Designation: B 348 – 06

Standard Specification for Titanium and Titanium Alloy Bars and Billets[1]

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

1. Scope

1.1 This specification[2] 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),

1.1.34 *Grade 37*—Titanium alloy (1.5 % aluminum), and

[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.

1.1.35 *Grade 38*—Titanium alloy (4 % aluminum, 2.5 % vanadium, 1.5 % iron).

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.

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 Alloys[4]

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] 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.

TABLE 1 Chemical Requirements[A]

Element	Composition, %									
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 9	Grade 11	Grade 12
Nitrogen, max	0.03	0.03	0.05	0.05	0.05	0.03	0.03	0.03	0.03	0.03
Carbon, max	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Hydrogen,[B,C] max	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Iron, max	0.20	0.30	0.30	0.50	0.40	0.50	0.30	0.25	0.20	0.30
Oxygen, max	0.18	0.25	0.35	0.40	0.20	0.20	0.25	0.15	0.18	0.25
Aluminum	...	...	...	...	5.5–6.75	4.0–6.0	...	2.5–3.5	...	...
Vanadium	...	...	...	...	3.5–4.5	...	...	2.0–3.0	...	...
Tin	...	...	...	...	...	2.0–3.0	...	...	...	...
Ruthenium	...	...	...	...	...	...	...	...	...	...
Palladium	...	...	...	...	...	...	0.12–0.25	...	0.12–0.25	...
Cobalt	...	...	...	...	...	...	...	...	...	...
Molybdenum	...	...	...	...	...	...	...	...	...	0.2–0.4
Chromium	...	...	...	...	...	...	...	...	...	...
Nickel	...	...	...	...	...	...	...	...	...	0.6–0.9
Niobium	...	...	...	...	...	...	...	...	...	...
Zirconium	...	...	...	...	...	...	...	...	...	...
Silicon	...	...	...	...	...	...	...	...	...	...
Residuals,[D,E,F] max each	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residuals,[D,E,F] max total	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Titanium[G]	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance

Element	Composition, %									
	Grade 13	Grade 14	Grade 15	Grade 16	Grade 17	Grade 18	Grade 19	Grade 20	Grade 21	Grade 23
Nitrogen, max	0.03	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Carbon, max	0.08	0.08	0.08	0.08	0.08	0.08	0.05	0.05	0.05	0.08
Hydrogen,[B,C] max	0.015	0.015	0.015	0.015	0.015	0.015	0.02	0.02	0.015	0.0125
Iron, max	0.20	0.30	0.30	0.30	0.20	0.25	0.30	0.30	0.40	0.25
Oxygen, max	0.10	0.15	0.25	0.25	0.18	0.15	0.12	0.12	0.17	0.13
Aluminum	...	...	...	...	...	2.5–3.5	3.0–4.0	3.0–4.0	2.5–3.5	5.5–6.5
Vanadium	...	...	...	...	...	2.0–3.0	7.5–8.5	7.5–8.5	...	3.5–4.5
Tin	...	...	...	...	...	...	...	...	...	...
Ruthenium	0.04–0.06	0.04–0.06	0.04–0.06	...	...	...	...	...	...	...
Palladium	...	...	...	0.04–0.08	0.04–0.08	0.04–0.08	...	0.04–0.08	...	...
Cobalt	...	...	...	...	...	...	...	...	...	...
Molybdenum	...	...	...	...	...	...	3.5–4.5	3.5–4.5	14.0–16.0	...
Chromium	...	...	...	...	...	...	5.5–6.5	5.5–6.5	...	...
Nickel	0.4–0.6	0.4–0.6	0.4–0.6	...	...	...	...	...	...	...
Niobium	...	...	...	...	...	...	...	...	2.2–3.2	...
Zirconium	...	...	...	...	...	...	3.5–4.5	3.5–4.5	...	...
Silicon	...	...	...	...	...	...	...	...	0.15–0.25	...
Residuals,[D,E,F] max each	0.1	0.1	0.1	0.1	0.1	0.1	0.15	0.15	0.1	0.1
Residuals,[D,E,F] max total	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Titanium[G]	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance