



Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service¹

This standard is issued under the fixed designation B 280; 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 Department of Defense.

1. Scope *

1.1 This specification establishes the requirements for seamless copper tube produced from Copper UNS No. C12200 and intended for use in the connection, repairs, or alternations of air conditioning or refrigeration units in the field.

NOTE 1—Fittings used for soldered or brazed connections in air conditioning and refrigeration systems are described in ASME Standard B16.22.

NOTE 2—The assembly of copper tubular systems by soldering is described in Practice B 828.

NOTE 3—Solders for joining copper tubular systems are described in Specification B 32. The requirements for acceptable fluxes for these systems are described in Specification B 813.

1.2 Values stated in inch-pound units are the standard except for grain size which is stated in SI units. SI values given in parentheses are for information only.

1.3 The following hazard statement pertains only to the test method described in Section 18.2.4 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 ASTM Standards:

B 32 Specification for Solder Metal²

B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tube³

B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast³

B 813 Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube³

B 828 Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings³

E 3 Guide for Preparation of Metallographic Specimens⁴

E 8 Test Methods for Tension Testing of Metallic Materials⁴

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵

E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry⁶

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Method)⁶

E 112 Test Methods for Determining the Average Grain Size⁴

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Seamless Copper and Copper-Alloy Tubes⁷

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁶

E 527 Practice for Numbering Metals and Alloys (UNS)⁸

2.2 ASME Standards:⁹

B1622 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings

3. Terminology

3.1 Definitions:

3.1.1 *average diameter (for round tubes only), n*—the average of the maximum and minimum outside diameters, or maximum and minimum inside diameters, whichever is applicable, as determined at any one cross section of the tube.

3.1.2 *bright anneal, n*—a thermal treatment carried out in a controlled atmosphere so that surface oxidation is reduced to a minimum and the surface remains relatively bright.

3.1.3 *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.

3.1.3.1 *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.

3.1.3.2 *level or traverse wound, n*—a coil in which the turns

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² *Annual Book of ASTM Standards*, Vol 02.04.

³ *Annual Book of ASTM Standards*, Vol 02.01.

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

⁵ *Annual Book of ASTM Standards*, Vol 14.02.

⁶ *Annual Book of ASTM Standards*, Vol 03.06.

⁷ *Annual Book of ASTM Standards*, Vol 03.06.

⁸ *Annual Book of ASTM Standards*, Vol 01.01.

⁹ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

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

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.”)

3.1.3.3 *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.”)

3.1.3.4 *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.”)

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

3.1.4.1 *specific, n*—straight lengths that are uniform in length, as specified, and subject to established length tolerances.

3.1.4.2 *standard, n*—uniform lengths recommended in a Simplified Practice Recommendation or established as a Commercial Standard.

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

3.1.5.1 *tube, air conditioning, n*—a seamless copper tube conforming to a standard series of sizes (Table 6) and to specified internal cleanness requirements, normally furnished in drawn temper straight lengths with the ends capped or sealed.

3.1.5.2 *tube, refrigeration service, n*—a seamless copper tube conforming to a standard series of sizes (Table 5) and to special internal cleanliness and dehydration requirements, normally furnished in soft temper coils and with ends capped or sealed.

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.

4. Ordering Information

4.1 Include this information for contracts or purchase orders for products furnished to this specification:

4.1.1 ASTM designation and year of issue (for example, B 280 – 99),

4.1.2 Dimensions; wall thickness, diameter, and so forth (Section 13),

4.1.3 How furnished: coils or straight lengths,

4.1.4 Temper (for example, O60 or H58),

4.1.5 Size (Tables 4 and 5),

4.1.6 Length (Section 13),

4.1.7 Quantity (total pieces of each size and type),

4.1.8 When product purchased for agencies of the U.S. Government (Section 12).

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

4.2.1 Expansion test (Section 10.1),

4.2.2 Cleanness test (Sections 10.2 and 18.2.4),

4.2.3 Certification (Section 22), and

4.2.4 Test report (Section 23).

5. Materials and Manufacture

5.1 *Materials*—The material of manufacture shall be billets,

bars, or tube of the Copper UNS¹⁰ No. C12200 and shall be of such soundness as to be suitable for processing into the tubular products described.

5.2 Manufacture:

5.2.1 The tube shall be manufactured by such hot or cold working processes as to produce a homogeneous uniform wrought structure in the finished product. The tube shall be cold drawn to the finished size and wall thickness.

5.2.2 Coiled lengths specified O60, soft annealed temper, shall be bright annealed after coiling, then dehydrated, and capped, plugged, crimped, or otherwise closed at both ends so as to maintain the internal cleanness of the tubing under normal conditions of handling and storage.

5.2.3 Straight lengths specified H58 hard-drawn temper shall be cleaned and capped, plugged, or otherwise closed at both ends so as to maintain the internal cleanness of the tubing under normal conditions of handling and storage.

6. Chemical Composition

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

Copper, min, % Including Silver	Phosphorus, Range, %
99.9	0.015–0.040

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

7. Temper

7.1 Product under this specification shall be furnished in either O60 (soft annealed) or H58 (drawn general purpose) temper, as specified in the contract or purchase order and defined in Classification B 601.

7.1.1 Coils are normally furnished in O60 temper and straight lengths in H58 temper.

8. Grain Size

8.1 Coiled lengths shall be furnished in the O60 temper and shall have a recrystallized average grain size of 0.035 mm minimum when determined in accordance with Test Methods E 112.

9. Tensile Requirements

9.1 The tube shall conform to the tensile requirements prescribed in Table 1.

¹⁰ Refer to Practice E 527 for explanation of unified numbering system (UNS).

TABLE 1 Tensile Requirements

Form	Temper Designation		Tensile Strength, min		Elongation in 2 in. (50.8 mm), min, %
	Standard	Former	ksi ^A	MPa ^B	
Coiled lengths	O60	soft annealed	30	205	40
Straight lengths	H58	drawn general purpose	36	250	...

^A ksi = 1000 psi.

^B See Appendix X1.

10. Performance Requirements

10.1 Expansion Test:

10.1.1 Tube furnished in the O60 soft annealed temper shall be capable of being expanded in accordance with Test Method B 153 to the following extent:

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

10.1.2 Unless specified in the contract or purchase order, this test is not required to be performed by the manufacturer.

10.2 Cleanliness of Interior Surface:

10.2.1 When specified in the contract or purchase order, this test shall be performed by the manufacturer.

10.2.2 After evaporation of the cleaning solvent, the residue weight shall not exceed 0.0035 g/ft² (0.038 g/m²) of the interior surface. The maximum amount of residue in grams per tube shall not exceed the limits specified in Tables 2-4.

11. Nondestructive Testing

11.1 Electromagnetic (Eddy-Current) Examination:

11.1.1 Each straight length of tube up to and including 3½ in. (79.4 mm) in outside diameter, shall be subjected to examination.

11.1.2 Tubes that do not actuate the signaling device on the testing unit, after having been adjusted to provide information on the suitability of the tube for the intended application, shall conform to the requirements of this test. Testing shall be in accordance with Practice E 243.

11.1.3 Testing of coiled lengths shall be subject to negotiation between the manufacturer and the purchaser.

11.1.4 For tubes too large for the testing unit, the test method to be used shall be by agreement between the manufacturer and the purchaser.

12. Purchases for Agencies of the U.S. Government

12.1 When specified in the contract or purchase order, product purchased for agencies of the U.S. Government shall conform to the requirements stipulated in the Supplementary Requirements.

13. Dimensions, Mass, and Permissible Variations

13.1 The standard dimensions and weights per foot for the various nominal sizes are given in Tables 5 and 6.

TABLE 2 Interior Surface Residue Limits of Soft Coiled Lengths

Standard Size, in.	Wall Thickness, in. (mm)	Internal Area per Length of Tube, ft ² (m ²)		Residue ^A Limit per 50-ft (15.2-m) Coil, g
		1 ft (0.305 m)	50 ft (15.2 m)	
⅛	0.030 (0.762)	0.0171 (0.001 59)	0.85 (0.0795)	0.0030
⅜	0.030 (0.762)	0.0333 (0.003 09)	1.67 (0.155)	0.0058
¼	0.030 (0.762)	0.0498 (0.004 67)	2.49 (0.234)	0.0087
⅝	0.032 (0.813)	0.6050 (0.006 04)	3.25 (0.302)	0.0114
⅝	0.032 (0.813)	0.0815 (0.007 57)	4.08 (0.379)	0.0143
½	0.032 (0.813)	0.1142 (0.0106)	5.71 (0.530)	0.0200
⅝	0.035 (0.889)	0.1453 (0.0135)	7.26 (0.675)	0.0254
¾	0.035 (0.889)	0.1780 (0.0165)	8.90 (0.827)	0.0312
¾	0.042 (1.07)	0.1744 (0.0162)	8.72 (0.810)	0.0305
⅞	0.045 (1.14)	0.2055 (0.0191)	10.28 (0.955)	0.0360
1⅞	0.050 (1.27)	0.2683 (0.0249)	13.42 (1.24)	0.0470
1⅝	0.055 (1.40)	0.3312 (0.0308)	16.56 (1.54)	0.0580
1⅝	0.060 (1.52)	0.3940 (0.0366)	19.70 (1.83)	0.0690

^A Residue limit 0.0035-g/ft² (0.038-g/m²) inside area.

TABLE 3 Interior Surface Residue Limits of Straight Lengths

Standard Size, in.	Wall Thickness, in. (mm)	Internal Area per Length of Tube, ft ² (m ²)		Residue ^A Limit per 20-ft (6.10-m) Straight Length, g
		1 ft (0.305 m)	20 ft (6.10 m)	
⅜	0.030 (0.762)	0.0824 (0.007 65)	1.65 (0.153)	0.0058
½	0.035 (0.889)	0.1126 (0.0105)	2.25 (0.210)	0.0079
⅝	0.040 (1.02)	0.1427 (0.0133)	2.85 (0.266)	0.0100
¾	0.042 (1.07)	0.1744 (0.0162)	3.49 (0.324)	0.0122
⅞	0.045 (1.14)	0.2055 (0.0191)	4.11 (0.382)	0.0144
1⅞	0.050 (1.27)	0.2683 (0.0249)	5.37 (0.498)	0.0188
1⅝	0.055 (1.40)	0.3312 (0.0308)	6.62 (0.616)	0.0232
1⅝	0.060 (1.52)	0.3940 (0.0366)	7.88 (0.732)	0.0276
2⅞	0.070 (1.78)	0.5197 (0.0423)	10.39 (0.846)	0.0364
2⅝	0.080 (2.03)	0.6453 (0.0599)	12.91 (1.120)	0.0453
3⅞	0.090 (2.29)	0.7710 (0.0716)	15.42 (1.43)	0.0540
3⅝	0.100 (2.54)	0.8966 (0.0833)	17.93 (1.67)	0.0628
4⅞	0.110 (2.79)	1.0220 (0.0949)	20.44 (1.90)	0.0717

^A Residue limit 0.0035-g/ft² (0.038-g/m²) inside area.

13.2 *Wall Thickness and Diameter*—The tolerances for wall thickness and diameter shall conform to the requirements specified in Tables 4 and 5.

13.3 Lengths and Tolerances:

13.3.1 *Standard Lengths and Tolerances*—The standard length for coils shall be 50 ft (15.2 m). The length tolerances for 50-ft coils shall be +12 in. (300 mm) and –0 in. The standard length for straight lengths shall be 20 ft (6.10 m). The length tolerances for 20-ft lengths shall be +1 in. (25 mm) and –0 in.

13.3.2 Tubes supplied in other than standard lengths and tolerances shall be in accordance with requirements established by agreement between the manufacturer or supplier and the purchaser.

13.4 *Roundness*—For drawn unannealed tube in straight lengths, the roundness tolerance as specified in Table 6. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. Roundness tolerance has not been established for annealed tube in straight lengths nor for tubes furnished in coils.

13.5 *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. (0.25 mm) for tube up to and including ⅝-in. (15.9-mm) standard size; and not more than 0.016 in./in. (0.016 mm/mm) of outside diameter, for tube larger than ⅝-in. standard size.

13.6 For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension shall be subject to rejection.

14. Workmanship, Finish and Appearance

14.1 The finished tube shall be smooth, free of internal and external mechanical imperfections, and shall have a clean, bright appearance.

15. Sampling

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

15.1.1 *Lot Size*—The lot size shall be 10 000 lbs (5000 kg) or fraction thereof.

TABLE 4 Standard Dimensions and Weights, and Tolerances in Diameter and Wall Thickness for Coil Lengths

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
				Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall ^B Thickness, Plus and Minus, in. (mm)
1/8	0.125 (3.18)	0.030 (0.762)	0.0347 (0.0516)	0.002 (0.051)	0.003 (0.08)
3/16	0.187 (4.75)	0.030 (0.762)	0.0575 (0.0856)	0.002 (0.051)	0.003 (0.08)
1/4	0.250 (6.35)	0.030 (0.762)	0.0804 (0.120)	0.002 (0.051)	0.003 (0.08)
5/16	0.312 (7.92)	0.032 (0.813)	0.109 (0.162)	0.002 (0.051)	0.003 (0.08)
3/8	0.375 (9.52)	0.032 (0.813)	0.134 (0.199)	0.002 (0.051)	0.003 (0.08)
1/2	0.500 (12.7)	0.032 (0.813)	0.182 (0.271)	0.002 (0.051)	0.003 (0.08)
5/8	0.625 (15.9)	0.035 (0.889)	0.251 (0.373)	0.002 (0.051)	0.004 (0.11)
3/4	0.750 (19.1)	0.035 (0.889)	0.305 (0.454)	0.0025 (0.064)	0.004 (0.11)
7/8	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.0025 (0.064)	0.004 (0.11)
1	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.003 (0.076)	0.004 (0.11)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.665 (0.975)	0.0035 (0.089)	0.005 (0.13)
1 3/8	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.004 (0.10)	0.006 (0.15)
1 1/2	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.0045 (0.11)	0.006 (0.15)

^A The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

^B The tolerances listed represent the maximum deviation at any point.

TABLE 5 Standard Dimensions and Weights, and Tolerances in Diameter and Wall Thickness for Straight Lengths

NOTE 1—Applicable to drawn temper tube only.

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
				Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall ^B Thickness, Plus and Minus, in. (mm)
3/8	0.375 (9.52)	0.030 (0.762)	0.126 (0.187)	0.001 (0.025)	0.003 (0.08)
1/2	0.500 (12.7)	0.035 (0.889)	0.198 (0.295)	0.001 (0.025)	0.004 (0.09)
5/8	0.625 (15.9)	0.040 (1.02)	0.285 (0.424)	0.001 (0.025)	0.004 (0.10)
3/4	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.001 (0.025)	0.004 (0.11)
7/8	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.001 (0.025)	0.004 (0.11)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.655 (0.975)	0.0015 (0.038)	0.004 (0.13)
1 3/8	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.0015 (0.038)	0.006 (0.14)
1 1/2	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.002 (0.051)	0.006 (0.15)
2 1/8	2.125 (54.0)	0.070 (1.78)	1.75 (2.60)	0.002 (0.051)	0.007 (0.18)
2 1/2	2.625 (66.7)	0.080 (2.03)	2.48 (3.69)	0.002 (0.051)	0.008 (0.20)
3 1/8	3.125 (79.4)	0.090 (2.29)	3.33 (4.96)	0.002 (0.051)	0.009 (0.23)
3 1/2	3.625 (92.1)	0.100 (2.54)	4.29 (6.38)	0.002 (0.051)	0.010 (0.25)
4 1/8	4.125 (105)	0.110 (2.79)	5.38 (8.01)	0.002 (0.051)	0.011 (0.28)

^A The average outside diameter of a tube is the average of the maximum and minimum outside diameters as determined at any one cross section of the tube.

^B The tolerances listed represent the maximum deviation at any point.

TABLE 6 Roundness Tolerance

NOTE 1—Applicable to drawn unannealed straight length tube only.

t/D (Ratio of Wall Thickness to Nominal Outside Diameter)	Roundness Tolerance Percent of Nominal 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

15.1.2 *Portion Size*—Sample pieces shall be selected to be representative of the lot as shown in Table 7.

TABLE 7 Sampling Schedule

NOTE 1—Each sample piece shall be taken from a separate tube.

Number of Pieces in Lot	Number of Sample Pieces to be Taken
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 to exceed 10 pieces

15.1.2.1 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 test. The remaining portion of these coils shall be included in the shipment, and the permissible variations in length on such coils shall be waived.

15.2 Chemical Composition:

15.2.1 The sample shall be taken in approximately equal weight from each piece selected in 15.1.2 and prepared in accordance with Practice E 255. The minimum weight of the composite sample shall be 150 g.

15.2.2 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of sampling at the time castings are poured or from the semifinished product. When the composition is determined during the course of manufacture, sampling of the finished product is not required.

15.2.3 The number of samples taken during the course of manufacture shall be as follows:

15.2.3.1 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.

15.2.3.2 When samples are taken from the semifinished

product, a sample shall be taken to represent each 10 000 lbs (5000 kg) or fraction thereof, except that not more than one sample per piece shall be required.

15.3 *Other Tests*—Specimens for all other tests shall be taken from two of the sample pieces selected in 15.1.2. In the event only one sample piece is selected, all specimens shall be taken from that piece.

16. Number of Tests and Retests

16.1 Tests:

16.1.1 Chemical composition shall be reported as the average of results from at least two replicate determinations for each specified element and each determination must meet specification requirement.

16.1.2 Tensile and grain size shall be reported as the average of results from the specimens tested and all specimens must conform to specification requirements.

16.1.3 Specimens for all other tests must meet specification requirements.

16.2 Retest:

16.2.1 When test results obtained by the purchaser fail to conform with the product specification requirement(s), the manufacturer or supplier shall have the option to perform a retest.

16.2.2 Retesting shall be as directed in the product specification for the initial test except for the number of test specimens which shall be twice that normally required for the test. Test results for all specimens shall conform to the product specification requirement(s) in retest and failure to comply shall be cause for lot rejection.

17. Specimen Preparation

17.1 *Chemical Analysis*—Preparation of the analytical specimens for the determination of chemical composition shall be the responsibility of the reporting laboratory.

17.2 Grain Size:

17.2.1 The specimen(s) shall be prepared in accordance with Guide E 3.

17.2.1.1 The surface of the specimen shall approximate a radial longitudinal section of the tube.

17.3 *Tensile*—Tensile test specimens shall be of the full section of the tube and shall conform with the requirements of the Test Specimen section of Test Methods E 8, unless the limitation of the testing machine precludes the use of such specimen in which case test specimen conforming to Type No. 1 of Fig. 13 in Test Methods E 8 shall be used.

17.4 *Electromagnetic (Eddy-Current) Test*—Tubes for this test require no special preparation.

17.5 *Expansion Test*—Test specimens shall be prepared in accordance with the Test Specimen section of Test Method B 153.

18. Test Methods

18.1 Chemical Composition:

18.1.1 Chemical composition, in case of disagreement, shall be determined as follows:

Element	Test Method
Copper	E 53
Phosphorus	E 62

18.1.2 The test method(s) to be followed for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer and the purchaser.

18.2 The tubes shall conform with the physical and mechanical properties and other requirements in this specification when tested in accordance with the following appropriate test method or practice:

Test	Test Method
Grain size	E 112
Tensile	E 8
Expansion (pin test)	B 153
Electromagnetic (eddy-current) test	E 243
Cleanliness	Section 18.2.4

18.2.1 *Grain size*, in case of dispute, shall be determined by the intercept method.

18.2.2 *Tensile strength* shall be determined in accordance with Test Methods E 8.

18.2.2.1 Whenever test results are obtained from both full-size and machined specimens and they differ, the test results from the full-size specimens shall prevail.

18.2.2.2 Test results are not seriously affected by variations in speed of testing. It is not prohibited to use a considerable range of testing speeds, 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).

18.2.3 *Electromagnetic (Eddy-Current) Test*—Each tube up to and including 3 $\frac{1}{8}$ in. (79.4 mm) in outside diameter, shall be subjected to an eddy-current test. Testing shall follow the procedures in Practice E 243. Tubes shall be passed through an eddy-current test unit adjusted to provide information on the suitability of the tube for the intended application.

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

(a) 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.

(b) 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, -0.000 in. of the hole diameter specified.

Tube Outside Diameter, in.	Diameter of Drilled Holes, in.	Drill Number
¼ to ¾, incl	0.025	72
Over ¾ to 1, incl	0.031	68
Over 1 to 1¼, incl	0.036	64
Over 1¼ to 1½, incl	0.042	58
Over 1½ to 1¾, incl	0.046	56
Over 1¾ to 2, incl	0.052	55

Tube Outside Diameter, mm	Diameter of Drilled Holes, mm	Drill Number
6.0 to 19.0, incl	0.635	72
Over 19.0 to 25, incl	0.785	68
Over 25 to 32, incl	0.915	64
Over 32 to 38, incl	1.07	58
Over 38 to 45, incl	1.17	56
Over 45 to 50, incl	1.322	55

18.2.3.2 Alternatively, at the option of the manufacturer, using speed-insensitive eddy-current units that are equipped to select a fraction of the maximum imbalance signal, the following percent maximum imbalance signals shall be used:

Standard Tube Size, in.	Maximum Percent Imbalance Signal Magnitude
Up to ¾, incl	0.2
½ to 2, incl	0.3
Over 2 to 3, incl	0.4

Standard Tube Size, mm	Maximum Percent Imbalance Signal Magnitude
Up to 9, incl	0.2
13 to 50, incl	0.3
Over 50 to 76, incl	0.4

18.2.3.3 Tubes that do not activate the signalling device of the eddy-current tester shall be considered as conforming to the requirements of this test. At the option of the manufacturer, tubes with discontinuities indicated by the testing unit are not prohibited from being 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.

18.2.4 Cleanliness Test:

18.2.4.1 In performing this 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 cutting of the sample. Because of test limitations, it is not required that straight tubes 1¾ in. (35 mm) and over be tested full length. For such tubes, it is not prohibited to test a shorter length to a minimum of 5 ft (1500 mm) with a corresponding reduced maximum permissible residue limit based upon 0.0035 g/ft² (0.038 g/m²) of sample interior surface.

18.2.4.2 Cap, or plug, one end of the tube and fill with solvent to one eighth of its capacity. Cap, or plug, the filling end and roll tube on horizontal supports to thoroughly wash the inside surface. A minimum quantity of 100 mL shall be used for diameters up to ½ in. (12.7 mm) and shall be increased proportionally for the larger sizes.

18.2.4.3 Remove a cap, or plug, and pour the solvent into a suitable clean weighed container. With adequate exhaust, the solvent in the container shall be evaporated to near dryness at a low temperature on a hot plate or sand bath. (**Warning**—Overheating is likely to cause charring of the residue.)

18.2.4.4 Place the container in a drying oven with the temperature set at 105 ± 5°C for 10 min to complete the drying process. When dry, remove the container, cool in a desiccator, and weigh.

18.2.4.5 A blank determination with the same volume of solvent as that poured from the cleaned tube shall be made.

18.2.4.6 Subtract the weight of the blank residue from the weight of the tube cleaning solvent residue. The corrected weight shall then be calculated to grams of residue per internal area of the tube as follows:

$$C = A - B \quad (1)$$

where:

A = weight of blank container plus residue,

B = net weight of empty container, and

C = weight of solvent residue from blank, g.

$$G = [(E - F) - C]/D \quad (2)$$

where:

E = weight of container plus residue from tube,

F = net weight of container,

C = weight of residue from solvent blank,

D = internal area of sample tube, ft² (see Tables 2 and 3),

G = weight of residue from tube, g.

19. Significance of Numerical Limits

19.1 For purposes of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding method of Practice E 29:

Property	Rounded Unit for Observed or Calculated Value
Chemical composition	nearest unit in the last right-hand place of figures of the specified limit
Tensile strength	nearest ksi (5 MPa)
Elongation	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

20. Inspection

20.1 The manufacturer, or supplier, shall inspect and make tests necessary to verify the product furnished conforms to specification requirements.

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

20.3 By mutual agreement, the manufacturer or supplier has the option of conducting the final inspection simultaneously.

21. Rejection and Rehearing

21.1 Rejection:

21.1.1 Product that fails to conform to the requirements of the product specification when inspected or tested by the purchaser, or purchaser's agent, is subject to rejection.

21.1.2 Rejection shall be reported to the manufacturer or supplier promptly and in writing.

21.1.3 The manufacturer or supplier has the option of making a claim for a rehearing in case of dissatisfaction with the results of the test.

21.2 *Rehearing*—As a result of product rejection, the manufacturer or supplier has the option to make claim for retest to be conducted by the manufacturer or supplier and the purchaser. Samples of the rejected product shall be taken in accordance with the product specification and tested by both parties as directed in the product specification, or, alternatively, upon agreement by both parties, an independent laboratory shall be selected for the tests using the test methods prescribed in the product specification.

22. Certification

22.1 When specified in the contract or purchase order, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and requirements have been met.

23. Test Report (Mill)

23.1 When specified in the contract or purchase order, a report of test results shall be furnished.

24. Product Identification

24.1 *Coils*—The name or trademark of the manufacturer and ACR shall be permanently incised on each tube, 1/4-in.

diameter and larger, at intervals not greater than 1½ ft (0.455 m).

24.2 Hard Straight Lengths:

24.2.1 The name or trademark of the manufacturer and the mark indicative of Type L or ACR shall be permanently incised on each tube at intervals not greater than 1½ ft (0.455 m). Tube in the hard temper straight lengths shall be further identified throughout its length by means of a continuous blue-colored stripe, symbol, or logo not less than 3/16 in. (4.76 mm) in height, including a legend repeated at intervals not greater than 3 ft (0.910 m). The legend shall include ACR, name or trademark of the manufacturer, or both, the outside diameter, and country of origin.

24.2.2 Such color marking is not applicable to tube furnished in coils.

NOTE 4—Other information is not prohibited from inclusion in either incise mark or ink marking at the option of the manufacturer.

25. Packaging and Package Marking

25.1 *Packaging*—The product shall be separated by size, composition, and temper. The product shall be 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 normal hazards of transportation.

25.2 *Package Marking*—Each shipping unit shall be legibly marked with the purchase order number, UNS copper designation, temper, size, total length or piece count, or both, and name of the supplier. The specification number shall be shown when specified.

26. Keywords

26.1 air conditioning tube; field service tube; refrigeration tube; seamless copper 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*:¹¹

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

S1.2 *Military Standard*:¹¹

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*:¹¹

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

S2. Quality Assurance

S2.1 *Responsibility for Inspection*—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 has the option 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 ensure 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.

¹¹ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, Attn: NPODS.

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 referred 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.

APPENDIX

(Nonmandatory Information)

X1. METRIC EQUIVALENTS

X1.1 The SI unit for strength properties now shown is in accordance with the International System of Units (SI). The derived SI unit for force is the newton (N), which is defined as that force which when applied to a body having a mass of one kilogram gives it an acceleration of one metre per second squared ($N = \text{kg} \cdot \text{m/s}^2$). The derived SI unit for pressure or

stress is the newton per square metre (N/m^2), which has been named the pascal (Pa) by the General Conference on Weights and Measures. Since $1 \text{ ksi} = 6\,894\,757 \text{ Pa}$, the metric equivalents are expressed as megapascal (MPa), which is the same as MN/m^2 and N/mm^2 .

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 280 – 99^{e1}) that may impact the use of this standard.

(I) Section 3.2.1 was modified to replace nonmandatory language with mandatory language.

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