



Standard Specification for Phosphor Bronze Plate, Sheet, Strip, and Rolled Bar¹

This standard is issued under the fixed designation B 103/B 103M; 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 (€) indicates an editorial change since the last revision or reapproval.

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

€¹ NOTE—Table 2 was editorially corrected in October 1999.

€² NOTE—Table 2 was editorially corrected in February 2003.

1. Scope *

1.1 This specification establishes copper-tin alloy (phosphor bronze), copper-tin-lead alloy (leaded phosphor bronze), and copper-tin-lead-zinc alloy (bearing bronze), plate, sheet, strip, and rolled bar. The phosphor bronzes commonly are used for deep drawing into bellows and stamping and forming into spring devices and into terminals and connectors for electrical apparatus because they combine high strength with high elongation. The leaded phosphor bronzes are used where strength, corrosion resistance, and machinability are required. The bearing bronze is used in bushings, bearings, and load-bearing thrust washers. The following alloys are covered:

Copper Alloy UNS No. ²	Nominal Composition, %				Previously Used Designation
	Copper	Tin	Zinc	Lead	
C51000	95	5	...	...	A1
C51100	96	4	...	...	A
C51900	94	6	...	...
C52100 ^A	92	8	...	...	C
C52400	90	10	...	...	D
C53400	94	5	...	1	B1
C54400	88	4	4	4	B2

^ASAE Specification CA 521 conforms to the requirements of UNS No. C52100.

NOTE 1—All of the above alloys contain small amounts of phosphorus, used as a deoxidant in melting, and to enhance the mechanical properties.

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

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 E 527) 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.

2. Referenced Documents

2.1 ASTM Standards:

- B 248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar³
- B 248M Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar [Metric]³
- B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast³
- B 846 Terminology for Copper and Copper Alloys³
- E 8 Test Methods for Tension Testing of Metallic Materials⁴
- E 8M Test Methods for Tension Testing of Metallic Materials [Metric]⁴
- E 54 Test Methods for Chemical Analysis of Special Brasses and Bronzes⁵
- E 62 Test Methods for Chemical Analysis of Copper and Copper Alloys (Photometric Method)⁵
- E 75 Test Methods for Chemical Analysis of Copper-Nickel and Copper Nickel-Zinc Alloys⁵
- E 255 Practice for Sampling Copper and Copper Alloys for Determination of Chemical Composition⁵
- E 478 Test Methods for Chemical Analysis of Copper Alloys⁶
- E 527 Practice for Numbering Metals and Alloys⁷

3. Terminology

3.1 *Definitions*— For definitions of terms used in this specification, refer to Terminology B 846.

4. Ordering Information

4.1 Contracts or purchase orders for product under this specification should include the following information:

4.1.1 ASTM designation and year of issue (for example, B 103/B 103M–98);

³ *Annual Book of ASTM Standards*, Vol 02.01.

⁴ *Annual Book of ASTM Standards*, Vol 03.01.

⁵ *Annual Book of ASTM Standards*, Vol 03.05.

⁶ *Annual Book of ASTM Standards*, Vol 03.06.

⁷ *Annual Book of ASTM Standards*, Vol 01.01.

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

4.1.2 Copper Alloy UNS No. designation (for example, C51000);

4.1.3 Temper (Section 8);

4.1.4 Dimensions: thickness, width, length, and so forth (Section 12);

4.1.5 Form: plate, sheet, strip, or rolled bar;

4.1.6 How furnished: coils, specific length or stock lengths, with or without ends;

4.1.7 Quantity: total weight each form, temper, and size; and,

4.1.8 When material is purchased for agencies of the U.S. Government (Section 11).

4.2 The following options are available under this specification and should be specified in the contract or purchase order when required.

4.2.1 Type of edge: slit, sheared, sawed, square corners, round corners, rounded edges, or full rounded edges;

4.2.2 Width and straightness tolerances (Section 12);

4.2.3 Heat identification or traceability details;

4.2.4 Certification, and

4.2.5 Mill test report.

5. General Requirements

5.1 The following sections of Specification B 248 constitute a part of this specification.

5.1.1 Terminology,

5.1.2 Materials and Manufacturing,

5.1.3 Workmanship, Finish, and Appearance,

5.1.4 Sampling, Except for Chemical Analysis,

5.1.5 Number of Tests and Retests,

5.1.6 Specimen Preparation,

5.1.7 Test Methods, Except for Chemical Analysis,

5.1.8 Significance of Numerical Limits,

5.1.9 Inspection,

5.1.10 Rejection and Reheating,

5.1.11 Certification,

5.1.12 Test Reports (Mill),

5.1.13 Packaging and Package Marking, and

5.1.14 Supplementary Requirements.

5.2 In addition, when a section with a title identical to that referenced in 5.1, appears in this specification, it contains additional requirements, which supplement those appearing in Specification B 248.

6. Materials and Manufacture

6.1 *Materials:*

6.1.1 The material of manufacture shall be a cast bar, cake, slab, or Copper Alloy UNS No. C51000, C51100, C51900, C52100, C52400, C53400, or C54400 as specified in the ordering information.

6.1.2 In the event heat identification or traceability is required, the purchaser shall specify the details desired.

NOTE 2—Because of the discontinuous nature of the processing of castings into wrought products, it is not always practical to identify a specific casting analysis with a specific quantity of finished material.

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 The product shall be hot or cold worked to the finished size and subsequently annealed, when required, to meet the temper properties specified.

6.2.3 *Edges*—Slit edges shall be furnished unless otherwise specified in the contract or purchaser order.

7. Chemical Composition

7.1 The materials shall conform to the chemical compositional requirements specified in Table 1 for the copper alloy UNS No. designation specified in the order.

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

7.3 Copper, specified as the “remainder,” may be taken as the difference between the sum of all the elements analyzed and 100 %. When all the elements in Table 1 are analyzed, the sum of results for each alloy shall be 99.5 % min.

8. Temper

8.1 *M20 (as Hot-Rolled Material)*—The standard temper of sheet and plate produced by hot rolling and is as designated in Table 2.

8.2 *H (Rolled Material)*—The standard tempers of rolled material are as designated in Table 2 with prefix “H.” Former designations and the standard designations as defined in Practice B 601 are shown.

NOTE 3—The properties of special and nonstandard tempers are subject to agreement between the manufacture and purchaser.

8.3 *O60 (Annealed)*— The standard temper is O60 (soft), as indicated in Table 2.

TABLE 1 Chemical Requirements

Element	Composition, %						
	Copper Alloy UNS No.						
	C51000	C51100	C51900	C52100	C52400	C53400 ^A	C54400 ^A
Tin	4.2-5.8	3.5-4.9	5.0-7.0	7.0-9.0	9.0-11.0	3.5-5.8	3.5-4.5
Phosphorus	0.03-0.35	0.03-0.35	0.03-0.35	0.03-0.35	0.03-0.35	0.03-0.35	0.01-0.50
Iron, max	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lead	0.05 max	0.05 max	0.05 max	0.05 max	0.05 max	0.8-1.2	3.5-4.5
Zinc	0.30 max	0.30 max	0.30 max	0.20 max	0.20 max	0.30 max	1.5-4.5
Copper	remainder	remainder	remainder	remainder	remainder	remainder	remainder

^AWhen specified for bearings, the phosphorus content shall be maintained from 0.01 to 0.15 %.

TABLE 2 Tensile Strength Requirements and Approximate Rockwell Hardness Values

NOTE 1—Plate is generally available in only the as hot-rolled (M20) temper. Required properties for other tempers shall be agreed upon between the manufacturer purchaser at the time of placing the order.

Temper Designation ^A		Thickness, in. [mm]	Tensile Strength, ksi ^B [MPa]		Approximate Rockwell Hardness			
Standard	Former		Min	Max	B Scale	Superficial		
Copper Alloy UNS No. C51000								
M20	as hot-rolled	Over 0.188 [4.775]	40 [275]	60 [415]	...	...
O60	soft	Over 0.039 [0.991]	43 [295]	58 [400]	16-64	...		
		Over 0.029 [0.737]			...	32-59		
		Over 0.020 [0.508] to 0.039 [0.991] incl			12-60	...		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	24-53		
H02	half-hard	0.003 [0.076] to 0.010 [0.254] incl			...	...
		Over 0.039 [0.991]	58 [400]	73 [505]	64-85	...		
		Over 0.029 [0.737]			...	59-73		
		Over 0.02 [0.508] to 0.039 [0.991] incl			60-82	...		
H04	hard	Over 0.010 [0.254] to 0.029 [0.737] incl			...	53-69		
		0.003 [0.076] to 0.010 [0.254] incl			...	...
		Over 0.039 [0.991]	76 [525]	91 [625]	86-93	...		
		Over 0.029 [0.737]			...	73-78		
H06	extra-hard	Over 0.020 [0.508] to 0.039 [0.991] incl			...	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	84-91		
		0.003 [0.076] to 0.010 [0.254] incl			...	71-75		
		Over 0.039 [0.991]	88 [606]	103 [710]	92-96	...		
H08	spring	Over 0.029 [0.737]			...	77-81		
		Over 0.020 [0.508] to 0.039 [0.991] incl			...	89-95		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	74-78		
		0.003 [0.076] to 0.010 [0.254] incl			...	...
H10	extra-spring	Over 0.039 [0.991]	95 [655]	110 [760]	94-98	...		
		Over 0.029 [0.737]			...	79-82		
		Over 0.020 [0.508] to 0.039 [0.991] incl			...	92-97		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	76-80		
		0.003 [0.076] to 0.010 [0.254] incl			...	...
		Over 0.039 [0.991]	100 [690]	114 [790]	96-99	...		
		Over 0.029 [0.737]			...	80-83		
		Over 0.020 [0.508] to 0.039 [0.991] incl			...	94-98		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	...
		0.003 [0.076] to 0.010 [0.254] incl			...	77-81		
		Copper Alloy UNS Nos. C51100, C53400, and C54400						
		M20	as hot-rolled	Over 0.188 [4.775]	40 [275]	58 [415]
O60	soft	Over 0.039 [0.991]	40 [275]	55 [380]	7-50	...		
		Over 0.029 [0.737]			...	24-50		
		Over 0.020 [0.508] to 0.039 [0.991] incl			0-45	...		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	16-46		
H02	half-hard	Over 0.010 [0.254] to 0.029 [0.737] incl			...	...
		Over 0.039 [0.991]	55 [380]	70 [45]	60-81	...		
		Over 0.029 [0.737]			...	57-73		
		Over 0.020 [0.508] to 0.039 [0.991] incl			53-78	...		
H04	hard	Over 0.010 [0.254] to 0.029 [0.737] incl			...	52-71		
		Over 0.039 [0.991]	72 [496]	87 [600]	82-90	...		
		Over 0.029 [0.737]			...	71-77		
		Over 0.020 [0.506] to 0.039 [0.991] incl			80-86	...		
H06	extra-hard	Over 0.010 [0.254] to 0.029 [0.737] incl			...	69-75		
		Over 0.039 [0.991]	84 [580]	99 [685]	88-94	...		
		Over 0.029 [0.737]			...	75-80		
		Over 0.020 [0.506] to 0.039 [0.991] incl			86-92	...		
H08	spring	Over 0.010 [0.254] to 0.029 [0.737] incl			...	73-78		
		Over 0.039 [0.991]	91 [625]	106 [720]	90-98	...		
		Over 0.029 [0.737]			...	77-81		
		Over 0.020 [0.508] to 0.039 [0.991] incl			86-94	...		
H10	extra-spring	Over 0.010 [0.254] to 0.029 [0.737] incl			...	75-79		
		Over 0.039 [0.991]	96 [680]	108 [750]	92-97	...		
		Over 0.029 [0.737]			...	78-82		
		Over 0.020 [0.508] to 0.039 [0.991] incl			89-94	...		
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	76-80		
						

TABLE 2 *Continued*

Temper Designation ^A		Thickness, in. [mm]	Tensile Strength, ksi ^B [MPa]		Approximate Rockwell Hardness	
Standard	Former		Min	Max	B Scale	Superficial
Copper Alloy UNS No. C51900						
O60	soft	Over 0.039 [0.991]	48 [330]	63 [435]	22-66	...
		Over 0.029 [0.737]			...	35-64
		Over 0.020 [0.508] to 0.039 [0.991] incl			18-63	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	25-57
H02	half-hard	Over 0.039 [0.991]	64 [440]	79 [545]	70-88	...
		Over 0.029 [0.737]			...	63-76
		Over 0.020 [0.508] to 0.039 [0.991] incl			65-85	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	58-72
H04	hard	Over 0.039 [0.991]	80 [550]	96 [680]	89-95	...
		Over 0.029 [0.737]			...	74-80
		Over 0.020 [0.508] to 0.039 [0.991] incl			86-93	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	72-78
Copper Alloy UNS No. C52100						
M20	as hot-rolled	Over 0.188 [4.775]	50 [345]	78 [485]	...	...
O60	soft	Over 0.039 [0.991]	53 [365]	67 [460]	29-70	...
		Over 0.029 [0.737]			...	38-68
		Over 0.020 [0.508] to 0.039 [0.991] incl			20-66	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	27-62
H02	half-hard	Over 0.039 [0.991]	69 [475]	84 [580]	76-91	...
		Over 0.029 [0.737]			...	67-78
		Over 0.020 [0.508] to 0.039 [0.991] incl			69-88	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	63-75
H04	hard	Over 0.039 [0.991]	85 [585]	100 [690]	91-97	...
		Over 0.029 [0.737]			...	76-81
		Over 0.020 [0.508] to 0.039 [0.991] incl			89-95	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	73-80
H06	extra-hard	Over 0.039 [0.991]	97 [670]	112 [770]	95-100	...
		Over 0.029 [0.737]			...	78-83
		Over 0.020 [0.508] to 0.039 [0.991] incl			93-98	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	77-82
H08	spring	Over 0.039 [0.991]	105 [720]	119 [820]	97-102	...
		Over 0.029 [0.737]			...	79-84
		Over 0.020 [0.508] to 0.039 [0.991] incl			95-100	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	78-83
H10	extra-spring	Over 0.039 [0.991]	110 [760]	122 [830]	98-103	...
		Over 0.029 [0.737]			...	80-84
		Over 0.020 [0.508] to 0.039 [0.991] incl			96-101	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	79-83
Copper Alloy UNS No. C52400						
M20	as hot-rolled	Over 0.188 [4.775]	55 [380]	75 [515]	...	...
O60	soft	Over 0.039 [0.991]	58 [400]	73 [506]	35-75	...
		Over 0.029 [0.737]			...	40-78
		Over 0.020 [0.508] to 0.039 [0.991] incl			25-71	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	29-84
H02	half-hard	Over 0.039 [0.991]	76 [525]	91 [625]	78-96	...
		Over 0.029 [0.737]			...	67-80
		Over 0.020 [0.508] to 0.039 [0.991] incl			74-93	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	63-77
H04	hard	Over 0.039 [0.991]	94 [650]	109 [750]	94-101	...
		Over 0.029 [0.737]			...	78-82
		Over 0.020 [0.508] to 0.039 [0.991] incl			92-100	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	75-81
H06	extra-hard	Over 0.039 [0.991]	107 [740]	122 [830]	98-103	...
		Over 0.029 [0.737]			...	80-84
		Over 0.020 [0.508] to 0.039 [0.991] incl			97-102	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	79-83
H08	spring	Over 0.039 [0.991]	115 [790]	129 [890]	99-104	...
		Over 0.029 [0.737]			...	81-85
		Over 0.020 [0.508] to 0.039 [0.991] incl			98-103	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	80-84
H10	extra-spring	Over 0.039 [0.991]	120 [830]	133 [920]	100-106	...
		Over 0.029 [0.737]			...	82-86
		Over 0.020 [0.508] to 0.039 [0.991] incl			99-104	...
		Over 0.010 [0.254] to 0.029 [0.737] incl			...	81-85

^A Standard designations defined in Practice B 601.

^B ksi = 1000 psi.

9. Grain Size of Annealed Tempers

9.1 Other than O60 (soft) temper, as indicated in Table 2, annealed tempers are special, and the material shall conform to grain size requirements agreed upon between manufacturer and purchaser as defined in Practice B 601.

10. Mechanical Property Requirements

10.1 Tensile Strength Requirements:

10.1.1 Products ordered to this specification in inch-pound units shall be tested in accordance with Test Methods E 8 and shall conform to tensile strength requirements prescribed in ksi units in Table 2.

10.1.2 Products ordered to this specification in SI units shall be tested in accordance with Test Methods E 8M, and shall conform to tensile strength requirements prescribed in MPa units in Table 2.

10.1.3 Acceptance or rejection based on mechanical properties shall depend only on the tensile strength.

10.1.4 The tension test specimens shall be taken so the longitudinal axis of the specimens is parallel to direction of rolling.

10.2 Rockwell Hardness:

10.2.1 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 4—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.

11. Other Requirements

11.1 *Purchases for U.S. Government Agencies*—When identified in the contract or purchase order, product purchased for agencies of the U.S. Government shall conform to the special government requirements stipulated in the supplemental requirements given in Specification B 248.

12. Dimensions, Mass, and Permissible Variations

12.1 The dimensions and tolerances for product described by this specification shall be as specified in Specification B 248 with particular reference to the following tables and related paragraphs in that specification.

12.1.1 Thickness:

12.1.1.1 *Tolerances*—See Table 1.

12.1.2 Width:

12.1.2.1 *Tolerances for Slit Metal and Slit Metal with Rolled Edges*—See Table 4.

12.1.2.2 *Tolerances for Square-Sheared Metal*—See Table 5.

12.1.2.3 *Tolerances for Sawed Metal*—See Table 6.

12.1.3 Length:

12.1.3.1 *Tolerances for Straight Lengths*—See Table 7.

12.1.3.2 *Schedule of Minimum Lengths with Ends*—See Table 8.

12.1.3.3 *Tolerances for Squared-Sheared Metal*—See Table 9.

12.1.3.4 *Tolerances for Sawed Metal*—See Table 10.

12.1.4 Straightness:

12.1.4.1 *Tolerances for Slit Metal or Slit Metal Either Straightened or Edge-Rolled*—See Table 11.

12.1.4.2 *Tolerances for Squared Sheared Metal*—See Table 12.

12.1.4.3 *Tolerance for Squared Sheared Metal*—See Table 13.

12.1.5 Edges:

12.1.5.1 *Tolerances for Radius of Square Edges*—See Table 14.

12.1.5.2 *Tolerances for Radius of Round Corners*—See Table 15.

12.1.5.3 *Tolerances for Radius of Round Edges*—See Table 16.

12.1.5.4 *Tolerances for Radius of Full-Rounded Edges*—See Table 17.

13. Sampling

13.1 Chemical Analysis:

13.1.1 The sample for chemical analysis shall be taken from the pieces selected and combined into one composite sample in accordance with Practice E 255 for product in its final form. The minimum weight of the composite sample shall be 150 g.

13.1.2 Instead of sampling in accordance with Practice E 255, the manufacturer shall have the option of taking samples at the time the castings are poured or by taking samples from the semi-finished product.

13.1.2.1 When composition of the material has been determined during the course of manufacture, sampling of the finished product by the manufacturer is not required.

13.1.3 The number of samples to be taken for determination of chemical composition shall be as follows.

13.1.3.1 When sampled at the time the castings are poured, at least one sample shall be taken for each group of castings poured from the same source of molten metal.

13.1.3.2 When sampled from the semi-finished product, at least one sample shall be taken to represent each 10 000 lb, or fraction thereof, except that not more than one sample shall be required per piece.

13.1.3.3 Only one sample need be taken from the semi-finished product of one cast bar from a single furnace melt charge continuously processed.

13.1.3.4 When the material is cast in the horizontal continuous casting mode, at least one sample will be taken to represent the composition of the holder per cast coil.

14. Test Methods

14.1 Chemical Analysis:

14.1.1 Chemical composition shall be determined, in case of disagreement, by the following appropriate methods:

Element	Test Method
Copper	E 478
Iron	E 75 (AA)
Lead	E 478 (AA)
Phosphorus	E 62
Tin	E 478 (Photometric)
Zinc	E 478 (AA)

14.1.2 Test methods(s) used for the determination of element(s) required by contractual or purchase order agreement shall be as agreed upon between the manufacturer and the purchaser.

15. Keywords

15.1 copper-tin alloy plate; copper-tin alloy rolled bar; copper-tin alloy sheet; copper-tin alloy strip; copper-tin-lead alloy plate; copper-tin-lead alloy rolled bar; copper-tin-lead

alloy sheet; copper-tin-lead alloy strip; copper-tin-lead-zinc alloy plate; copper-tin-lead-zinc alloy rolled bar; copper-tin-lead-zinc alloy sheet; copper-tin-lead-zinc alloy strip

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue B 103/B 103M-93 that may impact the use of this standard.

The standard has changed editorially as a result of the current outline of form. No technical changes to the tables have been made.

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