



# Standard Specification for Copper-Nickel-Silicon Alloy Rod and Bar<sup>1</sup>

This standard is issued under the fixed designation B 411/B 411M; 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-nickel-silicon alloy rod and bar produced from Copper Alloy UNS No. C64700 in straight lengths.

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>2</sup>

**B 193** Test Method for Resistivity of Electrical Conductor Materials

**B 249/B 249M** Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings

**B 601** Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

**B 846** Terminology 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>3</sup>

**E 54** Test Methods for Chemical Analysis of Special Brasses and Bronzes<sup>3</sup>

**E 478** Test Methods for Chemical Analysis of Copper Alloys

## 3. General Requirements

3.1 The following sections of Specification **B 249/B 249M** constitute a part of this specification:

<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 B05.02 on Rod, Bar, Wire, Shapes and Forgings.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Withdrawn. The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

- 3.1.1 Terminology,
- 3.1.2 Workmanship, Finish, and Appearance,
- 3.1.3 Sampling,
- 3.1.4 Number of Tests and Retests,
- 3.1.5 Specimen Preparation,
- 3.1.6 Test Methods,
- 3.1.7 Significance of Numerical Limits,
- 3.1.8 Inspection,
- 3.1.9 Rejection and Rehearing,
- 3.1.10 Certification,
- 3.1.11 Mill Test Report,
- 3.1.12 Packaging and Package Marking, and
- 3.1.13 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 Specification **B 249/B 249M**.

## 4. Terminology

4.1 For the definition of terms related to copper and copper alloys, refer to Terminology **B 846**.

## 5. Ordering Information

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

- 5.1.1 ASTM designation and year of issue (for example, B 411/B 411M – 06),
- 5.1.2 Copper alloy UNS No. designation,
- 5.1.3 Temper,
- 5.1.4 Product form (cross section such as round, hexagonal, square, and so forth),
- 5.1.5 Dimensions (diameter or distance between parallel surfaces, width, thickness),
- 5.1.6 Edge contours,
- 5.1.7 Length, nominal,
- 5.1.8 Quantity; total weight, length, or number of pieces for each form and size, and
- 5.1.9 When product is purchased for agencies of the U.S. government.

5.2 The following options are available and should be specified at the time of placing the order, when required:

- 5.2.1 Certification (Specification **B 249/B 249M**), and

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

5.2.2 Mill test report (Specification **B 249/B 249M**).

## 6. Material and Manufacture

6.1 *Material*—The material of manufacture shall be cast billets or ingots of Copper Alloy UNS No. C64700 of such soundness and structure that they are suitable for processing into the products prescribed herein.

6.2 *Manufacture*—The product shall be manufactured by hot extrusion or rolling and finished by such cold working, annealing, cooling, straightening, and heat treatment as may be necessary to achieve the required properties.

## 7. Chemical Composition

7.1 The material shall conform to the chemical composition requirements specified in **Table 1**.

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

7.2 Copper, given as the remainder, is the difference between the sum of results of all elements determined and 100 %.

7.3 When all elements specified in **Table 1** are determined, the sum of results shall be 99.5 % minimum.

## 8. Temper

8.1 The standard temper for product described in this specification is given in **Table 2**.

8.2 Tempers are as defined in Classification **B 601**.

8.3 Other tempers available when specified are:

8.3.1 TB00 (solution heat-treated).

8.3.2 TD00 (solution heat-treated and cold-worked 1/8 hard).

8.3.3 TD01 (solution heat-treated and cold-worked 1/4 hard).

8.3.4 TD02 (solution heat-treated and cold-worked 1/2 hard).

8.3.5 TD03 (solution heat-treated and cold-worked 3/4 hard).

8.3.6 TD04 (solution heat-treated and cold-worked hard).

## 9. Physical Property Requirements

9.1 *Electrical Resistivity Requirement*—The precipitation heat-treated product furnished shall conform to the electrical mass resistivity of 0.348 36 to 0.589 54  $\Omega \cdot \text{g}/\text{m}^2$  or conductivity of 44.0 to 26.0 % IACS at 68°F (20°C) when tested in accordance with Test Method **B 193**.

## 10. Mechanical Property Requirements

10.1 *Tensile Strength Requirements*:

10.1.1 Product furnished in the precipitation-hardened TF00 temper, as normally supplied, shall conform to the tensile requirements prescribed in **Table 2**, when tested in accordance with Test Methods **E 8** or **E 8M**.

10.1.2 Product furnished in TB00 (solution heat-treated) temper or TD00 through TD02 (solution heat-treated and cold-worked) inclusive, shall be capable of meeting the requirements specified in **Table 2** for each size and form after being given a suitable precipitation heat treatment and when tested in accordance with Test Methods **E 8** or **E 8M**.

NOTE 1—The purchaser should consult with the manufacturer for recommended precipitation heat treatment procedures.

10.1.3 The tensile requirements for as supplied rod and bar in sizes and tempers other than the standard, shall be as agreed between the supplier or manufacturer and the purchaser.

## 11. Performance Requirements

11.1 *Heat Treatment*—For purchaser's product acceptance only, the information shown in **Table 3** shall be considered suitable for precipitation heat treatment.

## 12. Other Requirements

12.1 *Purchases for the U.S. Government*—Product purchased for agencies of the U.S. government shall conform to the additional requirements prescribed in the Supplementary Requirements section of Specification **B 249/B 249M**.

## 13. Dimensions and Permissible Variations

13.1 The dimensions and tolerances for product described by this specification shall be as specified in Specification **B 249/B 249M** with particular reference to the following tables and related paragraphs:

13.1.1 *Diameter or Distance Between Parallel Surfaces*:

13.1.1.1 *Rod: Round, Hexagonal, Octagonal*—Refer to **Table 2**, Tolerances for Diameter of Cold-Drawn Rod.

13.1.1.2 *Bar: Rectangular and Square*—Refer to **Table 9**, Thickness Tolerances for Rectangular and Square Bar for thickness and **Table 11**, Width Tolerances for Rectangular Bar for width.

13.1.2 *Length*—Refer to **Table 13**, Length Tolerances for Rod, Bar, and Shapes for length tolerance and **Table 15**, Schedule of Lengths for schedule of lengths with ends.

13.1.3 *Straightness*—Refer to **Table 16**, Straightness Tolerances for Rod, Bar, and Shapes.

13.1.4 *Edge Contours*—Refer to the section entitled, "Edge Contours" and **Fig. 1**, **Fig. 2**, and **Fig. 3**.

## 14. Test Methods

14.1 *Chemical Analysis*:

14.1.1 In cases of disagreement, determine the composition, using the following methods:

| Element | ASTM Test Method              |
|---------|-------------------------------|
| Copper  | <b>E 478</b>                  |
| Iron    | <b>E 478</b>                  |
| Lead    | <b>E 478 (AA)</b>             |
| Nickel  | <b>E 478</b> (photometric)    |
| Silicon | <b>E 54</b> (perchloric acid) |
| Zinc    | <b>E 478 (AA)</b>             |

**TABLE 1 Chemical Requirements**

| Element             | Composition, % |
|---------------------|----------------|
| Nickel, incl cobalt | 1.6–2.2        |
| Silicon             | 0.40–0.8       |
| Lead, max           | 0.09           |
| Iron, max           | 0.10           |
| Zinc, max           | 0.50           |
| Copper, incl silver | remainder      |

**TABLE 2 Required Mechanical Properties for Material in the TF00 (Precipitation-Hardened (AT)) Condition**

| Form                    | Diameter or Distance Between Parallel Surfaces, <sup>A</sup> |  | Tensile Strength, min |     | Yield Strength at 0.5 % Extension Under Load, min |     | Elongation, <sup>B</sup> in 4D, min, % |
|-------------------------|--|--|-----------------------|-----|---|-----|--|
|                         | in.  | mm   | ksi                   | MPa | ksi   | MPa |  |
| Rod:                    |  |  |                       |     |   |     |  |
| Round                   | 3/32 to 1 1/2, incl  | 2.4 to 38, incl                            | 90                    | 620 | 75  | 515 | 8                                      |
|                         | Over 1 1/2 to 2, incl  | Over 38 to 50, incl                        | 80                    | 550 | 70  | 485 | 8                                      |
| Hexagonal and Octagonal | 1/8 to 1 1/2, incl   | 3 to 38, incl                              | 90                    | 620 | 75  | 515 | 8                                      |
|                         | Over 1 1/2 to 2, incl  | Over 38 to 50, incl                        | 80                    | 550 | 70  | 485 | 8                                      |
| Bar:                    |  |  |                       |     |   |     |  |
| Square                  | Over 0.188 to 1, incl  | 5 to 25, incl                              | 90                    | 620 | 75  | 515 | 8                                      |
|                         | Over 1 to 1 1/2, incl  | Over 25 to 38, incl                        | 80                    | 550 | 70  | 485 | 8                                      |
| Rectangular             | Over 0.188 to 1 1/2 thick and up to 2 1/2 wide, incl         | Over 5 to 38 thick and up to 65 wide, incl | 80                    | 550 | 70  | 485 | 8                                      |

<sup>A</sup> For rectangular bar the thickness dimension applies.

<sup>B</sup> Elongation in 4× diameter or thickness, but in any case, a minimum gage length of 1 in. (25 mm) shall be used.

**TABLE 3 Precipitation-Hardening Heat Treatment**

| Forms | Diameter or Distance Between Parallel Surfaces, <sup>A</sup> |                 | Temperature |     | Time at Temperature, min |
|-------|--|-----------------|-------------|-----|--------------------------|
|       | in.  | mm              | °F          | °C  |                          |
| All   | Under 0.050  | Under 1.3       | 800         | 427 | 90                       |
|       | 0.050 to 1.000, incl   | 1.3 to 25, incl | 850         | 454 | 90                       |
|       | Over 1.000   | Over 25         | 850         | 454 | 120                      |

<sup>A</sup> For rectangular bar, the thickness dimension applies.

## 15. Keywords

15.1 copper-nickel-silicon alloy bar; copper-nickel-silicon alloy rod; UNS C64700 bar; UNS C64700 rod

## SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B 411/B 411M – 06) that may impact the use of this standard. (Approved Oct. 1, 2008.)

(I) **Table 1**, Chemical Requirements, change the C64700 lead entry from .10 % max to .09 % max.

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