Designation: B216 – 16

Standard Specification for Tough-Pitch Fire-Refined Copper—Refinery Shapes[1]

This standard is issued under the fixed designation B216; 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.

1. Scope*

1.1 This specification establishes the requirements for tough-pitch fire-refined copper wire bars, cakes, slabs, and billets for fabricating into wrought products and ingot and ingot bars for use in the manufacture of copper and copper alloy castings. This copper is not intended for electrical purposes.

1.2 Copper under this specification corresponds to the designation "FRTP" (UNS C12500) as shown in Classification B224. This copper may also be used to produce other designations of copper where the chemical composition limits are not lower then those listed for C12500 in Table 1.

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. Therefore, in case of conflict, this ASTM specification shall govern.

1.4 *Units*—The 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.

1.5 The following safety hazard caveat pertains only to the test method described in the annex 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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B224 Classification of Coppers

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

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 For definitions of terms related to copper and copper alloys, refer to Classification B224 and Terminology B846.

4. Ordering Information

4.1 Include the following specified choices when placing orders for product under this specification, as applicable:

4.1.1 ASTM designation and year of issue,

4.1.2 Shape and Size: wire bar, cake, slab, billet, ingot, or ingot bar,

4.1.3 Quantity: total weight or number of pieces for each shape and size, and

4.2 When material is purchased for 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 herein.

4.3 The following options are available but may not be included unless specified at the time of placing of the order when required:

4.3.1 Certification (Section 16),

4.3.2 Test Report (Section 17).

5. Material

5.1 Any copper that will yield a product with a chemical composition conforming to the requirements of Table 1 may be used.

6. Chemical Composition

6.1 The product material shall conform to the requirements of Table 1.

[1] 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] 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**

TABLE 1 Chemical Requirements[A]

Element	Composition, %
Copper (including silver), min	99.88
Arsenic, max	0.012
Antimony, max	0.003
Bismuth, max	0.003
Lead, max	0.004
Nickel, max	0.050
Selenium + Tellurium, max	0.025

[A] Analytical variance is not incorporated into the specified limits. Refer to 10.1.

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

7. Dimensions, Mass, and Permissible Variations

7.1 A permissible variation of ±5 % in weight and ±¼ in. (6.35 mm) in any dimension from the manufacturer's published list or the purchaser's specified size shall be considered good delivery; provided, however, that cakes may vary ±3 % from the listed or specified size in any dimension greater than 8 in. (203.2 mm). The weight of copper in ingots and ingot bars shall not exceed that specified by more than 10 %, but otherwise its variation is not important.

8. Workmanship, Finish, and Appearance

8.1 Shapes intended for fabrication shall be substantially free of shrink holes, cold sets, pits, sloppy edges, concave tops, and similar defects in set or casting. This requirement shall not apply to ingots or ingot bars, in which physical defects are of no consequence.

9. Sampling

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

9.2 In case of dispute the lot size, portion size, and selection of pieces shall be as follows:

9.2.1 *Lot Size*—An inspection lot shall consist of all pieces the same shape and size from the same production lot or fraction thereof.

9.2.2 *Portion Size*—The portion shall be four or more pieces randomly selected to be representative of the lot. Should the lot consist of less than five pieces, each piece shall be sampled.

9.3 *Chemical Analysis:*

9.3.1 In case of dispute the sample for chemical analysis shall be taken from the pieces selected in 9.2.2 and combined into one composite sample in accordance with Practice E255 for a product in its final form. The minimum weight of the composite sample shall be 150 g.

9.3.2 Instead of sampling in accordance with 9.2.2, the manufacturer shall have the option of taking samples at the time the castings are poured.

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

9.3.3 The number of samples to be taken for determination of chemical composition shall be as follows:

9.3.3.1 When sampled at the time the castings are poured, at least two samples, one soon after the start of the pour and one near the end of the pour, shall be taken for each group of castings poured from the same source of molten metal.

10. Number of Tests and Retests

10.1 *Tests*—The chemical composition shall be determined as the average of results obtained from at least two replicate analyses for each specified element.

10.2 *Retests:*

10.2.1 When requested by the manufacturer or supplier, a retest shall be permitted when test results obtained by the purchaser fail to conform with the product specification requirement(s).

10.2.2 Retesting shall be as directed in the product specification for the initial test except for the number of test specimens which shall be twice that required for the original test. Test results for all specimens shall conform to the product specification requirement(s) in retest and failure to comply shall be cause for lot rejection.

11. Specimen Preparation

11.1 The preparation of the analytical specimen is the responsibility of the reporting laboratory.

12. Test Methods

12.1 For routine analysis, the method of analysis shall be at the discretion of the reporting laboratory.

12.2 In case of dispute concerning copper content, the method of analysis shall be in accordance with Test Method E53.

12.3 In case of dispute concerning antimony, arsenic, bismuth, lead, nickel, selenium, or tellurium content, the method of analysis shall be by electrothermal atomization atomic absorption spectrometry as described in the Annex.

12.4 Test method(s) for the determination of element(s) resulting from contractual or purchase order agreement shall be as agreed upon between the manufacturer or supplier and the purchaser.

13. Significance of Numerical Limits

13.1 Calculated values shall be rounded to the nearest unit in the last right-hand significant digit used in expressing the limiting value in accordance with the rounding method in Practice E29.

14. Inspection

14.1 The manufacturer, or supplier, shall inspect and make tests necessary to verify the furnished product conforms to the specification requirements.

15. Rejection and Rehearing

15.1 *Rejection:*

15.1.1 Product that fails to conform to the specification requirements when tested by the purchaser or purchasers shall be subject to rejection.

15.1.2 Rejection shall be reported to the manufacturer, or supplier, promptly. In addition, a written notification of rejection shall follow.

15.1.3 In case of dissatisfaction with the results of the test upon which rejection was based, the manufacturer, or supplier may make claim for a rehearing.

15.2 *Rehearing*—As a result of product rejection, the manufacturer, or supplier shall have the option to make claim for a retest to be conducted by the manufacturer, or supplier, and the purchaser. Samples of the rejected product shall be taken in accordance with the product specification and subjected to test by both parties using the test method(s) specified in the product specification, or, alternatively, upon agreement by both parties, an independent laboratory may be selected for the tests using the test method(s) specified in the product specification.

16. Certification

16.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been tested and inspected as directed in the product specification and the requirements have been met.

17. Test Report

17.1 When specified in the contract or purchase order, a report of test results shall be furnished.

18. Product Marking

18.1 All shapes intended for fabrication shall be identified with the producer's brand, furnace charge, or other identifying number.

18.2 Ingots and ingot bars shall have a brand identification but need have no other number.

19. Packaging and Package Marking

19.1 *Packaging:*

19.1.1 The product shall be separated by size and composition and prepared for shipment by common carrier in such a manner to afford protection from the normal hazards of transportation.

19.2 *Package Marking:*

19.2.1 Each shipping unit shall be legibly marked with the purchase order number, metal or alloy designation, size, shape, gross and net weight, and name of supplier.

19.2.2 When specified in the contract or purchase order, the product specification number shall be shown.

20. Keywords

20.1 fire refined copper; refinery shapes; tough pitch copper

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order, for agencies of the U.S. government.

S1. Referenced Documents

S1.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

S1.1.1 ASTM Standard:

B900, Practice for Packaging of Copper and Copper Alloy Mill Products for U.S. Government Agencies

S1.1.2 *Federal Standards:*[3]

Fed. Std. No. 102 Preservation, Packaging and Packing Levels

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)

Fed. Std. No. 185 Identification Marking of Copper and Copper-Base Alloy Mill Products

S1.1.3 *Military Standard:*[3]

MIL-STD-129 Marking for Shipment and Storage

S2. Quality Assurance

S2.1 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the manufacturer is responsible for the performance of all inspection and test requirements specified. Except as otherwise specified in the contract or purchase order, the manufacturer may use his own or any other suitable facilities for the performance of the inspection and test requirements unless disapproved by the purchaser at the time the order is placed. The purchaser shall have the right to perform any of the inspections or tests set forth when such inspections and tests are deemed necessary to ensure that the material conforms to prescribed requirements.

S3. Identification Marking

S3.1 All material shall be properly marked for identification in accordance with Fed. Std. No. 185 except that the ASTM specification number and the alloy number shall be used.

S4. Preparation for Delivery

S4.1 *Preservation, Packaging, Packing:*

S4.1.1 *Military Agencies*—The material shall be separated by size, composition, grade, or class and shall be preserved and packaged, Level A or C, packed, Level A, B, or C as specified in the contract or purchase order, in accordance with the requirements of B900.

S4.1.2 *Civil Agencies*—The requirements of Fed. Std. No. 102 shall be referenced for definitions of the various levels of packaging protection.

S4.2 *Marking:*

[3] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

S4.2.1 *Military Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with MIL-STD-129.

S4.2.2 *Civil Agencies*—In addition to any special marking required by the contract or purchase order, marking for shipment shall be in accordance with Fed. Std. No. 123.

ANNEX

(Mandatory Information)

A1. TEST METHOD FOR DETERMINATION OF COMPLIANCE WITH CHEMICAL COMPOSITIONAL REQUIREMENT FOR ANTIMONY, ARSENIC, BISMUTH, LEAD, NICKEL, SELENIUM, AND TELLURIUM IN SPECIFICATION B216 BY ELECTROTHERMAL ATOMIZATION ATOMIC ABSORPTION SPECTROMETRY

A1.1. Scope

A1.1.1 This test method covers the analysis of antimony, arsenic, bismuth, lead, nickel, selenium, and tellurium in tough-pitch fire-refined copper.

A1.1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

A1.1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns 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.*

A1.2. Summary of Test Method

A1.2.1 The test sample is dissolved in nitric acid and the solution diluted to a known volume. An aliquot is introduced into an electrothermal atomic absorption spectrometer, with background correction capability. The absorbance of the resonance line energy from the spectrum of the element is measured and compared with that of calibration solutions of the same element in a matched matrix.

A1.3. Significance and Use

A1.3.1 This test method is primarily intended to test tough-pitch fire-refined copper for compliance with chemical compositional requirements of Specification B216.

A1.3.2 It is assumed that all who use this test method will be trained analysts capable of performing common laboratory procedure skillfully and safely. It is expected that work will be performed in a properly equipped laboratory.

A1.4. Interferences

A1.4.1 Elements normally present in tough-pitch fire-refined copper do not interfere.

A1.4.2 Potential background interference is eliminated by instrumental background correction and by use of matrix-matched calibration solutions.

A1.5. Apparatus

A1.5.1 *Atomic Absorption Spectrometer and Electrothermal Atomizer*—The instrument shall be equipped with a background corrector, and high-speed read-out electronics or a high-speed recorder, or both. The instrument should be capable of using single-element hollow cathode lamps or electrodeless discharge lamps. Follow the manufacturer's manual for installation and operations.

A1.5.2 *Graphite Tubes*—Pyrolytically coated graphite tubes and L'vov platforms for use in the electrothermal atomizer.

A1.5.3 *Micropipets*—5 to 100 µL.

A1.5.4 *Operating Parameters*—Operating parameters vary instrument to instrument and must be established for a particular instrument following the recommendations of the manufacturer.

A1.5.4.1 The analytical wavelengths are:

Elements	Wavelength, nm
Antimony	217.6
Arsenic	193.9
Bismuth	223.0
Lead	283.3
Nickel	232.0
Selenium	196.0
Tellurium	214.3

A1.6. Reagents and Materials

A1.6.1 *Argon*—Purity: 99.98 %, min.

A1.6.2 *Copper Solution* (1 mL = 0.01 g Cu)—Dissolve 2 g of well-characterized high-purity copper (National Bureau of Standards, Standard Reference Material, NBS SRM 393) in 40 mL of HNO_3 (1 + 1). Heat gently to dissolve the metal and expel the brown fumes. Cool, transfer to a 200-mL volumetric flask. Add 20 mL of HNO_3, dilute to volume, and mix.

A1.6.3 *Antimony Standard Solution* (1 mL = 0.10 mg Sb)—Dissolve 0.0548 g of potassium antimony tartrate ($KSbC_4H_4O_7 \cdot ½\ H_2O$; purity: 99.9 %, min) with water and transfer to a 100-mL volumetric flask, dilute to volume, and mix.

A1.6.4 *Arsenic Standard Solution* (1 mL = 0.10 mg As)—Dissolve 0.0264 g of arsenic trioxide (As_2O_3; purity: 99.9 %, min) in 20 mL of water with one small pellet of potassium hydroxide (KOH) and transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume and mix.

A1.6.5 *Bismuth Standard Solution* (1 mL = 0.10 mg Bi)—Dissolve 10 mg of bismuth (Bi; purity: 99.9 %, min) in 5 mL

of HNO_3 (1 + 5). Heat gently to dissolve the metal. Transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume, and mix.

A1.6.6 *Lead Standard Solution* (1 mL = 0.10 mg Pb)—Dissolve 10 mg lead (Pb; purity: 99.9 %, min) in 5 mL of HNO_3 (1 + 5). Heat gently to dissolve the lead. Transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume, and mix.

A1.6.7 *Nickel Standard Solution* (1 mL = 0.20 mg Ni)—Dissolve 20 mg nickel (Ni; purity: 99.9 %, min) with 10 mL of HNO_3 (1 + 1). Heat gently to dissolve the nickel. Transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume, and mix.

A1.6.8 *Selenium Standard Solution* (1 mL = 0.10 mg Se)—Dissolve 14.1 mg of selenium dioxide (SeO_2; purity: 99.0 %, min) in 10 mL of water. Transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume, and mix.

A1.6.9 *Tellurium Standard Solution* (1 mL = 0.10 mg Te)—Dissolve 10 mg of tellurium in 2 mL of HNO_3. Dilute to 10 mL with water and transfer to a 100-mL volumetric flask. Add 10 mL of HNO_3, dilute to volume, and mix.

A1.7. Hazards

A1.7.1 *Safety Precautions:*

A1.7.1.1 The ultraviolet radiation must be shielded at all times to prevent eye damage.

A1.7.1.2 **Warning—**Arsenic trioxide (As_2O_3) is a hazardous reagent and may be fatal if swallowed. Avoid inhalation and prolonged or repeated skin contact.

A1.7.1.3 Selenium and selenium compounds are potentially hazardous reagents. Avoid ingestion, inhalation, or prolonged and repeated skin contact.

A1.7.1.4 **Warning—**Tellurium and tellurium compounds are hazardous reagents and may be fatal if ingested. Avoid inhalation and prolonged or repeated skin contact.

A1.7.1.5 For other specific hazards refer to Practices E50.

A1.8. Calibration

A1.8.1 *Calibration Solutions*—Using micropipets, transfer to individual 100-mL volumetric flasks the volume of each standard solution as indicated in the following table:

Flask No.	µL	ppm[A] Nickel	ppm[A] Sb, As, Bi, Pb, Se, Te
1	5	10	5
2	10	20	10
3	25	50	25
4	50	100	50
5	100	200	100
6	250	500	250

NOTE 1—Add 20 mL of copper standard solution to each flask.

[A] Concentration based upon 1 g/L.

A1.8.2 *Calibration:*

A1.8.2.1 *Instrument Parameters*—Set the required instrument parameters and align the electrothermal atomizer in accordance with the manufacturer's recommendation. Determine the optimum electrothermal atomizer parameters for the particular type atomizer, and sample size, as recommended by the instrument manufacturer.

A1.8.2.2 *Spectrometry:*

(1) Zero the instrument or set the base line on the recorder, or both.

(2) Check the zero stability and lack of spectral interference within the atomization by running the preset heating program for blank firing of the electrothermal atomizer. Repeat to ensure baseline stability.

(3) Inject and atomize the calibration solutions in the order of increasing concentrations. Inject each solution three times and record the readings. Should good replication not be achieved, repeat the process.

(4) Check for memory effects by running the blank firing program and reset the zero or baseline, or both, if necessary.

(5) Plot the average reading from each calibration solution versus the concentration of the analyte in the calibration solution.

(6) For systems with direct instrument calibration, a sufficient number of each calibration solution should be injected and atomized to determine that proper calibration has been achieved. Calibration should initially be checked as described in (*5*) of the Calibration Section to ascertain that the calibration is within the useful range of the curve.

A1.9. Procedure

A1.9.1 Dissolve 1-g sample, weighed to the nearest 1 mg, in 20 mL of HNO_3 (1 + 1). Heat gently to dissolve the metal and expel the brown fumes. Transfer to a 100-mL volumetric flask. Cool, add 10 mL of HNO_3, dilute to volume, and mix.

A1.9.2 Ensure that the test solution is within 1°C of the calibration solutions.

A1.9.2.1 Inject and atomize the test solution for three replicate readings and record the observations.

A1.9.2.1.1 Should a reading be beyond the useful range of the calibration curve, make the necessary dilutions of the test solution. Matrix concentration of test solution and calibration solution must be the same. Repeat A1.9.2.1.

A1.10. Calculation

A1.10.1 Calculate the concentration of each element to be determined using the calibration curves prepared in (*5*) of the Calibration Section.

A1.10.2 Systems with direct reading capabilities will provide results in the calibration units.

A1.10.3 Calculated values shall be rounded to the desired number of places in accordance with Practice E29.

A1.11. Precision and Bias

A1.11.1 *Precision*—The precision of this test method is dependent upon sampling, sample preparation, and preciseness of calibration.

A1.11.2 *Bias*—The accuracy of this test method is dependent to a great extent upon the care with which the calibration solutions are prepared as well as the purity of the reagents used.

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B216 – 10) that may impact the use of this standard. (Approved April 1, 2016.)

(1) Section 1.2 historically indicated specific other coppers that could be produced from C12500. Over the years new UNS alloys have been added and others dropped. A more appropriate statement has replaced the historical reference.
(2) Terminology B846 was added as a reference document to Section 2 and was added to Section 3, Terminology.
(3) Sections 4.1 and 4.3 and title of Section 19 were changed to reflect the recommendation of Guide B950.
(4) Suggested changes provided by the Editorial Review were incorporated in Sections 1.4, 3.1, 6.2, 14.1, 15, 17, and 19.