Designation: B439 − 18

Standard Specification for Iron-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)[1]

This standard is issued under the fixed designation B439; 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 covers the requirements for porous iron-base metallic sleeve, flange, thrust, and spherical bearings that are produced from metal powders utilizing powder metallurgy (PM) technology and then impregnated with oil to supply operating lubrication.

1.2 Listed are the chemical, physical, and mechanical specifications for those standardized ferrous PM materials that have been developed specifically for the manufacture of self-lubricating bearings.

1.3 This standard is a companion to Specification B438 that covers the requirements for porous oil-impregnated bronze-base bearings.

1.4 Typical applications for self-lubricating iron-base PM bearings are discussed in Appendix X1.

1.5 Commercial bearing dimensional tolerance data are shown in Appendix X2, while engineering information regarding installation and operating parameters of PM bearings is included in Appendix X3. Additional useful information on self-lubricating bearings can be found in MPIF Standard 35 (Bearings), ISO 5755 and the technical literature.[2]

1.6 *Units*—With the exception of the values for density and the mass used to determine density, for which the use of the g/cm^3 unit is the long-standing practice of the PM industry, 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 to be regarded as standard

1.7 *The following safety hazards caveat pertains only to the test methods described in 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.*

1.8 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

B243 Terminology of Powder Metallurgy

B438 Specification for Bronze-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)

B939 Test Method for Radial Crushing Strength, ***K***, of Powder Metallurgy (PM) Bearings and Structural Materials

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

E9 Test Methods of Compression Testing of Metallic Materials at Room Temperature

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

E1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel, Iron, Nickel, and Cobalt Alloys by Various Combustion and Fusion Techniques

2.2 *MPIF Standard:*[4]

MPIF Standard 35 Materials Standards for PM Self-Lubricating Bearings

[1] This specification is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.04 on Bearings.

Current edition approved April 1, 2018. Published May 2018. Replaces portions of B612 and B782. Originally approved in 1966 to replace portions of B202. Last previous edition approved in 2012 as B439 – 12. DOI: 10.1520/B0439-18.

[2] *Machine Design Magazine*, Vol 54, No. 14, June 17, 1982, pp. 130–142.

[3] 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.

[4] Available from Metal Powder Industries Federations, 105 College Road East, Princeton, NJ 08540, http://www.info@mpif.org.

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

2.3 *ISO Standards:*[5]

ISO 2795 Plain bearings from sintered metal—Dimensions and tolerances

ISO 5755 Sintered Metal Materials – Specifications,

3. Terminology

3.1 *Definitions*—The definitions of the terms used in this specification are found in Terminology B243. Additional descriptive information is available in the Related Materials section of Volume 02.05 of the *Annual Book of ASTM Standards*.

4. Classification

4.1 The following list of standardized iron-base oil-impregnated PM bearing material compositions classified by composition are included in this specification. Their complete chemical, physical and mechanical requirements can be found in the specification tables. Typical applications are discussed in Annex A1.

4.2 The three-part alphanumeric PM Material Designation Code, developed by the PM industry, is used to identify these materials. A complete explanation of this classification system is presented in Annex A1.

4.2.1 *Iron and Iron-Carbon Bearing Materials, (Prefix F)*

4.2.1.1 *Iron Materials*

F-0000-K15
F-0000-K23

4.2.1.2 *Iron-Carbon Materials*

F-0005-K20
F-0005-K28
F-0008-K20
F-0008-K32

4.2.2 *Iron-Copper Bearing Materials (Prefix FC)*

4.2.2.1 *Low-Copper Materials*

FC-0200-K20
FC-0200-K34

4.2.2.2 *Medium-Copper Materials*

FC-1000-K20
FC-1000-K30
FC-1000-K40

4.2.2.3 *High-Copper Materials*

FC-2000-K25
FC-2000-K30
FC-2000-K40

4.2.3 *Iron-Copper-Carbon Bearing Materials (Prefix FC)*

4.2.3.1 *Low-Copper-Carbon Materials.*

FC-0205-K20
FC-0205-K35
FC-0208-K25
FC-0208-K40

4.2.3.2 *Medium-Copper-Carbon Materials.*

FC-0508-K35
FC-0508-K46

4.2.3.3 *High-Copper-Carbon Materials.*

FC-2008-K44
FC-2008-K46

4.2.4 *Iron-Graphite Bearing Materials (Prefix FG)*

FG-0303-K10
FG-0303-K12
FG-0308-K16
FG-0308-K22

4.2.5 *Iron-Bronze-Graphite (Diluted Bronze) Bearing Materials (Prefix FCTG)*

FCTG-3604-K16
FCTG-3604-K22

4.2.6 *Diffusion Alloyed Iron-Bronze Bearing Materials (Prefix FDCT)*

FDCT-1802-K22
FDCT-1802-K31
FDCT-1802-K39

5. Ordering Information

5.1 Purchase orders or contracts for iron-base oil-impregnated PM bearings covered by this purchasing specification shall include the following information:

5.1.1 A copy of the bearing print showing dimensions and tolerances (Section 10),

5.1.2 Reference to this ASTM specification, including date of issue,

5.1.3 Identification of bearing material by the *PM Material Designation Code* (Section 4),

5.1.4 Request for certification and test report documents, if required (Section 16),

5.1.5 Type and grade of special lubricating oil, if required (6.2.3), and

5.1.6 Instructions for special packaging, if required (Section 17).

6. Materials and Manufacture

6.1 *Porous Metallic Bearing:*

6.1.1 Porous iron-base bearings shall be processed from a mixture of elemental, prealloyed or diffusion-alloyed metal powders with or without the additions of copper, tin, bronze or graphite powder that together meet the specified chemical composition of the material.

6.1.2 The powder mixture shall be compacted to produce a green bearing of the required dimensions, shape and density

6.1.3 The green bearings shall then be sintered in a furnace having a protective atmosphere for a time and temperature cycle that will produce the required sintered ferrous-base PM material.

6.1.4 After sintering, the iron-base bearings are normally sized to achieve the density, dimensional characteristics, concentricity, and surface finish required of the finished metallic bearing.

6.2 *Oil for Operating Lubrication:*

6.2.1 The surface-connected porosity in the bearings shall be filled to the required volume with lubricating oil, either by an extended soaking in the hot oil or preferably by a vacuum impregnation operation.

6.2.2 A medium viscosity petroleum oil is the lubricant used for most bearing applications, but extreme operating conditions such as elevated temperatures, intermittent rotation, extremely

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

low speeds, or heavy loads may require a synthetic lubricant or an oil with a different viscosity.

6.2.3 Unless otherwise specified by the purchaser, a high-grade turbine oil with antifoaming additives and containing corrosion and oxidation inhibitors, having a kinematic viscosity of 280 to 500 SSU [(60×10^{-6} to 110×10^{-6} m^2/s), (60 to 110 cSt)] at 100 °F (38 °C) is normally used as the general purpose lubricating oil.

7. Chemical Composition

7.1 *Chemical Composition Specifications*—Each iron-base PM bearing material shall conform to the chemical composition requirements prescribed in Table 1 when determined on a clean test sample obtained from oil-free bearings.

7.2 *Limits on Nonspecified Elements*—By agreement between the purchaser and the producer, limits may be established and chemical analyses required for elements or compounds not specified in Table 1.

8. Physical Properties

8.1 *Oil Content*—For each bearing material, the oil content of the as-received bearing shall not be less than the minimum percentage listed in Table 2.

8.2 *Impregnation Efficiency*—A minimum of 90 % of the surface-connected porosity in the as-received bearings shall be impregnated with lubricating oil.

8.3 *Impregnated Density*—The density of the sample bearings, when fully impregnated with lubricating oil, shall meet the requirements specified in Table 2 for each bearing material.

9. Mechanical Properties

9.1 *Radial Crushing Strength*—The radial crushing strength of the oil-impregnated bearing material determined on a plain sleeve bearing or a test specimen prepared from a flange or spherical bearing shall meet the minimum and maximum (if required) strength values listed in Table 2.

TABLE 1 Compositional Specifications for Iron-Base PM Bearing Materials

Material Designation Code	Chemical Composition Requirements						
	Iron mass %	Total Carbon mass %	Combined Carbon [A] mass %	Graphitic Carbon [B] mass %	Copper mass %	Tin mass %	All Others mass %
Iron and Iron-Carbon							
F-0000-K15	bal.	0 to 0.3			0 to 1.5		0 to 2.0
F-0000-K23	bal.	0 to 0.3			0 to 1.5		0 to 2.0
F-0005-K20	bal.		0.3 to 0.6		0 to 1.5		0 to 2.0
F-0005-K28	bal.		0.3 to 0.6		0 to 1.5		0 to 2.0
F-0008-K20	bal.		0.6 to 0.9		0 to 1.5		0 to 2.0
F-0008-K32	bal.		0.6 to 0.9		0 to 1.5		0 to 2.0
Iron-Copper							
FC-0200-K20	bal.	0 to 0.3			1.5 to 3.9		0 to 2.0
FC-0200-K34	bal.	0 to 0.3			1.5 to 3.9		0 to 2.0
FC-1000-K20	bal.	0 to 0.3			9.0 to 11.0		0 to 2.0
FC-1000-K30	bal.	0 to 0.3			9.0 to 11.0		0 to 2.0
FC-1000-K40	bal.	0 to 0.3			9.0 to 11.0		0 to 2.0
FC-2000-K25	bal.	0 to 0.3			18.0 to 22.0		0 to 2.0
FC-2000-K30	bal.	0 to 0.3			18.0 to 22.0		0 to 2.0
FC-2000-K40	bal.	0 to 0.3			18.0 to 22.0		0 to 2.0
Iron-Copper-Carbon							
FC-0205-K20	bal.		0.3 to 0.6		1.5 to 3.9		0 to 2.0
FC-0205-K35	bal.		0.3 to 0.6		1.5 to 3.9		0 to 2.0
FC-0208-K25	bal.		0.6 to 0.9		1.5 to 3.9		0 to 2.0
FC-0208-K40	bal.		0.6 to 0.9		1.5 to 3.9		0 to 2.0
FC-0508-K35	bal.		0.6 to 0.9		4.0 to 6.0		0 to 2.0
FC-0508-K46	bal.		0.6 to 0.9		4.0 to 6.0		0 to 2.0
FC-2008-K44	bal.		0.6 to 0.9		18.0 to 22.0		0 to 2.0
FC-2008-K46	bal.		0.6 to 0.9		18.0 to 22.0		0 to 2.0
Iron-Graphite							
FG-0303-K10	bal.		0 to 0.5	2.0 to 3.0			0 to 2.0
FG-0303-K12	bal.		0 to 0.5	2.0 to 3.0			0 to 2.0
FG-0308-K16	bal.		0.5 to 1.0	1.5 to 2.5			0 to 2.0
FG-0308-K22	bal.		0.5 to 1.0	1.5 to 2.5			0 to 2.0
Iron-Bronze (Diluted Bronze)							
FCTG-3604-K16	bal.	0.5 to 1.3	0.5 max	[C]	34.0 to 38.0	3.5 to 4.5	0 to 2.0
FCTG-3604-K22	bal.	0.5 to 1.3	0.5 max	[C]	34.0 to 38.0	3.5 to 4.5	0 to 2.0
Diffusion Alloyed Iron-Bronze							
FDCT-1802-K22	bal.	0 to 0.1		[D]	17.0 to 19.0	1.5 to 2.5	0 to 1.0
FDCT-1802-K31	bal.	0 to 0.1		[D]	17.0 to 19.0	1.5 to 2.5	0 to 1.0
FDCT-1802-K39	bal.	0 to 0.1		[D]	17.0 to 19.0	1.5 to 2.5	0 to 1.0

[A] The combined carbon value listed is based on the mass percent of the iron content, not the mass percent of the alloy.
[B] Graphitic Carbon is also known as Free Graphite.
[C] These compositions usually contain 0.5 to 1.3 % graphite.
[D] These compositions have no added graphite

TABLE 2 Physical and Mechanical Property Specifications for Iron-Base PM Bearing Materials

Material Designation Code	Physical Requirements		Mechanical Requirements[A]			
	Oil Content vol %	Impregnated Density g/cm³	Radical Crushing Strength, (K)			
			10^3 psi		MPa	
			min	max	min	max
Iron and Iron-Carbon						
F-0000-K15	21	5.6 to 6.0	12		100	
F-0000-K23	17	6.0 to 6.4	23		160	
F-0005-K20	21	5.6 to 6.0	20		140	
F-0005-K28	17	6.0 to 6.4	28		190	
F-0008-K20	21	5.6 to 6.0	20		140	
F-0008-K32	17	6.0 to 6.4	32		220	
Iron-Copper						
FC-0200-K20	22	5.6 to 6.0	20		140	
FC-0200-K34	17	6.0 to 6.4	34		230	
FC-1000-K20	22	5.6 to 6.0	20		140	
FC-1000-K30	19	5.8 to 6.2	30		210	
FC-1000-K40	17	6.0 to 6.4	40		280	
FC-2000-K25	22	5.6 to 6.0	25		170	
FC-2000-K30	19	5.8 to 6.2	30		210	
FC-2000-K40	17	6.0 to 6.4	40		280	
Iron-Copper-Carbon						
FC-0205-K20	22	5.6 to 6.0	20		140	
FC-0205-K35	17	6.0 to 6.4	35		240	
FC-0208-K25	22	5.6 to 6.0	25		170	
FC-0208-K40	17	6.0 to 6.4	40		280	
FC-0508-K35	22	5.6 to 6.0	35		240	
FC-0508-K46	17	6.0 to 6.4	46		320	
FC-2008-K44	22	5.6 to 6.0	44		300	
FC-2008-K46	17	6.0 to 6.4	46		320	
Iron-Graphite						
FG-0303-K10	18	5.6 to 6.0	10	25	70	170
FG-0303-K12	12	6.0 to 6.4	12	35	80	240
FG-0308-K16	18	5.6 to 6.0	16	45	110	310
FG-0308-K22	12	6.0 to 6.4	22	55	150	380
Iron-Bronze (Diluted Bronze)						
FCTG-3604-K16	22	5.6 to 6.0	16	36	110	250
FCTG-3604-K22	17	6.0 to 6.4	22	50	150	340
Diffusion Alloyed Iron-Bronze						
FDCT-1802-K22	24	5.6 to 6.0	22		150	
FDCT-1802-K31	19	6.0 to 6.4	31		215	
FDCT-1802-K39	13	6.4 to 6.8	39		270	

[A] These requirements are based on bearings in the finished, oil-impregnated condition.

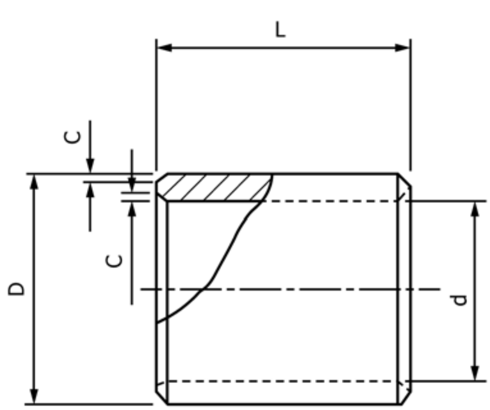

FIG. 1 Standard Sleeve Bearing

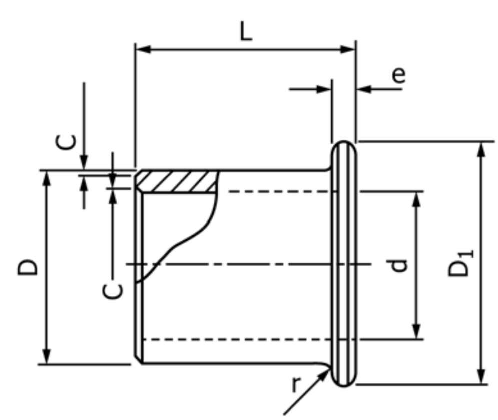

FIG. 2 Standard Flange Bearing

10. Dimensions, Mass, and Permissible Variations

10.1 This specification is applicable to iron-base PM sleeve and flange bearings having a 3 to 1 maximum length to inside diameter ratio and a 20 to 1 maximum length to wall thickness ratio.

10.2 Standard sleeve, flange, thrust, and spherical PM bearings covered by this specification are illustrated by Figs. 1-4. Most PM bearings are small and weigh less than one-quarter pound (~100 g) but they can be produced in sizes that will accommodate shafts up to approximately 8 in. (200 mm) in diameter.

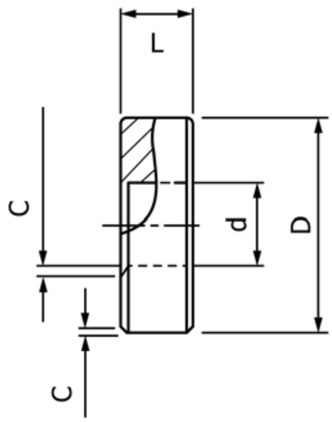

FIG. 3 Standard Thrust Bearing

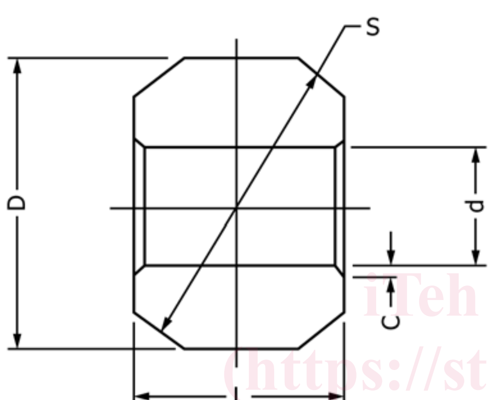

FIG. 4 Standard Spherical Bearing

10.3 Permissible variations in dimensions shall be within the limits specified on the bearing drawing accompanying the order or shall be within the limits specified in the purchase order or contract.

10.4 Recommended commercial tolerances for iron-base PM bearings are referenced throughout the tables in Appendix X2.

10.5 Chamfers of 30 to 45° are generally used on PM bearings to break the corners.

11. Workmanship, Finish, and Appearance

11.1 The bearings should have a matte surface, and not show oxidation. The surfaces of sized bearings should have a smooth bright finish.

11.2 When cut or fractured, the exposed surface shall exhibit a uniform appearance.

11.3 If metallographic examination is performed to determine degree of sintering, it should be done at 200 to 400× magnification. The iron materials should show a predominantly ferritic or pearlitic phase with uniformly dispersed graphitic carbon (if present). High copper content Iron-Copper materials should show evidence of melted copper as a copper rich skeletal network around a ferrous interior structure. Diluted Bronze material should show a bronze phase with no visible free tin, dispersed throughout an iron matrix. The structure should not show an excessive number of original particle boundaries.

11.4 To verify the presence of oil in the bearing, the as-received bearing may be heated to approximately 300 °F (150 °C) for approximately 5 min. If oil is present, the surfaces will show beads of oil being exuded from the open porosity.

11.5 When bearings are ordered as being "dry-to-the-touch" to allow automated handling by the purchaser, the excess surface oil is normally removed by a centrifugal tumbling operation. It is important that the Oil Content test (13.3.1) be performed after the surface drying treatment to make certain that the required volume of lubricating oil is present.

12. Sampling

12.1 *Lot*—Unless otherwise specified, a lot shall be defined as "a specific quantity of bearings manufactured under traceable, controlled conditions as agreed to between the producer and purchaser" (see Terminology B243).

12.2 *Sampling Plan*—The number of sample bearings agreed to between the producer and the purchaser to be used for dimensional inspection (13.1), chemical analysis (13.2), physical tests (13.3), and mechanical tests (13.4) shall be taken randomly from locations throughout the lot.

13. Test Methods

13.1 *Dimensional Measurements:*

13.1.1 Using suitable measuring equipment, the inside diameter of the bearings shall be measured to the nearest 0.0001 in. (0.0025 mm). The other bearing dimensions only require instrumentation capable of measuring to the tolerances specified on the bearing drawing.

13.2 *Chemical Analysis:*

13.2.1 *Oil Extraction*—Bearings and test samples must be dry and free of oil before performing chemical tests. The preferred method of oil removal is by use of the Soxhlet Apparatus specified in Test Method B963. However, upon agreement between purchaser and producer, a low-temperature furnace treatment [1000 to 1200 °F (540 to 650 °C)] with a flowing nitrogen or other inert gas atmosphere may be used to volatilize any oil or lubricant that may be present.

13.2.2 *Test Sample*—An oil-free test sample of chips shall then be obtained by milling, drilling, filing, or crushing the bearings using clean dry tools without lubrication.

13.2.3 *Metallic Elements*—The chemical analysis for specified metallic elements shall then be performed in accordance with the test methods prescribed in Volume 03.05 of the *Annual Book of ASTM Standards* or by another approved method agreed upon between the producer and the purchaser.

13.2.4 *Carbon Analysis*—Carbon analysis is a set of procedures for determining the total carbon, the graphitic carbon, and the combined carbon in iron-base PM bearings. Total carbon is the sum of graphitic carbon and the total combined carbon.

13.2.4.1 *Total Carbon*—Determine the total carbon in accordance with Test Method E1019 with the exception that a sample size as small as 0.25 g may be used upon agreement between purchaser and producer.

13.2.4.2 *Combined Carbon (Preferred Method)*—The combined carbon content in the iron portion is most easily determined by a metallographic estimate. The etched cross section of the iron matrix is viewed at 200 to 400× magnification and the combined carbon in the iron is estimated from the relative amounts of ferrite and pearlite in the structure. 100 % pearlite is equal to approximately 0.8 % combined carbon in the iron portion. The total combined carbon in the composition is then determined by multiplying the estimated combined carbon in the iron by the percentage of iron in the material.

13.2.4.3 *Graphitic Carbon (Preferred Method)*—Subtract the calculated total combined carbon from the total carbon as determined by Test Method E1019 (13.2.4.1) to obtain the graphitic carbon in the bearing.

13.2.4.4 *Graphitic Carbon (Alternative Method)*—This wet chemical analytical procedure may be used to determine graphitic carbon content but it is time-consuming and has been found to lack precision. Weigh and transfer a 0.25 g sample of chips to a 400 mL beaker. Add 25 mL of distilled water, then carefully add 25 mL of concentrated nitric acid and gently boil until all the iron is in solution. At this point, add five to ten drops of 48 mass % hydrofluoric acid to ensure complete solubility of all carbides, silicates, and other compounds. Filter the solution through a porous combustion crucible, wash with hot water until free of acid, then rinse with ethyl alcohol. Dry at 212 °F (100 °C) for 1 h. After drying, add approximately 1 g of carbon-free iron chips and 1 g of copper chips (or another approved accelerator) and follow Test Method E1019 for determining the total carbon.

13.2.4.5 *Combined Carbon (Alternative Method)*—If the graphitic carbon has been determined by wet chemical analysis (13.2.4.4) then the amount of total combined carbon is obtained by subtracting the amount of the graphitic carbon from the total carbon obtained in accordance with Test Method E1019 (13.2.4.1). Divide this total combined carbon value by the percentage of iron in the composition to determine the amount of combined carbon in the iron portion.

13.3 *Physical Properties:*

13.3.1 *Oil Content*—The oil content of the as-received bearing shall be determined following the procedure for *Oil Content By Volume As Received* in Test Method B963.

13.3.2 *Impregnation Efficiency*—The efficiency of the oil-impregnation process in volume percent units shall be calculated as the ratio of the *Oil Content by Volume* as received to the *Surface-Connected Porosity* using the procedures and formulas in Test Method B963.

13.3.3 *Impregnated Density*—The impregnated density in g/cm^3 units, measured after they have been fully impregnated, shall be determined following the procedure for *Impregnated Density* in Test Method B962.

13.4 *Mechanical Properties:*

13.4.1 *Radial Crushing Strength*—Radial crushing strength in psi (MPa) is the mechanical property by which the strength of oil-impregnated PM bearing material is characterized and evaluated. It is determined by breaking plain thin-walled bearings or hollow cylindrical test specimens under diametrical loading, following the procedures described in Test Method B939, and calculating the radial crushing strength according to the material strength formula contained therein.

13.4.1.1 Plain sleeve bearings and thrust bearings are tested in the as-received oil-impregnated condition. For acceptance, the radial crushing strength, determined on the test bearings, shall not be less than the minimum nor more than the maximum (if applicable) strength specification values listed in Table 2 for the bearing material.

13.4.1.2 Flanged oil-impregnated bearings shall be tested by cutting off the flange and crushing the body as a plain sleeve bearing. For acceptance, the radial crushing strength so determined shall meet the minimum and maximum (if applicable) material strength requirements prescribed in Table 2. The testing procedure and material strength requirements of the flange shall be a matter of agreement between producer and purchaser.

13.4.1.3 To evaluate spherical, or bearings of other configuration, a number of sample bearings from the lot shall first be machined to a right circular cylinder, measured, and then crushed to determine the radial crushing strength of the oil-impregnated bearing material. This value shall not be less than the minimum nor more than the maximum (if applicable) radial crushing strength specified in Table 2 for the material in the sample bearings.

13.4.2 *Bearing Breaking Load*—If agreed to by the producer and the purchaser, an acceptance specification for the minimum (maximum) bearing breaking load, P_{min} , (P_{max}) in lbf (N), may be established for any specific standard oil-impregnated bearing. This simplifies acceptance testing because the decision is now based solely upon reading the output of the testing machine without a need for further calculations. This acceptance procedure can be very useful when evaluating multiple or repeat shipments of the same bearing.

13.4.2.1 The following formula is used to calculate the breaking load, P, for a hollow cylinder or bearing test specimen.

$$P_{min}, (P_{max}) = \frac{K \times L \times t^2}{D - t} \quad (1)$$

where:

P_{min}, (P_{max})	=	minimum (maximum) bearing breaking load, lbf (N),
K	=	minimum (maximum) radial crushing strength, psi (MPa),
L	=	length of bearing, in. (mm),
t	=	wall thickness, [$t = (D - d)/2$], in. (mm),
D	=	outside diameter, in. (mm), and
d	=	inside diameter, in. (mm).

13.4.2.2 The minimum (maximum) breaking load, P_{min} (P_{max}) required for acceptance of any specific plain sleeve or thrust bearing is calculated using the minimum (maximum) radial crushing strength value specified for that specific bearing material from Table 1 and the actual D, d and L dimensions of the as-received bearing

NOTE 1—Using the allowable print dimensions that minimize (maximize) the volume of the bearing for the calculations will result in a