



Designation: B372 – 11

Standard Specification for Seamless Copper and Copper-Alloy Rectangular Waveguide Tube¹

This standard is issued under the fixed designation B372; 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 and copper-alloy rectangular tube intended for use as transmission lines in electronic equipment. Five types of material are specified having the following nominal compositions:²

Copper or Copper Alloy UNS ² No.	Previously Used Designation	Nominal Composition, %		
		Copper	Zinc	Phos- phorus
C10100	Copper, Type OFE ^A	99.99	...	...
C10200	Copper, Type OF ^A	99.95	...	...
C10300	Copper, Type OFXLP ^A	99.95	...	0.003
C12000	Copper, Type DLP ^A	99.90	...	0.008
C22000	Commercial bronze, 90 %	90	10	...

^A Types OF, OFE, OFXLP, and DLP are described in Classification B224.

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

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*:³

B170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes

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

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

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard’s Document Summary page on the ASTM website.

B193 Test Method for Resistivity of Electrical Conductor Materials

B224 Classification of Coppers

B428 Test Method for Angle of Twist in Rectangular and Square Copper and Copper Alloy Tube

B577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper

B846 Terminology for Copper and Copper Alloys

E18 Test Methods for Rockwell Hardness of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁴

E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

E478 Test Methods for Chemical Analysis of Copper Alloys

2.3 *Other Standard:*

ANSI B46.1 Surface Roughness, Waviness, and Lay⁵

3. Terminology

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

4. Ordering Information

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

4.1.1 Material (Sections 1 and 6),

4.1.2 Outer and inner rectangular dimensions (Section 11),

4.1.3 Length (see 11.6),

4.1.4 Total length of each size,

4.1.5 Special packaging, if required (Section 19),

4.1.6 Embrittlement test, if required (Section 9),

4.1.7 Electrical resistivity test, if required (Section 10), and

⁴ Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

4.1.8 Special finish, if required (see 12.2).

5. Materials and Manufacture

5.1 The material shall be of such quality and purity that the finished product shall have the properties and characteristics prescribed in this specification, and shall be cold drawn to size.

5.2 The copper will normally be of the types given in Table 1, but may be of such other types as may be agreed upon between the manufacturer or supplier, and the purchaser.

5.3 The copper and copper-alloy tubes shall be finished by such cold-working and annealing operations as are necessary to meet the required properties.

6. Chemical Composition

6.1 The material shall conform to the chemical requirements specified in Table 1.

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

6.3 For copper alloys in which zinc is specified as the remainder, either copper or zinc may be taken as the difference between the sum of all the elements analyzed and 100 %.

6.3.1 Alloy C22000—When all the elements in Table 1 are analyzed, their sum shall be 99.8 % minimum.

7. Rockwell Hardness

7.1 The material shall conform to the Rockwell hardness requirements prescribed in Table 2.

8. Microscopical Examination

8.1 The test specimens of Copper UNS Nos. C10100, C10200, C10300, and C12000 shall be free of cuprous oxide as determined by Procedure A of Test Methods B577. In case of a dispute, a referee method in accordance with Procedure C shall be employed.

9. Embrittlement Test

9.1 It is to be expected that samples of Copper UNS Nos. C10100, C10200, C10300, and C12000 covered by this speci-

TABLE 1 Chemical Requirements

Element	Composition, %				
	Copper UNS Nos.				Copper Alloy UNS No. C22000
	C10100 ^A	C10200 ^B	C10300	C12000	
Copper ^C	99.99 min	99.95 min	...	99.90 min	89.0–91.0
Copper, ^C + phosphorus, min	...	...	99.95	...	...
Phosphorus	0.0003 max	...	0.001–0.005	0.004–0.012	...
Zinc	0.0001 max	...	...	...	remainder
Lead, max	0.0005	...	...	...	0.05
Iron, max	0.0010	...	...	...	0.05

^A The following additional impurity maximum limits shall apply: As 0.0005%, Sb 0.0004%, Te 0.0002%, O 0.0005%, Bi 0.0001%, Cd 0.0001%, Mn 0.00005%, Ni 0.0010%, Se 0.0003%, Ag 0.0025%, S 0.0015% and Sn 0.0002%.

^B Oxygen in C10200 shall be 10 ppm max.

^C Silver counting as copper.

TABLE 2 Hardness Requirements

Copper or Copper Alloy UNS No.	Rockwell Hardness, 30T Scale ^A
C10100	30 min
C10200	30 min
C10300	30 min
C12000	30 min
C22000	43 to 66

^A The tube shall be split along the center line of its narrow side, and Rockwell hardness readings then taken on its inner surface.

fication shall be capable of passing the embrittlement test of Procedure B of Test Methods B577. The actual performance of this test is not mandatory under the terms of this specification unless definitely specified in the ordering information. In case of a dispute, a referee method in accordance with Procedure C shall be employed.

10. Electrical Resistivity

10.1 It is to be expected that samples of Copper UNS Nos. C10100, C10200, C10300, and C12000 covered by this specification will conform to the following electrical resistivity requirements, although actual determination of this property is not mandatory under the terms of this specification unless definitely specified. The electrical resistivity of representative samples of Copper UNS No. C10100, shall not exceed 0.15585 Ω·g/m², C10200 shall not exceed 0.15737 Ω·g/m² and Copper UNS No. C10300 shall not exceed 0.15940 Ω·g/m² and Copper UNS No. C12000 shall not exceed 0.17418 Ω·g/m² when tested at 68°F (20°C).

NOTE 1—The International Annealed Copper Standard electrical conductivity equivalents are as follows:

Electrical Resistivity, Ω·g/m ²	Conductivity, %
0.15176	101.00
0.15328	100.00
0.15585	
0.15614	98.16
0.15737	97.40
0.15940	96.16
0.17031	90
0.17418	88

11. Dimensions and Permissible Variations

11.1 General:

11.1.1 The standard method of specifying, ordering, and measuring rectangular waveguide tube shall be major by minor outer dimension and major by minor inner dimension.

11.1.2 All cross-sectional measurements shall be made at the corners at a point at least ½ in. (12.7 mm) from the ends.

11.1.3 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.

11.2 Dimensional Tolerances:

11.2.1 Standard dimensions and tolerances of waveguide tube shall be as specified in Table 3.

11.2.2 Other dimensions and tolerances shall be subject to agreement between the manufacturer or supplier and the purchaser.

TABLE 3 Dimensional Tolerances

Outer Dimensions, in. (mm)			Inner Dimensions, in. (mm)			Nominal Wall Thickness, in. (mm)
Major Dimensions	Minor Dimensions	Tolerance, plus and minus	Major Dimensions	Minor Dimensions	Tolerance, plus and minus	
0.420 (10.7)	0.250 (6.35)	0.003 (0.076)	0.340 (8.64)	0.170 (4.32)	0.002 (0.051)	0.040 (1.02)
0.500 (12.7)	0.250 (6.35)	0.003 (0.076)	0.420 (10.7)	0.170 (4.32)	0.002 (0.051)	0.040 (1.02)
0.590 (15.0)	0.335 (8.51)	0.003 (0.076)	0.510 (13.0)	0.255 (6.48)	0.002 (0.051)	0.040 (1.02)
0.702 (17.8)	0.391 (9.93)	0.003 (0.076)	0.622 (15.8)	0.311 (7.90)	0.002 (0.051)	0.040 (1.02)
0.850 (21.6)	0.475 (12.1)	0.003 (0.076)	0.750 (19.0)	0.375 (9.52)	0.003 (0.076)	0.050 (1.27)
1.000 (25.4)	0.500 (12.7)	0.004 (0.10)	0.900 (22.9)	0.400 (10.2)	0.004 (0.10)	0.050 (1.27)
1.250 (31.8)	0.625 (15.9)	0.004 (0.10)	1.122 (28.5)	0.497 (12.6)	0.004 (0.10)	0.064 (1.63)
1.500 (38.1)	0.750 (19.0)	0.004 (0.10)	1.372 (34.8)	0.622 (15.8)	0.004 (0.10)	0.064 (1.63)
1.718 (43.6)	0.923 (23.4)	0.005 (0.13)	1.590 (40.4)	0.795 (20.2)	0.005 (0.13)	0.064 (1.63)
2.000 (50.8)	1.000 (25.4)	0.005 (0.13)	1.872 (47.5)	0.872 (22.1)	0.005 (0.13)	0.064 (1.63)
2.418 (61.4)	1.273 (32.3)	0.006 (0.15)	2.290 (58.2)	1.145 (29.1)	0.006 (0.15)	0.064 (1.63)
3.000 (76.2)	1.500 (38.1)	0.006 (0.15)	2.840 (72.1)	1.340 (34.0)	0.006 (0.15)	0.080 (2.03)
3.560 (90.4)	1.860 (47.2)	0.006 (0.15)	3.400 (86.4)	1.700 (43.2)	0.006 (0.15)	0.080 (2.03)
4.460 (113)	2.310 (58.7)	0.008 (0.20)	4.300 (109)	2.150 (54.6)	0.008 (0.20)	0.080 (2.03)
5.260 (134)	2.710 (68.8)	0.008 (0.20)	5.100 (130)	2.550 (64.8)	0.008 (0.20)	0.080 (2.03)
6.660 (169)	3.410 (86.6)	0.008 (0.20)	6.500 (165)	3.250 (82.6)	0.008 (0.20)	0.080 (2.03)

11.3 *Corner Radii*—Outer corner radii shall be 0.015 in. (0.381 mm) min and 0.032 in. (0.813 mm) max. Maximum inner corner radii shall be as specified in [Table 4](#).

11.4 *Eccentricity*—The maximum allowable eccentricity, defined as one-half the difference between the maximum and minimum opposite wall thicknesses as measured at any cross section perpendicular to the longitudinal axis, shall be in accordance with [Table 5](#).

11.5 *Rectangularity*—The adjoining faces of the tube shall be as square in relation to each other as the best mill practice will permit.

11.6 *Length*—Unless otherwise specified, waveguide tube shall be furnished in 12-ft (3.66-m) standard (stock) straight lengths with ends. The shortest permissible length of the ends shall not be less than 60 % of the nominal length (specific and stock), and the maximum permissible weight of ends shall not exceed 25 % of the lot weight. Waveguide tube, ordered to specific or stock lengths, with or without ends, shall conform to the tolerances prescribed in [Table 6](#).

11.7 *Squareness of Cut*—The departure from the squareness of the end of any tube shall not exceed 0.010 in. (0.25 mm) for tube up to 5/8-in. (15.9-mm) dimension, inclusive, across the

TABLE 4 Permissible Inner Corner Radii

Nominal Wall Thickness, in. (mm)	Permissible Inner Corner Radii, max, in. (mm)
0.040 (1.02)	0.016 (0.41)
0.050 (1.27)	0.032 (0.81)
0.064 (1.63)	0.032 (0.81)
0.080 (2.03)	0.047 (1.2)

TABLE 5 Eccentricity Tolerances

Specified Major Outer Dimension, in. (mm)	Allowable Eccentricity, ^A max, in. (mm)
0.420 to 0.850 (10.7 to 21.6), excl	0.003 (0.08)
0.850 to 2.418 (21.6 to 61.4), excl	0.004 (0.10)
2.418 to 3.000 (61.4 to 76.2), excl	0.005 (0.13)
3.000 to 3.560 (76.2 to 90.4), excl	0.006 (0.15)
3.560 to 4.460 (90.4 to 113), excl	0.007 (0.18)
4.460 to 6.660 (113 to 169), incl	0.008 (0.20)

^A Applicable only to those sizes of tubes shown in [Table 3](#). See [11.2.2](#).

TABLE 6 Length Tolerances

Length, ft (m)	Tolerance, ^A plus in. (mm)
Standard (stock)	1 (25)
Specific:	
Up to 14 (4.27), incl	1/4 (6.4)
Over 14 (4.27)	1/2 (13)

^A Applicable only to full-length pieces.

measured section, and 0.016 in./in. (0.41 mm/mm) of distance between parallel surfaces for tube over 5/8-in. dimension across the measured section.

11.8 *Straightness*—The maximum curvature (depth of arc) measured along any 2-ft (0.610-m) portion of the total length shall not exceed 0.010 in. (0.25 mm) edgewise and 0.020 in. (0.51 mm) flatwise on the concave external surfaces. The tube shall be so positioned during measurement that gravity will not tend to increase the amount of bow. The edgewise and flatwise bow shall be determined by using a suitable straightedge.

11.9 *Twist*—The maximum twist about the longitudinal axis of the finished tube shall not exceed 1°/ft of length on the face