



Standard Specification for General Requirements for Wrought Copper and Copper- Alloy Rod, Bar, Shapes and Forgings¹

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 (ϵ) indicates an editorial change since the last revision or reapproval.

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

1. Scope *

1.1 This specification² establishes the general requirements common to wrought copper and copper alloy rod, bar, shapes, and forgings which shall apply to Specifications B 16, B 21, B 98, B 124, B 138, B 139, B 140/B 140M, B 150, B 151, B 196, B 283, B 301, B 371, B 411, B 441, B 453, 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.*

1.4 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 and B 272.

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 Specification for Free-Cutting Brass Rod, Bar, and Shapes for Use in Screw Machines³
- B 21 Specification for Naval Brass Rod, Bar, and Shapes³

¹ This specification is under the jurisdiction of ASTM Committee B0-5 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.02 on Rod, Bar, Shapes, and Forgings.

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

³ Annual Book of ASTM Standards, Vol 02.01.

- B 98/B 98 M Specification for Copper-Silicon Alloy Rod, Bar, and Shapes³
- B 124 Specification for Copper and Copper-Alloy Forging Rod, Bar, and Shapes³
- B 138 Specification for Manganese Bronze Rod, Bar, and Shapes³
- B 139 Specification for Phosphor Bronze Rod, Bar, and Shapes³
- B 140/B 140M Specification for Copper-Zinc-Lead (Leaded Red Brass or Hardware Bronze) Rod, Bar, and Shapes³
- B 150 Specification for Aluminum Bronze Rod, Bar, and Shapes³
- B 151 Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) and Copper-Nickel Rod and Bar³
- B 154 Test Method for Mercurous Nitrate Test for Copper and Copper Alloys³
- B 187 Specification for Copper Bar, Bus Bar, Rod and Shapes³
- B 193 Test Method for Resistivity of Electrical Conductor Materials⁴
- B 194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip and Rolled Bar³
- B 196 Specification for Copper-Beryllium Alloy Rod and Bar³
- B 206/B 206M Specification for Copper-Nickel-Zinc Alloy (Nickel Silver) Wire and Copper-Nickel Alloy Wire³
- B 272 Specification for Flat Copper Products With Finished (Rolled or Drawn) Edges (Flat Wire and Strip)⁴
- B 283 Specification for Copper and Copper-Alloy Die Forgings³
- B 301 Specification for Free-Cutting Copper Rod and Bar³
- B 371 Specification for Copper-Zinc-Silicon Alloy Rod³
- B 411 Specification for Copper-Nickel-Silicon Alloy Rod and Bar³
- B 441 Specification for Copper-Cobalt-Beryllium (UNS C17500) and Copper-Nickel-Beryllium (UNS C17510) Rod and Bar³
- B 453 Specification for Copper-Zinc-Lead Alloy (Leaded Brass) Rod³
- B 455 Specification for Copper-Zinc-Lead Alloy (Leaded

⁴ Annual Book of ASTM Standards, Vol 02.03.

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

- Brass) Extruded Shapes³
- B 570 Specification for Copper-Beryllium Alloy (UNS C17000 and C17200) Forgings and Extrusions³
- B 577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper³
- B 846 Terminology for Copper and Copper Alloys³
- B 858M Test Method for Determination of Susceptibility to Stress Corrosion Cracking in Copper Alloys Using an Ammonia Vapor Test³
- D 4855 Practice for Comparing Test Methods⁵
- E 3 Practice for Preparation of Metallographic Specimens⁶
- E 8 Test Methods for Tension Testing of Metallic Materials⁶
- E 8M Test Methods for Tension Testing of Metallic Materials [Metric]⁶
- E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials⁶
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications⁷
- E 53 Methods for Chemical Analysis of Copper⁸
- E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes⁸
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁸
- E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys⁸
- E 76 Test Method for Chemical Analysis of Nickel-Copper Alloys⁸
- E 112 Test Methods for Determining Average Grain Size⁶
- E 118 Test Methods for Chemical Analysis of Copper-Chromium Alloys⁸
- E 121 Test Methods for Chemical Analysis of Copper-Tellurium Alloys⁸
- E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁸
- E 290 Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials⁶
- E 478 Test Methods for Chemical Analysis of Copper Alloys⁹
- E 527 Practice for Numbering Metals and Alloys (UNS)¹⁰

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] 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

⁵ Annual Book of ASTM Standards, Vol 07.02.

⁶ Annual Book of ASTM Standards, Vol 03.01.

⁷ Annual Book of ASTM Standards, Vol 14.02.

⁸ Annual Book of ASTM Standards, Vol 03.05.

⁹ Annual Book of ASTM Standards, Vol 03.06.

¹⁰ Annual Book of ASTM Standards, Vol 01.01.

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

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 (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138, B 139, B 150, B 151, B 196, B 371, B 411, and B 441.

Table 3—Diameter tolerances for piston finish rod applicable to Specifications B 21, B 138, B 139, 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 124 (Copper Alloy UNS Nos. C36500, C37700, C46400, C48200, C48500, C61900, C62300, C63000, C63200, C64200, C64210, and C67500), B 138 (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 (Copper UNS Nos. C11000, C14500, C14700, C65500, and C77400), and B 138 (Copper Alloy UNS No. C67000).

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

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

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

Table 9—Thickness tolerances for rectangular and square bar applicable to Specifications B 98/B 98M (Copper Alloy

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

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

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, ^A 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 ^B [0.15] ^B	0.30 ^B [0.30] ^B

^AWhen tolerances are specified as all plus or all minus, double the values given.

^BPercent 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 (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138, B 139, B 150, B 196, B 371, B 411, and B 441.)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, ^A 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 ^B [0.20] ^B	0.40 ^B [0.40] ^B

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent 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 138, B 139, and B 150.)

Diameter, in. [mm]	Tolerances, Plus and Minus, ^A 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 ^B [0.10] ^B

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent 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 124 (Copper Alloy UNS Nos. C36500, C37700, C46400, C48200, C48500, C61900, C62300, C63000, C63200, C64200, C64210, and C67500), B 138 (Copper Alloy UNS No. C67500), and B 150.)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, ^A 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]	

^AWhen tolerances are specified as all plus or all minus, double the values given.

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

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

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

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

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 (Copper UNS Nos. C11000, C14500, and C14700 and Copper Alloy UNS Nos. C65500 and C77400), B 138 (Copper UNS No. C67000), B 196 (Copper UNS Nos. C17000, C17200) and B 441 (Copper UNS Nos. C17500, C17510.)

Diameter or Distance Between Parallel Surfaces, in. [mm]	Tolerances, Plus and Minus, ^A 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]	

^AWhen 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 138, B 150, B 196, and B 441.)

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

^AWhen tolerances are specified as all plus or all minus, double the values given.

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

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

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

TABLE 7 Thickness Tolerances for Rectangular and Square Bar
(Applicable to Specifications B 124, (Copper Alloy UNS Nos. C11000, C14500, and C14700), B 133, and B 301.)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, ^A in. [mm] for Widths Given in Inches					
	½ [12] and Under	Over ½ to 1¼ [12 to 30] Incl	Over 1¼ to 2 [30 to 50] Incl	Over 2 to 4 [50 to 100] Incl	Over 4 to 8 [100 to 200] Incl	Over 8 to 12 [200 to 300] Incl
Over 0.188 to 0.500 [4.8 to 12], incl	0.003 [0.08]	0.003 [0.08]	0.0035 [0.09]	0.004 [0.10]	0.0045 [0.11]	0.0055 [0.13]
Over 0.500 to 1.00 [12 to 25], incl	...	0.004 [0.10]	0.004 [0.10]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]
Over 1.00 to 2.00 [25 to 50], incl	...	0.0045 [0.11]	0.0045 [0.11]	0.005 [0.13]	0.006 [0.15]	...
Over 2.00 to 4.00 [50 to 100], incl	...	...	...	0.30 ^B	...	...

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent 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 21, B 98/B 98M, (Copper Alloy UNS Nos. C46400, C48200, and C48500), and B 140.)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, ^A in. for Widths Given in Inches					
	½ and Under	Over ½ to 1¼ Incl	Over 1¼ to 2 Incl	Over 2 to 4 Incl	Over 4 to 8 Incl	Over 8 to 12 Incl
Over 0.188 to 0.500 [4.8 to 12], incl	0.0035 [0.09]	0.004 [0.10]	0.0045 [0.11]	0.0045 [0.11]	0.006 [0.13]	0.008 [0.20]
Over 0.500 to 1.00 [12 to 25], incl	...	0.0045 [0.11]	0.005 [0.13]	0.005 [0.13]	0.007 [0.18]	0.009 [0.23]
Over 1.00 to 2.00 [25 to 50], incl	...	0.005 [0.13]	0.005 [0.13]	0.006 [0.15]	0.008 [0.20]	...
Over 2.00 to 4.00 [50 to 100], incl	...	...	...	0.30 ^B	...	...

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent of specified thickness expressed to the nearest 0.001 in. [0.01 mm].

TABLE 9 Thickness Tolerances for Rectangular and Square Bar
(Applicable to Specifications B 98/B 98M (Copper Alloy UNS Nos. C65500 and C66100), B 124 (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138, B 139, B 150, B 151, B 196, B 411, and B 441.)

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, ^A 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 ^B	...	...

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent 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 21, B 98/B 98M (Copper Alloy UNS No. C65100), B 124 (Copper Alloy UNS Nos. C11000, C14500, C14700, C46400, C48200, and C48500), B 140, and B 301.)

Width, in. [mm]	Tolerances, Plus and Minus, ^A 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] ^B
Over 4.00 to 12.00 [100 to 300], incl	0.30 ^B [0.30]

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent 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 (Copper Alloy UNS Nos. C36500, C37700, C61900, C62300, C63000, C63200, C64200, C65500, C67500, and C77400), B 138, B 139, B 150, B 151, B 196, B 411, and B 441.)

Width, in. [mm]	Tolerances, Plus and Minus, ^A 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 ^B [0.50] ^B

^AWhen tolerances are specified as all plus or all minus, double the values given.
^BPercent of specified width expressed to the nearest 0.001 in. [0.01 mm].

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 1/16 in. [1.5 mm] for sizes up to 2 in. [50 mm], incl., and 3/32 in. [2.5 mm] for sizes over 2 in. [50 mm].

6.5.3 *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

TABLE 12 Diameter Tolerances for Hot-Forged Rod and Bar
(Applicable to Specification B 138.)

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

TABLE 13 Length Tolerances for Rod, Bar, and Shapes (Full-Length Pieces Specific and Stock Lengths With or Without Ends)
(Applicable to Specifications B 16, B 21, B 98/B 98M, B 138, B 139, B 140/B 140M, B 150, B 151, B 196, B 301, B 371, B 411, B 441, and B 453.)

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 ^A [25] ^A

^AAs stock lengths are cut and placed in stock in advance of orders, departure from this tolerance is not practicable.

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:

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.

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 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