AEROSPACE MATERIAL SPECIFICATION

AMS4948™

Issued 2022-06

Titanium Alloy, Hot Rolled Sheet and Strip
5Al - 1Fe
Annealed

RATIONALE

AMS4948 is a new specification for hot rolled titanium alloy sheet and strip.

1. SCOPE

1.1 Form

This specification covers a titanium alloy in the form of hot rolled sheet and strip up to 0.165 inch (4.20 mm), inclusive, in thickness.

1.2 Application

These products have been used typically for parts requiring strength up to 750 °F (399 °C), but usage is not limited to such applications.

1.2.1 Certain processing procedures and service conditions may cause these products to become subject to stress-corrosion cracking; ARP982 recommends practices to minimize such conditions.

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.

AMS2249	Chemical Check Analysis Limits, Titanium and Titanium Alloys
AMS2368	Sampling and Testing of Wrought Titanium Raw Material Except Forgings and Forging Stock
AMS2750	Pyrometry
AMS2809	Identification, Titanium and Titanium Alloy Wrought Products
ARP982	Minimizing Stress-Corrosion Cracking in Wrought Titanium Alloy Products

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AMS4948/

AS1814 Terminology for Titanium Microstructures

AS4194 Sheet and Strip Surface Finish Nomenclature

AS6279 Standard Practice for Production, Distribution, and Procurement of Metal Stock

AS7766 Terms Used in Aerospace Metals Specifications

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 A480/A480M General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E384 Microindentation Hardness of Materials

ASTM E539 Analysis of Titanium Alloys by Wavelength Dispersive X-Ray Fluorescence Spectrometry

ASTM E1409 Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

ASTM E1447 Determination of Hydrogen in Titanium and Titanium Alloys by 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 E2371 Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Spectrometry (Performance-Based Test Methodology)

ASTM E2994 Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Test Method)

2.3 Definitions

Terms used in AMS are defined in AS7766.

2.3.1 Commercial corrosion-resistant steel finishes are defined ASTM A480/A480M and AS4194.

2.3.2 Terminology related to titanium microstructure is presented in AS1814.

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 E539, ASTM E2371. or ASTM E2994. Other analytical methods may be used if acceptable to the purchaser.

Table 1 - Composition

Element	Min	Max	
Aluminum	4.50	5.50	
Iron	0.50	1.50	
Oxygen		0.25	
Carbon		0.080	
Nitrogen		0.050	(500 ppm)
Hydrogen		0.015	(150 ppm)
Other Elements, each (3.1.1)		0.10	
Other Elements, total (3.1.1)		0.40	
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 multiple melted. The first melt shall be made using a 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. Alloy additions are not permitted in the final remelt cycle.

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

3.2.2 The electrode 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, annealed, descaled, and leveled, having a surface appearance comparable to a commercial corrosion-resistant steel No. 1 finish (see 2.3.1).

3.4 Annealing

The product shall be annealed as follows; pyrometery shall be in accordance with AMS2750.

3.4.1 When batch furnace is used, product shall be annealed by heating to a temperature between 1112 to 1382 °F (600 to 750 °C), holding at the selected temperature within ±25 °F (±14 °C) for a time commensurate with the thickness, and cooled using parameters that will produce product meeting the requirements of 3.5.

3.4.2 When continuous annealing is used, process parameters (e.g., furnace temperature set points, heat input, travel rate, etc.) for continuous heat treating lines shall be established by the material producer and validated by testing to requirements of 3.5.

3.5 Properties

3.5.1 Tensile Properties

Shall be as specified in Table 2, determined in accordance with ASTM E8/E8M with the rate of strain set at 0.005 in/in/min (0.005 mm/mm/min) and maintained within a tolerance of ±0.002 in/in/min (0.002 mm/mm/min) through the 0.2% offset yield strain.

Table 2 - Minimum room temperature tensile properties

Property	Value	
	Longitudinal	Transverse
Tensile Strength	116 ksi (800 MPa)	138 ksi (951 MPa)
Yield Strength at 0.2% Offset	102 ksi (703 MPa)	126 ksi (869 MPa)
Elongation in 2 Inches (50.8 mm) or 4D	10%	10%

3.5.1.1 Tensile property requirements for product outside the size range covered by 1.1 shall be agreed upon between purchaser and producer and reported per 4.4.2 (see 8.4).

3.5.2 Microstructure

Shall be that structure resulting from processing within the alpha-beta phase field. Microstructure shall conform to 3.5.2.1 or 3.5.2.2 (see 2.3.2).

3.5.2.1 Lamellar alpha with some equiaxed and/or elongated primary alpha and/or alpha in a transformed beta matrix.

3.5.2.2 Partially broken and distorted grain boundary alpha with plate-like alpha.

3.5.3 Surface Contamination

The product shall be free of any oxygen-rich layer, such as alpha case, or other surface contamination, determined as in any one of the following: 3.5.3.1, 3.5.3.2, or by other method agreed upon by purchaser and producer.

3.5.3.1 Examination of a metallographic cross-section at 400X minimum magnification.

3.5.3.2 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 g load, being 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 foreign materials and from imperfections detrimental to usage of the product.

3.7 Tolerances

Shall conform to the following:

3.7.1 Thickness, Width, and Length

Shall form to the requirements in Table 3.

Table 3 - Tolerance limits for product thickness, width, and length

	Tolerance Values
Thickness Tolerance, Plus and Minus	10% of product thickness
Width, Plus Only	0.800 inch (20 mm)
Length, Plus Only	0.800 inch (20 mm)

3.7.2 Flatness

Flatness tolerance, determined as the variation from flat, for product 36 inches (914 mm) and under in width shall be equal to or less than 2 inches (50.8 mm) if nominal thickness is under 0.062 inch (1.57 mm) and 1 inch if nominal thickness is 0.062 to 0.165 inch (1.57 to 4.20 mm), inclusive. Flatness tolerance requirements for product over 36 inches (914 mm) in width shall be agreed upon by purchaser and producer (see 8.4).

3.7.2.1 Flatness tolerances do not apply to coiled products.

3.8 Production, distribution, and procurement shall comply with AS6279.

3.9 Exceptions

Any exceptions shall be authorized by the purchaser and reported as in 4.4.2.

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 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.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Composition (3.1), tensile properties (3.5.1), microstructure (3.5.2), surface contamination (3.5.3), and tolerances (3.7) 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 For Acceptance Tests

4.3.1.1 Composition

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

4.3.1.2 Tensile Properties, Microstructure, and Surface Contamination

At least one sample from each lot.

4.3.1.2.1 Tensile testing is required for both the longitudinal and long transverse directions.

4.4 Reports

4.4.1 The producer shall furnish with each shipment a report showing producer identity, country where the metal was melted (i.e., 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 properties, microstructure, and surface contamination of each lot, and state that the product conforms to the other technical requirements. This report shall include the purchase order number, lot number, AMS4948, specific annealing treatment used, product form, size, and quantity.

4.4.2 When material produced to this specification is beyond the sizes allowed in the scope or tables, or other exceptions are taken to the technical requirements listed in Section 3, the report shall contain a statement “This material is certified as AMS4948(EXC) because of the following exceptions:” and the specific exceptions shall be listed (also see 5.1).

4.5 Resampling and Retesting

Shall be in accordance with AMS2368.

5. PREPARATION FOR DELIVERY

5.1 Identification

Shall be in accordance with AMS2809 as applicable. When technical exceptions are taken (see 4.4.2), the material shall be identified with AMS4948(EXC).

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. ACKNOWLEDGEMENT

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 Revision Indicator

A change bar (l) 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 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.

8.3 It is the purchaser's obligation to ensure that product they procure or resell as AMS4948 has any exceptions approved by their subsequent purchaser.

8.4 Purchase documents should specify not less than the following:

AMS4948
Product form and size of product desired
Quantity of product desired
Property and acceptance requirements from the cognizant engineering organization applicable to sizes outside the size range listed in 1.1 (see 3.5.1.1)
Flatness tolerances as needed (see 3.7.2)

PREPARED BY SAE AMS G TITANIUM AND REFRACTORY METALS COMMITTEE