



Designation: B694 – 03

Standard Specification for Copper, Copper-Alloy, Copper-Clad Bronze (CCB), Copper- Clad Stainless Steel (CCS), and Copper-Clad Alloy Steel (CAS) Sheet and Strip for Electrical Cable Shielding¹

This standard is issued under the fixed designation B694; 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.

1. Scope*

1.1 This specification establishes the requirements of copper, copper alloy, copper-clad bronze (CCB), copper-clad stainless steel (CCS), and copper-clad alloy steel (CAS) materials, sheet, and strip, in various thicknesses, for use as electrostatic or electromagnetic shielding for insulated power, control, instrumentation, and communication cables.

NOTE 1—See Specification B736, for related standards for aluminum-based shielding materials.

1.2 The products covered are the following:

Copper or Copper Alloy UNS No.	Type of Products
C11000	copper
C19400	copper-iron alloy
C22000	copper-zinc alloy (commercial bronze)
C23000	copper-zinc alloy (red brass)
C66400	copper-zinc-iron-cobalt alloy
C66410	copper-zinc-iron alloy
C66430	copper-zinc-iron-tin alloy
C71000	cupro-nickel 20 %
...	copper-clad bronze (CCB)
...	copper-clad stainless steel (CCS)
...	copper-clad alloy steel (CAS)

1.3 The values stated in inch-pound units are the standard, except for temperature and grain size which are given in SI units. Values in parentheses are for information only.

1.4 *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.*

¹ 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, 2003. Published November 2003. Originally approved in 1981. Last previous edition approved in 2002 as B694 – 02. DOI: 10.1520/B0694-03.

2. Referenced Documents

2.1 ASTM Standards:²

- A176 Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
 - A505 Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
 - B152/B152M Specification for Copper Sheet, Strip, Plate, and Rolled Bar
 - B248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar
 - B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast
 - B736 Specification for Aluminum, Aluminum Alloy and Aluminum-Clad Steel Cable Shielding Stock
 - B846 Terminology for Copper and Copper Alloys
 - E3 Guide for Preparation of Metallographic Specimens
 - E8 Test Methods for Tension Testing of Metallic Materials
 - E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes³
 - E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)³
 - E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys³
 - E112 Test Methods for Determining Average Grain Size
 - E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
 - E478 Test Methods for Chemical Analysis of Copper Alloys
- ### 2.2 International Standards Organization (ISO) Standards:
- ISO 3110/2 Determination of Aluminum; Flame Atomic

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.

³ 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.



Absorption Spectrometric Method (TC/26 Ref. No. N698 E/F)⁴

3. General Requirements

3.1 The following sections of Specification **B248** constitute a part of this specification:

- 3.1.1 Terminology—Definitions,
- 3.1.2 Materials and Manufacturing,
- 3.1.3 Workmanship, Finish, and Appearance,
- 3.1.4 Sampling—except for chemical analysis,
- 3.1.5 Number of Tests and Retests,
- 3.1.6 Specimen Preparation,
- 3.1.7 Test Methods—except for chemical analysis,
- 3.1.8 Significance of Numerical Limits,
- 3.1.9 Inspection,
- 3.1.10 Rejection and Rehearing,
- 3.1.11 Certification,
- 3.1.12 Test Reports (Mill),
- 3.1.13 Packaging and Package Marking, and
- 3.1.14 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 **B248**.

4. Terminology

4.1 For definitions of terms relating to copper and copper alloys, refer to Terminology **B846**.

4.1.1 *cladding ratio, n*—ratio by percent thickness of the component layers, for example, 16/68/16.

5. Ordering Information

5.1 Orders for material should include the following information:

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

- 5.1.1 ASTM designation and year of issue,
- 5.1.2 Quantity: total for each item, pounds (or kilograms),
- 5.1.3 Name of material: cable shielding (or “cable wrap”),
- 5.1.4 Form of material: strip,
- 5.1.5 Type of material: copper, copper-zinc alloy (commercial bronze), and so forth (see **1.2**),
- 5.1.6 Alloy number when appropriate (see **1.2**),
- 5.1.7 Temper (see Section **8**),
- 5.1.8 Dimensions: thickness and width (see Section **11**),
- 5.1.9 How furnished: coils (rolls), traverse wound on reels or spools, and so forth,
- 5.1.10 Whether the resistivity test is required for any item (Section **10**),
- 5.1.11 Coil dimension: inner or outer coil diameter limitation, or both, if required,
- 5.1.12 Weight of coils: coil weights or coil size limitations, if required,
- 5.1.13 Cladding ratio when appropriate (see **7.5.4**),
- 5.1.14 Certification, if required, (see Section **18**),
- 5.1.15 Mill test report, if required,
- 5.1.16 Specification designation and year of issue, and
- 5.1.17 Special tests or exceptions, if any.

6. Materials and Manufacture

6.1 *Material*—The material shall be of such quality that it conforms to the properties and characteristics prescribed in the specification.

6.2 *Manufacture*—Cladding metals as appropriate may be bonded to the specified base metal by any method that will produce a clad material that will conform to this specification.

7. Chemical Composition

7.1 Homogeneous copper and copper-alloy materials shall conform to the requirements prescribed in **Table 1** for the particular material.

7.2 Copper cladding shall be, unless otherwise specified, a copper conforming in chemical composition to that covered by

TABLE 1 Chemical Requirements

Element	Composition, %								
	Copper or Copper Alloy UNS No.								
	C11000	C19400	C22000	C23000	C66400	C66410	C66430	C71000	C64785 core of Copper-Clad Bronze
Copper (incl silver)	99.90 min	97.0 min	89.00–91.0	84.0–86.0	remainder	remainder	remainder	remainder	remainder
Iron	...	2.1–2.6	0.05 max	0.05 max	1.3–1.7	1.8–2.3	0.6–0.9	1.0 max	0.02 max
Lead, max	...	0.03	0.05	0.05	0.015	0.015	0.05	0.05	0.015
Tin	...	...	...	...	0.05 max	0.05 max	0.6–0.9	...	0.5–2.0
Zinc	...	0.05–0.20	remainder	remainder	11.0–12.0	11.0–12.0	13.0–15.0	1.0 max	3.0–6.0
Nickel (incl cobalt)	...	...	...	...	...	...	...	19.0–23.0	0.4–1.6
Manganese	...	...	...	...	...	...	...	1.0 max	0.2–1.0
Phosphorus	...	0.015–0.15	...	...	...	...	0.10 max	...	0.015 max
Cobalt	...	...	...	...	0.30–0.7	...	...	...	...
Iron and cobalt	...	...	...	...	1.8–2.3	...	...	...	...
Silicon	...	...	...	...	...	...	...	...	0.15 max
Aluminum	...	...	...	...	...	...	...	...	3.0–6.0

Specification **B152/B152M**. The grade provided shall be one of the following coppers, such that the final strip meets the conductivity and mechanical properties of this specification. These are:

C10920
C11000
C11020
C12000

7.3 These specification limits do not preclude the possible presence of other unnamed elements. Limits may be established and determination required for unnamed elements by agreement between the manufacturer and the purchaser.

7.4 Except for copper C11000, copper may be taken as the difference between all the elements analyzed and 100 %.

7.4.1 *Alloys C19400, C22000, and C23000*—When all elements specified in **Table 1** are determined, the sum of the results shall be 99.8 % min.

7.4.2 *Alloys C66400, C66410, C66430, C64785, and C71000*—When all elements specified in **Table 1** are determined, the sum of the results shall be 99.5 % min.

7.5 *Clad Metal:*

7.5.1 For stainless steel clad cores, the stainless steel shall conform in chemical composition to one covered by Specification **A176**. Unless otherwise specified, stainless steel in accordance with UNS No. S43000 (Type 430) shall be supplied.

7.5.2 For alloy steel clad cores, the steel shall conform in chemical composition to one covered by Specification **A505**. Unless otherwise specified, alloy steel UNS No. G41300 shall be supplied.

7.5.3 For bronze clad cores, the bronze shall conform in chemical composition to the requirements of UNS No. C64785 listed in **Table 1**.

7.5.4 Unless otherwise stated (see **5.1.13**), the cladding ratio shall be one of the standard ratios listed in **Table 2** and **Table 3**, and shall be expressed as XX/XX/XX, copper/bronze/copper, copper/stainless steel/copper, or copper/alloy steel/copper as appropriate.

8. Temper

8.1 As described in Classification **B601**, tempers furnished to this specification shall be:

- 8.1.1 Copper C11000—H00, H01, H02, and O61.
- 8.1.2 Copper alloy C19400—H02, O61, and O50.
- 8.1.3 Copper alloy C22000—H01, H02, and O81.
- 8.1.4 Copper alloy C23000—H01, H02, and O81.
- 8.1.5 Copper alloy C66400, C66410, and C66430—O60.
- 8.1.6 Copper alloy C71000—H01, H02, OS035, and OS015.
- 8.1.7 Copper-Clad Steel—O61.
- 8.1.8 Copper-Clad Bronze—O61 and O81.

9. Mechanical Property Requirements

9.1 *Grain Size:*

9.1.1 There are no minimum or maximum grain size requirements for product in annealed tempers O50, O61, and O81; however, the metal shall be fully recrystallized.

9.1.2 When tested in accordance with Test Methods **E112**, copper alloy UNS No. C71000 in annealed tempers OS035 and OS015 shall conform to the grain size requirements prescribed in **Table 2**.

9.2 *Hardness:*

9.2.1 *Rockwell Hardness*—The hardness test is a quick and convenient method for estimating tensile strength and grain size. Approximate hardness values are given in **Table 2**. For copper-clad materials, copper is etched off with a suitable reagent before testing the steel. This test is not required and shall not be used as a basis of rejection.

9.3 *Tensile Strength*—The finished product shall conform to the requirements prescribed in **Table 2** for the particular material and temper.

10. Physical Property Requirements

10.1 Annealed material shall conform to the requirements of **Table 4**.

11. Dimensions, Mass, and Permissible Variations

11.1 *General*—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.

11.2 *Thickness*—The standard method of specifying thickness shall be in decimal fractions of an inch. For material 0.021 in. (0.53 mm) and under in thickness, it is recommended that the nominal thickness be stated not closer than the nearest half-thousandth. (For example, specify 0.006 or 0.0065 in. (0.15 or 0.165 mm), but not 0.0063 in. (0.160 mm).) A list of preferred thicknesses is shown in **Appendix X2**. The thickness tolerance shall be those shown in **Table 5** and **Table 6**.

11.3 *Width*—The width tolerances shall be those required by Specification **B248**, unless otherwise stated in the purchase order.

11.4 *Straightness*—The straightness tolerances shall be those required by Specification **B248**, unless otherwise stated in the purchase order.

11.5 *Cladding Ratio*—Cladding ratios shall be within ± 10 % of nominal; test method shall be metallurgical micro-section of at least three samples per lot.

12. Workmanship, Finish, and Appearance

12.1 All material shall be uniform in quality and condition, sound and free of internal and external defects of a nature that interferes with normal fabrication or the performance of the cable shielding. It shall be well cleaned and free of dirt. A superficial film of residual light lubricant is permissible, unless otherwise specified.

12.2 Copper-clad material shall be free of defects including unbond or delamination of a nature that interferes with normal commercial operations.

13. Sampling

13.1 *Chemical Composition for Copper and Copper Alloys:*

13.1.1 Instead of sampling in accordance with Practice **E255**, the manufacturer shall have the option of sampling at the time castings are poured or from the semifinished or finished product.