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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar[1]

This standard is issued under the fixed designation B 194; 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 Department of Defense.

1. Scope

1.1 This specification covers copper-beryllium alloy plate, sheet, strip, and rolled bar. The following alloys are covered:[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 required, Copper Alloy UNS No. C17200 shall be the alloy furnished whenever Specification B 194 is specified without any alloy designation.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.4 The following hazard statement pertains only to the test method portions in the annex of this specification:

1.5 *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 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*

B 248 Specification for General Requirements for Wrought Copper and Copper-Alloy Plate, Sheet, Strip, and Rolled Bar[3]

B 601 Practice for Temper Designations for Copper and Copper Alloys—Wrought and Cast[3]

E 8 Test Methods for Tension Testing of Metallic Materials[4]

E 18 Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials[4]

E 112 Test Methods for Determining Average Grain Size[4]

E 527 Practice for Numbering Metals and Alloys (UNS)[5]

3. Ordering Information

3.1 Orders for material under this specification should include the following information:

3.1.1 Quantity,

3.1.2 Copper Alloy UNS number (1.1),

3.1.3 Form of material: plate, sheet, strip, or rolled bar,

3.1.4 Temper (5.1),

3.1.5 Dimensions: thickness and width, and length if applicable.

3.1.6 How furnished: rolls, stock lengths with or without ends, specific lengths with or without ends,

3.1.7 Type of edge, if required: slit, sheared, sawed, square corners, rounded corners, rounded edges, or full-rounded edges (Section 12),

3.1.8 Type of width and straightness tolerances, if required: slit-metal tolerances, square-sheared-metal tolerances, sawed-metal tolerances, straightened or edge-rolled-metal tolerances (Section 12),

3.1.9 Special thickness tolerances, if required (12.2),

3.1.10 Tension test or hardness as applicable (Section 6),

3.1.11 Bend test, if required (Section 9),

3.1.12 Grain size or grain count if required (Section 7 or 8),

3.1.13 Certification if required (see Specification B 248, Section 13),

3.1.14 Mill Test Report, if required (see Specification B 248, Section 14),

3.1.15 Specification number and year of issue, and

3.1.16 Special tests or exceptions, if any.

3.2 When material is purchased for agencies of the U.S. Government, this shall be specified in the contract or purchase order, and the material shall conform to the Supplementary requirements as defined in the current issue of Specification B 248.

4. Chemical Composition

4.1 The material shall conform to the chemical requirements specified in Table 1.

4.2 These specification limits do not preclude the presence of other elements. Limits for unnamed elements may be

[1] This specification is under the jurisdiction of ASTM Committee B-5 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.

[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 01.01.

TABLE 1 Chemical Requirements

Element	Composition, %	
	Copper Alloy UNS No. C17000	Copper Alloy UNS No. C17200
Beryllium	1.60–1.79	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

established, by agreement between manufacturer or supplier and purchaser. Copper may be given 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 analyzed, their sum shall be 99.5 % minimum.

5. Temper

5.1 Tempers available under this specification are defined in Practice B 601. The standard tempers of product are as designated in Table 2, Table 3, and Table 4. Plate is generally available in the TB00 (A), TD04 (H), TF00 (AT), and TH04 (HT) tempers.

NOTE 1—Plate is generally available in the TB00 (solution-heat treated) and TD04 (hard) tempers.

6. Mechanical Properties

6.1 Product less than 0.050 in. (0.127 mm) in thickness.

6.1.1 Tensile test results shall be the product acceptance criteria when tested in accordance with Test Method E 8.

6.1.2 The tensile strength requirements are given in Table 2, Table 3 and Table 4.

6.2 Product 0.050 in. (1.270 mm) and greater in thickness.

6.2.1 Rockwell hardness is the product acceptance criteria when tested in accordance with Test Method E 18.

6.2.2 The referee product rejection criteria shall be tensile test results when tested in accordance with Test Method E 8.

6.2.3 Rockwell hardness and tensile strength requirements are given in Table 2, Table 3, and Table 4.

6.3 Product, as specified in 5.1 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 10.

7. Grain Size

7.1 Material over 0.010 in. (0.254 mm) in thickness shall have an average grain size in accordance with Test Method E 112, 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.

8. Grain Count

8.1 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.

8.2 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.

9. Bend Test Requirements

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

9.2 When specified in the order (see 3.1.6), material in any temper 0.004 to 0.020 in. (0.102 to 0.508 mm), inclusive, in thickness shall conform to the requirements specified in Table 7 when tested in accordance with 11.2.

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.		Tensile Strength, ksi[B] (MPa)[C]	Elongation[D] in 2 in. or 50 mm, min,%	Rockwell Hardness[E]		
Standard	Former	Over	Incl			B Scale	30T Scale	15T Scale
TB00	A	...	...	60–78 (410–540)	35	45–78	46–67	75–85
TD01	¼ H	...	0.188	75–88 (520–610)	15	68–90	62–75	83–89
TD02	½ H	...	0.188	85–100 (590–690)	9	88–96	74–79	88–91
TD04	H	...	0.188	100–130 (690–900)	2	96–104	79–83	91–94
TD04	H	0.188	0.375	90–130 (660–900)	...	91–103	77	90
TD04	H	0.375	1.000	90–120 (620–830)	...	90–102	...	...
TD04	H	over 1.000		85–115 (590–800)	8	88–102	...	...

[A] Standard designations defined in Practice B 601.
[B] ksi = 100 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.		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		
Standard	Former	Over	Incl				C Scale	30N Scale	15N Scale
Copper Alloy UNS No. C17000									
TF00	AT	...	0.188	150–180[F] (1030–1240)	130 (890)	3	33	53	76.5
TF00	AT	0.188	...	165–195[F] (1140–1340)	130	3	36	56	78
TH01	¼ HT	...	...	160–190[F] (1100–1310)	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] (1140–1340)	140 (960)	3	36	56	78
TH01	¼ HT	...	0.188	175–205[F] (1210–1410)	150 (1030)	2.5	36	56	79
TH02	½ HT	...	0.188	185–215[F] (1280–1480)	160 (1100)	1	38	58	79.5
TH04	HT	...	0.188	190–220[F] (1310–1520)	165 (1140)	1	38	58	80
TH04	HT	0.188	0.375	180–215[F] (1240–1480)	160 (1100)	1	38	58	80
TH04	HT	0.375	1.000	180–210[F] (1240–1450)	155 (1070)	1	38	...	...
TH04	HT	1.000	2.000	175–205[F] (1210–1410)	150 (1030)	2	37	...	...
TH04	HT	over 2.000		165–200[F] (1140–1380)	130 (890)	2	36	...	...

[A] These values apply to mill products (Section 11). See 10.3 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.

9.3 Five specimens, ⅜ ± 1⁄16 in. (9.52± 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 10.2. The specimen shall be clamped firmly between a flat jaw and the test radius, as shown in Fig. 1. The test specimen shall be bent approximately 90° around the test radius, using a tangential wiping motion with adequate radial pressure to assure continuous contact between the specimen and the test radius. To pass the bend test, at least four specimens out of five, and at least 80 % of the total specimens tested from a lot must withstand the 90° bend without visible crack or fracture when observed in the full 90° bend position. The test radius shall be within ±6 % of the nominal radius up to 0.010 in. (0.254 mm), exclusive, and within ±4 % for radii 0.010 in. and over.

10. Precipitation Heat Treatment

10.1 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.

10.2 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.

10.3 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.

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

11. Specimen Preparation

11.1 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.

11.2 When required, five bend test specimens per test set shall be cut ⅜ ± 1⁄16 in. (9.52 ± 1.59 mm) in width and any convenient length. Specimens shall be precipitation heat treated after cutting and prior to testing. Precipitation heat treat parameters for these bend tests shall be in accordance with 10.2.

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		
Standard	Former[B]				C Scale	30N Scale	15N Scale
Copper Alloy UNS No. C17000							
TM00	AM	100–110[F] (690–760)	70–95 (480–660)	18	18	37	67.5
TM01	¼ HM	110–120[F] (760–830)	80–110 (550–760)	15	20	42	70
TM02	½ HM	120–135[F] (830–930)	95–125 (660–860)	12	24	45	72
TM04	HM	135–150[F] (930–1040)	110–135 (760–930)	9	28	48	75
TM05	SHM	150–160[F] (1030–1100)	125–140 (860–970)	9	31	52	75.5
TM06	XHM	155–175[F] (1070– 1210)	135–165 (930–1140)	3	32	52	76
Copper Alloy UNS No. C17200							
TM00	AM	100–110[F] (690–760)	70–95 (480–660)	16	R_B95	37	67.5
TM01	¼ HM	110–120[F] (760–830)	80–110 (550–760)	15	20	42	70
TM02	½ HM	120–135[F] (830–930)	95–125 (660–860)	12	23	44	72
TM04	HM	135–150[F] (930–1030)	110–135 (760–930)	9	28	48	75
TM05	SHM	150–160[F] (1030–1100)	125–140 (860–970)	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 (1030–1240)	3	33	53	76.5

[A] These values apply to mill products (Section 11). See 10.3 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 2.24), incl	OS045	0.045
Over 0.090 to 0.188 (2.24 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

11.3 Other specimens shall be prepared in accordance with Specification B 248, Section 9.

12. Test Methods

12.1 The method for determining chemical analysis for compliance and preparation of certifications and test reports shall be at the discretion of the reporting laboratory.

12.2 In case of dispute, the test methods found in Annex A1 shall be used for determining chemical requirements for the elements and ranges shown in Table 1.

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.

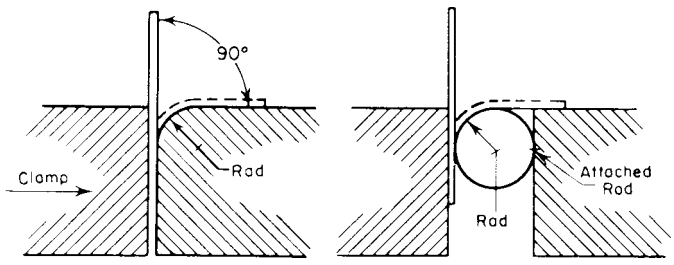

FIG. 1 Methods for Clamping Specimen to Radius for Bend Test

12.2.1 When analysis for unnamed or residual elements is required in the purchase order, the method of analysis shall be mutually agreed upon between manufacturer or supplier and purchaser.

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

12.3 Bend test specimens, when required, shall be tested by clamping them firmly between a flat jaw and the test radius, as shown in Fig. 1. The test specimen shall be bent approximately 90° around the test radius, using a tangential wiping motion with adequate radial pressure to ensure continuous contact between the specimen and the test radius. To pass the bend test, at least four specimens out of five, and at least 80 % of the total specimens tested from a lot must withstand the 90° bend without visible crack or fracture when observed in the full 90° bend position. The test radius shall be within ±6 % of the nominal radius up to 0.010 in. (0.254 mm), exclusive, and within ±4 % for radii 0.010 in. and over.

12.4 The methods for determining the other mechanical and physical properties are in Specification B 248.

13. Dimensions and Permissible Variations

13.1 The dimensions and tolerances for material covered by this specification shall be as prescribed in the current edition of Specification B 248 with particular reference to Section 5 and the following tables of that specification:

13.2 *Thickness*—See 5.2, Table 2, and for special tolerances, Table 3.

13.3 *Width*:

13.3.1 *Slit Metal and Slit Metal with Rolled Edges*—See 5.3.1, Table 4.

13.3.2 *Square-Sheared Metal*—See 5.3.2, Table 5.

13.3.3 *Sawed Metal*—See 5.3.3, Table 6.

13.4 *Length*:

13.4.1 *Specific and Stock Lengths With and Without Ends*—See 5.4.1, Table 7.

13.4.2 *Schedule of Lengths (Specific and Stock) With Ends*—See 5.4.2, Table 8.

13.4.3 *Length Tolerances for Square-Sheared Metal*—See 5.4.3, Table 9.

13.4.4 *Length Tolerances for Sawed Metal*—See 5.4.4, Table 10.

13.5 *Straightness*:

13.5.1 *Slit Metal or Slit Metal Either Straightened or Edge-Rolled*—See 5.5.2, Table 11.

13.5.2 *Square-Sheared Metal*—See 5.5.2, Table 12.

13.5.3 *Sawed Metal*—See 5.5.3, Table 13.

13.6 *Edges*—See 5.6:

13.6.1 *Square Edges*—See 5.6.1, Table 14.

13.6.2 *Rounded Corners*—See 5.6.2, Table 15.

13.6.3 *Rounded Edges*—See 5.6.3, Table 16.

13.6.4 *Full-Rounded Edges*—See 5.6.4, Table 17.

14. General Requirements

14.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification B 248.

15. Sampling

15.1 Sampling shall be in accordance with Specification B 248, Section 7, except that the heat size is defined as 12 000 lbs (5455 kg) or fraction thereof.

16. Keywords

16.1 copper-beryllium; flat products; copper plate; copper rolled bar; copper strip

ANNEX

(Mandatory Information)

A1. TEST METHODS FOR DETERMINATION OF COMPLIANCE WITH COPPER-BERYLLIUM ALLOYS CHEMICAL COMPOSITION REQUIREMENTS

A1.1 Scope

A1.1.1 These test methods describe the procedure(s) for the determination of chemical composition of copper-beryllium alloys.

A1.1.2 The analytical procedures appear in the following order:

Procedure	Sections
Test Method A—Copper by the Electrolytic Method	A1.8 to A1.15
Test Method B—Aluminum, Beryllium, Cobalt, Iron, and Nickel by the Flame Atomic Absorption Spectrophotometric Method	A1.16 to A1.24
Test Method C—Silicon by the Ammonium Molybdate Spectrophotometric Method	A1.28.2 to A1.35

A1.2 Referenced Documents

A1.2.1 *ASTM Standards:*

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[6]

E 50 Practice for Apparatus, Reagents, and Safety Precautions for Chemical Analysis of Metals[7]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Color Composition[7]

E 60 Practice for Photometric and Spectrophotometric Methods for Chemical Analysis of Metals[7]

E 663 Practice for Flame Atomic Absorption Analysis[8]

E 1024 Guide for Chemical Analysis of Metals and Metal

[6] *Annual Book of ASTM Standards*, Vol 14.02.
[7] *Annual Book of ASTM Standards*, Vol 03.05.
[8] *Annual Book of ASTM Standards*, Vol 03.06.

Bearing Ores by Flame Atomic Absorption Spectrophotometry[8]

A1.3 Significance and Use

A1.3.1 These test methods are primarily intended to test for compliance with compositional specifications. It is assumed that all who use these test methods will be trained analysts capable of performing common laboratory procedures skillfully and safely. It is expected that work will be performed in a properly equipped laboratory.

A1.4 Apparatus, Reagents, and Photometric Practice

A1.4.1 Apparatus and reagents required for each determination are listed in separate sections preceding the procedure. The apparatus, standard solutions, and certain other reagents are referred to by number and shall conform to the requirements prescribed in Practice E 50.

A1.4.2 Flame atomic absorption spectrophotometric practice prescribed in these test methods shall conform to the requirements prescribed in Practice E 663 and Guide E 1024.

A1.4.3 Spectrophotometric practice prescribed in these test methods shall conform to requirements prescribed in Practice E 60.

A1.5 Hazards

A1.5.1 For precautions to be observed in these test methods, refer to Practice E 50.

A1.5.2 Both beryllium metal and its compounds may be toxic. Exercise care to prevent contact of beryllium-containing solutions with the skin. Especially avoid the inhalation of any beryllium-containing substance, either as a volatile compound or as a finely divided powder. The proper precautions are to be observed in the disposition of beryllium-containing residues, especially ignited oxide.

A1.6 Sampling

A1.6.1 Sampling shall conform to the requirements of Practice E 55.

A1.7 Rounding Off Calculated Values

A1.7.1 Calculated values shall be rounded off to the proper number of places in accordance with the method given in 3.4 and 3.5 of Practice E 29.

TEST METHOD A—COPPER BY ELECTROLYTIC DEPOSITION AND ATOMIC ABSORPTION SPECTROPHOTOMETRY

A1.8 Scope

A1.8.1 This test method describes the determination of copper in copper-beryllium alloys with silver reported as copper.

A1.9 Summary of Test Methods

A1.9.1 The sample is dissolved in an acid mixture. A small amount of hydrofluoric acid is added to minimize possible interferences. Copper is electrolytically deposited on a tared platinum cathode. Copper remaining in the electrolyte is determined by atomic absorption spectrophotometry.

A1.10 Interferences

A1.10.1 Elements normally present do not interfere.

A1.11 Apparatus

A1.11.1 *Electrodes for Electrolysis*—Apparatus No. 9, in Practice E 50.

A1.11.2 *Atomic Absorption Spectrophotometer*—Determine the instrument to be suitable for use as directed in Guide E 1024. Instrument response must permit estimation of copper concentration to within 1 mg/

A1.11.3 *Operating Parameters*—Wavelength, fuel/oxidant, and flame conditions are as follows:

Wavelength, nm	Fuel/Oxidant	Flame Condition
Copper 327.5	Acetylene/air	Oxidizing

A1.12 Reagents

A1.12.1 *Sulfuric-Nitric Acid Mixture*—While stirring, slowly add 500 mL of H_2SO_4 to 1 L of water. Cool and transfer to a 2-L volumetric flask. Add 300 mL of HNO_3. Cool, dilute to volume, and mix.

A1.12.2 *Copper Standard Solution* (1 mL = 1.0 mg Cu)—Transfer 1.000 g of copper metal (purity, 99.9 % min) into a 250-mL beaker. Add 20 mL of the acid mixture. Cover the beaker and allow to stand until dissolution is nearly complete. Heat at 80 to 90°C until dissolution is complete and brown fumes have been expelled. Cool, transfer into a 1-L volumetric flask, dilute to volume, and mix.

A1.12.3 *Calibration Solutions*—Pipet 5, 10, 15, 20, and 25-mL portions of the copper standard solution into individual 1-L volumetric flasks. Add 50 mL of the acid mixture to each flask, dilute to volume, and mix. These solutions are equivalent to 0.005, 0.010, 0.015, 0.020, and 0.025 g of copper respectively.

A1.12.4 *Zero Calibration Solution*—Transfer 50 mL of the acid mixture into a 1-L volumetric flask, dilute to volume, and mix.

A1.13 Procedure

A1.13.1 Transfer 2.500-g portion into each of two electrolysis beakers, normally 300-mL. Add 50 mL of the mixed acid, cover the beaker, and allow to stand until the reaction subsides. Heat at 80 to 90°C until dissolution is complete and brown fumes have been expelled. Cool and wash down cover glass and inside of beaker. Add 1.0 mL of HF, hydrofluoric acid, (1 + 9) from a plastic pipet and dilute to about half volume.

A1.13.2 Insert the electrodes and dilute to just submerge the cathode. Cover the beaker with a pair of split cover glasses and electrolyze at a current density of about 0.6 A/dm^2 for about 16 h.

A1.13.3 Wash down the cover glasses, inside the beaker, electrode stems, and continue electrolysis for about 15 min. Should copper plate out on the newly exposed cathode surface, dilute a second time and continue electrolysis for an additional 15 min. Copper deposition shall be considered completed when no copper is deposited on a newly exposed surface.

A1.13.4 Quickly withdraw the cathode from the electrolyte while maintaining current flow (should the electrolysis system permit), and direct a gentle stream of water from a wash bottle over its surface. Rinse the cathode in a water bath and then dip