



# Standard Specification for Copper-Cobalt-Beryllium, Copper-Nickel-Beryllium, and Copper-Nickel-Lead-Beryllium Rod and Bar (UNS Nos. C17500, C17510, and C17465)<sup>1</sup>

This standard is issued under the fixed designation B 441; 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.*

## 1. Scope\*

1.1 This specification establishes the requirements for copper-cobalt-beryllium alloy (UNS No. C17500), copper-nickel-beryllium alloy (UNS No. C17510), and copper-nickel-lead-beryllium alloy (UNS No. C17465) rod and bar in straight lengths.

1.2 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.3 The following hazard statement pertains only to the test method portions 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 use.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- B 193 Test Method for Resistivity of Electrical Conductor Materials
- B 194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip and Rolled Bar
- 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 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
- E 1004 Practice for Determining Electrical Conductivity Using the Electromagnetic (Eddy-Current) Method

## 3. General Requirements

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

- 3.1.1 Terminology,
- 3.1.2 Materials and Manufacture,
- 3.1.3 Dimensions 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 Specimen Preparation,
- 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 Test Report,
- 3.1.14 Packaging and Package Marking, and
- 3.1.15 Supplementary Requirements.

3.2 In addition, when a section with a title identical to one of those referenced in 3.1 appears in this specification, it contains additional requirements that supplement those appearing in Specification B 249/B 249M.

## 4. Terminology

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

## 5. Ordering Information

5.1 Include the following information in orders for product:

- 5.1.1 ASTM designation and year of issue,
- 5.1.2 Copper alloy designation,
- 5.1.3 Temper (Section 7 and Table 1 and Table 2),
- 5.1.4 Form of product (cross section such as round, hexagonal, octagonal, rectangular, or square),

<sup>1</sup> This practice 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.

**TABLE 1 Tensile Strength and Rockwell Hardness Requirements for Rod and Bar<sup>A</sup>**

| Temper Designation                 |                                                 | As Supplied                                           |                            |                                     |
|------------------------------------|-------------------------------------------------|-------------------------------------------------------|----------------------------|-------------------------------------|
| Standard                           | Former                                          | Tensile Strength, ksi <sup>B</sup> (MPa) <sup>C</sup> | Rockwell Hardness, B Scale | Electrical Conductivity IACS min, % |
| TB00                               | solution heat-treated (A)                       | 35–55 (240–380)                                       | 50 max                     | 20                                  |
| TD04                               | solution heat-treated and cold-worked: hard (H) | 65–80 (450–550)                                       | 60–80                      | 20                                  |
| After Precipitation Heat Treatment |                                                 |                                                       |                            |                                     |
| TF00                               | precipitation hardened (AT)                     | 100–130 (690–895) <sup>D</sup>                        | 92–100                     | 45                                  |
| TH04                               | hard and precipitation heat-treated (HT)        | 110–140 (760–965) <sup>D</sup>                        | 95–102                     | 48                                  |

<sup>A</sup> These values apply to mill products. See Section 8 for exceptions in end products.

<sup>B</sup> ksi = 1000 psi.

<sup>C</sup> See Appendix.

<sup>D</sup> The upper limits in the tensile strength column are for design guidance only.

**TABLE 2 Precipitation Heat-Treatment Time for Acceptance Tests**

| Temper Designation |                                                 | Copper Alloy UNS No. C17500 At 900°F (482°C), h | Copper Alloy UNS No. C17510 At 850°F (454°C) <sup>A</sup> or 900°F (482°C) <sup>A</sup> , h |
|--------------------|-------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------|
| Standard           | Former                                          |                                                 |                                                                                             |
| TB00               | solution heat-treated (A)                       | 3                                               | 3                                                                                           |
| TD04               | solution heat-treated and cold-worked: hard (H) | 2                                               | 2                                                                                           |

<sup>A</sup> Specific temperature used must conform with supplier's certification.

**TABLE 3 Tensile Strength and Rockwell Hardness Requirements for Rod and Bar (C17465)<sup>A</sup>**

| Temper Designation |                                          | As Supplied                                           |                            |                                     |
|--------------------|------------------------------------------|-------------------------------------------------------|----------------------------|-------------------------------------|
| Standard           | Former                                   | Tensile Strength, ksi <sup>B</sup> (MPa) <sup>C</sup> | Rockwell Hardness, B Scale | Electrical Conductivity IACS min, % |
| TH04               | hard and precipitation heat-treated (HT) | 125–145 (860–1000) <sup>D</sup>                       | 95 min                     | 44                                  |

<sup>A</sup> These values apply to mill products. See Section 8 for exceptions in end products.

<sup>B</sup> ksi = 1000 psi.

<sup>C</sup> See Appendix.

<sup>D</sup> The upper limits in the tensile strength column are for design guidance only.

**TABLE 4 Chemical Composition**

| Element        | Concentration, %            |                             |                             |
|----------------|-----------------------------|-----------------------------|-----------------------------|
|                | Copper Alloy UNS No. C17500 | Copper Alloy UNS No. C17510 | Copper Alloy UNS No. C17465 |
| Beryllium      | 0.4–0.7                     | 0.2–0.6                     | 0.15–0.50                   |
| Cobalt         | 2.4–2.7                     | 0.3 max                     | ...                         |
| Nickel         | ...                         | 1.4–2.2                     | 1.0–1.4 <sup>A</sup>        |
| Iron, max      | 0.10                        | 0.10                        | 0.20                        |
| Aluminum, max  | 0.20                        | 0.20                        | 0.20                        |
| Silicon, max   | 0.20                        | 0.20                        | 0.20                        |
| Tin, max       | ...                         | ...                         | 0.25                        |
| Zirconium, max | ...                         | ...                         | 0.50                        |
| Lead           | ...                         | ...                         | 0.20–0.6                    |
| Copper         | remainder                   | remainder                   | remainder                   |

<sup>A</sup> Incl. Co.

5.1.5 Dimensions (diameter or distance between parallel surfaces),

5.1.6 Edge contours,

5.1.7 Length,

5.1.8 Quantity; total weight, footage or number of pieces for each form, temper, size, and copper alloy, and

5.1.9 When product is purchased for agencies of the U.S. government.

5.2 The following are options available under this specification and should be included in the contract or purchase order when required:

5.2.1 Heat identification or traceability details (Specification B 249/B 249M),

5.2.2 Tensile strength test (9.1),

5.2.3 Certification (Specification B 249/B 249M), and

5.2.4 Mill test report (Specification B 249/B 249M).

## 6. Chemical Composition

6.1 The material shall conform to the compositional limits given in Table 4 for the copper alloy designated in the ordering information.

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

6.2 Copper, listed as the “remainder” is the difference between the sum of results for all elements determined and 100 %.

6.3 When all elements specified in Table 4 for the copper alloy designated in the ordering information are determined, the sum of results shall be 99.5 % min.

## 7. Temper

7.1 Tempers, as described in Classification B 601, available under this specification are: TB00 (solution heat treated (A)), TF00 (precipitation hardened (AT)), TD04 (solution heat treated and cold worked: hard (H)), and TH04 (hard and precipitation heat treated (HT)).

NOTE 1—Although not produced under this specification, non-standard tempers are available by special order and the properties of such product are subject to negotiation between the manufacturer and the purchaser.



## **8. Physical Property Requirements**

### **8.1 Electrical Conductivity:**

8.1.1 Product furnished to this specification shall conform to the electrical conductivity requirement given in Table 1 for the applicable temper, when tested in accordance with Test Method E 1004 for product equal to and greater than  $\frac{3}{8}$  in. (9.52 mm) in nominal diameter or distance between parallel surfaces and other shapes having a nominal cross sectional area exceeding 0.141 in.<sup>2</sup> (91 mm<sup>2</sup>). On product less than  $\frac{3}{8}$  in. (9.5 mm) in nominal diameter or distance between parallel surfaces and other shapes having a nominal cross sectional area less than 0.141 in.<sup>2</sup> (91 mm<sup>2</sup>), resistivity will be measured in accordance with Test Method B 193 and converted to conductivity.

## **9. Mechanical Property Requirements**

9.1 Tensile test results shall be the product acceptance criteria, when tested in accordance with Test Methods E 8 for product equal to or less than  $\frac{3}{8}$  in. (9.5 mm) in nominal diameter or distance between parallel surfaces, and other shapes having a nominal cross sectional area equal to or less than 0.141 in.<sup>2</sup> (91 mm<sup>2</sup>).

9.1.1 Tensile strength requirements are given in Table 1.

9.2 Rockwell hardness is the product acceptance criteria, when tested in accordance with Test Methods E 18 for product larger than  $\frac{3}{8}$  in. (9.5 mm) in nominal diameter or distance between parallel surfaces, and other shapes having a nominal cross sectional area larger than 0.141 in.<sup>2</sup> (91 mm<sup>2</sup>).

9.2.1 The referee product rejection criteria shall be tensile test results, when tested in accordance with Test Methods E 18.

9.3 The tension test will be used for qualification of all material when specifically required by the purchaser, as in some government requirements.

## **10. Precipitation Heat-Treatment**

10.1 The precipitation heat-treatment is performed on TB00 (A) and TD04 (H) tempers by the purchaser after forming.

10.2 Conformance to the TF00 (AT) and TH04 (HT) specification limits shown in Table 1, for products supplied in the TB00 (A) or the TD04 (H) tempers, shall be determined by testing test specimens heat-treated at a uniform temperature of 850 to 900°F for the times shown in Table 2.

10.3 End products may be heat-treated at other times and temperatures for specific applications. These special combina-

tions of properties such as increased ductility, dimensional accuracy, and endurance strength may be obtained by special precipitation-hardening heat treatments. The mechanical requirements of Table 1 do not apply to such special heat treatment. Specific test requirements as needed shall be agreed upon between the manufacturer or the supplier and the purchaser of the end product.

10.4 TF00 (AT) and TH04 (HT) tempers as standard mill-hardened products have been precipitation heat-treated and tested by the manufacturer. An appropriate time and temperature has been used to produce properties within the specification limits shown in Table 1. Table 2 does not apply. Further thermal treatment of these tempers is not normally required.

10.5 Material may be supplied with nonstandard properties. Table 1 values would not apply. Specific test requirements as needed shall be agreed upon between the manufacturer or the supplier and the purchaser of these end products.

## **11. Number of Tests and Retests**

### **11.1 Retests:**

11.1.1 Refer to Specification B 249/B 249M with the following additional requirements:

11.1.2 Material that fails to conform to the requirements of this specification due to inadequate heat-treatment may be heat-treated subsequently and submitted for test. Only two such subsequent treatments shall be permitted.

## **12. Test Methods**

### **12.1 Chemical Analysis:**

12.1.1 The chemical composition shall be determined, in case of dispute, in accordance with the applicable method in the Annex of Specification B 194.

12.1.2 The test method(s) to be followed for the determination of element(s) resulting from contractual or purchase order agreement shall be as agreed upon between the supplier and the purchaser.

### **12.2 Mechanical Property Requirements:**

12.2.1 In case of dispute over Rockwell hardness test results, the rejection criteria shall be tensile test results, when tested in accordance with Test Methods E 8.

## **13. Keywords**

13.1 beryllium copper bar; beryllium copper rod; UNS C17500 bar; UNS C17500 rod; UNS C17510 bar; UNS C17510 rod; UNS C17465 bar; UNS C17465 rod



**SUMMARY OF CHANGES**

Committee B05 has identified the location of selected changes to this standard since the last issue (B 441 – 02) that may impact the use of this standard. (Approved May 1, 2004.)

(1) Added UNS Alloy No. C17465.

(2) Added Table 3.

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