Designation: ~~B348 – 11~~ B348 – 13

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

This standard is issued under the fixed designation B348; 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[2] covers annealed titanium and titanium alloy bars and billets 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 % 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 % palladiumm (Grade 16 with 58 (400 MPa) ksi 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 %–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 0.08–0.14 % ruthenium),

[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.

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

1.1.26 *Grade 29*—UNS R56404. Titanium alloy (6 % aluminum, 4 % vanadium, extra low interstitial, 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, 0.025 % ruthenium, 0.15 % chromium),
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), and
1.1.35 *Grade 38*—UNS R54250. Titanium alloy (4 % aluminum, 2.5 % vanadium, 1.5 % iron).

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.

~~The H grades were added in response to a user association request based on its study of over 5200 commercial Grade 2, 7, 16, and 26 test reports, where over 99 % met the 58 ksi minimum UTS.~~

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]

E8 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 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 *bar, n*—a hot rolled, forged, extruded or cold worked semifinished solid section product whose cross sectional area is equal to or less than 16 in.^{2} (10 323 mm^2); 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] 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.

3.1.1.1 *Discussion*—

Extruded bar has been approved for use on unalloyed titanium grades 1, 2, 3 and 4 only. Other grades may be produced via the extrusion process with agreement between the producer and the purchaser.

3.1.2 *billet, n*—a solid semifinished section hot worked or forged from an ingot, with a cross sectional area greater than 16 in.^{2} (10 323 mm^2) 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 2),
4.1.5 Marking (Section 16),
4.1.6 Finish (Section 8),

TABLE 1 Chemical Requirements

Composition, Weight Percent[A,B,C,D,E]

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
1	0.08	0.18	0.03	0.015	0.20	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
~~2~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~2H~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
3	0.08	0.35	0.05	0.015	0.30	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
4	0.08	0.40	0.05	0.015	0.50	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
~~5~~	~~0.08~~	~~0.20~~	~~0.05~~	~~0.015~~	~~0.40~~	~~5.5-6.75~~	~~3.5-4.5~~	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~6~~	~~0.08~~	~~0.20~~	~~0.03~~	~~0.015~~	~~0.50~~	~~4.0-6.0~~	—	—	—	—	—	—	—	—	—	~~2.0-3.0~~	—	~~0.1~~	~~0.4~~
~~7~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.12-0.25~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~7H~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.12-0.25~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~9~~	~~0.08~~	~~0.15~~	~~0.03~~	~~0.015~~	~~0.25~~	~~2.5-3.5~~	~~2.0-3.0~~	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~11~~	~~0.08~~	~~0.18~~	~~0.03~~	~~0.015~~	~~0.20~~	—	—	~~0.12-0.25~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~12~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	—	~~0.6-0.9~~	~~0.2-0.4~~	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~13~~	~~0.08~~	~~0.10~~	~~0.03~~	~~0.015~~	~~0.20~~	—	—	—	~~0.04-0.06~~	~~0.4-0.6~~	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~14~~	~~0.08~~	~~0.15~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	~~0.04-0.06~~	~~0.4-0.6~~	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~15~~	~~0.08~~	~~0.25~~	~~0.05~~	~~0.015~~	~~0.30~~	—	—	—	~~0.04-0.06~~	~~0.4-0.6~~	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~16~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~16H~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~17~~	~~0.08~~	~~0.18~~	~~0.03~~	~~0.015~~	~~0.20~~	—	—	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~18~~	~~0.08~~	~~0.15~~	~~0.03~~	~~0.015~~	~~0.25~~	~~2.5-3.5~~	~~2.0-3.0~~	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~19~~	~~0.05~~	~~0.12~~	~~0.03~~	~~0.02~~	~~0.30~~	~~3.0-4.0~~	~~7.5-8.5~~	—	—	—	~~3.5-4.5~~	~~5.5-6.5~~	—	~~3.5-4.5~~	—	—	—	~~0.15~~	~~0.4~~
~~20~~	~~0.05~~	~~0.12~~	~~0.03~~	~~0.02~~	~~0.30~~	~~3.0-4.0~~	~~7.5-8.5~~	~~0.04-0.08~~	—	—	~~3.5-4.5~~	~~5.5-6.5~~	—	~~3.5-4.5~~	—	—	—	~~0.15~~	~~0.4~~
~~21~~	~~0.05~~	~~0.17~~	~~0.03~~	~~0.015~~	~~0.40~~	~~2.5-3.5~~	—	—	—	—	~~14.0-16.0~~	—	—	—	~~2.2-3.2~~	—	~~0.15-0.25~~	~~0.1~~	~~0.4~~
~~23~~	~~0.08~~	~~0.13~~	~~0.03~~	~~0.0125~~	~~0.25~~	~~5.5-6.5~~	~~3.5-4.5~~	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~24~~	~~0.08~~	~~0.20~~	~~0.05~~	~~0.015~~	~~0.40~~	~~5.5-6.75~~	~~3.5-4.5~~	~~0.04-0.08~~	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~25~~	~~0.08~~	~~0.20~~	~~0.05~~	~~0.015~~	~~0.40~~	~~5.5-6.75~~	~~3.5-4.5~~	~~0.04-0.08~~	—	~~0.3-0.8~~	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~26~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	~~0.08-0.14~~	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~26H~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	—	~~0.08-0.14~~	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~27~~	~~0.08~~	~~0.18~~	~~0.03~~	~~0.015~~	~~0.20~~	—	—	—	~~0.08-0.14~~	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~28~~	~~0.08~~	~~0.15~~	~~0.03~~	~~0.015~~	~~0.25~~	~~2.5-3.5~~	~~2.0-3.0~~	—	~~0.08-0.14~~	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~29~~	~~0.08~~	~~0.13~~	~~0.03~~	~~0.0125~~	~~0.25~~	~~5.5-6.5~~	~~3.5-4.5~~	—	~~0.08-0.14~~	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~30~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.04-0.08~~	—	—	—	—	~~0.20-0.80~~	—	—	—	—	~~0.1~~	~~0.4~~
~~31~~	~~0.08~~	~~0.35~~	~~0.05~~	~~0.015~~	~~0.30~~	—	—	~~0.04-0.08~~	—	—	—	—	~~0.20-0.80~~	—	—	—	—	~~0.1~~	~~0.4~~
~~32~~	~~0.08~~	~~0.11~~	~~0.03~~	~~0.015~~	~~0.25~~	~~4.5-5.5~~	~~0.6-1.4~~	—	—	—	~~0.6-1.2~~	—	—	~~0.6-1.4~~	—	~~0.6-1.4~~	~~0.06-0.14~~	~~0.1.~~	~~0.4~~
~~33~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	—	—	~~0.01-0.02~~	~~0.02-0.04~~	~~0.35-0.55~~	—	~~0.1-0.2~~	—	—	—	—	—	~~0.1~~	~~0.4~~
~~34~~	~~0.08~~	~~0.35~~	~~0.05~~	~~0.015~~	~~0.30~~	—	—	~~0.01-0.02~~	~~0.02-0.04~~	~~0.35-0.55~~	—	~~0.1-0.2~~	—	—	—	—	—	~~0.1~~	~~0.4~~
~~35~~	~~0.08~~	~~0.25~~	~~0.05~~	~~0.015~~	~~0.20-0.80~~	~~4.0-5.0~~	~~1.1-2.1~~	—	—	—	~~1.5-2.5~~	—	—	—	—	—	~~0.20-0.40~~	~~0.1~~	~~0.4~~
~~36~~	~~0.04~~	~~0.16~~	~~0.03~~	~~0.015~~	~~0.03~~	—	—	—	—	—	—	—	—	—	~~42.0-47.0~~	—	—	~~0.1~~	~~0.4~~
~~37~~	~~0.08~~	~~0.25~~	~~0.03~~	~~0.015~~	~~0.30~~	~~1.0-2.0~~	—	—	—	—	—	—	—	—	—	—	—	~~0.1~~	~~0.4~~
~~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

Composition, Weight Percent[A,B,C,D,E]

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
1	R50250	0.08	0.18	0.03	0.015	0.20	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
2/2H	R50400	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
3	R50550	0.08	0.35	0.05	0.015	0.30	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
4	R50700	0.08	0.40	0.05	0.015	0.50	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4

TABLE 1 *Continued*

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
5	R56400	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
6	R54520	0.08	0.20	0.03	0.015	0.50	4.0-6.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	2.0-3.0	- -	0.1	0.4
7/7H	R52400	0.08	0.25	0.03	0.015	0.30	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
9	R56320	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
11	R52250	0.08	0.18	0.03	0.015	0.20	- -	- -	0.12-0.25	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
12	R53400	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	- -	0.6-0.9	0.2-0.4	- -	- -	- -	- -	- -	- -	0.1	0.4
13	R53413	0.08	0.10	0.03	0.015	0.20	- -	- -	- -	0.04-0.06	0.4-0.6	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
14	R53414	0.08	0.15	0.03	0.015	0.30	- -	- -	- -	0.04-0.06	0.4-0.6	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
15	R53415	0.08	0.25	0.05	0.015	0.30	- -	- -	- -	0.04-0.06	0.4-0.6	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
16/16H	R52402	0.08	0.25	0.03	0.015	0.30	- -	- -	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
17	R52252	0.08	0.18	0.03	0.015	0.20	- -	- -	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
18	R56322	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
19	R58640	0.05	0.12	0.03	0.02	0.30	3.0-4.0	7.5-8.5	- -	- -	- -	3.5-4.5	5.5-6.5	- -	3.5-4.5	- -	- -	- -	0.15	0.4
20	R58645	0.05	0.12	0.03	0.02	0.30	3.0-4.0	7.5-8.5	0.04-0.08	- -	- -	3.5-4.5	5.5-6.5	- -	3.5-4.5	- -	- -	- -	0.15	0.4
21	R58210	0.05	0.17	0.03	0.015	0.40	2.5-3.5	- -	- -	- -	- -	14.0-16.0	- -	- -	- -	2.2-3.2	- -	0.15-0.25	0.1	0.4
23	R56407	0.08	0.13	0.03	0.0125	0.25	5.5-6.5	3.5-4.5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
24	R56405	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	0.04-0.08	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
25	R56403	0.08	0.20	0.05	0.015	0.40	5.5-6.75	3.5-4.5	0.04-0.08	- -	0.3-0.8	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
26/26H	R52404	0.08	0.25	0.03	0.015	0.30	- -	- -	- -	0.08-0.14	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
27	R52254	0.08	0.18	0.03	0.015	0.20	- -	- -	- -	0.08-0.14	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
28	R56323	0.08	0.15	0.03	0.015	0.25	2.5-3.5	2.0-3.0	- -	0.08-0.14	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
29	R56404	0.08	0.13	0.03	0.0125	0.25	5.5-6.5	3.5-4.5	- -	0.08-0.14	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
30	R53530	0.08	0.25	0.03	0.015	0.30	- -	- -	0.04-0.08	- -	- -	- -	- -	0.20-0.80	- -	- -	- -	- -	0.1	0.4
31	R53532	0.08	0.35	0.05	0.015	0.30	- -	- -	0.04-0.08	- -	- -	- -	- -	0.20-0.80	- -	- -	- -	- -	0.1	0.4
32	R55111	0.08	0.11	0.03	0.015	0.25	4.5-5.5	0.6-1.4	- -	- -	- -	0.6-1.2	- -	- -	0.6-1.4	- -	0.6-1.4	0.06-0.14	0.1.	0.4
33	R53442	0.08	0.25	0.03	0.015	0.30	- -	- -	0.01-0.02	0.02-0.04	0.35-0.55	- -	0.1-0.2	- -	- -	- -	- -	- -	0.1	0.4
34	R53445	0.08	0.35	0.05	0.015	0.30	- -	- -	0.01-0.02	0.02-0.04	0.35-0.55	- -	0.1-0.2	- -	- -	- -	- -	- -	0.1	0.4

TABLE 1 *Continued*

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
35	R56340	0.08	0.25	0.05	0.015	0.20-0.80	4.0-5.0	1.1-2.1	- -	- -	- -	1.5-2.5	- -	- -	- -	- -	- -	0.20-0.40	0.1	0.4
36	R58450	0.04	0.16	0.03	0.015	0.03	- -	- -	- -	- -	- -	- -	- -	- -	- -	42.0-47.0	- -	- -	0.1	0.4
37	R52815	0.08	0.25	0.03	0.015	0.30	1.0-2.0	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	0.1	0.4
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, the analysis of samples from the top and bottom of the ingot shall be completed and reported for all elements listed for the respective grade in this table.
[B] Final product hydrogen shall be reported. Ingot hydrogen need not be reported. 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.

TABLE 2 Tensile Requirements[A]

Grade	Tensile Strength, min		Yield Strength (0.2 % Offset) min or range		Elongation in 4*D*, min, %	Reduction of Area, min %
	ksi	MPa	ksi	MPa		
1	35	240	20	138	24	30
2	50	345	40	275	20	30
2H[B,C]	58	400	40	275	20	30
~~3~~	~~65†~~	~~450†~~	~~55~~	~~380~~	~~18~~	~~30~~
3	65	450	55	380	18	30
~~4~~	~~80†~~	~~550†~~	~~70~~	~~483~~	~~15~~	~~25~~
4	80	550	70	483	15	25
5	130	895	120	828	10	25
6	120	828	115	795	10	25
7	50	345	40	275	20	30
7H[B,C]	58	400	40	275	20	30
9	90	620	70	483	15	25
~~9[D]~~	~~90~~	~~620~~	~~70~~	~~483~~	~~12~~	~~25~~
9[D]	90	620	70	483	12	25
11	35	240	20	138	24	30
12	70	483	50	345	18	25
13	40	275	25	170	24	30
14	60	410	40	275	20	30
~~15~~	~~70~~	~~483~~	~~55~~	~~380~~	~~18~~	~~25~~
15	70	483	55	380	18	25
16	50	345	40	275	20	30
16H[B,C]	58	400	40	275	20	30
17	35	240	20	138	24	30
~~18~~	~~90~~	~~620~~	~~70~~	~~483~~	~~15~~	~~25~~
18	90	620	70	483	15	25
~~18[D]~~	~~90~~	~~620~~	~~70~~	~~483~~	~~12~~	~~20~~
18[D]	90	620	70	483	12	20
~~19[E]~~	~~115~~	~~793~~	~~110~~	~~759~~	~~15~~	~~25~~
19[E]	115	793	110	759	15	25
~~19[F]~~	~~135~~	~~930~~	~~130 to 159~~	~~897 to 1096~~	~~10~~	~~20~~
19[F]	135	930	130 to 159	897 to 1096	10	20
19[G]	165	1138	160 to 185	1104 to 1276	5	20
~~20[E]~~	~~115~~	~~793~~	~~110~~	~~759~~	~~15~~	~~25~~
20[E]	115	793	110	759	15	25
~~20[F]~~	~~135~~	~~930~~	~~130 to 159~~	~~897 to 1096~~	~~10~~	~~20~~
20[F]	135	930	130 to 159	897 to 1096	10	20
20[G]	165	1138	160 to 185	1104 to 1276	5	20
21[E]	115	793	110	759	15	35
21[F]	140	966	130 to 159	897 to 1096	10	30
21[G]	170	1172	160 to 185	1104 to 1276	8	20
23	120	828	110	759	10	15
23[D]	120	828	110	759	7.5[H] , 6.0[I]	25
24	130	895	120	828	10	25
25	130	895	120	828	10	25
26	50	345	40	275	20	30
26H[B,C]	58	400	40	275	20	30
27	35	240	20	138	24	30
28	90	620	70	483	15	25
28[D]	90	620	70	483	12	20
29	120	828	110	759	10	25
29[D]	120	828	110	759	7.5[H] , 6.0[I]	15
30	50	345	40	275	20	30
31	65	450	55	380	18	30
32	100	689	85	586	10	25
33	50	345	40	275	20	30
34	65	450	55	380	18	30
35	130	895	120	828	5	20
36	65	450	60 to 95	410 to 655	10	...
37	50	345	31	215	20	30
38	130	895	115	794	10	25

[A] These properties apply to longitudinal sections up to 3 in. (76 mm) in thickness with a maximum of 10 in.^{2} (64.5 cm^2). Mechanical properties of larger sections shall be negotiated between the manufacturer and purchaser.

[B] 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. Grade 2H, 7H, 16H, and 26H are intended primarily for pressure vessel use.

[C] The H grades were added in response to a user association request based on its study of over 5200 commercial Grade 2, 7, 16, and 26 test reports, where over 99 % met the 58 ksi minimum UTS.

[D] Properties for material in transformed-beta condition.

[E] Properties for solution treated condition.

[F] Properties for solution treated and aged condition–Moderate strength (determined by aging temperature).

[G] Properties for solution treated and aged condition–High strength (determined by aging temperature).

[H] For product section or wall thickness values <1.0 in.

[I] For product section or wall thickness values ≥ 1.0 in.

~~† Tensile strength for Grade 3 and Grade 4 was corrected editorially.~~