



Designation: B 249/B 249M – 012

## 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 B 249/B 249M; 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 Department of Defense.*

<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.

Current edition approved Oct. 10, 2004<sup>2</sup>. Published ~~December 2001~~; November 2002. Originally published as B 249 – 51 T. Last previous edition B 249/B 249M – 001.

### 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 B 16/B 16M, B 21/B 21M, B 98/B 98M, B 124/B 124M, B 138/B 138M, B 139/B 139M, B 140/B 140M, B 150, B 151/B 151M, B 196/B 196M, B 283, B 301/B 301M, B 371, B 411/B 411M, B 441, B 453/B 453M, B 455, and B 570 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 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.~~

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1.3 The values stated in inch-pounds units or SI units are to be regarded separately in the standard. Within the text the SI values are given in brackets. The values stated in each system of units are not exact equivalents; each system is independent of the other. Combining values from the two systems may result in nonconformance with the specification.

NOTE 1—Requirements for flat wire (defined as flat products up to and including 0.188 in. thick and up to 1¼ in. in width, with all surfaces rolled or drawn, without having been slit, sheared or sawed) including square, furnished in coils or straight lengths, or on spools, reels, or bucks are described by the wire Specifications B 206/B 206M and B 272.

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 and health practices and determine the applicability of regulatory limitations prior to use.

### 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 16/B 16M Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines<sup>3</sup>

B 21/B 21M Specification for Naval Brass Rod, Bar, and Shapes<sup>3</sup>

B 98/B 98M Specification for Copper-Silicon Alloy Rod, Bar, and Shapes<sup>3</sup>

B 124/B 124M Specification for Copper and Copper-Alloy Forging Rod, Bar, and Shapes<sup>3</sup>

B 138/B 138M Specification for Manganese Bronze Rod, Bar, and Shapes<sup>3</sup>

B 139/B 139M Specification for Phosphor Bronze Rod, Bar, and Shapes<sup>3</sup>

B 140/B 140M Specification for Copper-Zinc-Lead (~~Leaded~~ Red Brass or Hardware Bronze) Rod, Bar, and Shapes<sup>3</sup>

B 150 Specification for Aluminum Bronze Rod, Bar, and Shapes<sup>3</sup>

B 151/B 151M Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Rod and Bar<sup>3</sup>

B 154 Test Method for Mercurous Nitrate Test for Copper and Copper Alloys<sup>3</sup>

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specifications SB-249 in Section II of that Code.

<sup>3</sup> Annual Book of ASTM Standards, Vol 02.01.

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

- B 187 Specification for Copper Bar, Bus Bar, Rod and Shapes<sup>3</sup>
- B 193 Test Method for Resistivity of Electrical Conductor Materials<sup>4</sup>
- B 194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip and Rolled Bar<sup>3</sup>
- B 196/B 196M Specification for Copper-Beryllium Alloy Rod and Bar<sup>3</sup>
- B 206/B 206M Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) Wire and Copper-Nickel Alloy Wire<sup>3</sup>
- B 272 Specification for Flat Copper Products With Finished (Rolled or Drawn) Edges (Flat Wire and Strip)<sup>3</sup>
- B 283 Specification for Copper and Copper-Alloy Die Forgings, Hot-Pressed<sup>3</sup>
- B 301/B 301M Specification for Free-Cutting Copper Rod and Bar<sup>3</sup>
- B 371 Specification for Copper-Zinc-Silicon Alloy Rod<sup>3</sup>
- B 411/B 411M Specification for Copper-Nickel-Silicon Alloy Rod and Bar<sup>3</sup>
- B 441 Specification for Copper-Cobalt-Beryllium (UNS C17500) and Copper-Nickel-Beryllium (UNS C17510) Rod and Bar<sup>3</sup>
- B 453/B 453M Specification for Copper-Zinc-Lead Alloy (Leaded Brass) Rod, Bar, and Shapes<sup>3</sup>
- B 455 Specification for Copper-Zinc-Lead Alloy (Leaded Brass) Extruded Shapes<sup>3</sup>
- B 570 Specification for Copper-Beryllium Alloy (UNS C17000 and C17200) Forgings and Extrusions<sup>3</sup>
- B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper<sup>3</sup>
- B 846 Terminology for Copper and Copper Alloys<sup>3</sup>
- B 858 Test Method for ~~Determination of Ammonia Vapor Test~~ for Determining Susceptibility to Stress Corrosion Cracking in Copper Alloys ~~Using an Ammonia Vapor Test~~<sup>3</sup>
- D 4855 Practice for Comparing Test Methods<sup>5</sup>
- E 3 Practice for Preparation of Metallographic Specimens<sup>6</sup>
- E 8 Test Methods for Tension Testing of Metallic Materials<sup>6</sup>
- E 8M Test Methods for Tension Testing of Metallic Materials [Metric]<sup>6</sup>
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>6</sup>
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications<sup>7</sup>
- E 53 Test Methods for Determination of Copper in Unalloyed Copper by Gravimetry<sup>8</sup>
- E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>9</sup>
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)<sup>8</sup>
- E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys<sup>8</sup>
- E 76 Test Methods for Chemical Analysis of Nickel-Copper Alloys<sup>10</sup>
- E 112 Test Methods for Determining Average Grain Size<sup>6</sup>
- E 118 Test Methods for Chemical Analysis of Copper-Chromium Alloys<sup>8</sup>
- E 121 Test Methods for Chemical Analysis of Copper-Tellurium Alloys<sup>8</sup>
- E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition<sup>8</sup>
- E 290 Test Method for Bend Testing of Material for Ductility<sup>6</sup>
- E 478 Test Methods for Chemical Analysis of Copper Alloys<sup>8</sup>
- E 527 Practice for Numbering Metals and Alloys (UNS)<sup>11</sup>
- E 581 Test Methods for Chemical Analysis of Manganese-Copper Alloys<sup>8</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *bar, n*—a solid rectangular section, or one with two-plane parallel surfaces and round or other simple regularly shaped finished edges, up to and including 12 in. [300 mm] in width and over 0.188 in. [5 mm] in thickness furnished in straight lengths or in rolls and with finished edges, either rolled, drawn, or extruded.

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

3.1.2.1 *bus bar, n*—of solid or square cross section or a solid section with two plane parallel surfaces and round or other simple regular shaped edges.

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

3.1.2.3 *bus shape, n*—a solid section other than regular rod, bar, plate, sheet, strip, or flat wire, and may be of oval, half oval, half round, triangular, pentagonal, or of any special cross section.

3.1.3 *capable of, adj*—possessing the required properties or characteristics, or both, necessary to conform to specification

<sup>4</sup> Annual Book of ASTM Standards, Vol 02.03.

<sup>5</sup> Annual Book of ASTM Standards, Vol 07.02.

<sup>6</sup> Annual Book of ASTM Standards, Vol 03.01.

<sup>7</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>8</sup> Annual Book of ASTM Standards, Vol 03.056.

<sup>9</sup> Discontinued. See 2001 Annual Book of ASTM Standards, Vol 03.065.

<sup>10</sup> Annual Book of ASTM Standards, Vol 01.01, 03.05.

<sup>11</sup> 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.

<sup>11</sup> Annual Book of ASTM Standards, Vol 01.01.

requirement(s) when subjected to specified test(s).

3.1.4 *coil, n*—a length of the product wound into a series of connected turns. The unqualified term as applied to “flat wire” refers to a coil in which the product is spirally wound, with the successive layers one atop the other (sometimes called a “roll”).

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

3.1.4.2 *coil, level or traverse wound on a reel or spool, n*—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.

3.1.4.3 *coil, stagger wound, n*—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.

3.1.5 *length, n*—straight pieces of the product.

3.1.5.1 *lengths, ends, n*—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.

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

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

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

3.1.5.5 *lengths, specific with ends, n*—specific lengths, including ends.

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

3.1.5.7 *lengths, stock with ends, n*—stock lengths, including ends.

3.1.6 *reel or spool, n*—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.

3.1.7 *rod, n*—a round, regular hexagonal, or regular octagonal solid section furnished in straight lengths (a regular hexagonal or a regular octagonal rod is a solid section having equal sides and equal angles).

3.1.7.1 *rod, piston finish, n*—a round rod having a special surface produced by turning or grinding to close tolerances for diameter and straightness.

3.1.7.2 *rod, shafting, n*—a round rod specially manufactured to the close straightness tolerances required for use in shafting.

3.1.8 *shape, n*—a solid section other than regular rod, bar, plate, sheet, strip, or flat wire, and may be of oval, half oval, half round, triangular, pentagonal, or of any special cross section furnished in straight lengths.

3.1.9 *unaided eye, adj*—visual inspection without the use of special equipment or enhancement excepting the use of corrective lenses.

3.2 For other terms not referenced herein, ~~consult~~ see Terminology B 846.

## 4. Materials and Manufacture

### 4.1 Materials:

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

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

NOTE 2—Because of 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 material.

### 4.2 Manufacture:

4.2.1 The product shall be produced by hot working, cold working, or both, and finished by such cold working, annealing or heat treatment and straightening as may be necessary 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 of manufacture shall conform to the compositional requirements prescribed in the product specification.

5.1.1 When a product (check) sample is analyzed by the purchaser, the material shall conform to the compositional 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 does not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer or supplier and the purchaser.

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.

NOTE 3—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, incl, for the product, specification indicated:

*Table 1*—Tolerances for diameter or distance between parallel surfaces of cold-drawn rod applicable to Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. C65100), B 124/B 124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B 140/B 140M, B 301/B 301M, and B 453/B 453M.

*Table 2*—Tolerances for diameter or distance between parallel surfaces of cold-drawn rod applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 371, B 411/B 411M, and B 441.

*Table 3*—Diameter tolerances for piston finish rod applicable to Specifications B 21/B 21M, B 138/B 138M, B 139/B 139M, and B 150.

*Table 4*—Tolerances for diameter or distance between parallel surfaces of as-extruded rod and bar applicable to Specifications B 21/B 21M, B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C46400, C48200, C48500, C61900, C62300, C63000, C63200, C64200, C64210, and C67500), B 138/B 138M (Copper Alloy UNS No. C67500), and B 150.

*Table 5*—Tolerances for diameter or distance between parallel surfaces of as-extruded rod and bar applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65100, C65500, and C66100), B 124/B 124M (Copper UNS Nos. C11000, C14500, C14700, C65500, and C77400), and B 138/B 138M (Copper Alloy UNS No. C67000), B 196/B 196M, and B 441.

*Table 6*—Diameter tolerances for hot-rolled round rod applicable to Specification B 98/B 98M, B 124/B 124M, B 138/B 138M, B 150, B 196/B 196M, and B 441.

*Table 7*—Thickness tolerances for rectangular and square bar applicable to Specifications B 124/B 124M (Copper Alloy UNS Nos. C11000, C14500, and C14700) and B 301/B 301M.

*Table 8*—Thickness tolerances for rectangular and square bar applicable to Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. C65100), B 124/B 124M (Copper Alloy UNS Nos. C46400, C48200, and C48500), and B 140/B 140M.

*Table 9*—Thickness tolerances for rectangular and square bar applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 411/B 411M, and B 441.

*Table 10*—Width tolerances for rectangular bar applicable to Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. C65100), B 124/B 124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B 140/B 140M, and B 301/B 301M.

*Table 11*—Width tolerances for rectangular bar applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 411/B 411M, and B 441.

*Table 12*—Diameter tolerances for hot-forged rod and bar applicable to Specification B 138/B 138M.

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 Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M, B 138/B 138M, B 139/B 139M, B 140/B 140M, B 150, B 151/B 151M, B 196/B 196M, B 301/B 301M, B 371, B 411/B 411M, B 441, and B 453/B 453M.

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

(Applicable to Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. C65100), B 124/B 124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B 140/B 140M, B 301/B 301M, and B 453/B 453M.)

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 B 98/B 98M (Copper Alloy UNS No. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 196/B 196M, B 371, B 411/B 411M, and B 441.)

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 B 21/B 21M, B 138/B 138M, B 139/B 139M, and B 150.)

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 B 21/B 21M, B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C46400, C48200, C48500, C61900, C62300, C63000, C63200, C64200, C64210, and C67500), B 138/B 138M (Copper Alloy UNS No. C67500), and B 150.)

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 14*—Schedule of lengths (specific and stock) with ends applicable to Specifications B 16/B 16M, B 21/B 21M, B 138/B 138M (Copper Alloy UNS No. C67500), B 140/B 140M, B 301/B 301M, and B 453/B 453M.

*Table 15*—Schedule of lengths (specific and stock) with ends applicable to Specifications B 98/B 98M, B 138/B 138M (Copper Alloy UNS No. C67000), B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 371, B 411/B 411M, and B 441.

#### 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, of which the deviation from straightness shall not exceed the limitations specified in Table 16. 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. 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.

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

(Applicable to Specifications B 98/B 98M (Copper UNS Nos. C65100, C65500, and C66100), B 124/B 124M (Copper UNS Nos. C11000, C14500, and C14700 and Copper Alloy UNS Nos. C65500 and C77400), B 138/B 138M (Copper UNS No. C67000), B 196/B 196M (Copper UNS Nos. C17000, C17200, and C17300), and B 441 (Copper UNS Nos. C17500, C17510).)

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 B 98/B 98M, B 124/B 124M, B 138/B 138M, B 150, B 196/B 196M, and B 441.)

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	$\frac{1}{16}$ [1.6]
Over 3.00 [75]	$\frac{1}{8}$ [3.2]

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

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

(Applicable to Specifications B 124/B 124M, (Copper Alloy UNS Nos. C11000, C14500, and C14700), B 133, and B 301/B 301M.)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A</sup> in. [mm] for Widths Given in Inches					
	$\frac{1}{2}$ [12] and Under	Over $\frac{1}{2}$ to $1\frac{1}{4}$ [12 to 30] Incl	Over $1\frac{1}{4}$ 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 B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. 65100), B 124/B 124M (Copper Alloy UNS Nos. C46400, C48200, and C48500), and B 140/B 140M.)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A</sup> in. for Widths Given in Inches					
	$\frac{1}{2}$ and Under	Over $\frac{1}{2}$ to $1\frac{1}{4}$ Incl	Over $1\frac{1}{4}$ 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].

## 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  $\frac{1}{16}$  in. [1.5 mm] for sizes up to 2 in. [50 mm], incl., and  $\frac{3}{32}$  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

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

(Applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 411/B 411M, and B 441.)

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 B 16/B 16M, B 21/B 21M, B 98/B 98M (Copper Alloy UNS No. C65100), B 124/B 124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B 140/B 140M, and B 301/B 301M.)

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 B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124/B 124M (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138/B 138M, B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 411/B 411M, and B 441.)

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].

**TABLE 12 Diameter Tolerances for Hot-Forged Rod and Bar**

(Applicable to Specification B 138/B 138M.)

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]

between parallel faces. The distance from corner to corner<sup>12</sup> shall be the basis for acceptance or rejection. the appropriate tolerances are listed in Table 18.

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 ½ in. [1.0 mm] for bars over ¾ in. [19 mm], inclusive, in thickness, and ¼ in. [6.3 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 ¼ in. [6.3 mm] for bars over ¾ in. [19 mm], inclusive, in thickness, and ⅛ in. [3.2 mm] for bars over 1 in. [25 mm] in thickness. The tolerance on the radius shall be ± 25 %.

<sup>12</sup> Available

<sup>12</sup> The distance from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS: corner to corner is determined by calculating the distance across parallel faces times 1.121 for hexagons and 1.064 for octagons.

**TABLE 13 Length Tolerances for Rod, Bar, and Shapes (Full-Length Pieces Specific and Stock Lengths With or Without Ends)**

(Applicable to Specifications B 16/B 16M, B 21/B 21M, B 98/B 98M, B 138/B 138M, B 139/B 139M, B 140/B 140M, B 150, B 151/B 151M, B 196/B 196M, B 301/B 301M, B 371, B 411/B 411M, B 441, and B 453/B 453M.)

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	$\frac{3}{8}$ [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.

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

(Applicable to Specifications B 16/B 16M, B 21/B 21M, B 138/B 138M (Copper Alloy UNS No. C67500), B 140/B 140M, B 301/B 301M, and B 453/B 453M.)

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  $\frac{1}{2}$  ft [150 mm].

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

(Applicable to Specifications B 98/B 98M, B 138/B 138M (Copper Alloy UNS No. C67000), B 139/B 139M, B 150, B 151/B 151M, B 196/B 196M, B 371, B 411/B 411M, and B 441.)

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  $\frac{1}{2}$  ft [150 mm].

**6.5.6 Rounded Edge**—When specified bar shall be finished with edges rounded as shown in Fig. 2, the radius of curvature being  $1\frac{1}{4}$  times the thickness of the bar for bars over  $\frac{3}{16}$  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:

7.1.1 The product shall be free from defects, but blemishes of a nature that do not interfere with normal operations are acceptable. The product shall be well cleaned and free from dirt.

### 7.2 Finish:

7.2.1 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 the normal quality for product ordered.

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

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

**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 16/B 16M, B 21/B 21M, B 98/B 98M, B 138/B 138M, B 139/B 139M, B 140/B 140M, B 150, B 151/B 151M, B 196/B 196M, B 301/B 301M, B 371, B 411/B 411M, B 441, and B 453/B 453M.)		
Rod: drawn	up to 2 [600] incl 2 to 5 [600 to 1500]  incl 5 to 10 [1500 to 3000]  10 [3000] and over	$\frac{1}{32}$ [0.80] $\frac{1}{32}$ in any 2-ft portion [0.80 in any 600-mm portion] <sup>A</sup> $\frac{1}{8}$ in any 5-ft portion [3.0 in any 1500-mm portion] <sup>A</sup> $\frac{1}{2}$ in any 10-ft portion [12 in any 3000-mm portion] <sup>A</sup>
Bar and shapes (rolled or drawn)	6 [2000] and over	$\frac{1}{2}$ 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 16/B 16M, B 140/B 140M, B 301/B 301M, and B 453/B 453M.)		
Round only:		
Under $\frac{1}{4}$ [6.35]	10 [3000] and over	$\frac{1}{2}$ in any 10-ft portion [12 in any 3000-mm portion] <sup>A</sup>
$\frac{1}{4}$ [6.35] and over	10 [3000] and over	$\frac{1}{4}$ in any 10-ft portion [6.35 in any 3000-mm portion] <sup>A</sup>
Local departure from straightness, $\frac{1}{4}$ [6.35] and over only	...	$\frac{1}{64}$ in any 1-ft portion of the total length [0.40 in any 300-mm portion of the total length]
Hexagonal and octagonal:		
Under $\frac{1}{4}$ [6.35]	10 [3000] and over	$\frac{1}{2}$ in any 10-ft portion [12.7 in any 3000-mm portion] <sup>A</sup>
$\frac{1}{4}$ [6.35] and over	10 [3000] and over	$\frac{3}{8}$ 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 B 21/B 21M, B 138/B 138M, B 139/B 139M, and B 150.)

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]	$\frac{1}{2}$ [12]
7 [1750]	0.007 [0.18]	$\frac{1}{2}$ [12]
8 [2400]	0.009 [0.23]	$\frac{1}{2}$ [12]
9 [2750]	0.012 [0.30]	$\frac{1}{2}$ [12]
10 [3050]	0.014 [0.36]	$\frac{1}{2}$ [12]
11 [3350]	0.017 [0.43]	$\frac{1}{2}$ [12]
12 [3650]	0.020 [0.50]	$\frac{1}{2}$ [12]
14 [4250]	0.028 [0.63]	$\frac{5}{8}$ [16]
16 [4875]	0.036 [0.91]	$\frac{3}{4}$ [20]
18 [5500]	0.045 [1.14]	1 [25]
20 [6100]	0.055 [1.4]	1 $\frac{1}{4}$ [30]
22 [6700]	0.068 [1.73]	1 $\frac{1}{2}$ [40]
24 [7300]	0.078 [2.00]	1 $\frac{3}{4}$ [44]
26 [7900]	0.094 [2.38]	2 [50]

## 8. Sampling

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

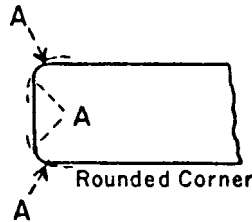
8.1.1 *Lot Size*—An inspection lot shall be 10 000 lbs [5000 kg], or less, of the same mill form, alloy, temper, and nominal dimensions, subject to inspection at one time. Alternatively, a lot shall be the product of one cast bar from a single melt charge, or one continuous casting run whose weight does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

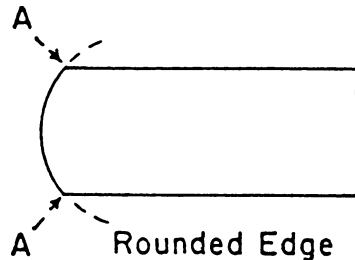
**TABLE 18 Tolerances for Rounded Corner Hexagons and Octagons**

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



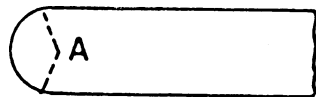
NOTE 1—The arc shall not necessarily be tangent at Points A but the product shall be commercially free from sharp, rough, or projecting edges.

**FIG. 1 Rounded Corners**



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**



**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**

8.2.1 The sample for chemical analysis shall be taken in accordance with Practice E 255 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 lbs [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 E 255.

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

10.2 *Tensile Test*—The test specimen shall conform to the requirements prescribed for the particular product in the Test Specimen Section of Test Methods E 8 and E 8M (see Round 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 the standard test method defined in Test Methods E 8. Statistical significance testing must follow Practice D 4855.

10.3 *Grain Size*—The test specimen shall be prepared in accordance with Practice E 3.

10.4 *Rockwell Hardness*—The test specimen shall be of a size and shape to permit testing by the available test equipment and shall be taken to permit testing in a plane parallel or perpendicular to the direction of deformation given to the product.

10.4.1 The surface of the test specimen shall be sufficiently smooth and even to permit the accurate determination of hardness.

10.4.2 The specimen shall be free of scale and foreign matter and care shall be taken to avoid any change in condition, that is, heating or cold work.

10.5 *Electrical Resistivity*—Test specimens are to be full size where practical and shall be the full cross section of the material it represents.

10.5.1 When the test specimen is cut from material in bulk, care shall be taken that the properties are not appreciably altered in the preparation. Plastic deformation may work harden a material and tend to raise the resistivity, while heating tends to anneal the material with a consequent reduction in resistivity.

10.5.2 When necessary, products are to be rolled or cold-drawn to a wire approximately 0.080 in. (12 gage AWG) (2.0 mm) and at least 160 in. [4000 mm] in length. The specimen shall be annealed at approximately 935 ± 10°F [500 ± 20°C] for 30 min in an inert atmosphere and cooled to ambient temperature in the inert atmosphere.

10.5.3 For heat-treatable material, diameter and heat treatment shall be agreed upon between the manufacturer and the purchaser.

10.6 *Mercurous Nitrate Test*—Test specimens shall conform to the requirements of Test Method B 154.

10.6.1 The specimen shall be obtained without bending, springing, polishing, or any other preparation.

10.7 *Determination of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper*—Test specimen shall conform to the appropriate requirements of the Test Specimen Section of Test Methods B 577.

10.8 *Bend Test*:

10.8.1 The test specimen shall be prepared in accordance with Test Method E 290.

10.8.2 When impractical to test full-size specimens but practical to test full-thickness specimens from material not exceeding 1½ in. [40 mm] in nominal thickness, the specimens shall be of the thickness of the material and the ratio of width to thickness shall be 2:1, provided the width is not less than ¾ in. [20 mm].

10.8.3 When material exceeds ½ in. [10 mm] in thickness diameter, or distance across flats, the specimen may be machined when full-section or full-thickness specimen are not used. The diameter or thickness of the specimen shall be at least ½ in. [10

mm] and the ratio of width to thickness of rectangular specimens shall be 2:1. In rectangular specimens of reduced thickness, the outside or tension surface shall be an as fabricated surface.

10.9 Should any test specimen show defective machining or develop flaws, it may be discarded and another specimen substituted.

## 11. Test Methods

11.1 The test method(s) used for quality control or production control, or both, for the determination of conformance with product property requirements are discretionary.

11.1.1 The test method(s) used to obtain data for the preparation of certification or test report, or both, shall be made available to the purchaser on request.

### 11.2 Chemical Composition:

11.2.1 In case of dispute, an applicable test method may be found in the following documents: Test Methods E 53, E 54, E 62, E 75, E 76, E 118, E 121, E 478, and E 581.

11.2.1.1 The specific method to be used for each specified element shall be prescribed in the product specification.

11.2.1.2 The test methods for the determination of composition for copper-beryllium alloys shall be as described in Annex A1 of Specification B 194.

11.2.2 The method(s) to be used for the determination of element(s) resulting from contractual or purchase order agreement shall be as agreed upon between the manufacturer or supplier and the purchaser.

### 11.3 Other Tests:

11.3.1 The product in final form shall conform with physical, mechanical, and other requirements specified in the product specification when subjected to test in accordance with the appropriate test method in the following table:

Test	Test Methods
Grain size	E 112
Electrical resistivity	B 193
Tensile	E 8/E 8M
Rockwell hardness	E 18
Hydrogen embrittlement	B 577
Semi-guided bend	E 290

11.3.2 *Grain Size*—The intercept method shall be used to determine grain size in case of dispute.

11.3.3 *Electrical Resistivity*—The limit of measurement uncertainty for Test Method B 193 shall be  $\pm 0.30\%$  as a routine method and  $\pm 0.15\%$  as an umpire method.

### 11.3.4 Tensile:

11.3.4.1 The method to be used for determining yield strength shall be specified in the product specification.

11.3.4.2 Elongation shall be determined in accordance with the first two paragraphs of the subsection entitled “Elongation” of the Procedure section of Test Methods E 8 and E 8M.

11.3.4.3 Whenever test results are obtained from both full-size and machined specimens and they differ, the test results from the full-size specimens shall prevail.

11.3.4.4 Test results are not seriously affected by variations in speed of testing. A considerable range of testing speed is permitted; however, the rate of stressing to the yield strength should not exceed 100 ksi/min. Above the yield strength the movement per minute of the testing machine head under load should not exceed 0.5 in./in. or gage length (or distance between grips for full-section specimens).

11.3.5 *Rockwell Hardness*—Special attention should be given the Standardizing Machine section of Test Methods E 18.

11.3.6 *Hydrogen Embrittlement*—In case of dispute, Procedure C, Closed Bend Test, of Test Methods B 577 shall be used.

11.4 The product shall meet the performance requirements of the product specification when subjected to the following test as required:

11.4.1 *Mercurous Nitrate Test*—The material shall be subjected to test in accordance with Test Method B 154.

11.4.2 *Ammonia Vapor Test*—The material shall be subjected to test in accordance with Test Method B 858 in lieu of Test Method B 154 when agreed upon between supplier and purchaser. If the pH value is not specified in the product specification, it shall be established per agreement between the supplier and purchaser.

11.4.3 *Semiguided Bend Test*—The mandrel radius and bend angle shall be specified in the product specification. When the test specimen has been machined, the retained original surface shall constitute the outer periphery of the bend that shall be made on a radius equal to that dimension of the machined radial to the bend.

## 12. Significance of Numerical Limits

12.1 For the purpose of determining compliance with the specified limits for requirements of the properties listed in the following table, an observed value or a calculated value shall be rounded as indicated in accordance with the rounding method of Practice E 29.

Property	Rounded Unit for Observed or Calculated Value
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Chemical composition	
Hardness	nearest unit in the last right-hand significant-
Electrical resistivity	digit used in expressing the limiting value
Tensile strength	
Yield strength	nearest ksi
Elongation:	
Below 5 %	nearest multiple of 0.5 %
5 % and over	nearest 1 %
Grain size:	
Up to 0.055 mm, incl	nearest multiple of 0.005 mm
Over 0.055 to 0.160 mm, incl	nearest 0.01 mm

### 13. Inspection

13.1 The manufacturer shall inspect and make tests necessary to verify that the product furnished conforms to the requirements prescribed in the product specification.

13.2 Source inspection of the material by the purchaser may be agreed upon between the manufacturer, or supplier, and the purchaser as part of the purchase order. In which case, the nature of the facilities needed to satisfy the inspector representing the purchaser that the product is being furnished in accordance with the product specification shall be included in the agreement. All tests and the inspection shall be conducted so as not to interfere unnecessarily with the operations of the works.

13.3 The manufacturer, or supplier, and the purchaser may accomplish the final inspection simultaneously by mutual agreement.

### 14. Rejection and Rehearing

#### 14.1 *Rejection:*

14.1.1 Product that fails to conform to the requirements of the product specification may be rejected.

14.1.2 Rejection shall be reported to the manufacturer, or supplier, promptly and in writing.

14.1.3 In case of disagreement or dissatisfaction with the results of the test upon which rejection was based, the manufacturer or supplier may make claim for a rehearing.

#### 14.2 *Rehearing:*

14.2.1 As a result of product rejection, the manufacturer or supplier may make claim for retest to be conducted by the manufacturer or supplier and the purchaser. Samples of the rejected product shall be taken in accordance with the product specification and tested by both parties as directed in the product specification, or, alternatively, upon agreement by both parties, an independent laboratory may be selected for the tests using the test methods prescribed in the specification.

### 15. Certification

15.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been tested and inspected as directed in the product specification and the requirements have been met.

15.2 Certification is mandatory for product purchased for ASME Boiler and Pressure Code application.

### 16. Mill Test Report

16.1 When specified in the purchase order or contract, the manufacturer or supplier shall furnish to the purchaser a manufacturer's test report showing the results of the required tests.

### 17. Packaging and Package Marking

#### 17.1 *Packaging:*

17.1.1 The material shall be separated by size, composition, and temper and prepared for shipment in such a manner as to ensure acceptance by common carrier for transportation and to afford protection from normal hazards of transportation.

#### 17.2 *Package Marking:*

17.2.1 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, temper, size, shape, gross and net weight, and name of supplier or manufacturer. The specification number shall be shown when specified.

### 18. Keywords

18.1 bar, general requirements; bar, rod, shapes, general requirements; rod, general requirements; shape, general requirements

**SUPPLEMENTARY REQUIREMENTS****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>13</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>13</sup>

MIL-STD-129 Marking for Shipment and Storage

**S1.1.3 Military Specification:**<sup>13</sup>

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

**S2. Quality Assurance****S2.1 Responsibility for Inspection:**

S2.1.1 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.

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<sup>13</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.

Current edition approved Oct. 10, 2002. Published November 2002. Originally published as B 249 – 51 T. Last previous edition B 249/B 249M – 01.

**APPENDIX**

**(Nonmandatory Information)**

**X1. STANDARD DENSITIES**

X1.1 For purposes of calculating weights, cross sections, and so forth, the densities of the coppers and copper alloys

covered by the specifications listed in Section 1 shall be taken as follows:

ASTM Designation	Material	Copper or Copper Alloy UNS No.	Density, lb/in. <sup>3</sup> [g/cm <sup>3</sup> ]
B 16/B 16M	free-cutting brass	C36000	0.307 [8.50]
B 21/B 21M	naval brass	C46200	0.305 [8.44]
		C46400	0.304 [8.41]
		C48200	0.305 [8.42]
		C48500	0.305 [8.41]
B 98/B 98M	copper-silicon alloy	C65100	0.316 [8.75]
		C65500	0.308 [8.53]
		C65800	0.308 [8.53]
		C66100	0.308 [8.53]
B 124/B 124M	copper	C11000	0.323 [8.94]
	copper-tellurium	C14500	0.323 [8.94]
	copper-sulfur	C14700	0.323 [8.94]
	forging brass	C37700	0.305 [8.44]
	naval brass	C46400	0.304 [8.41]
	medium leaded naval brass	C48200	0.305 [8.44]
	leaded naval brass	C48500	0.305 [8.44]
	aluminum-bronze	C61900	0.271 [7.5]
	aluminum-bronze, 9 %	C62300	0.277 [7.66]
	aluminum-nickel bronze	C63000	0.274 [7.58]
	aluminum-silicon bronze	C64200	0.278 [7.69]
	aluminum-silicon bronze, 6.7 %	C64210	0.278 [7.69]
	high-silicon bronze (A)	C65500	0.308 [8.53]
	manganese bronze (A)	C67500	0.302 [8.36]
B 138/B 138M	nickel silver, 45-10 manganese bronze	C77400	0.306 [8.47]
		C67000	0.286 [7.92]
B 139/B 139M	phosphor bronze	C67500	0.302 [8.36]
		C51000	0.320 [8.86]
		C52100	0.318 [8.80]
		C52400	0.317 [8.77]
B 139/B 139M	phosphor bronze	C53400	0.322 [8.91]
		C54400	0.320 [8.86]
		C51000	0.320 [8.86]
		C52100	0.318 [8.80]
B 140/B 140M	leaded red brass	C52400	0.317 [8.77]
		C53400	0.322 [8.91]
		C54400	0.320 [8.86]
B 140/B 140M	leaded red brass	C31400	0.319 [8.83]
		C31600	0.320 [8.86]
		C32000	0.317 [8.77]
B 150	aluminum bronze	C61300	0.285 [7.89]
		C61400	0.285 [7.89]
		C61900	0.270 [7.5]
		C62300	0.276 [7.66]
		C62400	0.269 [7.45]
		C63000	0.274 [7.58]
		C63200	0.276 [7.64]
		C64200	0.278 [7.69]
		C64210	0.278 [7.69]
		C70600	0.323 [8.94]
B 151/B 151M	copper-nickel-zinc alloy (nickel silver) and copper-nickel alloy	C71500	0.323 [8.94]
		C72000	0.323 [8.94]
		C74500	0.313 [8.86]
		C75200	0.317 [8.77]
		C75700	0.314 [8.69]
		C76400	0.315 [8.72]
		C77000	0.314 [8.69]
		C79200	0.314 [8.69]
		C79400	0.317 [8.77]
		...	0.323 [8.94]
B 187	copper: deoxidized and oxygen-free other classifications	...	0.321 [8.89]
		...	0.321 [8.89]
		...	0.321 [8.89]
B 196/B 196M	copper-beryllium alloy	C17000	0.297 [8.22]
		C17200	0.297 [8.22]
		C17300	0.297 [8.22]
B 301/B 301M	free-cutting copper	C14500	0.323 [8.94]
		C14700	0.323 [8.94]
		C14710	0.323 [8.94]
		C14720	0.323 [8.94]
		C18700	0.323 [8.94]

ASTM Designation	Material	Copper or Copper Alloy UNS No.	Density, lb/in. <sup>3</sup> [g/cm <sup>3</sup> ]
B 371	copper-zinc-silicon alloy	C69400	0.296 [8.94]
		C69700	0.300 [8.19]
B 411/B 411M	copper-nickel-silicon alloy	C64700	0.322 [8.91]
B 441	copper-cobalt-beryllium copper-nickel-beryllium	C17500	0.316 [8.75]
		C17510	0.316 [8.75]
B 453/B 453M	copper-zinc-lead (leaded brass)	C33500	0.306 [8.47]
		C34000	0.306 [8.47]
		C34500	0.306 [8.47]
		C35000	0.305 [8.44]
		C35300	0.306 [8.47]
		C35600	0.307 [8.50]
B 455	copper-zinc-lead (leaded brass)	C38000	0.305 [8.44]
		C38500	0.306 [8.47]

### SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this specification standard since the last issue (B 249/B 249M – 001) that may impact the use of this specification standard.

- (1) ~~Paragraph 6.5.2.1~~ In Section 6, references for Specifications B 196/B 196M and B 441 were added to match Table 18 5.
- (2) In Table 8, Alloy C65100 and Specification B 124/B 124M were added to match the description in Section 6.

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