



Designation: B171/B171M-99<sup>ε2</sup> Designation: B 171/B 171M - 04<sup>ε1</sup>

# Standard Specification for Copper-Alloy Plate and Sheet for Pressure Vessels, Condensers, and Heat Exchangers<sup>1</sup>

This standard is issued under the fixed designation B 171/B 171M; 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.*

<sup>ε1</sup> NOTE—Tables 1 and 3 were editorially corrected in January 2001.

<sup>ε2</sup> NOTE—Table 2 was corrected editorially in May 2002.

—An editorial change was made to paragraph 1.1 in July 2004.

## 1. Scope\*

1.1 This specification<sup>2</sup> establishes the requirements for copper-alloy plate, sheet, and circles cut from plate and sheet for pressure vessels, condensers, and heat exchangers. The following alloys are covered:

Copper Alloy	Previously Used Designation
C36500	Leaded Muntz Metal
C44300	Admiralty, Arsenical
C44400	Admiralty, Antimonial
C44500	Admiralty, Phosphorized
C46400	Naval Brass, Uninhibited
C46500	Naval Brass, Arsenical
C61300	Aluminum Bronze
C61400	Aluminum Bronze D
C63000	10 % Aluminum-Nickel Bronze
C63200	9 % Aluminum-Nickel Bronze
C70600	90-10 Copper Nickel
C70620	90-10 Copper Nickel -(modified for welding)
C71500	70-30 Copper Nickel
C71520	70-30 Copper Nickel-(modified for welding)
C72200	...

1.2 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the 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 in the current issue of the ~~Annual~~ Book of ASTM Standards form a part of this specification to the extent referenced herein:

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

B 248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip and Rolled Bar

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

B 601 ~~Practice~~ Classification for Temper Designations for Copper and Copper Alloys-Wrought and Cast

B 846 Terminology For for Copper and Copper Alloys

E 8 Test Methods for Tension Testing of Metallic Materials

E 8M Test Methods for Tension Testing of Metallic Materials [Metric]

<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 B5.01 on Plate, Sheet and Strip.

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<sup>2</sup> This specification is under the jurisdiction of ASTM Committee B05 on Copper and Copper Alloys and is the direct responsibility of Subcommittee B5.01 on Plate, Sheet, and Strip.

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<sup>3</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-171 in Section II of that Code.

<sup>4</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*, Vol 02.01, 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.

- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specification
- 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)
- E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition
- E 478 Test Methods for Chemical Analysis of Copper Alloys
- E 527 Practice for Numbering Metals and Alloys (UNS)

### 3. Terminology

3.1 *Definitions*— For definitions of terms used in this specification, refer to Terminology B 846.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *plate, n*—a wrought flat product over 0.188-in. [5.00-mm] thick and over 12-in. [300-mm] wide, in lengths.

3.2.2 *sheet, n*—a rolled flat product up to and including 0.188 in. [5.00-mm] thick and over 24-in. [600-mm] wide, in flat lengths or coils (rolls).

### 4. Ordering Information

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

4.1.1 ASTM Specification B 171/B 171M, year of issue,

4.1.2 Whether inch-pound or SI units are applicable (see 1.2),

4.1.3 Copper [~~Alloy~~] Alloy UNS. No. (see Section 6, Table 1),

4.1.4 Whether the alloy ordered will be used in applications requiring it to be welded (see Table 1, ~~footnotes B and C~~), <sup>2</sup> footnotes B and C for UNS Nos. C61300 and C72200, respectively, and UNS Nos. C70620 and C71520 in place of UNS Nos. C70600 and C71500),

4.1.5 Whether plate is to be machined (see 9.1.3),

4.1.6 How tolerance is specified (Table 2 Footnote A),

4.1.7 Certification, if required (Section 17),

4.1.8 Weight (total for each size),

4.1.9 Mill test report, if required (Section 18),

4.1.10 Special marking, if required (Section 19), and

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

<sup>ε</sup> Withdrawn.

**TABLE 1 Chemical Requirements**

Copper Alloy UNS No. <sup>A</sup>	Composition, % max (Unless Shown as a Range)									
	Copper, incl Silver	Tin	Nickel, incl Cobalt	Manganese, max	Lead	Iron	Zinc	Aluminum	Chromium	Other Named Elements
C36500	58.0-61.0	0.250	...	...	0.25-0.7	0.15	remainder	...	...	...
C36500	58.0-61.0	0.25	...	...	0.25-0.7	0.15	remainder	...	...	...
C44300	70.0-73.0	0.8-1.2	...	...	0.07	0.06	remainder	...	...	0.02-0.06 As
C44400	70.0-73.0	0.8-1.2	...	...	0.07	0.06	remainder	...	...	0.02-0.10 Sb
C44500	70.0-73.0	0.8-1.2	...	...	0.07	0.06	remainder	...	...	0.02-0.10 P
C46400	59.0-62.0	0.5-1.0	...	...	0.20	0.10	remainder	...	...	...
C46500	59.0-62.0	0.5-1.0	...	...	0.20	0.10	remainder	...	...	0.02-0.06 As
C61300 <sup>B</sup>	remainder	0.20-0.50	0.15	0.20	0.01	2.0-3.0	0.10 <sup>C</sup>	6.0-7.5	...	0.10 Si 0.015 P
C61400	remainder	...	...	1.0	0.01	1.5-3.5	0.20	6.0-8.0	...	0.015 P
C63000	remainder	0.20	4.0-5.5	1.5	...	2.0-4.0	0.30	9.0-11.0	...	0.25 Si
C63200	remainder	...	4.0-4.8 <sup>D</sup>	1.2-2.0	0.02	3.5-4.3 <sup>D</sup>	...	8.7-9.5	...	0.10 Si
C70600	remainder	...	9.0-11.0	1.0	0.05 <sup>C</sup>	1.0-1.8	1.0 <sup>C</sup>	...	...	...
C70620	86.5 min	...	9.0-11.0	1.0	0.02	1.0-1.8	0.50	...	...	0.05 C 0.02 P 0.02 S
C71500	remainder	...	29.0-33.0	1.0	0.05 <sup>C</sup>	0.40-1.0	1.0 <sup>C</sup>	...	...	...
C71520	65.0 min	...	29.0-33.0	1.0	0.02	0.40-1.0	0.50	...	...	0.05 C 0.02 P 0.02 S
C72200	remainder	...	15.0-18.0	1.0	0.05 <sup>C</sup>	0.50-1.0	1.0 <sup>C</sup>	...	0.03-0.70	0.03 Si 0.03 Ti 0.03 C

<sup>A</sup> Designation established in accordance with Practice E 527.

<sup>B</sup> When the product is for subsequent welding applications, and is so specified by the purchaser, chromium shall be 0.05 % max, cadmium 0.05 % max, zirconium 0.05 % max and zinc 0.05 % max.

<sup>C</sup> When the product is for subsequent welding applications, and is so specified by the purchaser, zinc shall be 0.50 % max, lead 0.02 % max, phosphorus 0.02 % max, sulfur 0.02 % max, and carbon 0.05 % max.

<sup>D</sup> Iron content shall not exceed the nickel content.

**TABLE 2 Thickness Tolerances**

Thickness, in. [mm]	Thickness Tolerances, Plus and Minus, <sup>A,B</sup> in. [mm] for Diameters or Widths			
	36 in. [1000 mm] or Under, incl	Over 36 to 60 in. [1000 to 1500 mm], incl	Over 60 to 96 in. [1500 to 2500 mm], incl	Over 96 to 132 in. [2500 to 3500 mm], incl
Over 0.125 to 0.250 [3.0 to 6.0 mm], incl	0.010 [0.25]	0.012 [0.30]	0.022 [0.56]	0.028 [0.71]
Over 0.250 to 0.500 [6.0 to 12.0 mm], incl	0.025 [0.64]	0.027 [0.69]	0.029 [0.74]	0.031 [0.79]
Over 0.500 to 0.750 [12.0 to 19.0 mm], incl	0.028 [0.71]	0.030 [0.76]	0.032 [0.81]	0.035 [0.89]
Over 0.750 to 1.000 [19.0 to 25.0 mm], incl	0.033 [0.84]	0.035 [0.89]	0.037 [0.94]	0.040 [1.0]
Over 1.000 to 1.500 [25.0 to 38.0], incl	0.038 [0.97]	0.040 [1.0]	0.042 [1.1]	0.045 [1.1]
Over 1.500 to 1.750 [38.0 to 44.0 mm], incl	0.043 [1.1]	0.045 [1.1]	0.047 [1.2]	0.050 [1.3]
Over 1.750 to 2.000 [44.0 to 50.0 mm], incl	0.050 [1.3]	0.055 [1.4]	0.062 [1.6]	0.065 [1.7]
Over 2.000 to 5.000 [50.0 to 127 mm], incl	0.058 [1.5]	0.062 [1.6]	0.065 [1.7]	...

<sup>A</sup>When tolerances are specified as all plus or all minus, double the values given.

<sup>B</sup>See 9.1.2 for specific alloys with a difference tolerance.

4.1.11 Whether 0.2 yield offset strength is required.

## 5. Materials and Manufacture

5.1 *Material*—The material and manufacture shall be cast cake of the Copper Alloy UNS No. specified in the purchase order and shall be of such shape and soundness so as to be suitable for processing into the final product.

5.2 *Manufacture*— The product shall be manufactured by hot rolling or forging and finished by such cold working and annealing as may be necessary to achieve the required dimensions and properties.

## 6. Chemical Composition

6.1 The materials shall conform to the chemical compositional requirements specified in Table 1 for the copper alloy UNS designations specified in the ordering information.

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

6.3 For the alloys listed below, depending on analytical methodology, either copper or zinc, respectively, may be taken as the difference between the sum of all the elements analyzed and 100 %. When all the elements in Table 1 are analyzed their sum shall be as shown below:

Copper Alloy UNS No.	Copper Plus Named Elements, % min
C36500	99.6
C44300	99.6
C44400	99.6
C44500	99.6
C46400	99.6
C46500	99.6

6.3.1 For the alloys listed below, copper may be taken as the difference between the sum of all the elements and 100 %. When all of the elements in Table 1 are analyzed, their sum shall be as shown below:

Copper Alloy UNS No.	Copper Plus Named Elements, % min
C61300	99.8
C61400	99.5
C63000	99.5
C63200	99.5
C70600	99.5
C70620	99.5
C71520	99.5
C71500	99.5
C72200	99.8

## 7. Temper

7.1 Tempers available under this specification, and as described in Practice Classification B 601, are As Hot Rolled (M20) and Hot Rolled and Annealed (O25) as given in Table 3.

7.1.1 Products manufactured for *ASME Boiler and Pressure Vessel Code* applications must be certified to the O25 temper.

7.1.2 Products manufactured for other than *ASME Boiler and Pressure Vessel Code* applications may be produced in either the M20 or O25 temper.

## 8. Mechanical Property Requirements

8.1 The plates and sheet shall conform to the tensile property requirements as prescribed in Table 3.

## 9. Dimensions, Mass, and Permissible Variations

9.1 *Thickness*:



TABLE 3 Tensile Requirements—M20 and O25 Tempers

Copper Alloy UNS No.	Thickness, in. [mm]	Tensile Strength, min, ksi <sup>A</sup> [MPa]	Yield Strength, <sup>B</sup> min, ksi <sup>A</sup> [MPa]	Yield Strength <sup>C</sup> 0.2 % Offset, min, ksi <sup>A</sup> [MPa]	Elongation in 2 in. [50.0 mm], min, %
C36500	2 [50.0] and under	50 [345]	20 [140]	20 [140]	35 [35]
	over 2 to 3.5 [50.0 to 100.0], incl	45 [310]	15 [105]	15 [105]	35 [35]
	over 3.5 to 5 [100.0 to 140.0], incl	40 [275]	12 [85]	12 [85]	35 [35]
C44300, C44400, and C44500	4 [100.0] and under	45 [310]	15 [105]	15 [105]	35 [35]
C46400, C46500	3 [80.0] and under	50 [345]	20 [140]	20 [140]	35 [35]
	over 3 to 5 [80.0 to 140.0], incl	50 [345]	18 [125]	18 [125]	35 [35]
C61300	2 [50.0] and under	75 [520]	37 [255]	36 [250]	30 [30]
	over 2 to 3 [50.0 to 80.0], incl	70 [485]	30 [205]	28 [195]	35 [35]
	over 3 to 5 [80.0 to 140.0], incl	65 [450]	28 [195]	26 [180]	35 [35]
C61400	2 [50.0] and under	70 [485]	30 [205]	28 [195]	35 [35]
	over 2 to 5 [50.0 to 140.0], incl	65 [450]	28 [195]	26 [180]	35 [35]
C63000 and C63200	2 [50.0] and under	90 [620]	36 [250]	34 [235]	10 [10]
	over 2 to 3.5 [50.0 to 100.0], incl	85 [585]	33 [230]	31 [215]	10 [10]
	over 3.5 to 5.0 [100.0 to 140.0], incl	80 [550]	30 [205]	28 [195]	10 [10]
C70600 and C70620	2.5 [60.0] and under	40 [275]	15 [105]	15 [105]	30 [30]
	over 2.5 to 5 [60.0 to 140.0], incl	40 [275]	15 [105]	15 [105]	30 [30]
C71500 and C71520	2.5 [60.0] and under	50 [345]	20 [140]	20 [140]	30 [30]
	over 2.5 to 5 [60.0 to 140.0], incl	45 [310]	18 [125]	18 [125]	30 [30]
C72200	2.5 [60.0] and under	42 [290]	16 [110]	16 [110]	35 [35]

<sup>A</sup>ksi = 1000 psi.<sup>B</sup>Yield strength is determined as the stress producing an elongation of 0.5 % or under load, that is 0.01 in. [0.254 mm] in a gage length of 2 in. [50.0 mm].<sup>C</sup>See 4.1.9.

9.1.1 The thickness tolerances for plates of Copper Alloy UNS Nos. C36500, C44300, C44400, C44500, C46400, and C46500 shall be as prescribed in Table 2.

9.1.2 The thickness tolerances for plates of Copper Alloy UNS Nos. C61300, C61400, C63000, C63200, C71500, C70620, C71520, and C72200 shall be 25 % greater than those prescribed in Table 2.

9.1.3 If plates are machined, the thickness tolerances shall apply to the machined portion only.

9.1.4 Closer thickness tolerances than those prescribed in Table 2 can be furnished by surface machining. This is a special product and is subject to agreement between the manufacturer and the purchaser. This special product shall apply only when specified by the purchaser in the contract or order.

9.1.5 Unless otherwise agreed to by the manufacturer and the purchaser, the thickness of plate to this specification shall be determined by measuring along the length of the plate up to a distance of 7 in. [180 mm] from the edge.

9.2 *Diameters, Lengths, or Widths*—The diameters, lengths, or widths of plates shall be not less than those specified. The diameters, lengths, or widths of plates may exceed those specified by the amounts shown in Table 4.

NOTE 1—For the purpose of determining conformance with the dimensional requirements prescribed in this specification, any measured value outside the specified limiting values for any dimension may be cause for rejection.

9.3 *Flatness*—The flatness tolerances of individual plates shall not exceed those prescribed in Table 5. The tolerances shown are the total permissible variations for plates as ordered, and do not apply to the 7-in. [180-mm] marginal area at the edge of the plate. Inspection for flatness shall be made by placing the plate on a flat surfaced table with the side marked “Straight Side” up, applying a 72-in. [2-m] straightedge when the size permits, or a shorter one equal to the dimensions to be inspected, and measuring the depth of arc between the straightedge and the plate.

9.4 *Plate and Sheet Lot Weight for Pressure Vessels*—When plate or sheet of Copper Alloy UNS Nos. C70600, C70620, C71500, C71520, or C72200 are ordered for pressure vessels exclusively, the maximum lot weight restriction in Table 6 shall apply in addition to the thickness tolerance requirement of Table 2. The weight of each lot of five or more plates or sheets shall not exceed the nominal weight by more than the amount prescribed in Table 6. Plate and sheet of lots of less than five shall be governed solely by the thickness tolerances of Table 2. For purposes of calculating weights, the densities used shall be as listed in Table 7.

## 10. Workmanship, Finish and Appearance

10.1 The material shall be free of injurious defects and have a smooth clean surface, such as results from rolling operation, unless otherwise specified.

TABLE 4 Diameter, Length, or Width Tolerances

Diameter, Length, or Width in. [mm]	Permissible Excess in Diameter, Length, or Width, in. [mm]
36 [1000] or under	<sup>3</sup> / <sub>64</sub> [1.2]
Over 36 to 60 [1000 to 1500], incl	<sup>1</sup> / <sub>16</sub> [1.6]
Over 60 to 96 [1500 to 2500], incl	<sup>3</sup> / <sub>32</sub> [2.4]
Over 96 to 132 [2500 to 3500], incl	<sup>7</sup> / <sub>64</sub> [2.8]