SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 4940A

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Superseding AMS 4940

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

(Composition similar to UNS R50250)

RATIONALE

AMS 4940A results from a Five Year Review and update of this specification.

1. SCOPE

1.1 Form

This specification covers one grade (Grade 1) 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 vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold heath 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 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: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

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.

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 International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E 8	Tension Testing of Metallic Materials
ASTM E 290	Bend Testing of Material for Ductility
ASTM E 384	Microindentation Hardness of Materials
ASTM E 1409	Determination of Oxygen and Nitrogen 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/Infrared Detection Technique
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

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	--	0.20	
Oxygen	--	0.15	
Carbon	--	0.08	
Nitrogen	--	0.03	(300 ppm)
Hydrogen (3.1.3)	--	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 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 cold hearth melting (Type 2) or shall be multiple melted (Type 1) with the final melting cycle under vacuum. When multiple melted, the 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. The final melting practice shall be made under vacuum using vacuum arc remelting (VAR) practice with no alloy additions permitted.

3.2.1.1 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.

3.2.1.2 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). Plate product shall be produced using standard industry practices designed strictly for the production of plate stock to the procured thickness. Bar, billet, forgings, or forging stock shall not be supplied in lieu of plate.

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 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 radius 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	1.5
Over 0.070 to 0.1875	Over 1.78 to 4.762	2

3.5.3 Average Grain Size

Shall be No. 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, inclusive, 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 specified requirements.