



Designation: B 903 – 00

Standard Specification for Seamless Copper Heat Exchanger Tubes With Internal Enhancement¹

This standard is issued under the fixed designation B 903; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This specification establishes the requirements for seamless, internally enhanced copper tube, in straight lengths or coils, suitable for use in refrigeration and air-conditioning products or other heat exchangers.

1.2 The values stated in inch-pound units are the standard. SI values are given in parentheses for information only.

1.3 Tubes for this application are manufactured from the following copper:

Copper UNS No.	Type of Metal
C12200	Phosphorized, high residual phosphorus (DHP)

1.4 The following pertains to the test method described in 15.4 of this specification: *This standard does not purport to address all 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 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing²
- B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube²
- B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast²
- B 846 Terminology for Copper and Copper Alloys²
- E 3 Practice for Preparation of Metallographic Specimens³
- E 8 Test Methods for Tension Testing of Metallic Materials⁴
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵
- E 53 Methods for Chemical Analysis of Copper⁶
- E 62 Test Methods for Chemical Analysis of Copper and

Copper Alloys (Photometric Methods)⁶

- E 112 Test Methods for Determining 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

3. General Requirements

3.1 The following sections of Specification B 251 constitute a part of this specification:

- 3.1.1 Workmanship, Finish, and Appearance.
- 3.1.2 Sampling.
- 3.1.3 Number of Tests and Retests.
- 3.1.4 Specimen Preparation.

3.2 In addition, when a section with a title identical to those referenced in 5.1 appears in this specification, it contains additional information which supplements those appearing in Specification B 251. In case of conflict, this specification shall prevail.

4. Terminology

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

- 4.1.1 *bottom wall, n*—the wall thickness measured from the base of the enhancement to the outside surface.
- 4.1.2 *coil, n*—a length of the product wound into a series of connected turns.
- 4.1.3 *enhancement, adj*—a geometrical feature intentionally formed on a tube I.D. surface to improve heat transfer.
- 4.1.4 *level wound, adj*—a 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.

4.2 Definitions of Terms Specific to This Standard:

4.2.1 *unaided eye, n*—visual inspection, without the use of special equipment or enhancement excepting the use of corrective lenses.

5. Ordering Information

5.1 Orders for products under this specification should include the following information:

- 5.1.1 ASTM Designation number and the year of issue.

¹ This specification is under the jurisdiction of ASTM Committee B-05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

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² Annual Book of ASTM Standards, Vol 02.01.

³ Discontinued. See 1982 Annual Book of ASTM Standards, Vol 03.01.

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 03.05.

⁷ Annual Book of ASTM Standards, Vol 03.03.

5.1.2 Temper.

5.1.3 Length, diameter, wall, and enhancement dimensions. Configuration of the enhanced surface shall be as agreed upon between the manufacturer, or supplier, and purchaser.

5.1.4 How furnished: straight or coils.

5.1.5 Quantity.

5.1.6 Certification, if required (see Section 19).

5.1.7 Mill test report, if required (see Section 20).

6. Materials and Manufacture

6.1 *Material:*

6.1.1 The material of manufacture shall be cast billet, bar, tube, or so forth of Copper UNS No. C12200 and shall be of such purity and soundness as to be suitable for processing into the tubular product described herein.

6.2 *Manufacture:*

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

6.2.2 The internal enhancement shall be produced by cold forming.

6.2.2.1 When annealed temper is required, the tube shall be annealed subsequent to the final cold-forming operation.

7. Chemical Composition

7.1 The material shall conform to the requirements specified in Table 1 as to chemical composition.

7.2 These specification limits do not preclude the possible presence of other unnamed elements. By agreement between the manufacturer, or supplier, and the purchaser, analysis may be required and limits established for elements not specified.

8. Temper

8.1 *As-Fabricated Temper*—The tube is in the cold-worked condition produced by the enhancing operation.

8.2 *O (Annealed) Temper*—The temper of annealed tube shall be designated as O50 (light-anneal) or O60 (soft-anneal) (see Table 2). Tempers are defined in Practice B 601.

NOTE 1—By agreement between the purchaser and manufacturer, product in special tempers may be supplied with properties as agreed upon between the purchaser and the manufacturer.

9. Grain Size of Annealed Tempers

9.1 Samples of annealed temper tubes shall be examined at a magnification of 75 diameters. The grain size shall be determined in the wall beneath the ridges. The microstructure shall show complete recrystallization and shall have an average grain size within the limits specified in Table 2, when tested in accordance with Test Method E 112.

10. Mechanical Properties

10.1 As-fabricated and O (annealed) temper tube shall conform to the mechanical properties specified in Table 3.

TABLE 1 Chemical Requirements, UNS C12200

Element	Composition, wt %
Copper (including silver)	99.9, min
Phosphorus	0.015–0.040

TABLE 2

Temper	Average Grain Size, mm
As fabricated	—
O60	0.040 min
O50	0.040 max

TABLE 3 Mechanical Property Requirements of Designated Tempers

Temper Designation	Tensile Strength, Min, ksi ^A (Mpa)	Yield Strength, ksi ^B (Mpa)	Elongation in 2 in., min %
As-fabricated	36 (245)	30 (205) min	—
O60	30 (205)	6 (40) min	40
O50	30 (205)	9–15 (60–105)	40

^Aksi = 1000 psi.

^BYield strength to be determined at 0.5 % extension under load.

11. Performance Requirements

11.1 *Expansion Test:*

11.1.1 Specimens of annealed product shall withstand the expansion shown in Table 4 when expanded in accordance with Test Method B 153.

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

12. Other Requirements

12.1 *Nondestructive Examination for Defects:*

12.1.1 Each tube shall be subjected to an eddy-current test.

12.1.2 *Electromagnetic (Eddy-Current) Test:*

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

12.1.2.2 The testing shall follow the procedures specified in Practice E 243. 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. Notch depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the nominal bottom wall thickness. Drilled-hole standards shall be 0.025-in. (0.635-mm) diameter for tubes up to and including ¾-in. specified diameter and 0.031-in. (0.785-mm) diameter for tubes over ¾-in. specified diameter.

12.1.2.3 Tubes that do not actuate the signaling device on the eddy-current tester shall be considered as conforming to the requirements of this test.

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

12.1.2.5 Tubes that are reconditioned and retested (see 12.1.2.4) shall be considered to conform to the requirements of this specification, if they do not cause output signals beyond the acceptable limits.

TABLE 4 Expansion of Annealed Product

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
¾ (19.0) and under	30
Over ¾ (19.0)	20