



Designation: B98/B98M – 13 (Reapproved 2019)

Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes¹

This standard is issued under the fixed designation B98/B98M; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification establishes requirements for copper-silicon rod, bar, and shapes for UNS Copper Alloys C65100, C65500, and C66100.

NOTE 1—Material for hot forging is covered by Specification [B124/B124M](#).

NOTE 2—For ASME Boiler and Pressure Vessel Code applications, see Specification SB-98 in Section II of that code.

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

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

2. Referenced Documents

2.1 *ASTM Standards*:²

[B124/B124M](#) Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes

[B249/B249M](#) Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings

[B950](#) Guide for Editorial Procedures and Form of Product Specifications for Copper and Copper Alloys

[B601](#) Classification for Temper Designations for Copper and

[Copper Alloys—Wrought and Cast](#)

[E8/E8M](#) Test Methods for Tension Testing of Metallic Materials

[E18](#) Test Methods for Rockwell Hardness of Metallic Materials

[E62](#) Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)³

[E478](#) Test Methods for Chemical Analysis of Copper Alloys

2.2 *ASME Standard*:⁴

[ASME Boiler and Pressure Vessel Code](#)

3. General Requirements

3.1 The following sections of Specification [B249/B249M](#) 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 Rehearing;

3.1.11 Certification;

3.1.12 Test Reports;

3.1.13 Packaging and Package Marking; and

3.1.14 Supplementary 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 [B249/B249M](#).

4. Ordering Information

4.1 Include the following specified choices when placing orders for product under this specification, as applicable:

4.1.1 ASTM Designation and year of issue;

¹ 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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² 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.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

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

- 4.1.2 Copper Alloy UNS No. designation;
- 4.1.3 Temper designation (see Temper Section 7);
- 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 Intended application.

4.2 The following options are available but may not be included unless specified at the time of placing of the order when required:

- 4.2.1 Certification (Specification B249/B249M), and
- 4.2.2 Mill Test Report (Specification B249/B249M).
- 4.2.3 Tensile test required for alloys in Table 4 or Table 5 (see 8.1.1.1),
- 4.2.4 If product is purchased for agencies of the U.S. Government (see Supplementary Requirements in Specification B249/B249M).

5. Material and Manufacture

5.1 *Materials*—The starting material shall be cast billets or rods of Copper Alloy UNS Nos. 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 *Manufacture*—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 material shall conform to the chemical requirements specified in Table 1 for the Copper Alloy UNS No. designated in the ordering information.

6.1.1 For alloys in which copper is listed as “remainder,” copper is the difference between the sum of the results of all elements determined and 100 %.

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

TABLE 1 Chemical Requirements

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

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 The standard tempers, as defined in Classification B601, for products described in this specification are given in Tables 2-5.

- 7.1.1 Soft annealed O60,
- 7.1.2 ¼-hard H01,
- 7.1.3 ½-hard H02,
- 7.1.4 Hard H04,
- 7.1.5 Extra-hard H06,
- 7.1.6 As hot rolled M20, and
- 7.1.7 As hot extruded M30.

7.2 Product of bars and shapes in the temper H06 is normally not produced.

8. Mechanical Property Requirements

8.1 Product furnished under this specification shall conform to the tensile and hardness requirements prescribed in Tables 2-5 for the Copper Alloy UNS No. designation specified in the ordering information.

8.1.1 *Rockwell Hardness Requirement*—For the alloys and tempers listed, product 0.5 in. [12 mm] and over in diameter or in the distance between parallel surfaces shall conform with the requirements given in Table 4 and Table 5, when tested in accordance with Test Methods E18.

8.1.1.1 For the alloys and tempers listed in Table 4 and Table 5, 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 Requirements*—The product shall conform with the requirements of Table 2 and Table 3 when tested in accordance with Test Methods E8/E8M.

8.1.2.1 The tensile requirements for all alloys and forms of M20 and M30 tempers shall be as agreed upon between the manufacturer and purchaser at the time of order.

9. Dimensions, Mass and Permissible Variations

9.1 Refer to the appropriate paragraphs in Specification B249/B249M 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.

TABLE 2 Tensile Requirements, Inch-Pound (see Table 3 for SI)

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^A in.	Tensile Strength min, ksi	Yield Strength at 0.5 % Extension Under Load, min, ksi	Elongation in 4 × Diameter or Thickness of Specimen, min, % ^B
Code	Name				
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 1/2, incl	55	20	11
		Over 1/2 to 2, incl	55	20	12
H04	Hard	Bars and shapes	<i>c</i>	<i>c</i>	<i>c</i>
		Rods:			
		Up to 1/2, incl	65	35	8
H06	Extra-hard	Over 1/2 to 2, incl	65	35	10
		Bars and shapes	<i>c</i>	<i>c</i>	<i>c</i>
		Rods:			
H06	Extra-hard	Up to 1/2, incl	85	55	6
		Over 1/2 to 1, incl	75	45	8
		Over 1 to 1 1/2, incl	75	40	8
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars					
O60	Soft anneal	All sizes	52	15	35
H04	Hard	Up to 1, incl	65	38	20
		Over 1 to 1 1/2, incl	60	30	25
		Over 1 1/2 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
H04	Hard	Shapes	<i>c</i>	<i>c</i>	<i>c</i>
		Rods and square bars:			
		Up to 1/4, incl	90	55	8
		Over 1/4 to 1, incl	90	52	13
		Over 1 to 1 1/2, incl	80	43	15
		Over 1 1/2 to 3, incl	70	38	17
		Over 3	<i>c</i>	<i>c</i>	<i>c</i>
H06	Extra-hard	Shapes	<i>c</i>	<i>c</i>	<i>c</i>
		Rods: up to 1/2, incl	100	55	7

^A For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^B In any case a minimum gage length of 1 in. shall be used.

^C As agreed upon between manufacturer and purchaser.

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 In cases of disagreement, test methods for chemical composition shall be subject to agreement between the manufacturer or supplier and the purchaser. The following table is a list of published test methods some of which are considered by ASTM as no longer viable. These, and others not listed, may be used subject to agreement.

Element	Test Methods
Copper	E478
Lead	E478, Atomic absorption
Manganese	E62
Nickel	E478, Photometric
Silicon	E62
Zinc	E478, 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 Specification B249/B249M 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; UNS No. C65100; UNS No. C65500; UNS No. C66100

TABLE 3 Tensile Requirements, SI (see Table 2 for Inch-Pound)

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^A mm	Tensile Strength min, MPa	Yield Strength at 0.5 % Extension Under Load, min, MPa	Elongation, min, % ^B
Code	Name				
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, incl	380	140	11
		Over 12 to 50, incl	380	140	12
H04	Hard	Bars and shapes	^C	^C	^C
		Rods:			
		Up to 12, incl	450	240	8
H06	Extra-hard	Over 12 to 50, incl	450	240	10
		Bars and shapes	^C	^C	^C
		Rods:			
		Up to 12, incl	585	380	6
		Over 12 to 25, incl	515	310	8
		Over 25 to 38, incl	515	275	8
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars					
O60	Soft anneal	All sizes	360	105	35
H04	Hard	Up to 25, incl	450	260	20
		Over 25 to 38, incl	415	205	25
		Over 38 to 75, 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, incl	485	260	20
H04	Hard	Shapes	^C	^C	^C
		Rods and square bars:			
		Up to 6, incl	615	380	8
		Over 6 to 25, incl	615	360	13
		Over 25 to 38, incl	545	295	15
		Over 38 to 75, incl	485	260	17
		Over 75	^C	^C	^C
H06	Extra-hard	Shapes	^C	^C	^C
		Rods: up to 12, incl	690	380	7

^A For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^B 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.

^C As agreed upon between manufacturer and purchaser.

TABLE 4 Rockwell Hardness Requirements, Inch-Pound^A (see Table 5 for SI)

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^B in.	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Code	Name		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	0.5 to 2.0, incl	60–85
H04	Hard	0.5 to 2.0, incl	65–90
H06	Extra-hard ^C	0.5 to 1.5, incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars			
H04	Hard	0.5 to 3.0, incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	0.5 to 1.0, incl	75–95
		over 1.0 to 1.5, incl	75–95
		over 1.5 to 3.0, incl	75–95
H04	Hard	0.5 to 1.0, incl	85–100
		over 1.0 to 1.5, incl	80–95
		over 1.5 to 3.0, incl	75–95

^A Rockwell hardness requirements are not established for diameters less than 0.5 in.

^B For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^C Bars and shapes are not produced in the H06 temper.

TABLE 5 Rockwell Hardness Requirements, SI^A (see Table 4 for Inch-Pound)

Temper Designation		Diameter or Distance Between Parallel Surfaces, ^B mm	Rockwell B Hardness Determined on the Cross Section Midway Between Surface and Center
Code	Name		
Copper Alloy UNS No. C65100 Rods, Bars, and Shapes			
H02	Half-hard	12 to 50, incl	60–85
H04	Hard	12 to 50, incl	65–90
H06	Extra-hard ^C	12 to 50, incl	75–95
Copper Alloy UNS Nos. C65500 and C66100 Rectangular Bars			
H04	Hard	12 to 75, incl	60–95
Copper Alloy UNS Nos. C65500 and C66100 Rods, Square Bars, and Shapes			
H02	Half-hard	12 to 25, incl	75–95
		over 25 to 38, incl	75–95
		over 38 to 75, incl	75–95
H04	Hard	12 to 25, incl	85–100
		over 25 to 38, incl	80–95
		over 38 to 75, incl	75–95

^A Rockwell hardness requirements are not established for diameters less than 12 mm.

^B For rectangular bar, the Distance Between Parallel Surfaces refers to thickness.

^C Bars and shapes are not produced in the H06 temper.

SUMMARY OF CHANGES

Committee B05 has identified the principal changes to this specification since the 2008 issue as follows:

(1) Editorial revisions throughout in accordance with Guide **B950**.

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