MIL-T-81556A
31 January 1983
SUPERSEDING
MIL-T-81556
20 March 1968

MILITARY SPECIFICATION

TITANIUM AND TITANIUM ALLOYS, EXTRUDED BARS AND SHAPES, AIRCRAFT QUALITY

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers aircraft quality titanium and titanium alloy extruded metal bar and shape products.

1.2 Classification. Products shall be of the following compositions and conditions, as specified (see 6.2.1, 6.5 and Tables I and IX).

1.2.1 Composition.

Commercially pure titanium (CP)

Yield strength (Ksi)	Code designation
70	CP-1
55	CP-2
40	CP-3
30	CP-4

Alpha titanium alloy

Nominal composition	Code designation 1/
5Al-2.5Sn	A-1
5Al-2.5Sn (ELI)	A-2
8Al-1Mo-1V	A-4

Alpha-beta titanium alloy

Nominal composition	Code designation
6Al-4V	AB-1
6Al-4V (ELI)	AB-2
6Al-6V-2Sn	AB-3
6Al-2Sn-4Zr-2Mo	AB-4

1/ A-3 has nominal composition 6Al-2Cb-1Ta-0.8Mo and is not subject to this specification.

2/ ELI means "extra low interstitials."

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

1.2.2 Condition.

Condition	Description (treatment)
F	As fabricated
A	Annealed
DA	Duplex annealed
ST	Solution treated
STA	Solution treated and aged

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. Unless otherwise specified, the following specifications and standards of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-H-81200 - Heat Treatment of Titanium and Titanium Alloys.

STANDARDS

FEDERAL

FED-STD-151 - Metals; Test Methods.

MILITARY

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).

(Copies of specifications and standards required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the documents which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E 8 - Tension Testing of Metallic Materials.

ASTM E 9	-	Compression Testing of Metallic Materials at Room Temperature.
ASTM E 120	-	Titanium and Titanium Alloys, Chemical Analysis of.
ASTM E 146	-	Zirconium and Zirconium Alloys, Chemical Analysis of.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

SAE

AEROSPACE MATERIAL SPECIFICATIONS (AMS)

AMS 2249	-	Chemical Check Analysis Limits, Titanium and Titanium Alloys.
AMS 2631	-	Ultrasonic Inspection of Titanium Alloys.
AMS 2643	-	Structural Examination of Titanium Alloys, Chemical Etch Inspection Procedure.

AEROSPACE RECOMMENDED PRACTICES (ARP)

ARP 982	-	Minimizing Stress Corrosion in Wrought Titanium Alloy Products.

(Application for copies should be addressed to SAE, 400 Commonwealth Drive, Warrendale, PA 15096.)

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

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

3. REQUIREMENTS

3.1 Material. Material for products supplied in accordance with this specification shall be multiple melted. The final melting cycle shall be consumable electrode practice under vacuum. The initial and intermediate melting cycles shall be consumable electrode practice under vacuum, unless otherwise specified (see 6.2.1). When specified (see 6.2.1), the first melting cycle shall be nonconsumable electrode practice under vacuum or inert gas at a pressure no greater than 250 mm of mercury and shall employ an electrode tip of either graphite or water-cooled copper.

3.2 Condition. Unless otherwise specified, extrusions shall be furnished in the as extruded and annealed (A) condition, with or without subsequent straightening (see 6.2.1).

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 conform to the requirements of AMS 2249.

3.4 Mechanical properties.

3.4.1 Products supplied. Products supplied in the A, DA, or STA conditions (see 1.2.2 for definitions) shall conform to the tensile property requirements of Tables II and III, as applicable. When specified (see 6.2.1), alpha-beta titanium alloy products in the A or STA conditions shall conform to the compressive property requirements of Table III, as applicable.

3.4.2 Heat-treatment capability. Products supplied in the F or A condition (see 1.2.2) shall be capable of being heat-treated in accordance with MIL-H-81200 to the tensile property, and, when specified (see 6.2.1), to the compressive property requirements of Tables II and III, as applicable to composition and condition. Such capability shall be demonstrated when specified (see 6.2.1).

3.4.3 Mechanical properties of alpha-beta alloys after aging. Alpha-beta alloys supplied in the ST condition (see 1.2.2) shall conform to the tensile property, and, when specified (see 6.2.1), to the compressive property requirements of Table III as applied to the STA condition when "aged" or "re-solution treated and aged" in accordance with MIL-H-81200.

3.5 Heat treatment. The heat treatment of products supplied in accordance with this specification shall conform to MIL-H-81200.

3.6 Stress relieving.

3.6.1 Stretching or straightening. Products which are stretched or straightened in Condition A, DA or STA shall be stress relieved in accordance with Table IV if the stretching or straightening is performed below the applicable stress relieving temperature specified in Table IV.

3.6.2 Straightening and stretching after solution treatment. Products supplied in Condition ST, if straightened or stretched after being heat treated to this condition, shall not be stress relieved; however, such products shall be subject to the mechanical property requirements specified herein for material supplied in Condition ST.

3.7 Ultrasonic quality. Unless otherwise specified (see 6.2.1), products shall conform to the ultrasonic quality requirement of Table V.

3.8 Microstructure. Products shall have a microstructure characteristic of extruding above the beta transus temperature.

3.9 Dimensional tolerances. Unless otherwise specified (see 6.2.1), dimensional tolerances shall conform to Table VI.

3.10 Finish. Unless otherwise specified (see 6.2.1), the product shall conform to the following finish requirements:

a. The surface shall be free of contamination by oxygen (alpha case), hydrogen, nitrogen and other harmful contamination (see 3.12).

b. The product shall be free of surface imperfections (laps, dents, gouges, die lines, etc.) with depths extending beyond the allowances specified in Table VI.

3.11 Identification of product. Each straight product 0.5 inch and greater in outside diameter or least width of flat surface, where such flat surface is accessible to a marking tool at least 0.5 inch wide and recesses not more than 1.0 inch below the outline of the product, shall be marked in a row of characters recurring at intervals not greater than three feet. Marking shall include the basic number and revision letter of this specification, producer's name or trademark, and product composition, heat or lot number and heat treat condition. The characters shall be of such size and clarity as to be legible with unaided normal vision. The marking fluid residue shall contain not more than traces of halogen-bearing compounds. Such markings shall have no deleterious effect on the product or its performance and shall be sufficiently stable to withstand normal handling, but shall be capable of being removed in hot alkaline cleaning solution without rubbing.

3.11.1 Sizes and shapes. Products of a size and shape, other than described in 3.11, shall be securely bundled or containerized (crated, boxed, etc.) for shipping. Each bundle or container shall be marked at both ends with the identification specified in 3.11. This identification shall be marked on the container or embossed on metal or plastic tags securely attached to the bundle or container.

3.12 Workmanship. The product shall be uniform in quality and condition, free from harmful alloy segregation and surface contamination by oxygen (alpha case), hydrogen, nitrogen or other contaminants, and free from foreign material. It shall be clean, sound and free from cracks, pipe, seams and other defects detrimental to the fabrication or performance of parts (see 4.4.2.1).

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 Government. The Government 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. Unless otherwise specified (see 6.2.1), a lot shall

consist of products of the same heat, composition, size, shape and condition processed at the same time.

4.3.1.2 Procedure. The procedure for sampling each heat or lot for determining conformance to the requirements of this specification shall be as specified in Table VII.

4.4 Methods of inspection and test.

4.4.1 Visual examination. Samples selected in accordance with Table VII shall be visually examined for conformance to the surface imperfections (see 3.10), identification (see 3.11) and workmanship (see 3.12) requirements.

4.4.2 Metallographic examination.

4.4.2.1 Macrostructure. A specimen, at least 0.5 inch long by full cross-section from the back end of each extruded length, shall be examined for conformance to the macrostructure workmanship (see 3.12) requirements. Unless otherwise specified (see 6.2.1), macrostructural examination shall be performed in accordance with AMS 2643.

4.4.2.2 Microstructure. In addition to the microstructure examination required by AMS 2643, conformance to the microstructure (see 3.8) and freedom from surface contamination (see 3.10) requirements shall be determined by examining at least one polished and etched specimen from each sample selected in accordance with Table VII. Examination for surface contamination shall be made at a magnification of 100X to 200X and for general microstructure at 200X to 250X. Other magnifications shall be used, as required, to ensure acceptable quality.

4.4.3 Dimensional inspection. Samples selected in accordance with Table VII for dimensional inspection shall be measured for conformance to the specified shape or dimensions (see 6.2.1) and dimensional tolerance (see 3.9) requirements.

4.4.4 Ultrasonic inspection. Ultrasonically inspected product shall be identified as agreed upon by the acquiring activity and the contractor (see 6.2.1).

4.4.4.1 Inspection personnel. Inspection shall be performed only by personnel qualified and certified to Level II or higher in accordance with MIL-STD-410.

6.2.1), each extruded length, 0.500 inch and greater in section thickness or diameter, shall be inspected in accordance with AMS 2631 for conformance to the ultrasonic quality requirements of 3.7.

4.4.4.3 Inspection of extrusion billets. Unless otherwise specified (see 6.2.1), ultrasonic inspection of billets shall be performed in lieu of such inspection of extruded product, when the products to be extruded from these billets will have thicknesses or diameters less than 0.500 inch, or are expected to have surfaces rougher than 250 microinches, even under conditions of best extrusion practice. Billets to be inspected shall have surfaces no rougher than 250 microinches. Inspection shall conform to AMS 2631 and billets shall be of Quality Level A as a minimum.

4.4.5 Packaging. Each shipment shall be inspected for conformance to the packing and marking requirements specified in 3.11.1 and Section 5.

4.4.6 *Chemical analysis*. Conformance to the chemical composition requirements shall be determined either by heat or lot analysis of samples selected in accordance with Table VII using ASTM E 120 methods of chemical analysis or FED-STD-151, Method 112.2 of spectrochemical analysis. Hydrogen shall be analyzed by the hot extraction method specified in ASTM E 146 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. In case of dispute, the results of referee chemical analysis, by the ASTM E 120 method, shall govern.

4.4.7 Mechanical property tests. Conformance to the mechanical property requirements shall be determined by testing at least one tensile specimen and, in the case of alpha-beta alloys, also one compression specimen from the back end of each sample selected in accordance with Table VII. The product shall be in the heat treat condition ordered (see 6.2.1), except that for products supplied in the solution treated (ST) condition, the ends cut from the test samples shall be aged to the STA condition prior to excising the test specimens therefrom.

4.4.7.1 Tension test. Tension tests shall be accomplished in accordance with ASTM E 8 using tension specimens conforming to Table VIII, except that the rate of strain shall be 0.003 to 0.007 inch per 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 inch per inch per minute through the yield strength and a minimum cross-head speed of 0.10 inch per minute above the yield strength shall govern.

4.4.7.2 Compression test. When compression properties meeting the requirements of Table III are specified (see 6.2.1), tests shall conform to the requirements of ASTM E 9. The strain rates shall be those specified in 4.4.7.1.

4.5 Rejection and retests.

4.5.1 Rejection. Failure of the test samples to meet the applicable requirements of this specification shall be cause for rejection of the represented lot. Retesting in accordance with 4.5.2 shall be permitted in the case of conformance to the mechanical property requirements. Retesting shall be at the discretion of the producer.

4.5.2 Retest. The sampling and test specimen requirements specified in Table VII and 4.4.7, respectively, shall be tripled for tensile or compression retest, as applicable. The retest samples shall include a sample from each of the extruded lengths that failed to meet properties in the original sampling. If one retest specimen fails, the lot shall be rejected and no further retesting shall be permitted.

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, products shall be separated by size, heat, composition 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 pack (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 the 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 shipments. In addition to any special marking required by the contract or order (see 6.2.1), shipping containers shall be marked in accordance with MIL-STD-129. The identification shall be composed of the following information listed in the order shown:

a. National stock no. or other identification number as specified in the acquisition document 1/

b. TITANIUM OR TITANIUM ALLOY, EXTRUDED METAL BARS, OR SPECIAL SHAPES, AIRCRAFT QUALITY (as applicable)

c. Size (inches) (cross-section by length)

d. Shape no. (if applicable)

e. MIL-T-81556A

f. Composition heat no.

g. Heat treatment condition

h. Lot no.

i. Gross weight (lbs)

j. Manufacturer's name or trademark

1/ The contractor shall enter the national stock no. specified in the acquisition document or as furnished by the acquiring activity. When the national stock no. is not provided or available from the acquiring activity, leave space therefore and enter the stock no. or other identification when provided by the acquiring activity.

6. NOTES

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

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

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

b. Composition (see 1.2.1).

c. Product (bar or shape) size, length, and quantity desired.

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

e. Heat treat condition (see 1.2.2).

f. Finish (see 3.10).

g. Heat treat response verification (see 3.4.2).

h. Dimensional tolerances, special sizes (see 3.9).

i. Whether ultrasonic quality (see 3.7) and ultrasonic inspection (see 4.4.4), as applicable, is waived, when conformance to either one or the other, or both, is not desired.

j. Metallographic examination (see 3.8, 3.10, 3.12 and 4.4.2).

k. Marking requirements (see 3.11).

l. Inspection lot consistency (see 4.3.1.1).

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

n. Additional marking, if necessary (see 4.4.4 and 5.3).

o. Whether compression properties are required (see 3.4 and 4.4.7).

6.4 Definitions.

6.4.1 Extruded bar. A solid section, long in relation to its cross sectional dimensions, having a symmetrical cross section that is round, square or rectangular (excluding flattened wire) with sharp or rounded corners or edges; or is a regular hexagon or octagon, and whose width or greatest distance between parallel faces is 3/8 inch or greater.

6.4.2 Extruded shape. A section produced by extrusion that is long in relation to its cross sectional dimension and has a cross section of other than that of bar.

6.4.3 Capability. The words "shall be capable of" are used 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.

6.5 Cross-reference. Table IX shows the correlation between the composition classifications used in this specification and the previous classifications used in MIL-T-81556.

6.6 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 other documents, such as, MIL-T-9046, MIL-R-81588, MIL-T-9047 and MIL-HDBK-5.

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

6.6.1 Design of coding system.

6.6.1.1 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.

6.6.1.2 Number coding of CP grades and alloys.

6.6.1.2.1 Numbering of CP grades. The order of numbering CP titanium grades follows 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 has generally been in the direction of increased purity, for example, the two grades of weld filler metal (see MIL-R-81588). It does not appear that there will be any additional effort to strengthen CP titanium by increasing oxygen concentration beyond that of CP-1.

6.6.1.2.2 Numbering 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 and 6Al-4V is coded AB-1. The 8Mn alpha-beta alloy, although of greater age than AB-1, has not enjoyed the usage of AB-1 and is assigned a higher number such as AB-6.

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

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodians:
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - AR, MI
Air Force - 99

User activities:
Army - CR
Navy - OS

Preparing activity:
Navy - AS

(Project 9540-0060)

TABLE I. Chemical composition, percent by weight (see 3.3).

Classification	Nominal composition or minys 6/	Elements											
		Al	Sn	Mo	V	Cu	Fe 1/	C (max)	N (max)	H (max) 2/	O (max)	Ti (max) 3/	Total other elements 3/
Commercially pure titanium													
CP-4	30	-	-	-	-	-	0.20	0.08	0.05	0.015	0.15	Bal	0.30
CP-3	40	-	-	-	-	-	0.30	0.08	0.05	0.015	0.20	Bal	0.30
CP-2	55	-	-	-	-	-	0.30	0.08	0.05	0.015	0.30	Bal	0.30
CP-1	70	-	-	-	-	-	0.50	0.08	0.05	0.015	0.40	Bal	0.30
Alpha titanium alloy 9/													
A-1	5Al-2.5Sn	4.50-5.75	2.00-3.00	-	-	-	0.50	0.08	0.05	0.020	0.20	Bal	0.40
A-2 8/	5Al-2.5Sn (ELI) 7/	4.50-5.75	2.00-3.00	-	-	-	0.25 4/	0.05	0.035	0.0125	0.12 4/	Bal	0.30 5/
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	Bal	0.40
Alpha-beta titanium alloy 9/													
AB-1	6Al-4V	5.50-6.75	-	-	3.50-4.50	-	0.30	0.08	0.05	0.0125	0.20	Bal	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	Bal	0.30 5/
AB-3	6Al-6V-2Sn	5.00-6.00	1.50-2.50	-	5.00-6.00	0.35-1.00	0.35-1.00	0.05	0.04	0.015	0.20	Bal	0.30
AB-4	6Al-2Sn-4Zr-2Mo + Si	5.50-6.50	1.80-2.20	1.80-2.20	-	-	0.25	0.05	0.04	0.015	0.15	Bal	0.30 10/ 11/

TABLE I. Chemical composition, percent by weight (see 3.3). - Continued

1/ Maximum, unless otherwise specified.

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

3/ Need not be determined routinely. Material shall meet stated limits 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 each shall be 0.05 percent maximum.

6/ "Min ys" = minimum yield strength at 0.2 percent offset, Ksi.

7/ "ELI" = extra low interstitials.

8/ A-3 classification has nominal composition: 6Al-2Cb-1Ta-0.8Mo and is not a subject of this specification (MIL-T-81556A)

9/ Yttrium shall not exceed 0.005 percent.

10/ Zirconium shall be 3.60 - 4.40 percent.

11/ Silicon shall be 0.06 - 0.10 percent.

TABLE II. Tensile properties of commercially pure and alpha titanium alloys. (see 3.4.1 and 3.4.2)

Alloy (code designation and composition)	Thickness, diameter or distance between flats (inches) 1/	Tensile strength, Ksi (min)	Yield strength at 0.2 percent offset, Ksi (min)	Elongation, percent in 2-inches or 4D (min)
Commercially pure titanium				
	Condition A			
CP-1	0.188 - 1.000	80	70	15
	1.001 - 2.000	80	70	12
	2.001 - 3.000	80	70	10
CP-2	0.188 - 1.000	65	55	18
	1.001 - 2.000	65	55	15
	2.001 - 3.000	65	55	12

TABLE II. Tensile properties of commercially pure and alpha titanium alloys. (see 3.4.1 and 3.4.2) - Continued

Alloy (code designation and composition)	Thickness, diameter or distance between flats (inches) 1/	Tensile strength, Ksi (min)	Yield strength at 0.2 percent offset, Ksi (min)	Elongation, percent in 2-inches or 4D (min)
Commercially pure titanium - Continued				
	Condition A			
CP-3	0.188 - 1.000	50	40	20
	1.001 - 2.000	50	40	18
	2.001 - 3.000	50	40	15
CP-4	0.188 - 1.000	40	30	25
	1.001 - 2.000	40	30	20
	2.001 - 3.000	40	30	18
Alpha titanium alloys				
	Condition A			
A-1 (5Al-2.5Sn)	0.188 - 1.000	120	115	10
	1.001 - 2.000	115	110	10
	2.001 - 3.000	115	110	8
	3.001 - 4.000	115	110	6
A-2 (5Al-2.5Sn(ELI))	0.188 - 1.000	100	95	10
A-4 (8Al-1Mo-1V)	0.188 - 0.500	145	135	10
	0.501 - 1.000	140	130	10
	1.001 - 2.500	130	120	10
	2.501 - 4.000	120	110	8
	Condition DA			
	0.188 - 1.000	130	120	10
	1.001 - 2.000	125	115	10
	2.001 - 4.000	120	110	8

1/ Thickness of the cross-section from which the specimen is taken shall determine the applicable tensile properties.

TABLE III. Tensile and compressive properties of alpha-beta titanium alloys (see 3.4.1, 3.4.2 and 3.4.3).

Alloy (code designation and composition)	Condition	Thickness, diameter or distance between flats (inches) 1/	Compressive yield strength Ksi (min)	Tensile properties			
				Tensile strength, Ksi (min)	Yield strength at 0.2 percent offset, Ksi 2/	Elongation percent in 2-inches or 4D (min) 3/	Reduction of area, percent (min) 4/
AB-1 (6Al-4V)	A	0.188 - 1.249	125	130	120 - 145	10 (8) 5/	20 (15) 5/
		1.250 - 2.000	125	130	120 - 145		
		2.001 - 4.000	125	130	120 - 145		
	STA	0.188 - 0.500	155	160	150	8	15
		0.501 - 0.750	150	155	145	8	15
		0.751 - 1.000	145	150	140	6	12
		1.001 - 2.000	140	145	135	6	12
		2.001 - 3.000	135	140	130	6	12
AB-2 (6Al-4V(ELI)	A	0.188 - 1.000	120	125	115 - 145	10	20
		1.001 - 2.000	115	120	110 - 140	10	20
		2.001 - 3.000	115	120	110 - 135	8	15
AB-3 (6Al-6V-2Sn)	A	0.188 - 1.500	145	150	140 - 165		
		1.501 - 3.000	140	145	135 - 160	10 (8) 5/	20 (15) 5/
		3.001 - 4.000	135	140	130 - 155		
	STA	0.188 - 0.500	165	170	160		
		0.501 - 1.500	160	165	155	8 (6) 5/	15 (12) 5/
		1.501 - 2.500	155	160	150		
		2.501 - 4.000	145	150	140		
AB-4 (6Al-2Sn-4Zr-2Mo)	A	0.188 - 4.000	125	130	120 - 145	10 (8)	20 (15)
	STA	0.188 - 0.500	145	150	140		
		0.501 - 1.000	140	145	135	10 (8) 5/	20 (15) 5/
		1.001 - 3.000	135	140	130		

TABLE III. Tensile and compressive properties of alpha-beta titanium alloys. (see 3.4.1, 3.4.2 and 3.4.3) - Continued

1/ Thickness of the cross section from which the specimen is taken shall determine the applicable tensile properties.

2/ Minimum yield strength, except where minimum - maximum range is specified.

3/ Not applicable to thicknesses under 0.062 inch.

4/ Not applicable to thicknesses under 0.375 inch.

5/ Values apply to all thickness ranges. First value applies to the longitudinal direction; value in parentheses applies to the transverse direction.

TABLE IV. Stress relieving (see 3.6.1). 1/

Alloy (code designation and composition	Stress relieving schedule		
	A 2/	DA 2/	STA 2/
Commercially pure titanium			
All	3/	4/	4/
Alpha titanium alloys			
A-1 and A-2 (5Al-2.5Sn and 5Al-2.5Sn (ELI))	1200° ± 25°F for 2 hours, minimum	4/	4/
A-4 (8Al-1Mo-1V)	1100° ± 25°F for 30 to 60 minutes	1000° ± 25°F for 30 to 60 minutes	4/
Alpha-beta titanium alloys			
AB-1 (6Al-4V) AB-2 (6Al-4V (ELI)) AB-3 (6Al-6V-2Sn)	1100° - 1200°F for 1 hour, minimum	4/	975° ± 25°F for 2 to 2-1/2 hours

TABLE IV. Stress relieving (see 3.6.1). - Continued 1/

1/ Stress relieving shall conform to MIL-H-81200, except that the stress relieving schedule shall be as specified herein.

2/ Heat treat condition of the material.

3/ Stress relieve per MIL-H-81200 schedules.

4/ Not applicable.

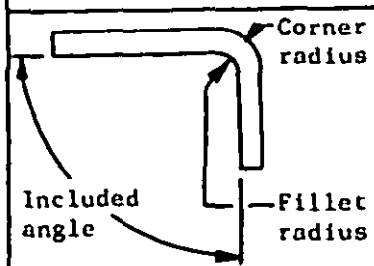
TABLE V. Ultrasonic quality (see 3.7).

Specified diameter - rod; Specified thickness - bar; Specified thickness - shape	Ultrasonic classification 1/
0.500 - 1.500 inches	AA
1.501 - 7.00 inches	A1
7.01 inches and greater	A

1/ Classification according to AMS 2631 (Grade 1 if double melted, Grade 2 if triple melted).

TABLE VI. Dimensional tolerances (see 3.9). 1/

Specified section thickness, inches	Tolerance, inch		Allowable depth of surface defects, inch
	plus	minus	
0 - 0.250	0.040	0.000	0.008
0.251 - 0.500	0.040	0.000	0.010
0.501 - 1.000	0.040	0.000	0.020
1.001 - 3.000	0.060	0.000	0.030
3.001 - 5.000	0.080	0.000	0.040
5.001 - 9.000	0.124	0.000	0.062

Parameter	Radius location	Tolerance inch	Min specified radius, inch
	1. Corner	± 0.032	0.062
	2. Fillet		
	2.1 Less than 70° incl angle	± 0.062	0.375
	2.2 70° incl angle or greater		
	2.2.1 Diam circumscribing circle less than 5-1/2 inches	± 0.062	0.188
	2.2.2 Diam circumscribing circle 5-1/2 inches or greater.	± 0.062	0.375

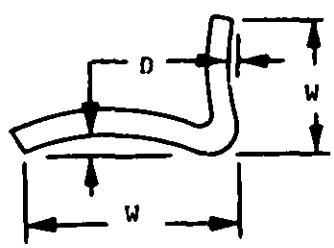
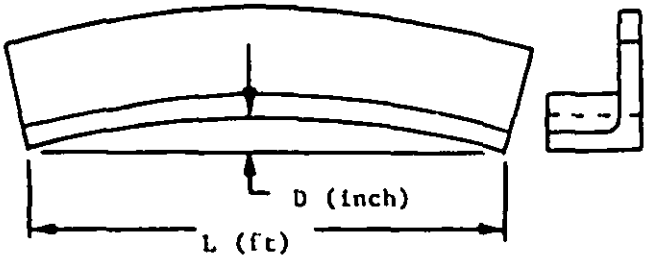
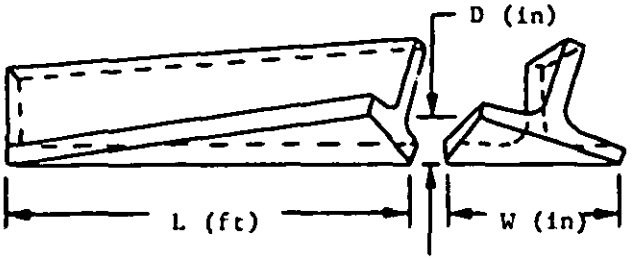
Parameter		Tolerance
Angle (degrees)		± 2 Degrees
Flatness 3/ 	Width (W), inch	D (max), inch
	1.000 and under	0.010
	Over 1.000	0.010 x width in inches
	In any one inch	0.010

TABLE VI. Dimensional tolerances (see 3.9). 1/ - Continued

<table>
<tr><th>Parameter</th><th>Tolerance</th></tr>
<tr><td>Longitudinal bow 2/ 3/
 

Length(L), ft
5 and under
Over 5
In any five feet</td><td>D (max), inch
0.125
0.025 by length in feet
0.125</td></tr>
<tr><td>Longitudinal twist 2/ 3/
 

<table>
<tr><th>L (ft)</th><th>W (in.)</th><th>D (max), inch</th></tr>
<tr><td>≤ 10</td><td>≤ 4</td><td>0.125</td></tr>
<tr><td>≤ 10</td><td>> 4 ≤ 9</td><td>0.188</td></tr>
<tr><td>> 10</td><td>≤ 9</td><td>0.025 x length in feet</td></tr>
</table></td><td></td></tr>
<tr><td>Length dimension</td><td>+ 0.25, - 0 inch</td></tr>
<tr><td>Squareness of cut (maximum deviation from square)</td><td>3 degrees</td></tr>
</table>

1/ Applicable to products having a cross-section that can be circumscribed by a circle 9 inches maximum in diameter.

2/ Pressure up to 100 pounds maximum is permissible when measuring straightness and twist.

3/ Definitions:

≤ designates "equal to or less than."

> designates "greater than."

D designates "maximum deviation from straightness or flatness."

TABLE VII. Quality conformance sampling (see 4.1, 4.3, 4.4.6, 4.4.7 and 4.5.2).

<table>
<tr><th rowspan="3">Inspection or test</th><th colspan="3">Samples 1/</th></tr>
<tr><th>Heat 2/</th><th colspan="2">Lot 3/</th></tr>
<tr><td>Visual examination</td><td rowspan="2">NA</td><td colspan="2" rowspan="2">Random samples per MIL-STD-105, inspection level II, AQL of 1.5 percent defective.</td></tr>
<tr><td>Dimensional inspection</td></tr>
<tr><td>Chemical analysis</td><td>Each ingot 4/ 5/</td><td colspan="2">Random samples per MIL-STD-105, inspection level S-3, acceptance number zero, rejection number 1. 4/ 6/</td></tr>
<tr><td rowspan="2">Mechanical properties</td><td rowspan="2">NA</td><td colspan="2">Product nominal weight (lb/lineal foot)</td></tr>
<tr><td>Under 1.6</td><td>1.6 and over</td></tr>
<tr><td>Metallographic examination</td><td>NA</td><td>One sample for the first 800 lbs or fraction thereof plus one additional sample for each subsequent 1600 lbs or fraction thereof.</td><td>One sample for the first 500 feet or fraction thereof plus one additional sample for each subsequent 1000 feet or fraction thereof.</td></tr>
</table>

1/ "NA" indicates "not applicable."

2/ Unit of sample is ingot.

3/ Unit of sample is the nominal length of the extruded product.

4/ Either heat or lot analysis is acceptable.

5/ Complete ingot analysis shall be available to the acquiring activity.

6/ The sample size shall be based only on the applicable sample size code letter corresponding to the specified inspection level of MIL-STD-105.

TABLE VIII. Mechanical property specimen requirements (see 4.4.7.1).

Product		Test specimen	
Form	Thickness, diameter or distance between flats (inch)	Configuration 1/	Test location and direction 4/
Round, square and hexagonal bar	0.375 - 1.500	R1, R2 or R3 2/	Center of cross-section
	1.501 and over	R1, R2 or R3	Midway between the center and surface of the cross-section
Rectangular bar	0.188 - 0.375	F2 3/	Full thickness 5/
	0.376 and over	R1, R2 or R3	Midway between the center and the surface on the thickness centerline
Other shapes	Unless otherwise specified (see 6.2.1), tension specimens shall be taken from the predominant area of the cross-section in accordance with the requirements specified for rectangular products.		

1/ Configurations shown are for tension specimens. Compression specimens shall conform to the requirements of ASTM E 9.

2/ R1, R2 and R3 designates specimens corresponding to round tension specimens as specified in ASTM E 8 for 0.500, 0.350 and 0.250 inch nominal diameters in the reduced test section, respectively. In case of dispute, the results obtained from testing the largest possible of these three specimen sizes shall govern.

3/ F2 designates standard sheet-type specimens with a 1/2 inch width reduced test section as specified in ASTM E 8 for rectangular tension specimens.

4/ Unless otherwise specified (see 6.2.1), the longitudinal axis of the tension specimens shall be parallel to the extruding direction and shall coincide with the specified test location within a radius of 1/16 inch.

5/ Machining the specimen thickness shall be permitted if it is limited to the removal of surface imperfections only (see 3.10).

TABLE IX. Cross-reference composition classifications (see 6.4).

MIL-T-81556A	MIL-T-81556
Commercially pure titanium	Type I - Commercially pure titanium
CP-4	A
CP-3	B
CP-2	C
CP-1	D
Alpha titanium alloy 1/	Type II - Alpha titanium alloy
A-1	A (5Al-2.5Sn)
A-2	B (5Al-2.5Sn (ELI))
A-4	C (8Al-1Mo-1V)
Alpha-beta titanium alloy	Type III - Alpha-beta titanium alloy
AB-1	A (6Al-4V)
AB-2	B (6Al-4V) (ELI)
AB-3	C (6Al-6V-2Sn)
2/	D (7Al-4Mo)
AB-4	3/

1/ Alloy A-3 has nominal composition 6Al-2Cb-1Ta-0.8Mo (see MIL-T-9046) and is not an alloy used for extrusions.

2/ Deleted composition in this specification.

3/ Composition not covered by this specification.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS This form is provided to solicit beneficial comments which may improve this document and enhance its use. DoD contractors, government activities, manufacturers, vendors, or other prospective users of the document are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity. A response will be provided to the submitter, when name and address is provided, within 30 days indicating that the 1426 was received and when any appropriate action on it will be completed.

NOTE: This form shall not be used to submit requests for waivers, deviations or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

DOCUMENT IDENTIFIER (Number) AND TITLE: MIL-T-81556A — TITANIUM AND TITANIUM ALLOYS, EXTRUDED BARS AND SHAPES, AIRCRAFT QUALITY

NAME OF ORGANIZATION AND ADDRESS OF SUBMITTER

☐ VENDOR ☐ USER ☐ MANUFACTURER

1. ☐ HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE? ☐ IS ANY PART OF IT TOO RIGID, RESTRICTIVE, LOOSE OR AMBIGUOUS? PLEASE EXPLAIN BELOW.

A. GIVE PARAGRAPH NUMBER AND WORDING

B. RECOMMENDED WORDING CHANGE

C. REASON FOR RECOMMENDED CHANGE(S)

2. REMARKS

SUBMITTED BY (Printed or typed name and address — Optional)

TELEPHONE NO.

DATE

DD FORM 1 OCT 76 1426 EDITION OF 1 JAN 72 WILL BE USED UNTIL EXHAUSTED.

FOLD

DEPARTMENT OF THE NAVY

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS PERMIT NO. 12503 WASHINGTON D. C.

POSTAGE WILL BE PAID BY THE DEPARTMENT OF THE NAVY

ENGINEERING SPECIFICATIONS AND STANDARDS
DEPARTMENT (CODE 93)
NAVAL AIR ENGINEERING CENTER
LAKEHURST, NJ 08733

FOLD