



# 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 B 96/B 96M; 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 exactly 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.*

## 2. Referenced Documents

### 2.1 ASTM Standards:

B 248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar<sup>3</sup>

B 248M Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar [Metric]<sup>3</sup>

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

B 846 Terminology for Copper and Copper Alloys<sup>3</sup>

E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>4</sup>

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Method)<sup>4</sup>

E 118 Test Methods for Chemical Analysis of Copper-Chromium Alloys<sup>4</sup>

E 478 Test Methods for Chemical Analysis of Copper Alloys<sup>5</sup>

## 3. General Requirements

3.1 The following sections of either Specification B 248 or B 248M constitute a part of this specification:

3.1.1 Terminology,

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,

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.

3.2 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 B 248 or B 248M.

## 4. Ordering Information

4.1 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 1),

4.1.3 Temper (Section 6),

4.1.4 Dimensions: Thickness, Width, and Length (Section 9),

<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> Annual Book of ASTM Standards, Vol 02.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 03.05.

<sup>5</sup> Annual Book of ASTM Standards, Vol 03.06.

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

- 4.1.5 Finish (Section 10),
- 4.1.6 Type of edge, if required: slit, sheared, sawed, square corners, rounded corners, rounded edges or full rounded edges (9.6),
- 4.1.7 How furnished (straight lengths or coils),
- 4.1.8 Weight (9.7),
- 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 B 248 or B 248M),
  - 4.2.2 Certification (Specifications B 248 or B 248M),
  - 4.2.3 Product identification (Specifications B 248 or B 248M),
  - 4.2.4 Pressure vessel use, if applicable<sup>2</sup> (1.2, 9.1, 9.2.1, and 9.7.1),
  - 4.2.5 Whether 0.2 % yield strength is required, and
  - 4.2.6 When product is purchased for agencies of the U.S. Government (Section 8).

**5. Chemical Composition**

- 5.1 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.
- 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 Table 1 are analyzed, their sum shall be 99.5 % min.

**6. Temper**

- 6.1 Tempers, as defined in Practice B 601 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. Mechanical Property Requirements**

- 7.1 *Tensile 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. Tension test specimens shall be taken so the longitudinal axis of the specimen is parallel to the direction of rolling.
  - 7.1.1 For Pressure Vessel Code Applications, the tensile requirements are prescribed in Table 3.
  - 7.1.2 For general purpose applications, the tensile requirements are prescribed in Table 2.
- 7.2 *Rockwell Hardness*—The approximate Rockwell hardness values given in Tables 2 and 3 are for general information and assistance in testing and shall not be used as a basis for product rejection.
- 7.3 *Grain Size*—The approximate grain size values for annealed tempers given in Tables 2 and 3 are for general information and shall not be used as a basis for product rejection.

**8. Purchases for U.S. Government Agencies**

- 8.1 If the product ordered is for an agency of the U.S. Government, when specifically stipulated in the contract or purchase order, the product furnished shall conform to the conditions specified in the Supplementary Requirements section of Specifications B 248 or B 248M.

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

- 9.1 The dimensions and tolerances for product described by this specification shall be as specified in Specifications B 248 or B 248M with particular reference to the following tables and related paragraphs in that specification (exceptions for *ASME Pressure Vessel Code* applications are noted):
  - 9.2 *Thickness*—Table 2.
    - 9.2.1 *Pressure Vessel Code Applications*—The thickness of any plate or sheet shall not be more than 0.01 in. under the thickness specified.
  - 9.3 *Width*:
    - 9.3.1 *Slit Metal and Slit Metal with Rolled Edges*—Table 4.
    - 9.3.2 *Square-Sheared Metal*—Table 5.
    - 9.3.3 *Sawed Metal*—Table 6.
  - 9.4 *Length*:
    - 9.4.1 *Schedule of Lengths (Specific and Stock) With Ends*—Table 7.
    - 9.4.2 *Length Tolerances for Square-Sheared Metal*—Table 9.
    - 9.4.3 *Length Tolerances for Sawed Metal*—Table 10.
    - 9.4.4 *Minimum and Maximum Weight of Ends*—Table 8.
  - 9.5 *Straightness*:
    - 9.5.1 *Slit Metal or Slit Metal Either Straightened or Edge-Rolled*—Table 11.
    - 9.5.2 *Square-Sheared Metal*—Table 12.

**TABLE 1 Chemical Requirements**

Element	Composition, %		
	Copper Alloy UNS No.		
	C65100	C65400	C65500
Copper, incl silver	remainder	remainder	remainder
Silicon	0.8–2.0 <sup>A</sup>	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	...	...	0.6
Lead, max	0.05	0.05	0.05

<sup>A</sup>An alloy containing as high as 2.6 % silicon is acceptable providing the sum of all named elements other than copper, silicon, and iron does not exceed 0.3 %.

**TABLE 2 Tensile Strength Requirements and Approximate Rockwell Hardness and Grain Size Values**

NOTE 1—Plate 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, mm
Standard	Former		F Scale	B Scale	
Copper Alloy UNS No. C65100					
O61	Annealed	38–45 [260–310]	45–55	...	0.050–0.120
O50	Light anneal	40–50 [275–345]	50–75	...	0.060 max <sup>A</sup>
H01	Quarter-hard	42–52 [290–360]	...	48–63	...
H02	Half-hard	47–57 [325–395]	...	64–73	...
H04	Hard	60–70 [415–485]	...	74–82	...
H06	Extra-hard	67–76 [460–525]	...	78–85	...
H08	Spring	71–79 [490–545]	...	81–86	...
Copper Alloy UNS Nos. C65500					
O61	Annealed	52–58 [360–400]	70–82	...	0.110 max <sup>A</sup>
O50	Light anneal	55–64 [380–440]	76–93	...	0.055 max <sup>B</sup>
H01	Quarter-hard	60–74 [414–510]	...	65–80	...
H02	Half-hard <sup>B</sup>	72–86 [596–593]	...	79–91	...
H04	Hard <sup>B</sup>	85–99 [586–683]	...	88–96	...
H06	Extra-hard <sup>B</sup>	95–109 [655–752]	...	93–98	...
H08	Spring <sup>B</sup>	102–116 [703–800]	...	94–99	...
M20	As hot-rolled	55–72 [380–500]	72 min	...	...
M25	As hot-rolled and rerolled	58–72 [400–500]	...	60–80	...
Copper Alloy UNS No. C65400			Superficial 30T	B Scale	
O61	Annealed	65–80 [450–550]	...	...	0.040 <sup>B</sup> max
H01	Quarter hard <sup>B</sup>	75–90 [520–620]	64–77	72–91	...
H02	Half hard <sup>B</sup>	86–101 [590–700]	75–79	89–95	...
H03	Three-quarter hard <sup>B</sup>	97–112 [670–770]	77–81	94–97	...
H04	Hard <sup>B</sup>	108–120 [745–830]	80–81	96–98	...
H06	Extra hard <sup>B</sup>	116–126 [800–870]	81–82	97–100	...
H08	Spring <sup>B</sup>	124–133 [855–920]	81–82	99–101	...
H10	Extra spring <sup>B</sup>	131–140 [900–965]	81 min	100–102	...
H14	Super spring <sup>B</sup>	137 min [945 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.

**TABLE 3 Tensile Strength Requirements and Approximate Rockwell Hardness and Grain Size Values for Pressure Vessel Applications**

Temper Designation		Tensile Strength, ksi [MPa]	Yield Strength at 0.5 % Extension Under Load, ksi [MPa] min	Yield Strength <sup>A</sup> at 0.2 % offset, min, ksi [MPa]	Elongation, min % <sup>B</sup>	Approximate Rockwell F Hardness	Approximate Grain Size, mm
Standard	Former						
Copper Alloy UNS No. C65500							
O61	Annealed	50–67 [345–460]	18 [125]	18 [125]	40	70–82	0.110 max <sup>C</sup>

<sup>A</sup>See 4.2.5.

<sup>B</sup>Elongation in 2 in. [50 mm].

<sup>C</sup>No minimum grain size requirement is specified, but all annealed material shall be fully recrystallized.

9.5.3 *Sawed Metal*—Table 13.

9.6 *Edges*:

9.6.1 *Square Edges*—Table 14.

9.6.2 *Rounded Corners*—Table 15.

9.6.3 *Rounded Edges*—Table 16.

9.6.4 *Full-Rounded Edges*—Table 17.

9.7 *Weight, Hot-Rolled Sheet and Plate*—Table 18.

9.7.1 *ASME Pressure Vessel Code Applications*—Table 4 of this specification.

## 10. Workmanship, Finish and Appearance

10.1 For workmanship and appearance requirements, refer to either Specification B 248 or B 248M.

10.2 *Finish*—The material is supplied regularly in the following finishes:

10.2.1 *Black*—After hot rolling retains all of the oxides.

10.2.2 *Plain Pickled*—Sulfuric acid pickle only, brick red oxide; has cuprous and silicon oxides still adherent.

10.2.3 *Specially Cleaned*—Commercially free of all oxides; has the golden color of the alloy.

10.2.4 *Sand Blasted*—Commercially free of all oxides; has a dull gray color.

## 11. Test Methods

11.1 In the case of disagreement, the chemical composition shall be determined as follows:

Element	Test Method
Copper	E 478
Silicon	E 54; Perchloric acid dehydration
Manganese	E 62
Tin	E 478; Titrimetric
Chromium	E 118
Zinc	E 478; Atomic absorption
Iron	E 478
Nickel	E 478; Photometric
Lead	E 478; Atomic absorption

11.2 *Mechanical Properties (Tensile, Rockwell, and*

**TABLE 4 Lot Weight Tolerances in Percentage of Theoretical Weight for Pressure Vessel Applications—All Plus**

Thickness, in. [mm]	Permissible Excess in Average Weight of Lots, Expressed in Percentage of Normal Weight					
	48 in. [1200 mm] and Under in Width	Over 48 to 60 in. [1200 to 1500 mm] in Width	Over 60 to 72 in. [1500 to 1800 mm] in Width	Over 72 to 96 in. [1800 to 2500 mm] in Width	Over 96 to 120 in. [2500 to 3000 mm] in Width	Over 120 to 132 in. [3000 to 3500 mm] incl in Width
1/8 to 3/16, incl [3.0 to 5.0]	6.5	8	9	11	...	...
Over 3/16 to 1/4, incl [6.0 to 8.0]	6.5	8	9	11	12	...
Over 1/4 to 5/16, incl [8.0 to 10]	6.5	7.75	8.75	11	12	13
Over 5/16 to 3/8, incl [9.0 to 10]	6.25	7.5	8.5	11	12	13
Over 3/8 to 7/16, incl [10 to 12]	6	7.25	8.25	11	12	13
Over 7/16 to 1/2, incl [12 to 14]	6	7	8	10	11	12
Over 1/2 to 5/8, incl [14 to 16]	5.75	6.5	7.5	9	10	11
Over 5/8 to 3/4, incl [16 to 20]	5.5	6	7	8	9	10
Over 3/4 to 1, incl [20 to 25]	5	5	6.25	7	8	9
Over 1 to 2, incl [25 to 50]	3.5	4	5	6	7	8

*Grain*)—Refer to the appropriate test method in either Specification B 248 or B 248M.

copper-silicon alloy pressure vessels; copper-silicon alloy sheet; copper-silicon alloy strip; UNS C65100; UNS C65400; UNS C65500

## 12. Keywords

12.1 copper-silicon alloy bar; copper-silicon alloy plate;

## SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this specification since the last issue of B 96/B 96M - 99 that may impact the use of this specification.

(1) Paragraph 4.1 was reworded.

(2) The order of Sections 3 and 4 was reversed.

(3) The value under Approximate Grain Size in Table 3 was changed.

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