Designation: B977/B977M – 19

Standard Specification for Titanium and Titanium Alloy Ingots[1]

This standard is issued under the fixed designation B977/B977M; 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 ingots as follows:

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

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

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,

1.1.8 *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,

1.1.15 *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 interstitials, ELI),

1.1.21 *Grade 24*—UNS R56405. Titanium alloy (6 % aluminum, 4 % vanadium) plus 0.4 to 0.8 % 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 R56404. Unalloyed titanium plus 0.08 to 0.14 % ruthenium,

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, 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, 0.025 % 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),

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

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

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

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *The following caveat pertains only to the test method portions of this specification: This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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]

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

E178 Practice for Dealing With Outlying Observations

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)

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

3. Terminology

3.1 *Lot Definitions:*

3.2 *ingot, n*—a quantity of metal cast into a shape suitable for subsequent processing to various mill products.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information as required to describe adequately the desired material:

4.1.1 Grade number (1.1),

4.1.2 Nominal weight in the unit system regarded as standard (inch-pound or SI),

4.1.3 Nominal size (width and gauge or diameter, length) in the unit system regarded as standard (inch-pound or SI),

4.1.4 ASTM designation and year of issue.

4.2 Orders for material under this specification may include (at the discretion of the purchaser) the following additional information:

4.2.1 Method of manufacture (5.1),

4.2.2 Surface condition (7.1 and 7.2),

4.2.3 Product analysis (6.2),

4.2.4 Additional chemical analysis (6.1.3),

4.2.5 Requirements for purchaser inspection/witness (11.1), and

4.2.6 Packaging (Section 15).

5. Materials and Manufacture

5.1 Materials covered by this specification are produced by one of the following methods:

5.1.1 double vacuum arc melting,

5.1.2 triple vacuum arc melting,

5.1.3 electron beam cold hearth melting followed by vacuum arc melting,

5.1.4 plasma arc cold hearth melting followed by vacuum arc melting,

5.1.5 electron beam cold hearth melting,

5.1.6 plasma arc cold hearth melting, or

5.1.7 other melting process as agreed upon by the purchaser and producer.

5.2 The melting method used to produce the ingot shall be reported to the purchaser on the certification.

5.3 The melting method shall be at the discretion of the producer, unless specified in the purchase order.

6. Chemical Composition

6.1 The chemistry of titanium and titanium alloy ingot covered by this specification shall conform to the requirements for the specified grade as prescribed in Table 1.

6.1.1 The elements listed for each grade in Table 1 are intentional alloy additions or elements that are inherent to the manufacture of titanium sponge or ingot.

6.1.2 Elements intentionally added to the melt, including additions made via revert additions, must be identified, analyzed and reported in the chemical analysis. Elements not listed in Table 1 for the specified grade shall not be required.

6.1.3 When agreed upon by the producer and purchaser and requested by the purchaser in the written purchase order, chemical analysis shall be completed for specific elements not listed in this specification.

6.2 The chemical analysis shall normally be conducted using the ASTM standard test methods referenced in 2.1. Other industry standard methods may be used where the ASTM test methods in 2.1 do not adequately cover the elements in the material or by other methods acceptable to the purchaser.

6.3 *Product Check Analysis*—Product check analysis is an analysis made by or for the purchaser for the purpose of

[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.

TABLE 1 Chemical Requirements

		Chemical Composition (Weight %)[A,B,C,D]																		
Grade	UNS Number	C max	O range or max	N max	H max[E]	Fe range or max	Al	V	Pd	Ru	Ni	Mo	Cr	Co	Zr	Nb	Sn	Si	Other Elements max, each	Other Elements max, total
1	R50250	0.08	0.18	0.03	0.003	0.20	...	...	...	...	...	...	...	...	...	...	...	...	0.1	0.4
2	R50400	0.08	0.25	0.03	0.003	0.30	...	...	...	...	...	...	...	...	...	...	...	...	0.1	0.4
3	R50550	0.08	0.35	0.05	0.003	0.30	...	...	...	...	...	...	...	...	...	...	...	...	0.1	0.4
4	R50700	0.08	0.40	0.05	0.003	0.50	...	...	...	...	...	...	...	...	...	...	...	...	0.1	0.4
5	R56400	0.08	0.20	0.05	0.003	0.40	5.5-6.75	3.5-4.5	...	...	...	...	...	...	...	...	...	...	0.1	0.4
6	R54520	0.08	0.20	0.03	0.003	0.50	4.0-6.0	...	...	...	...	...	...	...	...	...	2.0-3.0	...	0.1	0.4
7	R52400	0.08	0.25	0.03	0.003	0.30	...	...	0.12-0.25	...	...	...	...	...	...	...	...	...	0.1	0.4
9	R56320	0.08	0.15	0.03	0.003	0.25	2.5-3.5	2.0-3.0	...	...	...	...	...	...	...	...	...	...	0.1	0.4
11	R52250	0.08	0.18	0.03	0.003	0.20	...	...	0.12-0.25	...	...	...	...	...	...	...	...	...	0.1	0.4
12	R53400	0.08	0.25	0.03	0.003	0.30	...	...	...	...	0.6-0.9	0.2-0.4	...	...	...	...	...	...	0.1	0.4
13	R53413	0.08	0.10	0.03	0.003	0.20	...	...	...	0.04-0.06	0.4-0.6	...	...	...	...	...	...	...	0.1	0.4
14	R53414	0.08	0.15	0.03	0.003	0.30	...	...	...	0.04-0.06	0.4-0.6	...	...	...	...	...	...	...	0.1	0.4
15	R53415	0.08	0.25	0.05	0.003	0.30	...	...	...	0.04-0.06	0.4-0.6	...	...	...	...	...	...	...	0.1	0.4
16	R52402	0.08	0.25	0.03	0.003	0.30	...	...	0.04-0.08	...	...	...	...	...	...	...	...	...	0.1	0.4
17	R52252	0.08	0.18	0.03	0.003	0.20	...	...	0.04-0.08	...	...	...	...	...	...	...	...	...	0.1	0.4
18	R56322	0.08	0.15	0.03	0.003	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	0.003	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	0.003	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	0.003	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	0.003	0.25	5.5-6.5	3.5-4.5	...	...	...	...	...	...	...	...	...	...	0.1	0.4
24	R56405	0.08	0.20	0.05	0.003	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	0.003	0.40	5.5-6.75	3.5-4.5	0.04-0.08	...	0.3-0.8	...	...	...	...	...	...	...	0.1	0.4
26	R52404	0.08	0.25	0.03	0.003	0.30	...	...	...	0.08-0.14	...	...	...	...	...	...	...	...	0.1	0.4
27	R52254	0.08	0.18	0.03	0.003	0.20	...	...	...	0.08-0.14	...	...	...	...	...	...	...	...	0.1	0.4
28	R56323	0.08	0.15	0.03	0.003	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	0.003	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	0.003	0.30	...	...	0.04-0.08	...	...	...	...	0.20-0.80	...	...	...	...	0.1	0.4
31	R53532	0.08	0.35	0.05	0.003	0.30	...	...	0.04-0.08	...	...	...	...	0.20-0.80	...	...	...	...	0.1	0.4