 6 or finer determined by comparison of a polished and etched specimen with the chart in ASTM E 112.

3.5.4 Surface Contamination: The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in 3.5.4.1, or 3.5.4.2, or 3.5.4.3, or by other method acceptable to purchaser.

3.5.4.1 The bend test of 3.5.2.

3.5.4.2 Microscopic examination at 400X.

3.5.4.3 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.

3.6 Quality:

The product, as received by purchaser, shall be uniform in quality and condition, sound, and free from “oil cans” (see 8.4) of depth in excess of the flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.

3.6.1 When specified, titanium plate, 0.500 to 4.000 inches thick, shall meet ultrasonic quality standards agreed upon by purchaser and vendor (See 8.6).

3.7 Tolerances:

Shall conform to all applicable requirements of AMS 2242.

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:

All technical requirements are acceptance tests and shall be performed on each heat or lot as applicable.

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 and annealed in the same heat treatment batch:

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

4.3.2 Tensile Property, Bending, Grain Size, and Surface Contamination Requirements: At least one sample from each lot.

4.3.2.1 Specimens for tensile tests of widths 9 inches (229 mm) and over shall be taken with specimen axis in both the longitudinal and long-transverse directions; for widths under 9 inches (229 mm), specimens shall be taken with the specimen axis in the longitudinal direction.

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, tensile and bending properties, and grain size 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 4940, size, specific annealing treatment used, and quantity.

4.5 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the product may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the product represented. Results of all tests shall be reported.

5. PREPARATION FOR DELIVERY:

5.1 Identification:

Shall be in accordance with AMS 2809.

5.2 Packaging:

The product shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the product to ensure carrier acceptance and safe delivery.