Designation: B265 – 20a

Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate[1]

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

1. Scope

1.1 This specification[2] covers annealed titanium and titanium alloy strip, sheet, and plate as follows:

1.1.1 *Grade 1*—UNS R50250. Unalloyed titanium,

1.1.2 *Grade 2*—UNS R50400. Unalloyed titanium,

1.1.2.1 *Grade 2H*—UNS R50400. Unalloyed titanium (Grade 2 with 58 ksi (400 MPa) minimum UTS),

1.1.3 *Grade 3*—UNS R50550. Unalloyed titanium,

1.1.4 *Grade 4*—UNS R50700. Unalloyed titanium,

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

1.1.6 *Grade 6*—UNS R54520. Titanium alloy (5 % aluminum, 2.5 % tin),

1.1.7 *Grade 7*—UNS R52400. Unalloyed titanium plus 0.12 to 0.25 % palladium,

1.1.7.1 *Grade 7H*—UNS R52400. Unalloyed titanium plus 0.12 to 0.25 % palladium (Grade 7 with 58 ksi (400 MPa) minimum UTS),

1.1.8 *Grade 9*—UNS R56320. Titanium alloy (3.0 % aluminum, 2.5 % vanadium),

1.1.9 *Grade 11*—UNS R52250. Unalloyed titanium plus 0.12 to 0.25 % palladium,

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

1.1.11 *Grade 13*—UNS R53413. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

1.1.12 *Grade 14*—UNS R53414. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

1.1.13 *Grade 15*—UNS R53415. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),

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

1.1.14.1 *Grade 16H*—UNS R52402. Unalloyed titanium plus 0.04 to 0.08 % palladium (Grade 16 with 58 ksi (400 MPa) minimum UTS),

1.1.15 *Grade 17*—UNS R52252. Unalloyed titanium plus 0.04 to 0.08 % palladium,

1.1.16 *Grade 18*—UNS R56322. Titanium alloy (3 % aluminum, 2.5 % vanadium) plus 0.04 to 0.08 % palladium,

1.1.17 *Grade 19*—UNS R58640. Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum),

1.1.18 *Grade 20*—UNS R58645. Titanium alloy (3 % aluminum, 8 % vanadium, 6 % chromium, 4 % zirconium, 4 % molybdenum) plus 0.04 % to 0.08 % palladium,

1.1.19 *Grade 21*—UNS R58210. Titanium alloy (15 % molybdenum, 3 % aluminum, 2.7 % niobium, 0.25 % silicon),

1.1.20 *Grade 23*—UNS R56407. Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements, ELI),

1.1.21 *Grade 24*—UNS R56405. Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.04 % to 0.08 % palladium,

1.1.22 *Grade 25*—UNS R56403. 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*—UNS R52404. Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.23.1 *Grade 26H*—UNS R52404. Unalloyed titanium plus 0.08 to 0.14 % ruthenium (Grade 26 with 58 ksi (400 MPa) minimum UTS),

1.1.24 *Grade 27*—UNS R52254. Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

1.1.25 *Grade 28*—UNS R56323. Titanium alloy (3 % aluminum, 2.5 % vanadium) plus 0.08 to 0.14 % ruthenium,

1.1.26 *Grade 29*—UNS R56404. Titanium alloy (6 % aluminum, 4 % vanadium with extra low interstitial elements, ELI) plus 0.08 to 0.14 % ruthenium,

1.1.27 *Grade 30*—UNS R53530. Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.28 *Grade 31*—UNS R53532. Titanium alloy (0.3 % cobalt, 0.05 % palladium),

1.1.29 *Grade 32*—UNS R55111. Titanium alloy (5 % aluminum, 1 % tin, 1 % zirconium, 1 % vanadium, 0.8 % molybdenum),

1.1.30 *Grade 33*—UNS R53442. Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.02 5 % ruthenium, 0.15 % chromium),

[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 Specifications SB-265 in Section II of that Code.

1.1.31 *Grade 34*—UNS R53445. Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

1.1.32 *Grade 35*—UNS R56340. Titanium alloy (4.5 % aluminum, 2 % molybdenum, 1.6 % vanadium, 0.5 % iron, 0.3 % silicon),

1.1.33 *Grade 36*—UNS R58450. Titanium alloy (45 % niobium),

1.1.34 *Grade 37*—UNS R52815. Titanium alloy (1.5 % aluminum),

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

1.1.36 *Grade 39*—UNS R53390. Titanium alloy (0.25 % iron, 0.4 % silicon), and

1.1.37 *Grade 40*—UNS R54407. Titanium alloy (3.9 % vanadium, 0.85 % aluminum, 0.25 % iron, 0.25 % silicon).

NOTE 1—H grade material is identical to the corresponding numeric grade (that is, Grade 2H = Grade 2) except for the higher guaranteed minimum UTS, and may always be certified as meeting the requirements of its corresponding numeric grade. Grades 2H, 7H, 16H, and 26H are intended primarily for pressure vessel use.

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.

1.3 *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:*[3]

E8 Test Methods for Tension Testing of Metallic Materials [Metric] E0008_E0008M

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

E290 Test Methods for Bend Testing of Material for Ductility

E539 Test Method for Analysis of Titanium Alloys by Wavelength Dispersive 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

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)[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 Any product 0.187 in. (4.75 mm) and under in thickness and less than 24 in. (610 mm) in width is classified as strip; products 0.187 in. (4.75 mm) and under in thickness and 24 in. (610 mm) or more in width are classified as sheet; any product over 0.187 in. (4.75 mm) in thickness and over 10 in. (254 mm) in width is classified as plate.

4. Ordering Information

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

4.1.1 Grade number (Section 1),

4.1.2 Product limitations (Section 3),

4.1.2.1 For sheet specify cold or hot rolled. If not specified cold tolerances are the default.

(a) Cold rolled sheet tolerances are in Table 1, Table 2, and

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

TABLE 1 Permissible Variations in Thickness of Titanium Sheet

Specified Thickness, in. (mm)	Permissible Variations in Thickness, Plus and minus, in. (mm) For cold rolled sheet	Permissible Variations in Thickness Plus and minus, in. (mm) For hot rolled sheet	
		Width to 84 in. (2134 mm), incl	Width Over 84 in. (2134 mm)
0.146 to 0.1875 (3.71 to 4.76), excl	0.014 (0.36)	0.025 (0.64)	0.028 (0.71)
0.131 to 0.145 (3.33 to 3.68)	0.012 (0.31)	0.022 (0.558)	0.028 (0.71)
0.115 to 0.130 (2.92 to 3.30)	0.010 (0.25)	0.020 (0.508)	...
0.099 to 0.114 (2.51 to 2.90)	0.009 (0.23)	...	...
0.084 to 0.098 (2.13 to 2.49)	0.008 (0.20)	...	...
0.073 to 0.083 (1.85 to 2.11)	0.007 (0.18)	...	...
0.059 to 0.072 (1.50 to 1.83)	0.006 (0.15)	...	...
0.041 to 0.058 (1.04 to 1.47)	0.005 (0.13)	...	...
0.027 to 0.040 (0.69 to 1.02)	0.004 (0.10)	...	...
0.017 to 0.026 (0.43 to 0.66)	0.003 (0.08)	...	...
0.008 to 0.016 (0.20 to 0.41)	0.002 (0.05)	...	...
0.006 to 0.007 (0.15 to 0.18)	0.0015 (0.04)	...	...
0.005 (0.13)	0.001 (0.03)	...	...

TABLE 2 Permissible Variations in Width and Length of Cold Rolled Titanium Sheet

Specified Width, in. (mm), for Thicknesses Under 3/16 in.	Permissible Variations in Width, in. (mm)
24 to 48 (610 to 1220), excl	+1/16 (+1.60), −0
48 (1220) and over	+1/8 (+3.20), −0
Specified Length, ft (m)	**Permissible Variations in Length, in. (mm)**
Up to 10 (3)	+1/4 (+6.35), −0
Over 10 to 20 (3 to 6)	+1/2 (+12.7), −0

Table 3.

(b) Hot rolled sheet tolerances are in Table 1, Table 4, Table 5, and Table 6.

4.1.3 Special mechanical properties (Table 7),

4.1.4 Marking (Section 16),

4.1.5 Finish (Section 8),

4.1.6 Packaging (Section 16),

4.1.7 Additional required reports (Section 15), and

4.1.8 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 chemical composition requirements prescribed in Table 8.

5.1.1 The elements listed in Table 8 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 8 are deemed to be capable of occurring in the grades listed in Table 8 by and only by way of unregulated or unanalyzed scrap additions to the ingot melt. Therefore, product analysis for elements not listed in Table 8 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 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 that is outside the limits specified in Table 8 for the applicable grade. Product analysis limits shall be as specified in Table 9.

5.4 At least two samples for chemical analysis shall be tested to determine chemical composition. Samples shall be taken from the ingot or the extremes of the product to be analyzed.

TABLE 3 Permissible Variations in Weight of Cold Rolled Titanium Sheet

The actual weight of any one item of an ordered thickness and size in any finish is limited in overweight by the following tolerance:

Any item of five sheets or less, or any item estimated to weigh 200 lb (91 kg) or less, may actually weigh as much as 10 % over the estimated weight.

Any item of more than five sheets and estimated to weigh more than 200 lb may actually weigh as much as 7½ % over the estimated weight.

There is no under tolerance in weight for titanium sheets, under tolerance being restricted by the permissible thickness variations.

Only random (or mill size) sheets may be ordered on a square foot basis, and the number of square feet shipped may exceed the number ordered by as much as 5 %.

TABLE 4 Permissible Variations in Width and Length of Hot Rolled Titanium Sheet

Specified Length, in. (mm)	Specified Width, in. (mm)	Permissible Variations in. (mm)	
		Width	Length
Under 120 (3048)	Under 60 (1524)	+5/8 (15.88), +0	+3/4 (19.05), 0
	60 to 84 (1524 to 2134), excl	+11/16 (17.46), +0	+7/8 (22.23), 0
	84 to 108 (2134 to 2743), excl	+3/4 (19.05), +0	+1 (25.40), 0
120 to 240 (3048 to 6096), excl	Under 60 (1524)	+5/8 (15.88), +0	+1 (25.40, 0
	60 to 84 (1524 to 2134), excl	+3/4 (19.05), +0	+1 (25.40), 0
	84 to 108 (2134 to 2743), excl	+13/16 (20.64), +0	+1 1/8 (28.58), 0
240 to 360 (6098 to 9144), excl	Under 60 (1524)	+5/8 (15.88), +0	+1 1/4 (31.75), 0
	60 to 84 (1524 to 2134), excl	+3/4 (19.05), +0	+1 1/4 (31.75), 0
	84 to 108 (2134 to 2743), excl	+13/16 (20.64), +0	+1 1/4 (31.75), 0
360 to 480 (9144 to 12192) and over	Under 60 (1524)	+11/16 (17.46), +0	+1 3/8 (34.93), 0
	60 to 84 (1524 to 2134), excl	+3/4 (19.05), +0	+1 1/2 (38.10), 0
	84 to 108 (2134 to 2743), excl	+13/16 (20.64), +0	+1 1/2 (38.10), 0

TABLE 5 Permissible Variations in Weight of Hot Rolled Titanium Sheet

The actual weight of any one item or an order's thickness and size in any finish is limited in overweight by as much as 20 %.

6. Mechanical Properties

6.1 Material supplied under this specification shall conform to the mechanical property requirements given in Table 7 for the grade specified.

6.2 Tension testing specimens are to be machined and tested in accordance with Test Methods E8. 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.

6.3 For sheet and strip, the bend test specimen shall withstand being bent cold through an angle of 105° without fracture in the outside of the bent portion. The bend shall be made on a **radius** equal to that shown in Table 7 for the applicable grade. The bends are to be made in accordance with Test Method E290, using Method 1, Guided Bend Test described in paragraph 3.6, bent through 105°, and allowed to spring back naturally. The surface of the specimen must include the original material surface with no material removal or surface conditioning, except corners may be rounded to a maximum radius of 0.032 in. (0.8 mm). The width of the bend shall be at