



Designation: B171/B171M – 09a

# 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 B171/B171M; 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 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 Units—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated 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 standard.

## 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

<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.

Current edition approved Oct. 1, 2009. Published November 2009. Originally approved in 1942. Last previous edition approved in 2009 as B171/B171M – 09. DOI: 10.1520/B0171\_B0171M-09.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SB-171 in Section II 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.

- 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
- E8** Test Methods for Tension Testing of Metallic Materials
- E8M** Test Methods for Tension Testing of Metallic Materials [Metric]<sup>4</sup>
- E29** Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E54** Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>4</sup>
- E62** Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)
- E255** Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
- E478** Test Methods for Chemical Analysis of Copper Alloys
- E527** Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

## 3. Terminology

3.1 For definitions of terms related to copper and copper alloys, refer to Terminology **B846**.

## 4. Ordering Information

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

- 4.1.1 ASTM designation and year of issue,
- 4.1.2 Whether inch-pound or SI units are applicable (see 1.2),
- 4.1.3 Copper 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 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),

<sup>4</sup> Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

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

**TABLE 1 Chemical Requirements**

| Copper Alloy<br>UNS No. <sup>A</sup> | Composition, % max (Unless Shown as a Range) |           |                        |                   |                   |                      |                   |          |           |                            |
|--------------------------------------|--|-----------|------------------------|-------------------|-------------------|----------------------|-------------------|----------|-----------|----------------------------|
|                                      | Copper, incl<br>Silver                       | Tin       | Nickel, incl<br>Cobalt | Manganese,<br>max | Lead              | Iron                 | Zinc              | Aluminum | Chromium  | Other Named<br>Elements    |
| 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                                    | 0.50-1.0  | ...                    | ...               | 0.20              | 0.10                 | remainder         | ...      | ...       | ...                        |
| C46500                               | 59.0-62.0                                    | 0.50-1.0  | ...                    | ...               | 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<br>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<br>0.02 P<br>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<br>0.02 P<br>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<br>0.03 Ti<br>C    |

<sup>A</sup> Designation established in accordance with Practice E527.

<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,<br>incl  | Over 36 to 60 in. [1000 to 1500<br>mm], incl | Over 60 to 96 in. [1500 to 2500<br>mm], incl | Over 96 to 132 in. [2500<br>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.

- 4.1.7 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
- 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 |
|----------------------|-----------------------------------|

| 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 Classification **B601**, are As Hot Rolled (M20), Hot Rolled and Annealed (O25), Hot Forged and Annealed (O20), and As Hot Forged-Air Cooled (M10) as given in **Table 3**.

7.1.1 Products manufactured for *ASME Boiler and Pressure Vessel Code* applications must be certified to the O25 or O20 temper.

7.1.2 Products manufactured for other than *ASME Boiler and Pressure Vessel Code* applications may be produced in either the M20, M10, O20, or O25 temper.

## 8. Mechanical Property Requirements

### 8.1 Tensile Strength Requirements:

8.1.1 Product furnished under this specification shall conform to the tensile property requirements prescribed in **Table 3**, when tested in accordance with Test Method **E8 [E8M]**.

## 9. Dimensions, Mass, and Permissible Variations

### 9.1 Thickness:

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

**TABLE 3 Tensile Requirements—M20, M10, O20, and O25 Tempers**

| Copper Alloy UNS No.          | Thickness, in. [mm]                    | Tensile Strength, min, ksi <sup>A</sup><br>[MPa] | Yield Strength, <sup>B</sup> min, ksi <sup>A</sup><br>[MPa] | Yield Strength <sup>C</sup> 0.2 %<br>Offset, min, ksi <sup>A</sup> [MPa] | Elongation in 2 in.<br>[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]                                  |
| C44300, C44400, and<br>C44500 | over 3.5 to 5 [100.0 to 140.0], incl   | 40 [275]   | 12 [85]   | 12 [85]  | 35 [35]                                  |
|                               | 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]                                  |
| C61400                        | over 3 to 5 [80.0 to 140.0], incl      | 65 [450]   | 28 [195]  | 26 [180]   | 35 [35]                                  |
|                               | 2 [50.0] and under                     | 70 [485]   | 30 [205]  | 28 [195]   | 35 [35]                                  |
| C63000 and C63200             | over 2 to 5 [50.0 to 140.0], incl      | 65 [450]   | 28 [195]  | 26 [180]   | 35 [35]                                  |
|                               | 2 [50.0] and under                     | 90 [620]   | 36 [250]  | 34 [235]   | 10 [10]                                  |
| C70600 and C70620             | 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]                                  |
| C71500 and C71520             | 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]                                  |
| C72200                        | 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]                                  |
|                               | 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.