



# Standard Specification for Unalloyed Titanium, for Surgical Implant Applications (UNS R50250, UNS R50400, UNS R50550, UNS R50700)<sup>1</sup>

This standard is issued under the fixed designation F 67; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This specification covers the chemical, mechanical, and metallurgical requirements for four grades of unalloyed titanium strip, sheet, plate, bar, billet, forging, and wire used for the manufacture of surgical implants.

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

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**B 265** Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate

**B 348** Specification for Titanium and Titanium Alloy Bars and Billets

**B 381** Specification for Titanium and Titanium Alloy Forgings

**E 8** Test Methods for Tension Testing of Metallic Materials

**E 29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

**E 290** Test Methods for Bend Testing of Material for Ductility

**E 1409** Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique

**E 1447** Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity/Infrared Detection Method

**E 2371** Test Method for Analysis of Titanium and Titanium Alloys by Atomic Emission Plasma Spectrometry

**F 981** Practice for Assessment of Compatibility of Biomaterials for Surgical Implants with Respect to Effect of Materials on Muscle and Bone

2.2 *Aerospace Material Specification:*

**AMS 2249** Chemical Check Analysis Limits, Titanium and Titanium Alloys<sup>3</sup>

2.3 *ISO Standards:*

**ISO 5832-2** Implants for Surgery—Metallic Materials—Unalloyed Titanium<sup>4</sup>

**ISO 6892** Metallic Materials—Tensile Testing at Ambient Temperature<sup>4</sup>

**ISO 9001** Quality Management Systems<sup>4</sup>

2.4 *American Society for Quality (ASQ) Standard:*

**C1** Specifications of General Requirements for a Quality Program<sup>4</sup>

## 3. Terminology

3.1 *Definition of Term Specific to This Standard:*

3.1.1 *lot, n*—the total number of mill products produced from the same melt heat under the same conditions at essentially the same time.

## 4. Product Classification

4.1 Product classifications are consistent with Specifications **B 265**, **B 348**, and **B 381**.

4.1.1 *Strip*—Any product 0.1875 in. (4.76 mm) and under in thickness and less than 24 in. (610 mm) in width.

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

4.1.3 *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 thickness. Plate up to 4 in. (101.60 mm), thick inclusive is covered by this specification.

4.1.4 *Bar*—Rounds, flats, or other shapes from 0.1875 in. (4.76 mm) to 4 in. (101.60 mm) in diameter or thickness. (Other sizes and shapes by special order.)

4.1.5 *Billet*—A solid semi-finished section hot rolled or forged from an ingot, with a cross sectional area greater than 16 in.<sup>2</sup> (10 322 mm<sup>2</sup>) whose width is less than 5 times its thickness.

4.1.6 *Forging*—Any product of work on metal formed to a desired shape by impact or pressure in hammers, forging machines, upset presses, or related forming equipment.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.12 on Metallurgical Materials.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

<sup>4</sup> Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203.

\*A Summary of Changes section appears at the end of this standard.

**TABLE 1 Chemical Requirements**

Element	Composition <sup>A</sup> , % (mass/mass)			
	Grade 1 UNS R50250	Grade 2 UNS R50400	Grade 3 UNS R50550	Grade 4 UNS R50700
Nitrogen, max	0.03	0.03	0.05	0.05
Carbon, max	0.08	0.08	0.08	0.08
Hydrogen, max <sup>B</sup>	0.015	0.015	0.015	0.015
Iron, max	0.20	0.30	0.30	0.50
Oxygen, max	0.18	0.25	0.35	0.40
Titanium	balance	balance	balance	balance

<sup>A</sup> Forgings are designated Grade F-1, F-2, F-3, or F-4 respectively. Forging compositions are as specified in [Table 1](#).

<sup>B</sup> Maximum hydrogen content for billet is 0.0100 wt%.

**TABLE 2 Product Analysis Tolerances<sup>A</sup>**

Element	Limit or Maximum of Specified Range %, (mass/mass)	Tolerance Under the Minimum or Over the Maximum Limit <sup>B</sup>
Nitrogen	up to 0.05	0.02
Carbon	0.10	0.02
Hydrogen	up to 0.015	0.0020
Iron	up to 0.25	0.10
Iron	over 0.25	0.15
Oxygen	up to 0.20	0.02
Oxygen	over 0.20	0.03

<sup>A</sup> Refer to [AMS 2249](#).

<sup>B</sup> Under minimum limit not applicable for elements where only a maximum percentage is indicated.

4.1.7 *Wire*—Rounds, flats or other shapes less than 0.1875 in. (4.76 mm) in diameter or thickness.

4.1.8 *Other*—Other forms and shapes, including tubing, may be provided by agreement between purchaser and supplier.

## 5. Ordering Information

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

5.1.1 Quantity (weight or number of pieces),

5.1.2 Grade (1, 2, 3, or 4),

5.1.3 ASTM designation,

5.1.4 Form (sheet, strip, plate, bar, billet, forging, wire, or other forms),

5.1.5 Condition (see [6.1](#)),

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

5.1.7 Finish (see [6.2](#)),

5.1.8 Applicable dimensions and tolerances including size, thickness, width, and length (exact, random, multiples) or drawing number,

5.1.9 Special tests, and

5.1.10 Other requirements.

## 6. Manufacture

6.1 *Condition*—Material shall be furnished in the hot-worked, cold-worked, forged, annealed, or stress-relieved condition.

6.2 *Finish*—Unalloyed titanium material shall be free of injurious external and internal imperfections of a nature that will interfere with the purpose for which it is intended. The mill product may be furnished as descaled or pickled, abrasive blasted, chemically milled, ground, machined, peeled, polished, or as specified by the purchaser. On billets, bars, plates,

**TABLE 3 Mechanical Requirements: Annealed-Bar, Billet, Forgings, and Other Forms<sup>A</sup>**

Grade	Tensile Strength, min		Yield Strength, 0.2 % Offset, min		Elongation <sup>B</sup> in 4D, min, %	Reduction of Area, min, % <sup>C</sup>
	ksi	MPa	ksi	MPa		
1	35	240	25	170	24	30
2	50	345	40	275	20	30
3	65	450	55	380	18	30
4	80	550	70	483	15	25

<sup>A</sup> These properties apply to forgings having a maximum cross section area not greater than 3 in.<sup>2</sup> (1935 mm<sup>2</sup>). Mechanical properties of forgings having greater cross sections shall be negotiated between the manufacturer and the purchaser.

<sup>B</sup> Elongation of material 0.063 in. (1.6 mm) or greater in diameter (*D*) or width (*W*) shall be measured using a gauge length of 2 in. or 4*D* or 4*W*. The gauge length must be reported with the test results. The method for determining elongation of material under 0.063 in. (1.6 mm) in diameter or thickness may be negotiated. Alternatively, a gauge length corresponding to [ISO 6892](#) may be used when agreed upon between supplier and purchaser. (5.65 times the square root of *S*<sub>o</sub>, where *S*<sub>o</sub> is the original cross sectional area.)

<sup>C</sup> Reduction of area not required for tubing.

and forgings, it is permissible to remove minor surface imperfections by spot grinding if such grinding does not reduce the dimension below the minimum permitted by the dimensional tolerance ordered.

## 7. Chemical Composition

7.1 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 requirements specified in [Table 1](#) for the applicable grade.

7.1.1 Requirements for the 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.

7.2 *Product Analysis*—Product analysis tolerances do not broaden the specified heat analysis requirements but cover variations between laboratories in the measurement of chemical content. The product analysis tolerances shall conform to the product tolerances in [Table 2](#).

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

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

7.3 *Referee Analysis*—If the results of the purchaser's product analysis are outside the limits allowed in [Table 2](#), these