



Designation: **B88M—16 B88M – 18**

## Standard Specification for Seamless Copper Water Tube (Metric)<sup>1</sup>

This standard is issued under the fixed designation B88M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

### 1. Scope\*

1.1 This specification covers seamless copper water tube suitable for general plumbing, similar applications for the conveyance of fluids, and commonly used with solder, flared, or compression-type fittings. The type of copper water tube suitable for any particular application is determined by the internal or external fluid pressure, by the installation and service conditions, and by local requirements. Means of joining or bending are also factors that affect the selection of the type of tube to be used.<sup>2</sup>

NOTE 1—Annealed tube is suitable for use with flared or compression fittings, and with solder-type fittings, provided rounding and sizing of the tube ends is performed where needed.

NOTE 2—Drawn temper tube is suitable for use with solder-type fittings. Types A and B tube, in the drawn temper, are suitable for use with certain types and sizes of compression fittings.

1.2 The tube shall be produced from the following coppers, and the manufacturer has the option to supply any one of them, unless otherwise specified:

| Copper UNS No. | Previously Used Designation | Description                                     |
|----------------|-----------------------------|---|
| C10200         | OF                          | Oxygen free without residual deoxidants         |
| C12000         | DLP                         | Phosphorus deoxidized, low residual phosphorus  |
| C12200         | DHP                         | Phosphorus deoxidized, high residual phosphorus |

1.3 The assembly of copper plumbing or fire sprinkler systems by soldering is described in Practice B828.

1.4 Solders for joining copper potable water or fire sprinkler systems are covered by Specification B32. The requirements for acceptable fluxes for these systems are covered by Specification B813.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 3—This specification is the SI companion to Specification B88.

1.6 The following safety hazards caveat pertains only to the test methods portion, Section 15, 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

<sup>1</sup> 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.

Current edition approved Oct. 1, 2016; March 1, 2018. Published November 2016; March 2018. Originally approved in 1983. Last previous edition approved in 2013 as B88M—13; B88M—16. DOI: 10.1520/B0088M-16-10.1520/B0088M-18.

<sup>2</sup> The UNS system for copper and copper alloys (see Practice E527) is a simple expansion of the former standard designation system accomplished by the addition of a prefix “C” and a suffix “00.” The suffix is permitted to be used to accommodate composition variations of the base alloy.

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

## 2.2 ASTM Standards:<sup>3</sup>

- B32 Specification for Solder Metal
- B88 Specification for Seamless Copper Water Tube
- B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing
- 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
- E8/E8M Test Methods for Tension Testing of Metallic Materials
- E18 Test Methods for Rockwell Hardness 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
- E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)<sup>4</sup>
- E112 Test Methods for Determining Average Grain Size
- 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)

## 3. Terminology

3.1 *Definitions*—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, copper water, n*—a seamless copper tube conforming to the particular metric dimensions commercially known as Copper Water Tube and designated as Types A, B, and C.

## 4. Ordering Information

4.1 Include the following information for material ordered under this specification.

4.1.1 ASTM designation and year of issue (for example, B88M – 03),

4.1.2 Copper UNS No. (not necessary unless a specific copper is desired),

4.1.3 Nominal or standard size (Column 1 of Table 1) and whether Type A, B, or C (Section 3),

4.1.4 Temper (Section 7),

4.1.5 Length (see 11.5),

4.1.6 How furnished: straight or coils,

4.1.7 Quantity (pieces) of each size and type,

4.1.8 In addition, when material is purchased for agencies of the U.S. Government, it shall conform to the Supplementary Requirements as defined herein when specified in the contract or purchase order.

4.2 The following options are available and shall be specified in the contract or purchase order when required:

4.2.1 Tension test (Section 8),

4.2.2 Grain size determination (Section 8),

4.2.3 Expansion test (9.1), and

4.2.4 Microscopical Examination for Hydrogen Embrittlement, Procedure B (9.3.2).

## 5. Materials and Manufacture

5.1 The material shall be of such quality and purity that the finished product shall have the properties and characteristics prescribed in this specification, and shall be cold worked to size.

5.2 The tube shall be finished by such cold-working and annealing operations as are necessary to produce the required temper and surface finish.

5.3 Tube furnished in coils shall be annealed.

5.4 Tube furnished in straight lengths shall normally be in the drawn temper. Upon agreement between the manufacturer or supplier and the purchaser, the manufacturer shall have the option to supply annealed straight length tubing.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>4</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

**TABLE 1 Dimensions, Mass, and Tolerances in Diameter and Wall Thickness for Metric Copper Water Tube Sizes**  
(All tolerances are plus and minus except as otherwise indicated.)

| Nominal or Standard Size, mm | Outside Diameter, mm | Average Outside Diameter <sup>A</sup> Tolerance, mm |                 | Wall Thickness and Tolerances, mm |                        |                |                        |                |                        | Theoretical Mass, kg/m |        |        |
|------------------------------|----------------------|---|-----------------|-----------------------------------|------------------------|----------------|------------------------|----------------|------------------------|------------------------|--------|--------|
|                              |                      | Annealed  | Drawn           | Type A                            |                        | Type B         |                        | Type C         |                        | Type A                 | Type B | Type C |
|                              |                      |   |                 | Wall Thickness                    | Tolerance <sup>B</sup> | Wall Thickness | Tolerance <sup>B</sup> | Wall Thickness | Tolerance <sup>B</sup> |                        |        |        |
| 6                            | 6.0                  | 0.05  | 0.03            | 0.80                              | 0.08                   | 0.70           | 0.07                   | 0.60           | <sup>C</sup>           | 0.117                  | 0.104  | 0.091  |
| 8                            | 8.0                  | 0.05  | 0.03            | 0.90                              | 0.09                   | 0.80           | 0.08                   | 0.60           | <sup>C</sup>           | 0.179                  | 0.162  | 0.125  |
| 10                           | 10.0                 | 0.05  | 0.03            | 0.90                              | 0.09                   | 0.80           | 0.08                   | 0.60           | <sup>C</sup>           | 0.230                  | 0.207  | 0.158  |
| 12                           | 12.0                 | 0.06  | 0.03            | 1.2                               | 0.1                    | 0.90           | 0.09                   | 0.60           | 0.06                   | 0.364                  | 0.280  | 0.192  |
| 15                           | 15.0                 | 0.06  | 0.03            | 1.2                               | 0.1                    | 1.0            | 0.1                    | 0.70           | 0.07                   | 0.465                  | 0.393  | 0.281  |
| 18                           | 18.0                 | 0.06  | 0.03            | 1.2                               | 0.1                    | 1.0            | 0.1                    | 0.70           | 0.07                   | 0.566                  | 0.477  | 0.340  |
| 22                           | 22.0                 | 0.06  | 0.03            | 1.6                               | 0.15                   | 1.1            | 0.1                    | 0.80           | 0.08                   | 0.917                  | 0.646  | 0.476  |
| 28                           | 28.0                 | 0.07  | 0.04            | 1.6                               | 0.15                   | 1.2            | 0.1                    | 0.90           | 0.09                   | 1.19                   | 0.903  | 0.685  |
| 35                           | 35.0                 | 0.10  | 0.04            | 1.6                               | 0.15                   | 1.4            | 0.15                   | 1.1            | 0.1                    | 1.50                   | 1.32   | 1.05   |
| 42                           | 42.0                 | 0.10  | 0.05            | 1.8                               | 0.2                    | 1.5            | 0.15                   | 1.2            | 0.1                    | 2.03                   | 1.71   | 1.37   |
| 54                           | 54.0                 | 0.10  | 0.05            | 2.1                               | 0.2                    | 1.7            | 0.15                   | 1.5            | 0.15                   | 3.06                   | 2.50   | 2.21   |
| 67                           | 67.0                 | 0.12  | 0.05            | 2.4                               | 0.25                   | 2.0            | 0.2                    | 1.6            | 0.15                   | 4.35                   | 3.65   | 2.94   |
| 79                           | 79.0                 | 0.12  | 0.05            | 2.8                               | 0.3                    | 2.3            | 0.25                   | 1.8            | 0.2                    | 5.99                   | 4.95   | 3.90   |
| 105                          | 105.0                | 0.12  | 0.05            | 3.4                               | 0.35                   | 2.8            | 0.3                    | 2.4            | 0.25                   | 9.70                   | 8.04   | 6.92   |
| 130                          | 130.0                | 0.12  | 0.05            | 4.0                               | 0.4                    | 3.1            | 0.3                    | 2.7            | 0.25                   | 14.2                   | 11.0   | 9.65   |
| 156                          | 156.0                | 0.12  | 0.05            | 4.8                               | 0.5                    | 3.5            | 0.35                   | 3.1            | 0.3                    | 20.3                   | 15.0   | 13.3   |
| 206                          | 206.0                | 0.15  | + 0.05<br>-0.10 | 6.8                               | 0.7                    | 5.0            | 0.5                    | 4.3            | 0.45                   | 38.0                   | 28.2   | 24.4   |
| 257                          | 257.0                | 0.20  | + 0.05<br>-0.15 | 8.5                               | 0.85                   | 6.3            | 0.65                   | 5.4            | 0.55                   | 59.3                   | 44.4   | 38.2   |
| 308                          | 308.0                | 0.20  | + 0.05<br>-0.15 | 10.3                              | 1.0                    | 7.1            | 0.7                    | 6.4            | 0.65                   | 86.1                   | 60.0   | 54.2   |

<sup>A</sup> The average outside diameter of a tube is the average of the maximum and minimum outside diameter, as determined at any one cross section of the tube.

<sup>B</sup> Maximum deviation at any one point.

<sup>C</sup> Indicates that the material is not generally available or that no tolerance has been established.

## 6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements in **Table 2** for the specific type of copper.

6.2 These specification limits do not preclude the presence of other elements. When included in the contract or purchase order, and agreed upon by the manufacturer or supplier and the purchaser, limits shall be established and analysis required for unnamed elements.

## 7. Temper

7.1 The copper water tube shall be furnished in the tempers designated below. Current designations as defined in Classification **B601** are as follows:

Annealed-O  
Drawn-H

## 8. Mechanical Properties

8.1 The tube shall conform to the mechanical property requirements prescribed in **Table 3**. Tension tests and grain size determinations need not be made except when indicated by the purchaser at the time of placing the order. A convenient method of indicating that these tests are to be made is to state that “Test Procedure T is required” (see **4.2.1**). Where agreement on the Rockwell hardness tests cannot be reached, the tensile strength and grain-size requirements of **Table 3** shall be the basis for acceptance or rejection.

## 9. Performance Requirements

9.1 *Expansion Test*—The annealed (O) tube shall be capable of being expanded in accordance with Test Method **B153** with an expansion of the outside diameter in the following amount:

**TABLE 2 Chemical Composition—Weight %**

| Element                  | Copper UNS No.      |             |             |
|--------------------------|---------------------|-------------|-------------|
|                          | C10200 <sup>A</sup> | C12000      | C12200      |
| Copper, <sup>B</sup> min | 99.95               | 99.90       | 99.9        |
| Phosphorus               | ...                 | 0.004–0.012 | 0.015–0.040 |

<sup>A</sup> Oxygen shall be 10 ppm max.

<sup>B</sup> Copper + silver.

**TABLE 3 Mechanical Property Requirements**

| Temper Designation |          | Form             | Rockwell Hardness <sup>A</sup> |        | Tensile Strength,<br>min, MPa | Average Grain Size,<br>mm |
|--------------------|----------|------------------|--------------------------------|--------|-------------------------------|---------------------------|
| Standard           | Former   |                  | Scale                          | Value  |                               |                           |
| OS060              | annealed | coils            | F                              | 50 max | 200                           | 0.040 min                 |
| OS035              | annealed | straight lengths | F                              | 55 max | 200                           | 0.025 min                 |
| H58                | drawn    | drawn            | 30 T                           | 30 min | 250                           | ...                       |

<sup>A</sup> Rockwell hardness tests shall be made on the inside surfaces of the tube. When suitable equipment is not available for determining the specified Rockwell hardness, other Rockwell scales and values shall be specified subject to agreement between the purchaser and the supplier.

| Nominal or<br>Standard Size, mm | Expansion of<br>Outside Diameter, % |
|---------------------------------|-------------------------------------|
| 15 and under                    | 40                                  |
| Over 15                         | 30                                  |

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

9.2 *Flattening Test*—As an alternative to the expansion test for tube standard sizes 105 mm and over in the annealed condition, a section 100 mm in length shall be cut from the end of one of the lengths for a flattening test. This 100-mm test specimen shall be flattened so that a gage set at three times the wall thickness will pass over the tube freely throughout the flattened part. The tube so tested shall develop no cracks or flaws visible to the unaided eye as a result of this test. In making the flattening test the elements shall be slowly flattened by one stroke of the press.

9.3 *Microscopical Examination for Susceptibility to Hydrogen Embrittlement:*

9.3.1 Tubes furnished in Copper UNS No. C10200 and C12000 shall be essentially free of cuprous oxide as determined by Procedure A of Test Methods B577. When Copper UNS No. C12200 is supplied, examination is not required. In case of a dispute, Procedure C of Test Methods B577 shall be used as the referee method.

9.3.2 Tubes furnished in all coppers shall be capable of passing the embrittlement test specified in Procedure B of Test Methods B577. The actual performance of the test is not required unless specifically requested in the ordering document. In case of a dispute, Procedure C of Test Methods B577 shall be used as the referee method.

## 10. Nondestructive Testing

10.1 *Eddy-Current Test*—Each tube up to and including 79 mm in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedure of Practice E243, except the determination of “end effect” is not required. Tubes shall be passed through an eddy current test unit adjusted to provide information on the suitability of the tube for the intended application.

10.1.1 The testing of tube of dimensions beyond the capabilities of the eddy-current test apparatus shall be subject to negotiation between the producer and the purchaser.

10.1.2 Notch-depth standards, rounded to the nearest 0.03 mm, shall be 22 % of the wall thickness. The notch-depth tolerance shall be  $\pm 0.01$  mm. Alternatively, at the option of the manufacturer using speed insensitive eddy-current units that are equipped to select a fraction of the maximum unbalance signal, the following percent maximum unbalance signals shall be used:

| Nominal or Standard Tube Size, mm | Unbalance Signal<br>Magnitude, max % |
|-----------------------------------|--------------------------------------|
| Up to and incl 12                 | 0.2                                  |
| 15 to 54, incl                    | 0.3                                  |
| Over 54 to 79, incl               | 0.4                                  |

10.1.3 Tubes that do not actuate the signalling device of the eddy-current testers shall be considered as conforming to the requirements of this test. Tubes with discontinuities indicated by the testing unit shall, at the option of the manufacturer, be reexamined or retested to determine whether the discontinuity is cause for rejection. Signals that are found to have been caused by minor mechanical damage, soil, or moisture shall not be cause for rejection of the tubes provided the tube dimensions are still within the prescribed limits and the tube is suitable for its intended application.

## 11. Dimensions, Mass, and Permissible Variations

11.1 For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimensions shall make the tube subject to rejection at the option of the purchaser.

11.2 *Nominal or Standard Dimensions, Wall Thickness, and Diameter Tolerances*—The nominal or standard dimensions, wall thickness, and diameter tolerances shall be in accordance with Table 1.

11.3 *Mass*—For purposes of calculating mass, cross sections, and so forth, the density of the copper shall be taken as 8.94 g/cm<sup>3</sup>. The theoretical mass per metre is shown in Table 1.