



Designation: B 188 – 00

Standard Specification for Seamless Copper Bus Pipe and Tube¹

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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 bus pipe and tube intended for use as electrical conductors.

1.1.1 The product shall normally be made from one of the following coppers, as denoted in the ordering information:²

Copper UNS No. ²	Previously Used Designation	Type of Copper
C10100	OFE	Oxygen-free, electronic
C10200	OF	Oxygen-free without residual deoxidants
C10300	—	Oxygen-free, extra low phosphorus
C10400, C10500, C10700	OFS	Oxygen-free, silver bearing
C11000	ETP	Electrolytic tough pitch
C11300, C11400, C11600	STP	Silver-bearing tough pitch
C12000	DLP	Phosphorized, low residual phosphorus

1.2 Other coppers may be agreed upon between purchaser and supplier. Unless otherwise specified, any one of the above coppers may be furnished.

1.3 The values stated in inch-pound units are the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 The following documents form a part of this specification to the extent referenced herein:

2.2 ASTM Standards:

B 193 Test Method for Resistivity of Electrical Conductor Materials³

B 428 Test Method for Angle of Twist in Rectangular and Square Copper and Copper Alloy Tube⁴

B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper⁴

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast⁴

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 (see Practice E 527) 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 Annual Book of ASTM Standards, Vol 02.03.

⁴ Annual Book of ASTM Standards, Vol 02.01.

E 8 Test Methods for Tension Testing of Metallic Materials⁵

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁵

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁶

E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry⁷

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁷

E 243 Practice for Electromagnetic (Eddy-Current) Examination of Copper and Copper-Alloy Tubes⁸

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁷

E 527 Practice for Numbering Metals and Alloys (UNS)⁹

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 *bus pipe or tube*, *n*—a high-conductivity copper tubular product used as an electrical conductor.

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

3.1.3.1 *lengths, ends*, *n*—straight pieces, shorter than the nominal length, left over after cutting the product into mill lengths, stock lengths, or specific lengths. They are subject to minimum length and maximum weight requirements.

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

3.1.3.3 *lengths, specific with ends*, *n*—specific lengths, including ends.

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

3.1.3.5 *lengths, stock*, *n*—straight lengths that are mill cut and stored in advance of orders. They are usually 12 or 20 ft (3.66 or 6.10 m) and subject to established length tolerances.

⁵ Annual Book of ASTM Standards, Vol 03.01.

⁶ Annual Book of ASTM Standards, Vol 14.02.

⁷ Annual Book of ASTM Standards, Vol 03.05.

⁸ Annual Book of ASTM Standards, Vol 03.03.

⁹ Annual Book of ASTM Standards, Vol 01.01.

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

3.1.3.6 *lengths, stock with ends, n*—stock lengths, including ends.

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

3.1.4.1 *pipe, n*—a seamless tube conforming to the particular nominal or standard pipe sizes, Table 1.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *capable of, adv*—The term “capable of” as used in this specification means that the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

4. Ordering Information

4.1 Orders for product under this specification should contain the following information:

- 4.1.1 ASTM designation and year of issue,
- 4.1.2 Copper UNS designation,
- 4.1.3 Temper (Section 7),
- 4.1.4 Dimensions and form (Section 14),
- 4.1.5 Length (Section 14),
- 4.1.6 Total length of each size,
- 4.1.7 Quantity of each item,

4.2 The following options are available under this specification and should be specified in the contract or purchase order when required:

4.2.1 Bend test (Section 10),

4.2.2 Cuprous oxide test (Section 12),

4.2.3 Microscopical examination (Section 11),

4.2.4 Tension testing (Section 9),

4.2.5 Eddy-current test (Section 13),

4.2.6 Certification (Section 23),

4.2.7 Mill test report (Section 24), and

4.2.8 Special packaging, if required (Section 25).

5. Materials and Manufacture

5.1 Material:

5.1.1 The material shall be a copper of any one of the UNS alloy numbers as included in the scope, and as so specified in the contract or purchase order, and shall be of such soundness as to be suitable for processing into lengths of pipe or tube for the intended application.

5.2 Manufacture:

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

5.2.2 The manufacture shall be such that the finished material conforms to the specified temper properties (see 7.1).

6. Chemical Composition

6.1 The material shall conform to the requirements in Table

TABLE 1 Dimensions and Weights of Copper Pipe, Nominal or Standard Pipe Sizes^A

Nominal or Standard Pipe Size, in.	Dimensions, in. (mm)			Cross-Sectional Area of Wall, in. ² (mm ²)	Theoretical Weight, lb/ft (kg/m)
	Outside Diameter	Inside Diameter	Wall Thickness		
Regular					
¼	0.540(13.7)	0.376(9.55)	0.082(2.08)	0.118(0.761)	0.457(0.680)
⅜	0.675(17.1)	0.495(12.6)	0.090(2.29)	0.165(1.06)	0.641(0.954)
½	0.840(21.3)	0.626(15.9)	0.107(2.72)	0.246(1.59)	0.955(1.42)
¾	1.050(26.7)	0.822(20.9)	0.114(2.90)	0.335(2.16)	1.30(1.93)
1	1.315(33.4)	1.063(27.0)	0.126(3.20)	0.471(3.04)	1.82(2.71)
1¼	1.660(42.2)	1.368(34.7)	0.146(3.71)	0.694(4.48)	2.69(4.00)
1½	1.900(48.3)	1.600(40.6)	0.150(3.81)	0.825(5.32)	3.20(4.76)
2	2.375(60.3)	2.063(52.4)	0.156(3.96)	1.09(7.03)	4.22(6.28)
2½	2.875(73.0)	2.501(63.5)	0.187(4.75)	1.58(10.2)	6.12(9.11)
3	3.500(88.9)	3.062(77.8)	0.219(5.56)	2.26(14.6)	8.75(13.0)
3½	4.000 (102)	3.500(88.9)	0.250(6.35)	2.95(19.0)	11.4(17.0)
4	4.500 (114)	4.000 (102)	0.250(6.35)	3.34(21.5)	12.9(19.2)
5	5.562 (141)	5.062 (129)	0.250(6.35)	4.17(26.9)	16.2(24.1)
6	6.625 (168)	6.125 (156)	0.250(6.35)	5.01(32.3)	19.4(28.9)
8	8.625 (219)	8.001 (203)	0.312(7.92)	8.15(52.6)	31.6(47.0)
10	10.750 (273)	10.020 (255)	0.365(9.27)	11.9(76.8)	46.2(68.7)
12	12.750 (324)	12.000 (305)	0.375(9.52)	14.6(94.2)	56.5(84.1)
Extra Strong					
¼	0.540(13.7)	0.294(7.47)	0.123(3.12)	0.161(1.04)	0.625(0.930)
⅜	0.675(17.1)	0.421(10.7)	0.127(3.23)	0.219(1.41)	0.847(1.26)
½	0.840(21.3)	0.542(13.8)	0.149(3.78)	0.323(2.08)	1.25(1.86)
¾	1.050(26.7)	0.736(18.7)	0.157(3.99)	0.440(2.84)	1.71(2.54)
1	1.315(33.4)	0.951(24.2)	0.182(4.62)	0.648(4.18)	2.51(3.73)
1¼	1.660(42.2)	1.272(32.3)	0.194(4.93)	0.893(5.76)	3.46(5.15)
1½	1.900(48.3)	1.494(37.9)	0.203(5.16)	1.08(6.97)	4.19(6.23)
2	2.375(60.3)	1.933(49.1)	0.221(5.61)	1.50(9.68)	5.80(8.63)
2½	2.875(73.0)	2.315(58.8)	0.280(7.11)	2.28(14.7)	8.85(13.2)
3	3.500(88.9)	2.892(73.6)	0.304(7.72)	3.05(19.7)	11.8(17.6)
3½	4.000 (102)	3.358(85.3)	0.321(8.15)	3.71(23.9)	14.4(21.4)
4	4.500 (114)	3.818(97.0)	0.341(8.66)	4.46(28.8)	17.3(25.7)
5	5.562 (141)	4.812 (122)	0.375(9.52)	6.11(39.4)	23.7(35.3)
6	6.625 (168)	5.751 (146)	0.437(11.1)	8.50(54.8)	32.9(49.0)
8	8.625 (219)	7.625 (194)	0.500(12.7)	12.8(82.6)	49.5(73.7)
10	10.750 (273)	9.750 (248)	0.500(12.7)	16.1(104)	62.4(92.9)

^A1 in.² = 1 270 000 cmil.

2 for the copper UNS no. designated 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 purchaser.

7. Temper

7.1 The material shall be furnished in either the O60 (soft anneal) or H80 (hard drawn) temper as defined in Practice B 601. The requirements are specified in Table 3.

8. Electrical Resistivity Requirements

8.1 The material shall conform to the maximum electrical resistivity requirements prescribed in Table 3.

9. Mechanical Properties

9.1 The product shall conform to the mechanical requirements prescribed in Table 3.

9.1.1 Tension testing for tensile and elongation information need not be performed except when indicated by the purchaser at the time of placing the order (see 4.2.4).

9.1.2 The tension test shall be used to resolve cases of dispute.

9.2 All test specimens shall be tested in full size when practicable. When a machined specimen becomes necessary for any test required under this specification, enough metal shall be suitably removed from the sample to meet the limitations of the testing facilities.

10. Bend Test Requirements

10.1 The material shall conform to the bend testing requirements prescribed in Table 3.

10.1.1 Bend testing need not be performed except when indicated by the purchaser at the time of placing the order (see 4.2.4).

11. Microscopical Examination

11.1 The test specimens of material designated as Copper UNS Nos. C10100, C10200, C10300, C10400, C10500,

C10700, and C12000 shall be free of cuprous oxide as determined by Procedure A of Test Method B 577. In case of a dispute, a referee method in accordance with Procedure C shall be used.

11.1.1 The test need not be performed except when indicated at the time of placing the order (see 4.2.3).

12. Hydrogen Embrittlement Susceptibility Test

12.1 It is to be expected that material designated as Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, and C12000 shall be capable of passing the embrittlement test of Procedure B of Test Method B 577. 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 used.

13. Nondestructive Testing

13.1 When specified (see 4.2.5), the product shall be tested in the final size but may be tested before the final anneal or heat treatment, when these thermal treatments are required, unless otherwise agreed upon by the manufacturer or supplier and purchaser.

13.2 *Eddy-Current Test*—When specified, each piece of product from $\frac{1}{8}$ up to and including $3\frac{1}{8}$ -in. nominal outside diameter, or $2\frac{1}{2}$ -in. distance between outside parallel surfaces, shall be subjected to an eddy-current test. Testing shall follow the procedures of Practice E 243 except for determination of “end effect.” The product shall be passed through an eddy-current testing unit adjusted to provide information on the suitability of the product for the intended application.

13.2.1 Notch-depth standards rounded to the nearest 0.001 in. (0.025 mm) shall be 22 % of the nominal wall thickness. The notch depth tolerance shall be ± 0.0005 in. (0.013 mm). Alternatively, when the test is performed using speed-insensitive equipment that can select a maximum imbalance signal, a maximum imbalance signal of 0.3 % shall be used.

13.2.2 Product that does not actuate the signaling device of the eddy-current test shall be considered as conforming to the requirements of this test. Product with discontinuities indicated

TABLE 2 Chemical Requirements

NOTE 1—If the type of silver-bearing copper is not specified (that is, whether tough-pitch, phosphorized, or oxygen-free) any one of the three types may be supplied at the option of the manufacturer.

Element	Composition, %										
	Copper UNS No.										
	C10100 ^A	C10200	C10300	C10400 ^B	C10500 ^B	C10700 ^B	C11000	C11300 ^C	C11400 ^C	C11600 ^C	C12000
Copper (incl silver), min	99.99 ^D	99.95	99.95 ^E	99.95	99.95	99.95	99.90	99.90	99.90	99.90	99.90
Phosphorus	^A	...	0.001–0.005	...	...	...	...	...	...	...	0.004–0.0012
Oxygen, max.	0.0005	0.0010	...	0.0010	0.0010	0.0010	...	...	...	...	...
Silver	^A	...	...	8 ^F	10 ^F	25 ^F	...	8 ^F	10 ^F	25 ^F	...

^AImpurity maximums in ppm of C10100 shall be: antimony 4, arsenic 5, bismuth 1.0, cadmium 1, iron 10, lead 5, manganese 0.5, nickel 10, phosphorus 3, selenium 3, silver 25, sulfur 15, tellurium 2, tin 2, and zinc 1.

^BC10400, C10500, and C10700 are oxygen-free coppers with the addition of a specified amount of silver. The compositions of these alloys are equivalent to C10200 plus the intentional addition of silver.

^CC11300, C11400, C11500, and C11600 are electrolytic tough-pitch copper with silver additions. The compositions of these alloys are equivalent to C11000 plus the intentional addition of silver.

^DCopper shall be determined by difference between “impurity total” and 100 %.

^ECopper (includes silver) + phosphorus, min.

^FValues are minimum silver in troy ounces per avoirdupois ton (1 oz/ton is equivalent to 0.0034 %).