



Standard Specification for Hard-Drawn Copper Capillary Tube for Restrictor Applications¹

This standard is issued under the fixed designation B 360; 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 hard-drawn, seamless capillary tube made from Copper Alloy UNS Nos. C10800, C12000, or C12200.

1.2 This tube is commonly supplied in straight lengths intended for restrictor applications such as metering lines for liquids and gases where close control over smoothness and diameter of the bore is required to insure uniform flow characteristics between tubes.

1.3 The values stated in inch pound units are to be regarded as the 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 The following safety hazard caveat pertains only to the test method described in section 16.4 (Cleanness Test) of this specification: *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:

B 251 Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube²

B 577 Test Methods for Hydrogen Embrittlement of Copper³

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

B 846 Terminology for Copper and Copper Alloys²

E 8 Test Methods for Tension Testing of Metallic Specimens⁴

E 53 Test Method for Chemical Analysis of Copper⁵

E 62 Test Methods for Chemical Analysis of Copper and

Copper Alloys (Photometric Methods)⁵

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

2.2 *ASHRAE Standard:*

No. 28-88 Method for Testing Capillary Tubes⁶

3. General Requirements

3.1 The following sections of Specification **B 251** are a part of this specification.

3.1.1 Terminology,

3.1.2 Workmanship, Finish and Appearance,

3.1.3 Significance of Numerical Limits,

3.1.4 Inspection,

3.1.5 Rejection and Rehearing,

3.1.6 Certification,

3.1.7 Test Reports,

3.1.8 Package and Package Marking, and

3.2 In addition, when a section with a title identical with those referenced in 3.1 appears in this specification, it contains additional requirements which supplement those appearing in Specification **B 251**. In case of conflict this specification shall prevail.

4. Terminology

4.1 For the definition of terms related to copper and copper alloys refer to Terminology B 846.

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *capable of, adj*—possessing the required properties or characteristic, or both, necessary to conform to specification requirements when subjected to specified test(s).

5. Ordering Information

5.1 The contract or purchase order for product under this specification shall include the following information, as applicable:

5.1.1 ASTM designation and year of issue (for example, B360 – XX),

5.1.2 Copper Alloy UNS No. (for example, C10800, Section 7 and Table 1),

5.1.3 Dimensions: inside and outside diameter (Table 2),

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 *Annual Book of ASTM Standards*, Vol 02.01.

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

⁴ *Annual Book of ASTM Standards*, Vol 03.05.

⁵ *Annual Book of ASTM Standards*, Vol 01.01.

⁶ Available from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329.

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



TABLE 1 Chemical Requirements

Element, Percent	C10800	C12000	C12200
Copper	99.95 ^A	99.90 ^B	99.9 ^B
Phosphorus	0.005–0.012	0.004–0.012	0.015–0.040

^A Copper + Silver + Phosphorus.

^B Silver is counted as Copper.

5.1.4 Air Flow requirements (ft³/min), (see 10.3),

NOTE 1—Product is specified to air flow requirements for capillary applications.

5.1.5 Quantity, total length, number of pieces or total weight of each size,

5.1.6 Length per piece of each size, and

5.2 The following options are available and should be specified in the contract or purchase order when required:

5.2.1 Heat Identification or traceability details,

5.2.2 Embrittlement test, (see 10.1),

5.2.3 Certification, (see 3.1.6), and

5.2.4 Mill test report (see 3.1.7).

6. Material and Manufacture

6.1 Material:

6.1.1 The tube shall be from Copper UNS No. C10800 (oxygen free, low phosphorus), C12000 (phosphorus deoxidized, low residual phosphorus), or C12200 (phosphorus deoxidized, high residual phosphorus) and of such purity and soundness as to be suitable for processing in to the product prescribed herein.

6.1.2 When heat identification or traceability is required, the details desired shall be specified in the contract or purchase order.

NOTE 2—Due to the discontinuous nature of processing castings into wrought products it is not practical to identify specific casting analysis with a specific quantity of finished product.

6.2 Manufacture:

6.2.1 The product shall be finished by cold drawing.

6.2.2 The tube shall be finished by degreasing or other cleaning operations to meet the stringent requirements for cleanliness of the inner diameter.

6.2.3 The outside and inside of both ends of straight lengths shall be made free of burrs that could restrict flow, by burr-free cutting, brushing, or chamfering.

6.2.4 The maximum allowable residue as determined by the cleanness test described in 16.4 shall not exceed the value given in Table 2 for the tube size tested.

7. Chemical Composition

7.1 The product shall conform to the specified Copper UNS No. designation as in Table 1.

7.1.1 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for un-named elements by agreement between the manufacturer and purchaser.

8. Temper

8.1 The tubes shall be furnished in the H80⁷ (hard drawn) condition.

9. Mechanical Property Requirements

9.1 Tensile Strength:

9.1.1 The tubes shall have a tensile strength of 45 ksi (310 MPa) minimum.

10. Other Requirements

10.1 Embrittlement Requirement:

10.1.1 Samples of product produced from Coppers UNS Nos. C10800 and C12000 shall be capable of passing the embrittlement test of Procedure B of Test Methods B 577. The actual performance of this test is not mandatory under the terms of this specification unless specified in the ordering information. In case of a dispute, a referee method in accordance with Procedure C shall be employed.

10.2 Cleanness Requirement:

10.2.1 The residue attributable to the tubes shall not exceed 0.0002 g/in.² (0.310 g/m²) of internal surface of the tube when subjected to test as directed in 16.4 (Refer to Table 2)

10.3 Air Flow Requirement:

10.3.1 The tubes shall conform to the air flow requirements, in ft³/min [cfm] stipulated at the time of order placement, when tested in accordance with the test in 16.5.

11. Dimensions, Mass, and Permissible Variations

11.1 Outside Diameter Tolerance:

11.1.1 The average outside diameter tolerance shall be ±0.002 in. (0.051 mm).

11.2 Inside Diameter Tolerance:

11.2.1 The average inside diameter tolerance shall be ±0.001 in. (0.025 mm) which shall be determined by the air flow test.

11.3 Straightness:

11.3.1 The straightness tolerance shall be in accordance with Table 3.

12. Workmanship, Finish and Appearance

12.1 The inside and outside edges of both ends of straight lengths of tube shall be free of burrs (see 6.2.2).

13. Sampling

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

13.1.1 Lot Size—1000 pieces, or minimum of 100 lb, or fraction thereof.

13.1.2 Portion Size—0.2 % of the pieces in the lot, or a minimum of four pieces, whichever is greater.

13.2 Chemical Composition:

13.2.1 The sample shall be taken in approximately equal weight from each portion piece selected in 13.1.2 and prepared in accordance with Practice E 255. The minimum weight of the composite sample shall be 150 g.

⁷ Refer to Practice B 601 for definition of temper designations.

TABLE 2 Standard Dimensions and Residue Limits of Interior Surfaces for Capillary Tubes

Outside Diameter, in. (mm)	Inside Diameter, in. (mm)	Mean Wall Thickness, in. (mm)	Cross-Sectional Area of Tube Bore, in. ² (mm ²) ^A	Weight, lb/ft (kg/m)	Maximum Allowable Residue, g/linear ft (g/linear m)
0.072 (1.83)	0.026 (0.660)	0.023 (0.584)	0.0005309 (0.343)	0.01373 (0.0204)	0.00020 (0.000656)
0.072 (1.83)	0.028 (0.711)	0.022 (0.558)	0.0006158 (0.397)	0.01340 (0.0199)	0.00021 (0.000689)
0.081 (2.06)	0.031 (0.787)	0.025 (0.635)	0.0007548 (0.487)	0.01705 (0.0254)	0.00023 (0.000754)
0.081 (2.06)	0.033 (0.838)	0.024 (0.606)	0.0008553 (0.552)	0.01666 (0.0248)	0.00025 (0.000820)
0.087 (2.21)	0.036 (0.914)	0.0255 (0.648)	0.001018 (0.657)	0.01910 (0.0284)	0.00027 (0.000886)
0.087 (2.21)	0.039 (0.991)	0.024 (0.606)	0.001195 (0.771)	0.01842 (0.0239)	0.00029 (0.000951)
0.093 (2.36)	0.042 (1.07)	0.0255 (0.648)	0.001385 (0.893)	0.02096 (0.0312)	0.00032 (0.00105)
0.097 (2.47)	0.046 (1.17)	0.025 (0.648)	0.001662 (1.07)	0.02221 (0.0331)	0.00035 (0.00115)
0.099 (2.51)	0.049 (1.24)	0.025 (0.635)	0.001886 (1.22)	0.02253 (0.0335)	0.00037 (0.00121)
0.106 (2.69)	0.054 (1.37)	0.026 (0.660)	0.002290 (1.48)	0.02533 (0.0377)	0.00041 (0.00134)
0.112 (2.84)	0.059 (1.50)	0.0265 (0.673)	0.002734 (1.76)	0.02760 (0.0411)	0.00044 (0.00144)
0.125 (3.18)	0.064 (1.63)	0.0305 (0.775)	0.003217 (2.07)	0.03511 (0.0522)	0.00048 (0.00157)
0.125 (3.18)	0.070 (1.78)	0.0275 (0.698)	0.003848 (2.48)	0.03266 (0.0486)	0.00053 (0.00174)
0.125 (3.18)	0.075 (1.91)	0.025 (0.635)	0.004418 (2.85)	0.03054 (0.0454)	0.00057 (0.00187)
0.145 (3.68)	0.080 (2.03)	0.0325 (0.826)	0.005027 (3.24)	0.04453 (0.0663)	0.00060 (0.00197)
0.145 (3.68)	0.085 (2.16)	0.030 (0.762)	0.005674 (3.66)	0.04202 (0.0625)	0.00064 (0.00210)
0.145 (3.68)	0.090 (2.29)	0.0275 (0.698)	0.006362 (4.10)	0.03936 (0.0586)	0.00068 (0.00223)
0.160 (4.06)	0.100 (2.54)	0.030 (0.762)	0.007854 (5.07)	0.04750 (0.0707)	0.00075 (0.00246)
0.160 (4.06)	0.110 (2.79)	0.025 (0.635)	0.009503 (6.13)	0.04111 (0.0611)	0.00083 (0.00272)
0.188 (4.78)	0.120 (3.03)	0.034 (0.864)	0.01131 (7.29)	0.06377 (0.0949)	0.00090 (0.00295)
0.188 (4.78)	0.130 (3.30)	0.029 (0.737)	0.01327 (8.56)	0.05616 (0.0836)	0.00098 (0.00321)
0.200 (5.08)	0.145 (3.68)	0.0275 (0.698)	0.01651 (10.7)	0.05779 (0.0860)	0.00109 (0.00358)
0.220 (5.59)	0.160 (4.06)	0.030 (0.762)	0.02011 (13.0)	0.06943 (0.103)	0.00121 (0.00397)
0.240 (6.10)	0.175 (4.45)	0.0325 (0.826)	0.02405 (15.5)	0.08107 (0.121)	0.00132 (0.00433)

^A Cross-section area of tube bore in.² = (P i)(ID)²/4 where: $\pi = 3.1416$ and ID = inside diameter.

TABLE 3 Straightness Tolerance

Length Ft (m)	Maximum Curvature (Depth of Arc) in. (mm)
Over 3 (0.914) to 6 (1.83), incl.	.188 in. (4.8)
Over 6 (1.83) to 8 (2.44), incl.	.313 in. (7.9)
Over 8 (2.44) to 10 (3.05), incl.	.500 in. (13)
Over 10 (3.05)	.500 in. (13) in any 10 ft (3.05 m) section

13.2.2 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of sampling at the time castings are poured or taken from the semi-finished product. When the chemical composition has been determined during the course of manufacture, sampling of the finished product is not required.

13.2.3 The number of samples taken during the course of manufacture shall be as follows:

13.2.3.1 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.

13.2.3.2 When samples are taken from the semi-finished product, a sample shall be taken to represent each 10 000 lb (4537 kg) or fraction thereof, except that not more than one sample per piece shall be required.

13.3 Other Tests:

13.3.1 Specimens for all other tests shall be taken from two of the sample pieces taken in 13.1.2.

14. Number of Tests and Retests

14.1 Tests:

14.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element average of results from at least

two replicate analysis of the sample and each determination must meet the specification requirements.

14.1.2 *Tensile Strength*—Shall be reported as the average results obtained from the specimen prepared from each of two pieces selected in 13.1.2.

14.1.3 Specimens for all other test must conform to specification requirements.

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 with the product specification requirement(s).

14.2.2 Retesting shall be as directed in the product specification for the initial test, except for the number of test specimens which shall be twice that normally required for the test. Test results for all specimens shall conform to the product specification requirement(s) in retest and failure to comply shall be cause for lot rejection.

15. Specimen Preparation

15.1 Chemical Analysis:

15.1.1 Preparation of the analytical specimens shall be the responsibility of the reporting laboratory.

15.2 Tensile Strength:

15.2.1 The test specimen shall be of the full section of the tube and shall conform to the requirements specified in the section “Specimens for Pipe and Tube” in Test Methods E 8.

15.3 Embrittlement:

15.3.1 Test specimens shall be prepared in accordance with Procedure B of Test Methods B 577. In case of dispute, test specimens preparation shall be in accordance with Procedure C of Test Methods B 577.

15.4 Cleanliness:

15.4.1 Full-length specimens of finished product, subsequent to cleaning, shall be selected for testing, where feasible, to minimize the possibility of contamination from cutting operations.

15.4.2 If full-length specimens can not be utilized due to size, length, or other constraints, the specimen must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust, resulting from cutting operations.

15.4.3 In performing this test, care must be exercised to clean the outside surface of the end of the specimen to be immersed in the solvent.

15.5 Air Flow Test:

15.5.1 Full-length specimens of finished product shall be selected for testing.

16. Test Methods

16.1 Chemical Composition:

16.1.1 Material composition shall be determined, in case of dispute as follows:

Element	Method
Copper	E 53
Phosphorus	E 62

16.1.2 Test method(s) used for the determination of other element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer, or supplier, and the purchaser.

16.2 Tensile Strength:

16.2.1 Tensile strength shall be determined as directed in procedure for small tube in Test Methods E 8.

16.2.2 Test results are not seriously affected by variations in speed of testing. A considerable range of testing speed is permitted; 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).

16.3 Embrittlement:

16.3.1 Procedure B of Test Method B 577 shall be followed and in the case of dispute Procedure C shall be followed.

16.4 Cleanliness:

16.4.1 In performing this test care must be exercised to clean the outside surface of the end of the specimen to be immersed in the solvent. Full-length specimens of finished product should be tested to minimize the possibility of contamination from cutting operations. If full-length specimens can not be utilized the specimens must be prepared in such a manner as to prevent the inclusion in the residue of copper chips or dust, resulting from specimen preparations.

16.4.2 Using the schematic depicted in Fig. 1, clean the interior surface of the sample with a suitable solvent (not less than 50 mL per specimen).

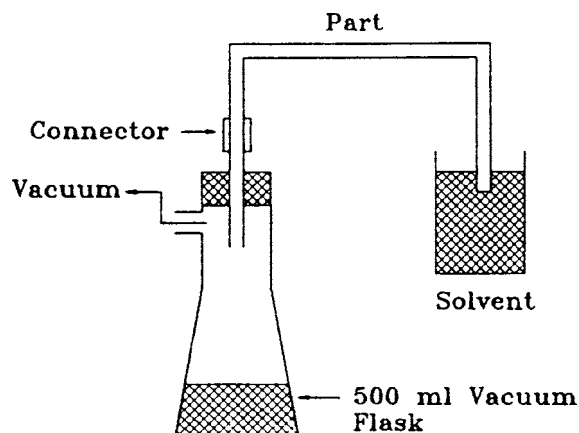


FIG. 1 Residue Extraction Apparatus

16.4.3 After collection of the solvent and residue in the vacuum flask transfer the contents of the vacuum flask to a beaker of known weight. Transfer an equivalent amount of clean solvent into a second beaker of known weight. (This is a blank to determine the contaminants in the solvent.)

16.4.4 With adequate exhaust, evaporate the solvent in both beakers to near dryness on a low temperature hot plate or sandbath. (**Warning**—Overheating may cause charring of the residue.)

16.4.5 Place the beakers in a drying oven set at $105 \pm 5^\circ\text{C}$ for approximately 10 min, or longer as necessary, to complete the drying process. Remove the dried containers, cool in a desiccator, and weigh.

16.4.6 Calculate the weight gain of the beakers by subtracting the original weight from the final weight for each.

$$(\text{Final Weight} - \text{Original Weight} = \text{Residue Weight})$$

16.4.7 The residue per unit area is then calculated using the following formula:

$$\frac{(\text{Residue Weight of Sample} - \text{Residue Weight of Blank})}{\text{Interior Surface Area of Sample (in.}^2\text{)}}$$

16.5 Air Flow:

16.5.1 Airflow shall be determined in accordance with ASHRAE Standard 28-88 after the bore has been washed with a suitable solvent.

16.5.2 The manufacturer and the purchaser shall agree upon the test method used for manufacturing quality control.

17. Packaging and Package Marking

17.1 The tube ends shall be protected in such a manner as to prevent entrance of dust, chips or other foreign matter.

18. Keywords

18.1 C10800; C12000; C12200; capillary tube; metering tube; restrictor tube; tube



SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.

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| (1) General rewrite and reorganization of the document to correspond with the B05 <i>Outline of Form of Specifications</i> . | (3) Purchases for Government Requirements was removed from the core of the document since the supplementary requirements referenced did not exist. |
| (2) Clarification of the Embrittlement Test application. | |

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