



Designation: B862 – 23

Standard Specification for Titanium and Titanium Alloy Welded Pipe¹

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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 covers the requirements for 33 grades of titanium and titanium alloy welded pipe intended for general corrosion resisting and elevated temperature service 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 5*—UNS R56400. Titanium alloy (6 % aluminum, 4 % vanadium),
- 1.1.5 *Grade 7*—UNS R52400. Unalloyed titanium plus 0.12 % to 0.25 % palladium,
 - 1.1.5.1 *Grade 7H*—UNS R52400. Unalloyed titanium plus 0.12 % to 0.25 % palladium (Grade 7 with 58 ksi (400 MPa) minimum UTS),
- 1.1.6 *Grade 9*—UNS R56320. Titanium alloy (3 % aluminum, 2.5 % vanadium),
- 1.1.7 *Grade 11*—UNS R52250. Unalloyed titanium plus 0.12 % to 0.25 % palladium,
- 1.1.8 *Grade 12*—UNS R53400. Titanium alloy (0.3 % molybdenum, 0.8 % nickel),
- 1.1.9 *Grade 13*—UNS R53413. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.10 *Grade 14*—UNS R53414. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.11 *Grade 15*—UNS R53415. Titanium alloy (0.5 % nickel, 0.05 % ruthenium),
- 1.1.12 *Grade 16*—UNS R52402. Unalloyed titanium plus 0.04 % to 0.08 % palladium,
 - 1.1.12.1 *Grade 16H*—UNS R52402. Unalloyed titanium plus 0.04 % to 0.08 % palladium (Grade 16 with 58 ksi (400 MPa) minimum UTS),
- 1.1.13 *Grade 17*—UNS R52252. Unalloyed titanium plus 0.04 % to 0.08 % palladium,

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

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

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

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

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

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

1.1.20 *Grade 25*—UNS R56403. Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.3 % to 0.8 % nickel and 0.04 % to 0.08 % palladium,

1.1.21 *Grade 26*—UNS R52404. Unalloyed titanium plus 0.08 % to 0.14 % ruthenium,

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

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

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

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

1.1.25 *Grade 33*—UNS R53442. Titanium alloy (0.4 % nickel, 0.015 % palladium, 0.025 % ruthenium, 0.15 % chromium),

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

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

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

1.1.29 *Grade 38*—UNS R54250. Titanium alloy (4 % aluminum, 2.5 % vanadium, 1.5 % iron), 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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1.1.30 *Grade 39*—UNS R53390. Titanium alloy (0.25 % iron, 0.4 % 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 Pipe 8 in. NPS (nominal pipe size) and larger is most frequently custom made for an order. In such cases, the purchaser carefully should consider the applicability of this specification. Since the pipe is custom made, the purchaser may choose a wall thickness other than those in **Table 1** to meet specific operating conditions. The purchaser may also be better served to specify only the portions of this specification that are required to meet the operating conditions (for example, annealing, flattening test, chemistry, properties, etc.).

1.3 Optional supplementary requirements are provided for pipe where a greater degree of testing is desired. These supplementary requirements may be invoked by the purchaser, when desired, by specifying in the order.

1.4 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.

1.5 *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

- A370** Test Methods and Definitions for Mechanical Testing of Steel Products
- B600** Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces
- 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 Wavelength Dispersive X-Ray Fluorescence Spectrometry
- E1409** Test Method for Determination of Oxygen and Nitrogen in Titanium and Titanium Alloys by Inert Gas Fusion
- E1417** Practice for Liquid Penetrant Testing
- E1447** Test Method for Determination of Hydrogen in Reactive Metals and Reactive Metal Alloys by Inert Gas Fusion with Detection by Thermal Conductivity or Infrared Spectrometry
- E1941** Test Method for Determination of Carbon in Refractory and Reactive Metals and Their Alloys by Combustion Analysis

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.

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)

E2994 Test Method for Analysis of Titanium and Titanium Alloys by Spark Atomic Emission Spectrometry and Glow Discharge Atomic Emission Spectrometry (Performance-Based Method)

2.2 ANSI/ASME Standards:³

- B.1.20.1** Pipe Threads, General Purpose (Inch)
- B 36.10** Carbon, Alloy and Stainless Steel Pipes
- B 36.19M-1985** Stainless Steel Pipe
- ASME Boiler and Pressure Vessel Code Section VIII**

2.3 AWS Standard:⁴

- AWS A5.16/A5.16M-2013** Specification for Titanium and Titanium Alloy Welding Electrodes and Rods

3. Terminology

3.1 Definitions:

3.1.1 *lot, n*—a number of pieces of pipe of the same nominal size and wall thickness manufactured by the same process from a single heat of titanium or titanium alloy and heat treated by the same furnace parameters in the same furnace.

3.1.2 *welded pipe, n*—a hollow tubular product produced by forming flat-rolled product and seam welding to make a right circular cylinder.

4. Ordering Information

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

- 4.1.1 Quantity,
- 4.1.2 Grade number (Section 1 and **Table 2**),
- 4.1.3 Nominal pipe size and schedule (**Table 1**),
- 4.1.4 Diameter tolerance (see **9.2**),
- 4.1.5 Method of manufacture and finish (Sections 5 and 10),
- 4.1.6 Product analysis, if required (Sections 6 and 7; **Table 1** and **Table 3**),
- 4.1.7 Mechanical properties, (Sections 8, 11, 13, 14, and 15, and **Table 4**),
- 4.1.8 Packaging (Section 22),
- 4.1.9 Inspection and test reports (Sections 18, 19 and 20), and
- 4.1.10 Supplementary requirements.

5. Manufacture

5.1 Welded pipe shall be made from annealed flat-rolled products by a welding process that will yield a product meeting the requirements of this specification. Filler metal, if used, shall be produced to the latest revision of Specification AWS A5.16/A5.16M-2013 employing the ER Ti-X grade listed in **Table 5**, unless specified otherwise on the purchase order.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁴ Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

TABLE 1 Dimensions of Pipe

NOTE 1—Schedule sizes conform to ANSI/ASME B 36.19M-1985 (for “S” sizes) or B 36.10 (for non-S sizes).
 NOTE 2—The decimal thickness listed for the respective pipe sizes represent their nominal wall dimensions.

NPS Desig.	Outside Dia.		Nominal Wall Thickness											
	in	mm	Schedule 5S ^A	Schedule 5 ^A	Schedule 10S ^A	Schedule 10 ^A	Schedule 40S	Schedule 40	Schedule 80S	Schedule 80				
			in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
1/6	0.405	10.29	x	x	0.049	1.24	0.049	1.24	0.068	1.73	0.068	1.73	0.095	2.41
1/4	0.540	13.72	x	x	0.065	1.65	0.065	1.65	0.088	2.24	0.088	2.24	0.119	3.02
3/8	0.675	17.15	x	x	0.065	1.65	0.065	1.65	0.091	2.31	0.091	2.31	0.126	3.20
1/2	0.840	21.34	0.065	1.65	0.083	2.11	0.083	2.11	0.109	2.77	0.109	2.77	0.147	3.73
3/4	1.050	26.67	0.065	1.65	0.083	2.11	0.083	2.11	0.113	2.87	0.113	2.87	0.154	3.91
1	1.315	33.40	0.065	1.65	0.109	2.77	0.109	2.77	0.133	3.38	0.133	3.38	0.179	4.55
1-1/4	1.660	42.16	0.065	1.65	0.109	2.77	0.109	2.77	0.140	3.56	0.140	3.56	0.191	4.85
1-1/2	1.900	48.26	0.065	1.65	0.109	2.77	0.109	2.77	0.145	3.68	0.145	3.68	0.200	5.08
2	2.375	60.32	0.065	1.65	0.109	2.77	0.109	2.77	0.154	3.91	0.154	3.91	0.218	5.54
2-1/2	2.875	73.02	0.083	2.11	0.120	3.05	0.120	3.05	0.203	5.16	0.203	5.16	0.276	7.01
3	3.500	88.90	0.083	2.11	0.120	3.05	0.120	3.05	0.216	5.49	0.216	5.49	0.300	7.62
3-1/2	4.000	101.60	0.083	2.11	0.120	3.05	0.120	3.05	0.226	5.74	0.226	5.74	0.318	8.08
4	4.500	114.30	0.083	2.11	0.120	3.05	0.120	3.05	0.237	6.02	0.237	6.02	0.337	8.56
5	5.563	141.30	0.109	2.77	0.134	3.40	0.134	3.40	0.258	6.55	0.258	6.55	0.375	9.53
6	6.625	168.27	0.109	2.77	0.134	3.40	0.134	3.40	0.280	7.11	0.280	7.11	0.432	10.97
8	8.625	219.07	0.109	2.77	0.148	3.76	0.148	3.76	0.322	8.18	0.322	8.18	0.500	12.70
10	10.75	273.05	0.134	3.40	0.165	4.19	0.165	4.19	0.365	9.27	0.365	9.27	0.500	12.70
12	12.75	323.85	0.156	3.96	0.180	4.57	0.180	4.57	0.375	9.53	0.375	9.53	0.500	12.70
14	14.00	355.60	0.156	3.96	0.188	4.78	0.188	4.78	x	x	x	x	x	x
16	16.00	406.40	0.165	4.19	0.188	4.78	0.188	4.78	x	x	x	x	x	x
18	18.00	457.20	0.165	4.19	0.188	4.78	0.188	4.78	x	x	x	x	x	x
20	20.00	508.00	0.188	4.78	0.218	5.54	0.218	5.54	x	x	x	x	x	x
22	22.00	558.80	0.188	4.78	0.218	5.54	0.218	5.54	x	x	x	x	x	x
24	24.00	609.60	0.218	5.54	0.250	6.35	0.250	6.35	x	x	x	x	x	x
26	26.00	660.40	x	x	x	7.92	0.312	7.92	x	x	x	x	x	x
28	28.00	711.20	x	x	x	7.92	0.312	7.92	x	x	x	x	x	x
30	30.00	762.00	0.250	6.35	0.312	7.92	0.312	7.92	x	x	x	x	x	x
32	32.00	812.80	x	x	x	7.92	0.312	7.92	x	x	x	x	x	x
34	34.00	863.60	x	x	x	7.92	0.312	7.92	x	x	x	x	x	x
36	36.00	914.40	x	x	x	7.92	0.312	7.92	x	x	x	x	x	x

^A Threading not permitted in accordance with ANSI B.1.20.1.