



Designation: B187/B187M – 06

# 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 B187/B187M; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*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 B124/B124M.

## 2. Referenced Documents

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

- B124/B124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
- B170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes
- B193 Test Method for Resistivity of Electrical Conductor Materials
- B216 Specification for Tough-Pitch Fire-Refined Copper—Refinery Shapes
- B224 Classification of Coppers
- B249/B249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings
- B577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper
- B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
- B846 Terminology for Copper and Copper Alloys
- E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry
- E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)
- E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
- E478 Test Methods for Chemical Analysis of Copper Alloys
- E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

## 3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.

<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 E527 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.



3.2 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 B249/B249M 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 Reheating,
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).
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,

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.

Table with 7 columns: Copper UNS No., Copper (Incl. Silver), Phosphorus, Silver, Oxygen, Tellurium, Tin. Rows include C10100, C10200, C10300, C10400, C10500, C10700, C10800, C10920, C10930, C10940, C11000, C11300, C11400, C11500, C11600, C12000, C12200.

A Copper value is determined by the difference between the impurity total and 100 %. The copper value is exclusive of Ag.
B 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.
C Copper value is determined by the difference between the impurity total and 100 %.
D Copper (includes silver) + phosphorus, min.
E 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.
F Values are minimum silver in Troy ounces per Avoirdupois ton (1 oz/ton is equivalent to 0.0034 %).
G Oxygen and trace elements may vary depending on the process.
H 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] <sup>F</sup>	50 [345] <sup>F</sup>	—	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.

- 5.2.4 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).

## 8. Temper

8.1 Tempers available under this specification and as described in Classification B601 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 B193.

## 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.

## 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.

## 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 **B577**.

11.2.2 In case of dispute, testing shall be in accordance with Procedure C, Closed Bend Test, of Test Methods **B577**.

### 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 **B577**.

11.3.2 In case of dispute, testing shall be in accordance with Procedure C, Closed Bend Test, of Test Methods **B577**.

## 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 ±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].