



# Standard Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes<sup>1</sup>

This standard is issued under the fixed designation B 187/B 187M; 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<sup>2</sup> establishes the requirements for copper conductor bar, rod, and shapes for electrical (bus) applications and rod, bar, and shapes for general applications.

1.1.1 The products for electrical (bus) applications shall be made from the following coppers:<sup>3</sup>

Copper UNS No. <sup>3</sup>	Reference Designation
C10100	OFE
C10200	OF
C10300	OFXLP
C10400, C10500, C10700	OFS
C10920, C10930, C10940	—
C11000	ETP
C11300, C11400, C11500, C11600	STP

1.1.1.1 The product may be furnished from any copper listed unless otherwise specified in the contract or purchase order.

1.2 The product for general applications shall be made from any of the coppers in 1.1.1 or the following coppers:

Copper UNS No. <sup>3</sup>	Reference Designation
C10800	OFLP
C12000	DLP
C12200	DHP

1.2.1 The product may be furnished from any copper listed above unless otherwise specified in the contract or purchase order. Other coppers may be used upon agreement between supplier and purchaser.

1.3 *Units*—The values stated in either inch-pound units or in SI units are to be regarded separately as the standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each

system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

NOTE 1—Material for hot forging will be found in Specification B 124/B 124M.

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>4</sup>

- B 124/B 124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
- B 170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes
- B 193 Test Method for Resistivity of Electrical Conductor Materials
- B 216 Specification for Tough-Pitch Fire-Refined Copper—Refinery Shapes
- B 224 Classification of Coppers
- B 249/B 249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings
- B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper
- B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
- B 846 Terminology for Copper and Copper Alloys
- E 53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)
- E 255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
- E 478 Test Methods for Chemical Analysis of Copper Alloys
- E 527 Practice for Numbering Metals and Alloys (UNS)

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.02 on Rod, Bar, Wire, Shapes, and Forgings.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-187 in Section II of that Code.

<sup>3</sup> Refer to Practice E 527 for an explanation of the Unified Numbering System.

<sup>4</sup> 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.

\*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 **B 846**.

**3.2 Definitions:**

3.2.1 *bus bar, n*—includes material of solid rectangular or square cross section or a solid section with two plane parallel surfaces and round or other simple regularly shaped edges up to and including 12 in. in width and 0.090 in. and over in thickness.

3.2.2 *bus conductor stock, n*—a bar, rod, or shape of high conductivity copper used to make electrical conductors.

3.2.3 *bus rod, n*—includes solid round and regular polygons of six and eight sides.

3.2.4 *bus shapes, n*—a solid section other than regular rod, bar, plate, sheet, strip, or flat wire, that may be oval, half oval, half round, triangular, pentagonal, or of any special cross section furnished in straight lengths. Shapes shall not include tube and pipe or other hollow sections.

**3.3 Definitions of Terms Specific to This Standard:**

3.3.1 *orange peel, n*—the surface roughness resulting from working metal of large grain size. The surface is similar in texture to that of the outside surface of an orange.

**4. General Requirements**

4.1 The following sections of Specification **B 249/B 249M** are a part of this specification:

- 4.1.1 Terminology,
- 4.1.2 Material and Manufacture,
- 4.1.3 Workmanship, Finish, and Appearance,

- 4.1.4 Sampling,
  - 4.1.5 Number of Tests and Retests,
  - 4.1.6 Test Methods,
  - 4.1.7 Specimen Preparation,
  - 4.1.8 Significance of Numerical Limits,
  - 4.1.9 Inspection,
  - 4.1.10 Rejection and Rehearing,
  - 4.1.11 Certification,
  - 4.1.12 Test Reports, and
  - 4.1.13 Packaging and Package Marking.
- 4.2 Identical sections in this specification supplement the referenced section.

**5. Ordering Information**

5.1 Include the following information in orders for product under this specification:

- 5.1.1 ASTM specification designation and year of issue,
- 5.1.2 Copper UNS No. (see **7.1** and **Table 1**),
- 5.1.3 Temper required (see **8.1** and **Table 2**),
- 5.1.4 Dimensions and form,
- 5.1.5 When product is ordered for *ASME Boiler and Pressure Vessel Code* applications (see **Section 16**),
- 5.1.6 Shapes; dimensional tolerances required and agreed upon (see **13.3**),
- 5.1.7 Quantity; number of pounds, pieces, or footage required,
- 5.1.8 Length: stock or specific (see **13.5**), and
- 5.1.9 When material is purchased for agencies of the U.S. government (see **Section 12**).

**TABLE 1 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.

Composition % Maximum (Unless shown as a range or minimum)						
Copper UNS No.	Copper (Incl. Silver)	Phos- phorus	Silver	Oxygen	Tellurium	Tin
C10100	99.99 <sup>A</sup> min	<i>B</i>	<i>B</i>	<i>B</i>	<i>B</i>	<i>B</i>
C10200	99.95 <sup>C</sup> min	...	...	0.0010	...	...
C10300	99.95 <sup>D</sup> min	0.001–0.005	...	...	...	...
C10400 <sup>E</sup>	99.95 <sup>C</sup> min	...	8 <sup>F</sup>	0.0010	...	...
C10500 <sup>E</sup>	99.95 <sup>C</sup> min	...	10 <sup>F</sup>	0.0010	...	...
C10700 <sup>E</sup>	99.95 <sup>C</sup> min	...	25 <sup>F</sup>	0.0010	...	...
C10800	99.95 <sup>D</sup> min	0.005–0.012	...	...	...	...
C10920	99.90 min	...	...	0.02	...	...
C10930	99.90 min	...	13 <sup>F</sup>	0.02	...	...
C10940	99.90 min	...	25 <sup>F</sup>	0.02	...	...
C11000	99.90 min	...	...	<sup>G</sup>	...	...
C11300 <sup>H</sup>	99.90 min	...	8 <sup>F</sup>	<sup>G</sup>	...	...
C11400 <sup>H</sup>	99.90 min	...	10 <sup>F</sup>	<sup>G</sup>	...	...
C11500 <sup>H</sup>	99.90 min	...	16 <sup>F</sup>	<sup>G</sup>	...	...
C11600 <sup>H</sup>	99.90 min	...	25 <sup>F</sup>	<sup>G</sup>	...	...
C12000	99.90 min	0.004–0.012	...	...	...	...
C12200	99.90 min	0.015–0.040	...	...	...	...

<sup>A</sup> Copper value is determined by the difference between the impurity total and 100 %. The copper value is exclusive of Ag.  
<sup>B</sup> Impurity maximums in ppm of C10100 shall be: antimony 4, arsenic 5, bismuth 1, cadmium 1, iron 10, lead 5, manganese 0.5, nickel 10, oxygen 5, phosphorus 3, selenium 3, silver 25, sulfur 15, tellurium 2, tin 2, and zinc 1.  
<sup>C</sup> Copper value is determined by the difference between the impurity total and 100 %.  
<sup>D</sup> Copper (includes silver) + phosphorus, min.  
<sup>E</sup> C10400, 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.  
<sup>F</sup> Values are minimum silver in Troy ounces per Avoirdupois ton (1 oz/ton is equivalent to 0.0034 %).  
<sup>G</sup> Oxygen and trace elements may vary depending on the process.  
<sup>H</sup> C11300, 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.

**TABLE 2 Mechanical (All Alloys) and Electrical Requirements<sup>A</sup> (Conductor Alloys Only)**

Temper Designation		Diameter or Distance Between Parallel Surfaces, in.	Tensile Strength, ksi, [MPa] <sup>B</sup>		Yield Strength, ksi, [MPa] Min <sup>C</sup>	Elongation in 4 × Diameter or Thickness of Specimen Min. % <sup>D</sup>	Bend Test Angle of Bend °	Electrical Resistivity, <sup>E</sup> Max, Ω·g/m <sup>2</sup> at 20°C (68°F)			
Standard	Former		Min	Max	Min			C10100	C10200, C10400, C10500, C10700, C10920, C10930, C10940, C11000, C11300, C11400, C11500, C11600	C10300	Rockwell Hardness F Scale, 60-kg Load, 1/16-in. Ball
O60	Soft anneal	Rod and bar:									
		All sizes	28 [195]	37 [255]	8 [55] <sup>C</sup>	25	180	0.151 76	0.153 28	0.156 14	50 max
H04	Hard	Rod:									
		Up to 3/8 [10] incl.	45 [310]	60 [410]	—	12	120	0.155 85	0.157 37	0.159 40	—
		Over 3/8 [10] to 1 [25] incl.	40 [275]	55 [380]	—	12	120	0.155 85	0.157 37	0.159 40	80 min
		Over 1 [25] to 2 [50] incl.	35 [240]	50 [345]	—	15	120	0.155 85	0.157 37	0.159 40	75 min
		Over 2 [50] to 3 [75] incl.	33 [230]	48 [330]	—	15	120	0.154 25	0.155 77	0.159 40	65 min
		Over 3 [75]	30 [205]	48 [330]	—	15	120	0.154 25	0.155 77	0.159 40	—
		Bar:									
		Up to 3/8 [10] incl. thickness and up to 4 [110] incl. in width	37.5 [260]	50 [345]	—	10	120	0.155 85	0.157 37	0.159 40	80 min
		All other sizes	33 [230] <sub>F</sub>	50 [345] <sub>F</sub>	—	15	120	0.154 25	0.155 77	0.159 40	65 min
		Channels, angles and shapes			—	15	—	0.154 25	0.155 77	0.159 40	—

<sup>A</sup> See 9.1.

<sup>B</sup> ksi = 1000 psi.

<sup>C</sup> Light-straightening operation is permitted.

<sup>D</sup> In any case, a minimum gage length of 1 in. shall be used.

<sup>E</sup> See Appendix X1.

<sup>F</sup> Special agreement shall be made between the manufacturer or supplier and the purchaser.

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 required,
- 5.2.2 Hydrogen embrittlement test,
- 5.2.3 Bend test,
- 5.2.4 Certification,
- 5.2.5 Mill test reports,
- 5.2.6 Special packaging requirements,
- 5.2.7 Edges other than finished edges (see 6.2.1.2), and
- 5.2.8 Edge contours other than square edge (see 13.7).

## 6. Materials and Manufacture

### 6.1 Material:

6.1.1 The materials shall conform to the published compositional requirements of the Copper or Copper Alloy UNS No. designation specified in the ordering information.

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

### 6.2 Manufacture:

#### 6.2.1 Edges:

6.2.1.1 Bar shall be furnished with finished edges (see 13.7) unless otherwise specified at the time of order placement.

6.2.1.2 Bar may be furnished with sawed edges and deburred corners upon agreement between the manufacturer or supplier and the purchaser (see 5.2.7).

## 7. Chemical Composition

7.1 The specified copper shall conform to the chemical requirements prescribed in Table 1.

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

## 8. Temper

8.1 Tempers available under this specification and as described in Classification B 601 are as follows:

Standard	Temper Designation	Former
O60		soft anneal
H04		hard

## 9. Physical Property Requirements

9.1 *Electrical Resistivity*—Bar, rod, and shapes of alloys Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, C10920, C10930, C10940, C11000, C11300, C11400, C11500, and C11600, shall conform to the electrical resistivity limits prescribed in Table 2 for specified copper, temper, form, and size when determined in accordance with Test Method B 193.

## 10. Mechanical Property Requirements

### 10.1 Tensile Requirements:

10.1.1 The bars and rod shall conform to the tensile, yield, and elongation requirements of Table 2.

10.1.1.1 For shapes, the tensile requirements (if any) shall be by agreement between the manufacturer and the purchaser.

10.2 *Rockwell Hardness*—Rockwell hardness tests offer a quick and convenient method of checking copper of any

temper for general conformity to the requirements of tensile strength. The approximate Rockwell hardness values for the specified tempers are given in **Table 2** for general information and assistance in testing.

## 11. Performance Requirements

### 11.1 Bending Requirements:

11.1.1 When specified in the contract or purchase order, for bar, bus bar, flat wire, and rod, test specimens shall withstand being bent cold (right way bend) through an angle as specified in **Table 2** for the specified temper and size without fracture on the outside of the bent portion and with no evidence of slivers, cracks, orange peel, or similar surface defects being visible to the unaided eye.

11.1.2 The bend shall be made on a radius equal to the minimum cross-sectional dimension of the specimen, and this dimension shall be radial to the bend.

11.1.3 The axis of the bend shall be at an angle of 90° to the direction of rolling, drawing, or extrusion (right way bend).

11.1.4 Edgewise and wrong way bend test requirements for bar or bus bar shall be by agreement between the manufacturer or supplier and the purchaser.

### 11.2 Microscopical Examination:

11.2.1 Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, C10800, and C12000 shall be substantially free of cuprous oxide as determined by Procedure A, Microscopical Examination, of Test Methods **B 577**.

11.2.2 In case of dispute, testing shall be in accordance with Procedure C, Closed Bend Test, of Test Methods **B 577**.

### 11.3 Embrittlement Test:

11.3.1 When specified in the contract or purchase order, Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, C10800, and C12000 shall pass the embrittlement test described in Procedure B, Microscopical Examination of Thermally Treated Specimens, in Test Methods **B 577**.

11.3.2 In case of dispute, testing shall be in accordance with Procedure C, Closed Bend Test, of Test Methods **B 577**.

## 12. Orders for U.S. Government Agencies

12.1 Orders for agencies of the U.S. government shall conform to the special government requirements stipulated in the Supplemental Requirements section.

## 13. Dimensions, Mass, and Permissible Variations

13.1 The dimensions and tolerances for material manufactured under this specification shall be as specified in the following tables:

### 13.2 Diameter or Distance Between Parallel Surfaces:

13.2.1 Rod: Round, Hexagonal, Octagonal—See **Table 3**.

13.2.2 Bar: Rectangular and Square:

13.2.2.1 Thickness Tolerances for Rectangular and Square Bar—See **Table 4** for rolled or drawn edges and **Table 5** for sawed edges with deburred corners.

13.2.2.2 Width Tolerances for Rectangular and Square Bar—See **Table 6** for rolled or drawn edges and **Table 7** for sawed edges with deburred corners.

13.3 Shapes—The dimensional tolerances of shapes shall be as agreed upon by the manufacturer or supplier and the purchaser and shall be specified in the order.

13.4 Coils—The coil size shall be as agreed upon between the manufacturer or supplier and the purchaser and shall be specified in the order.

### 13.5 Length:

13.5.1 Specified Length—When exact lengths are ordered, the lengths shall be not less than the ordered length and shall not exceed it by more than the amount specified in **Table 8**.

13.5.2 Stock Lengths—For material ordered in stock lengths, full-length pieces shall be not less than the designated length and shall not exceed it by more than 1 in. Short lengths may be included as prescribed in **Table 9**.

13.6 Straightness—Unless otherwise specified in the contract or purchase order, the material shall be supplied in straight lengths. The deviation from absolute straightness of any longitudinal surface or edge shall not exceed the limitations prescribed in **Table 10**.

13.6.1 To determine compliance with this section, rod and bar shall, in case of disagreement, be checked by the following method:

13.6.1.1 Place the rod or bar on a level table so that the arc or departure from straightness is horizontal. Measure the maximum depth of arc to the nearest 1/32 in. [0.8 mm] using a steel scale and a straight edge.

### 13.7 Edge Contours:

13.7.1 Angles—All polygonal sections shall have substantially exact angles and sharp corners.

13.7.2 Square Corners—Unless otherwise specified in the contract or purchase order, bar shall be finished with commercially square corners with the maximum permissible radius shown in **Table 11**.

13.7.3 Rounded Corners—When specified in the contract or purchase order, bar may be finished with corners rounded as shown in **Fig. 1** to a quarter circle with a radius as shown in **Table 12**. The tolerance on the radius shall be  $\pm 25\%$ .

**TABLE 3 Diameter Tolerances for Cold-Drawn Rod (H04 and O60 Tempers)**

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]	
	Round	Hexagonal or Octagonal
Up to 0.150 [3.8] incl.	0.0013 [0.035]	0.0025 [0.06]
Over 0.150 [3.8] to 0.500 [12] incl.	0.0015 [0.04]	0.003 [0.08]
Over 0.500 [12] to 1.00 [25] incl.	0.002 [0.05]	0.004 [0.10]
Over 1.00 [25] to 2.00 [50] incl.	0.0025 [0.06]	0.005 [0.13]
Over 2.00 [50]	0.15 <sup>B</sup>	0.30 <sup>B</sup>

<sup>A</sup> When tolerances are specified as all plus or all minus, double the values given.

<sup>B</sup> Percent of specified diameter or distance between parallel surfaces expressed to the nearest 0.001 in. [0.025 mm].

**TABLE 4 Thickness Tolerances for Drawn or Rolled Rectangular and Square Bar Plus and Minus,<sup>A</sup> in. [mm]**

Thickness	Width, in. [mm]			
	2 [50] and Under	Over 2 [50] to 4 [100] incl.	Over 4 [100] to 8 [200] incl.	Over 8 [200] to 12 [300] incl.
Up to 0.500 [13], incl.	0.003 [0.08]	0.004 [0.10]	0.0045 [0.11]	0.0055 [0.14]
Over 0.500 [13] to 1.000 [25], incl.	0.004 [0.10]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]
Over 1.000 [25] to 2.000 [50], incl.	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]	...

<sup>A</sup> When tolerances are specified as all plus or all minus, double the values given.

**TABLE 5 Thickness Tolerances for Sawed Edge, Deburred Corner Rectangular and Square Bar, Plus and Minus,<sup>A</sup> in. [mm] for Widths Given in Inches [mm]**

Thickness	2 [50] and Under incl.	Over 2 [50] to 4 [100] incl.	Over 4 [100] to 8 [200] incl.	Over 8 [200] to 12 [300] incl.
Up to 0.250 [6], incl.	0.0025 [0.06]	0.003 [0.08]	0.0035 [0.09]	0.005 [0.13]
Over 0.250 [6] to 0.375 [10] incl.	0.003 [0.08]	0.004 [0.10]	0.0045 [0.11]	0.005 [0.13]
Over 0.375 [10] to 0.500 [13] incl.	0.0035 [0.09]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]
Over 0.500 [13] to 0.750 [19] incl.	0.0055 [0.14]	0.0055 [0.14]	0.0055 [0.14]	0.007 [0.18]
Over 0.750 [19] to 1.000 [25] incl.	0.007 [0.18]	0.007 [0.18]	0.007 [0.18]	0.009 [0.23]
Over 1.000 [25] to 1.500 [38] incl.	0.015 [0.38]	0.020 [0.50]	0.022 [0.55]	0.025 [0.60]
Over 1.500 [38] to 2.000 [50] incl.	0.020 [0.50]	0.024 [0.60]	0.026 [0.65]	0.030 [0.75]

<sup>A</sup> When tolerances are specified as all plus or all minus, double the values given.

**TABLE 6 Width Tolerances for Drawn or Rolled Rectangular and Square Bar**

Width, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
2 [50] and under	0.008 [0.2]
Over 2 [50] to 4 [100], incl.	0.012 [0.3]
Over 4 [100] to 12 [310] incl.	0.30 <sup>B</sup>

<sup>A</sup> When tolerances are specified as all plus or all minus, double the values given.

<sup>B</sup> Percent of specified width expressed to the nearest 0.001 in. [0.01 mm].

**TABLE 7 Width Tolerances for Sawed Edge with Deburred Corner Rectangular and Square Bar, Plus and Minus, in. [mm]<sup>A</sup>**

Thickness	Width, in. [mm]	
	12 [300] and under incl.	Over 12 [300]
Up to 1.500 [40], incl.	1/32 [0.8]	1/16 [1.6]
Over 1.500 [40]	1/16 [1.6]	1/16 [1.6]

<sup>A</sup> When tolerances are specified as all plus or all minus, double the values given.

13.7.4 *Rounded Edge*—When specified in the contract or purchase order, bar may be finished with edges rounded as shown in Fig. 2, with a radius of curvature as shown in Table 13.

13.7.5 *Full Rounded Edge*—When specified in the contract or purchase order, bar may be finished with substantially uniform round edges, the radius of curvature being approximately one half the thickness of the product as shown in Fig. 3, but in no case to exceed one half the thickness of the product by more than 25 %.

**TABLE 8 Length Tolerances for Rod, Bar, and Shapes (Full-Length Pieces Specific and Stock Lengths with or without Ends)**

Length Classification	Tolerances, All Plus, in. [mm] (Applicable Only to Full-Length Pieces)
Specific lengths	
Up to 6 ft. [1800 mm]	1/8 [3]
Over 6 to 15 ft. [1800 to 4500 mm]	1/4 [6]
Over 15 ft. [4500 mm]	1/2 [13]
Specific lengths with ends	1 [25]
Stock lengths with or without ends	1 [25]

13.7.6 *Shapes*—Products with edge or corner contours other than described in 13.7.1-13.7.5 are classified as shapes.

NOTE 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 may be cause for rejection.

## 14. Specimen Preparation

14.1 *Microscopical Examination*—Specimen preparation shall be in accordance with Procedure A of Test Methods B 577.

## 15. Test Methods

15.1 Refer to Specification B 249/B 249M for the appropriate mechanical test method.

**TABLE 9 Schedule of Lengths (Specific and Stock) with Ends**

Diameter or Distance Between Parallel Surfaces for Round Hexagonal, Octagonal Rod and Square Bar, in. [mm]	Rectangular Bar Area, <sup>A</sup> in <sup>2</sup> [mm <sup>2</sup> ]	Nominal Length, ft [mm]	Shortest Permissible Length <sup>B</sup> % of Nominal Length	Maximum Permissible Weight of Ends, % of Lot Weight
½ [13] and under	0.250 [160] and under	6 to 14 [1800 to 4300] incl.	75	20
Over ½ to 1 [13 to 25] incl.	Over 0.250 to 1 [160 to 650] incl.	6 to 14 [1800 to 4300] incl.	70	30
Over 1 to 1½ [25 to 40] incl.	Over 1 to 2.25 [650 to 1450] incl.	6 to 12 [1800 to 3600] incl.	60	40
Over 1½ to 2 [40 to 50] incl.	Over 2.25 to 4 [1450 to 2600] incl.	6 to 12 [1800 to 3600] incl.	50	45
Over 2 to 3 [50 to 75] incl.	Over 4 to 9 [2600 to 5000] incl.	6 to 10 [1800 to 3000] incl.	40	50

<sup>A</sup> Width times thickness, disregarding any rounded corner or edges.

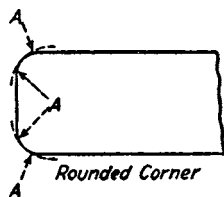
<sup>B</sup> Expressed to the nearest ½ ft [100 mm].

**TABLE 10 Straightness Tolerances Applicable to Any Longitudinal Surface or Edge**

	Maximum Curvature (Depth of Arc), in. [mm]	Portion of Total Length in Which Depth of Arc Is Measured, in. [mm]
Rod	½ [13]	120 [3000]
Shapes	½ [13]	72 [1800]
Bar (except hard rectangular bar listed in following line)	¼ [6]	60 [1500]
Hard rectangular bar ⅛ to ⅝ in. [3 to 15 mm] incl., in thickness, having widths ranging from 2 to 6 in. [50 to 150], incl.	⅛ [3]	96 [2400]

**TABLE 11 Radius for Square Corners**

Specified Thickness, in. [mm]	Maximum Radius Permissible for Square Corners, in. [mm]
Up to ¾ [5] incl.	¼ [0.4]
Over ¾ to 1 [5 to 25] incl.	⅓ [0.8]
Over 1 [25]	⅜ [1.6]



NOTE 1—The arc shall not necessarily be tangent at points, A, but the product shall be commercially free from sharp, rough, or projecting edges.

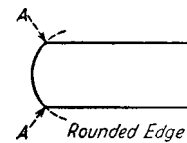
**FIG. 1 Rounded Corners**

15.2 Chemical composition shall, in case of disagreement be determined as follows:

Element	ASTM Test Method
Copper	E 53
Phosphorus	E 62
Selenium	Refer to Annex, Specification B 216
Silver	E 478
Tellurium	Refer to Annex, Specification B 216

**TABLE 12 Radius for Rounded Corners**

Specified Thickness, in. [mm]	Nominal Radius of Corners, in. [mm]	
	For Widths Up to and Including 2× Thickness	For Widths More Than 2× Thickness
Up to ⅛ [2], incl.	¼ [0.4]	full rounded edges as given in 13.7.5
Over ⅛ to ¾ [2 to 6], incl.	⅓ [0.8]	⅓ [0.8]
Over ¾ to 1 [6 to 25], incl.	⅜ [1.6]	⅜ [1.6]
Over 1 [25]	⅝ [3]	⅝ [3]



NOTE 1—The arc shall be substantially symmetrical with the axis of the product. The corners, A, will usually be sharp, but shall not have rough or projecting edges.

**FIG. 2 Rounded Edge**

**TABLE 13 Radius for Rounded Edge**

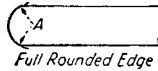
Specified Thickness, in. [mm]	Nominal Radius of Rounded Edge, in. [mm]	Tolerance on Radius, Plus and Minus, in. [mm]
Up to ¾ [5], incl.	¼ × thickness	½ × thickness
Over ¾ [5]	⅜ × thickness	¼ × thickness

15.2.1 For Copper No. C10100, refer to the Annex of Specification B 170 for test methods.

15.2.2 Test method(s) for the determination of element(s) resulting from contractual or purchaser order agreement shall be as agreed upon between the manufacturer or supplier and the purchaser.

**16. Certification**

16.1 When product is ordered to meet the requirements of the ASME Boiler and Pressure Vessel Code, the certification requirements of Specification B 249/B 249M are mandatory.



Full Rounded Edge

NOTE 1—The arc shall not necessarily be tangent at points, A, but shall be substantially symmetrical with the axis of the product, and the product shall be commercially free from sharp, rough, or projecting edges.

FIG. 3 Full Rounded Edge

17. Keywords

17.1 bar; bus bar; copper; electrical conductors; embrittlement test; rod; shapes; UNS No. C10100; UNS No. C10200; UNS No. C10300; UNS No. C10400; UNS No. C10500; UNS No. C10700; UNS No. C10920; UNS No. C10930; UNS No. C10940; UNS No. C11000; UNS No. C11300; UNS No. C11400; UNS No. C11500; UNS No. C11600; UNS No. C10800; UNS No. C12000; UNS No. C12200

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U.S. government.

S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

S1.1.1 *Federal Standards*:<sup>5</sup>

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products

S1.1.2 *Military Standards*:<sup>5</sup>

MIL-STD-105 Sampling Procedures and Table for Inspection by Attributes

MIL-STD-129 Marking for Shipment and Storage

S1.1.3 *Military Specification*:<sup>5</sup>

MIL-C-3993 Packaging of Copper and Copper-Base Alloy Mill Products

S2. Quality Assurance

S2.1 *Responsibility for Inspection*:—Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the

inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used.

S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing*:

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade or class and shall be preserved and packaged, Level A or C, packed Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of MIL-C-3993.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking*:

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

<sup>5</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

**APPENDIX****(Nonmandatory Information)****X1. RESISTIVITY**

X1.1 “Resistivity” is used in place of “conductivity.” The value of  $0.153\ 28\ \Omega\cdot\text{g}/\text{m}^2$  at  $20^\circ\text{C}$  ( $68^\circ\text{F}$ ) is the international standard for the resistivity of annealed copper equal to 100 % conductivity. This term means that a wire 1 m in length and weighing 1 g would have a resistance of  $0.153\ 28\ \Omega$ . This is equivalent to a resistivity value of  $875.20\ \Omega\cdot\text{lb}/\text{mile}^2$ , which signifies the resistance of a wire 1 mile in length weighing 1 lb. It is also equivalent, for example, to  $1.7241\ \mu\Omega/\text{cm}$  of length of a bar  $1\ \text{cm}^2$  in cross section. A complete discussion of this

subject is contained in *NBS Handbook 100* of the National Institute of Standards Technology.<sup>6</sup> Relationships that may be useful in connection with the values of resistivity prescribed in this specification are as shown in **Table X1.1**, each column containing equivalent expressions at  $20^\circ\text{C}$  ( $68^\circ\text{F}$ ):

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<sup>6</sup> Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 3460, Gaithersburg, MD 20899-3460.



**TABLE X1.1 Resistivity Relationships**

Conductivity at 68°F, %	101.0	100.0	98.40	98.16	97.40	96.16	90.0	88.0
$\Omega \cdot \text{g}/\text{m}^2$	0.151 76	0.153 28	0.155 77	0.156 14	0.157 37	0.159 40	0.170 31	0.174 18
$\Omega \cdot \text{lb}/\text{mile}^2$	866.53	875.20	889.42	891.60	898.55	910.15	972.44	994.55
$\Omega \cdot \text{cmil}/\text{ft}$	10.268	10.371	10.539	10.565	10.648	10.785	11.523	11.785
$\Omega \cdot \text{mm}^2/\text{m}$	0.017 070	0.017 241	0.017 521	0.017 564	0.017 701	0.017 930	0.019 156	0.019 592
$\mu\Omega \cdot \text{in.}$	0.672 07	0.678 79	0.689 81	0.691 51	0.696 90	0.705 90	0.754 21	0.771 35
$\mu\Omega \cdot \text{cm}$	1.7070	1.7241	1.7521	1.7564	1.7701	1.7930	1.9157	1.9592

### SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 187 – 03) that may impact the use of this standard. (Approved Oct. 1, 2006).

- (I) Changed second value in **Table X1.1**, column 1 to 866.53.

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