



Designation: B249/B249M – 06

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

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

## 1. Scope\*

1.1 This specification<sup>2</sup> establishes the 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, B196/B196M, B283, B301/B301M, B371/B371M, B411/B411M, B441, B453/B453M, B455, B570, and B927 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 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 B206/B206M and B272B206/B206MB272.

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.*

<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
- B206/B206M Specification for Copper-Nickel-Zinc (Nickel Silver) Wire and Copper-Nickel Alloy Wire
- B272 Specification for Copper Flat Products with Finished (Rolled or Drawn) Edges (Flat Wire and Strip)
- B283 Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed)

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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



**B301/B301M** Specification for Free-Cutting Copper Rod, Bar, Wire, and Shapes  
**B371/B371M** Specification for Copper-Zinc-Silicon Alloy Rod  
**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  
**B927** Specification for Brass Rod, Bar, and Shapes  
**B929** Specification for Copper-Nickel-Tin Spinodal Alloy Rod and Bar  
**D4855** Practice for Comparing Test Methods<sup>4</sup>  
**E3** Guide for Preparation of Metallographic Specimens  
**E8** Test Methods for Tension Testing of Metallic Materials  
**E8M** Test Methods for Tension Testing of Metallic Materials [Metric]<sup>4</sup>  
**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  
**E54** Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>4</sup>  
**E62** Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)  
**E75** Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys  
**E76** Test Methods for Chemical Analysis of Nickel-Copper Alloys<sup>4</sup>  
**E112** Test Methods for Determining Average Grain Size  
**E118** Test Methods for Chemical Analysis of Copper-Chromium Alloys  
**E121** Test Methods for Chemical Analysis of Copper-Tellurium Alloys  
**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

### 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 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].

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.

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



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, see Terminology B846.

## 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*—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.

4.2.1 *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 B16/B16M, B21/B21M, B98/B98M (Copper Alloy UNS No. C65100), B124/B124M (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B140/B140M, B301/B301M, B453/B453M, and B927.

*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. C36500, C37000, C37700, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C67500, C67600, C70620, C71520, and C77400), B138/B138M, B139/B139M, B150/B150M, B151/B151M, B196/B196M, B371/B371M, B411/B411M, and B441.

*Table 3*—Diameter tolerances for piston finish rod applicable to Specifications B21/B21M, B138/B138M, B139/B139M, and B150/B150M.

*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. C36500, C37000, C37700, C46400, C48200, C48500, C61900, C62300, C63000, C63200, C64200, C64210, C67500, C67600, C70620, and C71520), B138/B138M (Copper Alloy UNS Nos. C67500 and C67600), and B150/B150M.

*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, C65500, and C77400), and B138/B138M (Copper Alloy UNS No. C67000), B196/B196M, B441, and B929.

*Table 6*—Diameter tolerances for hot-rolled round rod applicable to Specification B98/B98M, B124/B124M, B124/B124MB98/B98M, B138/B138M, B150/B150M, B196/B196M, and B441.

*Table 7*—Thickness tolerances for rectangular and square bar applicable to Specifications B124/B124M (Copper Alloy UNS Nos. C11000, C14500, and C14700) and B301/B301M.

**Table 8**—Thickness tolerances for rectangular and square bar applicable to Specifications **B16/B16M**, **B21/B21M**, **B98/B98MB16/B16MB21/B21MB98/B98M** (Copper Alloy UNS No. C65100), **B124/B124M** (Copper Alloy UNS Nos. C46400, C48200, and C48500), **B140/B140M**, **B453/B453M**, and **B927**.

**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. C36500, C37000, C37700, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C67500, C67600, C70620, C71520, and C77400), **B138/B138M**, **B139/B139M**, **B150/B150M**, **B151/B151M**, **B196/B196M**, **B411/B411M**, **B441**, and **B929**.

**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, C48200, and C48500), **B140/B140M**, **B301/B301M**, **B453/B453M**, and **B927**.

**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. C36500, C37000, C37700, C61900, C62300, C63000, C63200, C64200, C64210, C65500, C67500, C67600, C70620, C71520, and C77400), **B138/B138M**, **B139/B139M**, **B150/B150M**, **B151/B151M**, **B196/B196M**, **B411/B411M**, **B441**, and **B929**.

**Table 12**—Diameter tolerances for hot-forged rod and bar applicable to Specification **B138/B138M**.

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 **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**, and **B929**.

**Table 14**—Schedule of lengths (specific and stock) with ends applicable to Specifications **B16/B16M**, **B21/B21M**, **B138/B138M** (Copper Alloy UNS Nos. C67500 and C67600), **B140/B140M**, **B301/B301M**, **B453/B453M**, **B927**, and **B929**.

**Table 15**—Schedule of lengths (specific and stock) with ends applicable to Specifications **B98/B98M**, **B138/B138M** (Copper Alloy UNS No. C67000), **B139/B139M**, **B150/B150M**, **B151/B151M**, **B196/B196M**, **B371/B371M**, **B411/B411M**, and **B441**.

#### 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  $\frac{1}{32}$  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.

#### 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 between parallel faces. The distance from corner to corner (see **Note 4**) shall be the basis for acceptance or rejection. The appropriate tolerances are listed in **Table 18**.

**NOTE 4**—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  $\frac{1}{32}$  in. [1.0 mm] for bars over  $\frac{3}{16}$  to 1 in. [5 to 25 mm], inclusive, in thickness, and  $\frac{1}{16}$  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  $\frac{1}{16}$  in. [1.5 mm] for bars over  $\frac{3}{16}$  to 1 in. [25 mm], inclusive, in thickness, and  $\frac{1}{8}$  in. [5 mm] for bars over 1 in. [25 mm] in thickness. The tolerance on the radius shall be  $\pm 25$  %.

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

## 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*:

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 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 arithmetic 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.

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 E8 and E8M (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 **E8E8M**. Statistical significance testing must follow Practice **D4855**.

10.3 *Grain Size*—The test specimen shall be prepared in accordance with Practice **E3**.

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 *Residual Stress Test*—When specified in the ordering information, test specimens shall conform to the requirements of Test Methods **B154** or **B858**, as applicable.

10.6.1 Residual stress test specimens shall be of the full size of the product and tested without bending, springing, polishing, or any other preparation, except as allowed by the test method.

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 **B577**.

#### 10.8 *Bend Test:*

10.8.1 The test specimen shall be prepared in accordance with Test Method **E290**.

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 **E53**, **E54**, **E62**, **E75**, **E76**, **E118**, **E121**, **E478**, and **E581**.

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 **B194**.

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	<b>E112</b>
Electrical resistivity	<b>B193</b>
Tensile	<b>E8/ E8ME8EM</b>
Rockwell hardness	<b>E18</b>
Hydrogen embrittlement	<b>B577</b>
Semi-guided bend	<b>E290</b>

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 **B193** shall be ±0.30 % as a routine method and ±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 **E8** and **E8M**.

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