Designation: ~~B521 – 19~~ B521 – 22

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

This standard is issued under the fixed designation B521; 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~~ Scope*

1.1 This specification covers tantalum and tantalum alloy seamless and welded tubes of the following grades:

1.1.1 *UNS Grade R05400*—Unalloyed tantalum, powder-metallurgy consolidation,

1.1.2 *UNS Grade R05200*—Unalloyed tantalum, vacuum melted,

1.1.3 *UNS Grade R05252*—Tantalum + 2.5 % tungsten alloy, vacuum melted.

1.1.4 *UNS Grade R05255*—Tantalum + 10 % tungsten alloy, vacuum melted.

1.1.5 *UNS Grade R05240*—Tantalum alloy, 60 % tantalum, 40 % niobium, electron-beam ~~furnace or~~ furnace, vacuum arc melt, or both.

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.

1.3 *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
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
E499 Practice for Leaks Using the Mass Spectrometer Leak Detector in the Detector Probe Mode

2.2 *Other Documents:*

ASNT Document SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing[3]

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[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 B10.03 on Niobium and Tantalum.

Current edition approved ~~Nov. 1, 2019~~April 1, 2022. Published ~~December 2019~~April 2022. Originally approved in 1970. Last previous edition approved in ~~2012~~2019 as ~~B521 – 12~~.B521 – 19. DOI: ~~10.1520/B0521-19~~.10.1520/B0521-22.

[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] Available from the American Society for Nondestructive Testing International Service Center, 1711 Arlingate Lane, Columbus, OH 43228-0518, https://www.asnt.org.

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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *lot*—all material produced from the same ingot or single powder blend, of the same size and last annealed in the same furnace charge.

3.1.2 *process length*—the one-piece length of each tube that results from the production operation that first yields the tubular form. Sampling and testing should in general be based on process lengths unless specifically stated otherwise.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Quantity,

4.1.2 UNS grade,

4.1.3 Type (welded or seamless),

4.1.4 Dimensions,

4.1.5 Nondestructive test requirements, designation of inspection and testing options if the purchaser has a preference, and

4.1.6 Additions to the specification and supplementary requirements, if any.

5. Materials and Manufacture

5.1 Seamless tube shall be made by any seamless method that will yield a product meeting the requirements of this specification. Intermediate and/or final annealing (if required) shall be accomplished in a manner to prevent contamination and absorption of hydrogen, nitrogen, oxygen, or carbon during the annealing process.

5.2 Welded tube shall be made from flat-rolled product by an automatic or semiautomatic fusion welding process with no addition of filler metal.

6. Chemical Composition

6.1 The material shall conform to the requirements of chemical composition prescribed in Table 1.

6.1.1 Analysis for elements not listed in Table 1 and not normally expected in tantalum shall not be required unless specified at time of purchase.

6.2 The manufacturer's ingot analysis shall be considered the chemical analysis for products supplied under this specification except for the interstitial elements carbon, oxygen, hydrogen, and nitrogen which shall be analyzed for each lot of a finished product.

TABLE 1 Ingot Chemical Requirements

Element	(Composition, max weight %)				
	R05200	R05400	R05252	R05255	R05240
O	0.015	0.030	0.015	0.015	0.020
N	0.010	0.010	0.010	0.010	0.010
C	0.010	0.010	0.010	0.010	0.010
H	0.0015	0.0015	0.0015	0.0015	0.0015
Nb	0.10	0.10	0.50	0.10	35.0–42.0
Mo	0.020	0.020	0.020	0.020	0.020
W	0.050	0.050	2.0–3.5	9.0–11.0	0.050
Ti	0.010	0.010	0.010	0.010	0.010
Si	0.005	0.005	0.005	0.005	0.005
Fe	0.010	0.010	0.010	0.010	0.010
Ni	0.010	0.010	0.010	0.010	0.010
Ta	remainder	remainder	remainder	remainder	remainder

~~6.3 When requested by the purchaser at the time of purchase the manufacturer shall report the values of the interstitial elements carbon, oxygen, hydrogen, and nitrogen as specified in Table 1 for each lot of finished product.~~

6.3 Seamless unalloyed tantalum tubing made from powder-metallurgy consolidation (UNS Grade R05400) shall be analyzed for all elements listed in Table 1 for each lot of a finished product.

7. Mechanical Properties

7.1 ~~*Tensile*~~—*Tensile, Yield, and Elongation*—The ~~tensile~~mechanical properties of the finished tube material shall conform to the requirements of Table 2.

7.2 *Flare*—A section of the finished tube shall be capable of being flared without cracking visibly to the unaided eye. The flare shall be made with a tool having a 60° included angle until the outside diameter has been increased 20 %.

7.3 *Reverse Flattening*—A section of welded tube that is slit longitudinally 90° either side of the weld shall be opened and flattened with the weld at the point of maximum bend. No cracking is permitted.

7.4 *Flattening Test*—Seamless tubing shall be subject to a flattening test with no evidence of cracking. Examination for cracking shall be performed by visual examination which may be supplemented using dye penetrant examination. A section of tube shall be flattened under a gradually applied load at room temperature until the distance between the load plattens is H inches. H shall be calculated as follows:

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

where:

~~H = minimum flattened height, in. (mm)~~
~~t = nominal wall thickness, in. (mm)~~
~~D = nominal tube diameter, in. (mm)~~
~~e = 0.040 for tubing through 1 in. (25.4 mm) diameter~~
~~e = 0.060 for tubing larger than 1 in. (25.4 mm) diameter~~

TABLE 2 Mechanical Requirements

	~~R05200/R05400~~	~~R05252~~	~~R05255~~	~~R05240~~
~~Ultimate tensile strength, min, psi (MPa)~~	~~30 000 (207)~~	~~40 000 (276)~~	~~70 000 (481)~~	~~40 000 (226)~~
~~Yield strength, 0.2 % offset, min, psi (MPa)~~	~~20 000 (138)~~	~~28 000 (193)~~	~~60 000 (414)~~	~~28 000 (193)~~
~~Elongation, min %, in 1 or 2 in. (25 or 51 mm)~~	~~25~~	~~20~~	~~15~~	~~20~~

TABLE 2 Mechanical Requirements

Grade		Ultimate Tensile Strength, min, psi (MPa)	Yield Strength, min, psi (MPa) (2 % Offset)	Elongation, min, % 1-in. or 2 in. Gage Length (25 or 51 mm)
Unalloyed tantalum (R05200)	Seamless, welded <0.060 in. thick	30 000 (207)	20 000 (138)	25
(R05400)	Welded ≥0.060 in. thick	25 000 (172)	15 000 (103)	30
90 % tantalum – 10 % tungsten (R05255)	Welded from sheet or strip	70 000 (482)	60 000 (414)	15
	Seamless or Welded from plate	70 000 (482)	55 000 (379)	20
97.5 % tantalum – 2.5 % tungsten (R05252)	Seamless	40 000 (276)	28 000 (193)	20
	Welded <0.125 in. thick	40 000 (276)	30 000 (207)	20
	Welded ≥0.125 in. thick	40 000 (276)	22 000 (152)	25
60 % tantalum – 40 % niobium (R05240)	Seamless, welded <0.060 in. thick	40 000 (276)	28 000 (193)	20
	Welded ≥0.060 in. thick	35 000 (241)	15 000 (103)	20

H = minimum flattened height, in. (mm),
t = nominal wall thickness, in. (mm),
D = nominal tube diameter, in. (mm),
e = 0.040 for tubing through 1 in. (25.4 mm) diameter, and
e = 0.060 for tubing larger than 1 in. (25.4 mm) diameter.

7.5 One set of these mechanical tests shall be made on each lot of tubes and for each fifty process length tubes of each lot or fraction thereof.

8. Nondestructive Test Requirements

8.1 Each tube shall be pressure tested by either hydrostatic or pneumatic methods as described in 8.2 or 8.3. Each tube shall also be examined for tube wall defects by either Ultrasonic Testing as described in 8.5 or Eddy Current testing per 8.6. The selection of the testing methods to be performed (hydrostatic or pneumatic and Eddy Current or Ultrasonic) shall be at the option of the manufacturer unless specified on the purchase order.

8.2 *Hydrostatic Test*—Each tube so tested shall withstand without showing bulges, leaks, or other defects, an internal hydrostatic pressure that will produce in the tube wall a stress of 75 % of the minimum specified yield strength at room temperature. This pressure shall be determined by the equation:

$$P = 2\,St/D \tag{2}$$

where:

P = minimum hydrostatic pressure, psi (or MPa),
S = allowable fiber stress of 75 % of the minimum yield strength, psi (or MPa),
t = average wall thickness of the tube, in. (or mm), and
D = outside diameter of the tube in. (or mm).

Maintain the test pressure for a minimum of 10 s. Any drop in pressure during the test interval greater than 5 % of the test pressure shall be considered as a rejectable defect. The test may be repeated if the pressure drop was due to test equipment malfunction. No additional pressure may be applied during the test interval in order to maintain pressure.

8.3 *Pneumatic Test*—As an alternative to hydrostatic testing, each tube shall withstand an internal air pressure of 100 psi (0.7 MPa), minimum for 5 s, minimum without showing evidence of leakage. The test method used shall permit easy visual detection of any leakage such as by placing the tube under water or by using the pressure differential method. Any evidence of the leakage shall be cause of rejection of that tube. See Practice E499.

8.4 *Helium Leak Test*—If specified in the purchase order, each tube shall be tested by evacuating to an internal pressure of 10×10^{-6} torr (1.3 MPa) or less and tested for leakage by spraying helium along the length of the outside surface. Detection of a leak at a rate greater than 10×10^{-7} standard cm^3/s shall be cause of rejection of that tube.

8.5 *Ultrasonic Test*—Each length of tube shall be tested ultrasonically. The test procedure and calibration standards shall be performed in accordance with Practice E213 and shall be agreed upon between the manufacturer and purchaser when specified on the purchase order. Any tube showing an indication in excess of that obtained from the calibration standard shall be set aside and be subject to rework, retest, or rejection. A tube thus set aside may be further examined by other methods for confirmation of the presence of a defect with or without rework; such a tube may be determined acceptable if no other evidence for a defect is found. (Rework by weld repair is not permitted.)

8.6 *Eddy Current Test*—As an alternative to Ultrasonic Testing (or in addition to Ultrasonic Testing if specified on the purchase order) each length of tubing shall be Eddy Current tested in accordance with the requirements of Practice E426. The procedure shall be agreed upon between the manufacturer and the purchaser when specified on the purchase order. The Eddy Current test shall use multiple frequency analysis (Eddy Array or equivalent) to achieve full volumetric inspection. The effectiveness of the Eddy Current examination procedure shall be verified by demonstrating the ability to detect OD pits of 25 %, 50 % and 75 % of the wall thickness plus a transverse OD ~~groove~~notch and longitudinal ID and OD ~~grooves.~~notches. OD pits shall include flat bottom and round defects if the tubing has sufficient wall thickness. The three OD pits shall be equally spaced circumferentially around the tube and longitudinally separated by a sufficient distance to allow distinct identification of the signal from each pit. The pits shall not be larger in diameter than 0.031 in. (0.787 mm). The depth of the notches shall not exceed 10 % of the wall thickness or 0.004