SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-T-9046B

Issued JUL 1999
Revised JUL 2002
Cancelled MAY 2006

Superseding AMS-T-9046A

Titanium and Titanium Alloy, Sheet, Strip, and Plate

CANCELLATION NOTICE

This specification has been declared “CANCELLED” by the Aerospace Materials Division, SAE, as of May, 2006 and has been superseded by the applicable AMS specification listed in Figure 1 below. The requirements of the latest issue of the AMS listed in Figure 1 shall be fulfilled whenever reference is made to the cancelled AMS-T-9046 for those materials. By this action, AMS-T-9046 will remain listed in the Numerical Section of the Index of Aerospace Material Specifications, noting that it has been superseded by the applicable AMS.

Alloys covered by AMS-T-9046 determined to be ‘no longer produced’ are listed in Figure 2. Where available, specifications with similar but not necessarily identical technical requirements are listed in Figure 2. However, this listing is provided for information only and does not constitute authority to substitute these specifications for the “CANCELLED” products listed in Figure 2.

AMS-T-9046 was a word-for-word translation of MIL-T-9046 that was cancelled on September 17, 1999.

Cancelled AMS specifications are available from SAE.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
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SAE WEB ADDRESS: **http://www.sae.org**

TYPE	AMS-T-9046 MATERIAL DESIGNATION	ALLOY	CONDITION	SUPERCEDING SPECIFICATION
Commercially Pure Titanium	CP-1	Commercially Pure	70 ksi Yield Strength	AMS 4901
	CP-2		55 ksi Yield Strength	AMS 4900
	CP-3		40 ksi Yield Strength	AMS 4902
	CP-4		25 ksi Yield Strength	AMS 4940
Alpha Titanium Alloys	A-1	5Al-2.5Sn	Annealed	AMS 4910
	A-2	5Al-2.5Sn (ELI)	Annealed	AMS 4909
	A-4	8Al-1Mo-1V	Annealed	AMS 4915
			Duplex Annealed	AMS 4916
Alpha-Beta Titanium Alloys	AB-1	6Al-4V	Annealed	AMS 4911
			Solution Treated	AMS 4903
			STA	AMS 4904
	AB-2	6Al-4V (ELI)	Annealed	AMS 4907
	AB-3	6Al-6V-2Sn	Annealed	AMS 4918
			Solution Treated	AMS 4988
			STA	AMS 4990
	AB-4	6Al-2Sn-4Zr-2Mo	Duplex Annealed	AMS 4919
	AB-5	3Al-2.5V	Annealed	AMS 4989
Beta Titanium Alloys	B-1	13V-11Cr-3Al	Solution Treated	AMS 4917
	B-3	3Al-8V-6Cr-4Mo-4Zr	Solution Treated	AMS 4939

FIGURE 1 – ALLOYS AND TEMPERS WITH SUPERCEDING AMS SPECIFICATIONS

TYPE	AMS-T-9046 MATERIAL DESIGNATION	ALLOY	CONDITION	SIMILAR SPECIFICATION
Alpha Titanium Alloy	A-3	6Al-2Cb-1Ta-0.8Mo	Annealed	NONE
Alpha-Beta Titanium Alloy	AB-4	6Al-2Sn-4Zr-2M	Triplex Annealed	NONE
	AB-6	8Mn	Annealed	AMS 4908 (Noncurrent)
Beta Titanium Alloys	B-1	13V-11Cr-3Al	STA	NONE
	B-2	11.5Mo-6Zr-4.5Sn	ST	NONE
			STA (1000)	NONE
			STA (925)	NONE
	B-3	3Al-8V-6Cr-4Mo-4Zr	STA	ASTM B265 Grade 20
	B-4	8Mo-8V-2Fe-3Al	ST	NONE
			STA (1100)	NONE
			STA (1000)	NONE

FIGURE 2 – ALLOYS AND TEMPERS WITHOUT SUPERCEDING SPECIFICATIONS

NOTICE

This document was originally taken directly from U.S. Military Specification MIL-T-9046J, Amendment 2, and contained only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document was intended to replace MIL-T-9046J, Amendment 2. Revisions made to the document since the original publication are intended to conform to current industrial practice.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

1. SCOPE:

1.1 Scope:

This specification covers aircraft quality titanium and titanium alloy metal sheet, strip and plate products.

1.2 Classification:

Products shall be of the following compositions and conditions, as specified (see 6.3.1, 6.6 and Tables I and IX):

1.2.1 Composition:

Commercially pure titanium (CP)

Code designation	Yield strength minimum, ksi 1/
CP-1	70.0
CP-2	55.0
CP-3	40.0
CP-4	25.0

Alpha titanium alloys (A)

Code designation	Composition
A-1	5Al-2.5Sn
A-2	5Al-2.5Sn (ELI) 2/
A-3	6Al-2Cb-1Ta-0.8Mo
A-4	8Al-1Mo-1V

Alpha-beta titanium alloys (AB)

Code designation	Composition
AB-1	6Al-4V
AB-2	6Al-4V (ELI)
AB-3	6Al-6V-2Sn
AB-4	6Al-2Sn-4Zr-2Mo
AB-5	3Al-2.5V
AB-6	8Mn

Beta titanium alloys (B)

Code designation	Composition
B-1	13V-11Cr-3Al
B-2	11.5Mo-6Zr-4.5Sn
B-3	3Al-8V-6Cr-4Mo-4Zr
B-4	8Mo-8V-2Fe-3Al

1/ 1.0 ksi = 1000 psi
2/ ELI means “extra low interstitials.”

1.2.2 Condition:

Code	Description (treatment)
A	Annealed
DA	Duplex annealed
TA	Triplex annealed
ST	Solution treated
STA	Solution treated and aged. (When multiple STA conditions are specified herein for a given alloy, as in table IV, the applicable aging temperature shall be added in parentheses as a suffix.)

2. APPLICABLE DOCUMENTS:

The following publications, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 (See 6.8).

FED-STD-151 Metals, Test Methods

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129 Marking for Shipment and Storage
MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage
MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification (Eddy Current, Liquid Penetrant, Magnetic Particle, Radiographic and Ultrasonic)

2.2 SAE Publications:

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

AMS 2242	Tolerances - Corrosion and Heat Resistant Steel and Iron Base Alloy Sheet, Strip and Plate and Titanium and Titanium Alloy Sheet, Strip and Plate
AMS 2249	Chemical Check Analysis Limits - Titanium and Titanium Alloys
AMS 2631	Ultrasonic Inspection of Titanium Alloys
ARP982A	Minimizing Stress Corrosion in Wrought Heat Treatable Titanium Alloys
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys

2.3 ASTM Publications:

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

ASTM A 480	General Requirements for Flat-Rolled Stainless and Heat Resisting Steels in Form of Plate, Sheet and Strip
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 120	Titanium and Titanium-Base Alloys, Chemical Analysis of
ASTM E 290	Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E 1447	Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Technique

2.4 Order of precedence:

In the event of a conflict between the text of the specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS:

3.1 Material:

3.1.1 Commercially pure alloys: The material shall be produced by either electron beam melting or by multiple melting under vacuum or inert atmosphere.

3.1.2 Alpha alloys, alpha-beta alloys and beta alloys: The material shall be produced by multiple melting.

3.1.3 Melting controls:

3.1.3.1 Multiple melting: The first melt and any intermediate melts shall be made by consumable electrode, non-consumable electrode, electron beam melting or other vacuum melting process, or the plasma arc melting process with the final melt being by consumable electrode arc melting under vacuum or inert atmosphere with no alloy additions made in the last consumable electrode melt.

3.1.3.2 Non-consumable electrode melting: The atmosphere shall be vacuum or inert gas at a pressure not higher than 250 mm of mercury. The electrode tip for nonconsumable electrode melting shall be watercooled copper.

3.2 Finish:

3.2.1 Sheet and strip: Sheet and strip shall have a surface finish comparable to corrosion resisting steel number 2D finish in accordance with ASTM A 480. Product shall be free of surface contamination by oxygen (alpha case), hydrogen, nitrogen or other such harmful contaminants.

3.2.2 Plate: Unless otherwise specified, plate shall have a surface finish comparable to corrosion resisting steel number 1 finish in accordance with ASTM A 480. Product shall be free of surface contamination by oxygen (alpha case), hydrogen, nitrogen or other such harmful contaminants.

3.3 Chemical composition:

The chemical composition, as determined by heat or lot analysis, shall be as specified in Table I.

3.3.1 Check analysis: Chemical composition variations shall meet the requirements of AMS 2249.

3.4 Tensile properties:

3.4.1 Commercially pure and alpha-titanium alloys: Tensile properties shall conform to Table II.

3.4.2 Alpha-beta titanium alloys: Tensile properties shall conform to Table III for the condition ordered.

3.4.2.1 Property capabilities: Any specified property capability shall be demonstrated when specified (see 6.3.1).

3.4.2.1.1 Solution treated and aged: Except for composition 6Al-2Sn-4Zr-2Mo, products supplied in the annealed condition shall be capable of meeting the solution treated (ST) and solution treated and aged (STA) tensile properties specified in table III, when heat treated to these conditions in accordance with AMS-H-81200.

3.4.2.1.2 Aged: Products supplied in the solution treated (ST) condition shall meet the solution treated and aged (STA) tensile properties, when aged to this condition in accordance with AMS-H-81200.

3.4.2.2 Composition 6Al-2Sn-4Zr-2Mo (AB-4):

3.4.2.2.1 Property capability: Any specified property capability shall be demonstrated when specified (see 6.3.1).

3.4.2.2.1.1 Triplex annealed: Sheet and strip supplied in the duplex annealed (DA) condition shall meet the triplex annealed (TA) tensile properties, when heat treated to this condition in accordance with AMS-H-81200.

3.4.2.2.1.2 Duplex annealed: Plate supplied in the annealed (A) condition shall meet the duplex annealed (DA) tensile properties, when heat treated to this condition in accordance with AMS-H-81200.

3.4.2.3 Composition 6Al-4V (AB-1):

3.4.2.3.1 Property capability - sheet, strip and plate: Sheet, strip and plate supplied in the annealed condition shall meet the minimum tensile properties of Condition A, Table III, after exposure to a temperature of 718° ± 14°C (1325° ± 25°F) for a period of 20 ± 2 minutes, such exposure to be followed by cooling in air. After temperature exposure and cooling, a minimum of 0.001 inch shall be removed from all surfaces of the sample prior to testing. Sufficient material shall be removed so as to insure compliance of the sample with the requirements of 3.2.1 and 3.2.2. Property capability shall be demonstrated when specified (see 6.3.1).

3.4.3 Beta titanium alloys: Tensile properties shall conform to Table IV for the condition ordered.

3.4.3.1 Property capability - solution treated and aged: Products supplied in the solution treated (ST) condition shall meet the solution treated and aged (STA) tensile properties specified in Table IV, when aged to this condition in accordance with AMS-H-81200. Property capability shall be demonstrated when specified (see 6.3.1).

3.5 Bending:

Sheet and strip products supplied in the annealed or solution treated condition shall withstand transverse bending at room temperature to an angle of 105-degrees on a radius equal to the “bend factor” times the nominal product thickness without evidence of cracking when examined at 20X magnification. Bend factors shall be as specified in Table V. Transverse bending shall consist of bends where the centerline of the bend is parallel to the principal rolling direction of the product.

3.6 Heat treatment:

Products shall be heat treated in accordance with AMS-H-81200.

3.7 Ultrasonic quality:

3.7.1 Alpha and alpha-beta titanium plate: Unless otherwise specified (see 6.3.1), alpha and alpha-beta titanium plate, 0.500 to 4.000 inches thick, shall meet the Class A1 requirements of AMS 2631.

3.7.2 Commercially pure and beta titanium alloy plate: When specified (see 6.3.1), commercially pure and beta titanium alloy plate shall meet ultrasonic quality standards agreed upon by the acquiring activity and producer (see 6.3.1).

3.8 Microstructure:

Except for 6Al-2Cb-1Ta-0.8Mo plate and the beta titanium alloys, the microstructure of products supplied in accordance with this specification shall be representative of final processing below the beta transus. Microstructure shall not be cause for rejection unless the products show definite non-conformance to the requirement of processing below the beta transus or to micrograph standards agreed upon by the acquiring activity and the contractor.

3.9 Dimensional tolerances:

Unless otherwise specified (see 6.3.1), dimensional tolerances shall conform to the following requirements.

3.9.1 Length, straightness, thickness, and width: Tolerances for these dimensions shall conform to AMS 2242.

3.9.2 Flatness:

3.9.2.1 Sheet and strip tolerance: Flatness tolerances for sheet and strip shall conform to Table VI, except that these tolerances shall not apply to coiled products.

3.9.2.2 Single and duplex annealed plate tolerance: Flatness tolerances for single and duplex annealed plate shall conform to Table VII. Unless otherwise specified (see 6.2.1), flatness tolerances for plate in Conditions ST and STA shall be twice the values specified in Table VII.

3.10 Identification of product:

Shall be in acordance with AMS 2809.

3.11 Workmanship:

The product shall be uniform in quality and condition, free from harmful alloy segregation and surface contamination by oxygen, nitrogen or other contaminant and foreign material. It shall be clean, sound, smooth, and free from cracks, seams, grind marks and other defects detrimental to the fabrication or performance of parts.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection:

The inspection specified herein is classified as quality conformance inspection.

4.3 Quality conformance inspection:

The quality conformance inspection shall consist of all the inspections and tests specified herein.

4.3.1 Sampling:

4.3.1.1 Inspection lot: A lot shall consist of all sheet, strip or plate of the same heat, condition, size and thickness processed at the same time.

4.3.1.2 Procedure: Sampling procedure for each heat or lot for determining conformance to the requirements of this specification shall conform to Table VIII.

4.4 Methods of inspection and test:

4.4.1 Visual examination: Samples of products selected in accordance with Table VIII shall be visually examined for conformance to the identification (see 3.10) and workmanship (see 3.11) requirements.

4.4.2 Microstructure examination: One polished and etched metallographic specimen, or as many as required to cover the product thickness from center to surface, shall be prepared from each sample selected in accordance with Table VIII. The specimens shall be examined at a magnification of 200X to 250X for conformance to the microstructure (see 3.8) and freedom from alloy segregation (see 3.11) requirements and at a magnification of 100X to 200X for freedom from surface contamination by oxygen (alpha case) and other harmful contaminants as specified in 3.11.

4.4.3 Dimensional inspection: Samples selected in accordance with Table VIII for dimensional inspection shall be measured for conformance with the specified dimensions (see 6.3.1) and dimensional tolerances (see 3.9) requirements.

4.4.4 Ultrasonic inspection: Unless the ultrasonic quality requirement is waived by the acquiring activity (see 6.2.1), each plate, 0.500 inches and over in thickness, shall be inspected in accordance with AMS 2631 for conformance to the ultrasonic quality requirements of 3.7 through 3.7.2, as applicable. Ultrasonically inspected products shall be identified as agreed upon by the acquiring activity and producer (see 6.3.1).

4.4.4.1 Inspection personnel: Ultrasonic inspection shall be performed only by personnel qualified and certified in accordance with MIL-STD-410.

4.4.5 Packaging: Each shipment shall be inspected for conformance to the packing and marking requirements specified in 3.10 and Section 5.

4.4.6 Chemical analysis: Conformance with the chemical composition requirements shall be determined either by heat or lot analysis of samples selected in accordance with Table VIII using ASTM E 120 methods for chemical analysis or FED-STD-151, Method 112.2, for spectrochemical analysis. Hydrogen shall be analyzed by the hot extraction method specified in ASTM E 1447 and shall be determined on each lot as shipped. Other analytical methods may be used with the written approval of the acquiring activity.

4.4.6.1 Referee method: In case of a dispute, the results of chemical analysis by the ASTM E 120 method shall govern.

4.4.7 Tension tests: Conformance to the mechanical property requirements shall be determined by testing at least two specimens (one longitudinal and one transverse) in the condition ordered (see 6.2.1) from each sample selected in accordance with Table VIII, except that transverse specimens are not required for strips under 9-inches wide. In addition, an equal quantity of specimens shall be aged and tested to determine conformance to the Condition STA tensile properties as specified in 3.4.2.1.2 and 3.4.3.1 when material is supplied in the solution treated (ST) condition. Tension tests shall be accomplished in accordance with the following provisions.

4.4.7.1 Tension specimen configuration: The tension specimens shall conform to the following configurations in accordance with ASTM E 8:

a. For product thickness up to 0.375 inch, standard “sheet-type” rectangular tension specimens shall be used.

b. For product thickness equal to or greater than 0.375 inch, substandard round tension specimens with a 0.250 inch diameter reduced test section shall be used.

4.4.7.2 Tension specimen preparation: Unless the lot consists of only one unit, not more than one specimen per grain direction per test condition shall be taken from each sample. Longitudinal specimens shall be prepared in such a manner that the longitudinal axis of the specimen is parallel to the principal rolling direction of the sample. Transverse specimens shall be prepared in such a manner that the longitudinal axis of the specimen is perpendicular to the principal rolling direction of the sample.

4.4.7.3 Tension test method: Tension tests shall be accomplished in accordance with ASTM E 8, except that the rate of strain shall be 0.003 to 0.007 inch/inch per minute through the yield strength and then is increased so as to produce failure in approximately one additional minute. In case of dispute, the results of referee tension tests performed on a tensile machine having a strain pacer and using a strain rate of 0.005 in/in per min. through the yield strength and a minimum crosshead speed of 0.10 inch per minute above the yield strength shall govern.

4.4.8 Bend tests: Conformance to the sheet and strip transverse bending requirements shall be determined by testing at least two full-thickness specimens from each lot. Two separate bends shall be made on each specimen so that each surface is tested in tension. Specimens and test methods shall conform to the following provisions.

4.4.8.1 Bend specimens: Full thickness specimens by one inch wide shall be taken from the test samples selected in accordance with Table VIII. The length dimension shall be perpendicular to the principal rolling direction of the sample. Whenever possible, each specimen shall be long enough to permit two separate bends in accordance with 4.4.8, otherwise, the minimum quantity of specimens stipulated in 4.4.8 shall be doubled to permit testing both surfaces of each sample sheet or strip.

4.4.8.2 Bend test methods: Bend tests shall conform to the V-block, U-channel or free-bend test method. In case of dispute, the results of bend tests using the V-block method shall govern.

4.4.8.2.1 V-block test method: Tooling shall conform to the general configuration of Figure 1. The dies shall be wide enough to accommodate the entire width of the bend specimens. The test speed shall be two to three inches per minute and the pressure shall be maintained on the bend specimen for at least five seconds after the dies are fully closed.

4.4.8.2.2 U-Channel test method: Tooling shall consist of a conventional punch and U-channel. The specimens shall be bent to an angle of at least 105-degrees around the required bend radius and, after removal from the fixture and allowing for springback, the angle shall be equal to or greater than 90-degrees.

4.4.8.2.3 Free-bend test method: Bend tests shall be accomplished in accordance with ASTM E 290.

4.5 Rejection and retests:

4.5.1 Rejection: Failure of the test samples to meet the requirements of this specification shall be cause for rejection of the represented lot, except that retesting in accordance with 4.5.2 shall be permitted in the case of nonconformance to the tensile and bend property requirements.

4.5.2 Retests: At the discretion of the producer, a rejected lot may be retested as specified below.

4.5.2.1 Flat products: All failed sample units from the original sample shall be excluded from the retest lot. Four new sample units shall be taken and tested in accordance with 4.4.7 and 4.4.8, as applicable. Failure of any retest specimen to meet the applicable property requirements shall be cause for rejection of the entire lot and no further retesting shall be permitted.

4.5.2.1.1 Retest lot: If the retest lot is accepted, the producer may at his discretion retest each sample unit which shows failure at one end only. Units which show failure at both ends shall not be retested and shall be rejected. Each sample unit acceptable for retesting of tensile properties shall be retested as follows: Two test specimens shall be taken from the failed end in either or both directions, longitudinal and transverse, which showed unacceptable tensile properties, and these specimens shall be tested in accordance with 4.4.7. Each sample unit for bend retesting shall be retested as follows: Two bend test specimens shall be taken from the failed end and tested in accordance with 4.4.8. If any retest shows that bend or tensile properties do not conform to the requirements of Tables II, III, IV and V, as applicable, then the parent unit may be cut back at the failed end and further retested until either: (a) both ends show acceptable properties, or (b) the length of material remaining in the parent unit is less than the minimum specified length in the acquisition documents, whichever first occurs. Acceptance or rejection of the parent unit shall then be made as appropriate.

4.5.2.2 Coiled products: Sample coils which show failure to meet tensile or bend property requirements at both ends shall not be retested and shall be rejected. Sample coils which show unacceptable tensile or bend properties at one end only may be retested at the producer's discretion. Specimens shall be taken and tested in the manner prescribed in 4.5.2.1.1. Failures of retests are cause for cutting back the failed end and further retesting until the coiled material either shows: (a) acceptable properties at both ends, or (b) is below minimum length or weight specified, whichever first occurs. Disposition of the coil shall then be made as appropriate.

4.5.3 Replacement of test specimens: Replacement of test specimens for reasons other than inferior or defective material shall be in accordance with FED-STD-151.

5. PACKAGING:

5.1 Preservation-packaging:

Not applicable.

5.2 Packing:

Packing shall be Level A or C, as specified (see 6.2.1).

5.2.1 Sorting: Unless otherwise specified, the products shall be separated by composition, heat, size and condition when packed for shipment.

5.2.2 Level A - for domestic shipment and storage, and overseas shipment: Products shall be packed in accordance with the requirements of MIL-STD-163, as referenced for stainless steel.

5.2.3 Level C - minimum military packing (for domestic shipment) with immediate use at initial destination: Packages which require overpacking for acceptance by the carrier shall be packed in exterior-type shipping containers in a manner that will assure safe transportation at lowest rate to the point of delivery. Container shall meet, as a minimum, the requirements of rules and regulations applicable to the mode of transportation.

5.3 Marking of shipment:

In addition to any special marking required by the contract or purchase order (see 6.2.1), shipping containers shall be marked in accordance with MIL-STD-129. The identification shall consist of the following information listed in the order shown:

a. National stock no. or other identification number as specified in the purchase document. 1/
b. TITANIUM AND TITANIUM ALLOY, SHEET, STRIP OR PLATE (as applicable).
c. Heat number.
d. Lot number.
e. Size (thickness by width by length).
f. Number and revision letter of this specification, including latest amendment if any.
g. Composition.
h. Heat treatment condition.
i. Gross weight.
j. Manufacturer's name or trademark.

1/ The contractor shall enter the national stock number specified in the acquisition document or as furnished by the acquiring activity. When the national stock number is not provided or available from the acquiring activity, leave space therefor and enter the stock number or other identification when provided by the acquiring activity.

6. NOTES:

6.1 A change bar (|) 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 specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revisions. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.

6.2 Intended use:

The products acquired under this specification are intended for structural applications in airborne vehicles and equipment.

6.3 Ordering data:

6.3.1 Acquisition requirements: Acquisition documents should specify the following:

a. Title, number, revision letter and amendment number (if any) of this specification.

b. Composition (see 1.2.1) and heat treat condition (see 1.2.2).

c. Product form (plate, sheet or strip, as applicable), size (thickness, width and length) and quantity.

6.3.1 (Continued):

d. Melting practice of initial and intermediate melts if other than consumable electrode under vacuum (see 3.1).

e. Demonstrations of property capability (see 3.4.2.1, 3.4.2.2, 3.4.2.3 and 3.4.3.1).

f. Minimum elongation value for commercially pure, alpha and alpha-beta products under 0.025 inch in thickness; and for beta products under 0.012 inch in thickness (see Tables II, III and IV).

g. Whether ultrasonic quality is waived (see 3.7.1 and 4.4.4).

h. Specify ultrasonic quality standards when required for commercially pure or beta alloy plate (see 3.7.2).

i. Define microstructure standards, if agreed upon, in accordance with 3.8.

j. Flatness tolerances for sheet sizes greater than 36 inches in width (see 3.9.2.1 and Tables VI and VIII).

k. Flatness tolerances for products in Condition ST or STA if other than specified in 3.9.2.2.

l. Additional marking (see 4.4.4).

m. Selection of applicable level of packing, i.e., whether domestic or overseas (Level A or C) packing is required (see 5.2).

6.4 Stress corrosion:

Certain processing procedures and service conditions may cause these titanium products to be subject to stress corrosion cracking. ARP 982 recommends practices to minimize the susceptibility to such stress corrosion cracking.

6.5 Definition:

6.5.1 Sheet: A flat rolled product up to and including 0.187 inch in thickness and twenty-four (24) inches and over in width.

6.5.2 Strip: A flat rolled product up to and including 0.187 inch in thickness and generally furnished with slit, sheared, or slit and edge rolled in widths up to twenty-four (24) inches, inclusive; or with finished drawn or rolled edges in widths over 1-1/4 inches to twelve (12) inches, inclusive.

6.5.3 Plate: A flat rolled product of 0.188 inch and over in thickness and over 12 inches in width with the width at least five times the thickness.

6.5.4 Capability: The words “shall be capable of” are used herein to indicate characteristics or properties required in the product but for which testing of each lot is not required. However, if such testing is performed, products not conforming to the requirements of this specification shall be subject to rejection.

6.6 Cross-reference composition classifications:

Table IX shows the correlation between the composition classifications used in this specification and some of the earlier revisions.

6.7 Revised classification coding system:

The classification coding system introduced in this specification (see 1.2.1) is designed to satisfy the following criteria:

a. Brevity, the importance of which is emphasized by the fifteen (15) digit restriction of the federal system for product identification, ordering and cataloging.

b. Adaptability across a range of specifications and documents such as, MIL-T-81556, MIL-R-81588, MIL-T-9047 and MIL-HDBK-5.

c. Ease of recognition of grade of purity and alloy composition.

6.7.1 Design of coding system:

6.7.1.1 Identification of type classes: The coding system uses one or two letters to identify the type class into which each grade or alloy falls. These letters are keyed to the four class names which are in wide use. Such coding is brief and makes for easier recognition than coding through the use of Roman numerals. Thus, “CP” is used to identify titanium of commercial purity grades; “A” identifies all-ALPHA titanium alloys; “AB” identifies ALPHA-BETA alloys; and “B” identifies all-BETA alloys.

6.7.1.2 Number coding of CP grades and alloys:

6.7.1.2.1 Numbering of CP grades: The order of numbering CP titanium grades follow directly the order of increasing purity with respect to oxygen concentration. This sequence is the reverse of the order of changes in yield strength. Such numerical sequencing was selected, because the thrust of development of the CP grades generally been in the direction of increased purity, for example, CP-5 and CP-6 for the two grades of weld filler metal. It does not appear that there will be any additional effort to strengthen CP titanium by increasing oxygen concentration beyond that of CP-1.

6.7.1.2.2 Number of alloys: The order of numbering alloys generally follows the historical and present breadth and volume of usage of each alloy. Thus, 5Al-2.5Sn is coded A-1; 6Al-4V is coded AB-1; and 13V-11Cr-3Al is coded B-1. The 8Mn AB alloy, although of greater age than AB-1, has not enjoyed the usage of AB-1 and is assigned a higher number, namely AB-6.

6.7.2 UNS coding system: This coding system has been considered for adoption into the subject specification. However, the system has not been adopted because its product code designations are not brief and make product identification difficult and subject to error without the use of a catalog.

6.8 Fed-STD-151, MIL-STD-163, MIL-STD-105, and MIL-STD-410 have been cancelled by the government. In those cases, the last published issue of those cancelled documents is available.

TABLE I. Chemical composition, percent by weight

Classification	Nominal composition or min 9/	Elements 1/ Al	Sn	Zr	Cb	Ta	Mo	V	Mn	Cr	Fe 6/	C (max)	N (max)	H (max) 2/	O (max)	Cu or Si, as noted	Total other elements (max) 3/
Commercially pure titanium																	
CP-4	25	-	-	-	-	-	-	-	-	-	0.20	0.08	0.05	0.015	0.15	-	0.30
CP-3	40	-	-	-	-	-	-	-	-	-	0.30	0.08	0.05	0.015	0.20	-	0.30
CP-2	55	-	-	-	-	-	-	-	-	-	0.30	0.08	0.05	0.015	0.30	-	0.30
CP-1	70	-	-	-	-	-	-	-	-	-	0.50	0.08	0.05	0.015	0.40	-	0.30
Alpha titanium alloy 11/																	
A-1	5Al-2.5Sn	4.50-5.75	2.00-3.00	-	-	-	-	-	-	-	0.50	0.08	0.05	0.020	0.20	-	0.40
A-2	5Al-2.5Sn (ELI) 10/	4.50-5.75	2.00-3.00	-	-	-	-	-	-	-	0.25 4/	0.05	0.035	0.0125	0.12 4/	-	0.30 5/
A-3	6Al-2Cb-1Ta-0.8Mo	5.50-6.50	-	-	1.50-2.50	0.50-1.50	0.50-1.00	-	-	-	0.25	0.05	0.03	0.0125	0.10	-	0.40
A-4	8Al-1Mo-1V	7.35-8.35	-	-	-	-	0.75-1.25	0.75-1.25	-	-	0.30	0.08	0.05	0.015	0.15	-	0.40
Alpha-beta titanium alloy 11/																	
AB-1	6Al-4V	5.50-6.75	-	-	-	-	-	3.50-4.50	-	-	0.30	0.08	0.05	0.015	0.20	-	0.40
AB-2	6Al-4V (ELI)	5.50-6.50	-	-	-	-	-	3.50-4.50	-	-	0.25	0.08	0.05	0.0125	0.13	-	0.30 5/
AB-3	6Al-6V-2Sn	5.00-6.00	1.50-2.50	-	-	-	-	5.00-6.00	-	-	0.35-1.00	0.05	0.04	0.015	0.20	7/	0.30
AB-4	6Al-2Sn-4Zr-2Mo	5.50-6.50	1.80-2.20	3.60-4.40	-	-	1.80-2.20	-	-	-	0.25	0.05	0.04	0.015	0.15	8/	0.30
AB-5	3Al-2.5V	2.50-3.50	-	-	-	-	-	2.00-3.00	-	-	0.30	0.05	0.020	0.015	0.12	-	0.40
AB-6	8Mn	-	-	-	-	-	-	-	6.50-9.00	-	0.50	0.08	0.05	0.015	0.20	-	0.40
Beta titanium alloy 11/																	
B-1	13V-11Cr-3Al	2.50-3.50	-	-	-	-	-	12.50-14.50	-	10.00-12.00	0.15-0.35	0.05	0.05	0.025	0.17	-	0.40
B-2	11.5Mo-6Zr-4.5Sn	-	3.75-5.25	4.50-7.50	-	-	10.00-13.00	-	-	-	0.35	0.10	0.05	0.020	0.18	-	0.40
B-3	3Al-8V-6Cr-4Mo-4Zr	3.00-4.00	-	3.50-4.50	-	-	3.50-4.50	7.50-8.50	-	5.50-6.50	0.30	0.05	0.03	0.020	0.12	-	0.40
B-4	8Mo-8V-2Fe-3Al	2.60-3.40	-	-	-	-	7.50-8.50	7.50-8.50	-	-	1.60-2.40	0.05	0.05	0.015	0.16	-	0.40

TABLE I. Chemical composition, percent by weight. - Continued

1/ Balance is titanium.

2/ Hydrogen shall be determined on each lot of the product as shipped.

3/ Need not be determined. Material shall meet this requirement when analyzed. Unless otherwise noted, other elements each shall be 0.10 percent maximum.

4/ Iron plus oxygen shall not exceed 0.32 percent.

5/ Other elements shall be 0.05 percent maximum each.

6/ Maximum, unless otherwise specified.

7/ 0.35 - 1.00 percent Cu.

8/ 0.13 Si percent maximum.

9/ "Min ys" = minimum yield strength at 0.2 percent offset, ksi.

10/ "ELI" = extra low interstitials.

11/ All alloys in this category shall have 0.005 percent yttrium maximum.

TABLE II. Commercially pure and alpha titanium alloy sheet, strip and plate annealed tensile properties.

Classification and nominal composition	Thickness, inches 4/	Tensile strength, ksi	Yield strength at 0.2 percent offset, ksi	Elongation, percent in 2-inches or 4D
CP-4	1.000 & Under	35	25 - 45	24 2/
CP-3	1.000 & Under	50	40 - 65	20 2/
CP-2	1.000 & Under	65	55 - 80	18 2/
CP-1	1.000 & Under	80	70 - 95	15 2/
A-1 (5Al-2.5Sn)	1.500 & Under	120	113	10 2/
	1.500 - 4.000	115	110	10
A-2 (5Al-2.5Sn) (ELI)	0.008 - 0.014	100	95	6
	0.014 - 0.024	100	95	8
	0.024 - 1.000	100	95	10
A3 (6Al-2Cb-1Ta-0.8Mo)	0.1875 - 4.000	103	95	10
A-4 (8Al-1Mo-1V) 3/	0.008 - 0.014	145 (135)	135 (120)	6
	0.014 - 0.024	145 (135)	135 (120)	8
	0.024 - 0.1875	145 (135)	135 (120)	10 (10)
	0.1875 - 0.500	145 (130)	135 (120)	10 (10)
	0.500 - 1.000	140 (130)	130 (120)	10 (10)
	1.000 - 2.000	130 (125)	120 (115)	10 (10)
	2.000 - 2.500	130 (120)	120 (110)	10 (8)
	2.500 - 4.000	120 (120)	110 (110)	8 (8)

TABLE II. Commercially pure and alpha titanium alloy sheet, strip and plate annealed tensile properties - Continued 1/

1/ Minimum tensile properties except where a yield strength range is specified. Properties apply in both the longitudinal and transverse directions and are for condition A (annealed), unless otherwise noted.

2/ For thickness under 0.025 inch, elongation values shall be as agreed upon by the acquiring activity and contractor (see 6.2.1).

3/ Values in parentheses apply to condition DA (duplex annealed).

4/ Thickness given as X.XXX - X.XXX shall be read as "over ---- to ----, inclusive."

TABLE III. Alpha-beta titanium alloys sheet, strip and plate minimum tensile properties 1/

Classification and nominal composition	Condition	Thickness, inch 5/	Tensile strength, ksi	Yield strength at 0.2 percent offset, ksi	Elongation, percent in 2-inches or 4D
AB-1 (6Al-4V)	A	0.062 & Under	134	126	8 2/
		0.062 - 0.1875	134	126	10
		0.1875 - 4.000	130	120	10
	ST	0.032 & Under	4/	150 (max)	6 2/
		0.032 - 0.1875	4/	150 (max)	8
	STA	0.032 & Under	160	145	3 2/
		0.032 - 0.049	160	145	4
		0.049 - 0.1875	160	145	5
		0.1875 - 0.750	160	145	8
		0.750 - 1.000	150	140	6
		1.000 - 2.000	145	135	6
AB-2 (6Al-4V) (ELI)	A	0.008 - 0.014	130	120	6
		0.014 - 0.024	130	120	8
		0.024 - 1.000	130	120	10
		1.000 - 3.000	125	115	10
AB-3 (6Al-6V-2Sn)	A	0.024 & Under	155	145 - 170	8 (6) 3/
		0.024 - 0.1875	155	145 - 170	10 (8) 3/
		0.1875 - 2.000	150	140	10 (8) 3/
		2.000 - 4.000	145	135	8 (6) 3/
	ST	0.1875 & Under	4/	160 (max)	10 2/
	STA	0.1875 & Under	170	160	8 (6) 3/
		0.1875 - 1.500	170	160	8
		1.500 - 2.500	160	150	6
		2.500 - 4.000	150	140	6
AB-4 (6Al-2Sn-4Zr-2Mo)	DA	0.062 & Under	135	125	8 2/
		0.062 - 1.000	135	125	10
		1.000 - 3.000	130	120	10
	TA	0.062 & Under	145	135	8 2/
		0.062 - 0.1875	145	135	10
AB-5 (3Al-2.5V)	A	1.000 & Under	90	75	15 2/
AB-6 (8Mn)	A	0.1875 & Under	125	110 - 140	10 2/

TABLE III. Alpha-beta titanium alloys sheet, strip and plate minimum tensile properties - Continued 1/

1/ Minimum tensile properties except as otherwise specified. Unless otherwise noted, properties apply in both the longitudinal and transverse directions.

2/ For thicknesses under 0.025 inch, elongation values shall be as agreed upon by the acquiring activity and contractor (see 6.2.1).

3/ Elongation value in parentheses is for transverse direction only.

4/ Spread between tensile strength and yield strength shall be 15 ksi minimum.

5/ Thickness given as X.XXX - X.XXX shall be read as "over X.XXX to X.XXX, inclusive."

TABLE IV. Beta titanium alloys sheet, strip and plate minimum tensile properties 1/

Classification and nominal composition	Condition	Thickness, inch 4/, 5/	Tensile strength, ksi	Yield strength 0.2 percent at offset, ksi	Elongation, percent in 2-inches 4/
B-1 (13V-11Cr-3Al)	ST 3/	0.049 & Under 0.049 - 4.000	132 125	126 120	8 10
	STA	0.024 & Under 0.024 - 4.000	170 170	160 160	3 4
B-2 (11.5Mo-6Zr-4.5Sn)	ST 3/	0.024 & Under 0.024 - 0.1875	100 100	90 90	10 12
	STA (1000)	0.1875 & Under	165	155	8
	STA (925)	0.024 & Under 0.024 - 0.1875 0.1875 & Over	180 180 180	170 170 170	3 4 2
B-3 (3Al-8V-6Cr-4Mo-4Zr)	ST 3/	0.029 & Under 0.029 - 0.1875 0.1875 - 1.999 1.999 - 4.000	125 125 125 120	120 6/ 120 6/ 120 115	6 8 10 (8) 2/ 8 (6) 2/
	STA	0.1875 & Under 0.1875 - 1.000 1.000 - 4.000	180 180 170	170 170 160	6 8 6 (4) 2/
B-4 (8Mo-8V-2Fe-3Al)	ST 3/	0.1875 & Under 0.1875 - 2.000 2.000 - 4.000	125 125 120	120 6/ 120 115	18 10 8 (6) 2/
	STA (1100)	0.1875 & Under	150	140	15
	STA (1000)	0.1875 & Under 0.1875 - 2.000 2.000 - 4.000	175 180 180	155 170 170	10 8 6 (4) 2/