



# Standard Specification for Copper-Beryllium Alloy Seamless Tube<sup>1</sup>

This standard is issued under the fixed designation B 643; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

<sup>€1</sup> NOTE—Referenced Documents were editorially corrected in November 2003.

## 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 B 643 is specified.

1.2 *Units*—The values given in parentheses are mathematical conversions to SI units, which 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:

- B 194 Specification for Copper-Beryllium Alloy Plate Sheet, Strip and Rolled Bar<sup>2</sup>
- B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube<sup>2</sup>
- B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast<sup>2</sup>
- B 846 Terminology for Copper and Copper Alloys<sup>2</sup>
- E 3 Practice for Preparation of Metallographic Specimens<sup>3</sup>
- E 8 Test Methods for Tension Testing of Metallic Materials<sup>3</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>3</sup>

- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>4</sup>
- E 112 Test Methods for Determining Average Grain Size<sup>3</sup>
- E 255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition<sup>5</sup>
- E 527 Practice for Numbering Metals and Alloys (UNS)<sup>6</sup>

## 3. General Requirements

3.1 The following sections of Specification B 251 (as noted) constitute a part of this specification:

- 3.1.1 Workmanship, Finish and Appearance,
- 3.1.2 Significance of Numerical limits,
- 3.1.3 Inspection,
- 3.1.4 Rejection and Rehearing,
- 3.1.5 Certification,
- 3.1.6 Mill Test Report, and
- 3.1.7 Packaging and Package Marking.

## 4. Terminology

4.1 *Definitions*—For terms relating to copper and copper alloys, refer to Terminology B 846.

### 4.2 Definitions of Terms Specific to This Standard:

4.2.1 *average diameter (for round tubes only)*,  $n$ —the average of the maximum and minimum outside diameters, or maximum and minimum inside diameters, whichever is applicable, as determined at any one cross section of the tube.

4.2.2 *lengths*,  $n$ —straight pieces of the product.

4.2.2.1 *ends*,  $n$ —straight pieces, shorter than the nominal length, left over after cutting the product into mill lengths, stock lengths, or specific lengths. They are subject to minimum length and maximum weight requirements.

4.2.2.2 *specific*, *adj*—straight lengths that are uniform in length, as specified, and subject to established length tolerances.

4.2.2.3 *specific with ends*, *adj*—specific lengths, including ends.

<sup>1</sup> 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 March 10, 2000. Published May 2000. Originally published as B 643 – 78. Last previous edition B 643 – 94.

<sup>2</sup> Annual Book of ASTM Standards, Vol 02.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>5</sup> Annual Book of ASTM Standards, Vol 03.05.

<sup>6</sup> Annual Book of ASTM Standards, Vol 01.01.

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

4.2.2.4 *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.

4.2.2.5 *stock with ends, adj*—stock lengths, including ends.

4.2.3 *tube, n*—a hollow product of round or any other cross section having a continuous periphery.

4.2.3.1 *tube, seamless, adj*—a tube produced with a continuous periphery in all stages of the operations.

## 5. Ordering Information

5.1 Include the following information:

5.1.1 Quantity, number of pieces or pounds,

5.1.2 Copper (Alloy) UNS number (see 1.1),

5.1.3 Temper (see Section 8),

5.1.4 Dimensions, including length if applicable,

5.1.5 How furnished, stock lengths with or without ends, specific lengths with or without ends,

5.1.6 ASTM designation and year of issue,

5.1.7 Special tests or exceptions, if any,

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 B 251),

5.1.12 Certification, if required (see Specification B 251), and

5.1.13 Mill test report, if required (see Specification B 251).

5.2 When material is purchased for agencies of the U. S. Government, this shall be specified in the contract or purchase order, and the material shall conform to the Supplementary Requirements as defined in the current issue of Specification B 251.

## 6. Materials and Manufacture

6.1 *Material:*

6.1.1 The material of manufacture shall be Alloy C17200, cast and worked into tubular form, and 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 a combination of hot and cold working, annealing, or precipitation heat treatment, or both, as to produce a uniform wrought structure in the finished product, to meet the temper specified.

## 7. Chemical Composition

7.1 The material shall conform to the chemical requirements shown in Table 1.

**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	

7.2 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer and purchaser. Copper may be given as remainder and may be taken as the difference between the sum of all elements analyzed and 100 %. When all elements in Table 1 are analyzed, their sum shall be 99.5 % minimum.

## 8. Temper

8.1 Tempers available under this specification are solution heat-treated TB00 (A) and cold drawn hard TD04 (H), to be precipitation heat-treated by the user (see Table 2). Also available are products already precipitation heat-treated by the manufacturer, tempers TF00 (AT) and TH04 (HT). These products meet property requirements in Table 3 and normally require no further heat treatment by the user.

8.2 Tempers available under this specification are defined in Practice B 601.

## 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

**TABLE 2 Mechanical Property Requirements Before Precipitation Heat Treatment**

Temper Designation <sup>A</sup>		Diameter Distance Between Cross-Sectional Parallel Surfaces, in. (mm)	Rockwell Hardness, <sup>B</sup> B Scale	Tensile Strength <sup>C</sup>	
Standard	Former			ksi <sup>D</sup>	(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)

<sup>A</sup>Standard designations defined in Practice B 601.

<sup>B</sup>Hardness values shown apply only to direct determinations, not converted values.

<sup>C</sup>Hardness is the normal commercial acceptance criterion. Mechanical properties apply only when specifically required.

<sup>D</sup>ksi = 1000 psi.

**TABLE 3 Tensile Strength and Hardness Requirements After Precipitation Heat Treatment<sup>A</sup>**

Temper Designation <sup>B</sup>		Diameter or Distance Between Cross-Sectional Parallel Surfaces, in. (mm)	Rockwell Hardness, C, min	Tensile Strength <sup>C</sup>		Yield Strength (min) (0.2 % Offset)		Elongation (min) in 4 × D
Standard	Former			ksi <sup>D</sup>	(MPa)	ksi	(MPa)	
TF00	AT	5/8 (15.9) and over	36	165–190 <sup>E</sup>	(1140–1310)	130	(900)	3 %
TH04	HT	5/8 (15.9) to 1 (25.4) incl	38	180–215 <sup>E</sup>	(1240–1480)	155	(1070)	4 %
		Over 1 (25.4) to 2 (50.8) incl	37	175–215 <sup>E</sup>	(1210–1480)	150	(1040)	4 %
		Over 2 (50.8) to 3 1/2 (88.9) incl	37	175–215 <sup>E</sup>	(1210–1480)	140	(970)	4 %

<sup>A</sup>These values apply to mill products. See 9.3 for exceptions in end products.

<sup>B</sup>Standard designations defined in Practice B 601.

<sup>C</sup>Hardness is the normal commercial acceptance criterion. Mechanical properties apply only when specifically required.

<sup>D</sup>ksi = 1000 psi.

<sup>E</sup>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		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

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 E 112.

## 11. Mechanical Property Requirements

11.1 Mechanical property requirements are as specified in Tables 2 and 3.

11.2 *Rockwell Hardness*—Rockwell hardness normally is used as the acceptance or rejection test for any product form for any temper.

11.3 *Tension Test*—Tension test properties apply for acceptance or rejection, only when specifically required in the contract or purchase order.

## 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)
3/4 (19.1) and over	0.062

12.6 *Straightness*—Refer to Table 7 of Specification B 251.

## 13. Sampling

13.1 *Sampling*—Sample pieces shall be taken from a heat and lot of material processed simultaneously in the same equipment, as follows:

13.1.1 *Heat*—A heat shall be the result of castings poured simultaneously from the same source of molten metal.

13.1.2 *Lot*—The lot shall be a heat, or fraction thereof.

## 14. Number of Tests and Retests

14.1 Section 8 of Specification B 251 constitutes a 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 Rockwell hardness. When required, they shall be taken for tension tests.

14.2.1.1 In the case of product shipped in 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 shipped in the precipitation heat-treated condition, one specimen from each sample shall be tested.

14.2.2 Microstructure and grain-size, when required.

**TABLE 5 Wall-Thickness Tolerances—TD04 (H) and TH04 (HT) Tempers<sup>A</sup>**

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 5/8 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)	0.013 (0.33)
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)	0.014 (0.36)
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)	0.015 (0.38)
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)	0.018 (0.46)
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)	0.020 (0.51)
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)	6 % <sup>B</sup>
Over 0.283 (7.19) to 0.379 (9.62) incl	0.014 (0.36)	0.015 (0.38)	0.018 (0.46)	6 % <sup>B</sup>	6 % <sup>B</sup>
Over 0.379 (9.62)	...	6 % <sup>B</sup>	6 % <sup>B</sup>	6 % <sup>B</sup>	6 % <sup>B</sup>

<sup>A</sup>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 %.

<sup>B</sup>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<sup>A</sup>**

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)			
	5/8 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)

<sup>A</sup>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<sup>A</sup>**

Specified Diameter, in. (mm)	Tolerance, Plus and Minus, in. (mm) <sup>B</sup>	
	Cold-Worked Tube	Hot-Worked Tube
Over 1/2 (12.7) to 3/4 (19.1), incl	0.003 (0.08)	0.020 (0.51)
Over 3/4 (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)

<sup>A</sup>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 %.

<sup>B</sup>Tolerance applies to inside or outside diameter.

14.2.2.1 In the case of product shipped in 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 shipped in the precipitation heat-treated condition, one specimen from each sample shall be tested.

## 15. Specimen Preparation

15.1 *Chemical Analysis*—Sample preparation shall be in accordance with Practice E 255.

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

**TABLE 8 Length Tolerance—All Tempers<sup>A</sup>**

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
Specific lengths:			
Up to 6 in. (152 mm), incl	1/32 (0.79)	1/16 (1.6)	1/8 (3.2)
Over 6 in. (152 mm) to 2 ft (610 mm), incl	1/16 (1.6)	3/32 (2.4)	1/4 (6.4)
Over 2 ft (610 mm) to 6 ft (1.83 m), incl	3/32 (2.4)	1/8 (3.2)	1/4 (6.4)
Over 6 ft (1.83 m) to 14 ft (4.27 m), incl	1/4 (6.4)	1/4 (6.4)	1/2 (13)
Over 14 ft (4.27 m)	1/2 (13)	1/2 (13)	1 (25)
Specific lengths with ends	1 (25)	1 (25)	1 <sup>A</sup> (25)
Stock lengths with or without ends	1 <sup>A</sup> (25)	<sup>A</sup> (25)	

<sup>A</sup> As stock lengths are cut and placed in stock in advance of orders, departure from this tolerance is not practicable.

15.2 *Tension Tests*—Sample preparation shall be in accordance with Section 9 of Specification B 251.

15.3 *Grain Size*—Sample preparation shall be in accordance with Practice E 3.

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 of Specification B 251 constitutes a part of this specification.

16.1.1 *Chemical Analysis*—Section 10.1 is amended to include in the group of chemical analysis techniques, Specification B 194 Annex.

16.1.2 *Tension Test*—Tension tests when required, shall be made according to Test Method E 8.

16.1.3 *Rockwell Hardness*—Rockwell hardness shall be determined in accordance with Test Method E 18.

## 17. Keywords

17.1 beryllium copper tube; copper UNS number C17200

## SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this specification since the last issue of B 643–94 that may impact the use of this specification.

### *B 643–00:*

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

(2) The required safety and hazard caveat was added.

(3) Reference to Terminology B 846 and Practice E 8 were added.

(4) The wording of the General Requirements, Materials and Manufacture, Number of Tests and Retests, and Specimen Preparation was expanded or adjusted to meet the requirements

of the B05 Outline of Form of Standards.

(5) The Sampling section was adjusted to include an identification of a heat.

(6) The Number of Tests and Retests section was added.

(7) The Test Methods section was amended to include the appropriate chemical analysis technique for beryllium.

(8) Supplementary requirements were included by reference to Specification B 251.

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).*