



# CERTIFICATE

## By Authority Of THE UNITED STATES OF AMERICA Legally Binding Document

By the Authority Vested By Part 5 of the United States Code § 552(a) and Part 1 of the Code of Regulations § 51 the attached document has been duly INCORPORATED BY REFERENCE and shall be considered legally binding upon all citizens and residents of the United States of America. *HEED THIS NOTICE:* Criminal penalties may apply for noncompliance.



**Document Name:** ASTM B88: Standard Specification for Seamless Copper Water Tube

**CFR Section(s):** 46 CFR 56.60-1(b)

**Standards Body:** American Society for Testing and Materials



*Official Incorporator:*

THE EXECUTIVE DIRECTOR  
OFFICE OF THE FEDERAL REGISTER  
WASHINGTON, D.C.





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

This standard is issued under the fixed designation B 88; 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 Department of Defense. Replaces WW-T-799. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

## 1. Scope

1.1 This specification covers Copper UNS No. C12200 seamless copper water tube suitable for general plumbing, and 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 which 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 K and L tube, in the drawn temper, are suitable for use with certain types and sizes of compression fittings.

NOTE 3—A complete metric companion to Specification B 88 has been developed—B 88M; therefore, no metric equivalents are presented in this specification.

NOTE 4—Fittings used for soldered or brazed connections in plumbing systems are described in ASME B16.18 and ASME 16.22.

1.2 The assembly of copper plumbing or fire sprinkler systems by soldering is described in Practice B 828.

1.3 Solders for joining copper potable water or fire sprinkler systems are covered by Specification B 32. The requirements for acceptable fluxes for these systems are covered by Specification B 813.

1.4 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 and health practices and determine the applicability of regulatory limitations prior to use.*

## 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 B-5 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

Current edition approved May 10, 1996. Published July 1996. Originally published as B 88 – 32 T. Last previous edition B 88 – 95a.

<sup>2</sup> The UNS system for copper and copper alloys (see Practice E 527) 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.

### 2.1.1 ASTM Standards:

- B 32 Specifications for Solder Metal<sup>3</sup>
  - B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing<sup>4</sup>
  - B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast<sup>4</sup>
  - B 813 Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube<sup>4</sup>
  - B 828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings<sup>4</sup>
  - E 2 Method of Preparation of Micrographs of Metals and Alloys<sup>5</sup>
  - E 3 Methods of Preparation of Metallographic Specimens<sup>6</sup>
  - E 8 Test Methods for Tension Testing of Metallic Materials<sup>6</sup>
  - E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>6</sup>
  - E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>7</sup>
  - E 53 Methods for Chemical Analysis of Copper<sup>8</sup>
  - E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition<sup>8</sup>
  - E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)<sup>8</sup>
  - E 112 Test Methods for Determining Average Grain Size<sup>6</sup>
  - E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes<sup>9</sup>
  - E 527 Practice for Numbering Metals and Alloys (UNS)<sup>10</sup>
- ### 2.1.2 ASME Standards:
- ASME B16.18—Cast copper alloy solder joint pressure fittings<sup>11</sup>
  - ASME B16.22—Wrought copper and copper alloy solder joint pressure fittings<sup>11</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 *coil*—a length of the product wound into a series of

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.04.

<sup>4</sup> Annual Book of ASTM Standards, Vol 02.01.

<sup>5</sup> Discontinued, see 1982 Annual Book of ASTM Standards, Part 11. Replaced by Practice E 883.

<sup>6</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>7</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>8</sup> Annual Book of ASTM Standards, Vol 03.05.

<sup>9</sup> Annual Book of ASTM Standards, Vol 03.03.

<sup>10</sup> Annual Book of ASTM Standards, Vol 01.01.

<sup>11</sup> Available from ASME, 345 E. 47th St., New York, NY 10017.

connected turns. The unqualified term "coil" as applied to tube usually refers to a bunched coil.

3.1.1.1 *bunched*—a coil in which the turns are bunched and held together such that the cross section of the bunched turns is approximately circular.

3.1.1.2 *double layer flat*—a 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 pancake coil" or "double layer spirally wound coil.")

3.1.1.3 *level or traverse wound*—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. (Sometimes called "helical coil.")

3.1.1.4 *single layer flat*—a coil in which the product is spirally wound into a single disk-like layer. (Sometimes called "pancake coil" or "single layer spirally wound coil.")

3.1.2 *lengths*—straight pieces of the product.

3.1.2.1 *standard*—uniform lengths recommended in a simplified practice recommendation or established as a commercial standard.

3.1.3 *tube, seamless*—a tube produced with a continuous periphery in all stages of the operations.

3.1.3.1 *tube, copper service*—a bendable copper water tube for underground water service.

3.1.3.2 *tube, copper water*—a seamless copper tube conforming to the particular dimensions commercially known as Copper Water Tube and designated as Types K, L, and M.

3.2 *Description of Term Specific to This Standard:*

3.2.1 *capable of*—as used in this specification, the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

#### 4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

4.1.1 Nominal or standard size (Column 1 of Table 1) and whether Type K, L, or M (Sections 3 and 11),

4.1.2 Temper (Sections 5 and 8),

4.1.3 Whether tension tests and grain size determinations are required (Section 8),

4.1.4 Length (see 11.5),

4.1.5 How furnished: straight or coils, and

4.1.6 Quantity (pieces) of each size and type.

4.2 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.

#### 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 drawn 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 when furnished in coils shall be annealed after coiling.

5.4 Tube when furnished in straight lengths shall normally

be in the drawn temper. Annealed straight length tubing is also permitted.

#### 6. Chemical Composition

6.1 The material shall conform to the following chemical requirements for Copper UNS No. C12200:

Copper (incl silver), min, %	99.9
Phosphorus, max, %	0.015-0.040

6.2 These specification limits do not preclude the presence of other elements. Limits for unnamed elements are permitted to be established by agreement between the manufacturer or supplier and the purchaser.

#### 7. Temper

7.1 Seamless copper water tube shall be furnished in the tempers designated below. Current designations as defined in Practice B 601 are shown.

Annealed—O  
Drawn—H

#### 8. Mechanical Properties

8.1 The tube shall conform to the mechanical property requirements prescribed in Table 2. 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 4.1.3). Where agreement on the Rockwell hardness tests cannot be reached, the tensile strength and grain-size requirements of Table 2 shall be the basis for acceptance or rejection.

#### 9. Expansion Test

9.1 The annealed (O) tube shall be capable of being expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following amount:

Nominal or Standard Size, in.	Expansion of Outside Diameter, %
3/8 and under	40
Over 3/8	30

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

9.2 As an alternative to the expansion test for tube standard sizes 4 in. and over in the annealed condition, a section 4 in. in length shall be cut from the end of one of the lengths for a flattening test. This 4-in. 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.

#### 10. Nondestructive Testing

10.1 Each tube up to and including 3/8 in. in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E 243, except for the determination of "end effect." 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 Notch-depth standards, rounded to the nearest 0.001 in., shall be 22 % of the wall thickness. The notch-

**TABLE 1 Dimensions, Weights, and Tolerances in Diameter and Wall Thickness for Nominal or Standard Copper Water Tube Sizes**  
(All tolerances are plus and minus except as otherwise indicated)

Nominal or Standard Size, in.	Outside Diameter, in.	Average Outside Diameter <sup>A</sup> Tolerance, in.		Wall Thickness and Tolerances, in.						Theoretical Weight, lb/ft		
		Annealed	Drawn	Type K		Type L		Type M		Type K	Type L	Type M
				Wall Thickness	Tolerance <sup>B</sup>	Wall Thickness	Tolerance <sup>B</sup>	Wall Thickness	Tolerance <sup>B</sup>			
1/4	0.375	0.002	0.001	0.035	0.0035	0.030	0.003	<sup>C</sup>	<sup>C</sup>	0.145	0.126	<sup>C</sup>
3/8	0.500	0.0025	0.001	0.049	0.005	0.035	0.004	0.025	0.002	0.269	0.198	0.145
1/2	0.625	0.0025	0.001	0.049	0.005	0.040	0.004	0.028	0.003	0.344	0.285	0.204
5/8	0.750	0.0025	0.001	0.049	0.005	0.042	0.004	<sup>C</sup>	<sup>C</sup>	0.418	0.362	<sup>C</sup>
3/4	0.875	0.003	0.001	0.065	0.006	0.045	0.004	0.032	0.003	0.641	0.455	0.328
1	1.125	0.0035	0.0015	0.065	0.006	0.050	0.005	0.035	0.004	0.839	0.655	0.465
1 1/4	1.375	0.004	0.0015	0.065	0.006	0.055	0.006	0.042	0.004	1.04	0.884	0.682
1 1/2	1.625	0.0045	0.002	0.072	0.007	0.060	0.006	0.049	0.005	1.36	1.14	0.940
2	2.125	0.005	0.002	0.083	0.008	0.070	0.007	0.058	0.006	2.06	1.75	1.46
2 1/2	2.625	0.005	0.002	0.095	0.010	0.080	0.008	0.065	0.006	2.93	2.48	2.03
3	3.125	0.005	0.002	0.109	0.011	0.090	0.009	0.072	0.007	4.00	3.33	2.68
3 1/2	3.625	0.005	0.002	0.120	0.012	0.100	0.010	0.083	0.008	5.12	4.29	3.58
4	4.125	0.005	0.002	0.134	0.013	0.110	0.011	0.095	0.010	6.51	5.38	4.66
5	5.125	0.005	0.002	0.160	0.016	0.125	0.012	0.109	0.011	9.67	7.61	6.66
6	6.125	0.005	0.002	0.192	0.019	0.140	0.014	0.122	0.012	13.9	10.2	8.92
8	8.125	0.006	+0.002 -0.004	0.271	0.027	0.200	0.020	0.170	0.017	25.9	19.3	16.5
10	10.125	0.008	+0.002 -0.006	0.338	0.034	0.250	0.025	0.212	0.021	40.3	30.1	25.6
12	12.125	0.008	+0.002 -0.006	0.405	0.040	0.280	0.028	0.254	0.025	57.8	40.4	36.7

<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.

depth tolerance shall be plus and minus 0.0005 in. 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, in.	Unbalance Signal Magnitude, max %
Up to 3/8, incl	0.2
1/2 to 2, incl	0.3
Over 2 to 3, incl	0.4

10.1.2 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 re-examined 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 prescribed limits and the tube is suitable for its intended application.

10.2 Tube made to this specification shall be capable of withstanding the pressure test of 10.2.1 or 10.2.2. Should subsequent testing by the purchaser establish that the material

does not meet these requirements, the material is subject to rejection at the option of the purchaser.

10.2.1 The tube shall stand, without showing evidence of leakage, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 psi, calculated from the following equation for thin hollow cylinders under tension:

$$P = 2 St / (D - 0.8t)$$

where:

*P* = hydrostatic pressure, psi,

*t* = wall thickness, in.,

*D* = outside diameter of the tube, in., and

*S* = allowable stress of the material, psi.

10.2.2 The tube shall stand an internal air pressure of 60 psig for 5 s without showing evidence of leakage. The test method used shall permit easy visual detection of any leakage, such as by having the tube under water or by the pressure differential method.

### 11. Dimensions, Weights, 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

**TABLE 2 Mechanical Property Requirements**

Temper Designation		Form	Rockwell Hardness <sup>A</sup>		Tensile Strength, min, ksi <sup>B</sup>	Average Grain Size, mm
Standard	Former		Scale	Value		
O60	annealed	coils	F	50 max	30	0.040 min
O50	annealed	straight lengths	F	55 max	30	0.025 min
H58	drawn	drawn	30 T	30 min	36	...

<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.

<sup>B</sup> ksi = 1000 psi.

**TABLE 3 Roundness Tolerance**

<i>t/D</i> (Ratio of Wall Thickness to Outside Diameter)	Roundness Tolerance % of Outside Diameter (Expressed to Nearest 0.001 in.)
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

**TABLE 4 Standard Lengths and Tolerances**

Nominal or Standard Size, in.	Type	Standard Length, ft	Tolerance, (all Plus)
Tubes Furnished in Straight Lengths			
Up to 8, incl	K, L, M	20	1 in.
10	L, M	20	1 in.
10	K	18	1 in.
12	M	20	1 in.
12	L	18	1 in.
12	K	12	1 in.
Tubes Furnished in Coils			
Up to 1, incl	K, L	60 and 100	2 ft
1¼ and 1½	K, L	60	2 ft
2	K, L	40 and 45	1 ft

**TABLE 5 Sampling Schedule**

Number of Pieces in Lot	Number of Sample Pieces to be Taken <sup>A</sup>
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of total number of pieces in the lot but not more than 10 sample pieces

<sup>A</sup> Each sample piece shall be taken from a separate tube.

**TABLE 6 Test Methods**

Test	ASTM Designation
Chemical Analysis	E 53, E 62
Tension	E 8 (see also 15.2, 15.3 and 15.4).
Rockwell Hardness	E 18
Grain Size	E 2, E 3, E 112 (see also 15.5).
Expansion (Pin Test)	B 153

**TABLE 7 Rounding Units**

Property	Rounded Unit for Observed or Calculated Value
Chemical Composition	nearest unit in the last right-hand place of figures of the specified limit
Hardness	
Tensile Strength	nearest ksi
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

values for any dimensions shall make the tube subject to rejection at the option of the purchaser.

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

**11.3 Weight**—For purposes of calculating weights, cross-

sections, etc., the density of the copper shall be taken as 0.323 lb/in.<sup>3</sup> The theoretical weight per foot is given in Table 1.

**11.4 Roundness**—For drawn unannealed tube in straight lengths the roundness tolerance shall be as prescribed in Table 2. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. No roundness tolerance has been established for annealed tube in straight lengths or for tubes furnished in coils.

**11.5 Lengths and Tolerances:**

**11.5.1 Standard Lengths and Tolerances**—The standard lengths and tolerances shall be as specified in Table 4.

**11.5.2 Other lengths and tolerances** are permitted to be established by agreement between the manufacturer or supplier and the purchaser.

**11.6 Squareness of Cut**—For tube in straight lengths, the departure from squareness of the end of any tube shall not exceed more than 0.010 in. for tube up to and including ½ in. standard size; and not more than 0.016 in./in. of outside diameter for tube larger than ½ in. standard size.

**12. Workmanship, Finish, and Appearance**

**12.1** The material shall be clean, free of dirt and defects of a nature that interfere with normal commercial applications.

**13. Sampling**

**13.1** Sample pieces shall be selected for test purposes from each lot of 5000 lb or fraction thereof, of each size and type, in accordance with the schedule of Table 5.

**14. Number of Tests and Retests**

**14.1 Chemical Analysis**—Samples for chemical analysis shall be taken in accordance with Practice E 55. Drillings, millings, etc., shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 13.1 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.

**14.1.1** Instead of sampling in accordance with Practice E 55, 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, he shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

**14.1.1.1** 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.

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

**14.1.1.3** Due to 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.

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

14.2 *Mechanical Tests*—For the mechanical tests, a specimen shall be taken from each of the sample pieces selected in accordance with 13.1. The required mechanical test shall be made on each of the specimens so selected. The value for the Rockwell hardness number of each specimen shall be established by taking the arithmetical average of at least three readings.

14.3 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 portion of these coils shall be included in the shipment, and the permissible variations in length of such coils shall be waived.

#### 14.4 *Retests*:

14.4.1 If any test specimen shows defective machining or develops flaws, it shall be discarded and another specimen substituted.

14.4.2 If the results of any test made to determine the mechanical properties fail to meet the specified requirements, two additional specimens shall be taken from different sample pieces and tested. The results of the tests on both of these specimens shall meet the specified requirements. Failure of more than one specimen to meet the specified requirements for a particular property shall be the cause for rejection of the entire lot.

14.4.3 If the chemical analysis fails to conform to the specified limits, analysis shall be made on a new composite sample prepared from additional pieces selected in accordance with 13.1. The results of this retest shall comply with the specified requirements.

## 15. Test Methods

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

15.2 Tension test specimens shall be of the full section of the tube and shall conform to the requirements of the section, Specimens for Pipe and Tube, of Test Methods E 8, unless the limitations of the testing machine preclude the use of such a specimen. Test specimens conforming to type No. 1 of Fig. 13, Tension Test Specimens for Large-Diameter Tubular Products, of Test Methods E 8, are permitted to be used when a full section specimen cannot be tested.

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

15.4 Tension test results on material covered by this specification are not seriously affected by variations in speed of testing. A considerable range of testing speed is permissible; however, the rate of stressing to the yield strength shall not exceed 100 ksi/min. Above the yield strength, the movement per minute of the testing machine head under

load shall not exceed 0.5 in./in. of gage length (or distance between grips for full section specimens).

15.5 The surface of the test specimen for microscopical examination shall approximate a radial longitudinal section of the tube.

## 16. Significance of Numerical Limits

16.1 For purposes 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.

## 17. Inspection

17.1 The manufacturer shall afford the inspector representing the purchaser, all reasonable facilities, without charge, to satisfy him that the tubes are being furnished in accordance with the specified requirements.

## 18. Rejection and Rehearing

18.1 Material that fails to conform to the requirements of this specification is subject to rejection at the option of the purchaser. Rejection shall be reported to the manufacturer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the manufacturer or supplier is permitted to make claim for a rehearing.

## 19. Packaging and Package Marking

19.1 The material shall be separated by size, composition, and temper, and prepared for shipment in such a manner as to ensure acceptance by common carrier for transportation at the lowest rate applicable and to afford protection from the normal hazards of transportation.

19.2 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, total length or piece count, or both, and name of supplier. The specification number shall be shown, when specified.

#### 19.3 *Product Identification*:

19.3.1 The name or trademark of the manufacturer and the mark indicative of the type shall be permanently (incised) marked on each tube at intervals not greater than 1½ ft. Tube in straight lengths shall be further identified throughout its length by means of a continuous colored stripe, symbol, or logo not less than 3/16 in. in height, including a legend repeated at intervals not greater than 3 ft. The legend shall include the type of the tube, name or trademark of the manufacturer, or both, and the country of origin. Other information is permitted to be included at the option of the manufacturer.

19.3.2 Colors used are: green for Type K, blue for Type L, and red for Type M. Such color marking is not applicable to tube furnished in annealed straight lengths or coils.

## 20. Keywords

20.1 copper tube; seamless; water tube

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U. S. Government.

### S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

S1.1.1 *Federal Standards*:<sup>12</sup>

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products

S1.1.2 *Military Standard*:<sup>12</sup>

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*:<sup>12</sup>

MIL-C-3993 Packaging of Copper and Copper-Base Alloy Mill Products

### S2. Quality Assurance

S2.1 *Responsibility for Inspection*:

S2.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer is permitted to use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at

the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to assure that the material conforms to prescribed requirements.

### S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used.

### S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing*:

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade or class and shall be preserved and packaged, Level A or C, packed, Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of MIL-C-3993.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking*:

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

<sup>12</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

*The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.*





## Standard Specification for Seamless Copper Water Tube [Metric]<sup>1</sup>

This standard is issued under the fixed designation B 88M; 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 Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.*

### 1. Scope

1.1 This specification covers Copper UNS No. C12200 seamless copper water tube suitable for general plumbing, and 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.

NOTE 3—This specification is the metric companion of Specification B 88.

1.2 The assembly of copper plumbing or fire sprinkler systems by soldering is described in Practice B 828.

1.3 Solders for joining copper potable water or fire sprinkler systems are covered by Specification B 32. The requirements for acceptable fluxes for these systems are covered by Specification B 813.

1.4 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 and health practices and determine the applicability of regulatory limitations prior to use.*

### 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:

#### 2.1.1 ASTM Standards:

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B-5 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.04 on Pipe and Tube.

Current edition approved May 10, 1996. Published July 1996. Originally published as B 88M - 83. Last previous edition B 88M - 95.

<sup>2</sup> The UNS system for copper and copper alloys (see Practice E 527) 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.

- B 32 Specifications for Solder Metal<sup>3</sup>
- B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing<sup>4</sup>
- B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast<sup>4</sup>
- B 813 Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube<sup>4</sup>
- B 828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings<sup>4</sup>
- E 2 Method of Preparation of Micrographs of Metals and Alloys<sup>5</sup>
- E 3 Methods of Preparation of Metallographic Specimens<sup>6</sup>
- E 8 Test Methods for Tension Testing of Metallic Materials<sup>6</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>6</sup>
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>7</sup>
- E 53 Test Methods for Chemical Analysis of Copper<sup>8</sup>
- E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition<sup>8</sup>
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)<sup>8</sup>
- E 112 Test Methods for Determining Average Grain Size<sup>6</sup>
- E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes<sup>9</sup>
- E 527 Practice for Numbering Metals and Alloys (UNS)<sup>10</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *coil*—a length of the product wound into a series of connected turns. The unqualified term "coil" as applied to tube usually refers to a bunched coil.

3.1.1.1 *bunched*—a coil in which the turns are bunched and held together such that the cross section of the bunched

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.04.

<sup>4</sup> Annual Book of ASTM Standards, Vol 02.01.

<sup>5</sup> Discontinued, see 1982 Annual Book of ASTM Standards, Part 11. Replaced by Practice E 883.

<sup>6</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>7</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>8</sup> Annual Book of ASTM Standards, Vol 03.05.

<sup>9</sup> Annual Book of ASTM Standards, Vol 03.03.

<sup>10</sup> Annual Book of ASTM Standards, Vol 01.01.

**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	c	0.117	0.104	0.091
8	8.0	0.05	0.03	0.90	0.09	0.80	0.08	0.60	c	0.179	0.162	0.125
10	10.0	0.05	0.03	0.90	0.09	0.80	0.08	0.60	c	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 -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 -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 -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.

turns is approximately circular.

3.1.1.2 *double layer flat*—a 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 pancake coil” or “double layer spirally wound coil.”)

3.1.1.3 *level or traverse wound*—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. (Sometimes called “helical coil.”)

3.1.1.4 *single layer flat*—a coil in which the product is spirally wound into a single disk-like layer. (Sometimes called “pancake coil” or “single layer spirally wound coil.”)

3.1.2 *lengths*—straight pieces of the product.

3.1.2.1 *standard*—uniform lengths recommended in a simplified practice recommendation or established as a commercial standard.

3.1.3 *tube, seamless*—a tube produced with a continuous periphery in all stages of the operations.

3.1.3.1 *tube, copper service*—a bendable copper water tube for underground water service.

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

3.2 *Description of Term Specific to This Standard:*

3.2.1 *capable of*—as used in this specification, the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

#### 4. Ordering Information

4.1 Orders for material under this specification shall in-

clude the following information:

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

4.1.2 Temper (Section 7),

4.1.3 Whether tension tests and grain size determinations are required (Section 8),

4.1.4 Length (see 11.5),

4.1.5 How furnished: straight or coils,

4.1.6 Quantity (pieces) of each size and type,

4.1.7 Specification number and date, and

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.

#### 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 when furnished in coils shall be annealed after coiling.

5.4 Tube when furnished in straight lengths shall normally be in the drawn temper. Annealed straight length tubing is also permitted.

#### 6. Chemical Composition

6.1 The material shall conform to the following chemical requirements for Copper UNS No. C12200:

**TABLE 2 Mechanical Property Requirements**

Temper Designation		Form	Rockwell Hardness <sup>A</sup>		Tensile Strength, min, MPa	Average Grain size, 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.

Copper (incl silver), min, % 99.9  
Phosphorus, max, % 0.015-0.040

6.2 These specification limits do not preclude the presence of other elements. Limits for unnamed elements are permitted to be established by agreement between the manufacturer or supplier and the purchaser.

## 7. Temper

7.1 The copper water tube shall be furnished in the tempers designated below. Current designations as defined in Practice B 601 are as follows:

Annealed-O  
Drawn-H

## 8. Mechanical Properties

8.1 The tube shall conform to the mechanical property requirements prescribed in Table 2. 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 4.1.3). Where agreement on the Rockwell hardness tests cannot be reached, the tensile strength and grain-size requirements of Table 2 shall be the basis for acceptance or rejection.

## 9. Expansion Test

9.1 The annealed (O) tube shall be capable of being expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following amount:

Nominal or Standard Size, mm	Expansion of Outside Diameter, %
15 and under	40
Over 15	30

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

NOTE 4—The term "unaided eye" as used herein permits the use of corrective spectacles necessary to obtain normal vision.

9.2 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.

## 10. Nondestructive Testing

10.1 *Eddy-Current Test*—Unless otherwise specified, each tube up to and including 79 mm in outside diameter, or within the capabilities of the eddy-current tester, shall be

subjected to an eddy-current test. Testing shall follow the procedure of Practice E 243, except the determination of "end effect" is not required.

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 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, etc., 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.

11.4 *Roundness*—For drawn unannealed tube in straight lengths the roundness tolerance shall be as prescribed in Table 2. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. No roundness tolerance has been established for annealed tube in straight lengths or for tubes furnished in coils.

11.5 *Lengths and Tolerances*:

11.5.1 *Standard Lengths and Tolerances*—The standard lengths and tolerances shall be as specified in Table 4.

11.5.2 Other lengths and tolerances are permitted to be established by agreement between the manufacturer or supplier and the purchaser.

11.6 *Squareness of Cut*—For tube in straight lengths, the departure from squareness of the end of any tube shall not exceed more than 0.25 mm for tube up to and including 15-mm standard size; and not more than 0.40 mm/mm of outside diameter for tube larger than 15-mm standard size.

**12. Workmanship, Finish, and Appearance**

12.1 The material shall be clean, free of dirt and defects of a nature that interfere with normal commercial applications.

**13. Sampling**

13.1 Sample pieces shall be selected for test purposes from each lot of 5000 kg or fraction thereof, of each size and type, according to the schedule of Table 5.

**TABLE 3 Roundness Tolerance**

t/D (Ratio of Wall Thickness to Outside Diameter)	Roundness Tolerance % of Outside Diameter (Expressed to Nearest 0.03 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

**TABLE 4 Nominal or Standard Lengths and Tolerances**

Nominal or Standard Size, mm	Type	Nominal or Standard Length, m	Tolerance, mm (all plus)
Tubes Furnished in Straight Lengths			
Up to 206, incl	A, B, C	6.0	25
257	B, C	6.0	25
257	A	5.5	25
308	C	6.0	25
308	B	5.5	25
308	A	3.6	25
Tubes Furnished in Coils			
Up to 28, incl	A, B	20	600
		30	600
35 and 42	A, B	20	600
54	A, B	12	600
		14	600

**TABLE 5 Sampling Schedule**

Number of Pieces in Lot	Number of Sample Pieces to be Taken <sup>A</sup>
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of total number of pieces in the lot but not more than 10 sample pieces

<sup>A</sup> Each sample piece shall be taken from a separate tube.

**TABLE 6 Test Methods**

Test	ASTM Designation
Chemical analysis	E 53, E 62
Tension	E 8 (see also 14.2, 14.3, and 14.4)
Rockwell hardness	E 18
Grain size	E 2, E 3, E 112 (see also 14.5)
Expansion (pin test)	B 153

**TABLE 7 Rounding Units**

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

**14. Number of Tests and Retests**

14.1 *Chemical Analysis*—Samples for chemical analysis shall be taken in accordance with Practice E 55. Drillings, millings, etc., shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 13.1 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.

14.1.1 Instead of sampling in accordance with Practice E 55, 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, he shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

14.1.1.1 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.

14.1.1.2 When samples are taken from the semifinished product, a sample shall be taken to represent each 5000 kg or fraction thereof, except that not more than one sample shall be required per piece.

14.1.1.3 Due to 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.

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

14.2 *Mechanical Tests*—For the mechanical tests, a specimen shall be taken from each of the sample pieces selected in accordance with 13.1. The required mechanical test shall be made on each of the specimens so selected. The value for the Rockwell hardness number of each specimen shall be established by taking the arithmetical average of at least three readings.

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

**14.4 Retests:**

14.4.1 If any test specimen shows defective machining or

develops flaws, it shall be discarded and another specimen substituted.

14.4.2 If the results of any test made to determine the mechanical properties fail to meet the specified requirements, two additional specimens shall be taken from different sample pieces and tested. The results of the tests on both of these specimens shall meet the specified requirements.

14.4.3 If the chemical analysis fails to conform to the specified limits, analysis shall be made on a new composite sample prepared from additional pieces selected in accordance with 13.1. The results of this retest shall comply with the specified requirements.

## 15. Test Methods

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

15.2 Tension test specimens shall be of the full section of the tube and shall conform to the requirements of the section, Specimens for Pipe and Tube, of Test Methods E 8, unless the limitations of the testing machine preclude the use of such a specimen. Test specimens conforming to Type No. 1 of Fig. 13, Tension Test Specimens for Large-Diameter Tubular Products, of Test Methods E 8, are permitted to be used when a full-section specimen cannot be tested.

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

15.4 Tension test results on material covered by this specification are not seriously affected by variations in speed of testing. A considerable range of testing speed is permissible; however, the rate of stressing to the yield strength shall not exceed 690 MPa/min. Above the yield strength, the movement per minute of the testing machine head under load shall not exceed 0.5 mm/mm of gage length (or distance between grips for full-section specimens).

15.5 The surface of the test specimen for microscopical examination shall approximate a radial longitudinal section of the tube.

## 16. Significance of Numerical Limits

16.1 For purposes 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.

## 17. Inspection

17.1 The manufacturer shall afford the inspector representing the purchaser, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with the specified requirements.

## 18. Rejection and Rehearing

18.1 Material that fails to conform to the requirements of this specification is subject to rejection at the option of the purchaser. Rejection shall be reported to the manufacturer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the manufacturer or supplier is permitted to make claim for a rehearing.

## 19. Packaging and Package Marking

19.1 The material shall be separated by size, composition, and temper, and prepared for shipment in such a manner as to ensure acceptance by common carrier for transportation at the lowest rate applicable and to afford protection from the normal hazards of transportation.

19.2 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, total length or piece count, or both, and name of supplier. The specification number shall be shown, when specified.

### 19.3 *Product Identification:*

19.3.1 The name or trademark of the manufacturer and the mark indicative of the type shall be permanently (incised) marked on each tube at intervals not greater than 0.5 m. Tube in straight lengths shall be further identified throughout its length by a colored marking of continuous X's, symbol, or logo not less than 4.5 mm in height, including a legend repeated at intervals not greater than 1 m. The legend shall include the type of the tube, name or trademark of the manufacturer, or both, and the country of origin. Other information is permitted to be included at the option of the manufacturer.

19.3.2 Colors used shall be green for Type A, blue for Type B, and red for Type C. Such color marking is not applicable to tube furnished in annealed straight lengths or coils.

## 20. Keywords

20.1 copper tube; seamless; water tube

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U.S. Government.

### S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

S1.1.1 *Federal Standards*.<sup>11</sup>

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 146A Tolerances for Copper and Copper Base Alloy Mill Products

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products

S1.1.2 *Military Standards*.<sup>11</sup>

MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*.<sup>11</sup>

MIL-C-3993 Packaging of Copper and Copper-Base Alloy Mill Products

### S2. Quality Assurance

S2.1 *Responsibility for Inspection*:

S2.1.1 Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer is permitted to use his own or any

other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification when such inspections and tests are deemed necessary to ensure that the material conforms to the prescribed requirements.

### S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used.

### S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing*:

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade, or class and shall be preserved and packaged, Level A or C, packed, Level A, B, or C, as specified in the contract or purchase order, in accordance with the requirements of MIL-C-3393.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking*:

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

<sup>11</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 100 Barr Harbor Drive, West Conshohocken, PA 19428.