



Standard Specification for Welded Copper Tube for Air Conditioning and Refrigeration Service¹

This standard is issued under the fixed designation B 640; 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 welded copper tube for air conditioning and refrigeration service for use in connections, repairs, and alterations. The tube shall be made from one of the following coppers:

Copper UNS No.	Previously Used Designation ⁴	Type of Copper
C10100	OFE	oxygen-free electronic
C10200	OF	oxygen-free without-residual oxidants
C12000	DLP	phosphorized, low-residual phosphorus
C12200	DHP	phosphorized, high-residual phosphorus

⁴Designation listed in Classification B 224.

1.2 Copper UNS No. C12200 shall be furnished, unless otherwise specified. The copper tube shall be supplied in annealed coils or drawn temper straight lengths.

1.3 *Units*—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.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

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

2.2 ASTM Standards:

B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing²

B 170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes²

B 224 Classification of Coppers²

B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper²

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² *Annual Book of ASTM Standards*, Vol 02.01.

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast²

B 846 Terminology for Copper and Copper Alloys²

E 3 Practice for Preparation of Metallographic Specimens³

E 8 Test Methods for Tension Testing of Metallic Materials³

E 8M Test Methods for Tension Testing of Metallic Materials [Metric]³

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁴

E 53 Methods for Chemical Analysis of Copper⁵

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁵

E 112 Test Methods for Determining the Average Grain Size³

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes⁶

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁵

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 *coil, n*—a length of the product wound into a series of connected turns. The unqualified term “coiled” as applied to tube usually refers to a bunched coil.

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

3.2.1.2 *level or traverse wound, adj*—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.

3.2.2 *flash, n*—the metal that protrudes at the weld, both on the inside and outside of a tube, as a result of the pressure applied when a forge-type seam is produced. The two types of flash are internal flash and external flash.

3.2.3 *tube, air-conditioning, n*—a welded copper tube conforming to a standard series of sizes and to specified internal

³ *Annual Book of ASTM Standards*, Vol 03.01.

⁴ *Annual Book of ASTM Standards*, Vol 14.02.

⁵ *Annual Book of ASTM Standards*, Vol 03.05.

⁶ *Annual Book of ASTM Standards*, Vol 03.03.

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

cleanness requirements, normally furnished in drawn temper straight lengths, with the ends capped or sealed.

3.2.4 *tube, refrigeration-service, n*—a welded copper tube conforming to a standard series of sizes and to special internal cleanness and dehydration requirements, normally furnished in soft temper coils, with ends capped or sealed.

4. Ordering Information

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

- 4.1.1 ASTM designation and year of issue,
 - 4.1.2 Copper UNS No. designation,
 - 4.1.3 Temper (Section 7),
 - 4.1.4 Dimensions: diameter, wall thickness, length, and so forth (Section 11),
 - 4.1.5 How furnished (coiled lengths or straight lengths), and
 - 4.1.6 Quantity: total weight or number of pieces or coils of each copper, size, and temper.
- 4.2 The following options are available and should be specified at the time of placing the order when required:
- 4.2.1 Hydrogen embrittlement susceptibility (9.3),
 - 4.2.2 Electromagnetic (eddy-current) test on coiled lengths (10.1),
 - 4.2.3 Expansion test (9.1),
 - 4.2.4 Cleanness test (10.2),
 - 4.2.5 Flattening test (9.4),
 - 4.2.6 Reverse bend test (9.5),
 - 4.2.7 Certification (Section 21),
 - 4.2.8 Test report (Section 18), and
 - 4.2.9 When product is purchased for agencies of the U.S. Government (10.3).

5. Materials and Manufacture

5.1 *Material*—The material of manufacture shall be sheet or strip of copper of such quality and soundness as to be suitable for processing into welded tube to meet the properties prescribed herein.

5.2 *Manufacture:*

5.2.1 The product shall be manufactured by forming the material into a tubular shape on a suitable forming mill and welded using an automatic process.

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

5.2.3 The product shall conform to “fully finished tube” as required in 5.2.3.1 and 5.2.3.2:

5.2.3.1 Welded tube with internal and external flash removed by scarfing, and the tube subsequently cold drawn, over a mandrel and annealed as necessary to conform to the specified temper.

5.2.3.2 Welded tube that has been mechanically worked into a smooth tube without the need for internal or external scarfing, or other metal removal and subsequently cold drawn over a mandrel and annealed as necessary to conform to the specified size and temper.

5.2.4 Coiled lengths specified as 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.

5.2.5 Straight lengths specified as 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 product shall conform to the chemical compositional requirements in Table 1 for the Copper UNS No. designation specified in the ordering information.

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

7. Temper

7.1 The standard tempers for products described in this specification are given in Table 2.

7.1.1 Drawn general purpose H58.

7.1.2 Annealed temper O60.

7.2 Tempers are defined in Practice B 601. Other special anneal tempers may be supplied as agreed upon between the manufacturer or supplier and the purchaser.

8. Mechanical Property Requirements

8.1 *Tensile Strength Requirements:*

8.1.1 Product furnished under this specification shall conform to the tensile requirements prescribed in Table 2 when tested in accordance with Test Methods E 8 and E 8M.

8.1.1.1 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength.

9. Performance Requirements

9.1 *Expansion Test:*

9.1.1 When specified in the contract or purchase order, product test specimens from tube furnished in the O60 annealed temper shall be expanded in accordance with Test Method B 153 with an expansion of the outside diameter in the following percentage:

Outside Diameter, in. (mm)	Expansion of Outside Diameter, %
5/8 (15.9) and under	30
Over 5/8 (15.9)	25

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

TABLE 1 Chemical Requirements

Copper or Copper Alloy UNS No.	Composition, %					
	Copper, ^A min	Iron	Zinc	Lead, Max	Phosphorus	Total Other Elements, Max
C10100	99.99 ^B	...	...	...	0.0003 max	...
C10200 ^C	99.95	...	...	...	...	...
C12000	99.90	...	...	...	0.004–0.012	...
C12200	99.9	...	...	...	0.015–0.040	...

^ASilver counting as copper.

^BThis value is exclusive of silver and shall be determined as the difference between the sum of results for all impurity elements listed in Table 1 of Specification B 170 for Grade 1 and 100 %.

^COxygen in C10200 shall be 10 ppm max.

TABLE 2 Mechanical Property Requirements

Copper UNS Nos. C10100, C10200, C12000, and C12200				
Form	Temper	Tensile Strength, Min		Elongation in 2 in. or 50 mm, Min, %
		ksi ^A	MPa ^B	
Coiled lengths	O60	30	205	40
Straight lengths	H58	36	250	...

^Aksi = 1000 psi.
^BSee Appendix X1.

9.2 *Microscopical Examination*—When specified in the contract or purchase order, product test specimens of Copper UNS Nos. C10100, C10200, and C12000 shall be free of cuprous oxide as determined by Test Method A of Test Methods B 577.

9.3 *Hydrogen Embrittlement Susceptibility*—When specified in the contract or purchase order, product test specimens of Copper UNS Nos. C10100, C10200, C12000, and C12200 shall conform to the requirements of Test Method B of Test Methods B 577.

9.4 *Flattening Test:*

9.4.1 When specified in the contract or purchase order, the product test specimens shall be flattened in accordance with the test method described in 16.2.6.

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

9.5 *Reverse Bend Test*—When specified in the contract or purchase order, the product test specimens when flattened and bent in accordance with the test method described in 16.2.7, shall show no evidence of cracks, lack of penetration in the weld, or overlaps resulting from flash removal visible to the unaided eye which are considered unacceptable for the intended application.

10. Other Requirements

10.1 *Electromagnetic (Eddy-Current) Test:*

10.1.1 Each straight length tube, up to and including 3 1/8-in. (79.4-mm) outside diameter, shall be passed through an eddy-current testing unit adjusted to provide information on the suitability of the tube for the intended application.

10.1.2 Tubes that do not actuate the signaling device of the eddy current testing unit shall be considered as conforming to the requirements of the test. Testing shall follow the procedures of Practice E 243, except for the determination of “end effect.”

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

10.1.4 For tubes greater than 3 1/8 in. (79.4 mm) in outside diameter, the manufacturer and purchaser shall agree on whatever nondestructive testing is required.

10.2 *Cleanliness Test:*

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

10.2.1.1 Testing shall follow the procedures in 16.2.9.

10.2.1.2 The maximum amount of residue from the test sample shall not exceed 0.0035 g/ft² of interior surface for tubes as given in Tables 3 and 4.

10.3 *Purchases for Agencies of the U.S. Government*—When specified in the contract or purchase order, product purchased for agencies of the U.S. government shall conform

TABLE 3 Interior Surface Residue Limits of Soft Coiled Lengths^A

Standard Size, in.	Wall Thickness, in. (mm)	Residue Limit ^B per 50 ft (15.2 m) coil, g
	Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200
1/8	0.030 (0.762)	0.0030
3/16	0.030 (0.762)	0.0058
1/4	0.030 (0.762)	0.0087
5/16	0.032 (0.813)	0.0114
3/8	0.032 (0.813)	0.0143
1/2	0.032 (0.813)	0.0200
5/8	0.035 (0.889)	0.0254
3/4	0.035 (0.889)	0.0312
7/8	0.042 (1.07)	0.0305
1	0.045 (1.14)	0.0360
1 1/8	0.050 (1.27)	0.0470
1 1/4	0.055 (1.40)	0.0580
1 1/2	0.060 (1.52)	0.0690

^ASee also Table 5.
^BResidue limit 0.0035-g/ft² (0.038-g/m²) inside area. The internal surface area per foot or tube is determined by the equation (3.1416 × inside diameter × 144)/1728.

TABLE 4 Interior Surface Residue Limits of Straight Lengths^A

Standard Size, in.	Wall Thickness, in. (mm)	Residue Limit ^B per 20 ft (6.10 m), g
	Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200
3/8	0.030 (0.762)	0.0058
1/2	0.035 (0.889)	0.0079
5/8	0.040 (1.02)	0.0100
3/4	...	...
7/8	...	...
1	0.042 (1.07)	0.0122
1 1/8	0.045 (1.14)	0.0144
1 1/4	0.050 (1.27)	0.0188
1 1/2	0.055 (1.40)	0.0232
1 3/4	0.060 (1.52)	0.0276
2	0.070 (1.78)	0.0364
2 1/4	0.080 (2.03)	0.0453
2 1/2	0.090 (2.29)	0.0540
2 3/4	0.100 (2.54)	0.0628
3	0.110 (2.79)	0.0717

^ASee also Table 6.
^BResidue limit 0.0035-g/ft² (0.038-g/m²) inside area. The internal surface area per foot of tube is determined by the equation (3.146 × inside diameter × 144)/1728.

to the requirements stipulated in the Supplementary Requirements.

11. Dimensions, Mass, and Permissible Variations

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

11.2 *Wall Thickness and Diameter:*

11.2.1 *Coil Lengths*—Table 5.

11.2.2 *Straight Lengths*—Table 6.

11.3 *Length:*

11.3.1 The standard length for coils shall be 50 ft (15.2 m). The length tolerances for all coils shall be +12 in. (300 mm) and -0 in.

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

Standard Size, in.	Outside Diameter, in. (mm)	Wall Thickness, in. (mm)	Weight, lb/ft (kg/m)	Tolerances	
		Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200	Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall Thickness, ^{B,C} 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 (0.076)
3/16	0.187 (4.75)	0.030 (0.762)	0.0575 (0.0856)	0.002 (0.051)	0.0025 (0.064)
1/4	0.250 (6.35)	0.030 (0.762)	0.0804 (0.120)	0.002 (0.051)	0.0025 (0.064)
5/16	0.312 (7.92)	0.032 (0.813)	0.109 (0.162)	0.002 (0.051)	0.0025 (0.064)
3/8	0.375 (9.52)	0.032 (0.813)	0.134 (0.199)	0.002 (0.051)	0.0025 (0.064)
1/2	0.500 (12.7)	0.032 (0.813)	0.182 (0.271)	0.002 (0.051)	0.0025 (0.064)
5/8	0.625 (15.9)	0.035 (0.889)	0.251 (0.373)	0.002 (0.051)	0.0030 (0.076)
3/4	0.750 (19.1)	0.035 (0.889)	0.305 (0.454)	0.0025 (0.064)	0.0035 (0.089)
7/8	0.875 (22.3)	0.042 (1.07)	0.362 (0.539)	0.0025 (0.064)	0.0035 (0.089)
1 1/8	1.125 (28.6)	0.045 (1.114)	0.455 (0.677)	0.003 (0.076)	0.004 (0.10)
1 1/4	1.375 (34.9)	0.050 (1.27)	0.665 (0.975)	0.0035 (0.089)	0.004 (0.10)
1 3/8	1.625 (41.3)	0.055 (1.40)	0.884 (1.32)	0.004 (0.10)	0.0045 (0.11)

^AThe 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.

^BThe tolerances listed represent the maximum deviation at any point.

^CMay contain a residual thickening at the weld not to exceed 0.006 in. (0.15 mm) or 10 % of the nominal wall thickness, whichever is greater.

TABLE 6 Standard Dimensions, Weights, and Tolerances for 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	
		Copper UNS Nos. C10100, C10200, C12000, and C12200	Copper UNS Nos. C10100, C10200, C12000, and C12200	Average ^A Outside Diameter, Plus and Minus, in. (mm)	Wall Thickness, ^{B,C} Plus and Minus, in. (mm)
3/8	0.375 (9.52)	0.030 (0.762)	0.126 (0.187)	0.001 (0.025)	0.0035 (0.089)
1/2	0.500 (12.7)	0.035 (0.889)	0.198 (0.295)	0.001 (0.025)	0.0035 (0.089)
5/8	0.625 (15.9)	0.040 (1.02)	0.285 (0.424)	0.001 (0.025)	0.0035 (0.089)
3/4	0.750 (19.1)	0.042 (1.07)	0.362 (0.539)	0.001 (0.025)	0.0035 (0.089)
7/8	0.875 (22.3)	0.045 (1.14)	0.455 (0.677)	0.001 (0.025)	0.004 (0.10)
1 1/8	1.125 (28.6)	0.050 (1.27)	0.655 (0.975)	0.0015 (0.038)	0.004 (0.10)
1 1/4	1.375 (34.9)	0.055 (1.40)	0.884 (1.32)	0.0015 (0.038)	0.0045 (0.11)
1 3/8	1.625 (41.3)	0.060 (1.52)	1.14 (1.70)	0.002 (0.051)	0.0045 (0.11)
2 1/8	2.125 (54.0)	0.070 (1.78)	1.75 (2.60)	0.002 (0.051)	0.006 (0.15)
2 3/8	2.625 (66.7)	0.080 (2.03)	2.48 (3.69)	0.002 (0.051)	0.006 (0.15)
3 1/8	3.125 (79.4)	0.090 (2.29)	3.33 (4.96)	0.002 (0.051)	0.007 (0.18)
3 3/8	3.625 (92.1)	0.100 (2.54)	4.29 (6.38)	0.002 (0.051)	0.007 (0.18)
4 1/8	4.125 (105)	0.110 (2.79)	5.38 (8.01)	0.002 (0.051)	0.009 (0.23)

^AThe 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.

^BThe tolerances listed represent the maximum deviation at any point.

^CMay contain a residual thickening at the weld not to exceed 0.006 in. (0.15 mm) or 10 % of the nominal wall thickness, whichever is greater.

11.3.2 The standard length for straight lengths shall be 20 ft (6.10 m). The length tolerances for all lengths shall be +1 in. (25 mm) and -0 in.

11.4 Roundness:

11.4.1 *Straight Lengths*—For unannealed drawn tube in straight lengths, the roundness tolerance is specified in Table 7.

TABLE 7 Roundness Tolerance

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

<i>t/D</i> (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

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.

11.4.2 *Coil Lengths*—Roundness tolerance has not been established for tubes furnished in coils.

11.5 *Squareness of Cut*—For tube in straight lengths, the deviation from squareness is measured as the difference between one side of a cross section of tube from the opposite side when measured against the projected perpendicularity of the plane of the projected center of the tube. 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 5/8-in. standard size; and not more than 0.016 in./in. (0.016 mm/mm) of outside diameter, for tube larger than 5/8-in. standard size.

NOTE 1—For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension may be cause for rejection.

12. Workmanship, Finish and Appearance

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

13. Sampling

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

13.1.1 *Lot Size*—For tube, the lot size shall be 10 000 lb (4 550 kg) or fraction thereof.

13.1.2 *Portion Size*—Sample pieces shall be taken for test purposes from each lot in accordance with the following schedule:

Number of Pieces in Lot	Number of Sample Pieces to Be Taken ^A
1 to 50	1
51 to 200	2
201 to 1500	3
Over 1500	0.2 % of the total number of the in the lot, but not to exceed 10 sample pieces

^AEach sample piece shall be taken from separate tube.

13.2 Chemical Analysis:

13.2.1 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 13.1.2 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.

13.2.1.1 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semifinished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, the manufacturer shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

(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.

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

(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.

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

13.3 For other tests, unless otherwise provided in the product specification, test specimens shall be taken from two of the sample pieces selected in accordance with 13.1.2.

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

14. Number of Tests and Retests

14.1 Tests:

14.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element mean of the results from at least two replicate analyses of the samples, and the results of each replication must meet the requirements of the product specification.

14.1.2 *Other Tests*—Tensile strength, grain size, and elongation shall be reported as individual test results obtained from each of two pieces selected in accordance with 13.1.2, and each specimen must meet the requirements of the product specification.

14.1.2.1 When only one piece is to be sampled, all specimens shall be taken from the piece selected.

14.1.2.2 *Grain Size*—The average grain size of each specimen shall be the arithmetic average of at least three different fields.

14.2 Retests:

14.2.1 When requested by the manufacturer or supplier, a retest shall be permitted when test results obtained by the purchaser fail to conform to the requirement(s) of the product specification.

14.2.2 The retest shall be as directed in the product specification for the initial test, except the number of test specimens shall be twice that normally required for the specified test.

14.2.3 All test specimens shall conform to the product specification requirement(s) in retest. Failure to comply shall be cause for rejection.

15. Specimen Preparation

15.1 *Chemical Analysis*—Preparation of the analytical test specimen shall be the responsibility of the reporting laboratory.

15.2 *Tensile Test*—Tension test specimens shall be of the full section of the tube and shall conform to the requirements of the Specimen for Pipe and Tube section of Test Methods E 8 and E 8M unless the limitations of the testing machine preclude the use of such a specimen. Test specimens conforming to Fig. 13, Tension Test Specimens for Large-Diameter Tubular Products, and the Specimen for Pipe and Tube section of Test Methods E 8 and E 8M may be used when a full-section specimen cannot be tested.

15.3 *Grain Size*—Test specimen shall be prepared in accordance with Practice E 3.

15.4 *Microscopical Examination*—The test specimen shall be prepared in accordance with Test Method A of Test Methods B 577.

15.5 *Hydrogen Embrittlement Susceptibility*—The test specimen shall be prepared in accordance with Test Method B of Test Methods B 577.

15.6 *Expansion Test*—The test specimen shall conform to

the requirements of the Specimen Preparation section of Test Methods B 153.

15.7 *Flattening Test*—A test specimen shall be cut to a length that will allow the tube to be flattened at three places along the length, with each flattened area to be at least 2 in. (50.8 mm) in length. When the temper is other than annealed, the sample may be annealed prior to testing.

15.8 *Reverse Bend Test*:

15.8.1 A representative tube sample shall be cut to a length that will accommodate the test. The sample is permitted to be annealed when the temper is other than annealed.

15.8.2 The product test specimen shall be cut longitudinally, 90° on each side of the weld, when visible or identifiable.

15.9 *Cleanness Test*—A section of straight tube, or a section of a straightened tube from the outside end of a coil, not less than 5 ft (1.5 m), shall be selected.

16. Test Methods

16.1 *Chemical Analysis*:

16.1.1 Composition shall be determined, in case of disagreement, as follows:

Element	Test Methods
Copper	E 53
Phosphorus	E 62

16.1.1.1 Refer to Annex 1 of Specification B 170 for test methods to be followed in the determination of composition for copper C10100 and oxygen in copper C10200.

16.1.1.2 Test methods for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer and the purchaser.

16.2 *Other Tests*:

16.2.1 The product furnished shall conform to all other requirements when subjected to tests in accordance with the following table.

Requirement	ASTM Standard
Grain size	E 112
Tensile strength	E 8
Expansion test	B 153
Microscopical examination	Test Method A, B 577
Hydrogen embrittlement susceptibility	Test Method B, B 577
Flattening test	16.2.6
Reverse bend test	16.2.7
Electromagnetic (eddy-current) test	E 243
Cleanness test	16.2.9

16.2.2 *Grain Size*—In case of dispute, the intercept method shall be followed.

16.2.3 *Tensile Strength*, shall be determined in accordance with Test Methods E 8 and E 8M. Whenever different tension test results are obtained from both full-size and machined specimens, the results obtained from full-size specimens shall be used to determine conformance to the requirements of this specification.

16.2.3.1 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 (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).

16.2.4 *Microscopical Examination*—In case of a dispute, Test Method C of Test Methods B 577 shall be followed.

16.2.5 *Hydrogen Embrittlement Susceptibility*—In case of a dispute, Test Method C of Test Methods B 577 shall be followed.

16.2.6 *Flattening Test*—Each test specimen shall be flattened in a press three times. The weld shall be placed in the position of maximum bend on at least two of the three flattened areas. The other position can be without regard to the position of the weld. Each flattened area shall be at least 2 in. (50.8 mm) in length. A flattened test specimen shall allow a micrometer caliper set at three times the wall thickness to pass freely over the flattened area.

16.2.7 *Reverse Bend Test*—The test specimen shall be flattened and bent around a mandrel with a diameter four times the wall thickness, with the mandrel parallel to the length and in contact with the outside surface of the tube. The weld shall be placed at the point of maximum bend.

16.2.8 *Electromagnetic (Eddy-Current) Test*:

16.2.8.1 Either notch-depth or drilled-hole, artificial discontinuity, calibration standards shall be used.

16.2.8.2 The depth of the round bottom traverse notches, rounded to the nearest 0.001 in. (0.025 mm), shall be 22 % of the nominal wall thickness with a tolerance of ±0.0005 in. (±0.013 mm).

16.2.8.3 The diameters of the drilled holes in the artificial discontinuity, calibration standard used to adjust the sensitivity of the testing unit are shown in Table 8 and shall not vary by more than +0.001, -0.000 in. (+0.026, -0.000 mm) of the hole diameter specified.

16.2.8.4 The manufacturer shall have the option of using a speed insensitive, eddy-current unit that is equipped capable of selecting a fraction of the maximum unbalance signal. In such instances, the following percent maximum unbalance signals shall be used:

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

16.2.8.5 The specimens with discontinuities used to calibrate the testing unit shall be permitted to be placed in the strip from which the tube will be manufactured. These calibration discontinuities will pass through the continuous operations of forming, welding, and eddy-current testing. The testing unit sensitivity required to detect the resultant discontinuities shall be equivalent to or greater than that required to detect the

TABLE 8 Diameter of Drilled Holes

Tube Outside Diameter, in. (mm)	Diameter of Drilled Holes, in. (mm)	Drill Number
1/4 to 3/4 (6.0 to 19.0), incl	0.025 (0.635)	72
Over 3/4 to 1 (19.0 to 25), incl	0.031 (0.785)	68
Over 1 to 1 1/4 (25 to 32), incl	0.036 (0.915)	64
Over 1 1/4 to 1 1/2 (32 to 38), incl	0.042 (1.07)	58
Over 1 1/2 to 1 3/4 (38 to 45), incl	0.046 (1.17)	56
Over 1 3/4 to 2 (45 to 50), incl	0.052 (1.32)	55

notches or drilled holes.

16.2.8.6 The round-bottom, traverse-notch, calibration discontinuities shall be on the outside tube surface or inside tube surface. The discontinuities, notch or drilled hole, shall be spaced to provide signal resolution adequate for interpretation. Each calibration discontinuity shall be detected by the testing unit.

16.2.8.7 Tubes with discontinuities indicated by the testing unit may, 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.

16.2.9 Cleaness Test:

16.2.9.1 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 of copper chips or dust in the residue resulting from the cutting of the sample. Because of test limitations, it is not required that straight-length tubes 1 $\frac{3}{8}$ in. (35 mm) and larger be tested in full lengths. For such tubes, shorter lengths 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.

16.2.9.2 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 tubes on horizontal supports to thoroughly wash the inside surface. A minimum quantity of 100 mL shall be used for diameters up to $\frac{1}{2}$ in. (12.7 mm) and shall be increased proportionately for the larger sizes.

16.2.9.3 Remove the 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. Overheating should be avoided to prevent charring of the residue.

16.2.9.4 Place the container in a drying oven with the temperature at 212 to 230°F (100 to 110°C) for 10 min. When dry, remove the container, cool in a desiccator, and weigh.

16.2.9.5 A blank determination shall be run on the same quantity of solvent as that used for the actual examination of the tube sample.

16.2.9.6 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 3 and 4), and

G = weight of residue from tube, g/ft².

17. Significance on Numerical Limits

17.1 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

18. Report

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

19. Inspection

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

19.2 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 case, the nature of the facilities needed to satisfy the inspector representing the purchaser 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.

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

20. Rejection and Rehearing

20.1 Rejection:

20.1.1 Product that fails to conform to the specification requirements, when tested by the purchaser or purchaser's agent, may be rejected.

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

20.1.3 In case of dissatisfaction with the results of the test upon which rejection is based, the manufacturer or supplier may make claim for a rehearing.

20.2 *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 the product specification and subjected to test by both parties using the test method(s) specified in the product specification, or, upon agreement of both parties, an independent laboratory may be selected for the test(s) using the test method(s) specified in the product specification.

21. Certification

21.1 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.

22. Product Marking

22.1 The name or trademark of the manufacturer and “ACRW” shall be permanently marked (incised) on the tube at intervals not greater than 18 in. (460 mm).

22.2 Straight length tube in H58 (drawn, general purpose) temper shall be further identified throughout its length by a continuous yellow colored stripe, symbol, or logo not less than $\frac{3}{16}$ in. (4.76 mm) in height, including a legend repeated at intervals not greater than 3 ft (0.91 m). The legend shall include “ACRW,” the name or trademark, or both, of the manufacturer, and the country of origin. Other information may be included at the option of the manufacturer.

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

23. Packaging and Package Marking

23.1 *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 and to afford protection from the normal hazards of transportation.

23.2 *Package Marking*—Each shipping unit shall be legibly marked with the purchase order number; metal or alloy designation; temper; size; shape; total length or piece count, or both; gross and net weight; and name of supplier. The specification number shall be shown when specified.

24. Keywords

24.1 air conditioning; copper; refrigeration; welded 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*:⁷

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

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

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

S1.1.2 *Military Standard*:⁷

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*:⁷

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 may use his own or any other suitable facilities for the performance of the inspection and test requirements specified unless disapproved

by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in the specification where such inspections 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.

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 and packed, Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of MIL-C-3993.

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

S4.2 *Marking*:

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

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

⁷ Available from Naval Publications and Forms Center, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, ATTN: NPODS.

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 ($N = \text{kg}\cdot\text{m}/\text{s}^2$). 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

Subcommittee B05.04 has identified the location of selected changes to this standard since the last issue (B 640 – 93) that may impact the use of this standard.

B 640 – 00:

(1) Copper UNS Nos. C10300 and C10800 and Copper Alloy UNS Nos. C19200 and C19400 were removed.

(2) A five-year review was conducted. Editorial changes were made to incorporate current form and style practices.

(3) The following sections were added: Temper, Performance Requirements, Specimen Preparation, Report, Inspection, Certification, Product Marking, Keywords, and Summary of Changes.

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