Designation: B372 – 22

Standard Specification for Seamless Copper and Copper-Alloy Rectangular Waveguide Tube[1]

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 U.S. 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	Phosphorus
C10100	Copper, Type OFE[A]	99.99[B]	...	...
C10200	Copper, Type OF[A]	99.95[B]	...	...
C10300	Copper, Type OFXLP[A]	99.95[B]	...	0.003
C12000	Copper, Type DLP[A]	99.90[B]	...	0.008
C22000	Commercial bronze, 90 %	90	10	...

[A] Types OF, OFE, OFXLP, and DLP are described in Classification B224.
[B] Minimum copper percentage.

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 that are provided for information only and are not considered standard.

1.3 The following safety hazard caveat pertains only to the test method(s) described in this specification.

1.3.1 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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
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 (Withdrawn 2022)[4]
E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)[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 Document:*[5]

ANSI B46.1 Surface Roughness, Waviness, and Lay

[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.

[4] 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**

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 specified choices when placing orders for products under this specification, as applicable:

4.1.1 ASTM designation and year of issue;

4.1.2 Copper or copper alloy UNS No. designation;

4.1.3 Outer and inner rectangular dimensions, dimensional tolerances (Section 10);

4.1.4 Length (10.6); and

4.1.5 Total length or number of pieces of each size.

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

4.2.1 Rockwell (8.1),

4.2.2 Electrical resistivity test (Section 7),

4.2.3 Embrittlement test (9.2),

4.2.4 Special finish (11.2),

4.2.5 Heat Identification (12.2.6),

4.2.6 Certification (Section 18),

4.2.7 Mill Test Report (Section 19), and

4.2.8 Special packing (Section 20).

5. Materials and Manufacture

5.1 *Materials:*

5.1.1 The material of manufacture shall be of such purity and soundness as to be suitable for processing into the products prescribed herein.

5.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 1—Due to the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify a specific casting analysis with a specific quantity of finished material.

5.2 *Manufacture:*

5.2.1 The product shall be manufactured by such hot working, cold-working and annealing process as to produce a uniform wrought structure in the finished product.

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

6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements in Table 1 for the copper or copper alloy UNS No. designation specified in the ordering information.

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 zinc is listed as "remainder," either copper or zinc may be taken as the difference between the sum of results of all other elements determined and 100 %. When all elements for C22000 in Table 1 are determined, the sum of the results shall be 99.8 % minimum.

TABLE 1 Chemical Requirements

Element	Composition, %				
	Copper UNS Nos.				Copper Alloy UNS No. C22000
	C10100[A]	C10200[B]	C10300	C12000	
Copper	99.99 min	99.95[C] min	...	99.90[C] min	89.0–91.0
Copper, + phosphorus	...	...	99.95[C] min	...	...
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 0.0010 % max.
[C] Silver counting as copper.

TABLE 2 Electrical Resistivity Requirements for Copper UNS Nos. C10100, C10200, C10300, and C12000

Alloys	Electrical Resistivity max. Ω·g/m^2
C10100	0.15585
C10200	0.15737
C10300	0.15940
C12000	0.17418

7. Physical Property Requirements

7.1 *Electrical Resistivity Requirement:*

7.1.1 When specified in the contract or purchase order, the product furnished shall conform to the electrical mass resistivity requirements prescribed in Table 2, when tested in accordance with Test Method B193.

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	98.35
0.15614	98.16
0.15737	97.40
0.15940	96.16
0.17031	90
0.17418	88

8. Mechanical Property Requirements

8.1 *Rockwell Hardness Requirements:*

8.1.1 When specified in the contract or purchase order, the product shall conform to the Rockwell hardness requirement prescribed in Table 3, when tested in accordance with Test Methods E18.

TABLE 3 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.

9. Performance Requirements

9.1 *Microscopical Examination:*

9.1.1 Samples 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 of Test Methods B577 shall be used.

9.2 *Hydrogen Embrittlement Test:*

9.2.1 Samples of Copper UNS Nos. C10100, C10200, C10300, and C12000 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. Dimensions and Permissible Variations

10.1 *General:*

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

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

10.1.3 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.

10.2 *Dimensional Tolerances:*

10.2.1 Standard dimensions and tolerances of waveguide tube shall be as specified in Table 4.

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

10.3 *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 5.

10.4 *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 6.

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

10.6 *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 7.

10.7 *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 ⅝ in. (15.9 mm) dimension, inclusive, across the measured section, and 0.016 in./in. (0.41 mm/mm) of distance between parallel surfaces for tube over ⅝ in. dimension across the measured section.

10.8 *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.

TABLE 4 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 (0.010)	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)