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Standard Specification for Seamless and Welded Titanium and Titanium Alloy Pipe[1]

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This specification has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification[2] covers eight grades of seamless and welded titanium pipe intended for general corrosion-resisting and elevated-temperature service.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products[3]

E 120 Test Methods for Chemical Analysis of Titanium and Titanium Alloys[4]

2.2 *ANSI Standard:*

B 36.19 Stainless Steel Pipe[5]

3. Ordering Information

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

3.1.1 Quantity,

3.1.2 Grade number (see 5.1 and 7.1),

3.1.3 Nominal pipe size and schedule (Section 14 and Table X1.1),

3.1.4 Lengths, random or specified cut lengths (see 14.3),

3.1.5 Method of manufacture and finish (Section 4 and 15.1),

3.1.6 Restrictive chemistry, if desired (see 5.1, Table 1),

3.1.7 Product analysis, if desired (Section 6),

3.1.8 Special mechanical properties, if desired (see 7.1, Table 3),

3.1.9 Flattening tests (see 9.1),

3.1.10 Finish (see 15.1),

3.1.11 Marking (see 19.1),

3.1.12 Packaging (see 18.1),

3.1.13 Inspection and required reports (Section 16), and

3.1.14 Disposition of rejected material (Section 17).

4. Materials and Manufacture

4.1 Seamless pipe may be made by any seamless method that will yield a product meeting the requirements of this specification.

4.2 Welded pipe shall be made from flat-rolled products by an arc-welding process that will yield a product meeting the requirements of this specification. Filler metal, if used, shall be the same grade as the base metal, or the next lower strength grade for welding Grades 2 and 3. For welding Grades 7, 9, 10, 11, and 12, the filler metal, if used, shall be the same as the grade specified. Welded pipe may be further reduced.

4.3 The pipe shall be furnished annealed, except for Grade 9, which may be furnished in either the annealed or stress-relief annealed condition, and Grade 10, which shall be solution treated.

5. Chemical Composition

5.1 The titanium shall conform to the chemical requirements prescribed in Table 1.

6. Product Analysis

6.1 When requested by the purchaser and stated in the purchase order, product analysis for any elements listed in Table 1 shall be made on the finished product.

6.2 The product analysis tolerances, listed in Table 2, do not broaden the specified heat analysis requirements, but cover variations between different laboratories in the measurement of chemical content. The manufacturer shall not ship finished product outside the limits specified in Table 1 for the applicable grade.

7. Tensile Requirements

7.1 The tensile properties of the pipe in the condition specified at room temperature, shall conform to the requirements prescribed in Table 3. Mechanical properties for other conditions may be established by agreement between the manufacturer and the purchaser.

8. Bending Test

8.1 Pipe 2 in. (51 mm) and under in nominal diameter, shall be capable of being bent cold through 90° around a cylindrical mandrel that is twelve times the nominal diameter of the pipe, without developing cracks.

9. Flattening Test

9.1 Welded or seamless pipe shall be capable of withstanding, without cracking, flattening under a load applied

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SB-337 in Section II of that Code.

[3] *Annual Book of ASTM Standards*, Vol 01.03.

[4] *Annual Book of ASTM Standards*, Vol 03.05.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

TABLE 1 Chemical Requirements

Element	Composition, %							
	Grade 1	Grade 2	Grade 3	Grade 7	Grade 9	Grade 10	Grade 11	Grade 12
Nitrogen, max	0.03	0.03	0.05	0.03	0.02	0.05	0.03	0.03
Carbon, max	0.10	0.10	0.10	0.10	0.05	0.10	0.10	0.08
Hydrogen,[A] max	0.015	0.015	0.015	0.015	0.013	0.020	0.015	0.015
Iron, max	0.20	0.30	0.30	0.30	0.25	0.35	0.20	0.3
Oxygen, max	0.18	0.25	0.35	0.25	0.12	0.18	0.18	0.25
Palladium	...	...	...	0.12 to 0.25	...	...	0.12 to 0.25	...
Aluminum	...	...	...	...	2.5 to 3.5	...	...	...
Molybdenum	...	...	...	...	...	10.0 to 13.0	...	0.2 to 0.4
Zirconium	...	...	...	...	...	4.50 to 7.50	...	...
Vanadium	...	...	...	...	2.0 to 3.0	...	...	...
Nickel	...	...	...	...	...	...	...	0.6 to 0.9
Residuals[B,C] (each), max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05
Residuals[B,C] (total), max	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
Titanium (by difference)	remainder	remainder	remainder	remainder	remainder	remainder	remainder	remainder

[A] Lower hydrogen values may be obtained by negotiation with the manufacturer.

[B] Need not be reported.

[C] A residual is an element present in a metal or alloy in small quantities and is inherent to the manufacturing process but not added intentionally. In titanium these elements include aluminum, vanadium, tin, iron, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten.

gradually at room temperature until the distance between the load platens is H inches. H is calculated as follows:

$$H, \text{ in.} = \frac{(1 + e)t}{e + t/D}$$

where:

H = minimum flattened height, in. (mm),
t = nominal wall thickness, in. (mm), and
D = nominal pipe diameter, in. (mm) (not pipe size).

For Grades 1, 2, 7, and 11

e = 0.06 in. for all pipe sizes

For Grades 3 and 12

e = 0.04 through 1 in. pipe size
e = 0.06 over 1 in. pipe size

NOTE 1—All calculations are rounded to two decimal places. Examination for cracking shall be by the unaided eye.

TABLE 2 Permissible Variations in Product Analysis

Element	%	
	Maximum or Specified Range	Permissible Variation in Product Analysis
Nitrogen	0.05	+0.02
Carbon	0.10	+0.02
Hydrogen	0.015	+0.002
Iron	0.50	+0.15
Oxygen	0.30	+0.03
	0.31 to 0.40	+0.04
Palladium	0.12 to 0.25	±0.02
Molybdenum	10.0 to 13.0	±0.25
Zirconium	4.50 to 7.50	±0.30
Aluminum	2.50 to 3.50	±0.40
Vanadium	2.00 to 3.00	±0.15
Molybdenum	0.2 to 0.4	±0.03
Nickel	0.6 to 0.9	±0.05
Residuals[A] (each)	0.1	+0.02

[A] A residual is an element present in a metal or alloy in small quantities and is inherent to the manufacturing process but not added intentionally. In titanium these elements include aluminum, vanadium, tin, iron, chromium, molybdenum, niobium, zirconium, hafnium, bismuth, ruthenium, palladium, yttrium, copper, silicon, cobalt, tantalum, nickel, boron, manganese, and tungsten.

9.2 For welded pipe, the weld shall be placed in the position of maximum deformation.

10. Hydrostatic Test

10.1 Each length of pipe shall withstand, without showing bulges, leaks, or other defects, an internal hydrostatic pressure that will produce in the pipe wall a stress of 50 % of the minimum specified yield strength at room temperature. This pressure shall be determined by the equation:

$$P = 2St/D$$

where:

P = minimum hydrostatic test pressure, psi (MPa),
S = allowable fiber stress of one-half the minimum yield strength,
t = wall thickness, in. (mm), and
D = outside diameter, in. (mm).

10.2 The maximum hydrostatic test pressure shall not exceed 2500 psi (17.4 MPa) for sizes 3 in. (76 mm) and under, or 2800 psi (19.3 MPa) for sizes over 3 in. (76 mm). Hydrostatic pressure shall be maintained for not less than 5 s. When requested by the purchaser and so stated in the order, pipe in sizes 14 in. (356 mm) in diameter and smaller, shall be tested to one and one-half times the specified working pressure, provided the fiber stress corresponding to those test pressures does not exceed one-half the minimum specified yield strength of the material, as determined by the equation given in 10.1. When one and one-half times the working pressure exceeds 2800 psi (19.3 MPa) the hydrostatic test pressure shall be a matter of agreement between the manufacturer and the purchaser.

11. Test Specimens and Methods of Testing

11.1 The test specimens and the tests required by this specification shall conform to those described in Test Methods and Definitions A 370.

11.2 All routine mechanical tests shall be made at room temperature.

11.3 For referee purposes, Test Methods E 120 shall be used.

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