



Designation: B170 – 99 (Reapproved 2020)

# Standard Specification for Oxygen-Free Electrolytic Copper—Refinery Shapes<sup>1</sup>

This standard is issued under the fixed designation B170; 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 ( $\epsilon$ ) 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 two grades of oxygen-free electrolytic copper wire bars, billets, and cakes produced without the use of metallic or metaloidal deoxidizers.

1.2 Oxygen-free copper, as described herein, is defined as copper containing oxygen not in excess of 0.0010 % (10 ppm).

1.2.1 Grade 1 copper (UNS C10100) corresponds to the designation OFE in Classification [B224](#).

1.2.2 Grade 2 copper (UNS C10200) corresponds to the designation OF in Classification [B224](#).

1.2.3 Grade 2 copper may be used to produce OFS designation coppers corresponding to UNS C10400, C10500, and C10700.

1.3 Although this specification includes certain UNS designations as described in Practice [E527](#), these designations are for cross reference only and are not specification requirements. In case of conflict, Specification B170 shall govern.

1.4 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only, except for analytical measurements where SI units are the norm.

1.5 The following hazard caveat pertains only to Section [13](#) and [Annex A1](#), 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization 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.*

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee [B05](#) on Copper and Copper Alloys and is the direct responsibility of Subcommittee [B05.07](#) on Refined Copper.

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## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

[B5](#) Specification for High Conductivity Tough-Pitch Copper Refinery Shapes

[B193](#) Test Method for Resistivity of Electrical Conductor Materials

[B224](#) Classification of Coppers

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

[B846](#) Terminology for Copper and Copper Alloys

[E29](#) Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

[E50](#) Practices for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials

[E53](#) Test Method for Determination of Copper in Unalloyed Copper by Gravimetry

[E76](#) Test Methods for Chemical Analysis of Nickel-Copper Alloys (Withdrawn 2003)<sup>3</sup>

[E255](#) Practice for Sampling Copper and Copper Alloys for the Determination of Chemical Composition

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

## 3. Terminology

3.1 *Definitions*:

3.1.1 Definition of terms used shall be that found in Classification [B224](#) and Terminology [B846](#).

## 4. Ordering Information

4.1 Orders for material shall include the following information:

4.1.1 ASTM designation and year of issue,

4.1.2 Grade,

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

4.1.2.1 Grade 1 copper, (UNS C10100), corresponds to the designation OFE in Classification B224,

4.1.2.2 Grade 2 copper (UNS C10200), corresponds to the designation OF in Classification B224,

4.1.3 Shape and size, and

4.1.4 Quantity.

4.2 The following options are available and should be specified at time of order when required:

4.2.1 Certification,

4.2.2 Test reports,

4.2.3 Piece identification,

4.2.4 The amount of silver required in troy oz/short ton for silver bearing (OFS) coppers,

4.2.4.1 The addition of silver up to an average of 30 troy oz/short ton (0.102 %) will be considered within the specification, with no individual silver analysis to exceed 35 troy oz/short ton (0.12 %), and

4.2.4.2 Copper with added silver corresponds to the designation OFS as shown in Classification B224 and to coppers UNS C10400, C10500, and C10700 as defined by the agreed silver content.

## 5. Chemical Composition

5.1 The composition of each grade shall be in accordance with the requirements of Table 1.

5.2 By agreement between purchaser and supplier, analysis may be required and limits established for elements not specified in Table 1.

## 6. Physical Properties

6.1 *Electrical Resistivity:*

6.1.1 The maximum mass resistivity for Grade 1 is 0.15176  $\Omega$  g/m<sup>2</sup> (conductivity 101 %, minimum, International Annealed Copper Standards, (IACS).

6.1.2 The maximum mass resistivity for Grade 2 is 0.15328  $\Omega$  g/m<sup>2</sup> (conductivity 100 %, minimum, IACS).

6.2 *Embrittlement Test:*

6.2.1 Grade 1 shall withstand ten *reverse* bends without breaking, in accordance with Test Method D of Test Methods B577.

6.2.2 Grade 2 shall withstand eight *reverse* bends without breaking in accordance with Test Method D of Test Methods B577.

## 7. Dimensions, Mass, and Permissible Variations

7.1 *Standard Shapes and Sizes*—The copper shall be supplied in the form of wire bars, cakes, and billets (Note 1).

NOTE 1—For available shapes and sizes consult the manufacturer’s published list.

7.1.1 Wire bars covered by this specification do not conform in dimension to Specification B5.

7.2 *Wire Bars:*

7.2.1 A variation of 5 % in weight, or

7.2.2 A variation of ¼ in. (6.4 mm) in height, or width, or both, or

7.2.3 A variation of 1 % in length from the purchaser’s specification shall be considered good delivery.

7.3 *Cakes:*

7.3.1 A variation of 5 % in weight, or

7.3.2 A variation of ¼ in. (6.4 mm) in height or width, or both, from the purchaser’s specification shall be considered good delivery.

7.3.3 Cakes may vary by 3 % from any listed or specified dimension greater than 8 in. (203 mm).

7.4 *Billets:*

7.4.1 For billets up to 6 in. (152.4 mm) in diameter, a variation of 5 % in weight and  $\pm 1/16$  in. (1.6 mm) in diameter from the purchaser’s specification shall be considered good delivery.

7.4.2 For billets 6 in. (152.4 mm) and over in diameter, the diameter tolerance shall be  $+1/16, -1/8$  in. (+1.6 mm, –3.2 mm) for good delivery.

7.4.3 By agreement between the manufacturer and the purchaser a diameter tolerance of +0 in.,  $-3/16$  in. (+0 mm, –4.8 mm) may be specified for billets 6 in. and over in diameter.

7.4.4 Billets varying in length by  $\pm 2$  % from the listed or specified length shall be considered good delivery.

7.4.5 Billets shall be straight within ¼ in. (6.4 mm) in 4 ft (1.22 m) as measured at the center of the billet.

7.4.6 Billets shall not be cupped except by specific agreement at time of purchase.

## 8. Workmanship, Finish, and Appearance

8.1 *Wire Bars, Billets, and Cakes*—Shall be substantially free of shrink holes, porosity, cracks, cold sets, pits, inclusions, and similar defects.

## 9. Sampling

9.1 For routine sampling, the method of sampling shall be at the discretion of the sampler.

TABLE 1 Chemical Composition<sup>A</sup>

Element	Grade 1	Grade 2
Copper, min %	99.99 <sup>B</sup>	...
Copper (including silver), min %	...	99.95
	ppm, max	ppm, max
Antimony	4	...
Arsenic	5	...
Bismuth	1	...
Cadmium	1	...
Iron	10	...
Lead	5	...
Manganese	0.5	...
Nickel	10	...
Oxygen	5	10
Phosphorus <sup>C</sup>	3	...
Selenium	3	...
Silver	25	...
Sulfur	15	...
Tellurium	2	...
Tin	2	...
Zinc	1	...

<sup>A</sup> Analytical uncertainty is not incorporated into the specified limits.

<sup>B</sup> Copper is determined by the difference of impurity total from 100.

<sup>C</sup> Refer to Section 13.

9.2 In the case of special requirements specified in the purchase order or contract, the method of sampling shall be as agreed upon between the producer, or supplier, and the purchaser.

9.3 In case of dispute, a sampling lot shall consist of all pieces in a shipment manufactured during a single production period as defined and recorded by the manufacturer.

9.4 *Chemical Composition*—In case of dispute concerning chemical composition, each party shall select two pieces from the lot to be investigated.

9.4.1 Each of the four selected pieces shall be sampled in the presence of both parties by drilling five holes, approximately ½ in. (12.7 mm) in diameter, at points equally spaced between the ends of the pieces.

9.4.2 For wire bars or billets, these holes shall be along an approximate center line, and with cakes, along an approximate diagonal line between opposite corners.

9.4.3 The drilling shall be completely through each piece. Surface drillings shall be rejected.

9.4.3.1 The drill bit used shall be thoroughly cleaned prior to use. The bit shall be made from a noncontaminating material.

9.4.3.2 No lubricant shall be used, and the drill shall not be forced sufficiently to cause oxidation of the drillings.

9.4.4 In case of a section more than 5 in. (125 mm) in thickness, drillings may be made from opposite sides for a depth of not less than 2 in. (51 mm) in each direction instead of completely through each piece, but, in other respects, the drillings shall be conducted as previously described.

9.4.5 The drillings from each of the four pieces are individually mixed and divided into three approximately equal portions.

9.4.5.1 Each portion shall be placed in a sealed, noncontaminating, package, and

9.4.5.2 The twelve portions shall be individually identified, and

9.4.5.3 Divided into three groups of four portion each, one portion from each of the original four pieces; one group each for the manufacturer, the purchaser, and the umpire, if necessary.

9.4.6 Sampling of individual pieces weighing over 1000 lb (453 kg) shall be by agreement between manufacturer and the purchaser.

9.5 *Oxygen*—In case of dispute concerning oxygen content, each party shall select two pieces from the lot to be investigated.

9.5.1 Each of the four selected pieces shall be sampled in the presence of both parties. A single piece of adequate size shall be cut from each of the four pieces by mutually agreeable means.

9.5.2 Each piece shall be cut into three approximately equal portions. The twelve portions thus obtained shall be individually identified.

9.5.3 The twelve portions shall be divided into three groups of four portions each, one from each of the original four pieces; one group each for the manufacturer, the purchaser, and the umpire, if necessary.

9.6 *Resistivity*—In case of dispute concerning mass resistivity, each party shall select two pieces from the lot.

9.6.1 In the presence of both parties, and by mutually agreeable means, a single sample of adequate size shall be cut from each of the four pieces and fabricated into a wire.

9.6.2 Each coil shall be cut into three portions of approximately equal length, and the twelve portions thus obtained shall be individually identified.

9.6.3 The twelve wires shall be divided into three groups of four wires each, one from each of the four original selected pieces; one group each for the manufacturer, the purchaser, and the umpire, if necessary.

9.7 *Embrittlement*—In case of dispute concerning freedom from embrittlement, sampling shall be described in 9.6.

9.8 *Variation in Weights or Dimensions*—In case of dispute concerning weights or dimensions, the representative of the manufacturer and purchaser shall inspect all pieces where physical defects or variations in weights are claimed. If such inspection is not practical, or if agreement is not reached, the question of fact shall be submitted to a mutually agreeable umpire.

## 10. Number of Tests and Retests

### 10.1 *Number of Tests:*

10.1.1 The chemical composition, except for oxygen, shall be determined as the mean of the observations from three replicate analyses of each of the four portions.

10.1.2 The oxygen content shall be determined as the mean of the results from the four test specimens.

10.1.3 The mass resistivity shall be determined as the mean of the results from the four test specimens.

10.1.4 The freedom from embrittlement shall be determined as the mean of the results from the four test specimens.

### 10.2 *Retest:*

10.2.1 In case of dispute one retest may be made by the manufacturer or the purchaser or both, under the conditions of 10.1.

### 10.3 *Umpire Test:*

10.3.1 In the case where the retest does not settle the dispute, a second retest may be made by a third qualified laboratory agreeable to the manufacturer and the purchaser. The second retest shall be made on the samples set aside for this purpose.

10.3.2 The umpire provision does not preclude other arrangements, by agreement or contract.

## 11. Specimen Preparation

### 11.1 *Oxygen:*

11.1.1 The test specimen shall originate as a single piece of appropriate size cut from a bar, cake, or billet from which a 0.25 in. (6.4 mm) test cube specimen is fabricated by means agreeable to the manufacturer and the purchaser.

11.1.2 The test specimen shall be etched with a solution of nitric acid (HNO<sub>3</sub>) (1+1) for a time sufficient to produce a visible reaction.