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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 for 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 *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 that are provided for information only and are not considered standard.

1.3.1 The only exception is grain size, which is reported in SI (mm) units.

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

1.5 *This international standard was developed in accordance with internationally recognized principles on standard-*

ization 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

A176 Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip (Withdrawn 2015)³

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

B193 Test Method for Resistivity of Electrical Conductor Materials

B248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar

B248M Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar (Metric)

B736 Specification for Aluminum, Aluminum Alloy and Aluminum-Clad Steel Cable Shielding Stock (Withdrawn 2015)³

B846 Terminology for Copper and Copper Alloys

E3 Guide for Preparation of Metallographic Specimens

E8/E8M Test Methods for Tension Testing of Metallic Materials

E54 Test Methods for Chemical Analysis of Special Brasses and Bronzes (Withdrawn 2002)³

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)³

E75 Test Methods for Chemical Analysis of Copper-Nickel and Copper-Nickel-Zinc Alloys (Withdrawn 2010)³

E112 Test Methods for Determining Average Grain Size

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 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 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

E255 Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition
E478 Test Methods for Chemical Analysis of Copper Alloys

5.1.4 Dimensions: thickness and width (Section 12),
 5.1.5 How furnished: coils, traverse wound on reels or spools,
 5.1.6 Quantity—total weight of each item,
 5.1.7 Name of material: cable shielding or cable wrap, and
 5.1.8 Type of product: (or abbreviation, in the case of clad materials) as listed in 1.2.

3. General Requirements

3.1 The following sections of Specification B248 or B248M constitute a part of this specification:

- 3.1.1 Terminology;
- 3.1.2 Materials and Manufacture;
- 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 Reheating;
- 3.1.11 Certification;
- 3.1.12 Test Report;
- 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 above, appears in this specification, it contains additional requirements which supplement those appearing in Specification B248 or B248M.

4. Terminology

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

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. (or other internationally recognized copper [alloy]) designation (see 1.2),
- 5.1.3 Temper (Section 8),

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 Electrical resistivity test;
- 5.2.2 Coil dimension: inner or outer coil diameter limitation, or both;
- 5.2.3 Weight of coils: coil weights or coil size limitations;
- 5.2.4 Cladding ratio (see 7.6.4);
- 5.2.5 Certification;
- 5.2.6 Mill Test Report; and
- 5.2.7 Special tests or exceptions.

6. Materials and Manufacture

6.1 Materials:

6.1.1 The material of manufacture shall be a form (cast bar, cake, slab, etc.) of the specified copper alloy UNS No. [or other designation] of such purity and soundness as to be suitable for processing into the products prescribed herein.

6.2 Manufacture:

6.2.1 The product shall be manufactured by such hot working, cold working, and annealing processes as to produce a uniform wrought structure in the finished product.

6.2.2 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 The material shall conform to the chemical composition requirements in Table 1 for the copper [alloy] UNS No. [or other designation] specified in the ordering information.

TABLE 1 Chemical Requirements

Element	Composition, %								
	Copper Alloy UNS No. (or other designation)								
	C11000	C19400	C22000	C23000	C66400	C66410	C66430	C71000	C64785 core of Copper-Clad Bronze
Copper	99.90 min ^A	97.0 min	89.0–91.0	84.0–86.0	Remainder ^A	Remainder ^A	Remainder ^A	Remainder ^A	Remainder ^A
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	...	0.50–2.0
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	19.0–23.0 ^B	0.40–1.6 ^B
Manganese	1.0 max	0.20–1.0
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

^A Copper value includes silver.

^B Nickel value includes cobalt.

7.2 Copper cladding shall be, unless otherwise specified, a copper conforming in chemical composition to that covered by 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 composition limits do not preclude the presence of other elements. By agreement between the manufacturer and purchaser, limits may be established and analysis required for unnamed elements.

7.4 For alloys in which copper is listed as “remainder,” copper is the difference between the sum of results of all elements determined and 100 %. When all elements in **Table 1** are determined, the sum of results shall be as shown in the following table:

Copper Alloy UNS No.	Copper Plus Named Elements, % min
C19400	99.8
C22000	99.8
C23000	99.8
C66400	99.5
C66410	99.5
C66430	99.5
C64785	99.5
C71000	99.5

7.5 For alloys in which zinc is listed as “remainder,” either copper or zinc may be taken as the difference between the sum of results of all other elements determined and 100 %. When all elements in **Table 1** are determined, the sum of results shall be as shown in the above table.

7.6 Clad Metal:

7.6.1 For stainless steel clad cores, the stainless steel shall conform in chemical composition to one established by Specification **A176**. If not specified on the purchase order, stainless steel in accordance with UNS No. S43000 (Type 430) shall be supplied as the core material.

7.6.2 For alloy steel clad cores, the steel shall conform in chemical composition to an alloy steel established by Specification **A505**. If not specified on the purchase order, alloy steel UNS No. G41300 shall be supplied as the core material.

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

7.6.4 Unless otherwise stated (see **5.2.4**), the cladding ratio shall be one of the standard ratios listed in **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 The standard tempers for products described in this specification are given in **Table 2**.

8.1.1 Cold rolled tempers H00, H01, and H02.

8.1.2 Annealed tempers O50, O60, O61, OS015, and OS035.

8.1.3 Annealed-to-temper O81.

9. Grain Size for Annealed Tempers

9.1 There are no minimum or maximum grain size requirements for product in annealed tempers O50, O60, O61, and O81; however, the metal shall be fully recrystallized.

9.2 For copper alloy UNS No. C71000 in annealed tempers OS015 and OS035, acceptance or rejection based upon grain size shall depend only on the average grain size of a test specimen taken from each of two sample portions, and each specimen shall be within the limits prescribed in **Table 2** when determined in accordance with Test Methods **E112**.

10. Physical Property Requirements

10.1 Electrical Conductivity Requirement:

10.2 The annealed product furnished shall conform to the electrical conductivity requirement prescribed in **Table 3** and **Table 4**.

10.3 The electrical resistivity of the material shall be determined in accordance with Test Method **B193**; the conductivity shall be calculated in accordance with Explanatory Notes 3 and 4 of Test Method **B193**.

11. Mechanical Property Requirements

11.1 Tensile Strength Requirements:

11.1.1 Product furnished under this specification shall conform to the tensile requirements prescribed in **Table 2**, when tested in accordance with Test Methods **E8/E8M**.

11.1.2 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength.

11.2 Rockwell Hardness Requirement:

11.2.1 The approximate Rockwell hardness values given in **Table 2** are for general information and assistance in testing, and shall not be used as a basis for product rejection.

NOTE 2—The Rockwell hardness test offers a quick and convenient method of checking for general conformity to the specification requirements for temper, tensile strength, and grain size. For copper-clad materials, copper is etched off with a suitable reagent before testing the steel.

12. Dimensions, Mass, and Permissible Variation

12.1 *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.

12.2 *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**.

12.3 *Width*—The width tolerances shall be those required by Specification **B248** or **B248M**, unless otherwise stated in the purchase order.

TABLE 2 Tensile Strength Requirements and Approximate Hardness Values

Description		Temper Designation		Tensile Strength, ksi ^A (MPa ^B)		Approximate Rockwell Hardness ^C			
Copper Alloy UNS No. (or other designation)	Type of Material	Code	Name	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)	F54–82	up to 49		
			quarter hard	34 (235)	42 (290)	F60–84	18–51		
		H02	half hard	37 (255)	46 (315)	F77–89	43–57		
			<i>Annealed-Tempers:</i>						
			annealed	...	34 (235)	...	...
C19400	Copper-iron alloy	O61	<i>Annealed-Tempers:</i>						
		annealed ^D	45 (310)	55 (380)	...	...	
		O50	light anneal ^D	50 (345)	60 (415)	...	...
		H02	<i>Cold Rolled Tempers:</i>						
C22000	Commercial bronze	H01	quarter hard	40 (275)	50 (345)	B27–52	38–53		
			half hard	47 (325)	57 (395)	B50–63	52–61		
		O81	<i>Annealed-to-Tempers:</i>						
			quarter hard	39 (270)	46 (315)	...	...
C23000	Red brass	H01	quarter hard	44 (305)	54 (370)	B33–58	45–60		
			half hard	51 (350)	61 (420)	B56–68	58–66		
		O81	<i>Annealed-to-Tempers:</i>						
			quarter hard	44 (305)	54 (370)	...	...
C66400	Copper-zinc-iron-cobalt alloy	O60	<i>Annealed-Tempers:</i>						
		soft anneal ^D	53 (365)	60 (415)	...	...	
		C66410	Copper-zinc-iron alloy	O60	soft anneal ^D	53 (365)	60 (415)
C66430	Copper-zinc-iron-tin alloy	O60	soft anneal ^D	59 (405)	69 (475)	...	59–69		
		C71000	Cupro-nickel 20 %	H01	quarter hard	47 (325)	63 (435)	B45–72	46–65
					half hard	56 (385)	70 (485)	B64–78	59–69
OS035	0.025–0.050 mm	52 (360)	...	B18–35	28–40				
OS015	0.010–0.020 mm	53 (365)	...	B35–88	40–58				
Copper-Clad Stainless (CCS) and Copper-Clad Alloy Steel (CAS)									
Cladding Ratio	Total Thickness								
	in. (mm)								
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	...		
Copper-Clad Bronze (CCB)									
Cladding Ratio	Total Thickness								
	in. (mm)								
12.5/75/12.5	^E	O61	annealed ^D	55 (380)	68 (470)	15T 89 max	...		
		O81	annealed to temper—quarter hard	62 (425)	75 (515)	15T 92 max	...		
16/68/16	^E	O61	annealed ^D	55 (380)	68 (470)	15T 89 max	...		
		O81	annealed to temper—quarter hard	62 (425)	75 (515)	15T 92 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.

^E See Appendix X2, Table X2.1.

TABLE 3 Preferred Cladding Ratios—Copper-Clad Materials

Clad Material	Nominal Total Thickness of Strip		Cladding Ratio	Nominal Thickness, in. (mm)			Conductivity, % IACS	
	in.	mm		Copper	Core	Copper	Nominal	Minimum
CCS or CAS	0.005	0.13	16/68/16	0.0008 (0.02)	0.0034 (0.09)	0.0008 (0.02)	30	28
CCS or CAS	0.006	0.15	33.3/33.3/33.3	0.002 (0.05)	0.002 (0.05)	0.002 (0.05)	61	60
CCB	0.005	0.13	16/68/16	0.0008 (0.02)	0.0034 (0.09)	0.0008 (0.02)	32	30
CCB	0.005	0.13	12.5/75/12.5	0.0006 (0.016)	0.0038 (0.1)	0.0006 (0.016)	30	28

12.4 *Straightness*—The straightness tolerances shall be those required by Specification B248 or B248M, unless otherwise stated in the purchase order.

12.5 *Cladding Ratio*—Cladding ratios shall be within ±10 % of the outer clad layer percentage (for example, the outer layers of a 16/68/16 clad product can have an outer layer