This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.

Designation: ~~B88 – 14~~ B88 – 16

Standard Specification for Seamless Copper Water Tube[1]

This standard is issued under the fixed designation B88; 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.

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

1. Scope*

1.1 This specification establishes the requirements for 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 which affect the selection of the type of tube to be used.[2]

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—Fittings used for soldered or brazed connections in plumbing systems are described in ASME B16.18 and ASME B16.22.

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

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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 inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.*~~

1.5 *Units*—This specification is the companion specification to SI Specification B88M; therefore, no SI equivalents are shown in this specification.

~~NOTE 4—This specification is the inch-pound companion to Specification B88M; therefore, no SI equivalents are presented in the specification.~~

1.6 The following safety hazards caveat pertains only to the test methods portion, Section ~~15~~16, 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:

[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.

Current edition approved ~~Sept. 1, 2014~~Oct. 1, 2016. Published ~~September 2014~~November 2016. Originally approved in 1932. Last previous edition approved in ~~2009~~2014 as ~~B88 – 09.~~B88 – 14. DOI: ~~10.1520/B0088-14.~~10.1520/B0088-16.

[2] 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**

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2.2 *ASTM Standards:*[3]
B32 Specification for Solder Metal
B88M Specification for Seamless Copper Water Tube (Metric)
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
E2B968/B968M Methods of Preparation of Micrographs of Metals and Alloys (Including Recommended Practice for Photography As Applied to Metallography); Replaced by E 883Test Method for Flattening of Copper and Copper-Alloy Pipe and Tube (Withdrawn 1983)
E3 Guide for Preparation of Metallographic Specimens
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)[4]
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)
2.3 *ASME Standards:*
ASME B16.18 Cast Copper Alloy Solder Joint Pressure Fittings[5]
ASME B16.22 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings[5]

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3. Terminology

3.1 *Definitions:*

3.1.1 *coil, n*—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, n*—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, n*—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, n*—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, n*—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.")—For

3.1.2 *lengths, n*—straight pieces of the product.

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

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

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

3.1.3.2 *tube, copper water, n*—a seamless copper tube conforming to the particular dimensions commercially known as Copper Water Tube and designated as Types K, L, and M.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 *capable of*—the test need not be performed by the producer of the material. However, if subsequent testing by the purchaser establishes that the material does not meet these requirements, the material shall be subject to rejection.

[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.
[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. Ordering Information

4.1 Include the following ~~information for material ordered under this specification.~~specified choices when placing orders under this specification, as applicable.

4.1.1 ASTM designation and year of issue (for example, B88 – 03),

4.1.2 Copper [Alloy] UNS No. (or other internationally recognized alloy) designation (not necessary unless a specific copper is desired),

4.1.3 Nominal or standard size (Column 1 of Table 1) and whether Type K, L, or M (Sections 3 and ~~11~~12),

4.1.4 Temper (~~Sections~~(Section ~~5 and~~ 7),

4.1.5 Length (see ~~11.5~~12.5),

4.1.6 How furnished: straight lengths or coils, and

4.1.7 Quantity (pieces) of each size and type.

4.1.8 ~~In addition, when material~~ If product 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~~at the time of the order, when required:

4.2.1 Expansion of chemical analysis (see 6.2),

4.2.2 Tensile test,

4.2.3 ~~Tension test~~ Grain size determination (Section 8),

4.2.4 ~~Grain size determination~~ Hardness test (Section ~~8~~9),

4.2.5 Expansion test (~~9.1~~10.1), ~~and~~

4.2.6 Flattening test (10.2),

4.2.7 Microscopical Examination for Hydrogen Embrittlement, Procedure B (~~9.3.2~~10.3.1.1).

4.2.8 Heat identification or traceability (5.1.2),

4.2.9 Certification,

4.2.10 Mill Test Report,

4.2.11 Product specification number to be shown on package (see 23.2).

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 drawn to size.~~*Materials:*

5.1.1 The material of manufacture shall be a form of such purity and soundness as to be suitable for processing into the products prescribed herein.

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[A] Tolerance, in.		Wall Thickness and Tolerances, in.						Theoretical Weight, lb/ft		
				Type K		Type L		Type M				
		Annealed	Drawn	Wall Thickness	Tolerance[B]	Wall Thickness	Tolerance[B]	Wall Thickness	Tolerance[B]	Type K	Type L	Type M
¼	0.375	0.002	0.001	0.035	0.0035	0.030	0.003	[C]	[C]	0.145	0.126	[C]
⅜	0.500	0.0025	0.001	0.049	0.005	0.035	0.004	0.025	0.002	0.269	0.198	0.145
½	0.625	0.0025	0.001	0.049	0.005	0.040	0.004	0.028	0.003	0.344	0.285	0.204
⅝	0.750	0.0025	0.001	0.049	0.005	0.042	0.004	[C]	[C]	0.418	0.362	[C]
¾	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
1¼	1.375	0.004	0.0015	0.065	0.006	0.055	0.006	0.042	0.004	1.04	0.884	0.682
1½	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
2½	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
3½	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

[A] 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.
[B] Maximum deviation at any one point.
[C] Indicates that the material is not generally available or that no tolerance has been established.

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ASTM B88-16

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

NOTE 4—Because of 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.

~~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.~~

5.2 ~~Tube when 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.~~*Manufacturer:*

5.2.1 The product shall be manufactured by such hot-working, cold-working, and annealing processes as to produce a uniform wrought structure in the finished product.

5.2.2 The product shall be hot- or cold-worked to the finished size and subsequently annealed, when required, to meet the temper properties specified.

5.2.3 Tube, when furnished in coils, shall be annealed after coiling.

5.2.4 Tube, when 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.

6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements in Table 2 for the ~~specific type of copper.~~copper [alloy] UNS No. designation if specified in the ordering information.

6.2 These ~~specification~~composition 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~~ By agreement between the manufacturer and the purchaser, limits ~~shall~~may be established and analysis required for unnamed elements.

7. Temper

7.1 The standard tempers for products described in this specification are given in Table 3.

7.1.1 Annealed tempers O60, and O50.

7.1.2 Drawn temper H58.

8. ~~Temper~~ Grain Size for Annealed Tempers

8.1 ~~Seamless copper water tube shall be furnished in the tempers designated below. Current designations as defined~~ When specified in the contract or purchase order, the annealed products furnished under this specification shall conform to the grain requirements prescribed in Table 3~~Classification~~ ~~.B601 are shown.~~

~~Annealed—O~~

~~Drawn—H~~

8.2 Acceptance or rejection based upon grain size shall depend on the average grain size of a test specimen and shall be within the limits prescribed in Table 3 when determined in accordance with Test Methods E112.

9. Mechanical Property Requirements

9.1 ~~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.~~*Tensile Strength Requirements:*

TABLE 2 Chemical Composition—Weight %

Element	Copper UNS No.	
	~~C10200~~[A] ~~C12000~~	~~C12200~~
	C12000	C12200
~~Copper,~~[B] ~~min~~	~~99.95~~ ~~99.90~~	~~99.9~~
Copper,[A] min	99.90	99.9
~~Phosphorus~~	~~...~~ ~~0.004–0.012~~	~~0.015–0.040~~
Phosphorus	0.004–0.012	0.015–0.040

~~[A] Oxygen shall be 10 ppm max.~~

[A] Copper + silver.

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TABLE 3 Mechanical Property Requirements

Temper Designation		Form	Rockwell Hardness[A]		Tensile Strength, min, ksi[B]	Average Grain Size, mm
~~Standard~~Code	~~Former~~Name		Scale	Value		
~~O60~~	~~annealed~~	~~coils~~	~~F~~	~~50 max~~	~~30~~	~~0.040 min~~
O60	Soft Anneal	straight lengths/coils	F	50 max	30	0.040 min
~~O50~~	~~annealed~~	~~straight lengths~~	~~F~~	~~55 max~~	~~30~~	~~0.025 min~~
O50	Light Anneal	straight lengths/coils	F	55 max	30	0.040 max
H58	drawn	drawn	30 T	30 min	36	...

[A] 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.
[B] ksi = 1000 psi.

9.1.1 The product furnished under this specification shall conform to the tensile requirements prescribed in Table 3, when tested in accordance with Test Method E8/E8M. Actual testing need not be performed unless specified at time of order placement. Acceptance or rejection based upon mechanical properties shall depend on tensile strength.

9.2 *Rockwell Hardness Requirement:*

9.2.1 When specified in the contract or purchase order, the product shall conform to the Rockwell hardness requirement prescribed in Table 3, when tested in accordance with Test Methods E18.

10. Performance Requirements

10.1 *Expansion Test:*

10.1.1 ~~The annealed (O) tube~~ When specified in the contract or purchase order, tube furnished annealed (O) shall be capable of ~~being expanded~~ expansion in accordance with Test Method B153 ~~with an expansion of the outside diameter in the following amount:~~to the following extent:

Nominal or Standard Size, in.	Expansion of Outside Diameter, %
⅝ and under	40
Over ⅝	30

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

10.2 *Flattening Test:*

10.2.1 When specified in the contract or purchase order, the flattening test in accordance with Test Method B968/B968M shall be performed. 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.

10.2.1.1 During inspection, the flattened areas of the test specimen shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

10.3 *Microscopical Examination for Susceptibility to Hydrogen Embrittlement:*

10.3.1 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.

10.3.1.1 Tubes furnished in all coppers shall be capable of passing the embrittlement test specified in Procedure B of Test Methods B577. 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.~~

11. ~~Nondestructive Testing~~Other Requirements

11.1 ~~Each tube up to and including 3⅛ in. in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E243, 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.~~*Nondestructive Testing Requirements:*

~~10.1.1 Notch-depth standards, rounded to the nearest 0.001 in., shall be 22 % of the wall thickness. The notch-depth tolerance shall be ±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 ⅜, incl	0.2
½ to 2, incl	0.3
Over 2 to 3, incl	0.4

11.1.1 Tubes that do not actuate the signallingEach tube up to and including 3⅛ 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 thein. in outside diameter shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E243manufacturer, 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 prescribed limits and the tube is suitable for its, 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.

11.1.1.1 Notch-depth standards, rounded to the nearest 0.001 in., shall be 22 % of the wall thickness. The notch-depth tolerance shall be ±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 ⅜, incl	0.2
½ to 2, incl	0.3
Over 2 to 3, incl	0.4

11.1.1.2 Tubes that do not actuate the signaling 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 prescribed limits and the tube is suitable for its intended application.

11.1.2 Tube made to this specification shall be capable of withstanding the pressure test of 11.1.2.1 or 11.1.2.2. On subsequent testing by the purchaser, failure to meet the requirements of 11.1.2.1 or 11.1.2.2 are grounds for rejection of the material by the purchaser.

11.1.2.1 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:

$$P = 2St/(D - 0.8t) \quad (1)$$

where:

P = hydrostatic pressure, psi;
t = wall thickness, in.;
D = outside diameter of the tube, in.; and
S = allowable stress of the material, psi.

11.1.2.2 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.

10.2 Tube made to this specification shall be capable of withstanding the pressure test of 10.2.1 or 10.2.2. On subsequent testing by the purchaser, failure to meet the requirements of 10.2.1 or 10.2.2 are grounds for rejection of the material by 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:

$$P = 2St/(D - 0.8t) \quad (1)$$

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.

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