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## Standard Specification for Copper-Silicon Alloy Plate, Sheet, Strip, and Rolled Bar for General Purposes and Pressure Vessels<sup>1</sup>

This standard is issued under the fixed designation B96/B96M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

### 1. Scope\*

1.1 This specification establishes the requirements for copper-silicon alloy plate, sheet, strip, and rolled bar for drawing, forming, stamping, bending, and general engineering applications, and for pressure vessel applications. The alloys involved are copper alloys UNS Nos. C65100, C65400, and C65500.

1.2 When product is ordered for ASME Boiler and Pressure Vessel Code applications, consult the Code<sup>2</sup> for applicable alloys.

~~1.3 The values stated in inch-pound 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.~~

~~1.4 The following safety hazard caveat pertains only to the test methods described in Section 11 of this specification: *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 its use.*~~

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

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>3</sup>

B248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar

B248M Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar (Metric)

B601 Classification for Temper Designations for Copper and Copper Alloys Wrought and Cast

B846 Terminology for Copper and Copper Alloys

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)

E118 Test Methods for Chemical Analysis of Copper-Chromium Alloys

E478 Test Methods for Chemical Analysis of Copper Alloys

### 3. General Requirements

3.1 The following sections of either Specification B248 or B248M constitute a part of this specification:

3.1.1 Terminology (see also Terminology B846),

3.1.2 Materials and Manufacture,

3.1.3 Dimensions, Mass, and Permissible Variations,

3.1.4 Workmanship, Finish, and Appearance,

3.1.5 Sampling,

<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 B05.01 on Plate, Sheet, and Strip.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-96 in Section 11 of that Code.

<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.

- 3.1.6 Number of Tests and Retests,
- 3.1.7 Test Specimens,
- 3.1.8 Test Methods,
- 3.1.9 Significance of Numerical Limits,
- 3.1.10 Inspection,
- 3.1.11 Rejection and Rehearing,
- 3.1.12 Certification,
- ~~3.1.13 Packing and Package Marking,~~
- ~~3.1.14 Mill Test Report, and~~
- ~~3.1.15 Supplementary Requirements:~~
  - ~~3.1.13 Mill Test Report,~~
  - ~~3.1.14 Product Identification~~
  - ~~3.1.15 Packing and Package Marking, and~~
  - ~~3.1.16 Supplementary Requirements.~~

3.2 In addition, when a section with a title identical to that referenced in 3.1 appears in this specification, it contains additional requirements which supplement those appearing in either Specification B248 or B248M.

#### **4. Terminology**

- 4.1 For definitions of terms related to copper and copper alloys, refer to Terminology B846.

#### **5. Ordering Information**

~~4. Include the following information when placing orders for products under this specification:~~

- ~~4.1.1 ASTM designation and year of issue,~~
- ~~4.1.2 Copper Alloy UNS No. (Section~~

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

- 5.1.1 ASTM designation and year of issue,
- 5.1.2 Copper Alloy UNS No. designations (Section 1),
- ~~4.1.3 Temper (Section 6~~
- 5.1.3 Temper (Section 7),
- ~~4.1.4 Dimensions: Thickness, Width, and Length (Section 9.1),~~
- 5.1.4 Dimensions: Thickness, Width, and Length (Section 9.1),
- ~~4.1.5 Finish (Section 10~~
- 5.1.5 Finish (section 12.2),

~~4.1.6 Type of edge, if required: slit, sheared, sawed, square corners, rounded corners, rounded edges or full rounded edges (9.6.1.6),~~

- ~~4.1.7 How furnished (straight lengths or coils);~~

~~4.1.8 Weight (9.7~~

- 5.1.7 How furnished (straight lengths or coils),

5.1.8 Weight (11.7),

~~4.2 The following options are available, and when required, are to be specified in the contract or purchase order at the time of placing of the order:~~

- ~~4.2.1 Mill test (Specifications~~

5.1.9 Intended application.

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

5.2.1 Mill test (Section 18),

5.2.2 Certification (Section 17),

5.2.3 Product identification for ASME Boiler and Pressure Vessel Code applications (Specifications B248 or B248M),

~~4.2.2 Certification (Specifications B248 or B248M);~~

~~4.2.3 Product identification (Specifications B248 or B248M);~~

~~4.2.4 Pressure vessel use, if applicable<sup>2</sup> (~~

5.2.4 If product is ordered for ASME Boiler and Pressure Vessel Code application, (1.2, 9.1.1.1, 9.2.1.1.2.1, and 9.7.1.1.7.1),

~~4.2.5.2.5 Whether 0.2 % yield strength is required, and required (Table 3),~~

~~4.2.6 When~~5.2.6 If product is purchased for agencies of the U.S. Government (Section 8.10).

#### **5.**

- 5.2.7 If specification number must be shown on package marking (Section 19.2.2).

#### **6. Chemical Composition**

~~5.1 The~~6.1 The material shall conform to the chemical composition requirements prescribed in Table 1 for the copper alloy UNS No. designation specified in the ordering information.

**TABLE 1 Chemical Requirements**

Element	Composition, %		
	Copper Alloy UNS No.		
	C65100	C65400	C65500
Copper, incl silver	remainder	remainder	remainder
Silicon	0.8–2.0	2.7–3.4	2.8–3.8
Manganese	0.7 max	...	0.50–1.3
Tin	...	1.2–1.9	...
Chromium	...	0.01–0.12	...
Zinc, max	1.5	0.50	1.5
Iron, max	0.8	...	0.8
Nickel, max <sup>A</sup>	...	...	0.6
Lead, max	0.05	0.05	0.05

<sup>A</sup> Incl cobalt.

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

5.2.1 Copper may be taken as the difference between the sum of all the elements analyzed and 100%.

5.2.2 When all the elements in

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

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

6.2.2 When all the elements in Table 1 are analyzed, their sum shall be 99.5% min.

**6. are determined, the sum of results shall be 99.5 % min.**

## 7. Temper

6.1 Tempers, as defined in Classification

7.1 The standard tempers for products described in this specification are in Tables 2-5.

7.2 Tempers, as defined in Classification B601 available under this specification are:

6.1.1 O61 (annealed),

6.1.2 O50 (light annealed),

6.1.3 H01 (quarter hard),

6.1.4 H02 (half-hard),

6.1.5 H03 (three-quarter hard),

6.1.6 H04 (hard),

6.1.7 H06 (extra-hard),

6.1.8 H08 (spring),

6.1.9 H10 (extra-spring),

6.1.10 H14 (super-spring),

6.1.11 M20 (as hot-rolled), and

6.1.12 M25 (as hot-rolled and rerolled).

6.2 Refer to Table 2 for the copper alloy UNS No. involved for each temper.

## 7.

7.2.1 O61 (annealed),

7.2.2 O50 (light anneal),

7.2.3 H01 (quarter hard),

7.2.4 H02 (half-hard),

7.2.5 H03 (three-quarter hard),

7.2.6 H04 (hard),

7.2.7 H06 (extra-hard),

7.2.8 H08 (spring),

7.2.9 H10 (extra-spring),

7.2.10 H14 (super-spring),

7.2.11 M20 (as hot-rolled), and

7.2.12 M25 (as hot-rolled and rerolled).

## 8. Grain Size for Annealed Tempers

8.1 The approximate grain size values for annealed tempers given in Tables 2-5 are for general information and shall not be used as a basis for product rejection.

**TABLE 2 Tensile Strength Requirements and Approximate Rockwell Hardness and Grain Size Values** Note 1—Plate grade, generally is available in only the as-hot-rolled (M20) temper. Required properties for other tempers shall be agreed upon between the manufacturer and the purchaser at the time of placing the order.

Temper Designation		Tensile Strength, ksi [MPa]	Approximate Rockwell Hardness		Approximate Grain Size, $\mu$ m
Standard	Former		Tensile Strength, ksi	Approximate Rockwell Hardness	
Code	Name	F Scale	B Scale		Approximate Gr Size, mm
Copper Alloy UNS No. C65100					
O61	Annealed	38–45 [260–310]	45–55	...	0.050–0.120
O61	Annealed	38–45	45–55	...	0.050–0.120
O50	Light anneal	40–50 [275–345]	50–75	...	0.060 max <sup>A</sup>
O50	Light anneal	40–50	50–75	...	0.060 max <sup>A</sup>
H01	Quarter-hard	42–52 [290–360]	...	48–63	...
H01	Quarter-hard	42–52	...	48–63	...
H02	Half-hard	47–57 [325–395]	...	64–73	...
H02	Half-hard	47–57	...	64–73	...
H04	Hard	60–70 [415–485]	...	74–82	...
H04	Hard	60–70	...	74–82	...
H06	Extra-hard	67–76 [460–525]	...	78–85	...
H06	Extra-hard	67–76	...	78–85	...
H08	Spring	71–79 [490–545]	...	81–86	...
H08	Spring	71–79	...	81–86	...
Copper Alloy UNS Nos. C65500					
O61	Annealed	52–58 [360–400]	70–82	...	0.110 max <sup>A</sup>
O61	Annealed	52–58	70–82	...	0.110 max <sup>A</sup>
O50	Light anneal	55–64 [380–440]	76–93	...	0.055 max <sup>B</sup>
O50	Light anneal	55–64	76–93	...	0.055 max <sup>B</sup>
H01	Quarter-hard	60–74 [415–510]	...	65–80	...
H01	Quarter-hard	60–74	...	65–80	...
H02	Half-hard <sup>B</sup>	72–86 [495–595]	...	79–94	...
H02	Half-hard <sup>B</sup>	72–86	...	79–94	...
H04	Hard <sup>B</sup>	85–99 [585–685]	...	88–96	...
H04	Hard <sup>B</sup>	85–99	...	88–96	...
H06	Extra-hard <sup>B</sup>	95–109 [655–750]	...	93–98	...
H06	Extra-hard <sup>B</sup>	95–109	...	93–98	...
H08	Spring <sup>B</sup>	102–116 [705–800]	...	94–99	...
H08	Spring <sup>B</sup>	102–116	...	94–99	...
M20	As-hot-rolled	55–72 [380–500]	72 min	...	...
M20	As-hot-rolled	55–72	72 min	...	...
M25	As-hot-rolled and-rolled	58–72 [400–500]	...	60–80	...
M25	As-hot-rolled and-rolled	58–72	...	60–80	...
Copper Alloy UNS No. C65400					
			Superficial 30T	B Scale	
O61	Annealed	65–80 [450–550]	...	...	0.040 <sup>B</sup> max
O61	Annealed	65–80	...	...	0.040 <sup>B</sup> max
H01	Quarter-hard <sup>B</sup>	75–90 [520–620]	64–77	72–94	...
H01	Quarter-hard <sup>B</sup>	75–90	64–77	72–94	...
H02	Half-hard <sup>B</sup>	86–104 [590–700]	75–79	89–95	...
H02	Half-hard <sup>B</sup>	86–104	75–79	89–95	...
H03	Three-quarter-hard <sup>B</sup>	97–112 [670–770]	77–81	94–97	...
H03	Three-quarter-hard <sup>B</sup>	97–112	77–81	94–97	...
H04	Hard <sup>B</sup>	108–120 [745–830]	80–84	96–98	...
H04	Hard <sup>B</sup>	108–120	80–84	96–98	...
H06	Extra-hard <sup>B</sup>	116–126 [800–870]	81–82	97–100	...
H06	Extra-hard <sup>B</sup>	116–126	81–82	97–100	...
H08	Spring <sup>B</sup>	124–133 [855–920]	81–82	99–104	...
H08	Spring <sup>B</sup>	124–133	81–82	99–104	...
H10	Extra-spring <sup>B</sup>	131–140 [905–965]	81 min	100–102	...
H10	Extra-spring <sup>B</sup>	131–140	81 min	100–102	...
H14	Super-spring <sup>B</sup>	137 min [945 min]	81 min	101 min	...
H14	Super-spring <sup>B</sup>	137 min	81 min	101 min	...

<sup>A</sup> No minimum grain size requirement is specified, but all annealed material shall be fully recrystallized.  
<sup>B</sup> Commercially supplied only as strip. The manufacturer should be consulted where these tempers are desired in sheet or plate.

## 9. Mechanical Property Requirements

### 9.1 Tensile Strength Requirements

The tension test shall be the standard test for all tempers of rolled, annealed, and hot-rolled materials. Acceptance or rejection based on mechanical properties shall depend only on the tensile properties, which shall conform to the requirements prescribed in Table 2 or Table 3, Table 4 or Table 5. Tension test specimens shall be taken so the longitudinal