Designation: B5 – 16

Standard Specification for High Conductivity Tough-Pitch Copper Refinery Shapes[1]

This standard is issued under the fixed designation B5; 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 high conductivity, tough-pitch, copper wire bars, cakes, slabs, billets, ingots, and ingot bars.

1.2 Copper under this specification corresponds to the designations "ETP" (UNS C11000) and "FRHC" (UNS C11020) as shown in Classification B224. These coppers may also be used to produce coppers corresponding to the following:

Copper UNS No.	Classification B224 Designation
C11300, C11400, C11500, and C11600	STP
C12000	DLP
C12200	DHP
C12300	DHPS
C14520	DPTE

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.

1.4.1 *Exception*—Electrical resistivity is expressed in SI units.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B193 Test Method for Resistivity of Electrical Conductor Materials

B224 Classification of Coppers

B846 Terminology for Copper and Copper Alloys

B950 Guide for Editorial Procedures and Form of Product Specifications for Copper and Copper Alloys

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

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

E478 Test Methods for Chemical Analysis of Copper Alloys

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 Terminology B846. For definitions of terms related to standard classification of coppers, refer to Classification B224.

4. Ordering Information

4.1 Include the following information, as applicable:

4.1.1 ASTM Specification Designation and year of issue;

4.1.2 Copper UNS No. Designation;

4.1.3 Quantity, shape, and dimension of each piece, and weight;

4.1.4 Should cakes, slabs, or billets be ordered for electrical use, it must be stated in the contract or purchase order.

4.1.5 Silver content in silver-bearing shapes, when required, in troy oz per short ton.

5. Materials and Manufacture

5.1 *Materials:*

5.1.1 The material of manufacture shall be a form (copper wire bar, cake, slabs, billets, ingots, and ingot bars) of Copper Alloy "ETP" (UNS C11000) or "FRHC" (UNS C11020) of such purity and soundness as to be suitable for processing into the prescribed herein.

5.1.2 When specified in the contract or purchase order that heat identification or traceability is required, the purchaser shall specify the details desired.

[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**

NOTE 1—Due to 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.

5.2 *Manufacture:*

5.2.1 The product shall be hot- or cold-worked as to produce a uniform wrought structure in the finished product.

6. Chemical Composition

6.1 The copper in all shapes shall meet the minimum requirement for copper, including silver, of 99.90 %.

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

6.2 For the STP (silver-bearing) coppers, the addition of silver up to an average of 30 troy oz per short ton (0.10 %) will be considered within the specification, with no individual silver analysis to exceed 35 troy oz per short ton (0.12 %).

7. Physical Property Requirements

7.1 *Electrical Resistivity:*

7.1.1 The maximum mass resistivity for wire bars, cakes, slabs, and billets for electrical use shall be 0.153 28 $\Omega \cdot g/m^2$ (conductivity 100.00 % minimum, International Annealed Copper Standard, (IACS)), at 68°F (20°C), annealed.

7.1.2 The maximum mass resistivity for other uses shall be 0.156 94 $\Omega \cdot g/m^2$ (conductivity 97.66 % minimum IACS), at 68°F (20°C), annealed.

7.1.3 The maximum mass resistivity for ingots and ingot bars shall be 0.156 94 $\Omega \cdot g/m^2$ (conductivity 97.66 % minimum IACS), at 68°F (20°C), annealed.

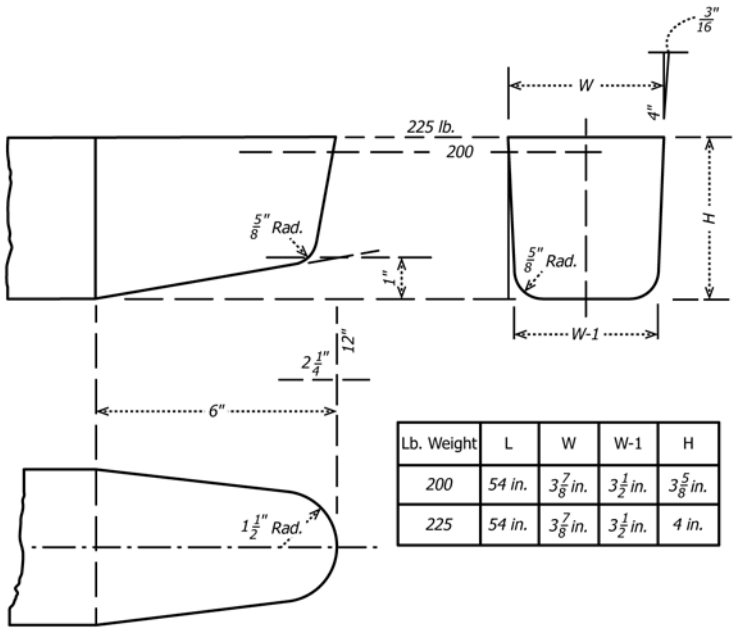
8. Dimensions, Mass, and Permissible Variations

8.1 *Standard Sizes and Shapes of Wire Bars:*

8.1.1 One size of mold shall be used for casting 200- to 230-lb (91- to 104-kg) wire bars, the bottom width of these bars to be 3½ in. (89 mm), the listed weights being 200 and 225 lbs (91 and 102 kg) (Fig. 1).

8.1.2 One size of mold shall be used for casting 240- to 300-lb (109- to 136-kg) wire bars, the bottom width of these bars to be 4 in. (102 mm), the listed weights being 250, 265, 275, and 300 lbs (113, 120, 125, and 136 kg) (Fig. 2).

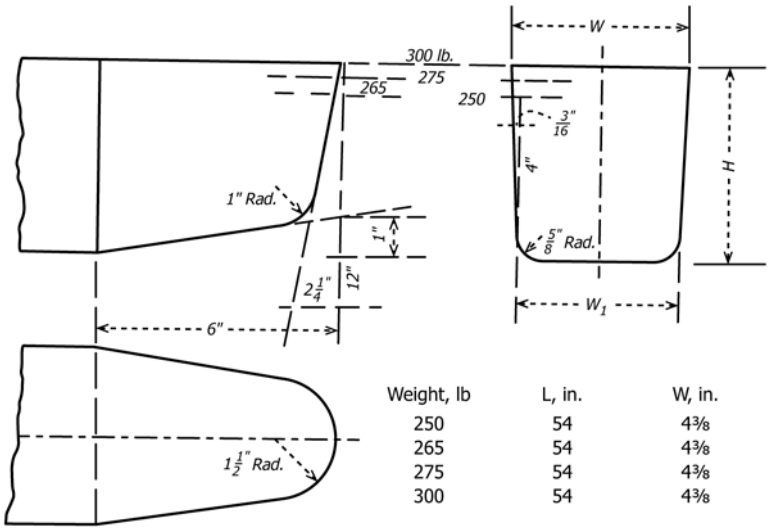
8.1.3 All bars shall be 54 in. (1.372 m) in length. The side draft or taper shall be ⅜ in. (9.5 mm) in 4 in. (3⁄16 in. (4.8 mm) in 4 in. on each side of the bar). The radius of the corners at the bottom of the bars shall be ⅝ in. (15.9 mm). The end taper at the bottom shall be 6 in. (152.4 mm) in overall length and approximately 2 in. (50.8 mm)/ft (304.8 mm). The end taper of the side shall be approximately 2¼ in. (57.1 mm)/ft and the end of the bar shall be approximately 3⅜ in. (85.7 mm) in depth at the point.



Lb. Weight	L	W	W-1	H
200	54 in.	3 7/8 in.	3 1/2 in.	3 5/8 in.
225	54 in.	3 7/8 in.	3 1/2 in.	4 in.

Inch-Pound Units	SI Units	Inch-Pound Units	SI Units
3⁄16 in.	4.763 mm	3⅞ in.	98 mm
⅝ in.	15.875 mm	4 in.	102 mm
1 in.	25.4 mm	6 in.	152.4 mm
1½ in.	38.1 mm	12 in.	304.8 mm
2¼ in.	57.15 mm	54 in.	1.372 m
3½ in.	89 mm	200 lbs	91 kg
3⅝ in.	92 mm	225 lbs	102 kg

FIG. 1 Copper Wire Bars, 200 and 225 lbs



Weight, lb	L, in.	W, in.	W_1, in.	H, in.
250	54	4⅜	4	4
265	54	4⅜	4	4 3/16
275	54	4⅜	4	4⅜
300	54	4⅜	4	4¾

Inch-Pound Units	SI Units	Inch-Pound Units	SI Units
3/16 in.	4.763 mm	4¾ in.	121 mm
⅝ in.	15.875 mm	6 in.	152.4 mm
1 in.	25.4 mm	12 in.	304.8 mm
1½ in.	38.1 mm	54 in.	1.372 m
2¼ in.	57.15 mm	250 lbs	113 kg
4 in.	102 mm	265 lbs	120 kg
4 3/16 in.	107 mm	275 lbs	125 kg
4⅜ in.	111 mm	300 lbs	136 kg

FIG. 2 Copper Wire Bars, 250, 265, 275, and 300 lbs

8.1.4 Wire bars not conforming to the requirements of Fig. 1 or Fig. 2, but otherwise meeting the requirements of this specification, may be supplied by agreement between the manufacturer and the purchaser.

8.2 *Permissible Variations in Weight and Dimensions*—A permissible variation of ±5 % in weight or ±¼ in. (6.3 mm) in any dimension from the manufacturer's published list or the purchaser's specified size shall be considered good delivery; provided, however, that wire bars may vary in length ±1 % from the listed or specified length, and 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.

9. Workmanship, Finish, and Appearance

9.1 Wire bars, cakes, slabs, and billets 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.

9.2 Blemishes of a nature that do not interfere with the intended application are acceptable.

10. Sampling

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

10.2 In case of dispute, a lot shall consist of all pieces the same shape and size bearing a common single identifying number.

10.3 *Chemical Composition*—In case of dispute concerning chemical composition, sampling shall be in accordance with Practice E255.

10.4 *Electrical Resistivity*—In case of dispute concerning the electrical resistivity, each party shall select two pieces from the lot. In the presence of both parties, and by means mutually agreeable, a single sample of adequate size shall be cut from each of the four pieces. See 12.2 for subsequent specimen preparation.

11. Number of Tests and Retest

11.1 *Tests:*

11.1.1 *Chemical Analysis*—Chemical composition shall be determined as per the element mean of the results from at least three replicate analyses of the sample(s).

11.2 *Other Tests:*

11.2.1 *Electrical Resistivity*—The mass resistivity shall be determined as the mean of the observations from the test on the four wires.

11.3 *Retest*—In case of dispute, one retest may be made for chemical composition determined as the mean of the results from replicate analyses. In case of dispute concerning electrical resistivity, 10.4 and 12.2 shall apply.

11.4 *Umpire Test:*

11.4.1 In the case in which the retest does not settle the dispute, further retest may be made by a qualified third-party laboratory agreeable to the producer and the purchaser. The retest shall be made on the sample set aside for that purpose.

11.4.2 The umpire provision does not preclude other contractual agreements.

12. Specimen Preparation

12.1 *Chemical Analysis*—The analytical specimen preparation shall be the responsibility of the reporting laboratory.

12.2 *Electrical Resistivity:*

12.2.1 Each test sample for electrical resistivity shall be fabricated into a rod.

12.2.2 The external oxide shall be removed and the rod cold drawn into a wire approximately 0.080 in. (2.00 mm) in diameter.

12.2.3 Each wire coil shall be cut into four wires of approximately the same length, and the sixteen wires thus obtained shall be individually identified. The sixteen wires shall be divided into four groups of four wires each, one wire from each of the four originally selected pieces; one group each for the producer, the purchaser, contingencies, and the umpire.

12.2.4 The resulting specimen shall be annealed in an inert atmosphere at approximately 932°F (500°C) for 30 min and quickly cooled to ambient temperature in the same inert atmosphere.

13. Test Methods

13.1 The test method used for routine chemical analysis for specification compliance and preparation of certifications and test report, when required, shall be at the discretion of the reporting laboratory.

13.1.1 The test method(s) to be followed for determination of element(s) resulting from contractual or purchase-order agreement shall be as agreed upon between the supplier and purchaser.

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

13.3 In case of dispute concerning silver content of silver-bearing shapes, the method of analysis shall be in accordance with Test Methods E478.

13.4 In case of dispute concerning the electrical resistivity, the method of test shall be in accordance with Test Method B193.

14. Significance of Numerical Limits

14.1 Calculated values shall be rounded to the specified number of places in accordance with Practice E29.

15. Inspection

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

16. Rejection and Rehearing

16.1 *Rejection:*

16.1.1 Product that fails to conform to the specification requirements when tested by the purchaser or purchaser's agent shall be subject to rejection.

16.1.2 Rejection shall be considered as follows:

16.1.2.1 Chemical composition and electrical resistivity by lots. See 10.2 for the definition of a lot as it pertains to this specification.

16.1.2.2 Physical defects by individual pieces.

16.1.2.3 Variations in weight or dimension by individual pieces.

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

16.1.4 In case of dissatisfaction with the results of the test upon which rejection is based, the manufacturer or supplier shall have the option to make claim for a rehearing.

16.2 *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 this specification, and subjected to test by both parties using the test method(s) specified, or alternately, upon agreement of both parties, an independent laboratory may be selected for the test(s) using the test method(s) specified in the product specification.

17. Certification

17.1 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 this specification and requirements have been met.

18. Test Report

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

19. Product Marking

19.1 Each wire bar, cake, slab, and billet shall be stamped, or otherwise identified, with the producer's brand and lot.

19.2 Ingots and ingot bars shall have the producer's brand stamped, or cast in, but need have no other number.

20. Packaging and Package Marking

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

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

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

20.4 In case of dispute, a lot shall consist of all pieces of the same shape and size bearing the same identifying number.

21. Keywords

21.1 billets; cakes; electrolytic copper; electrorefined copper; electrowon copper; fire-refined copper; high-conductivity copper; ingot bars; ingots; refinery shapes; slabs; tough-pitch copper; wire bars

SUMMARY OF CHANGES

Committee B05 has identified the location of selected changes to this standard since the last issue (B5 – 11) that may impact the use of this standard. (Approved Oct. 1, 2016.)

(1) Added Section 5, Materials and Manufacture, to comply with Guide B950.
(2) In 4.1.4, an editorial change was made.
(3) Added Section 17, Certification, and Section 18, Test Report, to comply with Guide B950.
(4) Renumbered Sections 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18.
(5) In 20.1, 20.2, and 20.3, changed and added language to comply with Guide B950.