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Standard Specification for Titanium and Titanium Alloy Bars and Billets¹

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

^{ε1} NOTE—Tensile strength for Grade 3 and Grade 4 in Table 3 was corrected editorially in January 2006.

1. Scope

1.1 This specification² covers annealed titanium and titanium alloy bars and billets as follows:

- 1.1.1 *Grade 1*—Unalloyed titanium,
- 1.1.2 *Grade 2*—Unalloyed titanium,
- 1.1.3 *Grade 3*—Unalloyed titanium,
- 1.1.4 *Grade 4*—Unalloyed titanium,
- 1.1.5 *Grade 5*—Titanium alloy (6 % aluminum, 4 % vanadium),
- 1.1.6 *Grade 6*—Titanium alloy (5 % aluminum, 2.5 % tin),
- 1.1.7 *Grade 7*—Unalloyed titanium plus 0.12 to 0.25 % palladium,
- 1.1.8 *Grade 9*—Titanium alloy (3 % aluminum, 2.5 % vanadium),
- 1.1.9 *Grade 11*—Unalloyed titanium plus 0.12 to 0.25 % palladium,
- 1.1.10 *Grade 12*—Titanium alloy (0.3 % molybdenum, 0.8 % nickel),
- 1.1.11 *Grade 13*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.12 *Grade 14*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.13 *Grade 15*—Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.14 *Grade 16*—Unalloyed titanium plus 0.04 to 0.08 % palladium,
- 1.1.15 *Grade 17*—Unalloyed titanium plus 0.04 to 0.08 % palladium,
- 1.1.16 *Grade 18*—Titanium alloy (3 % aluminum, 2.5 % vanadium) plus 0.04 to 0.08 % palladium,
- 1.1.17 *Grade 19*—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum),

1.1.18 *Grade 20*—Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum) plus 0.04 %–0.08 % palladium,

1.1.19 *Grade 21*—Titanium alloy (15 % molybdenum, 3 % aluminum, 2.7 % niobium, 0.25 % silicon),

1.1.20 *Grade 23*—Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements, ELI),

1.1.21 *Grade 24*—Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.04 % to 0.08 % palladium,

1.1.22 *Grade 25*—Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.3 % to 0.8 % nickel and 0.04 % to 0.08 % palladium,

1.1.23 *Grade 26*—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.24 *Grade 27*—Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.25 *Grade 28*—Titanium alloy (3 % aluminum, 2.5 % vanadium plus 0.08–0.14 % ruthenium),

1.1.26 *Grade 29*—Titanium alloy (6 % aluminum, 4 % vanadium, extra low interstitial, ELI plus 0.08–0.14 % ruthenium),

1.1.27 *Grade 30*—Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.28 *Grade 31*—Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.29 *Grade 32*—Titanium alloy (5 % aluminum, 1 % tin, 1 % zirconium, 1 % vanadium, 0.8 % molybdenum),

1.1.30 *Grade 33*—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

1.1.31 *Grade 34*—Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

1.1.32 *Grade 35*—Titanium alloy (4.5 % aluminum, 2 % molybdenum, 1.6 % vanadium, 0.5 % iron, 0.3 % silicon),

1.1.33 *Grade 36*—Titanium alloy (45 % niobium), and

1.1.34 *Grade 37*—Titanium Alloy (1.5 % aluminum).

1.2 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.

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 ASME Boiler and Pressure Vessel Code applications see related Specification SB-348 in Section II of that Code.

2. Referenced Documents

2.1 ASTM Standards:³

- 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 120 Test Methods for Chemical Analysis of Titanium and Titanium Alloys⁴
- 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

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *bar, n*—a hot rolled, forged, or cold worked semifinished solid section product whose cross sectional area is equal to or less than 16 in.² (10 323 mm²); rectangular bar must be less than or equal to 10 in. (254 mm) in width and greater than 0.1875 in. (4.8 mm) in thickness.

3.1.2 *billet, n*—a solid semifinished section hot rolled or forged from an ingot, with a cross sectional area greater than 16 in.² (10 323 mm²) whose width is less than five times its thickness.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information as applicable:

- 4.1.1 Grade number (Section 1),
- 4.1.2 Product classification (Section 3),
- 4.1.3 Chemistry (Table 1),
- 4.1.4 Mechanical properties (Table 3),
- 4.1.5 Marking (Section 16),
- 4.1.6 Finish (Section 8),
- 4.1.7 Packaging (Section 16),
- 4.1.8 Required reports (Section 15), and
- 4.1.9 Disposition of rejected material (Section 14).

5. Chemical Composition

5.1 The grades of titanium and titanium alloy metal covered by this specification shall conform to the requirements as to chemical composition prescribed in Table 1.

5.1.1 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.

5.1.1.1 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.

5.1.2 Elements intentionally added to the melt must be identified, analyzed and reported in the chemical analysis.

5.2 When agreed upon by the producer and 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.

5.3 *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 manufacturer 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. Mechanical Properties

6.1 Material supplied under this specification shall conform to the mechanical property requirements given in Table 3, as applicable.

6.2 Tension testing specimens are to 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 through the specified yield strength, and then increasing the rate so as to produce failure in approximately one additional minute.

7. Dimensions, Weight, and Permissible Variations

7.1 *Size*—Tolerances on titanium and titanium alloy material covered by this specification shall be as specified in Tables 4-11, as applicable.

7.2 *Weight*—Quantity extras are applicable to individual items of a grade, thickness, width, and length ordered at one time for shipment at one time to one destination. Different lengths of the same size and grade may be combined for quantity extra. The shipping weight of any item of an ordered size in any finish may exceed the theoretical weight by as much as 10 %.

8. Workmanship, Finish, and Appearance

8.1 Titanium and titanium alloy bar and billet shall be free of injurious external and internal imperfections of a nature that will interfere with the purpose for which it is intended. Annealed material may be furnished as descaled, sandblasted, ground, or rough turned. The manufacturer shall be permitted to remove minor surface imperfections by spot grinding if such grinding does not reduce the thickness of the material below the minimum permitted by the tolerance for the thickness ordered.

9. Sampling

9.1 Samples for chemical analyses shall be representative of the material being tested. The utmost care must be used in sampling titanium for chemical analysis because of its great 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. Chips should be collected from clean metal and tools should be clean and sharp. Samples for analysis should be stored in suitable containers.

9.2 At least two samples for chemical analysis shall be tested to determine chemical composition. Samples shall be

³ 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.

⁴ Withdrawn.