



Standard Specification for Seamless Copper Tube in Coils¹

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1. Scope*

1.1 This specification establishes the requirements for seamless copper tube in coils, suitable for use in refrigeration and air conditioning or other uses, such as oil lines and gasoline lines.

1.2 *Units*—The values stated in inch-pound units are standard. 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 tube shall be produced of the following coppers. Unless otherwise specified, tubes made from any one of these coppers may be supplied:

Copper Alloy UNS No.	Previously Used Designation	Type of Copper
C10200	OF	Oxygen-free without residual deoxidants ^A
C10300	...	Oxygen-free, extra low phosphorus ^A
C10800	...	Oxygen-free, low phosphorus ^A
C12000	DLP	Phosphorized, low residual phosphorus
C12200	DHP	Phosphorized, high residual phosphorus

^A See Classification B 224.

1.4 The following safety hazards caveat pertains to the test method portion, Section 17, 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:²

B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing

B 170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes

B 193 Test Method for Resistivity of Electrical Conductor Materials

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.

B 224 Classification of Coppers

B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube

B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper

B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

B 846 Terminology for Copper and Copper Alloys

E 2 Discontinued 1983; Methods of Preparation of Micrographs of Metals and Alloys (Including Recommended Practice for Photography As Applied to Metallography); Replaced by E 883³

E 3 Guide for Preparation of Metallographic Specimens

E 8 Test Methods for Tension Testing of Metallic Materials

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)

E 112 Test Methods for Determining Average Grain Size

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes

E 255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

3. General Requirements

3.1 The following sections of Specification B 251 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 In addition, when a section with a title identical to those referenced in 3.1 appears in this specification, it contains additional information which supplements those appearing in Specification B 251. In case of conflict, this specification shall prevail.

³ Withdrawn.

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

4. Terminology

4.1 *Definitions*—For the definitions of terms related to copper and copper alloys, refer to Terminology B 846.

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *level or traverse wound, adj*—coil in which the turns are wound into layers parallel to the axis of the coil such that successive turns in a given layer are next to one another (sometimes called “helical coil”).

4.2.2 *single layer flat, adj*—coil in which the product is spirally wound into a single disk-like layer (sometimes called “pan-cake coil” or “single layer spirally wound coil”).

4.2.3 *double layer flat, adj*—coil in which the product is spirally wound into two connected disk-like layers such that one layer is on top of the other (sometimes called “double layer pan-cake coil” or “double layer spirally wound coil”).

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 UNS No. (for example, C12200), if required (see 1.3 and Table 1),

5.1.3 Temper (see Section 8).

5.1.4 Dimensions, diameter, and wall thickness. Dimensional tolerances, if other than those included in this specification, are required,

5.1.5 Length (see 14.1 and Table 2),

5.1.6 Type of coil (see 4.2),

5.1.7 Total quantity of each item,

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

5.2.1 Embrittlement test (see 13.3),

5.2.2 Refrigeration or air-conditioning grade (see 13.4),

5.2.3 If coil ends are to be sealed (see 13.4.1.1),

5.2.4 Eddy-current test (see 13.1.1),

5.2.5 Expansion test (see 12.1.1),

5.2.6 Electrical resistivity requirement (see 10.1),

5.2.7 Certification (see Section 21),

5.2.8 Mill test report (see Section 22).

6. Materials and Manufacture

6.1 *Material:*

6.1.1 The material of manufacture shall be cast billet, bar, tube, and so forth of Copper Alloys Nos. C10200, C10300, C10800, C12000, or C12200 and of such purity and soundness as to be suitable for processing in to the product prescribed herein.

6.1.2 In the event heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 1—Due to the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify a specific casting analysis with a specific quantity of finished material.

6.2 *Manufacture:*

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

6.2.1.1 The product shall be cold drawn to the finish size and wall thickness.

6.2.1.2 When the cold-drawn temper is required, the final drawing operation shall be such as to meet the temper properties specified.

6.2.1.3 When the annealed temper is required, the tube shall be annealed after the final cold draw to meet the temper properties specified.

7. Chemical Composition

7.1 The material shall conform to the compositional requirements listed in Table 1 for the copper UNS No. designation specified in the ordering information.

7.1.1 Results of analysis on a product (check) sample shall conform to the composition requirements within the permitted analytical variance specified in Table 1.

7.2 These compositional 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 3.

8.2 *H (Drawn) Temper*—The temper of drawn tube shall be designated as H58 (drawn, general purpose).

8.3 *O (Annealed) Temper*—The temper of annealed tube shall be designated as 050 (light anneal) and 060 (soft anneal). Tempers are defined in Classification B 601.

9. Grain Size for Annealed Tempers

9.1 Grain size shall be the standard requirement for all product in the annealed tempers.

9.2 Acceptance or rejection based upon grain size shall depend only on the average grain size of a test specimen taken from each of two sample portions, and each specimen shall be within the limits prescribed in Table 4 when determined in accordance with Test Methods E 112.

10. Physical Property Requirements

10.1 *Electrical Resistivity Requirement*—When specified in the contract or purchase-order, the product ordered for electrical conductor application produced from Copper UNS No.

TABLE 1 Chemical Requirements

Element	Composition, % Copper Alloy UNS No.				
	C10200 ^A	C10300	C10800	C12000	C12200
Copper, ^B min	99.95	...	...	99.90	99.9
Copper + 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 Coil Length Tolerances (Specific Lengths)

Tube Outside Diameter, in. (mm)	Nominal Length, ft (m)	Shortest Permissible Length, % of Nominal Length	Maximum Permissible Weight of Ends, % of Lot Weight	Tolerance All Plus ft (m)
All sizes	Up to 100 (30.5), incl	100	0	1(0.3)
All sizes	Over 100 (30.5)	40	20	...

TABLE 3 Mechanical Property Requirements of Drawn-Temper and Annealed-Temper Tube

Temper Designation	Wall Thickness, in. (mm)	Rockwell Hardness		Tensile Strength Min, ksi ^A (Mpa)	Yield Strength ^B Min, ksi ^A (Mpa)	Elongation in 2 in., min %
		Scale	Value			
H58	Less than 0.020	N/A	N/A	36 (250)	30 (205)	N/A
	0.020 and over	30T ^C	30 min	36 (250)	30 (205)	N/A
O50	Less than 0.015	N/A	N/A	30 (205)	9 (62)	40
	0.015 to 0.035 (0.381 to 0.889)	15T ^C	65 max	30 (205)	9 (62)	40
	Over .035 (0.889)	F ^C	55 max	30 (205)	9 (62)	40
O60	Less than 0.015	N/A	N/A	30 (205)	6 (40)	40
	0.015 to 0.035 (0.381 to 0.889)	15T ^C	60 max	30 (205)	6 (40)	40
	Over 0.35 (0.889)	F ^C	50 max	30 (205)	6 (40)	40

^A ksi = 1000 psi.^B Yield strength to be determined at 0.5 % extension under load.^C Rockwell hardness values apply to tubes having an inside diameter of 5/16 in. (7.92 mm) or over, and Rockwell hardness test shall be made on the inside surface of the tube. When suitable equipment is not available for determining the specific Rockwell hardness, other Rockwell scales and values may be specified subject to agreement between the purchaser and supplier.

TABLE 4 Grain Size of Annealed Tempers

Temper	Average Grain Size, mm
O60	0.040 min
O50	0.040 max

C10200, C10300, or C12000 shall conform to the electrical mass resistivity, $\Omega \cdot \text{g}/\text{m}^2$ prescribed in Table 5 for the specified copper and temper when tested in accordance with Test Method B 193.

11. Mechanical Property Requirements

11.1 *Tensile and Yield Strength*—The product shall conform to the requirements in Table 3 for the specified temper.

11.2 Rockwell Hardness:

11.2.1 For product of the H58 temper and Rockwell hardness values are given for reference purposes only.

11.2.2 For product of the O (annealed) temper, the product shall conform to the Rockwell hardness values contained in Table 3.

12. Performance Requirements

12.1 Expansion Requirement:

12.1.1 When specified in the contract or purchase order, tube furnished in the annealed temper shall be capable of being

expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following percentage:

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
0.750 (19.1) and under	40
Over 0.750 (19.1)	30

12.1.2 The expanded tube shall show no cracking or rupture visible to the unaided eye.

13. Other Requirements

13.1 Nondestructive Examination for Defects:

13.1.1 Upon agreement between the manufacturer and the purchaser, each tube shall be subjected to an eddy-current test.

13.1.2 Tubes shall be tested normally in the drawn temper; however, they may be tested in the annealed temper at the option of the manufacturer.

13.1.3 Testing shall follow the procedures of Practice E 243 except for the determination of “end effect.”

NOTE 2—End effect is that length of the tube, which travels through the coil until the testing unit, has stabilized and is able to detect flaws. The magnitude of the spike, generated when an end passes through the test coils is such that it disrupts testing momentarily.

13.1.4 Unless otherwise agreed upon between the manufacturer, or supplier, and the purchaser, the manufacturer shall have the option of calibrating the test equipment using either notches or drilled holes. If agreement cannot be reached, drilled holes shall be used.

13.1.4.1 Notch-depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the nominal bottom-wall thickness.

13.1.4.2 Drilled-hole standards shall be 0.025 in. (0.635 mm) diameter for tubes up to and including 3/4 in. (19.05 mm)

TABLE 5 Resistivity ($\Omega \cdot \text{g}/\text{m}^2$) of Copper UNS No.

NOTE 1—Refer to Appendix X1 for the International Annealed Copper Standard (IACS) electrical conductivity equivalents.

Temper	C10200	C10300	C12000
O50, O60	0.153 28	0.156 14	0.170 31
H58	0.15737	0.159 40	0.174 18

specified diameter and 0.031 in. (0.785 mm) diameter for tubes over ¾ in. (19.05 mm) specified diameter.

13.1.5 Tubes that do not actuate the signaling device on the eddy-current tester shall be considered in conformance with the requirements of this test.

13.1.6 Tubes, rejected for irrelevant signals because of moisture, soil, and like effects, may be reconditioned and retested.

13.1.7 Tubes that are reconditioned and retested (see 13.1.6) shall be considered in conformance with the requirements of this specification, if they do not cause output signals beyond the acceptable limits.

13.1.8 Eddy-current discontinuities will be identified on coils in excess of 200 ft (61 m) in length for subsequent removal by the purchaser.

13.1.9 At the customer's discretion, the permissible number of identified eddy current discontinuities may be specified.

13.2 *Cuprous Oxide Requirement*—Samples of Copper UNS No. C10200, C10300, and C12000 shall be significantly free of cuprous oxide as determined by Procedure A of Test Methods B 577. In case of dispute, a referee method in accordance with Procedure C shall be used.

13.3 *Embrittlement*—Samples of Copper UNS Nos. C10200, C10300, C10800, 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 specified in the ordering information. In case of a dispute, a referee method in accordance with Procedure C shall be used.

13.4 *Cleanliness Requirement*:

13.4.1 When refrigeration or air conditioning grade is specified, the tube shall be capable of meeting the following cleanliness requirement described in 13.4.1.1.

13.4.1.1 The inside of the tube, with closed ends, shall be sufficiently clean such that when the interior of the tube is washed with a suitable solvent, such as re-distilled chloroform or redistilled trichloroethylene, the residue remaining upon evaporation of the solvent shall not exceed 0.0035 g/ft² (0.038 g/m²) of interior surface. See 17.3 for the test method.

14. Dimensions, Mass, and Permissible Variations

14.1 For specific coil lengths, see Table 2 of this specification.

14.2 If coils are produced to a specified nominal weight, no coil shall weigh less than 40 % of the nominal weight, and no more than 20 % of the coils in a lot shall weigh less than 70 % of the nominal weight unless otherwise agreed between supplier and purchaser.

15. Workmanship, Finish and Appearance

15.1 The product shall be free of defects of a nature that interfere with normal commercial applications, except as noted in 13.1.8.

15.2 The product shall be well cleaned and free of dirt.

15.3 Product of refrigeration and air conditioning grade shall meet the cleanliness requirement of 13.4.

16. Specimen Preparation

16.1 *Chemical Analysis*:

16.1.1 Sample preparation shall be in accordance with Practice E 255.

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

16.2 *Electrical Resistivity*:

16.2.1 The test specimen shall be full size and shall be the full cross section of the material it represents, when possible.

16.2.2 When the test specimen is taken from material in bulk, care must be taken that the properties are not appreciably altered in the preparation.

NOTE 3—Plastic deformation tends to work-harden a material and raise its resistivity, while heating tends to anneal the material with a subsequent reduction in resistivity.

16.3 *Microscopical Examination*—Samples preparation shall be in accordance with Test Method B 577.

16.4 *Embrittlement Test*—Samples preparation shall be in accordance with Test Method B 577.

16.5 *Grain-Size*—The test specimen shall be prepared in accordance with Test Method E 3 and shall approximate a radial longitudinal-section of the tube.

16.6 *Expansion Test Specimen*—Test specimens shall conform to the requirements of the specimen preparation section of Test Method B 153.

16.7 *Cleanliness Test Specimen*—A section of straight tube, or a section of a straightened tube from the outside end of a coil, not less than 5 ft (1.5 m), shall be selected.

17. Test Methods

17.1 In the case of disagreement, the properties enumerated in this specification shall be determined in accordance with the ASTM test methods listed in Table 6.

17.2 *Tension Test*:

17.2.1 Tension-test specimens shall be of the full-section of the tube and shall conform to the requirements of specimens for tube section, of Test Method E 8, unless the limitations of the testing machine preclude the use of such a specimen. Test specimens conforming to type No. 1, Fig. 9, of Test Methods E 8, may be used when a full-section specimen cannot be tested.

17.2.2 Whenever different tension-test results are obtained from both full-size and machined test specimens, the results obtained from full-size test specimens shall be used to determine conformance to the requirements of this specification.

17.2.3 Tension-test results on products produced under this specification are not seriously affected by variations in speed of

TABLE 6 Methods of Test

Test	ASTM Designation
Chemical analysis ^A	B 170
Copper	E 53
Phos	E 62
Eddy current	E 243
Tension	E 8
Rockwell hardness	E 18
Grain size	E 2, E 3, E 112
Expansion (pin test)	B 153

^A Reference to Specification B 170 is to the suggested chemical methods in the annex thereof. When Committee E-1 has tested and published methods for assaying the low level impurities in copper, the annex in Specification B 170 will be eliminated.

testing. A considerable range of testing speed is permissible; however, the rate of stressing to the yield strength should not exceed 100 ksi/min (690 MPa/min.) Above the yield strength, the movement per minute of the testing-machine head under load should not exceed 0.5 in./in. (0.5 mm/mm) of gage length (or distance between grips for full section specimens).

17.3 Cleanliness Test:

17.3.1 A section of a straightened tube from the outside end of a coil, not less than 5 ft (1.5 m), shall be selected. One end of the tube shall be closed, and the tube shall be filled with solvent to $\frac{1}{8}$ of capacity. The opposite end shall be closed and the tube shall be rolled back and forth on horizontal supports to thoroughly wash the inside surface. The closure shall be removed and the solvent shall be poured into a suitable weighed-container. The solvent in the container shall be evaporated to dryness on a low-temperature hot plate or sand bath. Overheating of the container shall be avoided to prevent charring of the residue. The container then shall be dried in an oven at 212 to 230°F (100 to 110°C) for 10 min, cooled in a desiccator, and weighed. A blank determination shall be run with the same volume of solvent and the gain in weight for the blank shall be subtracted from the weight of the residue sample. The corrected weight shall then be calculated in grams of residue per internal area of the tube in square feet.

17.3.2 The quantity of the solvent used will vary with the size of the tube being examined. The quantity of solvent used for the blank run shall be the same as that used for cleaning the tube sample.

17.3.3 The sample must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust resulting from the cutting of the sample.

18. Significance of Numerical Limits

18.1 For purpose of determining compliance with the specified limits for requirements of the properties listed in **Table 7**, an observed value or calculated value shall be rounded as indicated in accordance with the rounding method of Practice E 29.

19. Inspection

19.1 The manufacturer shall inspect and make the necessary tests to verify that the product furnished conforms to the requirements of this specification.

19.2 Source inspection of the product by the purchaser may be agreed upon between the manufacturer, or supplier, and the

purchaser as a part of the purchase order. In such case, the nature of the facilities needed to satisfy the inspector, representing the purchaser, that the product is being furnished in accordance with the specification shall be included in the agreement. All testing and inspection shall be conducted so as not to interfere unnecessarily with the operation of the works.

19.3 When mutually agreed upon, the manufacturer, or supplier, and the purchaser shall conduct the final inspection simultaneously.

20. Rejection and Rehearing

20.1 Rejection:

20.1.1 Product that fails to conform to the specification requirements when tested by the purchaser or purchaser's agent shall be subject to rejection.

20.1.2 Rejection shall be reported to the manufacturer or supplier promptly. In addition, a written notification of the rejection shall follow.

20.1.3 In case of dissatisfaction with the results of the test upon which rejection is based, the manufacturer, or supplier, may make claim for a rehearing.

20.2 *Rehearing*—As a result of product rejection, the manufacturer, or supplier, shall have the option to make claim for a retest to be conducted by the manufacturer, or supplier, and the purchaser. Samples of the rejected product shall be taken in accordance with the product specification and subjected to test by both parties using the test method(s) specified in the product specification, or alternatively, upon agreement of both parties, an independent laboratory may be selected for the test(s) using the test method(s) specified in the product specification.

21. Certification

21.1 When specified on the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have either been tested or inspected as directed in this specification and requirements have been met.

22. Mill Test Report

22.1 When specified in the contract or purchase order, a report of test results shall be furnished.

23. Packaging and Package Marking

23.1 *Packaging*—The product shall be separated by size, composition, and temper, and prepared for shipment by common carrier, in such a manner to afford protection from the normal hazards of transportation.

23.2 *Package Marking*—Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, gross and net weight, total length or piece count, or both, and name of supplier. The specification number shall be shown, when specified.

24. Keywords

24.1 coils; copper tubes; seamless; UNS No. C10200; UNS No. C10300; UNS No. C10800; UNS No. C12000; UNS No. C12200

TABLE 7 Rounding Units

Property	Rounded Unit for Observed or Calculated Value
Chemical composition hardness	nearest unit in the last righthand place of figures of the specified limit
Tensile strength	nearest ksi (nearest 5 MPa)
Expansion	nearest 1 %
Grain size:	
Up to 0.055 mm, incl	nearest multiple of 0.005 mm
Over 0.055 to 0.160 mm, incl	nearest 0.01 mm



APPENDIX

(Nonmandatory Information)

X1. INTERNATIONAL ANNEALED COPPER STANDARD (ELECTRICAL CONDUCTIVITY EQUIVALENTS)

TABLE X1.1 Electrical Conductivity Equivalents

Electrical Resistivity, $\Omega \cdot \text{gm}/\text{m}^2$	Conductivity, %	Electrical Resistivity, $\Omega \cdot \text{gm}/\text{m}^2$	Conductivity, %
0.151 76	101.00	0.159 40	96.16
0.153 28	100.00	0.170 31	90
0.156 14	98.16	0.174 18	88
0.157 37	97.40	. . .	...

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 473 – 00) that may impact the use of this standard. (Approved Oct. 1, 2006.)

- (1) The specification was generally rewritten to conform with the Committee B05 Outline of Form.
- (2) Redundant information was deleted.
- (3) The five year review was completed and language was corrected in accordance with Committee B05 Outline of Form.

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