



Designation: B 98/B 98M – 98

## Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes<sup>1</sup>

This standard is issued under the fixed designation B 98/B 98M; 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 requirements for copper-silicon rod, bar, and shapes for UNS Alloys C65100 (Low Silicon Bronze B), C65500 (High Silicon Bronze A), and C66100.

NOTE 1—Material for hot forging is covered by Specification B 124.

1.2 The values stated in inch-pound units or SI units are to be regarded separately as standard. Within the text, SI units are shown in brackets. The values in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

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

B 249 Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings<sup>3</sup>

B 249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings [Metric]<sup>3</sup>

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast<sup>3</sup>

E 8 Test Methods for Tension Testing of Metallic Materials<sup>4</sup>

E 8M Test Methods for Tension Testing of Metallic Materials [Metric]<sup>4</sup>

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials<sup>4</sup>

E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>5</sup>

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Method)<sup>5</sup>

E 478 Test Methods for Chemical Analysis of Copper Alloys<sup>6</sup>

### 3. General Requirements

3.1 The following sections of Specification B 249 or B 249M constitute a part of this specification:

3.1.1 Terminology,

3.1.2 Materials and Manufacture,

3.1.3 Workmanship, Finish, and Appearance,

3.1.4 Sampling,

3.1.5 Number of Tests and Retests,

3.1.6 Specimen Preparation,

3.1.7 Test Methods,

3.1.8 Significance of Numerical Limits,

3.1.9 Inspection,

3.1.10 Rejection and Reheating,

3.1.11 Certification,

3.1.12 Test Report (Mill),

3.1.13 Packaging and Package Marking, and

3.1.14 Supplemental Requirements.

3.2 In addition, when a section with a title identical to one of those referenced in 3.1 appears in this specification, it contains additional requirements that supplement those which appear in Specification B 249 or B 249M.

### 4. Ordering Information

4.1 Orders for product under this specification should include the following information:

4.1.1 ASTM Designation and year of issue,

4.1.2 Copper Alloy UNS No. designation,

4.1.3 Temper designation,

4.1.4 Quantity; total weight or length, or number of pieces of each temper, form, or alloy,

4.1.5 Dimensions; diameter or distance between parallel surfaces,

4.1.6 Type of edge; edge contours,

4.1.7 How furnished; specific lengths with or without ends, and

4.1.8 When material is purchased for agencies of the U.S. Government (see Specifications B 249 or B 249M).

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee B-5 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B05.02 on Rod, Bar, Wire, Shapes, and Forgings.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SB-98 in Section II of that code.

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

<sup>4</sup> *Annual Book of ASTM Standards*, Vol 03.01.

<sup>5</sup> *Annual Book of ASTM Standards*, Vol 03.05.

<sup>6</sup> *Annual Book of ASTM Standards*, Vol 03.06.

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

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4.2 The following options are available under this specification and should be specified in the contract or purchase order when required:

- 4.2.1 Certification (Specifications B 249 or B 249M), and
- 4.2.2 Mill Test Report (Specifications B 249 or B 249M).

**5. Material and Manufacture**

5.1 The starting material shall be cast billets or rods of Copper Alloy UNS Numbers C65100, C65500, or C66100, and shall be of such soundness and structure as to enable them to be processed into the product specified in the contract or purchase order.

5.2 The product shall be manufactured by such hot-working, cold-working, straightening, and annealing processing as to produce a uniform wrought structure and obtain the required finish properties.

**6. Chemical Composition**

6.1 The product shall conform to the chemical requirements specified in Table 1 for the Copper Alloy UNS No. designated in the ordering information.

6.1.1 When all elements listed in Table 1 are determined for the designated alloy, the sum of results shall be 99.5 % min.

6.1.2 Copper may be determined as the difference between the sum of results for all elements analyzed an 100 %.

6.2 These composition limits do not preclude the presence of other elements. Limits may be established and analysis required for unnamed elements by agreement between the manufacturer and the purchaser.

**7. Temper**

7.1 Tempers, as defined in Practice B 601, available under this specification are O60 (soft anneal), H01 (quarter-hard), H02 (half-hard), H04 (hard), H06 (extra hard), M20 (as hot rolled), and M30 (as hot extruded).

7.2 Product of bars and shapes in the H06 (extra-hard) temper is normally not produced.

**8. Mechanical Property Requirements**

8.1 The product shall conform to the mechanical property requirements given in Tables 2 and 3 for the Copper Alloy UNS No. designation specified in the ordering information.

8.1.1 *Rockwell Hardness*—For the alloys and tempers listed, product 0.5 in. [12.7 mm] and over in diameter or

distance between parallel surfaces shall conform with the requirements given in Table 3, when tested in accordance with Test Methods E 18 or B 249M.

8.1.1.1 For the alloys and tempers listed in Table 3, Rockwell hardness shall be the basis of acceptance or rejection for mechanical properties except when the tensile test is specified in the contract or purchase order.

8.1.2 *Tensile Strength*—The product shall conform with the requirements of Table 2 when tested in accordance with Test Methods E 8 or B 249M.

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

9.1 Refer to the appropriate paragraphs in Specification B 249/B 249M with particular reference to the following tables:

9.2 *Diameter or Distance Between Parallel Surfaces:*

9.2.1 *Rod: Round, Hexagonal, Octagonal*—Refer to Table 1 for Alloy C65100 and to Table 2 for Alloys C65500 and C66100.

9.2.2 *Rod: Round M20 Temper*—Refer to Table 6.

9.2.3 *Rod: Round, Hexagonal, Octagonal, M30 Temper*—Refer to Table 5.

9.2.4 *Bar: Rectangular and Square*—Refer to Tables 8 and 10 for Alloy C65100, and Tables 9 and 11 for Alloys C65500 and C66100.

9.2.5 *Bar: M30 Temper*—Refer to Table 5 for thickness and width tolerances.

9.3 *Shapes*—The dimensional tolerance for shapes shall be as agreed upon between the manufacturer and the purchaser, and shall be specified in the order.

9.4 *Length:*

9.4.1 *Rod, Bar and Shapes*—Refer to Tables 13 and 15.

9.5 *Straightness:*

9.5.1 *Rod and Bar*—Refer to Table 16.

9.6 *Edge Contours:*

9.6.1 *Rod and Bar*—Refer to the section entitled, “Edge Contours” and to Figs. 1, 2, and 3.

**10. Test Methods**

10.1 Chemical composition shall, in case of disagreement, be determined as follows:

Element	Test Methods
Copper	E 478
Lead	E 478, Atomic absorption
Manganese	E 62
Nickel	E 478, Photometric
Silicon	E 54, Perchloric acid dehydration
Zinc	E 478, Atomic absorption

10.1.1 Test Method(s) to be followed for the determination of elements required by contractual or purchase order agreement shall be as agreed upon between the supplier and purchaser.

10.2 Refer to Specifications B 249 or B 249M for other appropriate test methods.

**11. Keywords**

11.1 copper—rod, bar, shapes; copper-silicon alloy; high silicon bronze A; low silicon bronze B; silicon bronze

**TABLE 1 Chemical Requirements**

	Composition, % Maximum (Unless Shown as a Range or Minimum)		
	Copper Alloy UNS No.		
	C65100	C65500	C66100
Copper (Includes silver)	96.0 min	94.8 min	94.0 min
Lead	0.05	0.05	0.20–0.8
Iron	0.8	0.8	0.25
Zinc	1.5	1.5	1.5
Aluminum	...	...	...
Manganese	0.7	0.50–1.3	1.5
Silicon	0.8–2.0	2.8–3.8	2.8–3.5
Nickel	...	0.6	...

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**TABLE 2a Tensile Requirements**

Temper Designation		Diameter or Distance Between Parallel Surfaces, in.	Tensile Strength min, ksi	Yield Strength at 0.5 % Extension Under Load, min, ksi	Elongation in 4 × Diameter or Thickness of Specimen, min, % <sup>A</sup>
Standard	Former				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	40	12	30
H02	Half-hard	Rods: Up to ½, incl	55	20	11
		Over ½ to 2, incl	55	20	12
H04	Hard	Bars and shapes	<i>B</i>	<i>B</i>	<i>B</i>
		Rods: Up to ½, incl	65	35	8
		Over ½ to 2, incl	65	35	10
H06	Extra-hard <sup>C</sup>	Bars and shapes	<i>B</i>	<i>B</i>	<i>B</i>
		Rods: Up to ½, incl	85	55	6
		Over ½ to 1, incl	75	45	8
		Over 1 to 1½, incl	75	40	8
Copper Alloy UNS Nos. C65500 and C66100 Bars <sup>D</sup>					
O60	Soft anneal	All sizes	52	15	35
H04	Hard	Up to 1, incl	65	38	20
		Over 1 to 1½, incl	60	30	25
		Over 1½ to 3, incl	55	24	27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	52	15	35
H01	Quarter-hard	All forms, all sizes	55	24	25
H02	Half-hard	Rods and square bars: Up to 2, incl	70	38	20
		Shapes	<i>B</i>	<i>B</i>	<i>B</i>
H04	Hard	Rods and square bars: Up to ¼, incl	90	55	8
		Over ¼ to 1, incl	90	52	13
		Over 1 to 1½, incl	80	43	15
		Over 1½ to 3, incl	70	38	17
		Over 3—as agreed upon by manufacturer and purchaser			
		Shapes	<i>B</i>	<i>B</i>	<i>B</i>
H06	Extra-hard <sup>C</sup>	Rods: up to ½, incl	100	55	7

<sup>A</sup> In any case a minimum gage length of 1 in. shall be used.

<sup>B</sup> Tensile requirements for shapes of Copper Alloy UNS Nos. C65500 and C66100 and bars and shapes of the H02 and H04 tempers of Copper Alloy UNS No. C65100 and all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and the purchaser at time of order.

<sup>C</sup> Bars and shapes are not produced in the H06 extra-hard temper.

<sup>D</sup> Rectangular sections having thickness less than the width.

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**TABLE 2b Tensile Requirements**

Temper Designation		Diameter or Distance Between Parallel Surfaces, mm	Tensile Strength min, MPa	Yield Strength at 0.5 % Extension Under Load, min, MPa	Elongation, min, % <sup>A</sup>
Standard	Former				
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	275	85	30
H02	Half-hard	Rods: Up to 12.7, incl	380	140	11
		Over 12.7 to 50.8, incl	380	140	12 <sup>B</sup>
		Bars and shapes			
H04	Hard	Rods: Up to 12.7, incl	450	240	8
		Over 12.7 to 50.8, incl	450	240	10
		Bars and shapes	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>
H06	Extra-hard <sup>C</sup>	Rods: Up to 12.7, incl	585	380	6
		Over 12.7 to 25.4, incl	515	310	8
		Over 25.4 to 38.1, incl	515	275	8
Copper Alloy UNS Nos. C65500 and C66100 Bars <sup>D</sup>					
O60	Soft anneal	All sizes	360	105	35
H04	Hard	Up to 25.4, incl	450	260	20
		Over 25.4 to 38.1, incl	415	205	25
		Over 38.1 to 76.2, incl	380	165	27
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes					
O60	Soft anneal	All forms, all sizes	360	105	35
H01	Quarter-hard	All forms, all sizes	380	165	25
H02	Half-hard	Rods and square bars: Up to 50.8, incl	485	260	20
		Shapes	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>
H04	Hard	Rods and square bars: Up to 6.35, incl	615	380	8
		Over 6.35 to 25.4, incl	615	360	13
		Over 25.4 to 38.1, incl	545	295	15
		Over 38.1 to 76.2, incl	485	260	17
		Over 76.2—as agreed upon between manufacturer and purchaser			
		Shapes	<sup>B</sup>	<sup>B</sup>	<sup>B</sup>
H06	Extra-hard <sup>C</sup>	Rods: up to 12.7, incl	690	380	7

<sup>A</sup> Elongation values are based on a gage length of 5.65 times the square root of the area for dimensions greater than 2.5 mm.

<sup>B</sup> Tensile requirements for shapes of Copper Alloy UNS Nos. C65500 and C66100 and bars and shapes of the H02 and H04 tempers of Copper Alloy UNS No. C65100 and all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and the purchaser at time of order.

<sup>C</sup> Bars and shapes are not produced in the H06 extra-hard temper.

<sup>D</sup> Rectangular sections having thickness less than the width.

**TABLE 3 Rockwell Hardness Requirements<sup>A</sup>**

Temper Designation		Diameter or Distance Between Parallel Surfaces, in. [mm]	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Standard	Former		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	0.5 to 2.0 [12.7 to 50.8], incl	60–85
H04	Hard	0.5 to 2.0 [12.7 to 50.8], incl	65–90
H06	Extra-hard <sup>B</sup>	0.5 to 1.5 [12.7 to 38.1], incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Bars <sup>C</sup>			
H04	Hard	0.5 to 3.0 [12.7 to 76.1], incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	0.5 to 1.0 [12.7 to 25.4], incl	75–95
		over 1.0 to 1.5 [25.4 to 38.1], incl	75–95
		over 1.5 to 3.0 [38.1 to 50.8], incl	75–95
H04	Hard	0.5 to 1.0 [12.7 to 25.4], incl	85–100
		over 1.0 to 1.5 [25.4 to 38.1], incl	80–95
		over 1.5 to 3.0 [38.1 to 50.8], incl	75–95

<sup>A</sup> Rockwell hardnesses are not established for diameters less than 0.5 in. [12.7 mm].

<sup>B</sup> Bars and shapes are not produced in the H06 temper.

<sup>C</sup> Rectangular sections having thickness less than the width.



## SUMMARY OF CHANGES

Committee B-5 has identified the location of selected changes to this standard since the last issue B 98/B 98M – 97 that may impact the use of this standard.

- (1) Referenced Documents section has been expanded.                      (2) Mechanical Property Requirements section has been expanded.

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