Designation: ~~B367 – 09~~ B367 – 13

Standard Specification for Titanium and Titanium Alloy Castings[1]

This standard is issued under the fixed designation B367; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers titanium and titanium alloy castings intended for general corrosion resistant and industrial applications. as follows:

1.1.1 *Grade C-2*—UNS R52550. Unalloyed titanium,

1.1.2 *Grade C-3*—UNS R52550. Unalloyed titanium,

1.1.3 *Grade C-5*—UNS R56400. Titanium alloy (6 % aluminum, 4 % vanadium),

1.1.4 *Grade C-7*—UNS R52700. Unalloyed titanium plus 0.12 to 0.25 % palladium,

1.1.5 *Grade C-8*—UNS R52700. Unalloyed titanium plus 0.12 to 0.25 % palladium,

1.1.6 *Grade C-9*—UNS R56320. Titanium alloy (3 % aluminum, 2.5 % vanadium),

1.1.7 *Grade C-12*—UNS R53400. Titanium alloy (0.3 % molybdenum, 0.8 % nickel),

1.1.8 *Grade C-16*—UNS R52402. Unalloyed titanium plus 0.04 to 0.08 % palladium,

1.1.9 *Grade C-17*—UNS R52252. Unalloyed titanium plus 0.04 to 0.08 % palladium, and

1.1.10 *Grade C-38*—UNS R54250. Titanium alloy (4 % aluminum, 2.5 % vanadium, 1.5 % iron).

1.2 This specification is intended for use of purchasers and/or producers of reactive metal castings for defining the requirements and assuring the properties of castings for unique corrosion-resistant applications, that is, not for commodity items which must meet all potential purchasers' requirements.

1.2.1 Users are advised to use the specification as a basis for obtaining castings which will meet minimum acceptance requirements established and revised by consensus of the members of the committee.

1.2.2 User requirements considered more stringent may be met by the addition to the purchase order of one or more supplementary requirements, which may include, but are not limited to, those listed in Sections S1 through S8.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A802/A802M Practice for Steel Castings, Surface Acceptance Standards, Visual Examination

E8 Test Methods for Tension Testing of Metallic Materials

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E94 Guide for Radiographic Examination

E142 Method for Controlling Quality of Radiographic Testing (Withdrawn 2000)[3]

E165 Practice for Liquid Penetrant Examination for General Industry

E446 Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness

E539 Test Method for Analysis of Titanium Alloys by X-Ray Fluorescence Spectrometry

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[1] This specification is under the jurisdiction of ASTM Committee B10 on Reactive and Refractory Metals and Alloys and is the direct responsibility of Subcommittee B10.01 on Titanium.

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

[3] The last approved version of this historical standard is referenced on www.astm.org.

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

E1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Technique
E1447 Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by Inert Gas Fusion Thermal Conductivity/Infrared Detection Method
E1941 Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis
E2371 Test Method for Analysis of Titanium and Titanium Alloys by Direct Current Plasma and Inductively Coupled Plasma Atomic Emission Spectrometry (Performance-Based Test Methodology)
E2626 Guide for Spectrometric Analysis of Reactive and Refractory Metals

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 *lot, n*—shall consist of all castings of the same design produced from the same pour.
3.1.2 *pour, n*—shall consist of all material melted and cast at one time.

4. Ordering Information

4.1 Orders for castings to this specification shall include the following as required, to describe the requirements adequately:
4.1.1 Description of the castings by pattern number or drawing. Dimensional tolerances shall be included on the casting drawing,
4.1.2 Quantity,
4.1.3 Grade designation (see Table 1),
4.1.4 Options in the specification, and
4.1.5 Supplementary requirements desired, including the standards of acceptance.

5. Materials and Manufacture

5.1 Materials for this specification shall be melted by conventional processes used for reactive metals. Typical methods include the consumable electrode and induction-slag, plasma arc, induction-skull, and electron beam melting processes.

6. Chemical Composition

6.1 *Pour Analysis*—An analysis of each pour shall be made by the producer from a sample such as a casting or test bar that is representative of the pour. The chemical composition determined shall conform to the requirements specified for the relevant grade in Table 1.
6.1.1 The elements listed in Table 1 are intentional alloy additions or elements which are inherent to the manufacture of titanium sponge, ingot or mill product.
6.1.1.1 Elements other than those listed in Table 1 are deemed to be capable of occurring in the grades listed in Table 1 by and only by way of unregulated or unanalyzed scrap additions to the ingot melt. Therefore product analysis for elements not listed in Table 1 shall not be required unless specified and shall be considered to be in excess of the intent of this specification.
6.1.2 Elements intentionally added to the melt must be identified, analyzed, and reported in the chemical analysis.

6.2 When agreed upon by the producer and the purchaser and requested by the purchaser in his written purchase order, chemical analysis shall be completed for specific residual elements not listed in this specification.

6.3 *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 producer shall not ship material which is outside the limits specified in Table 1 for the applicable grade. Product analysis limits shall be as specified in Table 2.

6.4 *Sampling*—Samples for chemical analysis may be made by the purchaser on a representative casting from any lot. Due to the possibility of oxygen or other interstitial contamination, samples for oxygen, carbon, hydrogen, and nitrogen analysis shall be taken no closer than ¼ in. (6.3 mm) to a cast surface except that castings too thin for this shall be analyzed on representative material. The chemical composition determined shall conform to the analysis in Table 1 within the check analysis variations shown in Table 2 or shall be subject to rejection by the purchaser.

7. Heat Treatment

7.1 Unless otherwise specified in the contract, all castings will be supplied in the as-cast condition except when post-weld heat treatment is required.

7.2 If post-weld heat treatment is required, it shall consist of a stress relief performed at 1075 ± 25°F (580 ± 14°C) for Grades C-2, C-3, C-7, C-8, C-12, C-16 and C-17, and 1200 ± 25°F (650 ± 14°C) for Grades C-5, C-6, C-9, C-18, and C-38. Time at temperature shall be a minimum of ½ h plus an additional ½ h at temperature per inch of thickness for section sizes greater than 1 in. (25 mm). After heat treatment, the castings should be cooled in air or in the furnace to ambient temperature unless otherwise agreed upon between the purchaser and producer.

TABLE 1 Chemical Requirements

Grade	Carbon, max.	Oxygen range or max.	Nitrogen, max.	Hydrogen, max.	Iron range or max.	Aluminum	Vanadium	Palladium	Ruthenium	Nickel	Molybdenum	Chromium	Cobalt	Zirconium	Niobium	Tin	Silicon	Other Elements, max. each	Other Elements, max. total
						Composition, Weight Percent[A,B,C,D,E]													
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C-2	0.10	0.40	0.05	0.015	0.20	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C-3	0.10	0.40	0.05	0.015	0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
~~C-5~~	~~0.10~~	~~0.25~~	~~0.05~~	~~0.015~~	~~0.40~~	~~5.5-6.75~~	~~3.5-4.5~~	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~C-6~~	~~0.10~~	~~0.20~~	~~0.05~~	~~0.015~~	~~0.50~~	~~4.0-6.0~~	—	—	—	—	—	—	—	—	—	~~2.0-3.0~~	—	~~0.1~~	~~0.4~~
~~C-7~~	~~0.10~~	~~0.40~~	~~0.05~~	~~0.015~~	~~0.20~~	—	—	~~0.12-0.25~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~C-8~~	~~0.10~~	~~0.40~~	~~0.05~~	~~0.015~~	~~0.25~~	—	—	~~0.12-0.25~~	—	—	—	—	—	—	—	—	—	—	—
~~C-9~~	~~0.10~~	~~0.20~~	~~0.05~~	~~0.015~~	~~0.25~~	~~2.5-3.5~~	~~2.0-3.0~~	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
~~C-12~~	~~0.10~~	~~0.25~~	~~0.05~~	~~0.015~~	~~0.30~~	—	—	—	—	~~0.6-0.9~~	~~0.2-0.4~~	—	—	—	—	—	—	~~0.1~~	~~0.4~~
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
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—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
~~C-16~~	~~0.10~~	~~0.18~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
~~C-17~~	~~0.10~~	~~0.20~~	~~0.03~~	~~0.015~~	~~0.25~~	—	—	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~C-18~~	~~0.08~~	~~0.20~~	~~0.03~~	~~0.015~~	~~0.25~~	~~2.5-3.5~~	~~2.0-3.0~~	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
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—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
~~C-38~~	~~0.08~~	~~0.20-0.30~~	~~0.03~~	~~0.015~~	~~1.2-1.8~~	~~3.5-4.5~~	~~2.0-3.0~~	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~

TABLE 1 Chemical Requirements

Grade	UNS Number	Carbon, max.	Oxygen range or max.	Nitrogen, max.	Hydrogen, max.	Iron range or max.	Aluminum	Vanadium	Palladium	Ruthenium	Nickel	Molybdenum	Chromium	Cobalt	Zirconium	Niobium	Tin	Silicon	Other Elements, max. each	Other Elements, max. total
							Composition, Weight Percent[A,B,C,D,E]													
—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C-2	R52550	0.10	0.40	0.05	0.015	0.20	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C-3	R52550	0.10	0.40	0.05	0.015	0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Grade	UNS Number	Composition, Weight Percent[A,B,C,D,E] Carbon, max.	Oxygen range or max.	Nitrogen, max.	Hydrogen, max.	Iron range or max.	Aluminum	Vanadium	Palladium	Ruthenium	Nickel	Molybdenum	Chromium	Cobalt	Zirconium	Niobium	Tin	Silicon	Other Elements, max. each	Other Elements, max. total
C-5	R56400	0.10	0.25	0.05	0.015	0.40	5.5-6.75	3.5-4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
C-6	R54520	0.10	0.20	0.05	0.015	0.50	4.0-6.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	2.0-3.0	- -	0.1	0.4
C-7	R52700	0.10	0.40	0.05	0.015	0.20	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
C-8	R52700	0.10	0.40	0.05	0.015	0.25	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
C-9	R56320	0.10	0.20	0.05	0.015	0.25	2.5-3.5	2.0-3.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
C-12	R53400	0.10	0.25	0.05	0.015	0.30	- -	- -	- -	- -	0.6-0.9	0.2-0.4	- -	- -	- -	- -	- -	- -	0.1	0.4
C-16	R52402	0.10	0.18	0.03	0.015	0.30	- -	- -	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
C-17	R52252	0.10	0.20	0.03	0.015	0.25	- -	- -	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
C-18	R58465	0.08	0.20	0.03	0.015	0.25	2.5-3.5	2.0-3.0	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
C-38	R54250	0.08	0.20-0.30	0.03	0.015	1.2-1.8	3.5-4.5	2.0-3.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4

[A] At minimum, one pour analysis shall be completed and reported for all elements listed for the respective grade in this table.
[B] If the casting is subjected to thermal or chemical processing following the pour, final product hydrogen shall be reported in lieu of pour hydrogen. Lower hydrogen may be obtained by negotiation with the manufacturer.
[C] Single values are maximum. The percentage of titanium is determined by difference.
[D] Other elements need not be reported unless the concentration level is greater than 0.1 % each, or 0.4 % total. Other elements may not be added intentionally. Other elements may be present in titanium or titanium alloys in small quantities and are inherent to the manufacturing process. In titanium these elements typically include aluminum, vanadium, tin, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten.
[E] The purchaser may, in the written purchase order, request analysis for specific elements not listed in this specification.