Designation: B 863 – 08

Standard Specification for Titanium and Titanium Alloy Wire[1]

This standard is issued under the fixed designation B 863; 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.

1. Scope

1.1 This specification covers titanium and titanium alloy wire as follows:

1.1.1 *Grade 1*—Unalloyed titanium, low oxygen,

1.1.2 *Grade 2*—Unalloyed titanium, standard oxygen,

1.1.2.1 *Grade 2H*—Unalloyed titanium (Grade 2 with 58 ksi minimum UTS),

1.1.3 *Grade 3*—Unalloyed titanium, medium oxygen,

1.1.4 *Grade 4*—Unalloyed titanium, high oxygen,

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, standard oxygen,

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

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, low oxygen,

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, standard oxygen,

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

1.1.15 *Grade 17*—Unalloyed titanium plus 0.04 to 0.08 % palladium, low oxygen,

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 to 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,

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

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 to 0.14 % ruthenium,

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

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

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

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

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

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

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

1.1.33 *Grade 38*—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.

[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.

Current edition approved May 15, 2008. Published June 2008. Originally approved in 1995. Last previous edition approved in 2006 as B 863 – 06a.

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 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:* [2]

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[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *coils*, *n*—wire in coil form with pitch and cast as described by purchaser.

3.1.2 *straight lengths*, *n*—wire in straight lengths, generally made by straightening wire from coils by the producer.

3.1.3 *weld wire*, *n*—round wire for welding.

3.1.4 *wire*, *n*—rounds, flats, or special shapes from 0.020 in. (0.5 mm) to 0.250 in. (6.4 mm) in thickness or major dimension.

4. Product Classification

4.1 *Wire*—See 3.1.4.

4.2 *Coils*—Coiled wire may be spooled on spools if required by the user.

4.3 *Straight Lengths*—After straightening, it may be necessary to perform cleaning or other finishing operations. Straight lengths are normally 10 to 12 ft long (random). Exact lengths may be specified by the purchaser when necessary.

4.4 *Weld Wire*—Weld wire usually has a degree of cold work to provide sufficient stiffness to feed from spools in automatic welders. Weld wire is delivered on standard spools as described by the user, or in packages of straight lengths for manual welding operations. There are no tensile strength requirements for the weld wire; however, the chemical analysis of the wire will conform to Table 1.

5. Ordering Information

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

5.1.1 Grade number (Section 1),

5.1.2 Product description (Sections 3 and 4),

5.1.3 Chemistry (Table 1),

5.1.4 Mechanical properties (if applicable, Table 2),

5.1.5 Marking and packaging (Section 17),

5.1.6 Finish (Section 9),

5.1.7 Applicable dimensions including size, thickness, width, spool size, coil diameter, and length (exact, random, multiples) or print number,

5.1.8 Required reports (Section 16),

5.1.9 Special tests or requirements, and

5.1.10 Disposition of rejected material (Section 15).

6. Chemical Composition

6.1 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.

6.1.1 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.

6.1.1.1 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.

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

6.2 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.

6.3 *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 3.

7. Mechanical Requirements

7.1 Annealed material supplied under this specification shall conform to the mechanical property requirements given in Table 2, as applicable. Material may be ordered in the cold worked condition to higher ultimate tensile strengths and lower elongation levels as agreed upon between the supplier and the purchaser.

7.2 Tension testing shall be performed 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. (SI equivalent mm/mm/min) through the yield strength, and then the cross-head speed shall be increased so as to produce fracture in approximately one additional minute.

7.2.1 Wire and shapes with the diameter or smallest dimension between 0.250 and 0.125 in. (6.4 to 3.2 mm) shall have the yield strength determined in accordance with Test Methods E 8, and the elongation measured and reported over 4*D* (4 diameters).

7.2.2 Wire and shapes with the diameter or smallest dimension less than 0.125 in. (3.2 mm) shall have the elongation determined over 2 in. (50.8 mm) unless defined otherwise by the purchaser. The reported value shall be expressed as a percentage elongation in 1 in. or equivalent.

7.3 The yield strength requirements in Table 2 only apply to sizes of 0.125 in. (3.2 mm) and above.

[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.

[3] Withdrawn.

TABLE 1 Chemical Requirements[A]

Element	Composition, %												
	Grade 1	Grade 2	Grade 2H	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 7H	Grade 9	Grade 11	Grade 12	Grade 13
Nitrogen, max	0.03	0.03	0.03	0.05	0.05	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	0.08	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	0.015	0.015	0.015
Iron, max	0.20	0.30	0.30	0.30	0.50	0.40	0.50	0.30	0.30	0.25	0.20	0.30	0.20
Oxygen, max	0.18	0.25	0.25	0.35	0.40	0.20	0.20	0.25	0.25	0.15	0.18	0.25	0.10
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	...	...	...	...	...	...	...	...	...	...	...	...	0.04–0.06
Palladium	...	...	...	...	...	...	...	0.12–0.25	0.12–0.25	...	0.12–0.25	...	...
Cobalt	...	...	...	...	...	...	...	...	...	...	...	...	...
Molybdenum	...	...	...	...	...	...	...	...	...	...	...	0.2–0.4	...
Chromium	...	...	...	...	...	...	...	...	...	...	...	...	...
Nickel	...	...	...	...	...	...	...	...	...	...	...	0.6–0.9	0.4–0.6
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	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	0.4	0.4	0.4
Titanium[G]	balance	balance	balande	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance

Element	Composition, %											
	Grade 14	Grade 15	Grade 16	Grade 16H	Grade 17	Grade 18	Grade 19	Grade 20	Grade 21	Grade 23	Grade 24	Grade 25
Nitrogen, max	0.03	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05
Carbon, max	0.08	0.08	0.08	0.08	0.08	0.08	0.05	0.05	0.05	0.08	0.08	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	0.015	0.0125
Iron, max	0.30	0.30	0.30	0.30	0.20	0.25	0.30	0.30	0.40	0.25	0.40	0.40
Oxygen, max	0.15	0.25	0.25	0.25	0.18	0.15	0.12	0.12	0.17	0.13	0.20	0.20
Aluminum	...	...	...	...	...	2.5–3.5	3.0–4.0	3.0–4.0	2.5–3.5	5.5–6.5	5.5–6.75	5.5–6.75
Vanadium	...	...	...	...	...	2.0–3.0	7.5–8.5	7.5–8.5	...	3.5–4.5	3.5–4.5	3.5–4.5
Tin	...	...	...	...	...	...	...	...	...	...	...	...
Ruthenium	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	...	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	...	...	...	...	...	...	...	...	...	0.3–0.8
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	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	0.4	0.4
Titanium[G]	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance	balance

Element	Composition, %											
	Grade 26	Grade 26H	Grade 27	Grade 28	Grade 29	Grade 32	Grade 33	Grade 34	Grade 35	Grade 36	Grade 37	Grade 38
Nitrogen, max	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.03	0.03	0.03