Designation: B194 – 15

Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar[1]

This standard is issued under the fixed designation B194; 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-beryllium alloy plate, sheet, strip, and rolled bar. The following alloys are specified:[2]

Copper Alloy UNS No.[2]	Previously Used Commercial Designations	Nominal Beryllium Content, %
C17000	Alloy 165	1.7
C17200	Alloy 25	1.9

1.2 Unless otherwise specified in the contract or purchase order, Copper Alloy UNS No. C17200 shall be the alloy furnished.

1.3 *Units*—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.

1.4 The following safety hazard caveat pertains only to the test method(s) described in the annex of this specification:

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

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

E112 Test Methods for Determining Average Grain Size

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

3. General Requirements

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

3.1.1 Terminology
3.1.2 Materials and Manufacture
3.1.3 Dimensions, Weights, 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.

3.2 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 B248.

4. Terminology

4.1 For definitions of terms relating 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. designation (1.1),
5.1.3 Form of material: plate, sheet, strip, or 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 B05.01 on Plate, Sheet, and Strip.

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[2] The UNS system for copper and copper alloys (see Practice E527) is a simple expansion of the former standard designation system accomplished by the addition of a prefix "C" and a suffix "00." The suffix can be used to accommodate composition variations of the base alloy.

[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.

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

5.1.4 Temper (7.1),
5.1.5 Dimensions: thickness and width, and length if applicable.
5.1.6 How furnished: rolls, stock lengths with or without ends, specific lengths with or without ends,
5.1.7 Quantity: total weight or total length or number of pieces of each size,
5.1.8 Type of edge, if required: slit, sheared, sawed, square corners, rounded corners, rounded edges, or full-rounded edges (Specification B248, Section 5.6),
5.1.9 Type of width and straightness tolerances, if required: slit-metal tolerances, square-sheared-metal tolerances, sawed-metal tolerances, straightened or edge-rolled-metal tolerances (Specification B248, Section 5.3),
5.1.10 Special thickness tolerances, if required (Specification B248, Table 3),
5.1.11 Tension test or hardness as applicable (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 Bend test, if required (Section 11),
5.2.2 Grain size or grain count, if required (Section 9 or 10),
5.2.3 Certification, if required (see Specification B248, Section 14),
5.2.4 Test Report, if required (see Specification B248, Section 15),
5.2.5 Special tests or exceptions, if any.

5.3 If the product is purchased for agencies of the U.S. Government, see the Supplementary Requirement of Specification B248 for additional requirements, if specified.

6. Chemical Composition

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

6.2 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. Copper is listed as “remainder,” and may be taken as the difference between the sum of all elements analyzed and 100 %. When all elements in Table 1 are determined, the sum of the results shall be 99.5 % minimum.

7. Temper

7.1 The standard tempers for products described in this specification are given in Table 2, Table 3, Table 4, and Table 5.

TABLE 1 Chemical Requirements

Element	Composition, %	
	Copper Alloy UNS No. C17000	Copper Alloy UNS No. C17200
Beryllium	1.60–1.85	1.80–2.00
Additive elements:		
Nickel + cobalt, min	0.20	0.20
Nickel + cobalt + iron, max	0.6	0.6
Aluminum, max	0.20	0.20
Silicon, max	0.20	0.20
Copper	remainder	remainder

7.1.1 Solution Heat Treated TB00.
7.1.2 Solution Heat Treated and Cold Worked TD00 to TD04.
7.1.3 Solution Heat Treated and Precipitation Heat Treated TF00.
7.1.4 Solution Heat Treated, Cold Worked and Precipitation Heat Treated TH01 to TH04.
7.1.5 Mill Hardened TM00 to TM08.
7.1.6 Plate is generally available in the TB00, TD04, TF00, and TH04 tempers.

8. Mechanical Property Requirements

8.1 For product less than 0.050 in. (1.27 mm) in thickness:
8.1.1 Tensile test results shall be the product acceptance criteria, when tested in accordance with Test Methods E8/E8M.
8.1.2 The tensile strength requirements are given in Table 2, Table 3, and Table 4.

8.2 For product 0.050 in. (1.27 mm) and greater in thickness.
8.2.1 Rockwell hardness is the product acceptance criteria, when tested in accordance with Test Methods E18.
8.2.2 The referee product rejection criteria shall be tensile test results, when tested in accordance with Test Methods E8/E8M.
8.2.3 Rockwell hardness and tensile strength requirements are given in Table 2, Table 3, and Table 4.

8.3 Product, as specified in 7.1, shall conform to the requirements specified in Table 2, in the solution heat-treated, or solution heat-treated and cold-worked conditions, and in Table 3, after precipitation heat-treatment or Table 4 in the mill-hardened condition. Precipitation heat-treatment parameters for Table 2 and Table 3 are shown in Section 12.

9. Grain Size

9.1 Material over 0.010 in. (0.254 mm) in thickness shall have an average grain size in accordance with Test Methods E112, not exceeding the limits specified in Table 5. The determinations are made on the separate samples and in a plane perpendicular to the surface and perpendicular to the direction of rolling.

10. Grain Count

10.1 The grain count of a sample of material, in any temper, over 0.004 to 0.010 in. (0.102 to 0.254 mm), inclusive, in thickness shall not be less than the limits specified in Table 6.

10.2 Grain count is the number of grains per stock thickness, averaged for five locations one stock thickness apart. Grain count shall be determined in a plane perpendicular to the surface and perpendicular to the direction of rolling.

11. Bend-Test Requirements

11.1 The optional bend test is a method for evaluating the ductility of precipitation heat-treated copper-beryllium strip in thin gages.

11.2 When specified in the order (see 5.1.6), material in any temper 0.004 to 0.020 in. (0.102 to 0.508 mm), inclusive, in

TABLE 2 Mechanical Property Requirements for Material in the Solution-Heat-Treated or Solution-Heat-Treated and Cold-Worked Condition

Temper Designation[A]		Material Thickness, in. (mm)		Tensile Strength, ksi[B] (MPa)[C]	Elongation[D] in 2 in. or 50 mm, min,%	Rockwell Hardness[E]		
Code	Former	Over	Incl			B Scale	30T Scale	15T Scale
TB00	A	...	...	60–78 (415–540)	35	45–78	46–67	75–85
TD01	¼ H	...	0.188 (4.78)	75–88 (520–610)	15	68–90	62–75	83–89
TD02	½ H	...	0.188 (4.78)	85–100 (585–690)	9	88–96	74–79	88–91
TD04	H	...	0.188 (4.78)	100–130 (690–895)	2	96–104	79–83	91–94
TD04	H	0.188 (4.78)	0.375 (9.53)	90–130 (620–895)	...	91–103	77 min	90 min
TD04	H	0.375 (9.53)	1.000 (25.4)	90–120 (620–825)	...	90–102	...	...
TD04	H	over 1.000 (25.4)		85–115 (585–790)	8	88–102	...	...

[A] Standard designations defined in Classification B601.
[B] ksi = 1000 psi.
[C] See Appendix X1.
[D] Elongation requirement applies to material 0.004 in. (0.102 mm) and thicker.
[E] The thickness of material that may be tested by use of the Rockwell hardness scales is as follows:
B Scale.....0.040 in. (1.016 mm) and over
30T Scale.....0.020 to 0.040 in. (0.508 to 1.016 mm), excl.
15T Scale.....0.015 to 0.020 in. (0.381 to 0.508 mm), excl.
Hardness values shown apply only to direct determinations, not converted values.

TABLE 3 Mechanical Property Requirements After Precipitation Heat-Treatment[A]

Temper Designation		Material Thickness, in. (mm)		Tensile Strength, ksi[B] (MPa)[C]	Yield Strength, ksi (MPa), min, 0.2 % Offset	Elongation in 2 in. (50 mm), min, %[D]	Rockwell Hardness,[E] min		
Code	Former	Over	Incl				C Scale	30N Scale	15N Scale
Copper Alloy UNS No. C17000									
TF00	AT	...	0.188 (4.78)	150–180[F] (1035–1240)	130 (895)	3	33	53	76.5
TF00	AT	0.188 (4.78)	...	165–195[F] (1140–1345)	130 (895)	3	36	56	78
TH01	¼ HT	...	...	160–190[F] (1105–1310)	135 (930)	2.5	35	55	77
TH02	½ HT	...	...	170–200[F] (1170–1380)	145 (1000)	1	37	57	78.5
TH04	HT	...	...	180–210[F] (1240–1450)	155 (1070)	1	38	58	79.5
Copper Alloy UNS No. C17200									
TF00	AT	...	...	165–195[F] (1140–1345)	140 (965)	3	36	56	78
TH01	¼ HT	...	0.188 (4.78)	175–205[F] (1205–1415)	150 (1035)	2.5	36	56	79
TH02	½ HT	...	0.188 (4.78)	185–215[F] (1275–1480)	160 (1105)	1	38	58	79.5
TH04	HT	...	0.188 (4.78)	190–220[F] (1310–1520)	165 (1140)	1	38	58	80
TH04	HT	0.188 (4.78)	0.375 (9.53)	180–215[F] (1240–1480)	160 (1105)	1	38	58	80
TH04	HT	0.375 (9.53)	1.000 (25.4)	180–210[F] (1240–1450)	155 (1070)	1	38	...	...
TH04	HT	1.000 (25.4)	2.000 (50.8)	175–205[F] (1205–1415)	150 (1035)	2	37	...	...
TH04	HT	over 2.000 (50.8)		165–200[F] (1140–1380)	130 (895)	2	36	...	...

[A] These values apply to mill products (Section 14). See 12.3 for exceptions in end products.
[B] ksi = 1000 psi.
[C] See Appendix X1.
[D] Elongation requirement applies to material 0.004 in. (0.102 mm) and thicker.
[E] The thickness of material that may be tested by use of the Rockwell Hardness scales is as follows:
C Scale.....0.040 in. (1.016 mm) and over
30N Scale.....0.020 to 0.040 in. (0.508 to 1.016 mm), excl.
15N Scale.....0.015 to 0.02 in. (0.381 to 0.508 mm), excl.
Hardness values shown apply only to direct determinations, not converted values.
[F] The upper limits in the tensile strength column are for design guidance only.

thickness shall conform to the requirements specified in Table 7, when tested in accordance with 14.2.

11.3 Five specimens, ⅜ ± 1⁄16 in. (9.53 ± 1.59 mm) in width, of any convenient length, with the rolling direction parallel to the ⅜-in. dimension, shall be precipitation heat-treated in accordance with 12.2. To pass the bend test, at least four specimens out of five, and at least 80 % of the total specimens tested from a lot shall withstand the 90° bend without visible crack or fracture, when tested in accordance with 15.3.

12. Precipitation Heat-Treatment

12.1 Solution-heat-treated or solution-heat-treated and cold-worked material is normally precipitation hardened by the purchaser after forming or machining. For the purpose of determining conformance to specified mechanical properties of Table 3, a sample of the as-supplied material shall be heat treated as shown in Table 8. Other heat treating temperatures and times may be preferred for end products of this material.

TABLE 4 Strip Mechanical Property Requirements—Mill-Hardened Condition[A]

Temper Designation		Tensile Strength, ksi[B] (MPa)[C]	Yield Strength, ksi (MPa), 0.2 % Offset	Elongation in 2 in. (50 mm), min, %[D]	Rockwell Hardness,[E] min		
Code	Former[B]				C Scale	30N Scale	15N Scale
Copper Alloy UNS No. C17000							
TM00	AM	100–110[F] (690–760)	70–95 (485–655)	18	18	37	67.5
TM01	¼ HM	110–120[F] (760–825)	80–110 (550–760)	15	20	42	70
TM02	½ HM	120–135[F] (825–930)	95–125 (655–860)	12	24	45	72
TM04	HM	135–150[F] (930–1035)	110–135 (760–930)	9	28	48	75
TM05	SHM	150–160[F] (1035–1100)	125–140 (860–965)	9	31	52	75.5
TM06	XHM	155–175[F] (1070–1205)	135–165 (930–1140)	3	32	52	76
Copper Alloy UNS No. C17200							
TM00	AM	100–110[F] (690–760)	70–95 (485–660)	16	R_B95	37	67.5
TM01	¼ HM	110–120[F] (760–825)	80–110 (550–760)	15	20	42	70
TM02	½ HM	120–135[F] (825–930)	95–125 (655–860)	12	23	44	72
TM04	HM	135–150[F] (930–1035)	110–135 (760–930)	9	28	48	75
TM05	SHM	150–160[F] (1035–1105)	125–140 (860–965)	9	31	52	75.5
TM06	XHM	155–175[F] (1070–1210)	135–170 (930–1170)	4	32	52	76
TM08	XHMS	175–190[F] (1210–1310)	150–180 (1035–1240)	3	33	53	76.5

[A] These values apply to mill products (Section 14). See 12.3 for exceptions in end products.
[B] ksi = 1000 psi.
[C] See Appendix X1.
[D] Elongation requirement applies to material 0.004 in. (0.102 mm) and thicker.
[E] The thickness of material that may be tested by use of the Rockwell Hardness scales is as follows:
C Scale.....0.040 in. (1.016 mm) and over
30N Scale.....0.020 to 0.040 in. (0.508 to 1.016 mm), excl.
15N Scale.....0.015 to 0.020 in. (0.381 to 0.508 mm), excl.
Hardness values shown apply only to direct determinations, not converted values.
[F] The upper limits in the tensile strength column are for design guidance only.

TABLE 5 Grain-Size Requirements for TB00 (Solution-Heat-Treated) Material

Thickness, in. (mm)	Grain Size Specified	Maximum Average Grain Size, mm
Over 0.010 to 0.030 (0.254 to 0.762), incl	OS035	0.035
Over 0.030 to 0.090 (0.762 to 2.29), incl	OS045	0.045
Over 0.090 to 0.188 (2.29 to 4.78), incl	OS060	0.060

TABLE 6 Grain-Count Requirements

Thickness, in. (mm)	Minimum Number of Grains
Over 0.004 to 0.006 (0.102 to 0.152), incl	6
Over 0.006 to 0.008 (0.152 to 0.203), incl	7
Over 0.008 to 0.010 (0.203 to 0.254), incl	8

TABLE 7 Bend-Test Requirements After Precipitation Heat Treatment

Temper Designation		Test Radius[A]
Standard	Former	
TF00	AT	5*t*
TH01	¼ AT	6*t*
TH02	½ HT	9*t*
TH04	HT	15*t*

[A] The *t* refers to the measured average stock thickness to be tested.

TABLE 8 Precipitation-Heat-Treatment Time for Acceptance Tests

Temper Designation (Before Precipitation Heat Treatment)		Time at 600 to 675°F (316 to 357°C), h
Standard	Former	
TB00	A	3
TD01	¼ H	2
TD02	½ H	2
TD04	H	2

12.2 The solution-heat-treated and cold-worked test specimens shall be heat treated at a uniform temperature of 600 to 675°F (316 to 357°C) for the time shown in Table 8.

12.3 Special combinations of properties such as increased ductility, electrical conductivity, dimensional accuracy, endurance life, and resistance to elastic drift and hysteresis in springs may be obtained by special precipitation-hardening heat treatments. The mechanical requirements of Table 3 do not apply to such special heat treatments.

12.4 Mill-hardened products have been precipitation heat-treated by the manufacturer. Further thermal treatment is not normally required.

13. Sampling

13.1 Sampling shall be in accordance with Specification B248, Section 7, except that the heat size is defined as 12 000 lbs (5455 kg) or fraction thereof.

14. Specimen Preparation

14.1 The tension specimen direction shall have the longitudinal test-axis parallel to the rolling direction, unless mutually agreed upon between the supplier and purchaser at the time the order is placed.

14.2 When required, five bend-test specimens per test set shall be cut ⅜ ± 1/16 in. (9.53 ± 1.59 mm) in width and any convenient length. Specimens shall be precipitation heat-treated after cutting and prior to testing. Precipitation heat-treatment parameters for these bend tests shall be in accordance with 12.2.