Designation: B643 – 12 (Reapproved 2016)

Standard Specification for Copper-Beryllium Alloy Seamless Tube[1]

This standard is issued under the fixed designation B643; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification establishes requirements for copper-beryllium alloy seamless tube in straight lengths. Copper Alloy UNS C17200 will be the alloy furnished whenever Specification B643 is specified.

1.2 *Units*—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 The following safety hazard caveat pertains only to the test methods described in this specification.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

B194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar

B251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube

B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

B846 Terminology for Copper and Copper Alloys

E3 Guide for Preparation of Metallographic Specimens

E8/E8M Test Methods for Tension Testing of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

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

E112 Test Methods for Determining Average Grain Size

E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

3. Terminology

3.1 *Definitions*—For terms relating to copper and copper alloys, refer to Terminology B846.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *stock, n*—straight lengths that are mill cut and stored in advance of orders. They are usually 8, 10, 12, or 20 ft (2.44, 3.05, 3.66, or 6.10 m) and subject to established length tolerances.

4. General Requirements

4.1 The following sections of Specification B251 constitute a part of this specification:

4.1.1 Workmanship, Finish and Appearance,
4.1.2 Significance of Numerical limits,
4.1.3 Inspection,
4.1.4 Rejection and Rehearing,
4.1.5 Certification,
4.1.6 Mill Test Report, and
4.1.7 Packaging and Package Marking.

5. Ordering Information

5.1 Include the following information when placing orders for product under this specification, as applicable:

5.1.1 ASTM designation and year of issue,
5.1.2 Copper (Alloy) UNS No. designation (see 1.1),
5.1.3 Temper (see Section 8),
5.1.4 Dimensions, specify O.D./I.D., O.D./wall, or I.D./wall and include length if applicable,
5.1.5 How furnished, stock lengths with or without ends, specific lengths with or without ends,
5.1.6 Quantity: total weight or number or pieces,
5.1.7 Special tests or exceptions, if any,

[1] This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

Current edition approved Oct. 1, 2016. Published October 2016. Originally approved in 1978. Last previous edition approved in 2012 as B643 – 12. DOI: 10.1520/B0643-12R16.

[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.

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

5.1.8 Hardness tests, if required,
5.1.9 Special tests such as tension test or grain size, if required,
5.1.10 Special marking or packaging, if required,
5.1.11 Inspection, if required (see Specification B251),
5.1.12 Certification, if required (see Specification B251), and
5.1.13 Mill test report, if required (see Specification B251).

5.2 If the product is purchased for agencies of the U.S. Government (see Supplementary Requirements section of Specification B251, for additional requirements, if specified).

6. Materials and Manufacture

6.1 *Material:*
6.1.1 The material of manufacture shall be billets, cast bars or tube of Copper Alloy UNS No. C17200, of such purity and soundness as to be suitable for processing into the products prescribed herein.
6.1.2 The tube shall have heat traceable identity.

6.2 *Manufacture:*
6.2.1 The product shall be manufactured by such hot working, cold working, annealing, or precipitation heat treatment, or both, as to produce a uniform wrought structure in the finished product.

7. Chemical Composition

7.1 The material shall conform to the chemical requirements in Table 1 for the copper alloy UNS No. C17200 specified in this ordering information.

7.2 These composition limits do not preclude the presence of other elements. By agreement between the manufacturer and purchaser, limits may be established and analysis required for unnamed elements.

7.3 For alloys in which copper is listed as "remainder," copper is the difference between the sum of results of all elements determined and 100 %. When all elements in Table 1 are determined, the sum of the results shall be 99.5 % minimum.

8. Temper

8.1 The standard tempers for products described in this specification are given in Table 2 and Table 3.
8.1.1 Solution heat-treated TB00 (A).
8.1.2 Heat Treated and Cold Worked to hard temper TD04 (H).
8.1.3 Precipitation Hardened TF00 (AT).

TABLE 1 Chemical Requirements

Element	Composition, %
	Copper Alloy UNS No. C17200
Beryllium	1.80–2.00
Additive elements:	
Nickel + cobalt, min	0.20
Nickel + cobalt + iron, max	0.6
Aluminum, max	0.20
Silicon, max	0.20
Copper	remainder

8.1.4 Hard and Precipitation Heat Treated TH04 (HT).

8.2 Tempers available under this specification are defined in Classification B601.

9. Precipitation Heat Treatment

9.1 When material is purchased in the TB00(A) or the TD04(H) tempers, the precipitation heat treatment is performed by the purchaser.

9.2 When testing for conformance to the TF00(AT) and the TH04(HT) property requirements shown in Table 3 for products supplied in the TB00(A) and TD04(H) tempers, the appropriate test specimens shall be heat treated for times and temperatures within those stated in Table 4. The times and temperatures used by the manufacturer to qualify the material will be stated on the mill test report. The use of other times and temperatures, within the allowable ranges, shown in Table 4, may produce properties other than those stated on the mill test report. This will not be cause for rejection.

9.3 This material may be heat-treated at other times and temperature for specific applications. These special combinations of properties, such as increased ductility, dimensional accuracy, endurance life, may be obtained by special precipitation-hardening heat treatments. The mechanical requirements of Table 3 do not apply to such special heat treatments. Specific test requirements as needed shall be agreed upon between the manufacturer, or supplier, and the purchaser of the end product.

9.4 TF00 (AT) and TH04 (HT) tempers are standard mill-hardened products that have been precipitation heat-treated and tested by the manufacturer. An appropriate time and temperature has been used to produce properties within the specification limits shown in Table 3. Table 4 does not apply. Further, thermal treatments of these tempers is not normally required.

10. Physical Property Requirements

10.1 Microstructure and Grain Size
10.1.1 The product in the precipitation heat-treated condition shall have a microstructure with a minimum of second phase (beta) constituents.
10.1.2 Grain size, if required, shall be agreed upon between the purchaser and the manufacturer or the supplier and shall be determined in accordance with Test Methods E112.

11. Mechanical Property Requirements

11.1 *Rockwell Hardness Requirement:*
11.1.1 Product furnished under this specification shall conform to the Rockwell hardness requirements in Table 2 and Table 3, when tested in accordance with Test Methods E18.
11.1.2 Acceptance or rejection based on mechanical properties shall depend only on Rockwell hardness.
11.1.3 Where agreement on Rockwell hardness tests cannot be reached, the tensile strength requirements of Table 2 and Table 3 shall be the basis for acceptance or rejection.

11.2 *Tension Strength Requirements:*
11.2.1 When specified in the contract or purchase order, product furnished under this specification shall conform to the

TABLE 2 Mechanical Property Requirements Before Precipitation Heat Treatment

Temper Designation[A]		Diameter Distance Between Cross-Sectional Parallel Surfaces, in. (mm)	Rockwell Hardness,[B] B Scale	Tensile Strength[C]	
Standard	Former			ksi[D]	(MPa)
TB00	Solution-heat treated (A)	¾ (19.1) and over	45–85	60–85	(410–570)
TD04	Hard (H)	¾ (19.1) and over	88–103	85–115	(590–800)

[A] Standard designations defined in Classification B601.
[B] Hardness values shown apply only to direct determinations, not converted values.
[C] Hardness is the normal commercial acceptance criterion. Mechanical properties apply only when specifically required.
[D] ksi = 1000 psi.

TABLE 3 Tensile Strength and Hardness Requirements After Precipitation Heat Treatment[A]

Temper Designation[B]		Diameter or Distance Between Cross-Sectional Parallel Surfaces, in. (mm)	Rockwell Hardness, C, min	Tensile Strength[C]		Yield Strength (min) (0.2 % Offset)		Elongation (min) in 4 × D
Standard	Former			ksi[D]	(MPa)	ksi	(MPa)	
TF00	AT	⅝ (15.9) and over	36	165–190[E]	(1140–1310)	130	(900)	3 %
TH04	HT	⅝ (15.9) to 1 (25.4) incl	38	180–215[E]	(1240–1480)	155	(1070)	4 %
		Over 1 (25.4) to 2 (50.8) incl	37	175–215[E]	(1210–1480)	150	(1040)	4 %
		Over 2 (50.8) to 3½ (88.9) incl	37	175–215[E]	(1210–1480)	140	(970)	4 %

[A] These values apply to mill products. See 9.3 for exceptions in end products.
[B] Standard designations defined in Classification B601.
[C] Hardness is the normal commercial acceptance criterion. Mechanical properties apply only when specifically required.
[D] ksi = 1000 psi.
[E] The upper limits in the tensile strength column are for design guidance only.

TABLE 4 Standard Precipitation Heat-Treatment Time for Acceptance Tests

Temper Designation Before Hardening		Diameter	Time at 600 to 675°F (316 to 357°C), h
Standard	Former		
TF00	Solution-heat treated (A)	all sizes	3–4
TH04	Hard (H)	all sizes	2–3

tensile strength requirements in Table 2 and Table 3, when tested in accordance with Test Methods E8/E8M.

11.2.2 Only when specified in the contract or purchase order, acceptance or rejection based upon mechanical properties shall depend only on tensile strength.

12. Dimensions, Mass and Permissible Variations

12.1 *General:*

12.1.1 The standard method of specifying wall thickness shall be in decimal fractions of an inch.

12.1.2 For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified values for any dimension may be cause for rejection.

12.1.3 Tolerances on a given tube may be specified with respect to any two, but not all three, of the following: outside diameter, inside diameter, wall thickness.

NOTE 1—Blank spaces in the tolerance tables indicate either that the material is not generally available or no tolerances have been established.

12.2 *Wall-Thickness Tolerances*—Wall-thickness tolerances shall be in accordance with Table 5 and Table 6.

12.3 *Diameter Tolerances*—Diameter tolerances shall be in accordance with Table 7.

12.4 *Length Tolerances*—Length tolerances shall be in accordance with Table 8.

12.5 *Squareness*—For tube in straight lengths, the departure from squareness of the end shall not exceed the following:

Specified Outside Diameter, in. (mm)	Tolerance, in./in. (mm/mm)
¾ (19.1) and over	1/16 (1.6)

12.6 *Straightness*—Refer to Table 7 of Specification B251.

13. Sampling

13.1 *Sampling*—The lot size, portion size, and selection of sample pieces shall be as follows:

13.1.1 *Lot Size*—The lot size shall be 10 000 lb or fraction thereof.

13.1.2 *Portion Size*—Two sample pieces shall be taken from each lot.

14. Number of Tests and Retests

14.1 *Test:*

14.1.1 Section 8, on Tests, of Specification B251 constitutes this part of this specification.

14.2 *Other Tests:*

14.2.1 Test specimens shall be taken from the sample pieces selected in accordance with 13.1 for any other tests required on the contract or purchase order.

14.2.1.1 In the case of product produced to the TB00 or TD04 condition, two test specimens shall be taken from each sample piece. One is to be tested in the as-sampled condition and one in the precipitation heat-treated condition.

14.2.1.2 In the case of product produced to the precipitation heat-treated condition, one specimen from each sample shall be tested.

TABLE 5 Wall-Thickness Tolerances—TD04 (H) and TH04 (HT) Tempers[A]

NOTE 1—*Maximum Deviation of Any Point*—The following tolerances are plus and minus: if tolerances all plus or all minus are desired double the values given.

Wall Thickness, in. (mm)	Outside Diameter, in. (mm)				
	Over ⅝ to 1 (15.9 to 25.4), incl	Over 1 to 2 (25.4 to 50.8), incl	Over 2 to 4 (50.8 to 102), incl	Over 4 to 7 (102 to 173), incl	Over 7 to 12 (173 to 305), incl
				...	...
				...	...
				...	...
Over 0.034 (0.864), to 0.057 (1.45) incl	0.0045 (0.11)	0.0045 (0.11)	0.0065 (0.17)	0.009 (0.23)	...
Over 0.057 (1.45) to 0.082 (2.08) incl	0.005 (0.13)	0.005 (0.13)	0.0075 (0.19)	0.010 (0.25)	0.013 (0.33)
Over 0.082 (2.08) to 0.119 (3.02) incl	0.0065 (0.17)	0.0065 (0.17)	0.009 (0.23)	0.011 (0.28)	0.014 (0.36)
Over 0.119 (3.02) to 0.164 (4.17) incl	0.007 (0.18)	0.0075 (0.19)	0.010 (0.25)	0.013 (0.33)	0.015 (0.38)
Over 0.164 (4.17) to 0.219 (5.56) incl	0.009 (0.23)	0.010 (0.25)	0.012 (0.30)	0.015 (0.38)	0.018 (0.46)
Over 0.219 (5.56) to 0.283 (7.19) incl	0.012 (0.30)	0.013 (0.33)	0.015 (0.38)	0.018 (0.46)	0.020 (0.51)
Over 0.283 (7.19) to 0.379 (9.62) incl	0.014 (0.36)	0.015 (0.38)	0.018 (0.46)	6 %[B]	6 %[B]
Over 0.379 (9.62)	...	6 %[B]	6 %[B]	6 %[B]	6 %[B]

[A] When tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in this table more than 50 %.
[B] Percent of the specified wall thickness expressed to the nearest 0.001 in. (0.025 mm).

TABLE 6 Wall-Thickness Tolerances—TB00 (A) and TF00 (AT) Tempers[A]

NOTE 1—*Maximum Deviation of Any Point*—The following tolerances are plus and minus: if tolerances all plus or all minus are desired double the values given.

Wall Thickness, in. (mm)	Outside Diameter, in. (mm)			
	⅝ to 1 (15.9 to 25.4)	Over 1 to 2 (25.4 to 50.8)	Over 2 to 4 (50.8 to 102)	Over 4 (102)
Over 0.125 (3.2) to 0.250 (6.5) incl	±0.014 (0.36)	±0.017 (0.43)	±0.020 (0.51)	±0.030 (0.76)
Over 0.250 (6.5) to 0.500 (12.7) incl	±0.017 (0.43)	±0.023 (0.58)	±0.032 (0.81)	±0.053 (1.35)
Over 0.500 (12.7) to 1.000 (25.4) incl	...	±0.030 (0.76)	±0.053 (1.35)	±0.083 (2.11)
Over 1.000 (25.4)	...	...	±0.068 (1.73)	±0.098 (2.49)

[A] When tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in this table more than 50 %.

TABLE 7 Average Diameter Tolerances[A]

Specified Diameter, in. (mm)	Tolerance, Plus and Minus, in. (mm)[B]	
	Cold-Worked Tube	Hot-Worked Tube
Over ½ (12.7) to ¾ (19.1), incl	0.003 (0.08)	0.020 (0.51)
Over ¾ (19.1) to 1 (25.4), incl	0.006 (0.15)	0.020 (0.51)
Over 1 (25.4) to 2 50.8), incl	0.008 (0.20)	0.030 (0.76)
Over 2 (50.8) to 3 (76.2), incl	0.010 (0.25)	0.040 (1.02)
Over 3 (76.2) to 4 (102), incl	0.012 (0.30)	0.050 (1.27)
Over 4 (102) to 5 (127), incl	0.016 (0.41)	0.060 (1.52)
Over 5 (127) to 6 (152), incl	0.018 (0.46)	0.060 (1.52)
Over 6 (152) to 8 (203), incl	0.020 (0.51)	0.060 (1.52)
Over 8 (203) to 12 (305), incl	0.030 (0.76)	0.060 (1.52)

[A] When tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in this table more than 50 %.
[B] Tolerance applies to inside or outside diameter.

TABLE 8 Length Tolerance—All Tempers[A]

NOTE 1—Tolerances are all plus: if all minus tolerances are desired use the same values: if tolerances plus and minus are desired, halve the values given

Length	Tolerances, in. (mm)	Applicable Only to Full-Length Pieces	
	Outside Diameters Up to 1 in. (25.4 mm) incl	Outside Diameters Over 1 in. (25.4 mm) to 4 in. (102 mm) incl	Outside Diameters Over 4 in. (102 mm)
Specific lengths:			
Up to 6 in. (152 mm), incl	1/32 (0.79)	1/16 (1.6)	⅛ (3.2)
Over 6 in. (152 mm) to 2 ft (610 mm), incl	1/16 (1.6)	3/32 (2.4)	¼ (6.4)
Over 2 ft (610 mm) to 6 ft (1.83 m), incl	3/32 (2.4)	⅛ (3.2)	¼ (6.4)
Over 6 ft (1.83 m) to 14 ft (4.27 m), incl	¼ (6.4)	¼ (6.4)	½ (13)
Over 14 ft (4.27 m)	½ (13)	½ (13)	1 (25)
Specific lengths with ends	1 (25)	1 (25)	1[A] (25)
Stock lengths with or without ends	1[A] (25)	1[A] (25)	1[A] (25)

[A] As stock lengths are cut and placed in stock in advance of orders, departure from this tolerance is not practicable.

14.2.2 If microstructure and grain-size are required on the contract or purchase order, the following shall occur:

14.2.2.1 In the case of product produced to the TB00 or TD04 condition, one specimen shall be taken from each sample, precipitation heat-treated, and tested.

14.2.2.2 In the case of product produced to the precipitation heat-treated condition, one specimen from each sample shall be tested.

14.3 *Retests:*

14.3.1 Section 8, on Retests, of Specification B251 constitutes this part of this specification.

15. Specimen Preparation

15.1 *Chemical Analysis*—A composite sample of the semi-finished or finished product shall be prepared in accordance with Practice E255.

15.1.1 Analytical specimen preparation shall be the responsibility of the reporting laboratory.

15.2 *Tension Tests*—Sample preparation shall be in accordance with Section 9 of Specification B251.

15.3 *Grain Size*—Sample preparation shall be in accordance with Guide E3.

15.4 *Rockwell Hardness*—The test specimens shall be of a size and shape to permit testing by the available test equipment and shall permit testing in a plane parallel to the direction of deformation given to the product.

15.4.1 The surface of the test specimens shall be sufficiently smooth and even to permit the accurate determination of hardness.

15.4.2 Each specimen shall be free of scale and foreign matter and care shall be taken to avoid change in condition, that is, heating or cold working.

16. Test Methods

16.1 Section 10, on Test Methods, of Specification B251 constitutes this part of this specification.

16.1.1 *Chemical Analysis*—Section 10.1 is amended to include in the group of chemical analysis techniques, Specification B194 Annex.

16.1.2 *Tension Test*—Tension tests when required, shall be made according to Test Methods E8/E8M.

16.1.3 *Rockwell Hardness*—Rockwell hardness shall be determined in accordance with Test Methods E18.

17. Keywords

17.1 beryllium copper tube; copper UNS No. C17200

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B643 - 00 (2005)) that may impact the use of this standard. (Approved April 1, 2012.)

(1) Alloy, tempers, and property requirements remain unchanged.

(2) The Editorial Subcommittee made changes to bring the specification up to current editorial standard.