



## Standard Specification for Seamless Copper Tube for Medical Gas Systems<sup>1</sup>

This standard is issued under the fixed designation B 819; 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 B 88.

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, which 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 and health practices and determine the applicability of regulatory limitations prior to use.*<sup>2</sup>

### 2. Referenced Documents

2.1 The following documents in the current issue of the Book of Standards in effect on date of material purchase form a part of this specification to the extent referenced herein:

#### 2.2 ASTM Standards:

B 88 Specification for Seamless Copper Water Tube<sup>3</sup>

B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube<sup>3</sup>

B 280 Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service<sup>3</sup>

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast<sup>3</sup>

B 846 Terminology for Copper and Copper Alloys

E 8 Test Methods for Tension Testing of Metallic Materials<sup>4</sup>

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>4</sup>

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>5</sup>

E 53 Methods for Chemical Analysis of Copper<sup>6</sup>

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)<sup>6</sup>

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes<sup>7</sup>

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition<sup>6</sup>

E 527 Practice for Numbering Metals and Alloys (UNS)<sup>8</sup>

#### 2.3 Other Standards:

National Fire Protection Association (NFPA) 99, Gas and Vacuum Systems (NFPA) 99C and Standard for Hypobaric Facilities (NFPA) 99B<sup>9</sup>

Compressed Gas Association (CGA) G-4.1, Cleaning Equipment for Oxygen Service<sup>10</sup>

Canadian Standards Association (CSA) Z 305.1/Z 7396.1, Nonflammable Medical Gas Piping Systems<sup>11</sup>

### 3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B 846.

#### 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).

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

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

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 02.01.

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 14.02.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>7</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>8</sup> *Annual Book of ASTM Standards*, Vol 01.01.

<sup>9</sup> Available from National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

<sup>10</sup> Available from Compressed Gas Association Inc., 1725 Jefferson Davis Highway, Suite 1004, Arlington, VA 22202-4102.

<sup>11</sup> Available from Canadian Standards Association, 178 Rexdale Blvd., Rexdale, Ontario, Canada M9W 1R3.

**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 <sup>A</sup> 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			
¼	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)		
⅜	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)		
½	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)		
⅝	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)		
¾	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)		
1¼	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)		
1½	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)		
2½	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	(0.510)	0.109	(2.77)	0.011	(0.28)	0.090	(2.29)	0.009	(0.23)	4.000	(5.95)	3.330	(4.96)		
3½	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)													

<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.

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 B 819–00.

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), %  
Phosphorous, %

99.9 minimum  
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 H58 (Drawn General Purpose) temper, as defined in Practice B 601.

**TABLE 2 Mechanical Properties**

Temper Designation		Form	Rockwell Hardness <sup>A</sup>		Tensile Strength	
Standard	Former		Scale	Value	min, ksi <sup>B</sup>	(MPa) <sup>C</sup>
H58	drawn general purpose	straight lengths	30T	30 min	36	(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 may be specified subject to between the purchaser and the supplier.

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

<sup>C</sup>MPa = pascal × 10<sup>6</sup>.

#### 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 E 18 and E 8, 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 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.

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.<sup>3</sup> (8.94 g/cm<sup>3</sup>).

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.

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 1/2-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 1/2-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

TABLE 3 Roundness Tolerance

$t/D$ (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)

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 remain-

ing upon evaporation of the solvent shall not exceed 0.0035 g/ft<sup>2</sup> (0.038 g/m<sup>2</sup>) 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 1¼-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

TABLE 5 Interior Surface Residue Limits of Straight Lengths, Type K

NOTE 1—The conversion of square feet to square metres is; square ft<sup>2</sup> × 0.092 903 = m<sup>2</sup>.

Nominal or Standard Size, in.	Outside Diam- eter, in.	Wall Thickness, in. (mm)		Internal Area per Length of Tube, ft <sup>2</sup> (m <sup>2</sup> ) <sup>A</sup>				Residue Limit <sup>B</sup> / 20 ft (6.10 m), Straight Length, g
				1 ft (0.305 m)		20 ft (6.10 mm) <sup>C</sup>		
¼	0.375	0.035	(0.889)	0.0798	(0.0074)	1.596	(0.1483)	0.0056
⅜	0.500	0.049	(1.2)	0.1052	(0.0098)	2.104	(0.1955)	0.0074
½	0.625	0.049	(1.2)	0.1380	(0.0128)	2.760	(0.2564)	0.0097
⅝	0.750	0.049	(1.2)	0.1707	(0.0159)	3.414	(0.3172)	0.0120
¾	0.875	0.065	(1.6)	0.1950	(0.0181)	3.900	(0.3623)	0.0137
1	1.125	0.065	(1.6)	0.2605	(0.0242)	5.210	(0.4840)	0.0182
1¼	1.375	0.065	(1.6)	0.3260	(0.0303)	6.520	(0.6057)	0.0228
1½	1.625	0.072	(1.8)	0.3877	(0.0360)	7.754	(0.7204)	0.0271
2	2.125	0.083	(2.1)	0.5219	(0.0476)	10.258	(0.9530)	0.0359
2½	2.625	0.095	(2.4)	0.6375	(0.0592)	12.750	(1.1845)	0.0446
3	3.125	0.109	(2.8)	0.7611	(0.0707)	15.222	(1.4142)	0.0533
3½	3.625	0.120	(3.0)	0.8862	(0.0823)	17.724	(1.6466)	0.0620
4	4.125	0.134	(3.4)	1.0098	(0.0938)	20.196	(1.8763)	0.0707
5	5.125	0.160	(4.0)	1.2580	(0.1169)	25.160	(2.3374)	0.0881
6	6.125	0.192	(4.8)	1.5030	(0.1396)	30.060	(2.7927)	0.1052
8	8.125	0.271	(6.8)	1.9852	(0.1844)	39.704	(3.6887)	0.1390

<sup>A</sup>Internal area per length of tube ft<sup>2</sup> = (π)(ID)(12)/144

where:

π = 3.1416, and

ID = inside diameter of tube.

<sup>B</sup>Residue limit = (c) (0.0035 g/ft<sup>2</sup> or 0.038 g/m<sup>2</sup>)

where:

<sup>C</sup>is the numerical value for 20 ft of internal area per size, and (0.0035 g/ft<sup>2</sup> or 0.038 gm<sup>2</sup>) is the standard limit.

TABLE 6 Interior Surface Residue Limits of Straight Lengths, Type L

NOTE 1—The conversion of square foot to square metre is  $\text{ft}^2 \times 0.092\,903 = \text{m}^2$ .

Nominal or Standard Size, in.	Outside Diameter, in.	Wall Thickness, in. (mm)	Internal Area Per Length of Tube, ft <sup>2</sup> (m <sup>2</sup> ) <sup>A</sup>				Residue Limit <sup>B/20</sup> ft (6.10 m), Straight Length, g
			1 ft (0.305)		20 ft (6.10 mm) <sup>C</sup>		
1/4	0.375	0.030 (0.762)	0.0825	(0.0077)	1.65	(0.153)	0.0058
3/8	0.500	0.035 (0.889)	0.1126	(0.0105)	2.25	(0.209)	0.0079
1/2	0.625	0.040 (1.016)	0.1427	(0.0133)	2.85	(0.265)	0.0100
5/8	0.750	0.042 (1.07)	0.1744	(0.0162)	3.49	(0.324)	0.0122
3/4	0.875	0.045 (1.14)	0.2055	(0.0191)	4.11	(0.382)	0.0144
1	1.125	0.050 (1.27)	0.2683	(0.0249)	5.37	(0.499)	0.0188
1 1/4	1.375	0.055 (1.40)	0.3312	(0.0308)	6.62	(0.615)	0.0232
1 1/2	1.625	0.060 (1.52)	0.3940	(0.0366)	7.88	(0.732)	0.0276
2	2.125	0.070 (1.78)	0.5197	(0.0423)	10.39	(0.846)	0.0364
2 1/2	2.625	0.080 (2.03)	0.6453	(0.0599)	12.91	(1.199)	0.0453
3	3.125	0.090 (2.77)	0.7611	(0.0707)	15.42	(1.432)	0.0540
3 1/2	3.625	0.100 (2.54)	0.8966	(0.0833)	17.93	(1.666)	0.0628
4	4.125	0.110 (2.80)	1.0220	(0.0949)	20.44	(1.898)	0.0717
5	5.125	0.125 (3.18)	1.2763	(0.1186)	25.53	(2.372)	0.0894
6	6.125	0.140 (3.56)	1.5302	(0.1422)	30.60	(2.843)	0.1071
8	8.125	0.200 (5.08)	2.0224	(0.1879)	40.45	(3.758)	0.1416

<sup>A</sup>Internal area per length of tube  $\text{ft}^2 = (\pi)(\text{ID})(12)/144$

where:

$\pi = 3.1416$ , and

ID = inside diameter of tube.

<sup>B</sup>Residue limit = (c) (0.0035  $\text{g}/\text{ft}^2$  or 0.038  $\text{g}/\text{m}^2$ )

where:

<sup>C</sup>is the numerical value for 20 ft of internal area per size, and 0.0035  $\text{g}/\text{ft}^2$  of 0.038  $\text{g}/\text{m}^2$  is the standard limit.

with a correspondingly reduced maximum permissible residue limit based upon 0.0035  $\text{g}/\text{ft}^2$ (0.038  $\text{g}/\text{m}^2$ ) of sample interior surface.

### 13. Workmanship, Finish, and Appearance

13.1 The finished tube shall be smooth, free of internal and external mechanical imperfections, but blemishes of a nature that do not interfere with the intended application are acceptable, and shall have a clean, bright appearance.

### 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 lbs or less of the same mill form, alloy, temper, and nominal dimensions subject to inspection at one time.

14.1.2 *Portion Size*—The portion size shall be in accordance with the schedule of Table 7. Each sample shall be taken from a separate tube.

14.2 Sample pieces shall be selected for test purposes from each lot of 10 000 lbs (4550 kg) or fraction thereof, of each size and type, according to the schedule of Table 7. Each sample shall be taken from a separate tube.

14.3 *Chemical Analysis*—Samples for chemical analysis shall be taken in accordance with Practice E 255. Drillings, millings, and so forth shall be taken in approximately equal

weight from each of the sample pieces selected in accordance with 14.2 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.

14.3.1 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of determining conformance to chemical composition as follows: (1) 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 and (2) the number of samples taken for determination of chemical composition shall be as follows:

14.3.1.1 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.

14.3.1.2 When samples are taken from the semifinished product, a sample shall be taken to represent 10 000 lbs (4550 kg) or fraction thereof, except that not more than one sample shall be required per piece.

14.3.1.3 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.

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

### 15. Number of Tests and Retests

15.1 *Chemical Analysis*—At least two replicate analyses of each element with a limiting value shall be conducted.

15.2 *Mechanical Tests*—For the mechanical tests, a specimen shall be taken from each of the sample pieces selected in accordance with 14.2. The required mechanical test shall be

TABLE 7 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 pieces in the lot but not more than 10 sample pieces

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



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.

### 15.3 Retests:

15.3.1 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 14.2. The results of this retest shall comply with the specified requirements.

15.3.2 If any results of any test made to determine the mechanical properties fails 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.

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

## 16. Test Methods

16.1 The properties enumerated in this specification shall, in case of disagreement, be determined in accordance with the ASTM test methods listed in Table 8.

16.2 Tension test specimens shall be of the full section of the tube and shall conform to the requirements of 6.9 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. 12 of Test Methods E 8 may be used when a full-section specimen cannot be tested.

16.3 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.

16.4 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 should not exceed 100 ksi/min (690 MPa/min). Above the yield strength, the movement per minute of the testing machine head under load should not exceed 0.5 in./in. (0.5 mm/mm) of gage length (or distance between grips for full-section specimens).

## 17. Significance of Numerical Limits

17.1 For purpose of determining compliance with the specified limits for requirements of the properties listed in Table 9, an observed value or calculated value shall be rounded as indicated in accordance with the rounding of Practice E 29.

TABLE 8 Test Methods

Test	ASTM Designation
Chemical analysis	E 53, E62
Tension	E 8 (see also Sections 17.2, 17.3, and 17.4)
Rockwell hardness	E 18
Eddy current	E 243

TABLE 9 Rounding Units

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

## 18. Inspection

18.1 The manufacturer or supplier shall inspect and make tests necessary to verify the product furnished conforms to the requirements of this specification.

18.2 Source inspection of the product by the purchaser may be agreed upon between the manufacturer or supplier and the purchaser as part of the purchase order. In such cases, the nature of facilities needed to satisfy the inspector representing the purchaser that the product is being furnished in accordance with specification shall be included in the agreement. All tests and the inspection shall be conducted so as not to interfere unnecessarily with the operation of the works.

18.3 The manufacturer or supplier and the purchaser may conduct the final inspection simultaneously by mutual agreement.

## 19. Rejection and Rehearing

### 19.1 Rejection:

19.1.1 Product that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing.

19.1.2 In case of dissatisfaction with results of the test, the producer or supplier may make claim for a rehearing.

19.2 *Rehearing*—As a result of product rejection, the manufacturer or supplier may make claim for a retest to be conducted by the manufacturer or supplier and the purchaser. Samples of the rejected product shall be taken in accordance with Section 14 of this specification and subjected to test by both parties using the test methods specified in this standard or, alternatively, upon agreement of both parties, an independent laboratory may be selected for the test(s) using the test method(s) specified in the standard.

## 20. Certification

20.1 When specified in the contract or purchase order, the purchaser shall be furnished certification that samples representing each lot have been tested or inspected as directed in this specification and requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

## 21. Mill Test Report

21.1 When specified in the contract or purchase order, the manufacturer or supplier shall furnish to the purchaser a test report showing the results of tests required by this specification.

## 22. Packaging and Package Marking

22.1 *Packaging*—The product 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.

22.2 *Package Marking*—Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, size, gross and net weight, and name of supplier. The specification number shall be shown when specified.

### **23. Product Marking**

23.1 The name or trademark of the manufacturer and the mark indicative of Type K or L shall be permanently (incised) marked on each tube at intervals not greater than 1½ ft (0.46 m).

23.2 The tube shall be further identified throughout its length by means of a continuous colored stripe, symbol, or logo

not less than ⅜ in. (4.76 mm) in height, including a legend repeated at intervals not greater than 3 ft (0.91 m). The legend shall include the type of tube, name or trademark of the manufacturer or both, and the country of origin. Other information may be included at the option of the manufacturer.

23.3 The tube shall be marked with any of the following in the color appropriate to the tube type: “OXY,” “MED,” “OXY/MED,” “OXY/ACR,” or “ACR/MED.” Colors used are green for Type K and blue for Type L.

### **24. Keywords**

24.1 ACR medical gas tube; copper tube; seamless; MED medical gas tube; medical gas systems; OXY medical gas tube; Type K medical gas tube; Type L medical gas tube

## **SUMMARY OF CHANGES**

Committee B05 has identified the location of selected changes to this standard since the last issue of B 819 - 95 that may impact the use of this standard.

(1) General revision throughout to comply with the Form and Style for ASTM Standards, 10th edition.

(2) Sampling—Lot size has been changed to be consistent with Specification B 251.

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