



# AEROSPACE MATERIAL SPECIFICATION

**AMS4901**
**REV. T**

 Issued 1952-11  
 Revised 2015-03

Superseding AMS4901S

Titanium Sheet, Strip, and Plate  
 Commercially Pure  
 Annealed, 70.0 ksi (485 MPa)  
 (Composition similar to UNS R50700)

## RATIONALE

AMS4901T results a Five Year Review and update of this specification that includes the removal of sample size allowance for hydrogen of Table 1 (covered by ASTM E1447), requires agreement on mechanical property values for material outside specification ranges (3.5.1), the addition of AS6279 (3.8), adds AMS2368 in sampling and resampling (4.3 and 4.5) and revises the report paragraph (4.4).

### 1. SCOPE

#### 1.1 Form

This specification covers one grade of commercially-pure titanium in the form of sheet, strip, and plate up through 1.000 inch (25.40 mm), inclusive.

#### 1.2 Application

These products have been used typically for parts requiring moderate, sustained strength up to 400 °F (204 °C) and oxidation resistance up to 600 °F (316 °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 +1 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

AMS2242 Tolerances, Corrosion and Heat-Resistant Steel, Iron Alloy, Titanium, and Titanium Alloy Sheet, Strip, and Plate

AMS2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys

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AMS2368	Sampling and Testing of Wrought Titanium Raw Materials, Except Forging and Forging Stock
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products
AS6279	Industry Standard Practices for Production, Distribution, and Procurement of Metal Stock

## 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](http://www.astm.org).

ASTM E8 / E8M	Tension Testing of Metallic Materials
ASTM E112	Determining Average Grain Size
ASTM E290	Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E384	Knoop and Vickers Hardness of Materials
ASTM E1409	Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
ASTM E1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
ASTM E1941	Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis
ASTM 2371	Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission 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 E1941, hydrogen in accordance with ASTM E1447, oxygen and nitrogen in accordance with ASTM E1409, and other elements in accordance with ASTM E2371. Other analytical methods may be used if acceptable to the purchaser.

**Table 1 - Composition**

Element	min	max
Iron	--	0.50
Oxygen	--	0.40
Carbon	--	0.08
Nitrogen	--	0.05 (500 ppm)
Hydrogen	--	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 AMS2249.

### 3.2 Melting Practice

Alloy shall be produced by electron beam cold hearth or plasma arc cold hearth melting method, or shall be multiple melted with the final melting cycle under vacuum. When multiple melted, the first melt shall be made by vacuum consumable electrode, nonconsumable electrode, electron beam cold hearth, or plasma arc cold hearth melting practice. The subsequent melt or melts shall be made under vacuum using vacuum arc remelting (VAR) practice. Alloy additions are not permitted in the final melt cycle.

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.

3.2.1.1 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, and, unless anneal is performed in an atmosphere yielding a bright finish, descaled having a surface appearance comparable to a commercial corrosion-resistant steel sheet No. 2D finish (See 8.2).

#### 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 8.2). 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 substituted for 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  $\pm 25$  °F ( $\pm 14$  °C) for a time commensurate with the thickness and the heating equipment and procedure used, and cooling as required. Pyrometry shall be in accordance with AMS2750.

### 3.5 Properties

The product shall conform to the following requirements:

#### 3.5.1 Tensile Properties

Shall be as shown in Table 2 for product 1.000 inch (25.40 mm) and under in nominal thickness, determined in accordance with ASTM E8 / E8M with the rate of strain set at 0.005 inch/inch/minute (0.005 mm/mm/minute) and maintained within a tolerance of  $\pm 0.002$  inch/inch/minute (0.002 mm/mm/minute) through the 0.2% offset yield strain.

**Table 2 - Room-temperature tensile properties**

Property	Value
Tensile Strength, minimum	80 ksi (552 MPa)
Yield Strength at 0.2% Offset	70 to 95 ksi (483 to 655 MPa)
Elongation in 2 Inches (50.8 mm) or 4D, minimum	15%

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

3.5.1.2 Mechanical property requirements for product outside the size range covered by 3.5.1 shall be agreed upon between purchaser and producer.

### 3.5.2 Bending

Product under 0.1875 inch (4.762 mm) 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 E290 through the angle of 105 degrees. The test fixture supports shall have a contact radius 0.010 inch (0.25 mm) minimum, and the plunger shall have a radius equal to the bend factor times the nominal thickness. Examination of the bent sample shall not show evidence of cracking when examined at 15 to 25X magnification.

**Table 3 - Bending parameters**

Nominal Thickness Inch	Nominal Thickness Millimeters	Bend Factor
Up to 0.070, incl	Up to 1.78, incl	2.5
Over 0.070 to 0.1875, excl	Over 1.78 to 4.762, excl	3

### 3.5.3 Grain Size

Shall be predominantly 6 or finer determined in accordance with ASTM E112 on a polished and etched sample.

### 3.5.4 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined by the bend test of 3.5.2, by hardness differential of 3.5.4.1, or by other method acceptable by purchaser.

3.5.4.1 Hardness differential; a surface hardness more than 40 points higher than the subsurface hardness, determined in accordance with ASTM E384 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 8.3.1) of depth in excess of the flatness tolerances, ripples, and foreign materials and from imperfections detrimental to usage of the product.

### 3.7 Tolerances

Shall conform to all applicable requirements of AMS2242.

3.8 Production, distribution, and procurement of metal stock shall comply with AS6279. This requirement becomes effective September 1, 2016.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The producer of the product shall supply all samples for producer's tests and shall be responsible for their 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.

### 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 AMS2368 and 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 Properties, Bending, Average Grain Size, and Surface Contamination Requirements

One or more samples from each lot for each requirement.

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

4.3.2.2 For U-channel bend tests, specimen width shall be not less than 10 times the nominal thickness or 1 inch (25 mm), whichever is greater. For free bend tests, minimum specimen width shall, when possible, be not less than 10 times the nominal thickness; maximum width need not be greater than 1 inch (25 mm).

### 4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing producer identity, country where the metal was melted (e.g., final melt in the case of metal processed by multiple melting operations) and the results of tests for composition of each heat and for the hydrogen content, tensile and bending properties, and average grain size of each lot, and state that the product conforms to the other technical requirements. This report shall include the purchase order number, heat and lot numbers, AMS4901T, specific annealing treatment used, product form, surface finish, mill produced size, and quantity.

4.4.2 When the product size is outside the range covered by 3.5.1, the report shall contain a statement to that effect.

### 4.5 Resampling and Retesting

In accordance with AMS2368.

## 5. PREPARATION FOR DELIVERY

### 5.1 Identification

In accordance with AMS2809.

### 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.

## 6. ACKNOWLEDGMENT

A producer shall include this specification number and its revision letter in all quotations and when acknowledging purchase orders.

## 7. REJECTIONS

Product not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

## 8. NOTES

8.1 A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 Commercial corrosion-resistant steel finishes are defined in ASTM A480/A480M.

8.3 Terms used in AMS are clarified in ARP1917 and as follows:

### 8.3.1 "Oil Can"

An excess of material in a localized area of a sheet that causes the sheet to buckle in that area. When the sheet is placed on a flat surface and hand pressure applied to the buckle, the buckle will spring through to the opposite surface or spring up in another area of the sheet.

8.4 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

8.5 Purchase documents should specify not less than the following:

AMS4901T

Type of melting practice desired

Product form and size of product desired

Surface finish desired for sheet and strip

Quantity of product desired

Property and acceptance requirements from the cognizant engineering organization applicable to sizes outside the size ranges listed in 1.1.

PREPARED BY AMS COMMITTEE "G"