



Designation: B543/B543M – 18

Standard Specification for Welded Copper and Copper-Alloy Heat Exchanger Tube¹

This standard is issued under the fixed designation B543/B543M; 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.

1. Scope*

1.1 This specification establishes the requirements for welded tube of copper and various copper alloys up to 3 1/8 in., inclusive, in diameter, for use in surface condensers, evaporators, heat exchangers, and general engineering applications. The following coppers or copper alloys are involved:²

Copper or Copper Alloy UNS No. ²	Previously Used Designation	Type of Metal
C10800 ^A	...	oxygen-free, low phosphorus
C12200 ^A	...	DHP phosphorized, high residual phosphorus
C19400	...	copper-iron alloy
C23000	...	red brass
C44300	...	arsenical admiralty
C44400	...	antimonial admiralty
C44500	...	phosphorized admiralty
C68700	...	arsenical aluminum brass
C70400	...	95-5 copper-nickel
C70600	...	90-10 copper-nickel
C70620	...	90-10 copper-nickel (Modified for Welding)
C71000	...	80-20 copper-nickel
C71500	...	70-30 copper-nickel
C71520	...	70-30 copper-nickel (Modified for Welding)
C71640	...	copper-nickel-iron-manganese
C72200

^A Copper UNS Nos. C10800 and C12200 are classified in Classification B224.

1.2 The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *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 deter-*

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 New designation established in accordance with Practice E527. In the new UNS system, the designations for copper alloys are simply expansions of the present standard designations by a prefix "C" and a suffix "00."

mine the applicability of regulatory limitations prior to use. (**Warning**—Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Use caution when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for additional information. The potential exists that selling mercury or mercury-containing products, or both, is prohibited by local or national law. Users must determine legality of sales in their location.

1.4 *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:³

- B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing
- B154 Test Method for Mercurous Nitrate Test for Copper Alloys
- B224 Classification of Coppers
- B846 Terminology for Copper and Copper Alloys
- B858 Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in 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

³ 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

Copper by Gravimetry

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)⁴

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)⁴

E112 Test Methods for Determining Average Grain Size

E118 Test Methods for Chemical Analysis of Copper-Chromium Alloys (Withdrawn 2010)⁴

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

E478 Test Methods for Chemical Analysis of Copper Alloys

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 *ASME Standard*.⁵

ASME Boiler and Pressure Vessel Code

3. Terminology

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

4. Types of Welded Tube

4.1 *Forge-Welded Tube* manufactured as described in **6.2.2.1**, **6.2.2.2**, and **6.2.2.3**.

4.1.1 *As-Welded Tube*—Forge-welded tube with internal and external flash removed and no further refinement of grain structure.

4.1.2 *Welded and Annealed Tube*—Forge-welded tube with internal and external flash removed, that has been annealed to produce a uniform grain size appropriate to the specified annealed temper.

4.1.3 *Welded and Cold-Reduced Tube*—Forge-welded tube with internal and external flash removed and subsequently cold-reduced to conform to the specified size and temper.

4.1.4 *Welded and Cold-Drawn Tube*—Forge-welded tube with internal and external flash removed and subsequently cold-drawn over a plug or mandrel to the specified size and temper.

4.2 *Fusion-Welded Tube* manufactured as described in section **6.3**.

4.2.1 *As-Welded Tube*—Fusion-welded tube with no further refinement of grain structure.

4.2.2 *Welded and Annealed Tube*—Fusion-welded tube that has been annealed to produce a uniform grain size appropriate to the specified annealed temper. The structure of the weld zone shall be that which is typical of a fusion weld.

4.2.3 *Welded and Cold-Reduced Tube*—Fusion-welded tube subsequently cold-reduced to conform to the specified size and temper.

4.2.4 *Welded and Cold-Drawn Tube*—Fusion-welded tube subsequently cold-drawn over a plug or mandrel to the specified size and temper.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

4.3 *Fully Finished Tube*—Welded tube with internal and external flash removed, if present, and subsequently cold-drawn over a plug or mandrel and annealed, and redrawn when necessary to conform to the specified temper.

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 or Copper Alloy UNS No. designation (for example, UNS No. C10800);

5.1.3 Tube type (Section **4**);

5.1.4 Temper (Section **8**);

5.1.5 Dimensions, the diameter, wall thickness, whether minimum or nominal wall, and length, (Section **14**); and

5.1.6 Quantity of each size (number of pieces and length, in inches or feet and inches);

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 When heat identification or traceability details;

5.2.2 Whether a pressure test is to be used instead of the eddy-current test (Section **13.1**);

5.2.3 Whether cut ends of the tube are to be deburred, chamfered, or otherwise treated (Section **15**);

5.2.4 If the product is to be subsequently welded, (see **Table 1**, Footnote F);

5.2.5 Certification, if required (Section **23**); and

5.2.6 Mill test report, if required (Section **24**).

5.3 If product is purchased for agencies of the U.S. Government (see the Supplementary Requirements section of {this specification or the general requirements section} for additional requirements, if specified), and

5.3.1 If product is ordered for *ASME Boiler and Pressure Vessel Code* application (see Certification Section **23**).

6. Materials and Manufacture

6.1 Materials:

6.1.1 The material of manufacture shall be strip of one of the Copper Alloy UNS Nos. listed in section **1.1** of such purity and soundness as to be suitable for processing into the products prescribed herein.

6.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

6.2 Manufacture:

6.2.1 The product shall be manufactured by forming the material into a tubular shape on a suitable forming mill.

6.2.2 Welding shall be accomplished by any process that produces a forge weld leaving no crevice in the weld seam visible to the unaided eye.

6.2.2.1 *Forge-Welded Tube*—The edges of the strip shall be heated to the required welding temperature, usually by high frequency electric current, and be pressed firmly together causing a forge-type joint to be formed with internal and external flash or bead.

6.2.2.2 The external flash (that portion of the weld which extends beyond the normal wall) shall always be removed.

TABLE 1 Chemical Requirements

Copper or Copper Alloy UNS No.	Composition, %											
	Copper ^A	Nickel incl Cobalt	Lead, max	Iron	Zinc	Man- ganese	Aluminum	Phosphorus	Tin	Antimony	Arsenic	Other Elements
C10800	99.95 ^{A, B} min	...	...	...	...	...	...	0.005–0.012	...	...	...	...
C12200	99.9 ^A min	...	...	...	...	...	...	0.015–0.040	...	...	...	...
C19400	97.0 min	...	0.03	2.1–2.6	0.05–0.20	...	...	0.015–0.15	...	...	...	...
C23000	84.0–86.0 ^{C, D}	...	0.05	0.05 max	remainder	...	...	...	...	...	...	...
C44300	70.0–73.0	...	0.07	0.06 max	remainder	...	...	...	0.8–1.2 ^E	...	0.02–0.06	...
C44400	70.0–73.0	...	0.07	0.06 max	remainder	...	...	...	0.8–1.2 ^E	0.02–0.10	...	...
C44500	70.0–73.0	...	0.07	0.06 max	remainder	...	...	0.02–0.10	0.8–1.2 ^E	...	...	...
C68700	76.0–79.0 ^{A, F}	...	0.07	0.06 max	remainder	...	1.8–2.5	...	...	...	0.02–0.06	...
C70400	remainder ^{A, F}	4.8–6.2	0.05	1.3–1.7	1.0 max	0.30–0.8	...	...	...	...	...	...
C70600	remainder ^{A, F}	9.0–11.0	0.05	1.0–1.8	1.0 max	1.0 max	...	...	...	...	...	...
C70620	86.5 min ^{A, F}	9.0–11.0	0.02	1.0–1.8	0.50 max	1.0	...	0.02 max	...	...	...	C 0.05 max S 0.02 max G
C71000	remainder ^{A, F, G}	19.0–23.0	0.05	0.50–1.0	1.0 max ^G	1.0 max	...	G	...	...	...	...
C71500	remainder ^{A, F}	29.0–33.0	0.05	0.40–1.0	1.0 max	1.0 max	...	...	...	...	...	...
C71520	65.0 min ^{A, F}	29.0–33.0	0.02	0.40–1.0	0.50 max	1.0 max	...	0.02 max	...	...	...	C 0.05 max S 0.02 max C 0.06 ^G max S 0.03 max G Si 0.03 max Ti 0.03 max ^H
C71640	remainder ^{A, F, G}	29.0–32.0	0.05 ^G	1.7–2.3	1.0 max ^G	1.5–2.5	...	G	...	...	...	...
C72200	remainder ^{A, C, G, H}	15.0–18.0	0.05 ^G	0.50–1.0	1.0 max ^G	1.0 max	...	G	...	...	...	...

^A Cu value includes Ag.

^B Copper + silver + phosphorus.

^C Cu + Sum of Named Elements, 99.8 % min.

^D Not including Ag.

^E For tubular products, the minimum Sn content may be 0.9 %

^F Cu + Sum of Named Elements, 99.5 % min.

^G When the product is for subsequent welding applications and so specified by the purchaser, zinc shall be 0.50 % max, lead 0.02 % max, phosphorus 0.02 % max, sulfur 0.02 % max, and carbon 0.05 % max.

^H Chromium 0.30 to 0.7.

6.2.2.3 The internal flash shall be removed to the extent that it shall not exceed 0.006 in. [0.152 mm] in height or 10 % of the nominal wall thickness, whichever is greater.

6.3 *Fusion-Welded Tube*—The edges of the strip shall be brought together and welded, usually by a GTAW welding process, without the addition of filler metal, causing a fusion-type joint to be formed with no internal or external flash or bead removal necessary.

6.4 *Fully Finished Tube*—May be welded and subsequently processed by any method that would produce a tube suitable for subsequent cold-drawing and annealing.

6.5 There shall be no crevice in the weld seam visible to the unaided eye.

7. Chemical Composition

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

7.2 The 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.

7.3 For copper alloys in which copper is specified as the remainder, copper may be taken as the difference between the sum of all the elements analyzed and 100 %.

7.3.1 *Copper Alloy UNS Nos. C70400, C70600, C70620, C71000, C71500, and C71640*—When all the elements in **Table 1** are analyzed, their sum shall be 99.5 % minimum.

7.3.2 *Copper Alloy UNS No. C72200*—When all the elements in **Table 1** are analyzed, their sum shall be 99.8 % minimum.

7.4 For copper alloys in which zinc is specified as the remainder, either copper or zinc may be taken as the difference between the sum of all the elements analyzed and 100 %.

7.4.1 *Copper Alloy UNS No. C23000*—When all the elements in **Table 1** are analyzed, their sum shall be 99.8 % minimum.

7.4.2 *Copper Alloy UNS Nos. C44300, C44400, and C44500*—When all the elements in **Table 1** are analyzed, their sum shall be 99.6 % minimum.

7.4.3 *Copper Alloy UNS No. C68700*—When all the elements in **Table 1** are analyzed, their sum shall be 99.5 % minimum.

8. Temper

8.1 Tube tempers shall be designated as follows:

8.1.1 Welded and annealed WO61.

8.1.1.1 Welded and light cold worked WC55.

8.2 Other tempers shall be produced to the mechanical properties as agreed upon between the manufacturer or supplier and the purchaser.

8.3 Tubes of Copper Alloy UNS Nos. C23000, C44300, C44400, C44500, and C68700 shall be furnished in the annealed temper or the stress-relieved condition as specified in the purchase order unless otherwise agreed upon between the purchaser and the manufacturer or supplier.