



Designation: B 694 – 02

Standard Specification for Copper, Copper-Alloy, and 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 B 694; 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 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 B 736, 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 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.*

2. Referenced Documents

2.1 ASTM Standards:

A 176 Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip²

A 505 Specification for Steel, Sheet and Strip, Alloy, Hot-Rolled and Cold-Rolled, General Requirements for²

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.

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² *Annual Book of ASTM Standards*, Vol 01.03.

B 152/B 152M Specification for Copper Sheet, Strip, Plate, and Rolled Bar³

B 248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar³

B 601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast³

B 736 Specification for Aluminum, Aluminum Alloy, and Aluminum-Clad Steel Cable Shielding Stock⁴

B 846 Terminology for Copper and Copper Alloys³

E 3 Guide for Preparation of Metallographic Specimens⁵

E 8 Test Methods for Tension Testing of Metallic Materials⁵

E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes⁶

E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods)⁷

E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys⁷

E 112 Test Methods for Determining Average Grain Size⁵

E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁷

E 478 Test Methods for Chemical Analysis of Copper Alloys⁷

2.2 *International Standards Organization (ISO) Standards:*
ISO 3110/2 Determination of Aluminum; Flame Atomic Absorption Spectrometric Method (TC/26 Ref. No. N698 E/F)⁸

3. General Requirements

3.1 The following sections of Specification B 248 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 *Annual Book of ASTM Standards*, Vol 02.01.

⁴ *Annual Book of ASTM Standards*, Vol 02.02.

⁵ *Annual Book of ASTM Standards*, Vol 03.01.

⁶ *Annual Book of ASTM Standards*, Vol 03.05.

⁷ *Annual Book of ASTM Standards*, Vol 03.06.

⁸ Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

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



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- 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 B 248.

4. Terminology

4.1 For definitions of terms relating to copper and copper alloys, refer to Terminology B 846.

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:

- 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 7.5.3),
- 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 Specification B 152/B 152M. 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, 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 A 176. Unless otherwise specified, stainless steel in

TABLE 1 Chemical Requirements

Element	Composition, %							
	Copper or Copper Alloy UNS No.							
	C11000	C19400	C22000	C23000	C66400	C66410	C66430	C71000
Copper (incl silver)	99.90 min	97.0 min	89.00–91.0	84.0–86.0	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
Lead, max	...	0.03	0.05	0.05	0.015	0.015	0.05	0.05
Tin	...	...	...	...	0.05 max	0.05 max	0.6–0.9	...
Zinc	...	0.05–0.20	remainder	remainder	11.0–12.0	11.0–12.0	13.0–15.0	1.0 max
Nickel (incl cobalt)	...	...	...	...	...	...	...	19.0–23.0
Manganese	...	...	...	...	...	...	...	1.0 max
Phosphorus	...	0.015–0.15	...	...	...	...	0.10 max	...
Cobalt	...	...	...	...	0.30–0.7	...	...	...
Iron and cobalt	...	...	...	...	1.8–2.3	...	...	...



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 A 505. Unless otherwise specified, alloy steel UNS No. G41300 shall be supplied.

7.5.3 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/stainless steel/copper, or copper/alloy steel/copper as appropriate.

8. Temper

8.1 As described in Classification B 601, 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.

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 E 112, 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.

TABLE 2 Tensile Strength Requirements and Approximate Hardness Values for Shielding Materials in Commonly Ordered Tempers

Description		Temper Designation		Tensile Strength, ksi ^A (Mpa ^B)		Approximate Rockwell Hardness ^C	
Copper or Copper Alloy UNS No.	Type of Material	Standard	Former	Min	Max	Other Scales Thicknesses >0.020 in.	Superficial 30T Thicknesses >0.012 in.
C11000	Copper	H00	<i>Cold-Rolled Tempers:</i> eighth hard	32 (220)	40 (275)	F 54–82	up to 49
		H01	quarter hard	34 (235)	42 (290)	F 60–84	18–51
		H02	half hard	37 (255)	46 (315)	F 77–89	43–57
		O61	<i>Annealed Tempers:</i> annealed	...	34 (235)	...	...
C19400	Copper-iron alloy	O61	<i>Annealed Tempers:</i> annealed ^D	45 (310)	55 (380)	...	...
		O50	light annealed ^D	50 (345)	60 (415)	...	...
		H02	<i>Cold-Rolled Tempers:</i> half hard	53 (365)	63 (435)	B 49–69	52–63
C22000	Commercial bronze	H01	<i>Cold-Rolled Tempers:</i> quarter hard	40 (275)	50 (345)	B 27–52	38–53
		H02	half hard	47 (325)	57 (395)	B 50–63	52–61
		O81	<i>Annealed Tempers:</i> quarter hard	39 (270)	46 (315)	...	...
C23000	Red brass	H01	<i>Cold-Rolled Tempers:</i> quarter hard	44 (305)	54 (375)	B 33–58	45–60
		H02	half hard	51 (350)	61 (420)	B 56–68	58–66
		O81	<i>Annealed Tempers:</i> quarter hard	44 (305)	54 (375)	...	...
C66400	Copper-zinc-iron-cobalt alloy	O60	<i>Annealed Tempers:</i> soft ^D	53 (365)	60 (415)	...	...
C66410	Copper-zinc-iron alloy	O60	soft ^D	53 (365)	60 (415)	...	...
C66430	Copper-zinc-iron-tin alloy	O60	soft ^D	59 (405)	69 (475)	...	59–69
C71000	Cupro-nickel 20 %	H01	<i>Cold-Rolled Tempers:</i> quarter hard	47 (325)	63 (435)	B 45–72	46–65
		H02	half hard	56 (385)	70 (485)	B 64–78	59–69
		OS035	<i>Annealed Tempers:</i> 0.025–0.050 mm	52 (355)	...	B 18–35	28–40
		OS015	0.010–0.020 mm	53 (365)	...	B 35–88	40–58
Copper-Clad Stainless (CCS) and Copper-Clad Alloy Steel (CAS)							
Cladding Ratio	Total Thickness						
	in. (mm)	Annealed Tempers					
16/68/16	0.005 (0.13)	O61	annealed ^D	55 (380)	68 (470)	15T 89 max	...
33.3/33.3/33.3	0.006 (0.15)	O61	annealed ^D	44 (305)		15T 89 max	...

^A ksi = 1000 psi.

^B See Appendix X3.

^C Rockwell values normally apply as follows: The B and F scales apply to metal 0.020 to 0.036 in. (0.5 to 0.91 mm) in thickness. The Superficial 30-T scale applies to metal 0.012 to 0.028 in. (0.30 to 0.71 mm) in thickness.

^D There is no grain size requirement but all annealed metal shall be fully recrystallized.