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Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube¹

This standard is issued under the fixed designation B 251; 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.

^{ε1} NOTE—Referenced Documents were editorially corrected in November 2003.

1. Scope*

1.1 This specification covers a group of general requirements common to several wrought product specifications. Unless otherwise specified in the purchase order, or in an individual specification, these general requirements shall apply to copper and copper-alloy tube supplied under Specifications B 68, B 75, B 135, B 466/B 466M, and B 743.

NOTE 1—A complete metric companion to Specification B 251 has been developed—B 251M; therefore, no metric equivalents are presented in this specification.

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:

- B 68 Specification for Seamless Copper Tube, Bright Annealed²
- B 75 Specification for Seamless Copper Tube²
- B 135 Specification for Seamless Brass Tube²
- B 153 Test Method for Expansion (Pin Test) of Copper and Copper-Alloy Pipe and Tubing²
- B 154 Test Method for Mercurous Nitrate Test for Copper and Copper Alloys²
- B 170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes²
- 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 Tube²
- B 466/B 466M Specification for Seamless Copper-Nickel Pipe and Tube²
- B 643 Specification for Copper-Beryllium Alloy Seamless Tube²
- B 743 Specification for Seamless Copper Tube in Coils²
- E 3 Guide for Preparation of Metallographic Specimens⁴
- E 8 Test Methods for Tension Testing of Metallic Materials⁴
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁴
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁵
- E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry⁶
- E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁶
- E 112 Test Methods for Determining Average Grain Size⁴
- E 255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

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 02.03.

⁴ Annual Book of ASTM Standards, Vol 03.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vol 03.06.

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

3. Terminology

3.1 Definitions:

3.1.1 *average diameter (for round tubes only)*— 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 *coil*—a length of the product wound into a series of connected turns. The unqualified term “coil” as applied to tube usually refers to a bunched coil.

3.1.2.1 *bunched*—a coil in which the turns are bunched and held together such that the cross section of the bunched turns is approximately circular.

3.1.2.2 *double layer flat*—a coil in which the product is spirally wound into two connected disk-like layers such that one layer is on top of the other. (Sometimes called “double layer pancake coil” or “double layer spirally wound coil.”)

3.1.2.3 *level or traverse wound*—a coil in which the turns are wound into layers parallel to the axis of the coil such that successive turns in a given layer are next to one another. (Sometimes called “helical coil.”)

3.1.2.4 *level or traverse wound on a reel or spool*—a coil in which the turns are positioned into layers on a reel or spool parallel to the axis of the reel or spool such that successive turns in a given layer are next to one another.

3.1.2.5 *single layer flat*—a coil in which the product is spirally wound into a single disk-like layer. (Sometimes called “pancake coil” or “single layer spirally wound coil.”)

3.1.2.6 *stagger wound*—a coil in which the turns are positioned into layers approximately parallel to the axis of the coil, but not necessarily with the fixed regularity of a level or traverse wound coil.

3.1.3 *lengths*—straight pieces of the product.

3.1.3.1 *ends*—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 *mill*—straight lengths, including ends, that are conveniently manufactured in the mills. Full-length pieces are usually 10, 12, or 20 ft and subject to established length tolerances.

3.1.3.3 *multiple*—straight lengths of integral multiples of a base length, with suitable allowance for cutting, if and when specified.

3.1.3.4 *random*—run of mill lengths without any indicated preferred length.

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

3.1.3.6 *specific with ends*—specific lengths, including ends.

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

3.1.3.8 *stock*—straight lengths that are mill cut and stored in advance of orders. They are usually 10, 12, or 20 ft and subject to established length tolerances.

3.1.3.9 *stock with ends*—stock lengths, including ends.

3.1.4 *reel or spool*—a cylindrical device that has a rim at each end and an axial hole for a shaft or spindle, and on which the product is wound to facilitate handling and shipping.

3.1.5 *tube*—a hollow product of round or any other cross section, having a continuous periphery.

3.1.5.1 *tube, automotive and general service*—a seamless copper tube of small diameter conforming to a standard series of sizes commercially known as Automotive and General Service Tube.

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

4. Materials and Manufacture

4.1 The material shall be of such quality and purity that the finished product shall have the properties and characteristics prescribed in the applicable product specification listed in Section 1.

4.2 The material shall be produced by either hot or cold working operations, or both. It shall be finished, unless otherwise specified, by such cold working and annealing or heat treatment as necessary to meet the properties specified.

5. Dimensions and Permissible Variations

5.1 General:

5.1.1 The standard method of specifying wall thickness shall be in decimal fractions of an inch.

5.1.2 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 shall be cause for rejection.

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

5.1.4 When round tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in Table 1 by more than 50 %.

⁷ Annual Book of ASTM Standards, Vol 03.05.

TABLE 1 Wall Thickness Tolerances for Copper and Copper-Alloy Tube
(Applicable to Specifications B 68, B 75, B 135, and B 743)

NOTE 1—*Maximum Deviation at Any Point:* The following tolerances are plus and minus; if tolerances all plus or all minus are desired, double the values given.

Wall Thickness, in.	Outside Diameter, in. ^A						
	1/32 to 1/8 , incl	Over 1/8 to 5/16 , incl	Over 5/16 to 1, incl	Over 1 to 2, incl	Over 2 to 4, incl	Over 4 to 7, incl	Over 7 to 10, incl
Up to 0.017, incl	0.002	0.001	0.0015	0.002	...	...	...
Over 0.017–0.024, incl	0.003	0.002	0.002	0.0025	...	...	...
Over 0.024–0.034, incl	0.003	0.0025	0.0025	0.003	0.004	...	...
Over 0.034–0.057, incl	0.003	0.003	0.0035	0.0035	0.005	0.007	...
Over 0.057–0.082, incl	...	0.0035	0.004	0.004	0.006	0.008	0.010
Over 0.082–0.119, incl	...	0.004	0.005	0.005	0.007	0.009	0.011
Over 0.119–0.164, incl	...	0.005	0.006	0.006	0.008	0.010	0.012
Over 0.164–0.219, incl	...	0.007	0.009	0.009	0.011	0.012	0.014
Over 0.219–0.283, incl	...	...	0.011	0.012	0.014	0.015	0.016
Over 0.283–0.379, incl	...	...	0.014	6 ^B %	6 ^B %	7 ^B %	7 ^B %
Over 0.379	...	...	...	6 ^B %	6 ^B %	7 ^B %	7 ^B %

^A When round tube is ordered by outside and inside diameters, the maximum plus and minus deviation of the wall thickness from the nominal at any point shall not exceed the values given in the table by more than 50 percent.

^B Percent of specified wall expressed to the nearest 0.001 in.

NOTE 2—Blank spaces in the tolerance tables indicate either that the material is not generally available or that no tolerances have been established.

5.2 *Wall Thickness Tolerances for Copper and Copper-Alloy Tube*—Wall thickness tolerances applicable to Specifications B 68, B 75, B 135, and B 743 for round tubes only shall be in accordance with Table 1. Wall thickness tolerances for rectangular including square tube applicable to B 75 and B 135 shall be in accordance with Table 2.

5.3 *Diameter or Distance between Parallel Surfaces, Tolerances for Copper and Copper-Alloy Tube*—Diameter tolerances applicable to Specifications B 68, B 75, B 135, and B 743 for round tubes only shall be in accordance with Table 3. Tolerances on distance between parallel surfaces for rectangular including square tube applicable to Specifications B 75 and B 135 shall be in accordance with Table 4.

5.4 *Roundness (Applicable to Specifications B 75, B 135, and B 466/B 466M)*—For drawn unannealed tube in straight lengths, the roundness tolerances shall be as follows:

t/D (Ratio of Wall Thickness to Outside Diameter)	Roundness Tolerance as Percent of Outside Diameter (Expressed to the Nearest 0.001 in.)
0.01–0.03, incl	1.5
Over 0.03–0.05, incl	1.0
Over 0.05–0.10, incl	0.8 or 0.002 in. whichever is greater
Over 0.10	0.7 or 0.002 in. whichever is greater

5.4.1 Compliance with the roundness tolerances shall be determined by taking measurements on the outside diameter only, irrespective of the manner in which the tube dimensions are specified. The deviation from roundness is measured as the difference between major and minor diameters as determined at any one cross section of the tube. The major and minor diameters are the diameters of two concentric circles just enclosing the outside surface of the tube at the cross section.

5.4.2 No tolerances have been established for as-extruded tube, redraw tube, annealed tube, any tube furnished in coils or drawn tube whose wall thickness is under 0.016 in.

TABLE 2 Wall Thickness Tolerances for Copper and Copper-Alloy Rectangular and Square Tube
(Applicable to Specifications B 75, B 135, and B 743)

NOTE 1—Maximum deviation at any point. The following tolerances are plus and minus; if tolerances all plus or all minus are desired, double the values given.

Wall Thickness, in.	Distance Between Outside Parallel Surface, in. ^A						
	1/32 to 1/8 , incl	Over 1/8 to 5/16 , incl	Over 5/16 to 1, incl	Over 1 to 2, incl	Over 2 to 4, incl	Over 4 to 7, incl	Over 7 to 10, incl
Up to 0.017, incl	0.002	0.002	0.0025	0.003	...	...	...
Over 0.017–0.024, incl	0.003	0.0025	0.003	0.0035	...	...	...
Over 0.024–0.034, incl	0.0035	0.0035	0.0035	0.004	0.006	...	...
Over 0.034–0.057, incl	0.004	0.004	0.0045	0.005	0.007	0.009	...
Over 0.057–0.082, incl	...	0.005	0.006	0.007	0.008	0.010	0.012
Over 0.082–0.119, incl	...	0.007	0.008	0.009	0.010	0.012	0.014
Over 0.119–0.164, incl	...	0.009	0.010	0.011	0.012	0.014	0.016
Over 0.164–0.219, incl	...	0.011	0.012	0.013	0.015	0.017	0.019
Over 0.219–0.283, incl	...	...	0.015	0.016	0.018	0.020	0.022

^A In the case of rectangular tube the major dimension determines the thickness tolerance applicable to all walls.

TABLE 3 Average Diameter Tolerances for Copper and Copper-Alloy Tube^A
(Applicable to Specifications B 68, B 75, B 135, and B 743)

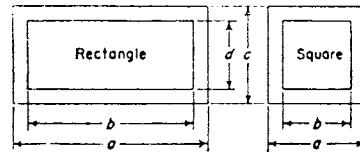
Specified Diameter, in.	Tolerance, Plus and Minus, in.
Up to 1/8, incl	0.002
Over 1/8 – 5/8, incl	0.002
Over 5/8 – 1, incl	0.0025
Over 1–2, incl	0.003
Over 2–3, incl	0.004
Over 3–4, incl	0.005
Over 4–5, incl	0.006
Over 5–6, incl	0.007
Over 6–8, incl	0.008
Over 8–10, incl	0.010

^A Applicable to inside or outside diameter.

TABLE 4 Tolerances on Distance Between Parallel Surfaces for Copper and Copper-Alloy Rectangular and Square Tube
(Applicable to Specifications B 75, B 135, and B 743)

NOTE 1—The following tolerances are plus and minus; if tolerances all plus or all minus are desired, double the values given.

Dimension <i>a</i> or <i>b</i> (see sketches), in.	Tolerances, in.
Up to 1/8, incl	0.003
Over 1/8 – 5/8, incl	0.004
Over 5/8 – 1, incl	0.005
Over 1–2, incl	0.006
Over 2–3, incl	0.007
Over 3–4, incl	0.008
Over 4–5, incl	0.009
Over 5–6, incl	0.010
Over 6–8, incl	0.011
Over 8–10, incl	0.012



Nominal dimension *a* determines tolerance applicable to both *a* and *c*.
Nominal dimension *b* determines tolerance applicable to both *b* and *d*.

5.5 Length Tolerances:

5.5.1 *Straight Lengths*—Length tolerances, straight lengths, applicable to Specifications B 68, B 75, B 135, and B 466/B 466M shall be in accordance with Table 5.

5.5.2 *Schedule of Tube Lengths*—Specific and stock lengths of tube with ends, applicable to Specifications B 68, B 75, B 135, and B 466/B 466M, shall be in accordance with Table 6. Tube in straight lengths shall be furnished in stock lengths with ends, unless the order requires specific lengths or specific lengths with ends.

5.6 *Squareness of Cut (Applicable to Specifications B 68, B 75, B 135, and B 466/B 466M)* — For tube in straight lengths, the departure from squareness of the end of any tube shall not exceed the following:

TABLE 5 Length Tolerances for Copper and Copper-Alloy Tube, Straight Lengths
(Applicable to Specifications B 68, B 75, B 135, and B 466/B 466M)

NOTE 1—Tolerances are all plus; if all minus tolerances are desired, use the same values; if tolerances plus and minus are desired, halve the values given.

Length	Tolerances, in. Applicable Only to Full-Length Pieces		
	For Major Outside Dimensions Up to 1 in., incl	For Major Outside Dimensions Over 1 to 4 in., incl	For Major Outside Dimensions Over 4 in.
Specific lengths:			
Up to 6 in., incl	1/32	1/16	...
Over 6 in.–2 ft, incl	1/16	3/32	1/8
Over 2–6 ft, incl	3/32	1/8	1/4
Over 6–14 ft, incl	1/4	1/4	1/4
Over 14 ft	1/2	1/2	1/2
Specific lengths with ends	1	1	1
Stock lengths with or without ends	1 ^A	1 ^A	1 ^A

^A As stock lengths are cut and placed in stock in advance of orders, departure from this tolerance is not practicable.

TABLE 6 Schedule of Tube Lengths (Specific and Stock) with Ends for Copper and Copper-Alloy Tube
(Applicable to Specifications B 68, B 75, B 135 and B 466/B 466M)

Major Outside Dimensions, in.	Specific Length, ft	Shortest Permissible Length, ^A Percent of Specific Length	Maximum Permissible Weight of Ends, Percent of Lot Weight
Up to 1, incl	6–20, incl	70	20
Over 1–2, incl	6–20, incl	60	25
Over 2–3, incl	6–20, incl	55	30
Over 3–4, incl	6–20, incl	50	40

^A Expressed to the nearest ½ ft.

5.6.1 Round Tube:

Specified Outside Diameter, in.	Tolerance
Up to 5/8, incl	0.010 in.
Over 5/8	0.016 in./in. of diameter

5.6.2 Rectangular and Square Tube :

Specified Distance Between Major Outside Parallel Surfaces, in.	Tolerance
Up to 5/8, incl	0.016 in.
Over 5/8	0.025 in./in. of distance between outside parallel surfaces

5.7 Straightness Tolerances:

5.7.1 *Round Tubes*— For round tubes of any drawn temper, ¼ to 3½ in. in outside diameter, inclusive, but not redraw tube, extruded tube, or any annealed tube, the straightness tolerances applicable to Specifications B 75, B 135, and B 466/B 466M shall be in accordance with Table 7.

5.7.2 *Rectangular and Square Tubes*—For rectangular and square tubes of any drawn temper, the straightness tolerance applicable to Specifications B 75 and B 135 shall be ½ in. maximum curvature (depth of arc) in any 6-ft portion of the total length. (Not applicable to extruded tube, redraw tube, or any annealed tube.)

5.8 *Corner Radius, Rectangular and Square Tubes*—The permissible radii for commercially square corners applicable to Specifications B 75 and B 135 shall be in accordance with Table 8.

5.9 *Twist Tolerances, Rectangular and Square Tubes* —The maximum twist about the longitudinal axis of drawn temper rectangular and square tubes applicable to Specifications B 75 and B 135 shall not exceed 1°/ft of length, measured to the nearest degree, and the total angle of twist shall not exceed 20° when measured in accordance with Test Method B 428. The requirement is not applicable to tubes in the annealed temper or to tubes whose specified major dimension is less than ½ in.

6. Workmanship, Finish, and Appearance

6.1 The material shall be free of defects of a nature that interfere with normal commercial applications. It shall be well cleaned and free of dirt.

7. Sampling

7.1 *Sampling*—The lot, size, portion size, and selection of sample pieces shall be as follows:

7.1.1 *Lot Size*—For tube, the lot size shall be 10 000 lb or fraction thereof.

TABLE 7 Straightness Tolerances for Copper and Copper-Alloy Tube^A in Any Drawn Temper

(Applicable to Specifications B 75, B 135, B 466/B 466M and B 643)

NOTE 1—Applies to round tube in any drawn temper from ¼ (6.35) to 3½ in. (88.9 mm), incl, in outside diameter.

Length, ft ^B	Maximum Curvature (Depth of Arc), in.
Over 3–6, incl	3/16
Over 6–8, incl	5/16
Over 8–10, incl	½

^A Not applicable to pipe, redraw tube, extruded tube or any annealed tube.

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

TABLE 8 Permissible Radii for Commercially Square Corners for Copper and Copper-Alloy Rectangular and Square Tube
(Applicable to Specifications B 75, B 135, and B 743)

Wall Thickness, in.	Maximum Radii, in.	
	Outside Corners	Inside Corners
Up to 0.058, incl	3/64	1/32
Over 0.058–0.120, incl	1/16	1/32
Over 0.120–0.250, incl	3/32	1/32
Over 0.250	none established	none established

7.1.2 *Portion Size*—Sample pieces shall be taken for test purposes from each lot according to the following schedule:

Number of Pieces in Lot	Number of Sample Pieces to be Taken ^A
1–50	1
51–200	2
201–1500	3
Over 1500	0.2 % of total number of pieces in the lot, but not to exceed 10 sample pieces

^A Each sample piece shall be taken from a separate tube.

8. Number of Tests and Retests

8.1 *Chemical Analysis*—Samples for chemical analysis shall be taken in accordance with Practice E 255. Drillings, millings, etc., shall be taken in approximately equal weight from each of the sample pieces selected in accordance with 7.1.2 and combined into one composite sample. The minimum weight of the composite sample that is to be divided into three equal parts shall be 150 g.

8.1.1 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of determining conformance to chemical composition as follows: Conformance shall be determined by the manufacturer by analyzing samples taken at the time the castings are poured or samples taken from the semi-finished product. If the manufacturer determines the chemical composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product. The number of samples taken for determination of chemical composition shall be as follows:

8.1.1.1 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.

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

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

8.1.1.4 In the event that heat identification or traceability is required, the purchaser shall specify the details desired.

8.2 *Other Tests*—For other tests, unless otherwise provided in the product specification, test specimens shall be taken from two of the sample pieces selected in accordance with 7.1.2.

8.2.1 In the case of tube furnished in coils, a length sufficient for all necessary tests shall be cut from each coil selected for purpose of tests. The remaining portion of these coils shall be included in the shipment, and the permissible variations in length on such coils shall be waived.

8.3 *Retests*:

8.3.1 If any test specimen shows defective machining or develops flaws, it shall be discarded and another specimen substituted.

8.3.2 If the percentage elongation of any tension test specimen is less than that specified and any part of the fracture is outside the middle two thirds of the gage length or in a punched or scribed mark within the reduced section, a retest on an additional specimen either from the same sample piece or from a new sample piece shall be allowed.

8.3.3 If the results of the test on one of the specimens fail to meet the specified requirements, two additional specimens shall be taken from different sample pieces and tested. The results of the test on both of these specimens shall meet the specified requirements. Failure of more than one specimen to meet the specified requirements for a particular property shall be cause for rejection of the entire lot.

8.3.4 If the chemical analysis fails to conform to the specified limits, analysis shall be made on a new composite sample prepared from additional pieces selected in accordance with 7.1.2. The results of this retest shall comply with the specified requirements.

9. Test Specimens

9.1 Tension test specimens shall be of the full section of the tube and shall conform to the requirements of Test specimens section of Test Methods E 8, unless the limitations of the testing machine preclude the use of such a specimen. Test specimens