



Designation: B441 – 22

Standard Specification for Copper-Cobalt-Beryllium Alloy, Copper-Nickel-Beryllium Alloy, Copper-Nickel-Lead-Beryllium Alloy, and Copper- Nickel-Cobalt Alloy Rod and Bar¹

This standard is issued under the fixed designation B441; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification establishes the requirements for Copper Alloy UNS Nos. C17500, C17510, C17540, and 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 safety hazard caveat pertains only to the test method(s) described in this specification.

1.3.1 *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, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards*:²

[B193 Test Method for Resistivity of Electrical Conductor Materials](#)

[B194 Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar](#)

¹ 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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² 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.

[B249/B249M Specification for General Requirements for Wrought Copper and Copper-Alloy Rod, Bar, Shapes and Forgings](#)

[B846 Terminology for Copper and Copper Alloys](#)

[E8/E8M Test Methods for Tension Testing of Metallic Materials](#)

[E18 Test Methods for Rockwell Hardness of Metallic Materials](#)

[E1004 Test Method for Determining Electrical Conductivity Using the Electromagnetic \(Eddy Current\) Method](#)

3. General Requirements

3.1 The following sections of Specification [B249/B249M](#) 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

3.1.15 Supplementary Requirements

3.2 In addition, when a section with a title identical to that referenced in 3.1, above, appears in this specification, it contains additional requirements that supplement those appearing in Specification [B249/B249M](#).

4. Terminology

4.1 For definition of terms related to copper and copper alloys, refer to Terminology [B846](#).

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

5. Ordering Information

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

- 5.1.1 ASTM designation and year of issue,
- 5.1.2 Copper Alloy UNS No. designation,
- 5.1.3 Temper (Section 7),
- 5.1.4 Form of product (cross section such as round, hexagonal, octagonal, rectangular, or square),
- 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, or total length, or number of pieces for each form, temper, size, and copper alloy,
- 5.1.9 Intended application.

5.2 The following options are available but may not be included unless specified at the time of placing of the order when required:

- 5.2.1 Heat identification or traceability details,
- 5.2.2 Tensile test (9.1),
- 5.2.3 Certification,
- 5.2.4 Test Report,
- 5.2.5 When product is purchased for agencies of the U.S. government, see the Supplementary Requirements section of **B249/B249M** for additional requirements, if specified.

6. Chemical Composition

6.1 The material shall conform to the chemical composition requirements in **Table 1** for the copper alloy UNS No. designation specified in the ordering information.

6.1.1 Results of analysis on a check sample shall conform to the composition requirements within the permitted analytical variance specified in **Table 1**.

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

6.2 For the alloys in which copper is listed as the “remainder,” copper is the difference between the sum of results of all elements determined and 100 %. When all elements specified in **Table 1** are determined, the sum of results shall be 99.5 % min.

TABLE 1 Chemical Requirements

Element	Composition, % Copper Alloy UNS No.			
	C17500	C17510	C17540	C17465
Beryllium	0.4–0.7	0.2–0.6	0.4–0.7	0.15–0.50
Cobalt	2.4–2.7	0.3 max	0.8–1.3	...
Nickel	...	1.4–2.2	0.8–1.3	1.0–1.4 ^A
Iron, max	0.10	0.10	0.2	0.20
Aluminum, max	0.20	0.20	...	0.20
Silicon, max	0.20	0.20	0.2	0.20
Tin, max	...	...	...	0.25
Zirconium, max	...	...	...	0.50
Lead	...	...	...	0.20–0.6
Copper	remainder	remainder	remainder	remainder

^A Incl. Co.

7. Temper

7.1 The standard tempers for products described in this specification are given in **Table 2** and **Table 3**.

8. Physical Property Requirements

8.1 Electrical Conductivity Requirement:

8.1.1 Electrical conductivity shall be the product accept/reject criterion when tested in accordance with Test Method **E1004** for product equal to or 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 equal to or exceeding 0.141 in.² (91 mm²).

8.1.2 The electrical conductivity requirements are given in **Table 2** and **Table 3**.

8.1.3 Electrical resistivity shall be the product acceptance criterion when tested in accordance with Test Method **B193** for product smaller 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.² (91 mm²).

8.1.4 The electrical resistivity shall be converted to electrical conductivity to determine compliance with the requirements given in **Table 2** and **Table 3**.

8.1.5 The referee product accept/reject criterion shall be subject to agreement between the manufacturer and purchaser.

9. Mechanical Property Requirements

9.1 Tensile Strength Requirements:

9.1.1 Tensile properties shall be the product accept/reject criteria when tested in accordance with Test Methods **E8/E8M** for product equal to or smaller 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.² (91 mm²).

9.1.2 Tensile strength requirements are given in **Table 2**.

9.2 Rockwell Hardness Requirements:

9.2.1 Rockwell hardness shall be the product accept/reject criterion when tested in accordance with Test Methods **E18** 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.² (91 mm²).

9.2.2 The referee product accept/reject criteria shall be tensile test results, when tested in accordance with Test Methods **E8/E8M**.

9.3 The tension test shall 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 2** and **Table 3** for products supplied in the TB00 (A) or the TD04 (H) tempers shall be determined by testing specimens heat-treated at a uniform temperature of 850 °F to 900 °F for the times shown in **Table 4**.

TABLE 2 Mechanical and Physical Property Requirements for Rod and Bar (C17500, C17510, and C17540)^A

Temper Designation		As Supplied		
Code	Name	Tensile Strength, ksi ^B (MPa ^C)	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 (690–900) ^D	92–100	45
TH04	Hard and Precipitation Heat-Treated (HT)	110–140 (760–970) ^D	95–102	48

^A These values apply to mill products. See Section 10 for exceptions in end products.

^B ksi = 1000 psi.

^C See Appendix.

^D The upper limits in the tensile strength column are for design guidance only.

TABLE 3 Mechanical and Physical Property Requirements for Rod and Bar (C17465)^A

Temper Designation		As Supplied		
Code	Name	Tensile Strength, ksi ^B (MPa ^C)	Rockwell Hardness, B Scale	Electrical Conductivity IACS min, %
TH04	Hard and Precipitation Heat-Treated (HT)	125–145 (860–1000) ^D	95 min	44

^A These values apply to mill products. See Section 10 for exceptions in end products.

^B ksi = 1000 psi.

^C See Appendix.

^D The upper limits in the tensile strength column are for design guidance only.

TABLE 4 Precipitation Heat-Treatment Time for Acceptance Tests

Temper Designation		Copper Alloy UNS No. C17500 at 900 °F (482 °C), h	Copper Alloy UNS Nos. C17510, C17540, and C17465 at 850 °F (454 °C) ^A or 900 °F (482 °C), ^A h
Standard	Former		
TB00	Solution Heat-Treated (A)	3	3
TD04	Solution Heat-Treated and Cold-Worked: Hard (H)	2	2

^A Specific temperature used must conform with supplier's certification.

10.3 End products may be heat-treated at other times and temperatures for specific applications. Special combinations 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 2** and **Table 3** 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 2** and **Table 3**. **Table 4** does not apply. Further thermal treatment of these tempers is not normally required.

11. Number of Tests and Retests

11.1 Retests:

11.1.1 Refer to Specification **B249/B249M** 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 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.

12.1.2 In cases of disagreement, test methods for chemical analysis shall be subject to agreement between the manufacturer and the purchaser. The Annex of Specification **B194** may be used subject to agreement.

12.2 Other Tests:

12.2.1 The product furnished shall conform to specified requirements when subjected to test in accordance with the following table:

Test	Method
Tensile Properties	E8/E8M
Hardness	E18
Electrical Resistivity	B193
Electrical Conductivity	E1004

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