Designation: F 1472 – 00

Standard Specification for Wrought Titanium-6Aluminum-4Vanadium Alloy (UNS R56400) for Surgical Implant Applications[1]

This standard is issued under the fixed designation F 1472; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the chemical, mechanical, and metallurgical requirements for wrought annealed titanium-6aluminum-4vanadium alloy (UNS R56400) to be used in the manufacture of surgical implants.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

B 265 Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate[2]

B 348 Specification for Titanium and Titanium Alloy Bars and Billets[2]

B 381 Specification for Titanium and Titanium Alloy Forgings[2]

E 8 Test Methods for Tension Testing of Metallic Materials[3]

E 120 Test Methods for Chemical Analysis of Titanium and Titanium Alloys[4]

E 290 Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials[3]

E 527 Practice for Numbering Metals and Alloys (UNS)[5]

E 1409 Test Method for Determination of Oxygen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique[4]

E 1447 Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method[6]

F 136 Specification for Wrought Titanium-6 Aluminum-4 Vanadium ELI (Extra Low Interstitial) Alloy (UNS R56401) for Surgical Implant Applications[7]

2.2 *Other Standard:*

ASQ C1 Specifications of General Requirements for a Quality Program[8]

2.3 *Aerospace Material Specifications:*

AMS 2249 Chemical Check Analysis Limits, Titanium and Titanium Alloys[9]

AMS 4928 Titanium Alloy Bars, Wire, Forgings and Rings 6Al-4V[9]

AMS 4965 Titanium Alloy, Bars, Wire, Forgings, and Rings 6.0Al-4.0V Solution Heat Treated and Aged[9]

3. Classification

3.1 *Strip*—Any product under 0.1875 in. (4.76 mm) in thickness and under 24 in. (610 mm) wide.

3.2 *Sheet*—Any product under 0.1875 in. (4.76 mm) in thickness and 24 in. (610 mm) or more in width.

3.3 *Plate*—Any product 0.1875 in. (4.76 mm) thick and over and 10 in. (254 mm) wide and over, with widths greater than five times the thickness. Plate up to 4.00 in. (101.60 mm) thick, inclusive, is covered by this specification.

3.4 *Bar*—Round bars and flats from 0.1875 in. (4.75 mm) to 4.00 in. (101.60 mm) in diameter or thickness (other sizes and shapes by special order).

3.5 *Forging Bar*—Bar as described in 3.4, used for production of forgings, may be furnished in the hot-rolled condition.

3.6 *Wire*—Rounds less than 0.1875 in. (4.76 mm) in diameter.

4. Ordering Information

4.1 Inquiries and orders for material under this specification shall include the following information:

4.1.1 Quantity (weight or number of pieces),

4.1.2 Applicable ASTM designation,

4.1.3 Form (sheet, strip, plate, wire, bar, or forging bar),

4.1.4 Condition (see 5.1),

4.1.5 Mechanical properties (if applicable, for special conditions),

[1] This specification is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.02 on Resources.

Current edition approved Nov. 10, 2000. Published March 2001. Originally published as F 1472 – 93. Last previous edition F 1472 – 99.

[2] *Annual Book of ASTM Standards*, Vol 02.04.

[3] *Annual Book of ASTM Standards*, Vol 03.01.

[4] *Annual Book of ASTM Standards*, Vol 03.05.

[5] *Annual Book of ASTM Standards*, Vol 01.01.

[6] *Annual Book of ASTM Standards*, Vol 03.06.

[7] *Annual Book of ASTM Standards*, Vol 13.01.

[8] Available from American Society for Quality, 611 E. Wisconsin Ave., PO Box 3005, Milwaukee, WI 53201–3005.

[9] Available from the SAE World Headquarters, 400 Commonwealth Dr., Warrendale, PA 15096–0001.

4.1.6 Finish (see 5.2),

4.1.7 Applicable dimensions including size, thickness, width, or drawing number,

4.1.8 Special tests, and

4.1.9 Special requirements.

5. Materials and Manufacture

5.1 *Finish*—Annealed material may be furnished to the implant manufacturer as descaled or pickled, sandblasted, ground, machined, vapor blasted, or combinations of these operations.

5.2 Alloy shall be multiple melted; at least one of the melting cycles shall be under vacuum. The first melt shall be made by consumable electrode, nonconsumable electrode, electron beam, or plasma arc melting practice. The subsequent melt or melts shall be made using consumable electrode practice with no alloy additions permitted in the last consumable electrode melt.

5.2.1 The atmosphere for nonconsumable electrode melting shall be inert gas at a pressure not higher than 250 mm of mercury.

5.2.2 The electrode tip for nonconsumable electrode melting shall be water-cooled copper.

5.2.3 The product, as received by the purchaser, shall be uniform in quality and condition, sound, and free from foreign materials and from internal and external imperfections detrimental to usage of the product.

6. Chemical Requirements

6.1 The heat analysis shall conform to the chemical composition of Table 1. Ingot analysis may be used for reporting all chemical requirements, except hydrogen. Samples for hydrogen shall be taken from the finished mill product. Supplier shall not ship material with chemistry outside the limits specified in Table 1.

6.1.1 Requirements for major and minor elemental constituents are listed in Table 1. Also listed are important residual elements. Analysis for elements not listed in Table 1 is not required to verify compliance with this specification.

6.2 The product analysis is either for the purpose of verifying the composition of a heat or lot or to determine variations in the composition within the heat.

6.2.1 Acceptance or rejection of a heat or lot of material may be made by the purchaser on the basis of this product analysis.

6.2.2 Product analysis tolerances do not broaden the specified heat analysis requirements but cover variation between laboratories in the measurement of chemical content. Product analysis limits shall be as specified in Table 2.

6.3 For referee purposes, Test Methods E 120, E 1409, and E 1447 shall be used.

6.4 Samples for chemical analysis shall be representative of the material being tested. The utmost care must be used in sampling titanium for chemical analysis because of its affinity for elements such as oxygen, nitrogen, and hydrogen. Therefore, in cutting samples for analysis, the operation should be carried out insofar as possible in a dust-free atmosphere. Cutting tools should be clean and sharp. Chips should be clean. Samples for analysis should be stored in suitable containers.

7. Mechanical Requirements

7.1 Material supplied under this specification shall conform to the mechanical property requirements given in Table 3.

7.2 Specimens for tension tests shall be machined and tested in accordance with Test Methods E 8. Tensile properties shall be determined using a strain rate of 0.003 to 0.007 in./in./min (mm/mm/min) through the specified yield strength, and then the crosshead speed shall be increased so as to produce fracture in approximately one additional minute.

7.3 For sheet and strip, the bend test specimen shall withstand being bent cold through an angle of 105° without fracture in the outside surface of the bent portion. The bend shall be made on a diameter equal to that shown in Table 3. Test condition shall conform to Test Method E 290.

8. Special Requirements

8.1 The microstructure shall be a fine dispersion of the alpha and beta phases resulting from processing in the alpha plus beta field. There shall be no continuous alpha network at prior beta grain boundaries. There shall be no course, elongated alpha platelets.

8.2 The beta transus temperature shall be determined by a suitable method and reported on the material's certification.

8.3 Products supplied with a machined or ground surface finish shall have no alpha case. For other products, there shall be no continuous layer of alpha case when examined at 100×.

9. Quality Program Requirements

9.1 The producer shall maintain a quality program such as that defined in Specifications ASQ C1.

TABLE 1 Chemical Requirements[A]

Element	Composition, %
Nitrogen, max	0.05
Carbon, max	0.08
Hydrogen, max[B]	0.015
Iron, max	0.30
Oxygen, max	0.20
Aluminum	5.5–6.75
Vanadium	3.5–4.5
Yttrium, max	0.005
Titanium[C]	balance

[A]Refer to AMS 4928.

[B]Billets shall have a maximum of 0.01 % hydrogen content.

[C]The percentage of titanium is determined by difference and need not be determined or certified.

TABLE 2 Permissible Variation in Product Analysis Tolerance[A]

Element	Tolerance Under the Minimum or Over the Maximum Limit (Composition %)[B]
Nitrogen	0.02
Carbon	0.02
Hydrogen	0.002
Iron	0.10
Oxygen	0.02
Aluminum	0.04
Vanadium	0.015
Yttrium	0.0006

[A]Refer to AMS 2249.

[B]Under minimum limit not applicable for elements in which only a maximum percentage is indicated.