



Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification² establishes the requirements for copper sheet, strip, plate, and rolled bar produced from the following coppers.

Copper UNS No. ^A	Previous Designation	Type of Copper
C10100 ^B	OFE	Oxygen-free electronic
C10200 ^B	OF	Oxygen-free without residual deoxidants
C10300	...	Oxygen-free extra low phosphorus
C10400, C10500, C10700	OFS	Oxygen-free, silver bearing
C10800	...	Oxygen-free low phosphorus
C10910	...	Low oxygen
C11000 ^{B,C}	ETP, TP ^C	Electrolytic tough pitch ^C , Tough pitch ^C
C11300, C11400, C11600 ^B	STP	Silver bearing tough pitch
C12000	DLP	Phosphorized, low residual phos- phorus
C12200 ^B	DHP	Phosphorized, high residual phos- phorus
C12300	DPS	Phosphorized, silver bearing
C14200	DPA	Phosphorus deoxidized, arsenical
C14420	...	Tin bearing tellurium copper
C14530	...	Tin tellurium bearing copper

^A Except Copper UNS Nos. C10910 (low oxygen), C14200 (phosphorus deoxidized, arsenical), C14420 (tin bearing tellurium), and C14530 (tin tellurium bearing) these types of copper are classified in Classification B224.

^B SAE Specification CA101 conforms to Copper UNS No. C10100; SAE Specification CA102 conforms to the requirements for Copper UNS No. C10200; SAE Specification CA110 conforms to the requirements for Copper UNS No. C11000; SAE Specifications CA113, CA114, and CA116 conform to the requirements for Copper UNS Nos. C11300, C11400, and C11600; SAE Specification CA120 conforms to Copper UNS No. C12000; and SAE Specification CA122 conforms to the requirements for Copper UNS No. C12200.

^C Unless specified in the contract or purchase order the supplier is permitted to provide ETP copper or TP copper.

NOTE 1—Each of the coppers listed has unique properties that can make it suitable for specific applications. The purchaser should consult with the supplier to determine which copper would be best suited for the intended application.

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 ASME Boiler and Pressure Vessel Code applications see related Specification SB-152 in Section II of that Code.

NOTE 2—This specification is not intended to establish requirements for material rolled to ounce-weight thicknesses. Such material is defined in Specification B370.

Plates for locomotive fireboxes are defined in Specification B11.

Flat copper products with finished (rolled or drawn) edges (flat wire and strip) are defined in Specification B272.

1.1.1 When a specific copper is not identified in the contract or purchase order, the supplier may furnish product from any of the listed coppers.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 The following safety hazards caveat only pertains to the test method portion, Section 13 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:³

B11 Specification for Copper Plates for Locomotive Fireboxes (Withdrawn 1980)⁴

B170 Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes

B193 Test Method for Resistivity of Electrical Conductor Materials

B216 Specification for Tough-Pitch Fire-Refined Copper—Refinery Shapes

B224 Classification of Coppers

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

³ 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.

⁴ 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



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

B272 Specification for Copper Flat Products with Finished (Rolled or Drawn) Edges (Flat Wire and Strip)

B370 Specification for Copper Sheet and Strip for Building Construction

B577 Test Methods for Detection of Cuprous Oxide (Hydrogen Embrittlement Susceptibility) in Copper

B601 Classification for Temper Designations for Copper and Copper Alloys—Wrought and Cast

B846 Terminology for Copper and Copper Alloys

E3 Guide for Preparation of Metallographic Specimens

E8 Test Methods for Tension Testing of Metallic Materials

E8M Test Methods for Tension Testing of Metallic Materials [Metric] (Withdrawn 2008)⁴

E53 Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

E62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Methods) (Withdrawn 2010)⁴

E112 Test Methods for Determining Average Grain Size

E478 Test Methods for Chemical Analysis of Copper Alloys

E527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.2 ASME Standard:

ASME Boiler Pressure Vessel Code⁵

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 Sampling.
- 3.1.4 Number of Tests and Retests.
- 3.1.5 Specimen Preparation.
- 3.1.6 Test Methods.
- 3.1.7 Packaging and Package Marking.
- 3.1.8 Workmanship, Finish, and Appearance.
- 3.1.9 Significance of Numerical Limits.
- 3.1.10 Rejection and Reheating.

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** or **B248M**.

4. Terminology

4.1 *Definitions*—Terms used in this specification are in accordance with Terminology **B846** and Specifications **B248** and **B248M**.

4.2 *Definitions of Terms Specific to This Standard:*

4.2.1 *capable of*—the test need not be performed by the producer of the material. However, should subsequent testing by the purchaser establish that the material does not meet these requirements the material shall be subject to rejection.

5. Ordering Information

5.1 Orders for products under this specification shall include the following:

- 5.1.1 ASTM specification designation and year of issue,
- 5.1.2 Quantity,
- 5.1.3 Copper UNS No. (Section **1**). When Alloys C10400, C10500, C10700, C11300, C11400, C11600, or C12300, the amount of silver in ounces per ton,
- 5.1.4 Temper (Section **7**),
- 5.1.5 Dimensions: thickness, width, and weight (Section **12**),
- 5.1.6 How furnished (straight lengths or coils),
- 5.1.7 Length (Section **12**),
- 5.1.8 Weight of coils: coil weights or coil size limitations, if required,
- 5.1.9 When the product is purchased for agencies of the U.S. Government,

5.2 The following requirements shall be specified if applicable:

- 5.2.1 Certification, if required (Section **15**),
- 5.2.2 Mill test report, if required (Section **16**),
- 5.2.3 Resistivity test for alloys listed in **Table 5** (see Section **9**),
- 5.2.4 Embrittlement test for the alloys listed in **11.2**,
- 5.2.5 Type of edge, if other than slit, and
- 5.2.6 Supplemental requirements for agencies of the U.S. government as given in Specifications **B248** and **B248M**.

6. Chemical Composition

6.1 The materials shall conform to the chemical requirements prescribed in **Table 1**.

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

7. Temper

7.1 *As Hot-Rolled (M20)*—The standard temper of copper sheet and plate produced by hot rolling as designated in **Tables 2 and 3** with the prefix “M”. Former designation and standard designation are detailed in Classification **B601** are shown.

7.1.1 Plate not specified for ASME Boiler Pressure Vessel Code applications are generally available in the M20 temper.

7.2 *Rolled (H)*—The standard tempers of cold rolled copper sheet, strip, plate, and rolled bar are as designated in **Tables 2 and 3** with the prefix “H”. Former designation and standard designation are detailed in Classification **B601** are shown.

7.3 *Annealed (O)*—The standard temper of annealed copper sheet, strip, and plate are as designated in **Tables 2-4** with the prefix “O”. Former designation and standard designation are detailed in Classification **B601** are shown.

7.3.1 The temper of copper sheet and plate hot-rolled and annealed shall be that produced by hot rolling and subsequent annealing is designated in **Tables 2 and 3** as O25.

7.3.1.1 Plates specified for ASME Boiler Pressure Vessel Code applications shall be furnished in the O25 temper.

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

TABLE 1 Chemical Requirements

Element	Composition, %																	
	Copper UNS No.																	
	C10100 ^A	C10200	C10300	C10400 ^B	C10500 ^B	C10700 ^B	C10800	C10910	C11000	C11300 ^C	C11400 ^C	C11600 ^C	C12000	C12200	C12300 ^D	C14200	C14420	C14530
Copper (incl silver), min	99.99 ^E	99.95	99.95 ^F	99.95	99.95	99.95	99.95 ^F	99.95	99.90	99.90	99.90	99.90	99.90	99.9	99.90	99.4	99.90 ^G	99.90 ^H
Phosphorus	^A	...	0.001–0.005	...	...	...	0.005–0.012	...	...	...	...	...	0.004–0.012	0.015–0.040	0.015–0.040	0.015–0.040	...	0.001–0.010
Arsenic	^A	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.15–0.50	...	...
Oxygen, max	0.0005	0.0010	...	0.0010	0.0010	0.0010	...	0.005	...	...	...	...	...	...	...	...	...	...
Silver	^A	...	...	8 ^I	10 ^I	25 ^I	...	...	...	8 ^I	10 ^I	25 ^I	...	...	4 ^I	...	...	...
Selenium + tellurium, max	^A	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.023
Tellurium	^A	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.005–0.05	0.003–0.023 ^J
Tin	^A	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0.04–0.15	0.003–0.023

^A Impurity maximums in ppm of C10100 shall be: antimony 4, arsenic 5, bismuth 1, cadmium 1, iron 10, lead 5, manganese 0.5, nickel 10, oxygen 5, phosphorus 3, selenium 3, silver 25, sulfur 15, tellurium 2, tin 2, and zinc 1.

^B C10400, C10500, and C10700 are oxygen-free coppers with the addition of a specified amount of silver. The compositions of these alloys are equivalent to C10200 plus the intentional addition of silver.

^C C11300, C11400, and C11600 are electrolytic tough-pitch copper with silver additions. The compositions of these alloys are equivalent to C11000 plus the intentional addition of silver.

^D Copper UNS No. C12300 is produced by the addition of silver to phosphorus-deoxidized copper.

^E Copper shall be determined by difference between impurity total and 100 %.

^F Includes phosphorus.

^G Includes tellurium + tin.

^H Includes tin + tellurium + selenium.

^I Values are minimum silver Troy oz/Avoirdupois ton (1 oz/ton is equivalent to 0.0034 %).

^J Tellurium or selenium, or both.



**TABLE 2 Tensile Strength (inch-pound units) Requirements and Approximate Hardness Values for the Tempers Given**

Temper Designation		Tensile Strength, ksi ^A		Approximate Rockwell Hardness ^B	
Standard	Former	Min	Max	F Scale	Superficial 30T
	Cold-rolled tempers:				
H00	Eighth hard	32	40	54–82	up to 49
H01	Quarter hard	34	42	60–84	18–51
H02	Half hard	37	46	77–89	43–57
H03	Three-quarter-hard	41	50	82–91	47–59
H04	Hard	43	52	86–93	54–62
H06	Extra hard	47	56	88–95	56–64
H08	Spring	50	58	91–97	60–66
H10	Extra spring	52	...	92 and over	61 and over
	Hot-rolled tempers:				
M20 ^C	Hot-rolled	30 ^E	38	up to 75	up to 41
O25 ^D	Hot-rolled and annealed	30 ^E	38	up to 65	up to 31

^A ksi = 1000 psi.^B Rockwell values apply as follows: The F scale applies to metal 0.020 in. and over in thickness. The Superficial 30-T scale applies to metal 0.012 in. and over in thickness.^C See Section 7.1.1.^D See Section 7.3.1.1.^E When material is specified to meet the requirements of ASME Boiler Pressure Vessel Code, the minimum yield strength at 0.5 % extension under load or at 0.2 % offset shall be 10 ksi.**TABLE 3 Tensile Strength (SI units) Requirements and Approximate Hardness Values for the Tempers Given**

Temper Designation		Tensile Strength, MPa		Approximate Rockwell Hardness ^A	
Standard	Former	Min	Max	F Scale	Superficial 30T
	Cold-rolled tempers:				
H00	Eighth hard	220	275	54–82	up to 49
H01	Quarter hard	235	295	60–84	18–51
H02	Half hard	255	315	77–89	43–57
H03	Three-quarter-hard	285	345	82–91	47–59
H04	Hard	295	360	86–93	54–62
H06	Extra hard	325	385	88–95	56–64
H08	Spring	345	400	91–97	60–66
H10	Extra spring	360	...	92 and over	61 and over
	Hot-rolled tempers:				
M20 ^B	Hot-rolled	205 ^D	260	up to 75	up to 41
O25 ^C	Hot-rolled and annealed	205 ^D	260	up to 65	up to 31

^A Rockwell values apply as follows: The F scale applies to metal 0.50 mm and over in thickness. The Superficial 30-T scale applies to metal 0.30 mm and over in thickness.^B See Section 7.1.1.^C See Section 7.3.1.1.^D When material is specified to meet the requirements of ASME Boiler Pressure Vessel Code, the minimum yield strength at 0.5 % extension under load or at 0.2 % offset shall be 70 MPa.**TABLE 4 Grain Size Requirements and Approximate Rockwell Hardness Values for Cold-Rolled Annealed Tempers**

Temper Designation		Grain Size, mm		Approximate Rockwell Hardness ^A	
Standard	Former	Min	Max	F Scale	
				Min	Max
O60	Soft anneal	^B			65
O68	Deep-drawing anneal	^B	0.050	30	75

^A Rockwell hardness values apply as follows: The F scale applies to metal 0.020 in. or 0.50 mm and over in thickness.^B Although no minimum grain size is required, this material must be fully recrystallized.

7.3.2 The standard tempers of copper sheet, strip, and plate cold-rolled annealed are designated in Table 4 as follows: O60, soft anneal and O68, deep drawing anneal.

NOTE 3—Any product produced in a temper other than those listed in Table 2, Table 3 or Table 4 will be produced and sold by contract and cannot be said to be produced under this specification.

NOTE 4—Soft-anneal temper is suitable for most industrial users of copper such as forming, spinning, and simple drawing operations in which close control of temper is not essential. Deep drawing anneal temper is especially suited for very severe drawing and forming operations in which maximum ductility and close control of temper is required.

8. Grain Size for Cold Rolled Annealed Tempers

8.1 Grain Size shall be standard requirement for all products of the cold rolled annealed (O60 and O68) tempers.

8.2 Acceptance or rejection based upon grain size shall depend only on the average grain size of the test specimens and shall be within the limits prescribed in Table 4 when determined in accordance with Test Methods E112.



8.3 The test specimen shall be prepared in accordance with Guide E3. The average grain size shall be determined on a plane parallel to the surface of the product.

9. Physical Property Requirements

9.1 Electrical Resistivity Requirement:

9.1.1 When specified in the contract or purchase order on the alloys listed below, the electrical resistivity determined on representative samples shall not exceed the limits in Table 5 when test in accordance with Test Method B193.

TABLE 5 Electrical Resistivity Requirements for Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, C10910, C11000, C11300, C11400, and C11600

Alloy	Temper	Electrical Resistivity max, $\Omega \cdot \text{g}/\text{m}^2$
C10100	Annealed	0.15176
C10100	Cold Rolled	0.15614
C10200, C10300, C10400, C10500, C10700, C10910, C11000, C11300, C11400, C11600	Annealed	0.15328
C10200, C10300, C10400, C10500, C10700, C10910, C11000, C11300, C11400, C11600	Cold Rolled	0.15775

9.1.2 Copper UNS Nos. C10800, C12000, C12200, C12300, C14200, C14420, and C14530 when specified at the time of purchase for electrical conductor use shall meet resistivity requirements as agreed upon between the manufacturer or supplier and the purchaser.

NOTE 5—The International Annealed Copper Standard electrical conductivity equivalents are as follows:

Electrical Resistivity, $\Omega \cdot \text{g}/\text{m}^2$	Conductivity, % IACS
0.151 76	101.00
0.153 28	100.00
0.156 14	98.16
0.157 75	97.16

10. Mechanical Property Requirements

10.1 *Tensile Requirements of As Hot-Rolled (M20), and Hot-Rolled and Annealed (O25) Tempers:*

10.1.1 Product furnished to this specification shall conform to the tensile strength requirements prescribed in Tables 2 and 3. Furthermore, Copper UNS Nos. C11000 and C12200 plate shall have 40 % minimum elongation in 2 in. (50 mm) and Copper UNS No. C14200 plate shall have 45 % minimum elongation in 2 in. or 50 mm. The test specimens shall be taken so the longitudinal axis of the specimen is parallel to the direction and tested in accordance with Test Methods E8 or E8M.

10.1.2 *Plate Item Test*—Five specimens shall be taken either from the excess portion of the plate or from separate pieces produced under the same specification and temper.

10.1.3 Acceptance or rejection based upon mechanical properties shall depend only on tensile strength. Copper UNS Nos. C11000, C12200, and C14200 plate, acceptance or

rejection based upon mechanical properties shall depend on tensile strength and elongation (see 10.1.1).

10.2 Tensile Requirements of Rolled (R) Tempers:

10.2.1 Product furnished to this specification shall conform to the tensile strength requirements prescribed in Tables 2 and 3. The test specimens shall be taken so the longitudinal axis of the specimen is parallel to the direction and tested in accordance with Test Methods E8 or E8M.

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

10.3 *Rockwell Hardness*—The approximate Rockwell hardness values for each temper are given in Table 2, Table 3, or Table 4 for general information and assistance in testing and shall not be used as a basis for rejection.

NOTE 6—Rockwell hardness tests offer a quick and convenient method of checking copper of any temper for general conformity to the requirements for tensile strength or grain size.

11. Performance Requirements

11.1 Microscopical Examination:

11.1.1 Samples of Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, and C12000 shall be substantially free of cuprous oxide as determined by Procedure A of Test Methods B577. In case of a dispute, a referee method in accordance with Procedure C of Test Methods B577 shall be used.

11.1.2 When Copper UNS Nos. C10800, C12200, or C12300 are supplied, microscopical examination for cuprous oxide is not required.

11.2 *Hydrogen Embrittlement Susceptibility Test*—Samples of Copper UNS Nos. C10100, C10200, C10300, C10400, C10500, C10700, C10800, C12000, C12200, and C12300 shall be capable of passing the embrittlement test of Procedure B of Test Methods B577. The actual performance of this test is not mandatory under the terms of this specification unless definitely specified in the ordering information. In case of a dispute, a referee method in accordance with Procedure C shall be used.

12. Dimensions, Mass, and Permissible Variations

12.1 The dimensions and tolerances for material covered by this specification shall be as prescribed in the current edition of Specification B248 or B248M, with particular reference to the dimensions, weights, and permissible variations section and the following tables of that specification.

12.1.1 Thickness Tolerances.

12.1.2 Width Tolerances.

12.1.2.1 Slit Metal and Slit Metal with Rolled Edges.

12.1.2.2 Square-Sheared Metal.

12.1.2.3 Sawed Metal.

12.1.3 Length Tolerances.

12.1.3.1 Length Tolerances for Straight Lengths.

12.1.3.2 Schedule of Lengths (Specific and Stock) With Ends.

12.1.3.3 Length Tolerances for Square-Sheared Metal.

12.1.3.4 Length Tolerances for Sawed Metal.

12.1.4 Straightness:

12.1.4.1 *Slit Metal and Slit Metal Either Straightened or Edge-Rolled.*



- 12.1.4.2 *Square-Sheared Metal.*
- 12.1.4.3 *Sawed Metal.*
- 12.1.5 *Weight—Hot-Rolled Sheet and Plate.*
- 12.1.6 *Edges.*
 - 12.1.6.1 *Square Edges.*
 - 12.1.6.2 *Rounded Corners.*
 - 12.1.6.3 *Rounded Edges.*
 - 12.1.6.4 *Full-Rounded Edges.*

13. Test Methods

13.1 Refer to Specification **B248** or **B248M** for the appropriate mechanical test method.

13.2 Chemical composition shall, in case of disagreement be determined as follows:

Element	ASTM Test Method
Copper	E53
Phosphorus	E62
Selenium	Refer to Annex, Specification B216
Silver	E478
Tellurium	Refer to Annex, Specification B216
Arsenic	E62

13.2.1 For Copper No. C10100, refer to the Annex of Specification **B170** for test methods.

13.2.2 Test method(s) for the determination of elements resulting from contractual or purchaser order shall be as agreed upon between the manufacture and the purchaser.

14. Inspection

14.1 The manufacturer shall inspect and make tests necessary to verify that the product furnished conforms to the specified requirements.

14.2 The manufacturer and the purchaser, by mutual agreement, may accomplish the final inspection simultaneously.

15. Certification

15.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a certificate stating that each lot has been sampled, tested, and inspected in accordance with this specification and has met the requirements.

15.2 When material is specified to meet the requirements of ASME Boiler Pressure Vessel Code, the certification requirements are mandatory.

16. Mill Test Report

16.1 When specified on the purchase order, the manufacturer shall furnish to the purchaser a test report showing results of tests required by the specification.

17. Keywords

17.1 annealed; copper bars; copper plate; copper sheet; copper strip ; hot-rolled; rolled; UNS No. C10100; UNS No. C10200; UNS No. C10300; UNS No. C10400; UNS No. C10500; UNS No. C10700; UNS No. C10800; UNS No. C10910; UNS No. C11000; UNS No. C11300; UNS No. C11400; UNS No. C11600; UNS No. C12000; UNS No. C12200; UNS No. C12300; UNS No. C14200; UNS No. C14420; UNS No. C14530

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B152/B152M – 09) that may impact the use of this standard. (Approved Jan. 15, 2013.)

(1) Corrected the chemical composition of C14530 by adding footnote J to Table 1.

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