



Designation: B819 – 19

Standard Specification for Seamless Copper Tube for Medical Gas Systems¹

This standard is issued under the fixed designation B819; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This specification establishes the requirements for two wall thickness schedules of specially cleaned, straight lengths of seamless copper tube, identified as Types K and L, suitable for medical gas systems. The tube shall be installed in conformance with the requirements of the National Fire Protection Association (NFPA) Standard 99, Gas and Vacuum Systems (NFPA) Standard 99C, Standard for Hypobaric Facilities (NFPA) Standard 99B, and Canadian Standards Association (CSA) Standard Z 305.1/Z 7396.1, Nonflammable Medical Gas Piping Systems.

NOTE 1—Types K and L tube are defined in Specification B88.

NOTE 2—Drawn temper tube is suitable for use with capillary (solder joint) fittings for brazing.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The following safety hazard caveat pertains only to the test method portion of Section 12 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.*²

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recom-*

mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:³

- B88 Specification for Seamless Copper Water Tube
- B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
- B846 Terminology for Copper and Copper Alloys
- 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
- 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)

2.2 Other Standards:

- National Fire Protection Association (NFPA) 99, Gas and Vacuum Systems (NFPA) 99C and Standard for Hypobaric Facilities (NFPA) 99B⁵
- Compressed Gas Association (CGA) G-4.1, Cleaning Equipment for Oxygen Service⁶

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

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

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 National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169, http://www.nfpa.org.

⁶ Available from Compressed Gas Association (CGA), 14501 George Carter Way, Suite 103, Chantilly VA 20151-2923, http://www.cganet.com.

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

3. Terminology

3.1 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 lengths—straight pieces of the product.

3.2.2 standard—uniform lengths established as commercial standards.

3.2.3 tube, copper water—a seamless copper tube conforming to the particular dimensions commercially known as Copper Water Tube and designated as Types K and L (see Table 1).

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

4. Ordering Information

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

4.1.1 Specification B819–00.

4.1.2 Nominal or standard size (Column 1 of Table 1) and whether Type K or L (Sections 3 and 10),

4.1.3 Temper (Sections 7 and 8),

4.1.4 Length (see 10.5),

4.1.5 Quantity (pieces) of each size and type,

4.2 The following options are available and should be specified at the time of placing the order when required.

4.2.1 Whether tension test determinations are required (Section 8),

4.2.2 Whether the tube shall be charged with dry, oil-free nitrogen during capping, closing, or plugging (see 11.8),

4.2.3 Certification, if required (see Section 20), and

4.2.4 Mill Test Report, if required, (see Section 21).

4.2.5 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 Material—The materials of manufacture shall be a cast billet of Copper Alloy UNS C12200 of such purity and soundness as to be suitable for processing into the products prescribed herein.

5.2 Manufacture—The product shall be manufactured by such hot working necessary to convert the billet to a tubular shape and cold worked to the finished size.

6. Chemical Composition

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

Copper (incl silver), %	99.9 minimum
Phosphorous, %	0.015 to 0.040

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

7. Temper

7.1 Seamless copper tube for medical gas systems shall be furnished in the H55 (Light Drawn) temper or H58 (Drawn General Purpose) temper, as defined in Classification B601.

⁷ Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, <http://www.csagroup.org>.

TABLE 1 Dimensions, Mass, 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. (mm)		Average Outside Diameter ^A Tolerances, in. (mm)		Wall Thickness and Tolerances, in.								Theoretical Mass, lb/ft (kg/m)			
					Type K				Type L							
					Wall Thickness		Wall Tolerance		Thickness		Tolerance		Type K		Type L	
1/8	0.250	(6.35)	0.001	(0.025)	0.030	(0.762)	0.003	(0.08)	0.025	(0.635)	0.0025	(0.06)	0.080	(0.119)	0.068	(0.102)
1/4	0.375	(9.52)	0.001	(0.025)	0.035	(0.889)	0.0035	(0.089)	0.030	(0.762)	0.003	(0.076)	0.145	(0.216)	0.126	(0.187)
3/8	0.500	(12.7)	0.001	(0.025)	0.049	(1.24)	0.005	(0.13)	0.035	(0.889)	0.004	(0.10)	0.269	(0.400)	0.198	(0.295)
1/2	0.625	(15.9)	0.001	(0.025)	0.049	(1.24)	0.005	(0.13)	0.040	(1.02)	0.004	(0.10)	0.344	(0.512)	0.285	(0.424)
5/8	0.750	(19.1)	0.001	(0.025)	0.049	(1.24)	0.005	(0.13)	0.042	(1.07)	0.004	(0.10)	0.418	(0.622)	0.362	(0.539)
3/4	0.875	(22.3)	0.001	(0.025)	0.065	(1.65)	0.006	(0.15)	0.045	(1.14)	0.004	(0.10)	0.641	(0.954)	0.455	(0.677)
1	1.125	(28.6)	0.0015	(0.038)	0.065	(1.65)	0.006	(0.15)	0.050	(1.27)	0.005	(0.13)	0.839	(1.25)	0.655	(0.975)
1 1/4	1.375	(34.9)	0.0015	(0.038)	0.065	(1.65)	0.006	(0.15)	0.055	(1.40)	0.006	(0.15)	1.040	(1.55)	0.884	(1.32)
1 1/2	1.625	(41.3)	0.002	(0.051)	0.072	(1.83)	0.007	(0.18)	0.060	(1.52)	0.006	(0.15)	1.360	(2.02)	1.140	(1.70)
2	2.125	(54.0)	0.002	(0.051)	0.083	(2.11)	0.008	(0.20)	0.070	(1.78)	0.007	(0.18)	2.060	(3.07)	1.750	(2.60)
2 1/2	2.625	(66.7)	0.002	(0.051)	0.095	(2.41)	0.010	(0.25)	0.080	(2.03)	0.008	(0.20)	2.930	(4.36)	2.480	(3.69)
3	3.125	(79.4)	0.002	(0.051)	0.109	(2.77)	0.011	(0.28)	0.090	(2.29)	0.009	(0.23)	4.000	(5.95)	3.330	(4.96)
3 1/2	3.625	(92.1)	0.002	(0.051)	0.120	(3.05)	0.012	(0.30)	0.100	(2.54)	0.010	(0.25)	5.120	(7.62)	4.290	(6.38)
4	4.125	(105)	0.002	(0.051)	0.134	(3.40)	0.013	(0.33)	0.110	(2.79)	0.011	(0.28)	6.510	(9.69)	5.380	(8.01)
5	5.125	(130)	0.002	(0.051)	0.160	(4.06)	0.016	(0.41)	0.125	(3.18)	0.012	(0.30)	9.670	(14.4)	7.610	(11.3)
6	6.125	(156)	0.002	(0.051)	0.192	(4.88)	0.019	(0.48)	0.140	(3.56)	0.014	(0.36)	13.900	(20.7)	10.200	(15.2)
8	8.125	(206)	+0.002	(0.051)	0.271	(6.88)	0.027	(0.69)	0.200	(5.08)	0.020	(0.51)	25.900	(38.5)	19.300	(28.7)
			-0.006	(0.150)												

^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.

8. Mechanical Properties

8.1 The tube shall conform to the mechanical property requirements specified in **Table 2** when tested in accordance with Test Methods **E18** and **E8/E8M**, respectively. Tension test 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 requirements of **Table 2** shall be the basis for acceptance or rejection.

9. Nondestructive Testing

9.1 Each tube up to and including 3 in. (76.2 mm) standard size, 3 1/8 in. (79.4 mm) 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.

9.1.1 Either notch depth or drilled hole standards shall be used.

9.1.1.1 Notch-depth standards, rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the wall thickness. The notch-depth tolerance shall be plus and minus 0.0005 in. (0.013 mm). Alternatively at the option of the manufacturer using speed-insensitive eddy-current units that are equipped so that a fraction of the maximum imbalance signal can be selected, the following percent maximum imbalance signals may be used:

Standard Tube Size, in.	Maximum Percent Imbalance Signal Magnitude
Up to 3/8, incl	0.2
1/2 to 2, incl	0.3
Over 2 to 3, incl	0.4

9.1.1.2 Drilled holes shall be drilled radially through the wall using a suitable drill jig that has a bushing to guide the drill, care being taken to avoid distortion of the tube while drilling. The diameter of the drilled hole shall be in accordance with the following and shall not vary by more than +0.001 in. (+0.026 mm), -0.000 in. (-0.000 mm) of the hole diameter specified.

Tube Outside Diameter, in.	Diameter of Drilled Holes, in.	Drill Number
1/4 to 3/4, incl	0.025	72
Over 3/4 to 1, incl	0.031	68
Over 1 to 1 1/4, incl	0.036	64
Over 1 1/4 to 1 1/2, incl	0.042	58
Over 1 1/2 to 1 3/4, incl	0.046	58
Over 1 3/4 to 2, incl	0.052	55

9.1.2 Tubes that do not activate 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 may at the option of the manufacturer be reexamined or retested to determine whether the discontinuing 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.

9.2 Tube made to this specification shall be capable of withstanding the pressure test of **9.2.1** or **9.2.2**. Should subsequent testing by the purchaser establish that the material does not meet these requirements, the material may be rejected.

9.2.1 The tube shall stand without showing evidence of leakage, and an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 6000 psi (41 MPa) calculated from the following equation for thin hollow cylinders under tension:

$$P = \frac{2 St}{D - 0.8t} \quad (1)$$

where:

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

9.2.2 The tube shall stand an internal air pressure of 60 psig (415 kPa) 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. Dimensions, Mass and Permissible Variations

10.1 For the purpose of determining conformance with the dimensional requirements specified in this specification, any measured value outside the specified limiting values for any dimensions may be cause for rejection.

10.2 *Standard Dimensions, Wall Thickness, and Diameter Tolerances* shall be in accordance with **Table 1**.

10.3 *Theoretical Weights* for purposes of calculating weights, cross sections, and so forth, the density of the copper shall be taken as 0.323 lb/in.³ (8.94 g/cm³).

10.4 *Roundness Tolerance* shall be as specified in **Table 3**. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube.

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

TABLE 2 Mechanical Properties

Temper Designation	Standard	Former	Form	Rockwell Hardness ^A		Tensile Strength	
				Scale	Value	ksi ^B	(MPa) ^C
H55	light drawn		straight lengths	30T	30 to 60	36 to 47	(250 to 325)
H58	drawn general purpose		straight lengths	30T	30 min	36 min	(250) min

^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 may be specified subject to between the purchaser and the supplier.

^B ksi = 1000 psi.

^C MPa = pascal × 10⁶.

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. or 0.010 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 Standard Lengths and Tolerances

Nominal or Standard Size, in.	Type	Standard Length, ft (m)	Tolerance (All Plus), in. (mm)
Tubes Furnished in Straight Lengths			
Up to 8 incl	K,L	20 (6.1)	1 in. (25)

10.6 *Squareness of Cut*—The departure from squareness of the end of any tube shall not exceed more than 0.010 in. (0.25 mm) for tube up to and including ½ in. (12.7 mm) standard size; and not more than 0.016 in./in. (0.40 mm/mm) of outside diameter for tube larger than ½ in. (12.7 mm) standard size.

11. Tube Cleaned for Medical Gas Systems

11.1 Tube for medical gas systems shall be cleaned to meet the requirements of Section 12. The following are recommended practices for cleaning, but the producer is not limited to these procedures.

NOTE 3—Some cleaning techniques are found in CGA G-4.1.

11.2 *Alkaline Washing*—Washing in a solution of approximately 4 oz of commercial alkaline cleaner per gallon (30 g/L) of hot water at approximately 180 °F (82 °C), followed by rinsing thoroughly first with cold then with clean hot water and drying. The cleaner may contain but is not restricted to tri or tetra sodium phosphate, sodium carbonate, sodium hydroxide, sodium metasilicate, or sodium orthosilicate plus a wetting agent or any combination of the foregoing.

11.3 *Steam Solvent Washing*—Washing by flushing with steam containing Stoddard Solvent or its equivalent, rinsing thoroughly with clean steam, and purging with hot or dry air.

11.4 *Steam Detergent Washing*—Washing by flushing with steam containing a detergent, rinsing thoroughly with clean steam, and purging with hot or dry air.

11.5 *Steam Washing*—Washing by flushing with clean steam and purging with hot or dry air.

11.6 *Vapor Degreasing*—Washing thoroughly with trichloroethylene or 1,1,1 trichloroethane (methyl chloroform) solvent by “vapor-immersion” or “vapor-flushing-vapor” techniques and then purging with dry air.

11.7 *Refrigerant Degreasing*—Vapor flushing with refrigerant and purging with hot or dry air.

11.8 After washing and drying, the tube shall be immediately capped, plugged, or otherwise sealed or closed at both ends. In addition, and as an option, the tube may be charged with dry, oil-free nitrogen before or following capping or plugging.

12. Cleanness Requirements

12.1 The tube shall be capable of passing the following cleanness test, although actual performance of this test is not mandatory under the terms of this specification unless specified. Cleanness requirements in addition to those of this specification are the responsibility of the user.

12.1.1 The inside of tube with sealed or closed ends shall be sufficiently clean so that when the interior of the tube is washed with trichloroethylene, or other suitable solvent such as methyl chloroform or redistilled trichloroethylene, the residue remaining upon evaporation of the solvent shall not exceed 0.0035 g/ft² (0.038 g/m²) of interior surface. The maximum amount of residue in grams per tube shall not exceed the requirements specified in Table 5 or Table 6.

12.1.2 To perform the test, cap (or plug) one end of the tube and fill with solvent to one eighth of its capacity. Cap (or plug) the opposite end and roll tubes on horizontal supports to wash the inside surfaces thoroughly (Note 4). Remove cap or plug and pour solvent into a suitable clean weighed container. The solvent in the container shall be evaporated to dryness on a low-temperature hot plate or sand bath. Overheating of the container should be avoided to prevent charring of the residue. The container shall then be dried in an oven at 100 to 110 °C for 10 min, cooled in a desiccator, and weighed. A blank determination shall be run on the determined quantity of solvent and the gain in weight for the blank shall be subtracted from the weighing of the residue sample. The corrected weight shall then be calculated to grams of residue per internal area of tube.

12.1.3 The quantity of the solvent used may vary with the size of the tube being examined. A minimum quantity of 100 mL should be used for standard sizes up to ½ in. (12.7 mm) and should be increased proportionately for the larger size. The quantity of solvent used for the blank run shall be the same as that used for the actual examination of the tube sample.

12.1.4 In performing the test, care must be exercised to clean the outside surface of the end of the sample to be immersed in the solvent. The sample must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust, resulting from the cutting of the sample.

NOTE 4—Because of limitations of test, it is not required that straight tubes ¼ in. (31.8 mm) standard size and over be tested in full length. For such tubes, a shorter length to a minimum of 5 ft. (1.52 m) may be tested with a correspondingly reduced maximum permissible residue limit based upon 0.0035 g/ft² (0.038 g/m²) of sample interior surface.

13. Workmanship, Finish, and Appearance

13.1 The product shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable.

14. Sampling

14.1 The lot size, portion size, and selection of sample pieces shall be as follows:

14.1.1 *Lot Size*—An inspection lot shall be 10 000 lb or less of the same mill form, alloy, temper, and nominal dimensions subject to inspection at one time.