Designation: B823 – 15

Standard Specification for Materials for Copper Base Powder Metallurgy (PM) Structural Parts[1]

This standard is issued under the fixed designation B823; 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 covers a variety of copper base powder metallurgy (PM) structural materials, including those used in applications where high electrical conductivity is required. It includes a classification system, or material designation code. With the classification system, this specification includes chemical composition and minimum tensile yield strength.

NOTE 1—Paragraphs 6.1 and 8.1 govern material classification by the designation code. The classification system is explained in the Appendix.

NOTE 2—Materials classified as C-0000 are expected to be used in applications where high electrical conductivity is required.

1.2 With the exception of density values, for which the cubic centimetre (g/cm^3) unit is the industry standard, the values stated in inch-pound units are to be regarded as the standard. Values in SI units result from conversion. They may be approximate and are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

B243 Terminology of Powder Metallurgy

B925 Practices for Production and Preparation of Powder Metallurgy (PM) Test Specimens

B962 Test Methods for Density of Compacted or Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

B963 Test Methods for Oil Content, Oil-Impregnation Efficiency, and Surface-Connected Porosity of Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle

E8 Test Methods for Tension Testing of Metallic Materials

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

2.2 *MPIF Standard:*

MPIF Standard 35, Materials Standards for PM Structural Parts[3]

3. Terminology

3.1 *Definitions*—Definitions of powder metallurgy terms can be found in Terminology B243. Additional descriptive information is available in the Related Materials section of Vol 02.05 of the *Annual Book of ASTM Standards*.

4. Ordering Information

4.1 Materials for parts covered by this specification shall be ordered by materials designation code.

4.2 Orders for parts under this specification may include the following information:

4.2.1 Certification, if required (see Section 13),

4.2.2 Dimensions (see Section 9),

4.2.3 Chemical composition (see 6.1, 10.1, and Table 1),

4.2.4 Test methods and mechanical properties (see 8.2 , 8.3, Table 2, Table X1.1, and Table X1.2),

4.2.5 Density (see 7.1 and Table 3),

4.2.6 Porosity and oil content (see 7.3),

4.2.7 Electrical properties (see 7.3 and Table X2.1), and

4.2.8 Special packaging, if required.

5. Materials and Manufacture

5.1 Structural parts shall be made by compacting and sintering metal powders. Parts may also be made by repressing and resintering sintered parts, if necessary, to produce finished parts in conformance with the requirements of this specification.

6. Chemical Composition

6.1 The material shall conform to the requirements provided in Table 1.

6.2 Chemical analysis shall be performed in accordance with the methods prescribed in Vol 03.05 of the Annual Book

[1] This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.05 on Structural Parts.

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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.

[3] Available from Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540, http://www.mpif.org.

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

TABLE 1 Chemical Requirements

Material Designation	Chemical Composition, %[A,B]					
	Cu	Zn	Pb	Sn	Ni	
C-0000	99.8					min
	100					max
CZ-1000	88.0	Bal.	. . .	. . .	. . .	min
	91.0	Bal.	. . .	. . .	. . .	max
CZP-1002	88.0	Bal.	1.0	. . .	. . .	min
	91.0	Bal.	2.0	. . .	. . .	max
CZ-2000	77.0	Bal.	. . .	. . .	. . .	min
	80.0	Bal.	. . .	. . .	. . .	max
CZP-2002	77.0	Bal.	1.0	. . .	. . .	min
	80.0	Bal.	2.0	. . .	. . .	max
CZ-3000	68.5	Bal.	. . .	. . .	. . .	min
	71.5	Bal.	. . .	. . .	. . .	max
CZP-3002	68.5	Bal.	1.0	. . .	. . .	min
	71.5	Bal.	2.0	. . .	. . .	max
CNZ-1818	62.5	Bal.	. . .	. . .	16.5	min
	65.5	Bal.	. . .	. . .	19.5	max
CNZP-1816	62.5	Bal.	1.0	. . .	16.5	min
	65.5	Bal.	2.0	. . .	19.5	max
CT-1000	87.5	. . .	. . .	9.5	. . .	min
	90.5	. . .	. . .	10.5	. . .	max

[A] Other elements: For the C-0000 material, the total by difference equals 0.2 % maximum; for all others, the total by difference equals 2.0% maximum; these may include other minor elements added for specific purposes.
[B]For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29

TABLE 2 Minimum Yield Strength for Copper Base Alloys

Material Designation Code	Minimum Yield Strength, 10^3 psi[A]
C-0000–5	5
C-0000–7	7
CZ-1000-9	9
-10	10
-11	11
CZP-1002-7	7
CZ-2000-11	11
-12	12
CZP-2002-11	11
-12	12
CZ-3000-14	14
-16	16
CZP-3002-13	13
-14	14
CNZ-1818-17	17
CNZP-1816-13	13
CT-1000-13 (repressed)	13

[A]For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.

of ASTM Standards, or by any other approved method agreed upon between the producer and the purchaser.

NOTE 3—Iron contamination should be avoided. Iron in solid solution in copper has a deleterious effect on both electrical and thermal conductivity. Iron not in solid solution (admixed) has a much lesser effect on conductivity. An example of the effect of iron on conductivity is shown in Fig. X2.1.

7. Physical Properties

7.1 *Density:*

TABLE 3 Density Requirements for High Electrical Conductivity Applications

Material Designation Code	Sintered Density, g/cm^{3A}
C-0000–5	7.8 to 8.3
C-0000–7	8.3 min

[A]For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.

7.1.1 *High Electrical Conductivity Application:* In applications where high electrical conductivity is required, if the density does not vary more than 0.3 g/cm^3 from one section of the structural part to any other section, the overall density shall fall within the limits prescribed in Table 3. If the density varies more than 0.3 g/cm^3 from one section of the part to another, the producer and the purchaser shall agree upon a critical section of the part where the stresses are highest. The density of this critical section, rather than the average density, shall fall within the limits prescribed in Table 3.

7.1.2 *Other Applications:* The producer and the purchaser may agree upon a minimum average density for the part and minimum densities for specific regions of the part. Typical density values may be found in Table X1.1.

7.1.3 Density shall be determined in accordance with Test Method B962.

7.2 *Porosity:*

7.2.1 The producer and the purchaser may agree upon a minimum volume oil content for parts that are to be self-lubricating. The oil content shall be determined in accordance with Test Methods B963.

7.2.2 The producer and the purchaser may agree upon a functional test for porosity in parts that are to be self-lubricating, or for permeability where fluid flow must be restricted.

7.3 *Electrical Conductivity:*

7.3.1 The producer and the purchaser shall agree on qualification tests to determine the electrical conductivity. The test shall be made on sample parts or specimens compacted to a given density using an apparatus based on the eddy-current principle.

7.3.1.1 Conductivity is determined with an instrument that indicates the resistance of a material to the flow of eddy currents. Prior to making the tests, the instrument is allowed to warm up for a period of time recommended by the manufacturer. The instrument is adjusted using three standards of known conductivity supplied by the manufacturer. Test specimens shall be at the same temperature as the reference materials used in adjusting the instrument. Several readings at different locations are taken on each test specimen to obtain an average value.

7.3.1.2 No specimen preparation is required providing the surface is flat in the probe area.

7.3.1.3 Electrical conductivity values shall be reported in percent IACS (International Annealed Copper Standards).

NOTE 4—Typical electrical conductivity values that may be expected from special specimens compacted to size are given in Table X2.1.

8. Mechanical Properties

8.1 The minimum guaranteed tensile yield strength, as shown in Table 2, is a numerical suffix to the material designation code and is read as 10^3 psi. The code is adopted from MPIF Standard 35. All tensile yield strengths are defined as the 0.2 % offset yield strengths.

8.2 The producer and purchaser shall agree upon the method to be used to verify the minimum strength characteristics of the finished parts. Since it is usually impossible to machine tensile test specimens from these parts, alternative strength tests are advisable. An example would be measuring the force needed to break teeth off a gear with the gear properly fixtured.

8.3 The tensile yield strength of the part may be measured indirectly by testing flat unmachined tension test specimens as specified in Practices B925, compacted from the same mixed powder lot at the density of the critical region of the parts and then processed along with the parts.

8.4 Transverse rupture strength values can also be related to tensile yield strengths by correlation. While many nonferrous PM materials are technically too ductile for this simple beam test, the test values are reproducible and useful.

8.5 Typical mechanical property values may be found in Table X1.1 and Table X1.2.

9. Permissible Variations in Dimension

9.1 Permissible variations in dimensions shall be within the limits specified on the drawings which describe the structural parts that accompany the order, or variations shall be within the limits specified in the order.

10. Sampling

10.1 *Chemical Analysis*—When requested on the purchase order, at least one sample for chemical analysis shall be taken from each lot. A sample of chips may be obtained by dry-milling, drilling, or crushing at least two pieces with clean dry tools without lubrication. In order to obtain oil-free chips, the parts selected for test shall have the oil extracted in accordance with Test Methods B963, if necessary.

10.2 *Mechanical Tests*—The producer and the purchaser shall agree upon a representative number of specimens for mechanical tests.

10.3 *Conductivity Tests*—At least two samples shall be taken from each lot for conductivity measurement, if required.

11. Inspection

11.1 Inspection of the material shall be agreed upon between the producer and purchaser as part of the purchase order or contract.

12. Rejection and Rehearing

12.1 Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with test results, the producer or supplier may make claim for a rehearing.

13. Certification

13.1 When specified in the purchase order or contract, the purchaser shall be furnished certification stating samples representing each lot have been tested and inspected as indicated in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished. Test reports may be transmitted to the purchaser by electronic services. The content of the electronically transmitted document shall conform to any existing agreement between the producer and purchaser.

14. Keywords

14.1 brass; bronze; copper alloys; copper base; nickel silver; nonferrous powder metallurgy; nonferrous structural parts; powder metallurgy (PM); structural parts

SUPPLEMENTARY REQUIREMENTS

Metallographic Examination

When specified in the purchase order or contract, either or both of the following supplementary requirements may be applied. Details of these supplementary requirements shall be agreed upon in writing between the producer or supplier and purchaser. Supplementary requirements shall in no way negate any requirement of the specification itself.

Sintering

Requirements for uniformity and quality of sintering may be agreed upon.

Porosity

Requirements excluding excessively large pores may be included when specified and agreed upon in writing.

APPENDIXES

(Nonmandatory Information)

X1. USE OF THIS SPECIFICATION

X1.1 *PM Material Code Designation:*

X1.1.1 The PM material code designation, or identifying code for structural PM parts, defines a specific material as to chemical compositionand minimum strength, expressed in 10^3 psi (6.895 MPa (6.895 N/mm^2)). For example, CZ-1000-9 is a PM copper zinc material containing nominal 90 % copper and 10 % zinc. It has a minimum yield strength of 9×10^3 psi (9000 psi) in the as-sintered condition.

X1.1.2 The system offers a convenient means of designating both the chemical compositionand minimum strength value of any standard PM material. For each standard material, the density is given as one of the typical values and is no longer a requirement of the specification.

X1.1.3 Code designations in this specification and revisions thereof apply only to PM materials for which specifications have been adopted. In order to avoid confusion, the PM material designation coding system is intended for use only with such materials, and it should not be used to create nonstandard materials. The explanatory notes, property values, and other contents of this specification have no application to any other materials.

X1.1.4 In the coding system, the prefix letters denote the general type of material. For example, the prefix CZ represents copper (C) and zinc (Z), which is known as brass. The prefix letter codes are as follows:

X1.1.4.1 C = copper (Cu),
X1.1.4.2 CT = bronze (Cu-Sn),
X1.1.4.3 CNZ = nickel silver (Cu-Ni-Zn),
X1.1.4.4 CZ = brass (Cu-Zn),
X1.1.4.5 N = nickel (Ni),
X1.1.4.6 P = lead (Pb), and
X1.1.4.7 T = tin (Sn).

X1.2 *Prefix and Four-Digit Code*—The four digits following the prefix letter code refer to the composition of the material. In nonferrous materials, the first two numbers in the four-digit series designate the percent of the major alloying constituent; the last two numbers of the four digit series designate the percent of the minor alloying constituent. For improved machinability, lead is sometimes the third alloying element in a nonferrous alloy system. Lead will then be indicated only by the letter "P" in the prefix. The percent of lead or any other minor alloying element that happens to be excluded from the four-digit nomenclature is represented in the "chemical composition" information that appears with each standard material. For an illustration of PM nonferrous material designation coding, see Fig. X1.1.

X1.3 *Suffix Digit Code*—The two-digit suffix represents the minimum strength value, expressed in 10^3 psi (6.895 MPa (6.895 N/mm^2)), that the user can expect from the PM material possessing that chemical composition. The minimum tensile yield strength for these materials in the as-sintered condition is given in Table X1.1 and Table X1.2.

X1.4 *Data Source*—Information used in compiling this specification was contributed by the membership of ASTM Committee B09 on Metal Powders and Metal Powder Products and the Standards Committee of the Metal Powder Industries Federation (MPIF). These technical data are on file at MPIF Headquarters[3] and are, reproduced in this specification with the permission of the Metal Powder Industries Federation.

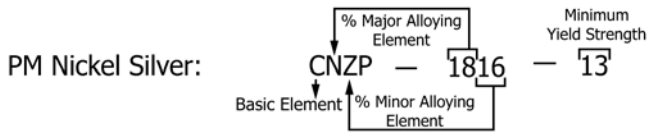


FIG. X1.1 Illustration of Powder Metallurgy Copper Base Material Designation Coding

TABLE X1.1 Copper Base Alloys: Copper, Brass, Bronze, and Nickel Silver

Powder Metallurgy Material Properties

Minimum Values[A,B]		Typical Values[C]									
		Tensile Properties									Hardness
Material Designation Code	Minimum Strength, Yield,[A] 10^3 psi	Ultimate Strength, 10^3 psi	Yield Strength, 0.2 %, 10^3 psi	Elongation, in 1 in., %	Young's Modulus, 10^6 psi	Poisson's Ratio	Transverse Rupture Strength, 10^3 psi	Unnotched Charpy Impact Energy, ft-lb	Density, g/cm ^{3}	Compressive Yield Strength, 0.1 %, 10^3 psi	Apparent (Direct), HRH
C-0000-5	5	23	6	20	12.5	0.31	N/D[E]	25	8.00	7	25
-7	7	28	8.5	25	13.5	0.31	N/D[E]	45	8.30	10	30[D]
CZ-1000-9	9	18	9.5	9	11.5	0.31	39	15	7.6	12	65
-10	10	20	11	10	13.0	0.31	46	24	7.9	12	72
-11	11	23	12	12	14.5	0.31	52	31	8.1	12	80
CZP-1002-7	7	20	8.5	10.	13.0	0.31	45	24	7.9	10	66
CZ-2000-11	11	23	13.5	9	12.5	0.31	52	27	7.6	12	73
CZ-2000-12	12	35	17	18	14.5	0.31	70	45	8.0	14	82
CZP-2002-11	11	23	13.5	9	12.5	0.31	52	27	7.6	12	73
-12	12	35	17	18	14.5	0.31	70	45	8.0	14	82
CZ-3000-14	14	28	16	14	12.0	0.31	62	23	7.6	18	84
-16	16	34	19	17	13.0	0.31	86	38	8.0	19	92
CZP-3002-13	13	27	15.0	14	12.0	0.31	57	12	7.6	12	80
-14	14	31.5	16.5	16	13.0	0.31	71	25.0	8.0	15	88
CNZ-1818-17	17	34	20	11	13.5	0.31	73	24	7.9	24	90
CNZP-1816-13	13	26	15	10	13.5	0.31	50	22	7.9	18	86
CT-1000-13 (repressed)	13	22	16	4	8.5	0.31	45	4	7.2	20	82

[A] Suffix numbers represent minimum strength values in 10^3 psi.
[B] For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.
[C] Mechanical property data derived from laboratory-prepared test specimens sintered under commercial manufacturing conditions.
[D] If C-0000-7 is repressed, typical hardness is 60 HRH.
[E] N/D—not determined for the purpose of this standard.

TABLE X1.2 Copper Base Alloys: Copper, Brass, Bronze, and Nickel Silver Powder Metallurgy Material Properties (SI)

Minimum Values[A,B]		Typical Values[C]									
		Tensile Properties									Hardness
Material Designation Code	Minimum Strength, Yield,[A] MPa	Ultimate Strength, MPa	Yield Strength, 0.2%, MPa	Elongation, in 25 mm, %	Young's Modulous, GPa	Poisson's Ratio	Transverse Rupture Strength, MPa	Unnotched Charpy Impact Energy, J	Density, g/cm^3	Compressive Yield Strength, 0.1%, MPa	Apparent (Direct), HRH
C-0000-5	35	160	40	20	85	0.31	N/D[E]	34	8.0	50	25
-7	50	190	60	25	90	0.31	N/D[E]	61	8.3	70	30[D]
CZ-1000-9	60	120	70	9	80	0.31	270	20	7.6	80	65
-10	70	140	80	10	90	0.31	320	33	7.9	80	72
-11	80	160	80	12	100	0.31	360	42	8.1	80	80
CZP-1002-7	50	140	60	10	90	0.31	310	33	7.9	70	66
CZ-2000-11	80	160	90	9	85	0.31	360	37	7.6	80	73
CZ-2000-12	80	240	120	18	100	0.31	480	61	8.0	100	82
CZP-2002-11	80	160	90	9	85	0.31	360	37	7.6	80	73
-12	80	240	120	18	100	0.31	480	61	8.0	100	82
CZ-3000-14	100	190	110	14	80	0.31	430	31	7.6	120	84
-16	110	230	130	17	90	0.31	590	52	8.0	130	92
CZP-3002-13	90	190	100	14	80	0.31	390	16	7.6	80	80
-14	100	220	110	16	90	0.31	490	34	8.0	100	88
CNZ-1818-17	120	230	140	11	95	0.31	500	33	7.9	170	90
CNZP-1816-13	90	180	100	10	95	0.31	340	30	7.9	120	86
CT-1000-13 (repressed)	90	150	110	4	60	0.31	310	5	7.2	140	82

[A] Suffix numbers represent minimum strength values in MPa.
[B] For the purpose of determining conformance with this specification, measured values shall be rounded "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29.
[C] Mechanical property data derived from laboratory-prepared test specimens sintered under commercial manufacturing conditions.
[D] If C-0000-7 is repressed, typical hardness is 60 HRH.
[E] N/D – not determined for the purposes of this standard.

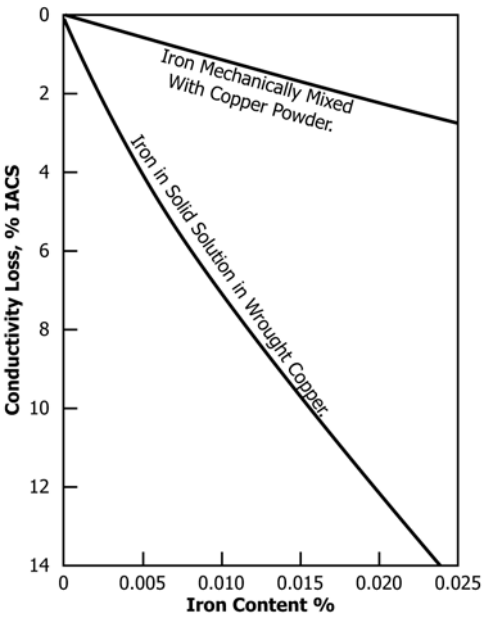
X2. TENSILE AND ELECTRICAL CONDUCTIVITY PROPERTIES

X2.1 Typical tensile and electrical conductivity properties of compacted and sintered copper specimens are shown in Table X2.1. These data do not constitute a part of this specification. They merely indicate to the purchaser the properties that may be expected from special tension specimens conforming to the specified density and chemical composition requirements. It should be thoroughly understood that the values represent specimens compacted to size and not specimens cut from commercial parts or specimens machined from sample blanks. The tension tests are run on flat specimens approximately ¼ by ¼ in. (6.4 mm by 6.4 mm) in cross section with a gage length of 1 in (25 mm). For specimen size and test details, refer to Test Methods E8. The electrical conductivity may be measured on the finished part if it is at least ½ in. (13 in.) in diameter. See also Fig. X2.1.

TABLE X2.1 Typical Tensile Properties and Electrical Conductivity of Copper PM Parts

NOTE 1—Properties depend on whether specimens are: (a) in the sintered condition only; (b) in the sintered and repressed condition; and (c) in the sintered, repressed, and resintered condition.

	C-0000-5	C-0000-7
Density, g/cm^3	8.0	8.3 min
Ultimate tensile strength, psi	23 000	28 000 min
Ultimate tensile strength, MPa	159	193 min
Elongation, %	20	30 min
Electrical conductivity (grade 1), % IACS	85	90 min
Electrical conductivity (grade 1), S/m	0.493×10^8	0.522×10^8



NOTE 1—325 mesh iron powder admixed with copper powder, compacted at 20 tons per square inch (tsi) and sintered at 1832 °F (1000 °C) for 30 min in hydrogen

FIG. X2.1 Electrical Conductivity Loss Resulting from Iron Contamination

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B823–09) that may impact the use of this standard.

(1) Revised units statement in subsection 1.2.
(2) Replaced terms "manufacturer" and "supplier" with "producer," and "buyer" with "purchaser" throughout standard.
(3) Revised table footnotes in Table X1.1.
(4) Added Table X1.2.