



Designation: B249/B249M – 22

# Standard Specification for General Requirements for Wrought Copper and Copper- Alloy Rod, Bar, Shapes and Forgings<sup>1</sup>

This standard is issued under the fixed designation B249/B249M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope\*

1.1 This specification<sup>2</sup> establishes the general requirements common to wrought copper and copper alloy rod, bar, shapes, and forgings which shall apply to Specifications B16/B16M, B21/B21M, B98/B98M, B124/B124M, B138/B138M, B139/B139M, B140/B140M, B150/B150M, B151/B151M, B187/B187M, B196/B196M, B283/B283M, B301/B301M, B371/B371M, B411/B411M, B441, B453/B453M, B455, B570, B870, B927/B927M, B929, B967/B967M, B974/B974M, and B981/B981M to the extent referenced therein.

1.2 The chemical composition, physical and mechanical properties, and all other requirements not included in this specification are prescribed in the product specification.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.3.1 Within the text the SI values are given in brackets.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<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 Specifications SB-249 in Section II of that Code.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- B16/B16M Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines
- B21/B21M Specification for Naval Brass Rod, Bar, and Shapes
- B98/B98M Specification for Copper-Silicon Alloy Rod, Bar and Shapes
- B124/B124M Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes
- B138/B138M Specification for Manganese Bronze Rod, Bar, and Shapes
- B139/B139M Specification for Phosphor Bronze Rod, Bar, and Shapes
- B140/B140M Specification for Copper-Zinc-Lead (Red Brass or Hardware Bronze) Rod, Bar, and Shapes
- B150/B150M Specification for Aluminum Bronze Rod, Bar, and Shapes
- B151/B151M Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Rod and Bar
- B154 Test Method for Mercurous Nitrate Test for Copper Alloys
- B187/B187M Specification for Copper, Bus Bar, Rod, and Shapes and General Purpose Rod, Bar, and Shapes
- B193 Test Method for Resistivity of Electrical Conductor Materials
- B194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar
- B196/B196M Specification for Copper-Beryllium Alloy Rod and Bar
- B283/B283M Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)
- B301/B301M Specification for Free-Cutting Copper Rod, Bar, Wire, and Shapes
- B371/B371M Specification for Copper-Zinc-Silicon Alloy Rod

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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



**B411/B411M** Specification for Copper-Nickel-Silicon Alloy Rod and Bar

**B441** Specification for Copper-Cobalt-Beryllium, Copper-Nickel-Beryllium, and Copper-Nickel-Lead-Beryllium Rod and Bar (UNS Nos. C17500, C17510, and C17465)

**B453/B453M** Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Rod, Bar, and Shapes

**B455** Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Extruded Shapes

**B570** Specification for Copper-Beryllium Alloy (UNS Nos. C17000 and C17200) Forgings and Extrusions

**B577** Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper

**B846** Terminology for Copper and Copper Alloys

**B858** Test Method for Ammonia Vapor Test for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys

**B870** Specification for Copper-Beryllium Alloy Forgings and Extrusions (UNS Nos. C17500, C17510, and C17540)

**B900** Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies

**B927/B927M** Specification for Brass Rod, Bar, and Shapes

**B929** Specification for Copper-Nickel-Tin Spinodal Alloy Rod and Bar

**B967/B967M** Specification for Copper-Zinc-Tin-Bismuth Alloy Rod, Bar and Wire

**B974/B974M** Specification for Free-Cutting Bismuth Brass Rod, Bar and Wire

**B981/B981M** Specification for Low-Leaded Brass Rod, Bar, Wire, and Shapes

**D4855** Practice for Comparing Test Methods (Withdrawn 2008)<sup>4</sup>

**E3** Guide for Preparation of Metallographic Specimens

**E8/E8M** Test Methods for Tension Testing of Metallic Materials

**E18** Test Methods for Rockwell Hardness of Metallic Materials

**E29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

**E53** Test Method for Determination of Copper in Unalloyed Copper by Gravimetry (Withdrawn 2022)<sup>4</sup>

**E54** Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)<sup>4</sup>

**E62** Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)<sup>4</sup>

**E75** Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys (Withdrawn 2010)<sup>4</sup>

**E76** Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)<sup>4</sup>

**E112** Test Methods for Determining Average Grain Size

**E118** Test Methods for Chemical Analysis of Copper-Chromium Alloys (Withdrawn 2010)<sup>4</sup>

**E121** Test Methods for Chemical Analysis of Copper-Tellurium Alloys (Withdrawn 2010)<sup>4</sup>

**E255** Practice for Sampling Copper and Copper Alloys for

the Determination of Chemical Composition

**E290** Test Methods for Bend Testing of Material for Ductility

**E478** Test Methods for Chemical Analysis of Copper Alloys

**E581** Test Methods for Chemical Analysis of Manganese-Copper Alloys

2.2 *ASME Code*:<sup>5</sup>

**ASME Boiler and Pressure Vessel Code**

### 3. Terminology

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

#### 3.2 Definitions of Terms Specific to This Standard:

3.2.1 *lengths, mill, n*—straight lengths, including ends, that can be conveniently manufactured in the mill. Full length pieces are usually 10 ft or 12 ft [3000 mm or 3600 mm].

3.2.2 *lengths, stock, n*—straight lengths that are mill cut and stored in advance of orders. They are usually 10 ft or 12 ft [3000 mm or 3600 mm] and subject to established length tolerances.

### 4. Materials and Manufacture

#### 4.1 Materials:

4.1.1 The material of manufacture shall be a form of the Copper or Copper Alloy UNS No. designation specified in the ordering information of such purity and soundness as to be suitable for processing into the products described in the product specification.

4.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 1—Due to the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify specific casting analysis with a specific quantity of finished product. **B249/B249M-22**

4.2 *Manufacture*—The product shall be manufactured by such hot-working, cold-working, and annealing processes as to produce a uniform wrought structure in the finished product.

4.2.1 The product shall be hot- or cold-worked to the finished size and subsequently annealed or heat treated when required, and straightened to meet the properties specified.

4.2.2 *Edges*—The edge shall be drawn, extruded, or rolled; refer to Edge Contours in Section 6.

### 5. Chemical Composition

5.1 The material shall conform to the chemical composition requirements prescribed in the product specification.

5.1.1 Results of analysis on a product (check) sample shall conform to the composition requirements within the permitted analytical variance given in the product specification.

5.2 The composition limits established for the Copper or Copper Alloy UNS No. designation specified in the product specification do not preclude the presence of other elements.

<sup>4</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>5</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

By agreement between the manufacturer or supplier and the purchaser, limits may be established and analysis required for unnamed elements.

5.3 When material composition has been determined during the course of manufacture, analysis of the finished product by the manufacturer is not required.

**6. Dimensions, Mass and Permissible Variations**

6.1 *General*—For the purpose of determining conformance with the dimensional requirements, any measured value outside the specified limiting values for any dimension may be cause for rejection.

6.1.1 The dimensions and tolerances for products referenced to this specification shall be as noted in the following paragraphs and tables, where the product specification is noted in the table heading.

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

6.2 *Diameter or Distance Between Parallel Surfaces*—The diameter of round sections or the distance between parallel surfaces in the case of other sections, except shapes, shall not vary from that specified by more than the amounts specified in Tables 1-12, included, for the product specification indicated.

Table 1 and Table 2—List the tolerances for diameter or distance between parallel surfaces of cold-drawn rod in round, hexagonal, and octagonal cross sections. Applicable product specifications and alloys are shown in the table titles.

Table 3—Lists the diameter tolerances for piston finish rod applicable to product specifications shown in the table title.

Table 4 and Table 5—List the tolerances for diameter or distance between parallel surfaces of as-extruded rod and bar applicable to the specifications and alloys shown in the table titles. These tolerances are applicable to round, hexagonal, and octagonal rod as well as square and rectangular bar.

Table 6—Lists the diameter tolerances for hot-rolled round rod applicable to the product specification shown in the table title.

**TABLE 1 Tolerances for Diameter or Distance Between Parallel Surfaces of Cold-Drawn Rod**

(Applicable to Specifications B16/B16M, B21/B21M, B98/B98M (Copper Alloy UNS No. C65100), B124/B124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C46750, C48200, C48500, C48640, C48645, C49250, C49255, C49260, C49265, C49300, C49340, C49345, C49350, and C49360), B140/B140M, B301/B301M, B453/B453M, B927/B927M, B967/B967M, and B974/B974M)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]	
	Round	Hexagonal, Octagonal
Up to 0.150 [3.8], incl	0.0013 [0.035]	0.0025 [0.06]
Over 0.150 to 0.500 [3.8 to 12], incl	0.0015 [0.04]	0.003 [0.08]
Over 0.500 to 1.00 [12 to 25], incl	0.002 [0.05]	0.004 [0.10]
Over 1.00 to 2.00 [25 to 50], incl	0.0025 [0.06]	0.005 [0.13]
Over 2.00 [50]	0.15 <sup>B</sup> [0.15] <sup>B</sup>	0.30 <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. [0.01 mm].

**TABLE 2 Tolerances for Diameter or Distance Between Parallel Surfaces of Cold-Drawn Rod**

(Applicable to Specifications B98/B98M (Copper Alloy UNS Nos. C65500 and C66100), B124/B124M (Copper Alloy UNS Nos. C27450, C27453, C28500, C36300, C36500, C37000, C37700, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C65680, C67500, C67600, C69240, C69300, C69410, C69850, C70620, C71520, and C77400), B138/B138M, B139/B139M, B150/B150M, B151/B151M, B196/B196M, B371/B371M, B411/B411M, B441, and B981/B981M)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]	
	Round	Hexagonal, Octagonal
Up to 0.150 [3.8], incl	0.002 [0.050]	...
Over 0.150 to 0.500 [3.8 to 12], incl	0.002 [0.050]	0.004 [0.10]
Over 0.500 to 1.00 [12 to 25], incl	0.003 [0.08]	0.005 [0.13]
Over 1.00 to 2.00 [25 to 50], incl	0.004 [0.10]	0.006 [0.15]
Over 2.00 [50]	0.20 <sup>B</sup> [0.20] <sup>B</sup>	0.40 <sup>B</sup> [0.40] <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. [0.01 mm].

**TABLE 3 Diameter Tolerances for Piston-Finish Rod**

(Applicable to Specifications B21/B21M, B138/B138M, B139/B139M, and B150/B150M)

Diameter, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
Over 0.500 to 1.00 [12 to 25], incl	0.0013 [0.35]
Over 1.00 to 2.00 [25 to 50], incl	0.0015 [0.04]
Over 2.00 [50]	0.10 <sup>B</sup> [0.10] <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 expressed to the nearest 0.0005 in. [0.01 mm].

**TABLE 4 Tolerances for Diameter or Distance Between Parallel Surfaces of As-Extruded Rod and Bar**

(Applicable to Specifications B21/B21M, B124/B124M (Copper Alloy UNS Nos. C27450, C27453, C28500, C36300, C36500, C37000, C37700, C46400, C46750, C48200, C48500, C48640, C48645, C49250, C49255, C49260, C49265, C49300, C49340, C49345, C49350, C49355, C49360, C61900, C62300, C63000, C63200, C64200, C64210, C67500, C67600, C69240, C69300, C69410, C69850, C70620, and C71520), B138/B138M (Copper Alloy UNS Nos. C67500 and C67600), B150/B150M, B967/B967M, and B981/B981M)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
	Rod (Round, Hexagonal, and Octagonal) Bar (Rectangular and Square)
Up to 1.00 [25], incl	0.010 [0.25]
Over 1.00 to 2.00 [25 to 50], incl	0.015 [0.38]
Over 2.00 to 3.00 [50 to 75], incl	0.025 [0.65]
Over 3.00 to 3.50 [75 to 90], incl	0.035 [0.90]
Over 3.50 to 4.00 [90 to 100], incl	0.060 [1.5]

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

Table 7, Table 8 and Table 9—List the thickness tolerances for rectangular and square bar applicable to the product specifications and alloys shown in the table titles.

Table 10 and Table 11—List the width tolerances for rectangular bar applicable to the product specifications and alloys shown in the table titles.

**TABLE 5 Tolerances for Diameter or Distance Between Parallel Surfaces of As-Extruded Rod and Bar**

(Applicable to Specifications B98/B98M, B124/B124M (Copper UNS Nos. C11000, C14500, C14700 and Copper Alloy UNS Nos. C65500, C65680, C77400, C87700, and C87710), B138/B138M (Copper UNS No. C67000), B196/B196M, B441 and B929)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
	Rod (Round, Hexagonal, and Octagonal) Bar (Rectangular and Square)
Up to 1.00 [25], incl	0.020 [0.50]
Over 1.00 to 2.00 [25 to 50], incl	0.030 [0.75]
Over 2.00 to 3.00 [50 to 75], incl	0.050 [1.3]
Over 3.00 to 3.50 [75 to 90], incl	0.070 [1.8]
Over 3.50 to 4.00 [90 to 100], incl	0.120 [3.0]

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

**TABLE 6 Diameter Tolerances for Hot-Rolled Round Rod**  
(Applicable to Specifications B98/B98M, B124/B124M, B138/B138M, B150/B150M, B196/B196M, and B441)

Diameter, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
0.250 [6.35] only	+0.020 [+0.50] -0.010 [-0.25]
Over 0.250 to 0.750 [6.35 to 20], incl	0.015 [0.38]
Over 0.750 to 1.25 [20 to 30], incl	0.020 [0.50]
Over 1.25 to 1.50 [30 to 38], incl	0.030 [0.75]
Over 1.50 to 3.00 [38 to 75], incl	1/16 [1.6]
Over 3.00 [75]	1/8 [3.2]

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

**Table 12**—Lists the diameter or distance between parallel surfaces tolerances for hot-forged rod and bar applicable to the product specification shown in the title.

**6.3 Length**—Rod, bar, and shapes shall be furnished in stock lengths with ends, unless the order specifies stock lengths, specific lengths, or specific lengths with ends as specified in **Table 13**, **Table 14**, and **Table 15** for the product specification indicated.

**Table 13**—Length tolerances for full-length pieces applicable to product specifications shown in the table title.

**Table 14 and Table 15**—Lists the schedule of lengths (specific and stock) with ends applicable to product specifications and alloys shown in the table titles.

#### 6.4 Straightness:

**6.4.1** Unless otherwise specified, drawn rod, bar, and shapes, other than shafting rod, piston-finish rod shall be furnished in straight lengths. The deviation from straightness shall not exceed the limitations specified in **Table 16** for either general or automatic screw machine use for the product specifications and alloys shown in the table titles. To determine compliance with this tolerance, the lengths shall, in case of disagreement, be checked by the following method:

**6.4.1.1** Place the lengths on a level table so that the arc or departure from straightness is horizontal. Measure the depth of arc to the nearest 1/32 in. [1.0 mm], using a steel scale and a straightedge. Local departure from straightness should be measured with a 1 ft [300 mm] straightedge and a feeler gage.

**6.4.2** Shafting rod, when so specified, shall comply with the tolerances of **Table 17** for the product specifications shown in

the table title. To determine compliance with this paragraph, shafting shall, in case of disagreement, be checked by the following method:

**6.4.2.1** Place the shaft upon two freely rotating supports, one fourth of the shaft length extending beyond each support. Measure the departure from straightness at each end and at the center by means of a dial gage mounted on a suitable movable block and set successively at the three points to be measured while rotating the shaft slowly and carefully to avoid vibration. The total range of the dial reading at a given point, divided by two, gives the departure from straightness at that point.

#### 6.5 Edge Contours:

**6.5.1 Finish**—All rectangular and square bar shall have finished edges.

**6.5.2 Angles**—All regular polygonal sections shall have substantially exact angles. For hexagonal and octagonal rods cold-drawn to size, corner radii shall not exceed 1/16 in. [1.5 mm] for sizes up to 2 in. [50 mm], incl., and 3/32 in. [2.5 mm] for sizes over 2 in. [50 mm].

**6.5.2.1** When specified, hexagons and octagons shall be furnished with corners rounded to a radius of 11 % of the distance between parallel faces. The distance from corner to corner (see **Note 3**) shall be the basis for acceptance or rejection. The appropriate tolerances are listed in **Table 18**.

**NOTE 3**—The distance from corner to corner is determined by calculating the distance across parallel faces times 1.121 for hexagons and 1.064 for octagons.

**6.5.3 Rectangular and Square Bar**—Unless otherwise specified, square corners shall be furnished on rectangular and square bar. When so ordered, the edge contours described in **6.5.4 – 6.5.7** inclusive shall be furnished.

**6.5.4 Square Corners**—Unless otherwise specified, bar shall be finished with commercially square corners with a maximum permissible radius of 1/32 in. [1.0 mm] for bars over 3/16 to 1 in. [5 to 25 mm], inclusive, in thickness, and 1/16 in. [1.5 mm] for bars over 1 in. [25 mm] in thickness.

**6.5.5 Rounded Corners**—When specified, bar shall be finished with corners rounded as shown in **Fig. 1** to a quarter circle with a radius of 1/16 in. [1.5 mm] for bars over 3/16 to 1 in. [25 mm], inclusive, in thickness, and 1/8 in. [5 mm] for bars over 1 in. [25 mm] in thickness. The tolerance on the radius shall be ±25 %.

**6.5.6 Rounded Edge**—When specified bar shall be finished with edges rounded as shown in **Fig. 2**, the radius of curvature being 1/4 times the thickness of the bar for bars over 3/16 in. [5 mm] in thickness. The tolerance on the radius shall be one fourth the thickness of the bar.

**6.5.7 Full Rounded Edge**—When specified, bar shall 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 %.

## 7. Workmanship, Finish, and Appearance

**7.1 Workmanship**—The product shall be free of defects, but blemishes of a nature that do not interfere with the intended application are acceptable. The product shall be well cleaned and free from dirt.

**TABLE 7 Thickness Tolerances for Rectangular and Square Bar**

 (Applicable to Specifications **B124/B124M**, (Copper Alloy UNS Nos. C11000, C14500, and C14700), **B301/B301M**, and **B974/B974M**)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A</sup> in. [mm] for Widths Given in Inches					
	½ [12] and Under	Over ½ to 1¼ [12 to 30] Incl	Over 1¼ to 2 [30 to 50] Incl	Over 2 to 4 [50 to 100] Incl	Over 4 to 8 [100 to 200] Incl	Over 8 to 12 [200 to 300] Incl
Over 0.188 to 0.500 [4.8 to 12], incl	0.003 [0.08]	0.003 [0.08]	0.0035 [0.09]	0.004 [0.10]	0.0045 [0.11]	0.0055 [0.13]
Over 0.500 to 1.00 [12 to 25], incl	...	0.004 [0.10]	0.004 [0.10]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]
Over 1.00 to 2.00 [25 to 50], incl	...	0.0045 [0.11]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]	...
Over 2.00 to 4.00 [50 to 100], 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 thickness expressed to the nearest 0.001 in. [0.01 mm].

**TABLE 8 Thickness Tolerances for Rectangular and Square Bar**

 (Applicable to Specifications **B16/B16M**, **B21/B21M**, **B98/B98M**, (Copper Alloy UNS No. 65100), **B124/B124M** (Copper Alloy UNS Nos. C46400, C46750, C48200, and C48500), **B140/B140M**, **B453/B453M**, **B927/B927M**, and **B967/B967M**)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A</sup> in. for Widths Given in Inches					
	½ and Under	Over ½ to 1¼ Incl	Over 1¼ to 2 Incl	Over 2 to 4 Incl	Over 4 to 8 Incl	Over 8 to 12 Incl
Over 0.188 to 0.500 [4.8 to 12], incl	0.0035 [0.09]	0.004 [0.10]	0.0045 [0.11]	0.0045 [0.11]	0.006 [0.13]	0.008 [0.20]
Over 0.500 to 1.00 [12 to 25], incl	...	0.0045 [0.11]	0.005 [0.13]	0.005 [0.13]	0.007 [0.18]	0.009 [0.23]
Over 1.00 to 2.00 [25 to 50], incl	...	0.005 [0.13]	0.005 [0.13]	0.006 [0.15]	0.008 [0.20]	...
Over 2.00 to 4.00 [50 to 100], 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 thickness expressed to the nearest 0.001 in. [0.01 mm].

**TABLE 9 Thickness Tolerances for Rectangular and Square Bar**

 (Applicable to Specifications **B98/B98M** (Copper Alloy UNS Nos. C65500 and C66100), **B124/B124M** (Copper Alloy UNS Nos. C27450, C27453, C28500, C36300, C36500, C37000, C37700, C48640, C48645, C65680, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C67500, C67600, C69240, C69300, C69410, C69850, C70620, C75120, C77400, C87700, and C87710), **B138/B138M**, **B139/B139M**, **B150/B150M**, **B151/B151M**, **B196/B196M**, **B411/B411M**, **B441**, **B929**, and **B981/B981M**)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A</sup> in. [mm] for Widths Given in Inches					
	½ [12] and Under	Over ½ to 1¼ [12 to 30] Incl	Over 1¼ to 2 [30 to 50] Incl	Over 2 to 4 [50 to 100] Incl	Over 4 to 8 [100 to 200] Incl	Over 8 to 12 [200 to 300] Incl
Over 0.188 to 0.500 [4.8 to 12], incl	0.005 [0.13]	0.005 [0.13]	0.006 [0.15]	0.007 [0.18]	0.009 [0.23]	0.012 [0.30]
Over 0.500 to 1.00 [12 to 25], incl	...	0.006 [0.15]	0.007 [0.18]	0.008 [0.20]	0.010 [0.25]	0.013 [0.33]
Over 1.00 to 2.00 [25 to 50], incl	...	0.006 [0.15]	0.007 [0.18]	0.009 [0.23]	0.011 [0.28]	...
Over 2.00 to 4.00 [50 to 100], incl	...	...	...	0.50 <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 thickness expressed to the nearest 0.001 in. [0.1 mm].

**TABLE 10 Width Tolerances for Rectangular Bar**

 (Applicable to Specifications **B16/B16M**, **B21/B21M**, **B98/B98M** (Copper Alloy UNS No. C65100), **B124/B124M** (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C46750, C48200, and C48500), **B140/B140M**, **B301/B301M**, **B453/B453M**, **B927/B927M**, **B967/B967M** and **B974/B974M**)

Width, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
Over 0.188 to 0.500 [4.8 to 12], incl	0.0035 [0.09]
Over 0.500 to 1.25 [12 to 30], incl	0.005 [0.13]
Over 1.25 to 2.00 [30 to 50], incl	0.008 [0.20]
Over 2.00 to 4.00 [50 to 100], incl	0.012 [0.30] <sup>B</sup>
Over 4.00 to 12.00 [100 to 300], incl	0.30 <sup>B</sup> [0.30]

<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 11 Width Tolerances for Rectangular Bar**

 (Applicable to Specifications **B98/B98M** (Copper Alloy UNS Nos. C65500 and C66100), **B124/B124M** (Copper Alloy UNS Nos. C27450, C27453, C28500, C36300, C36500, C37000, C37700, C48640, C48645, C65680, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C67500, C67600, C69240, C69300, C69410, C69850, C70620, C75120, C77400, C87700, and C87710), **B138/B138M**, **B139/B139M**, **B150/B150M**, **B151/B151M**, **B196/B196M**, **B411/B411M**, **B441**, **B929**, and **B981/B981M**)

Width, in. [mm]	Tolerances, Plus and Minus, <sup>A</sup> in. [mm]
Over 0.188 to 0.500 [4.8 to 12], incl	0.005 [0.13]
Over 0.500 to 1.25 [12 to 30], incl	0.007 [0.18]
Over 1.25 to 2.00 [30 to 50], incl	0.010 [0.25]
Over 2.00 to 4.00 [50 to 100], incl	0.015 [0.38]
Over 4.00 to 12.00 [100 to 300], incl	0.50 <sup>B</sup> [0.50] <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].

7.2 *Finish*—A superficial film of residual light lubricant normally is present and is permissible unless otherwise specified.

7.3 *Appearance*:

7.3.1 The surface finish and appearance shall be of the normal quality for product ordered.

7.3.2 When intended application information is provided in the ordering information of the contract or purchase order, the surface shall be that normally produced for the application.

**TABLE 12 Diameter Tolerances for Hot-Forged Rod and Bar**  
(Applicable to Specification B138/B138M)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, All Plus, in. [mm]	
	As-Forged	Rough-Turned
Over 3.50 [90]	0.125 [3.2]	0.050 [1.3]

**TABLE 13 Length Tolerances for Rod, Bar, and Shapes (Full-Length Pieces Specific and Stock Lengths With or Without Ends)**  
(Applicable to Specifications B16/B16M, B21/B21M, B98/B98M, B138/B138M, B139/B139M, B140/B140M, B150/B150M, B151/B151M, B196/B196M, B301/B301M, B371/B371M, B411/B411M, B441, B453/B453M, B927/B927M, B929, B967/B967M, B974/B974M, and B981/B981M)

NOTE 1—The length tolerances in this table are all plus; if all minus tolerances are desired, use the same values; if tolerances are desired plus and minus, halve the values given.

Length Classification	Tolerances, All Plus, in. [mm] (Applicable Only to Full-Length Pieces)
Specific lengths	3/8 [10]
Specific lengths with ends	1 [25]
Stock lengths with or without ends	1 <sup>A</sup> [25] <sup>A</sup>

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

7.3.3 Superficial films of discoloration, or lubricants, or tarnish inhibitors are permissible unless otherwise specified.

## 8. Sampling

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

8.1.1 *Lot Size*—An inspection lot shall be 10 000 lb [5000 kg], or less, of the same mill form, alloy, temper, and nominal dimensions, subject to inspection at one time. Alternatively, a lot shall be the product of one cast bar from a single melt charge, or one continuous casting run whose weight does not exceed 40 000 lb [20 000 kg] that has been continuously processed and subject to inspection at one time.

8.1.2 *Portion Size*—The portion shall be four or more pieces selected as to be representative of each lot. Should the lot consist of less than five pieces, representative samples shall be taken from each piece.

### 8.2 Chemical Analysis:

8.2.1 The sample for chemical analysis shall be taken in accordance with Practice E255 for product in its final form from the pieces selected in 8.1.2 and combined into one composite sample. The minimum weight of the composite sample shall be 150 g.

8.2.2 Instead of sampling as directed in 8.2.1, the manufacturer shall have the option of sampling at the time castings are poured or from the semifinished product. When samples are taken during the course of manufacture, sampling of the finished product by the manufacturer is not required. The number of samples taken for the determination of composition shall be as follows:

8.2.2.1 When samples are taken at the time the castings are poured, at least one sample shall be taken for each group of castings poured from the same source of molten metal.

8.2.2.2 When samples are taken from semifinished product, a sample shall be taken to represent each 10 000 lb [5000 kg], or fraction thereof, except that not more than one sample shall be required per piece.

8.2.2.3 Only one sample need be taken from the semifinished product of one cast bar from a single melt charge continuously processed.

8.3 *Samples for All Other Tests*—Samples for all other tests shall be taken from the sample portions selected in 8.1.2 and be of a convenient size to accommodate the test and comply with the requirements of the appropriate product specification and test method.

## 9. Number of Tests and Retests

### 9.1 Tests:

9.1.1 *Chemical Analysis*—Chemical composition shall be determined as the per element mean of results from at least two replicate analyses of the sample(s) and the results of each replication shall meet the requirements of the product specification.

9.1.2 *Tensile Strength, Grain Size, Electrical Resistivity*—The test results for each individual test specimen shall be reported as the average of results obtained from specimens prepared from each of two pieces selected in 8.1.2 and each specimen must meet the requirements of the product specification. In the case of copper-beryllium alloy, two specimens shall be taken for each required test. One specimen from each piece shall be tested without further treatment, and the other specimen shall be tested after precipitation heat treatment.

9.1.2.1 *Rockwell Hardness*—The value of the hardness number of each specimen shall be established as the arithmetical average of at least three readings and each specimen must meet the requirements of the product specification.

9.1.2.2 *Bend, Cuprous Oxide (Hydrogen Embrittlement Susceptibility), and Mercurous Nitrate Tests*—All specimens tested must meet the product requirements to qualify for specification conformance.

9.1.3 *Other Requirements*—At least two specimens shall be subjected to test for each of the other requirements and each specimen shall conform to the test requirements.

### 9.2 Retests:

9.2.1 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).

9.2.2 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.

## 10. Specimen Preparation

10.1 *Chemical Analysis*—Sample preparation shall be in accordance with Practice E255.

10.1.1 Analytical specimen preparation shall be the responsibility of the reporting laboratory.

**TABLE 14 Schedule of Lengths (Specific and Stock) with Ends for Rod, Bar, and Shapes**

(Applicable to Specifications **B16/B16M, B21/B21M, B138/B138M** (Copper Alloy UNS Nos. C67500 and C67600), **B140/B140M, B301/B301M, B453/B453M, B927/B927M, and B974/B974M**)

Diameter or Distance Between Parallel Surfaces for Round, Hexagonal, and 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
0.500 [12] and under	0.250 [160] and under	6 to 14 [2000 to 4250], incl	75	20
Over 0.500 to 1.00 [12 to 25], incl	over 0.250 to 1.00 [160 to 650], incl	6 to 14 [2000 to 4250], incl	70	30
Over 1.00 to 1.50 [25 to 38], incl	over 1.00 to 2.25 [650 to 1500], incl	6 to 12 [2000 to 3750], incl	60	40
Over 1.50 to 2.00 [38 to 50], incl	over 2.25 to 4.00 [1500 to 2500], incl	6 to 12 [2000 to 3750], incl	50	45
Over 2.00 to 3.00 [50 to 75], incl	over 4.00 to 9.00 [2500 to 5850], incl	6 to 10 [2000 to 3000], incl	40	50

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

<sup>B</sup> Expressed to the nearest ½ ft [150 mm].

**TABLE 15 Schedule of Lengths (Specific and Stock) with Ends for Rod, Bar, and Shapes**

(Applicable to Specifications **B98/B98M, B138/B138M** (Copper Alloy UNS No. C67000), **B139/B139M, B150/B150M, B151/B151M, B196/B196M, B371/B371M, B411/B411M, B441, B929, B967/B967M, and B981/B981M**)

Diameter or Distance Between Parallel Surfaces for Round, Hexagonal, and 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
0.500 [12] and under	0.250 [160] and under	6 to 12 [2000 to 4000], incl	65	30
Over 0.500 to 1.00 [12 to 25], incl	over 0.250 to 1.00 [160 to 650], incl	6 to 12 [2000 to 4000], incl	60	40
Over 1.00 to 1.50 [25 to 38], incl	over 1.00 to 2.25 [650 to 1500], incl	6 to 10 [2000 to 3000], incl	50	50
Over 1.50 to 2.00 [38 to 50], incl	over 2.25 to 4.00 [1500 to 2500], incl	6 to 10 [2000 to 3000], incl	40	60

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

<sup>B</sup> Expressed to the nearest ½ ft [150 mm].

**TABLE 16 Straightness Tolerances for Rod, Bar, and Shapes**

Form and Size, in. [mm]	Length, ft [mm]	Maximum Curvature (Depth of Arc), in. [mm]
FOR GENERAL USE		
(Applicable to Specifications <b>B16/B16M, B21/B21M, B98/B98M, B138/B138M, B139/B139M, B140/B140M, B150/B150M, B151/B151M, B196/B196M, B301/B301M, B371/B371M, B411/B411M, B441, B453/B453M, B927/B927M, B929, B967/B967M, B974/B974M, and B981/B981M</b> )		
Rod: drawn	up to 2 [600]	1/32 [0.80]
	incl 2 to 5 [600 to 1500]	1/32 in any 2 ft portion [0.80 in any 600 mm portion] <sup>A</sup>
	incl 5 to 10 [1500 to 3000]	1/8 in any 5 ft portion [3.0 in any 1500 mm portion] <sup>A</sup>
	10 [3000] and over	1/2 in any 10 ft portion [12 in any 3000 mm portion] <sup>A</sup>
Bar and shapes (rolled or drawn)	6 [2000] and over	1/2 in any 6 ft portion [12 in any 2000 mm portion] <sup>A,B</sup>
DRAWN ROD—FOR AUTOMATIC SCREW MACHINE USE		
(Applicable to Specifications <b>B16/B16M, B140/B140M, B301/B301M, B453/B453M, B974/B974M, and B981/B981M</b> )		
Round only:		
Under 1/4 [6.35]	10 [3000] and over	1/2 in any 10 ft portion [12 in any 3000 mm portion] <sup>A</sup>
1/4 [6.35] and over	10 [3000] and over	1/4 in any 10 ft portion [6.35 in any 3000 mm portion] <sup>A</sup>
Local departure from straightness, 1/4 [6.35] and over only	...	1/64 in any 1 ft portion of the total length [0.40 in any 300 mm portion of the total length]
Hexagonal and octagonal:		
Under 1/4 [6.35]	10 [3000] and over	1/2 in any 10 ft portion [12.7 in any 3000 mm portion] <sup>A</sup>
1/4 [6.35] and over	10 [3000] and over	3/8 in any 10 ft portion [9.5 in any 3000 mm portion] <sup>A</sup>

<sup>A</sup> Of total length.

<sup>B</sup> Applicable to any longitudinal surface or edge.

**TABLE 17 Straightness Tolerances for Shafting**

(Applicable to Specifications **B21/B21M, B138/B138M, B139/B139M, and B150/B150M**)

Length of Shaft, ft [mm]	Maximum Permissible Departure from Straightness of Either Center or End Portions, in. [mm]	Minimum Diameter Applicable for Length Indicated, in. [mm]
Up to 6 [2000], incl	0.005 [0.13]	1/2 [12]
7 [1750]	0.007 [0.18]	1/2 [12]
8 [2400]	0.009 [0.23]	1/2 [12]
9 [2750]	0.012 [0.30]	1/2 [12]
10 [3050]	0.014 [0.36]	1/2 [12]
11 [3350]	0.017 [0.43]	1/2 [12]
12 [3650]	0.020 [0.50]	1/2 [12]
14 [4250]	0.028 [0.63]	5/8 [16]
16 [4875]	0.036 [0.91]	3/4 [20]
18 [5500]	0.045 [1.14]	1 [25]
20 [6100]	0.055 [1.4]	1 1/4 [30]
22 [6700]	0.068 [1.73]	1 1/2 [40]
24 [7300]	0.078 [2.00]	1 3/4 [44]
26 [7900]	0.094 [2.38]	2 [50]

**TABLE 18 Tolerances for Rounded Corner Hexagons and Octagons**

Distance Between Parallel Faces, in. [mm]	Tolerances on Distance Across Corners (Plus and Minus), in. [mm]
Up to 1 1/16 [17.3], incl	0.008 [0.20]
Over 1 1/16 to 2 [17.3 to 50], incl	0.010 [0.25]
Over 2 [50]	0.5 %

Specimens; Specimens for Wire, Rod, and Bar; Specimens for Rectangular Bar; or Specimens for Shapes Structure or Other). Unless specified, tensile testing may be performed on unmachined samples by using the maximum gage length extensometers that will fit between the gripping devices. The testing facility must be able to demonstrate that there is no statistically significant difference between the unmachined test results and