



Designation: B640 – 12a (Reapproved 2021)

Standard Specification for Welded Copper Tube for Air Conditioning and Refrigeration Service¹

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1. Scope*

1.1 This specification establishes the requirements for welded copper tube for air conditioning and refrigeration service for use in connections, repairs, and alterations. The tube shall be made from one of the following coppers:

Copper UNS No.	Previously Used Designation	Type of Copper
C10100	OFE	Oxygen-free electronic
C10200	OF	Oxygen-free without-residual oxidants
C12000	DLP	Phosphorus-deoxidized, low-residual phosphorus
C12200	DHP	Phosphorus-deoxidized, high-residual phosphorus

NOTE 1—Fittings used for soldered or brazed connections in air conditioning and refrigeration systems are described in ASME Standard B 16.22.

NOTE 2—The assembly of copper tubular systems by soldering is described in Practice B828.

NOTE 3—Solders for joining copper tubular systems by described in Specification B32. The requirements for acceptable fluxes for these systems are described in Specification B813.

1.2 Copper UNS No. C12200 shall be furnished, unless otherwise specified. The copper tube shall be supplied in annealed coils or drawn temper straight lengths.

1.3 *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.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

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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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

- B32 Specification for Solder Metal
- B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing
- B170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes
- B577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper
- B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
- B813 Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
- B828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
- B846 Terminology for Copper and Copper Alloys
- B900 Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies
- B968/B968M Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube
- E3 Guide for Preparation of Metallographic Specimens
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

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

- 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
- 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)
- 2.2 ASME Standard.⁴
- B 16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *tube, air-conditioning, n*—a welded copper tube conforming to a standard series of sizes and to specified internal cleanness requirements, normally furnished in drawn temper straight lengths, with the ends capped or sealed.

3.2.2 *tube, refrigeration-service, n*—a welded copper tube conforming to a standard series of sizes and to special internal cleanness and dehydration requirements, normally furnished in soft temper coils, with ends capped or sealed.

4. Ordering Information

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

- 4.1.1 ASTM designation and year of issue;
- 4.1.2 Copper Alloy UNS No. designation;
- 4.1.3 Temper (Section 7);
- 4.1.4 Dimensions: diameter, wall thickness, length, and so forth (Section 11);
- 4.1.5 How furnished (straight lengths or coils); and
- 4.1.6 Quantity: total weight or number of pieces or coils of each copper, size, and temper.

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

- 4.2.1 Hydrogen embrittlement susceptibility (9.3),
- 4.2.2 Microscopical Examination (9.2),
- 4.2.3 Expansion test (9.1),
- 4.2.4 Cleanness test (10.2),
- 4.2.5 Flattening test (9.4),
- 4.2.6 Reverse bend test (9.5),
- 4.2.7 Certification (Section 20),
- 4.2.8 Test report (Section 21), and
- 4.2.9 When product is purchased for agencies of the U.S. Government (10.3).

5. Materials and Manufacture

5.1 *Material*—The material of manufacture shall be sheet or strip of Copper Alloy UNS No. C10100, or C10200, or

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>.

C12000, or C12200 of such purity and soundness as to be suitable for processing into welded tube to meet the properties prescribed herein.

5.2 Manufacture:

5.2.1 The product shall be manufactured by forming the material into a tubular shape on a suitable forming mill and welded using an automatic process.

5.2.2 The product shall be cold worked to the finished size and wall thickness and subsequently annealed, when required, to meet the temper properties specified.

5.2.3 The product shall conform to “fully finished tube” as required in 5.2.3.1 and 5.2.3.2:

5.2.3.1 Welded tube with internal and external flash removed by scarfing, and the tube subsequently cold drawn, over a mandrel and annealed as necessary to conform to the specified temper.

5.2.3.2 Welded tube that has been mechanically worked into a smooth tube without the need for internal or external scarfing, or other metal removal and subsequently cold drawn over a mandrel and annealed as necessary to conform to the specified size and temper.

5.2.4 Coiled lengths specified as O60, soft-annealed temper, shall be bright annealed after coiling, then dehydrated, and capped, plugged, crimped, or otherwise closed at both ends so as to maintain the internal cleanness of the tubing under normal conditions of handling and storage.

5.2.5 Straight lengths specified as H58, 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.

6. Chemical Composition

6.1 The material shall conform to the chemical compositional requirements in Table 1 for the Copper UNS No. designation specified in the ordering information.

6.2 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.

TABLE 1 Chemical Requirements

Copper UNS No.	Copper, ^A min	Phosphorus	
		Min	Max
C10100	99.99 ^{B,C}	...	C
C10200	99.95 ^D
C12000	99.90	0.004	0.012
C12200	99.9	0.015	0.040

^A Copper (including silver).

^B This value is exclusive of silver and shall be determined by difference of “impurity total” from 100 %. “Impurity total” is defined as the sum of sulfur, silver, lead, tin, bismuth, arsenic, antimony, iron, nickel, zinc, phosphorus, selenium, tellurium, manganese, cadmium, and oxygen present in the sample.

^C Impurity parts per million maximums for C10100 shall be: antimony 4, arsenic 5, bismuth 1, cadmium 1, iron 10, lead 5, manganese 0.5, nickel 10, oxygen 5, phosphorus 3, selenium 3, silver 25, sulfur 15, tellurium 2, tin 2, and zinc 1.

^D Oxygen in C10200 shall be 10 ppm max.

7. Temper

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

- 7.1.1 Drawn general purpose H58.
- 7.1.2 Annealed temper O60.

7.2 Tempers are defined in Classification **B601**. Other special anneal tempers may be supplied as agreed upon between the manufacturer or supplier and the purchaser.

8. Mechanical Property Requirements

8.1 *Tensile Strength Requirements:*

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

8.1.1.1 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength.

9. Performance Requirements

9.1 *Expansion Test:*

9.1.1 When specified in the contract or purchase order, product test specimens from tube furnished in the O60 annealed temper shall be expanded in accordance with Test Method **B153** with an expansion of the outside diameter in the following percentage:

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
5/8 (15.9) and under	30
Over 5/8 (15.9)	25

9.1.2 The expanded tube shall show no cracking or other defects visible to the unaided eye.

9.2 *Microscopical Examination*—When specified in the contract or purchase order, product test specimens of Copper UNS Nos. C10100, C10200, and C12000 shall be free of cuprous oxide as determined by Test Method A of Test Methods **B577**.

9.3 *Hydrogen Embrittlement Susceptibility*—When specified in the contract or purchase order, product test specimens of Copper UNS Nos. C10100, C10200, C12000, and C12200 shall conform to the requirements of Test Method B of Test Methods **B577**.

9.4 *Flattening Test:*

9.4.1 When specified in the contract or purchase order, the flattening test shall be performed in accordance with Test Method **B968/B968M**.

9.5 *Reverse Bend Test*—When specified in the contract or purchase order, the product test specimens when flattened and

bent in accordance with the test method described in **16.2.5**, shall show no evidence of cracks, lack of penetration in the weld, or overlaps resulting from flash removal visible to the unaided eye which are considered unacceptable for the intended application.

10. Other Requirements

10.1 *Electromagnetic (Eddy-Current) Test:*

10.1.1 Each straight length tube, up to and including 3 1/8 in. (79.4 mm) outside diameter, shall be passed through an eddy-current testing unit adjusted to provide information on the suitability of the tube for the intended application.

10.1.2 Tubes that do not actuate the signaling device of the eddy-current testing unit shall be considered as conforming to the requirements of the test. Testing shall follow the procedures of Practice **E243**, except for the determination of “end effect.”

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

10.1.4 For tubes greater than 3 1/8 in. (79.4 mm) in outside diameter, the manufacturer and purchaser shall agree on whatever nondestructive testing is required.

10.2 *Cleaness Test:*

10.2.1 When specified in the contract or purchase order, a cleanliness test described in **16.2.7** shall be performed.

10.2.1.1 After evaporation of the cleaning solvent, the residue weight shall not exceed 0.0035 g/ft² (0.038 g/m²). The maximum amount of residue in grams per tube shall not exceed the limits in **Tables 3 and 4**.

10.3 *Purchases for Agencies of the U.S. Government*—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.

TABLE 3 Interior Surface Residue Limits of Soft Coiled Lengths^A

Standard Size, in.	Wall Thickness, in. (mm)	Residue Limit ^B per 50 ft (15.2 m) coil, g
	Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200
1/8	0.030 (0.762)	0.0030
3/16	0.030 (0.762)	0.0058
1/4	0.030 (0.762)	0.0087
5/16	0.032 (0.813)	0.0114
3/8	0.032 (0.813)	0.0143
1/2	0.032 (0.813)	0.0200
5/8	0.035 (0.889)	0.0254
3/4	0.035 (0.889)	0.0312
7/8	0.042 (1.07)	0.0305
1	0.045 (1.14)	0.0360
1 1/8	0.050 (1.27)	0.0470
1 1/4	0.055 (1.40)	0.0580
1 3/8	0.060 (1.52)	0.0690

^A See also **Table 5**.

^B Residue limit 0.0035 g/ft² (0.038 g/m²) inside area. The internal surface area per foot or tube is determined by the equation (3.1416 × inside diameter × 144)/1728.

TABLE 2 Mechanical Property Requirements

Copper UNS Nos. C10100, C10200, C12000, and C12200				
Form	Temper	Tensile Strength, Min		Elongation in 2 in. (50 mm), Min, %
		ksi ^A	MPa ^B	
Coiled lengths	O60	30	205	40
Straight lengths	H58	36	250	...

^A ksi = 1000 psi.

^B See **Appendix X1**.

TABLE 4 Interior Surface Residue Limits of Straight Lengths^A

Standard Size, in.	Wall Thickness, in. (mm)	Residue Limit ^B per 20 ft (6.10 m), g
	Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200
3/8	0.030 (0.762)	0.0058
1/2	0.035 (0.889)	0.0079
5/8	0.040 (1.02)	0.0100
3/4
3/4
3/4	0.042 (1.07)	0.0122
7/8	0.045 (1.14)	0.0144
1 1/8	0.050 (1.27)	0.0188
1 3/8	0.055 (1.40)	0.0232
1 5/8	0.060 (1.52)	0.0276
2 1/8	0.070 (1.78)	0.0364
2 5/8	0.080 (2.03)	0.0453
3 1/8	0.090 (2.29)	0.0540
3 5/8	0.100 (2.54)	0.0628
4 1/8	0.110 (2.79)	0.0717

^A See also **Table 6**.

^B Residue limit 0.0035 g/ft² (0.038 g/m²) inside area. The internal surface area per foot of tube is determined by the equation (3.146 × inside diameter × 144)/1728.

11. Dimensions, Mass, and Permissible Variations

11.1 The standard dimensions, weights per foot, and tolerances for the various nominal sizes are given in **Tables 5 and 6**.

11.2 *Wall Thickness and Diameter:*

11.2.1 *For Coil Lengths—Table 5.*

11.2.2 *For Straight Lengths—Table 6.*

11.3 *Length:*

11.3.1 The standard length for coils shall be 50 ft (15.2 m). The length tolerances for all coils shall be +12 in. (300 mm) and -0 in.

11.3.2 The standard length for straight lengths shall be 20 ft (6.10 m). The length tolerances for all lengths shall be +1 in. (25 mm) and -0 in.

11.4 *Roundness:*

11.4.1 *Straight Lengths*—For unannealed drawn tube in straight lengths, the roundness tolerance is specified in **Table 7**. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. Roundness tolerance has not been established for annealed tube in straight lengths.

11.4.2 *Coil Lengths*—Roundness tolerance has not been established for tubes furnished in coils.

11.5 *Squareness of Cut*—For tube in straight lengths, the deviation from squareness is measured as the difference between one side of a cross section of tube from the opposite side when measured against the projected perpendicularity of the plane of the projected center of the tube. The departure from squareness of the end of any tube shall not exceed more than 0.010 in. (0.25 mm) for tube up to and including 5/8 in. (15.9 mm) standard size; and not more than 0.016 in./in. (0.016 mm/mm) of outside diameter, for tube larger than 5/8 in. (15.9 mm) standard size.

NOTE 4—For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension may be cause for rejection.

12. Workmanship, Finish, and Appearance

12.1 The product shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

13. Sampling

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

13.1.1 *Lot Size*—For tube, the lot size shall be 10 000 lb (4 550 kg) or fraction thereof.

13.1.2 *Portion Size*—Sample pieces shall be taken for test purposes from each lot in accordance with the following schedule:

TABLE 5 Standard Dimensions, Weights, and Tolerances for Diameter and Wall Thickness for Coil Lengths

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
		Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200	Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall Thickness, ^{B,C} Plus and Minus, in. (mm)
1/8	0.125 (3.18)	0.030 (0.762)	0.0347 (0.0516)	0.002 (0.051)	0.003 (0.076)
3/16	0.187 (4.75)	0.030 (0.762)	0.0575 (0.0856)	0.002 (0.051)	0.0025 (0.064)
1/4	0.250 (6.35)	0.030 (0.762)	0.0804 (0.120)	0.002 (0.051)	0.0025 (0.064)
5/16	0.312 (7.92)	0.032 (0.813)	0.109 (0.162)	0.002 (0.051)	0.0025 (0.064)
3/8	0.375 (9.52)	0.032 (0.813)	0.134 (0.199)	0.002 (0.051)	0.0025 (0.064)
1/2	0.500 (12.7)	0.032 (0.813)	0.182 (0.271)	0.002 (0.051)	0.0025 (0.064)
5/8	0.625 (15.9)	0.035 (0.889)	0.251 (0.373)	0.002 (0.051)	0.0030 (0.076)
3/4	0.750 (19.1)	0.035 (0.889)	0.305 (0.454)	0.0025 (0.064)	0.0035 (0.089)
3/4	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.0025 (0.064)	0.0035 (0.089)
7/8	0.875 (22.3)	0.045 (1.114)	0.455 (0.677)	0.003 (0.076)	0.004 (0.10)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.665 (0.975)	0.0035 (0.089)	0.004 (0.10)
1 3/8	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.004 (0.10)	0.0045 (0.11)

^A The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

^B The tolerances listed represent the maximum deviation at any point.

^C May contain a residual thickening at the weld not to exceed 0.006 in. (0.15 mm) or 10 % of the nominal wall thickness, whichever is greater.

TABLE 6 Standard Dimensions, Weights, and Tolerances for Diameter and Wall Thickness for Straight Lengths

NOTE 1—Applicable to drawn temper tube only.

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
		Copper UNS Nos. C10100, C12000, and C12200	Copper UNS Nos. C10100, C12000, and C12200	Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall Thickness, ^{B,C} Plus and Minus, in. (mm)
3/8	0.375 (9.52)	0.030 (0.762)	0.126 (0.187)	0.001 (0.025)	0.0035 (0.089)
1/2	0.500 (12.7)	0.035 (0.889)	0.198 (0.295)	0.001 (0.025)	0.0035 (0.089)
5/8	0.625 (15.9)	0.040 (1.02)	0.285 (0.424)	0.001 (0.025)	0.0035 (0.089)
3/4	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.001 (0.025)	0.0035 (0.089)
7/8	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.001 (0.025)	0.004 (0.10)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.655 (0.975)	0.0015 (0.038)	0.004 (0.10)
1 3/8	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.0015 (0.038)	0.0045 (0.11)
1 5/8	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.002 (0.051)	0.0045 (0.11)
2 1/8	2.125 (54.0)	0.070 (1.78)	1.75 (2.60)	0.002 (0.051)	0.006 (0.15)
2 5/8	2.625 (66.7)	0.080 (2.03)	2.48 (3.69)	0.002 (0.051)	0.006 (0.15)
3 1/8	3.125 (79.4)	0.090 (2.29)	3.33 (4.96)	0.002 (0.051)	0.007 (0.18)
3 5/8	3.625 (92.1)	0.100 (2.54)	4.29 (6.38)	0.002 (0.051)	0.007 (0.18)
4 1/8	4.125 (105)	0.110 (2.79)	5.38 (8.01)	0.002 (0.051)	0.009 (0.23)

^A The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

^B The tolerances listed represent the maximum deviation at any point.

^C May contain a residual thickening at the weld not to exceed 0.006 in. (0.15 mm) or 10 % of the nominal wall thickness, whichever is greater.

TABLE 7 Roundness Tolerance

NOTE 1—Applicable to drawn unannealed straight length tube only.

t/D (Ratio of Wall Thickness to Nominal Outside Diameter)	Roundness Tolerance, Percent of Nominal Outside Diameter (Expressed to Nearest 0.001 in. or 0.010 mm)
0.01 to 0.03, incl	1.5
Over 0.03 to 0.05, incl	1.0
Over 0.05 to 0.10, incl	0.8

to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

(1) When samples are taken at the time the castings are poured, at least one sample shall be taken for each group of castings poured simultaneously from the same source of molten metal.

(2) When samples are taken from the semifinished product, a sample shall be taken to represent each 10 000 lb (4550 kg) or fraction thereof, except that not more than one sample shall be required per piece.

(3) Because of the discontinuous nature of the processing of castings into wrought products, it is not practical to identify specific casting analysis with a specific quantity of finished material.

(4) In the event that heat identification or traceability is required, the purchaser shall specify the details desired.

13.3 For other tests, unless otherwise provided in the product specification, test specimens shall be taken from two of the sample pieces selected in accordance with 13.1.2.

13.4 In the case of tube furnished in coils, a length sufficient for all necessary tests shall be cut from each coil selected for the purpose of tests. The remaining portions of these coils shall be included in the shipment, and the permissible variations in length on such coils shall be waived.

14. Number of Tests and Retests

14.1 Tests:

14.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element mean of the results from at least two replicate analyses of the samples, and the results of each replication must meet the requirements of the product specification.

14.1.2 *Other Tests*—Tensile strength and elongation shall be reported as individual test results obtained from each of two

Number of Pieces in Lot	Number of Sample Pieces 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 the in the lot, but not to exceed 10 sample pieces

^A Each sample piece shall be taken from separate tube.

13.2 Chemical Analysis:

13.2.1 Samples for chemical analysis shall be taken in accordance with Practice E255. Drillings, millings, and so forth shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 13.1.2 and combined into one composite sample. The minimum weight of the composite sample that is to be divided into three equal parts shall be 150 g.

13.2.1.1 Instead of sampling in accordance with Practice E255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semifinished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, the manufacturer shall not be required