



Designation: B1017 – 21

Standard Specification for Seamless Copper-Iron Tube for Air Conditioning and Refrigeration¹

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1. Scope

1.1 This specification establishes the requirements for seamless copper iron tube intended for use in heat exchangers and connection lines of high-pressure air conditioning or refrigeration units.

1.2 The tube shall be produced from the following copper alloy:

Copper UNS No.

C19400

1.3 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.

1.4 The following safety caveat pertains only to the test method(s) described in this specification:

1.4.1 *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.*

1.5 *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

B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing

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 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.

B251/B251M Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube

B846 Terminology for Copper and Copper Alloys

B900 Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies

E8/E8M Test Methods for Tension Testing of Metallic Materials

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)³

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)³

E243 Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper-Alloy Tubes

E478 Test Methods for Chemical Analysis of Copper Alloys

2.2 *ASME Standard:*⁴

ASME Boiler and Pressure Vessel Code Application

2.3 *CEN Standard:*⁵

EN 14276-1 Pressure equipment for refrigerating systems and heat pumps - Part 1: Vessels - General requirements

3. General Requirements

3.1 The following sections of Specification **B251/B251M** constitute a part of this specification:

3.1.1 Sampling,

3.1.2 Number of tests and retests,

3.1.3 Dimensions and permissible variations,

3.1.4 Test specimens, and

3.1.5 Significance of numerical limits.

3.2 When a section with an identical title to those referenced in 3.1 appears in this specification and is in conflict with the section appearing in Specification **B251/B251M**, the section in this specification shall prevail.

4. Terminology

4.1 *Definitions*—For definitions of terms related to copper and copper alloys, refer to Terminology **B846**.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁵ Available from European Committee for Standardization (CEN), Rue de la Science 23, B - 1040 Brussels, Belgium, <http://www.cen.eu>.

TABLE 1 Chemical Composition—Weight %

Copper Alloy UNS No.	Composition %				
	Copper	Iron	Zinc	Lead, max	Phosphorus
C19400	97.0 min	2.1–2.6	0.05–0.20	0.03	0.015–0.15

5. Ordering Information

5.1 Include the following specified choices 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. C19400 (or other internationally recognized copper [alloy]) designation;
- 5.1.3 Temper (Section 8);
- 5.1.4 Dimensions, diameter, and wall thickness (Section 12);
- 5.1.5 How furnished: straight lengths or level wound coils;
- 5.1.6 Quantity—total weight or total length or number of pieces of each size; and
- 5.1.7 Intended application.

5.2 The following options are available but may not be included unless specified at the time of placing of the order, when required:

- 5.2.1 Heat identification or traceability details,
- 5.2.2 Expansion test (10.1),
- 5.2.3 Cleanness test (10.2 and 17.2.4),
- 5.2.4 Sealed coil ends,
- 5.2.5 Certification,
- 5.2.6 Test report,
- 5.2.7 If product is purchased for agencies of the U.S. government, and
- 5.2.8 If product is ordered for ASME Boiler and Pressure Vessel Code Application.

6. Materials and Manufacture

6.1 Materials:

6.1.1 The material of manufacture shall be billets, bars, or tube of UNS No. C19400 of such purity and soundness as to be suitable for processing into the tubular products prescribed herein.

6.2 Manufacture:

6.2.1 The product shall be manufactured by such hot-working, cold-working, and annealing processes as to produce a uniform wrought structure in the finished product.

6.2.2 The product shall be hot or cold worked to the finished size and subsequently annealed, when required, to meet the temper properties specified.

6.2.3 Straight lengths specified as O61 annealed temper or H80 hard-drawn temper shall be cleaned and capped, plugged, or otherwise closed at both ends so as to maintain the internal cleanness of the tubing under normal conditions of handling and storage.

7. Chemical Composition

7.1 The material shall conform to the chemical composition requirements in Table 1 for copper [alloy] UNS No. C19400 specified in the ordering information.

7.1.1 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.

8. Temper

8.1 The standard tempers for products described in this specification are given in Table 2.

- 8.1.1 Soft annealed temper O61.
- 8.1.2 Hard drawn temper H80.

9. Mechanical Property Requirements

9.1 Tensile and Yield Strength Requirements:

9.1.1 Product furnished under this specification shall conform to the tensile and yield strength requirements prescribed in Table 2 when tested in accordance with Test Methods E8/E8M.

10. Performance Requirements

10.1 Expansion Test:

10.1.1 When specified in the contract or purchase order, tube furnished in the annealed temper (O61) shall withstand an expansion of 30 % of the outside diameter when tested in accordance with Test Method B153.

10.1.2 The expanded tube shall show no cracking or other defects visible to the naked eye.

10.2 Cleanness of Interior Surface:

10.2.1 When specified in the contract or purchase order, this test shall be performed by the manufacturer.

TABLE 2 Tensile and Yield Strength Requirements

Form	Temper Designation		Tensile Strength, min		% Elongation, min in 2 in. (50 mm)	Yield Strength 0.2 % Offset, min		Yield Strength 1.0 % Offset, min	
	Standard	Former	ksi ^A	MPa ^B		ksi ^A	MPa ^B	ksi ^A	MPa ^B
	O61	Soft annealed	45	(310)	30	20	(140)	23	(160)
	H80	Hard drawn	61	(420)	5

^A ksi = 1000 psi.

^B See X1.2.

10.2.2 After evaporation of the cleaning solvent, the residue weight shall not exceed 0.0035 g/ft² (0.038 g/m²) of the interior surface.

11. Other Requirements

11.1 *Nondestructive Testing Requirements:*

11.1.1 *Electromagnetic (Eddy-Current) Examination:*

11.1.1.1 Each tube up to and including 2⁵/₈ in. (66.7 mm) in outside diameter shall be subjected to examination.

11.1.1.2 Tubes that do not actuate the signaling device on the testing unit, after having been adjusted to provide information on the suitability of the tube for the intended application, shall conform to the requirements of this test. Testing shall be in accordance with Practice E243.

11.1.1.3 Testing of coiled lengths shall be subject to negotiation between the manufacturer and the purchaser.

11.1.1.4 For tubes too large for the testing unit, the test method to be used shall be by agreement between the manufacturer and the purchaser.

11.1.1.5 Eddy-current discontinuities will be identified on level wound coils for subsequent removal by the purchaser.

11.1.1.6 At the customer’s discretion, the permissible number of identified eddy-current discontinuities per coil may be specified.

11.2 When specified in the contract or purchase order, product purchased for agencies of the U.S. government shall conform to the requirements stipulated in the Supplementary Requirements.

12. Dimensions, Mass, and Permissible Variations

12.1 The wall thicknesses of tubes in condition O61 shall be as described in Table 3 of this specification. Wall thicknesses of other pressure levels have to be determined in accordance with EN 14276-1. See Appendix X2.

12.2 The wall thicknesses of tubes in condition H80 have to be determined in accordance with EN 14276-1. See Appendix X2.

12.3 The tolerances for product described by this specification shall be as specified in Specification B251/B251M with particular reference to the following tables and related subsections:

12.3.1 *Wall Thickness Tolerances*—Refer to Tables 1 and 2.

12.3.2 *Tolerances for Diameter*—Refer to Tables 5 and 6.

12.3.3 *Length Tolerances*—Refer to Tables 9 and 10.

12.3.4 *Straightness Tolerance*—Refer to Tables 13 and 14.

12.3.5 *Roundness*—Refer to 5.4.1.

12.3.6 *Squareness of Cut*—Refer to 5.6.1.

12.4 *Coil Weight:*

12.4.1 If level wound coils are produced to a specified nominal weight, no one coil shall weigh less than 40 % of the nominal weight. No more than 20 % of the coils in a lot shall weigh less than 70 % of the nominal weight unless otherwise agreed upon by the manufacturer or supplier and the purchaser.

13. Workmanship, Finish, and Appearance

13.1 The finished tube shall be free of defects, but blemishes of a nature that do not interfere with the intended applications are acceptable.

14. Sampling

14.1 Refer to sampling section in Specification B251/B251M.

15. Number of Tests and Retests

15.1 *Test:*

15.1.1 *Chemical Analysis*—Chemical composition shall be determined in accordance with the element mean of the results from at least two replicate analyses of the sample(s).

15.2 *Retest:*

15.2.1 When requested by the manufacturer or supplier, a retest shall be permitted when results of the test obtained by the purchaser fail to conform to the requirements of the product specification.

TABLE 3 Standard Wall Thickness, in. (mm)^A

Pressure Level of Refrigerant on Inside of Tube, psi (bar^B)

OD in (mm)	1160 (80)	1305 (90)	1450 (100)	1595 (110)	1740 (120)	1885 (130)	2030 (140)
0.197 (5.00)	0.008 (0.21)	0.009 (0.23)	0.010 (0.26)	0.011 (0.28)	0.012 (0.30)	0.013 (0.32)	0.013 (0.34)
¼ (6.35)	0.010 (0.26)	0.011 (0.29)	0.012 (0.31)	0.013 (0.34)	0.015 (0.37)	0.015 (0.39)	0.017 (0.44)
0.276 (7.00)	0.011 (0.28)	0.012 (0.31)	0.013 (0.34)	0.015 (0.37)	0.016 (0.40)	0.018 (0.45)	0.019 (0.48)
⅝ (7.94)	0.013 (0.32)	0.014 (0.35)	0.015 (0.38)	0.017 (0.44)	0.019 (0.47)	0.020 (0.50)	0.021 (0.54)
¾ (9.53)	0.015 (0.37)	0.017 (0.43)	0.019 (0.47)	0.020 (0.51)	0.022 (0.55)	0.023 (0.59)	0.025 (0.64)
½ (12.70)	0.020 (0.51)	0.022 (0.56)	0.024 (0.62)	0.027 (0.68)	0.029 (0.73)	0.031 (0.78)	0.033 (0.84)
⅝ (15.88)	0.025 (0.63)	0.028 (0.70)	0.030 (0.76)	0.033 (0.83)	0.035 (0.90)	0.039 (0.98)	0.041 (1.05)
¾ (19.05)	0.029 (0.74)	0.032 (0.82)	0.037 (0.93)	0.040 (1.01)	0.043 (1.09)	0.046 (1.17)	0.049 (1.25)
⅞ (22.23)	0.033 (0.85)	0.039 (0.98)	0.042 (1.07)	0.046 (1.17)	0.050 (1.26)	0.053 (1.35)	0.057 (1.44)
1⅛ (28.58)	0.044 (1.11)	0.048 (1.23)	0.053 (1.35)	0.058 (1.47)	0.063 (1.60)	0.068 (1.72)	0.072 (1.84)
1⅜ (34.93)	0.053 (1.34)	0.059 (1.49)	0.065 (1.65)	0.070 (1.79)	0.076 (1.94)	0.083 (2.10)	0.089 (2.25)
1⅝ (41.28)	0.062 (1.57)	0.069 (1.75)	0.076 (1.93)	0.083 (2.12)	0.090 (2.29)	0.097 (2.46)	0.104 (2.63)
2⅛ (53.98)	0.084 (2.13)	0.093 (2.36)	0.102 (2.59)	0.111 (2.82)	0.120 (3.04)	0.128 (3.26)	0.137 (3.49)
2⅝ (66.68)	0.102 (2.58)	0.113 (2.87)	0.124 (3.15)	0.135 (3.43)	0.146 (3.71)	0.157 (3.99)	0.170 (4.31)

^A Verification of wall thickness is done based on calculation, which is made in accordance with EN 14276-1 up to and including a temperature of 300 °F (150 °C).

See Appendix X2.

^B See X1.3.

psi = 0.06895 bar.

15.2.2 The retest shall be as directed in the product specification for the initial test, except the number of test specimens shall be twice that normally required for the specified test.

15.2.3 All test specimens shall conform to the product specification requirement(s) in retest. Failure to conform shall be cause for rejection.

16. Specimen Preparation

16.1 *Chemical Analysis*—Preparation of the analytical specimens for the determination of chemical composition shall be the responsibility of the reporting laboratory.

16.2 *Tensile*—Tensile test specimens shall be of the full section of the tube and shall conform with the requirements of the Test Specimen section of Test Methods E8/E8M, unless the limitation of the testing machine precludes the use of a specimen in which case a test specimen conforming to Type No. 1 of Fig. 13 in Test Methods E8/E8M shall be used.

16.3 *Electromagnetic (Eddy-Current) Test*—Tubes for this test require no special preparation.

16.4 *Expansion Test*—Test specimens shall be prepared in accordance with the Test Specimen section of Test Method B153.

17. Test Methods

17.1 Chemical Analyses:

17.1.1 In cases of disagreement, test methods for chemical analysis shall be subject to agreement between the manufacturer or supplier and the purchaser. The following table is a list of published methods, some of which may no longer be viable, which along with others not listed, may be subject to agreement.

Element	Test Method
Copper	E478
Iron	E54
Phosphorus	E62
Zinc	E478
Lead	E478 (AA)

17.1.2 The test method(s) to be followed for the determination of element(s) resulting from contractual or purchase order agreement shall be as agreed upon between the manufacturer or supplier and the purchaser.

17.2 Other Tests:

17.2.1 The tubes shall conform to the physical and mechanical properties and other requirements in this specification when tested in accordance with the following appropriate test method or practice:

Test	Test Method
Tensile	E8/E8M
Expansion (pin test)	B153
Electromagnetic (eddy-current) test	E243
Cleanliness	17.2.4

17.2.2 *Tensile Strength*—The tensile and yield strength tests shall be determined in accordance with Test Methods E8/E8M.

17.2.2.1 Whenever test results are obtained from both full-size and machined specimens, and they differ, the test results from the full-size specimens shall prevail.

17.2.2.2 Test results are not seriously affected by variations in speed of testing. It is not prohibited to use a considerable

range of testing speeds; however, the rate of stressing to the yield strength shall not exceed 100 ksi/min. Above the yield strength, the movement per minute of the testing machine head under load shall not exceed 0.5 in./in. of gauge length (or distance between grips for full-section specimens).

17.2.3 Electromagnetic (Eddy-Current) Examination:

17.2.3.1 Each tube up to and including 2⁵/₈ in. (66.7 mm) in outside diameter shall be subjected to eddy-current test. Testing shall follow the procedures in Practice E243. Tubes shall be passed through an eddy-current test unit adjusted to provide information on the suitability of the tube for the intended application.

17.2.3.2 Either notch depth or drilled hole standards shall be used:

(1) Notch depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % (max) of the nominal bottom wall thickness. The notch depth tolerance shall be +0.0005 in. (0.0013 mm).

(2) 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.	Max Diameter of Drilled Holes, in.
¼ to ¾, incl.	0.025
Over ¾ to 1, incl.	0.031
Over 1 to 1¼, incl.	0.036
Over 1¼ to 1½, incl.	0.042
Over 1½ to 1¾, incl.	0.046
Over 1¾ to 2 incl.	0.052

Tube Outside Diameter, mm	Max Diameter of Drilled Holes, mm
6.0 to 19.0, incl.	0.635
Over 19.0 to 25, incl.	0.785
Over 25 to 32, incl.	0.915
Over 32 to 38, incl.	1.07
Over 38 to 45, incl.	1.17
Over 45 to 50, incl.	1.322

17.2.3.3 Tubes that do not actuate the signaling device on the testing unit, after having been adjusted to provide information on the suitability of the tube for the intended application, shall conform to the requirements of this test. Testing shall be in accordance with Practice E243.

17.2.4 Cleanliness Test:

17.2.4.1 In performing this test, care must be exercised to clean the outside surface of the end of the sample to be immersed in the solvent. The sample must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust, resulting from cutting of the sample. Testing may be performed on less than full lengths, minimum of 5 ft (1524 mm), with a corresponding reduced maximum permissible residue limit based upon 0.0035 g/ft² (0.038 g/m²) of sample interior surface.

17.2.4.2 Cap or plug one end of the tube, and fill with solvent to one-eighth of its capacity. Cap or plug the filling end and roll tube on horizontal supports to thoroughly wash the inside surface. A minimum quantity of 3.4 oz (100 mL) shall be used for diameters up to ½ in. (12.7 mm) and shall be increased proportionally for the larger sizes.