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Standard Specification for Copper-Beryllium Welded Heat Exchanger and Condenser Tube (UNS No. C17510)[1]

This standard is issued under the fixed designation B944; 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 copper-beryllium alloy UNS No. C17510 welded tube in straight lengths.

1.2 *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.

1.3 *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:*[2]

B153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing
B194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
B846 Terminology for Copper and Copper Alloys
E8/E8M Test Methods for Tension Testing of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E243 Practice for Electromagnetic (Eddy Current) Examination of Copper and Copper-Alloy Tubes
E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method

3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.

4. Ordering Information

4.1 Include the following information when placing orders for product under this specification, as applicable:

4.1.1 ASTM designation and year of issue,
4.1.2 Copper Alloy UNS No. designation,
4.1.3 Temper (Section 7),
4.1.4 Dimensions, diameter, and wall thickness (Section 12). For tube or pipe, specify either OD/wall, ID/wall, or OD/ID,
4.1.5 Minimum wall thickness or average (nominal) wall thickness,
4.1.6 Tube length, specific or random, and
4.1.7 *Quantity*—Total weight or total length or number of pieces of each size.

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

4.2.1 Hydrostatic test,
4.2.2 Pneumatic test,
4.2.3 Weld bead conditioning, and
4.2.4 Certification.

5. Materials and Manufacture

5.1 *Materials*—The material of manufacture shall be sheet or strip of UNS Alloy No. C17510 of such purity and soundness to be suitable for processing into the products prescribed herein.

5.2 *Manufacture*—The product shall be manufactured from cold rolled strip which is subsequently formed and welded by an automatic welding process without the addition of filler metal.

6. Chemical Composition

6.1 Material shall conform to the chemical composition requirements in Table 1 for Copper Alloy UNS No. C17510.

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

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Chemical Requirements

Composition, %	
Element	UNS No. C17510
Beryllium	0.2–0.6
Cobalt, max	0.3
Nickel	1.4–2.2
Iron, max	0.10
Aluminum, max	0.20
Silicon, max	0.20
Copper	Remainder

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

6.3 For alloys in which copper is listed as "Remainder," copper is the difference between the sum of results of all elements determined and 100 %. When all elements in Table 1 are determined, the sum of results shall be 99.5 % min.

7. Temper

7.1 The standard temper for products described in this specification is TF00 (precipitation hardened) as defined in Classification B601.

8. Physical Property Requirements

8.1 *Electrical Conductivity*—Product furnished to this specification shall conform to the electrical conductivity requirement given in Table 2, when tested in accordance with Test Method E1004.

9. Mechanical Property Requirements

9.1 *Tensile Strength Requirements:*

9.1.1 Product furnished under this specification shall conform to the tensile requirements prescribed in Table 2, when tested in accordance with Test Methods E8/E8M.

9.2 When specified in the contract or purchase order, the product shall conform to the Rockwell hardness requirement prescribed in Table 2 when tested in accordance with Test Methods E18.

9.2.1 The approximate Rockwell hardness values given in Table 2 are for general information and assistance in testing, and shall not be used as a basis for product rejection.

10. Performance Requirements

10.1 *Expansion Test Requirements*—Tube specimens selected for test shall withstand an expansion of 15 % when expanded in accordance with Test Method B153. This is defined as expansion of tube outside diameter in percent of original outside diameter. The expanded tube shall show no cracking or rupture visible to the unaided eye.

10.2 *Flattening Test Requirements*—Test specimens at least 4 ft in length shall be flattened on different elements throughout the length remaining after specimens for the expansion and metallographic tests have been taken. Each element shall be slowly flattened by one stroke of a press. The term "flattened" shall be interpreted as follows: A micrometer caliper set at three times the wall thickness shall pass over the tube freely throughout the flattened part except at the points where the change in element of flattening takes place. The flattened elements shall not show cracking or rupture visible to the unaided eye. The weld when visible or identifiable shall be placed in the position of maximum bend on one half of the flattened elements.

10.3 *Reverse Bend Test Requirements*—A section 4 in. in length shall be split longitudinally 90° on each side of the weld. The sample shall then be opened and bent around a mandrel with a diameter four times the wall thickness, with the mandrel parallel to the weld and on the outside of the tube. The weld when visible or identifiable shall be at the point of maximum bend. There shall be no evidence of cracks, or lack of penetration in the weld.

11. Other Requirements

11.1 Each tube shall be subjected to an eddy-current test. The purchaser may specify either of the tests in 11.2 or 11.3 as an alternative to the eddy-current test.

11.1.1 *Eddy Current Test*—Each tube shall be passed through an eddy-current testing unit adjusted to provide information on the suitability of the tube for the intended application. Testing shall follow the procedures of Practice E243, except as modified in 11.1.1.2.

11.1.1.1 The depth of the round-bottom transverse notches and the diameters of the drilled holes in the calibrating tube used to adjust the sensitivity of the test unit are shown in Table 3 and Table 4 respectively.

11.1.1.2 The discontinuities used to calibrate the test system may 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 test unit sensitivity required to detect the resultant discontinuities shall be equivalent to or greater than that required to detect the notches or drilled holes of Table 3 and Table 4 respectively, or other calibration discontinuities that may be used by mutual agreement between the manufacturer or supplier and the purchaser. Calibration discontinuities may be on the outside tube surface, the internal tube surface, or through the tube wall and shall be spaced to provide signal resolution adequate for interpretation. Each calibration discontinuity shall be detected by the eddy-current tester.

11.1.1.3 Tubes that do not actuate the signaling device of the eddy-current tester shall be considered as conforming to the

TABLE 2 Mechanical Property and Electrical Conductivity Requirements After Precipitation Heat Treatment

Temper Designation		Tensile Strength		Elongation in 2 in. (50 mm), % min	Yield Strength, ksi min, 0.2 % Offset		Rockwell Hardness B	Electrical Conductivity IACS min, %
Standard	Former	ksi	MPa		ksi	MPa		
TF00	AT	100–130	(690–895)	10	80	(550)	92–100	45

TABLE 3 Notch Depth

Specified Wall Thickness, in.	Outside Diameter, in.		
	0.625 to 0.750, incl.	Over 0.750 to 1.250, incl.	Over 1.250 to 2.000, incl.
Over 0.017–0.032	0.005	0.006	0.007
Incl. 0.032–0.049	0.006	0.006	0.008
Incl. 0.049–0.083	0.007	0.008	0.008

TABLE 4 Diameter of Drilled Holes

Outside Diameter, in.	Diameter of Drilled Holes, in.	Drill No.
0.250–1.000, incl.	0.031	68
Over 1.000–1.025, incl.	0.036	64
Over 1.250–1.500, incl.	0.042	58
Over 1.500–1.750, incl.	0.046	56
Over 1.750–2.000, incl.	0.052	55

requirements of this test. Tubes causing irrelevant signals because of moisture, soil, and like effects may be reconditioned and retested. Such tubes, when retested to the original test parameters, shall be considered to conform if they do not cause output signals beyond the acceptable limits. Tubes causing irrelevant signals because of visible and identifiable handling marks may be retested by the hydrostatic test prescribed in 11.2, or the pneumatic test prescribed in 11.3. Tubes meeting requirements of either test shall be considered to conform if the tube dimensions are within the prescribed limits, unless otherwise agreed to by the manufacturer or supplier and the purchaser.

11.2 *Hydrostatic Test*—When specified, each tube shall withstand, without showing evidence of leakage, an internal hydrostatic pressure sufficient to subject the material to a fiber stress of 7000 psi, determined by the following equation for thin hollow cylinders under tension. The tube need not be tested at a hydrostatic pressure of over 1000 psig unless so specified.

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

where:

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

11.3 *Pneumatic Test*—When specified, each tube shall be subjected to an internal air pressure of 100 psig minimum 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. Any evidence of leakage shall be cause for rejection.

12. Dimensions, Mass, and Permissible Variations

12.1 Dimensions and tolerances for product described by this specification shall be as specified: Wall Thickness, Table 3; Diameter, Table 4; Length, Table 5; and Straightness, Table 6.

12.1.1 Tolerances on a given tube may be specified with respect to any two, but not all three, of the following: outside diameter, inside diameter, wall thickness.

TABLE 5 Wall Thickness Tolerances

Specified Wall Thickness, in.	Outside Diameter, in.		
	0.625 to 1.00, incl.	Over 1.00 to 2.00, incl.	Over 2.00 to 3.00, incl.
	Wall Thickness Tolerances, Plus and Minus, in.		
0.020 incl. to 0.032	0.004	0.004	0.004
0.032 incl. to 0.035	0.004	0.004	0.005
0.035 incl. to 0.058	0.006	0.006	0.006
0.058 incl. to 0.083	0.008	0.008	0.008

TABLE 6 Diameter Tolerances

Outside Diameter, in.	Wall Thickness, in.			
	0.020 incl. to 0.032	0.032 incl. to 0.035	0.035 incl. to 0.058	0.058 incl. to 0.083
	Diameter Tolerance, Plus and Minus, in.			
0.625 incl. to 0.740	0.006	0.006	0.005	0.005
0.740 incl. to 1.000	0.006	0.006	0.005	0.004
1.000 incl. to 1.250	0.008	0.008	0.007	0.006
1.250 incl. to 1.500	0.008	0.008	0.008	0.007
1.500 incl. to 3.000	0.008	0.008	0.008	0.008

12.2 Wall-thickness tolerances shall be in accordance with Table 5.

12.2.1 *Tubes Ordered to Minimum Wall*—No tube at its thinnest point shall be less than the specified wall thickness or greater than the specified wall thickness plus twice the tolerance values shown in Table 5.

12.2.2 *Tubes Ordered to Nominal Wall*—The maximum plus and minus deviation from the nominal wall at any point shall not exceed the values shown in Table 5.

12.3 Diameter Tolerances shall be in accordance with Table 6.

12.3.1 *Diameter*—The outside diameter of the tubes shall not vary from that specified by more than the amounts shown in Table 6 as measured by "go" and "no-go" ring gauges. If no values are shown in the table, dimensions shall be as agreed between the Purchaser and the manufacturer or supplier.

12.4 Length Tolerances shall be in accordance with Table 7.

12.4.1 *Length*—The length of the tubes shall not be less than that specified but may exceed the specified value by the amounts given in Table 7

12.5 *Squareness*—The departure from squareness of the end shall not exceed 0.016 in./in. of diameter.

12.6 Straightness Tolerances shall be in accordance with Table 8.

12.6.1 For lengths greater than 10 ft the maximum curvature shall not exceed ½ in. in any 10-ft portion of the total length.

13. Workmanship, Finish, and Appearance

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

TABLE 7 Length Tolerances

Specified Length, ft	Tolerance, all plus, in.
Up to 30, incl.	0.125
Over 30–60, incl.	0.250
Over 60–100, incl.	0.375