Designation: ~~B988 – 13~~ B988 – 18

Standard Specification for Powder Metallurgy (PM) Titanium and Titanium Alloy Structural Components[1]

This standard is issued under the fixed designation B988; 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~~ Scope*

1.1 This specification covers powder metallurgy (PM) structural components fabricated from:

1.1.1 Commercially pure (CP) (that is, unalloyed) titanium powder,

1.1.2 Pre-alloyed powders.

1.1.3 Mixtures of elemental powders or mixtures of elemental powders and pre-alloyed powders.

1.2 This specification covers:

1.2.1 *Grade 1 PM*—Unalloyed titanium,

1.2.2 *Grade 2 PM*—Unalloyed titanium,

1.2.3 *Grade 3 PM*—Unalloyed titanium,

1.2.4 *Grade 4 PM*—Unalloyed titanium,

1.2.5 *Grade 5 PM*—Titanium alloy ~~(6%~~(6 % aluminum, ~~4%~~4 % vanadium),

1.2.6 *Grade 9 PM*—Titanium alloy ~~(3%~~(3 % aluminum, ~~2.5%~~2.5 % vanadium),

1.2.7 Ti-6Al-4V PM Low Interstitial (LI),

1.2.8 Ti-6Al-6V-2Sn PM.

1.3 The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.4 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B243 Terminology of Powder Metallurgy

B311 Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity

B348 Specification for Titanium and Titanium Alloy Bars and Billets

B923 Test Method for Metal Powder Skeletal Density by Helium or Nitrogen Pycnometry

B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

E8/E8M Test Methods for Tension Testing of Metallic Materials

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

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

E1409 Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion

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

[1] This specification is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.11 on Near Full Density Powder Metallurgy Materials.

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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.

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

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 (Withdrawn 2017)[3]

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy terms can be found in Terminology B243.

4. Ordering Information

4.1 Orders for components under this specification should include the following information, or portions of it, as agreed to between purchaser and ~~supplier:~~producer:

4.2 Grade or alloy composition (see Section 6 and Table 1).

4.3 Mechanical properties (see Section 8 and Table 2).

4.4 Density (see 7.1).

4.5 Component description (see Section 9).

4.6 Processing route (see Section 5).

4.7 Certification (see Section 12).

4.8 *Sampling*—Sample size for determining chemical composition will be decided by purchaser and ~~supplier.~~producer. Methods for chemical analysis are referenced in 10.1.1.

4.9 Number of tensile tests required as mutually agreed upon by purchaser and ~~supplier.~~producer.

5. Materials and Manufacture

5.1 Structural components may be fabricated from powders by processing to a ~~near net~~ near-net or net shape with final machining performed if required. Powders may include titanium, pre-alloyed titanium alloys, master alloys, and other elemental powders. The consolidation method shall be sufficient to achieve the final mechanical properties specified. The processing method may include any combination of cold compaction (for example, cold isostatic pressing, uniaxial pressing), powder roll compaction, hot compaction (for example, hot isostatic pressing, powder forging, and pneumatic isostatic forging), sintering, and heat treatment.

6. Chemical Composition

6.1 Chemical composition shall conform to the requirements of Table 1. The purchaser may negotiate with the ~~supplier~~producer for other chemical requirements.

6.2 Chemical analysis shall be made in accordance with Test Methods E2371, E1409, E1447, E1941; alternatively, Test Method E539, or any other standard method mutually agreed upon between the purchaser and ~~supplier.~~producer. Alternative techniques are discussed in Guide E2626.

7. Physical Properties

7.1 *Density*—This specification covers high-and full-density parts with no interconnected porosity.

TABLE 1 Chemical Composition Requirements[A]

NOTE 1—Additional compositions may be added with future revisions.

Composition, Weight %	N, max	C, max	H, max	Fe	O, max	Al	V	Sn	Cu	Cr	Nb	Residual max ea.
Grade 1 PM	0.03	0.08	0.015	0.20 max	0.18	—	—	—	—	—	—	0.1
Grade 2 PM	0.03	0.08	0.015	0.30 max	0.25	—	—	—	—	—	—	0.1
Grade 3 PM	0.05	0.08	0.015	0.30 max	0.35	—	—	—	—	—	—	0.1
Grade 4 PM	0.05	0.08	0.015	0.50 max	0.40	—	—	—	—	—	—	0.1
Grade 5 PM (Ti-6Al-4V)	0.05	0.08	0.015	0.40 max	0.30	5.50–6.75	3.50–4.50	—	—	—	—	0.1
Grade 9 PM (Ti-3Al-2.5V)	0.03	0.08	0.015	0.25 max	0.30	2.50–3.50	2.00–3.00	—	—	—	—	0.1
Ti-6Al-4V, LI[B]	0.03	0.08	0.0125	0.25 max	0.20	5.50–6.75	3.50–4.50	—	—	—	—	0.1
Ti-6Al-6V-2Sn	0.04	0.1	0.015	0.35–1.0	0.30	5.0–6.0	5.0–6.0	1.5–2.5	0.35–1.0	—	—	0.1

[A] For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit in accordance with the rounding method of Practice E29. The specified elements of the chemical composition for the Grades in Table 1 reference the chemical compositions from Specification B348.
[B] LI = low interstitial.

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