



Standard Specification for Seamless Copper Tube, Bright Annealed ¹

This standard is issued under the fixed designation B 68; 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 Department of Defense.

1. Scope *

1.1 This specification establishes the requirements for bright annealed seamless copper tube suitable for use in refrigeration, oil lines, gasoline lines, and so forth, where tube with an interior surface essentially free from scale and dirt is required.

1.1.1 Tubes made from any of the following Copper UNS No. designations shall be supplied, unless otherwise specified in the contract or purchase order:

Copper UNS No. ²	Type of Copper
C10200	Oxygen-free without residual deoxidants
C10300	Oxygen-free, extra low phosphorus
C10800	Oxygen-free, low phosphorus
C12000	Phosphorus deoxidized, low residual phosphorus
C12200	Phosphorus deoxidized, high residual phosphorus

1.2 Values stated in inch-pound units are the standard except for grain size, which is given in SI units.

1.3 This specification is the companion to SI Specification B 68M; therefore, no SI equivalents are presented in this specification.

1.4 The following hazard statement pertains only to the test method described in Sections 20.5 and 21.2.6 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- B 68M Specification for Seamless Copper Tube, Bright Annealed [Metric]³
- B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing³
- B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube³
- B 577 Test Methods for Detection of Cuprous Oxide (Hy-

- drogen Embrittlement Susceptibility) in Copper³
- B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast³
- B 846 Terminology for Copper and Copper Alloys³
- E 3 Guide for Preparation of Metallographic Specimens⁴
- E 8 Test Methods for Tension Testing of Metallic Material⁴
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵
- E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry⁶
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁶
- E 112 Test Methods for Determining the Average Grain Size⁴
- E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes⁷
- E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁶
- E 527 Practice for Numbering Metals and Alloys (UNS)⁸

3. Terminology

3.1 Definitions:

3.1.1 See Terminology B 846 for definitions of terms related to copper and copper alloys.

3.1.2 *bright anneal, n*—a thermal treatment carried out in a controlled atmosphere so that surface oxidation is reduced to a minimum and the surface remains relatively bright.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *capable of*—the test need not be performed by the producer of the material. However, if subsequent testing by the purchaser establishes that the material does not meet these requirements, the material shall be subject to rejection.

4. Ordering Information

4.1 Include the following information in orders for products:

4.1.1 ASTM designation and year of issue (for example, B 68 – 95),

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.

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² Refer to Practice E 527 for explanation of unified numbering system (UNS).

³ *Annual Book of ASTM Standards*, Vol 02.01.

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

⁶ *Annual Book of ASTM Standards*, Vol 03.06.

⁷ *Annual Book of ASTM Standards*, Vol 03.03.

⁸ *Annual Book of ASTM Standards*, Vol 01.01.

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

- 4.1.2 UNS copper number (for example, C10200),
- 4.1.3 Temper (Section 8),
- 4.1.4 Dimensions, diameter, and wall thickness (Section 16),
- 4.1.5 How furnished: straight lengths or coils,
- 4.1.6 Total length, or number of pieces, of each size,
- 4.1.7 Total weight, each size, and
- 4.1.8 When product is purchased for agencies of the U.S. Government.

4.2 The following options are available and shall be specified at the time of placing the order, when required:

- 4.2.1 Electromagnetic (eddy-current) test,
- 4.2.2 Embrittlement test,
- 4.2.3 Expansion test,
- 4.2.4 Flattening test,
- 4.2.5 Certification, and
- 4.2.6 Mill test report.

5. General Requirements

5.1 The following sections of Specification B 251 are a part of this specification.

- 5.1.1 Terminology, General,
- 5.1.2 Material and Manufacture,
- 5.1.3 Workmanship, Finish, and Appearance,
- 5.1.4 Significance of Numerical Limits,
- 5.1.5 Inspection,
- 5.1.6 Rejection and Rehearing,
- 5.1.7 Certification,
- 5.1.8 Test Reports,
- 5.1.9 Packaging and Package Marking, and
- 5.1.10 Supplementary Requirements.

5.2 In addition, when a section with an identical title to those referenced in 5.1 appears in this specification, such section may contain requirements which supersede those appearing in Specification B 251. In case of conflict, this specification prevails.

6. Materials and Manufacture

6.1 Materials:

6.1.1 The material of manufacture shall be billets, bars, or tube of the Copper UNS No. C10200, C10300, C10800, C12000, or C12200 and shall be of such soundness as to be suitable for processing into the tubular products described.

6.2 Manufacture:

6.2.1 The tube shall be manufactured by such hot- or cold-working processes as to produce a homogeneous uniform wrought structure in the finished product. The tube shall be cold drawn to the finished size and wall thickness and shall be bright annealed to meet the specified temper.

7. Chemical Composition

7.1 The material shall conform to the requirements prescribed in Table 1 for the specified copper.

7.2 These specification limits do not preclude the presence of other elements. It is not prohibited to establish limits for unnamed elements and to require analysis by agreement between the manufacturer or supplier and the purchaser.

8. Temper

8.1 The tube shall be furnished in either of two annealed tempers as follows:

Annealed (O)	Temper Designation
O50	(Light annealed)
O60	(Soft annealed)

8.1.1 Tempers are defined in Classification B 601.

9. Grain Size

9.1 Tube in the tempers O50 (light annealed) and O60 (soft annealed) shall conform to the requirements of Table 2.

10. Mechanical Property Requirements

10.1 Tensile Strength:

10.1.1 The tube shall have a minimum tensile strength of 30 ksi when tested in accordance with Test Methods E 8.

10.2 Elongation:

10.2.1 The tensile elongation of the tube shall be a minimum 40 % (2-in. gage length) when tested in accordance with Test Methods E 8.

11. Performance Requirements

11.1 Expansion Test:

11.1.1 When specified in the contract or purchase order, the outside diameter of the tube furnished shall be capable of being expanded as follows when tested in accordance with Test Method B 153.

Outside Diameter, in.	Expansion, %
¾ and under	40
over ¾	30

11.1.1.1 The expanded tube shall show no cracks or ruptures seen through visual inspection without the use of special equipment or enhancement excepting the use of corrective lenses.

11.1.2 A flattening test is an optional alternative to the expansion test for annealed tube over 4 in. in diameter.

11.2 Flattening Test:

11.2.1 When specified in the contract or purchase order, the tube shall be capable of being flattened in accordance with the

TABLE 1 Chemical Composition

Element	Composition, %				
	Copper UNS No.				
	C10200 ^A	C10300	C10800	C12000	C12200
Copper, ^B min	99.95	...	...	99.90	99.9
Copper ^B + phosphorus, min	...	99.95	99.95	...	...
Phosphorus	...	0.001–0.005	0.005–0.012	0.004–0.012	0.015–0.040

^A Oxygen in C10200 shall be 10 ppm max.

^B Silver counting as copper.

TABLE 2 Average Grain Size Requirements

Temper	Grain Size, mm
O50	0.015 to 0.040
O60	0.040, min

method described in 21.2.6.1 and shall contain no cracks or flaws visible to the unaided eye in the flattened section.

12. Microscopical Examination

12.1 Samples of Copper UNS Nos. C10200, C10300, and C12000 shall be free of cuprous oxide as determined by Procedure A of Test Methods B 577. When Copper UNS Nos. C10800 or C12200 are supplied, examination is not required. In case of a dispute, a referee method shall be used in accordance with Procedure C of Test Methods B 577.

13. Hydrogen Embrittlement

13.1 Samples of Copper UNS Nos. C10200, C12000, and C12200 shall be capable of passing the embrittlement test of Procedure B of Test Methods B 577. The actual performance of this test is not mandatory under the terms of this specification unless definitely specified in the ordering information. In case of a dispute, a referee method shall be used in accordance with Procedure C of Test Methods B 577.

14. Nondestructive Testing

14.1 Upon agreement between the manufacturer and the purchaser, each tube up to 3½ in. in outside diameter shall be subjected to electromagnetic (eddy-current) test. For this test, the tube shall be examined in the final drawn or annealed temper, before coiling or in straight lengths before final anneal.

14.2 Electromagnetic (Eddy-Current) Test:

14.2.1 When examined in accordance with Practice E 243, tubes that do not actuate the signaling device of the testing unit shall be considered as conforming to the requirements of the test.

15. Purchases for U.S. Government Agencies

15.1 When the contract or purchase order stipulates the purchase is for an agency of the U.S. Government, the tubes furnished shall conform to the conditions specified in the Supplementary Requirements of Specification B 251.

16. Dimensions and Permissible Variations

16.1 The dimensions and tolerances for product covered by this specification shall be as specified in the following tables and related paragraphs of Specification B 251:

16.1.1 Wall Thickness Tolerance—Table 1.

16.1.2 Diameter Tolerances—Table 3.

16.1.3 Length Tolerances—Tables 5 and 6.

16.1.4 *Squareness of Cut*—Refer to Squareness of Cut section.

16.2 *Coils, Length Tolerances*—Refer to Table 2, Table 3, Table 4, and Table 5 of this specification.

17. Workmanship, Finish, and Appearance

17.1 Workmanship:

TABLE 3 Coil Length Tolerances (Specific Lengths)

Tube Outside Diameter, in.	Tolerances, in., All Plus, for Nominal Lengths in Feet	
	Up to 50, incl	Over 50 to 100, incl
Up to 2, incl	12	24

TABLE 4 Coil Length Tolerances (Mill Lengths)
(Applicable only full-length pieces)

Tube Outside Diameter, in.	Tolerances, %, for Nominal Lengths in Feet	
	Up to 100, incl	Over 100 to 2000, incl
Up to 1, incl	5 ^A or 2 ft, whichever is greater	10 ^A
Over 1 to 2, incl	5 ^A or 2 ft, whichever is greater	No tolerances established

^A Expressed to the nearest 1 ft.

TABLE 5 Coil Schedule of Mill Lengths with Ends

Tube Outside Diameter, in.	Nominal Length, ft	Shortest Permissible Length, % of Nominal Length	Maximum Permissible Weights of Ends, % of Lot Weight
Up to 1, incl	up to 100, incl	70 ^A	10
Over 1, to 2, incl	up to 100, incl	60 ^A	20
Up to 1, incl	over 100 to 2000, incl	50	50 ^B

^A Expressed to the nearest 1 ft.

^B Short pieces shall, at the option of the supplier, be included as follows: up to 10 % of lot weight between 50 ft and one quarter of full length and up to 40 % between one quarter and full length.

17.1.1 The tube furnished shall be clean, free of dirt, scale, and other defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

17.1.2 The tube shall be bright annealed after the last drawing operation or, when required, after coiling.

17.2 Finish and Appearance:

17.2.1 The interior and exterior surfaces of the tube shall be typical in appearance to that of bright annealed copper.

18. Sampling

18.1 The lot size, portion size, and selection of sample portions shall be as follows:

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

18.1.2 *Portion Size*—Sample portions shall be selected as to be representative of the lot according to the following schedule:

Number of Pieces in Lot	Number of Sample Portions to Be Taken ^A
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of the total number of pieces in the lot, but not to exceed 10 pieces

^AEach sample portion shall be taken from a separate tube.

18.1.2.1 In case of tube furnished in coils, a length sufficient for all necessary tests shall be cut from each coil selected for testing. The remaining portion of the selected coils shall be included in the shipment and the permissible variation in length on such coils shall be waived.

18.2 Chemical Composition:

18.2.1 The composite sample shall be prepared from approximate equal weights taken from the sample portions and prepared in accordance with Practice E 255. The minimum weight of the composite sample shall be 150 g.

18.2.2 The manufacturer shall have the option of sampling at the time castings are poured or from the semifinished product. When composition has been determined during the manufacturing process, sampling of the finished product is not required.

18.2.3 When sampled at the time castings are poured, at least two samples shall be taken, one after the start and one near the end of the pour, for each group of castings poured simultaneously from the same source of molten metal.

18.2.4 When samples are taken from the semifinished product, a sample shall be taken to represent each 10 000 lb or fraction thereof, except that not more than one sample per piece shall be required.

19. Number of Tests and Retests

19.1 Tests:

19.1.1 *Chemical Composition*—Shall be determined as the arithmetic mean of results from at least two replicate determinations for each specified element.

19.1.2 *Tensile, Elongation, and Grain Size*—Shall be reported as the average of results from test specimens and each specimen must conform to specification requirements.

19.1.3 *Other Tests*—At least two specimens shall be prepared for each of the other tests and each must meet test requirements.

19.2 Retest:

19.2.1 When test results obtained by the purchaser fail to conform with the product specification requirement(s), the manufacturer or supplier shall have the option to perform a retest.

19.2.2 Retesting shall be as directed in this specification for the initial test except for the number of test specimens which shall be twice that normally required for the test.

19.2.3 Test results for all specimens shall conform to the requirement(s) of this specification in retest and failure to comply shall be cause for lot rejection.

20. Specimen Preparation

20.1 Chemical Composition:

20.1.1 Preparation of the analytical specimens for the determination of chemical composition shall be the responsibility of the reporting laboratory.

20.2 Grain Size, Microscopical Examination, and Hydrogen Embrittlement:

20.2.1 Test specimens shall be prepared in accordance with Guide E 3.

20.2.1.1 The surface of the specimen shall approximate a radial longitudinal section of the tube.

20.3 Tensile and Elongation Test:

20.3.1 The test specimens shall be of the full section of the tube and shall conform to the requirements specified in the section 'Specimens for Pipe and Tube' in Test Methods E 8, unless the limitations of the testing machine precludes the use of such specimens.

20.3.2 Test specimens conforming to Specimen No. 1 in Fig. 13, of Test Methods E 8 are acceptable for use when a full-section specimen cannot be used.

20.4 Expansion (Pin) Test:

20.4.1 Test specimens shall be prepared in accordance with Test Method B 153.

20.5 Flattening Test:

20.5.1 Test specimens, 4 in. in length, shall be cut from one end of two lengths of tube. No special preparation is required.

21. Test Methods

21.1 Chemical Analysis:

21.1.1 In case of disagreement, chemical composition shall be determined as follows:

Element	Test Method
Copper	E 53
Phosphorus	E 62

21.1.2 Test method(s) for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer or supplier and the purchaser.

21.2 The tubes furnished shall conform with the physical and mechanical properties and all other requirements of this specification when tested or examined in accordance with the following appropriate test method or practice:

Test	Test Method or Practice
Grain size	E 112
Tensile	E 8
Elongation	E 8
Expansion (pin test)	B 153
Microscopical examination	B 577
Procedure A	
Hydrogen embrittlement	B 577
Procedure B	
Flattening test	Section 21.2.6
Electromagnetic (eddy-current) examination	E 243

21.2.1 *Grain Size*—In case of dispute, grain size shall be determined by the intercept method.

21.2.2 *Tensile Strength*—In case of dispute, tensile strength shall be determined in accordance with Test Methods E 8.

21.2.3 Microscopical Examination:

21.2.3.1 Procedure A shall be followed; however, in case of dispute, Procedure C of Test Methods B 577 shall be followed.

21.2.4 Hydrogen Embrittlement:

21.2.4.1 Procedure B shall be followed; however, in case of dispute, Procedure C of Test Methods B 577 shall be followed.

21.2.5 *Electromagnetic (Eddy-Current) Test*—Each tube up to and including 3½ in. in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedures in Practice E 243. Tubes shall be passed through an eddy-current test unit adjusted to provide information on the suitability of the tube for the intended application.

21.2.5.1 Either notch depth or drilled hole standards shall be used.

(a) Notch depth standards, rounded to the nearest 0.001 in. shall be 22 % of the wall thickness. The notch depth tolerance shall be ±0.0005 in.

(b) Drilled holes shall be drilled radially through the wall using a suitable drill jig that has a bushing to guide the drill, care being taken to avoid distortion of the tube while drilling. The diameter of the drilled hole shall be in accordance with the following and shall not vary by more than +0.001, –0.000 in. of the hole diameter specified.

Tube Outside Diameter, in.	Diameter of Drilled Holes, in.	Drill Number
¼ to ¾, incl	0.025	72
Over ¾ to 1, incl	0.031	68
Over 1 to 1¼, incl	0.036	64
Over 1¼ to 1½, incl	0.042	58
Over 1½ to 1¾, incl	0.046	56
Over 1¾ to 2, incl	0.052	55

21.2.5.2 Alternatively, at the option of the manufacturer, using speed insensitive eddy-current units that are equipped to select a fraction of the maximum imbalance signal, the following maximum imbalance signals shall be used:

Standard Tube Size, in.	Maximum Percent Imbalance Signal Magnitude
Up to ¾, incl	0.2
½ to 2, incl	0.3
Over 2 to 3, incl	0.4

21.2.5.3 Tubes that do not activate the signalling device of the eddy-current tester shall be considered as conforming to the requirements of this test. Tubes with discontinuities indicated by the testing unit shall, at the option of the manufacturer, be reexamined or retested to determine whether the discontinuity is cause for rejection. Signals that are found to have been caused by minor mechanical damage, soil, or moisture, shall not be cause for rejection of the tubes provided the tube dimensions are still within prescribed limits and the tube is suitable for its intended application.

21.2.6 Flattening Test:

21.2.6.1 The specimen shall be slowly flattened by a press so a gage set at three times the tube wall thickness shall pass freely over the flattened section of the tube.

22. Keywords

22.1 bright annealed; copper tube; seamless tube

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 68 – 99) that may impact the use of this standard.

(1) Sections 3.1.1, 3.2.1, 17.1.1, and 20.3.2 were modified to replace nonmandatory language with mandatory language.

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