Designation: B523/B523M – 18 (Reapproved 2023)

Standard Specification for Seamless and Welded Zirconium and Zirconium Alloy Tubes[1]

This standard is issued under the fixed designation B523/B523M; 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[2] covers two grades of zirconium and zirconium alloy seamless and welded tubes.

1.2 Unless a single unit is used, for example corrosion mass gain in mg/dm^2, the values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.3 The following precautionary caveat pertains only to the test methods portion 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:*[3]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

B551/B551M Specification for Zirconium and Zirconium Alloy Strip, Sheet, and Plate

B614 Practice for Descaling and Cleaning Zirconium and Zirconium 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

E213 Practice for Ultrasonic Testing of Metal Pipe and Tubing

E426 Practice for Electromagnetic (Eddy Current) Examination of Seamless and Welded Tubular Products, Titanium, Austenitic Stainless Steel and Similar Alloys

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *annealed, n*—for purposes of this specification "annealed" denotes material that exhibits a recrystallized grain structure.

3.2 *Lot Definitions:*

3.2.1 *tubes, n*—a lot shall consist of a material of the same size, shape, condition, and finish produced from the same ingot or powder blend by the same reduction schedule and the same heat treatment parameters. Unless otherwise agreed between manufacturer and purchaser, a lot shall be limited to the product of an 8 h period for final continuous anneal, or to a single furnace load for final batch anneal.

4. Classification

4.1 The tubes are furnished in two grades as follows:

4.1.1 *Grade R60702*—Unalloyed zirconium.

4.1.2 *Grade R60704*—Zirconium-tin alloy.

5. Ordering Information

5.1 Orders for material under this specification should include the following information:

5.1.1 Quantity (weight or number of pieces, or both),

5.1.2 Name of material (zirconium seamless or welded tube),

5.1.3 Dimensions (diameter, wall thickness as either average or minimum, lengths),

5.1.4 ASTM designation and year of issue,

5.1.5 Grade number (see 4.1), and

[1] This specification is under the jurisdiction of ASTM Committee B10 and is the direct responsibility of Subcommittee B10.02 on Zirconium and Hafnium.

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[2] For ASME Boiler and Pressure Vessel Code Applications, see related Specification SB–523 in Section II of that Code.

[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.

5.1.6 Additions to the specification, if required. See 6.3.1, 7.3, 10.1, 12.7.3, 14.1, and 15.1 for additional optional requirements for the purchase order.

NOTE 1—A typical ordering description is as follows: 1000 pieces of seamless zirconium tubes, 2 in. [50 mm] in outside diameter by 0.06 in. [15 mm] in average wall thickness by 10 ft [3 m] in length, vacuum annealed, ASTM B523/B523M - 01, Grade R60702.

6. Materials and Manufacture

6.1 Seamless tube shall be made by any seamless method that will yield a product meeting the requirements of this specification.

6.2 Welded tube shall be made from sheet or strip meeting the requirements of Specification B551/B551M by an automatic arc-welding process or other method of welding that will yield a product meeting the requirements of this specification. Filler metal shall not be used. Welded tubing shall be supplied as follows:

6.2.1 As welded, or

6.2.2 As welded and further reduced.

6.3 The tube shall be furnished annealed.

6.3.1 Purchaser shall specify one of the following:

(a) annealed in air

(b) annealed in vacuum

7. Chemical Composition

7.1 The material shall conform to the requirements as to chemical composition prescribed in Table 1.

7.2 The manufacturer's ingot analysis shall be considered the chemical analysis for tubing, except for hydrogen and nitrogen, which shall be determined on the finished product.

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

7.3.1 The manufacturer's analysis shall be considered as verified if the check analysis confirms the manufacturer's reported values within the tolerances prescribed in Table 2.

8. Tensile Requirements

8.1 The material, as represented by the test specimens, shall conform to the tensile properties prescribed in Table 3.

TABLE 1 Chemical Requirements[A]

Element	Composition, %	
	UNS Grade Designation	
	R60702	R60704
Zirconium + hafnium, min[B]	99.2	97.5
Hafnium, max	4.5	4.5
Iron + chromium	0.2 max	0.2 to 0.4
Tin	. . .	1.0 to 2.0
Hydrogen, max	0.005	0.005
Nitrogen, max	0.025	0.025
Carbon, max	0.05	0.05
Niobium	. . .	. . .
Oxygen, max	0.16	0.18

[A] By agreement between the purchaser and the manufacturer, analysis may be required and limits established for elements and compounds not specified in the table of chemical composition.

[B] The value for zirconium + hafnium, min, is a warranted but not a measured value.

TABLE 2 Permissible Variation in Product Analysis Between Different Laboratories

Element	Permissible Variation in Product Analysis, %
Hydrogen	0.002
Nitrogen	0.01
Carbon	0.01
Hafnium	0.1
Iron + chromium	0.025
Tin	0.05
Niobium	0.05
Oxygen	0.02

TABLE 3 Tensile Requirements

	UNS Grade Designation	
	R60702	R60704
Tensile strength, min, ksi [MPa]	55 [380]	60 [415]
Yield strength, min, ksi [MPa]	30 [205]	35 [240]
Elongation in 2 in. or 50 mm, min, %	16	14

9. Permissible Variation in Dimensions

9.1 *Diameter*—At any point (cross section) along the length of the tube, the variation in outside diameter shall not exceed those prescribed in Table 4.

9.2 *Length*—When tubes are ordered cut to length, the length shall be not less than that specified, but a variation of ⅛ in. [3.2 mm] will be permitted on tube up to 10 ft [3 m], inclusive. For lengths over 10 ft, an additional over-tolerance of ⅛ in. [3.2 mm] for each 10 ft [3 m] or fraction thereof shall be permissible up to ½ in. [13 mm], maximum.

9.3 *Straightness*—The tube shall be free of bends or kinks and the maximum uniform bow shall not exceed the values shown in Table 5.

9.4 *Squareness of Cut*—The angle of cut of the end of any tube up to 1½ in. [40 mm] in outside diameter may depart from square not more than 0.016 in./in. [mm/mm].

10. Workmanship and Quality Level Requirements

10.1 The finished tube shall be clean and free of foreign material, shall have smooth ends, free of burrs, and shall be free of injurious external and internal imperfections in accordance with standards of acceptability agreed upon between the manufacturer and the purchaser. Minor defects may be removed provided the dimensional tolerances of Table 4 are not exceeded.

11. Significance of Numerical Limits

11.1 For the purpose of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding methods of Practice E29.