



Designation: ~~B439-07~~ Designation: **B 439 – 08**

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

This standard is issued under the fixed designation B 439; 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 Department of Defense.

1. Scope*

1.1 This specification covers porous metallic sleeve, flange, thrust, and spherical iron-base bearings that are produced from mixed metal powder utilizing powder metallurgy (PM) technology and then impregnated with oil to supply operating lubrication.

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

~~1.3 This specification is a companion standard to Specification B 438/B 438M~~

1.3 This specification accompanies Specification B 438/B 438M that covers the requirements for Bronze-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated).

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

~~1.5 Commercial~~ 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) and the technical literature.²

~~1.6 With~~ 1.6 With the exception of density values for which the g/cm^3 unit is the industry standard, the values stated in inch-pound units are to be regarded as standard. The SI equivalents of inch-pound units, shown in parenthesis, have been converted in accordance with IEEE/ASTM Standard SI10, may be approximate and are only for information. unit is the industry standard, the values stated in inch-pound units are to be regarded as standard. The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*³ <http://www.astm.org/catalog/standards/sist/e6ebae9f46dd-4854-8d11-717b097e55e6/astm-b439-08>

B 243 Terminology of Powder Metallurgy

B 328 Test Method for Density, Oil Content, and Interconnected Porosity of Sintered Metal Structural Parts and Oil-Impregnated Bearings

B 438/B 438M Specification for Bronze Powder Metallurgy (P/M) Bearings (Oil-Impregnated)

B 939 Test Method for Radial Crushing Strength, K , of Powder Metallurgy (P/M) Bearings and Structural Materials

E 9 Test Methods of Compression Testing of Metallic Materials at Room Temperature

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 1019 Test Methods for Determination of Carbon, Sulfur, Nitrogen, and Oxygen in Steel and in Iron, Nickel, and Cobalt Alloys

2.2 *MPIF Standard:*⁴

MPIF Standard 35 Materials Standards for PM Self-Lubricating Bearings

2.3 *IEEE/ASTM Standard:*³

SI 10 ~~American~~ American National Standard for Use of the International System of Units (SI): The Modernized Metric

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 ~~June~~ April 1, 2007-2008. Published ~~June 2007~~ May 2008. Replaces portions of B 612 and B 782. Originally approved in 1966 to replace portions of B 202. Last previous edition approved in 2006-2007 as B 439 – 067.

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.

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2.4 *ISO Standard:*⁵

ISO 2795 Plain Bearings from Sintered Metal—Dimension and Tolerances—Plain bearings from sintered metal—Dimensions and tolerances

3. Terminology

3.1 *Definitions*—The definitions of the terms used in this specification are found in Terminology B 243. 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 This specification uses the established three-part alphanumeric *PM Material Designation Code* to identify the ferrous materials used for self-lubricating bearings. The complete explanation of this classification system is presented in Annex A1.

4.2 The following standard oil-impregnated iron-base bearing material compositions are contained in this specification:

4.2.1 *Prefix F—Iron Bearing Material:*

4.2.1.1 *F-0000-K15—Iron with less than 0.3% combined carbon at 5.6 to 6.0 g/cm³ wet density.—Iron with 21 % oil.*

4.2.2 *Prefix F—Iron-Carbon (Steel) Bearing Material:*

4.2.2.1 *F-0005-K20—Low carbon steel with 0.3 to 0.6% combined carbon at 5.6 to 6.0 g/cm³ wet density.—Low carbon steel with 21 % oil.*

4.2.3 *Prefix FC—Iron-Copper Bearing Materials:*

4.2.3.1 *FC-1000-K20—Iron with 10% copper at 5.6 to 6.0 g/cm³ wet density.—Iron, 10 % copper with 22 % copper oil.*

4.2.3.2 *FC-2000-K25—Iron with 20% copper at 5.6 to 6.0 g/cm³ wet density.—Iron, 20 % copper with 22 % oil.*

4.2.4 *Prefix FCTG—Iron-Bronze-Graphite (Diluted Bronze) Bearing Material:*

4.2.4.1 *FCTG-3604-K22—90/10 bronze with 60% iron and 0.75% graphitic carbon at 6.0 to 6.4 g/cm³ wet density.—Iron, 40 % bronze, ¾ % graphite with 17 % oil.*

4.2.5 *Prefix FG—Iron-Graphite Bearing Materials:*

4.2.5.1 *FG-0303-K10—Iron with less than 0.5% combined carbon and 2.5% graphitic carbon at 5.6 to 6.0 g/cm³ wet density.—Iron, 2 1/2 % graphite with 18 % oil.*

4.2.5.2 *FG-0308-K16—Steel with 0.5 to 1.0% combined carbon and 2% graphitic carbon at 5.6 to 6.0 g/cm³ wet density.—Steel, 2 % graphite with 18 % oil.*

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 produced by first compacting a mixture of elemental iron powder and copper, tin, pre-alloyed bronze or graphite powders having the specified chemical composition to the required bearing configuration and green density.

6.1.1 Porous iron-base bearings shall be produced by first preparing a mixture of elemental iron powder with additions of copper, tin, pre-alloyed bronze or graphite powders to the specified chemical composition and then compacting the powder mixture into a bearing configuration having the required green density.

6.1.2 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.

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

⁵ Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland, <http://www.iso.ch>.

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

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 m²/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 supplier, limits may be established and chemical analyses required for elements or compounds not specified in Table 1.

8. Physical Properties

8.1 *Wet Density*—For each bearing material, the wet density of the as-received bearings, supplied impregnated with lubricating oil shall be within the limits prescribed in Table 1.

8.2 *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 1.

8.3

8.2 *Impregnation Efficiency*—A minimum of 90 % of the interconnected 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 1 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 1.

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.

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.

TABLE 1 Specifications for Iron-Base Materials Used in PM Bearings

Material Designation Code	Chemical Composition Requirements						Physical Requirements		Mechanical Requirements	
	Iron mass %	Combined Carbon ^A mass %	Graphitic Carbon mass %	Copper mass %	Tin mass %	All Others mass %	Impregnated Density g/cm ³	Oil Content vol %	Radial Crushing Strength, (K)	
									10 ³ psi	(MPa)
Iron F-0000-K15	bal	0.3 max	...	1.5 max	...	2.0 max	5.6 to 6.0	21 min	15 min	(100 min)
Iron-Carbon (Steel) F-0005-K20	bal	0.3 to 0.6	...	1.5 max	...	2.0 max	5.6 to 6.0	21 min	20 min	(140 min)
Iron-Copper FC-1000-K20	bal	0.3 max	...	9.0 to 11.0	...	2.0 max	5.6 to 6.0	22 min	20 min	(140 min)
FC-2000-K25	bal	0.3 max	...	18.0 to 22.0	...	2.0 max	5.6 to 6.0	22 min	25 min	(170 min)
Iron-Bronze-Graphite (Diluted Bronze)										
FCTG-3604-K22	bal	0.5 max	0.5 to 1.0 ^B	34.0 to 38.0	3.5 to 4.5	2.0 max	6.0 to 6.4	17 min	22 to 50	(150 to 340)
FCTG-3604-K22	bal	0.5 max	... ^B	34.0 to 38.0	3.5 to 4.5	2.0 max	6.0 to 6.4	17 min	22 to 50	(150 to 340)
Iron-Graphite FG-0303-K10	bal	0.5 max	2.0 to 3.0	2.0 max	5.6 to 6.0	18 min	10 to 25	(70 to 170)
FG-0308-K16	bal	0.5 to 1.0	1.5 to 2.5	2.0 max	5.6 to 6.0	18 min	16 to 45	(110 to 310)

^A Metallurgically combined carbon expressed as a percentage of the iron in the material composition.

^B This specification is listed as 0.5 to 1.3 % total carbon in MPlF Standard 35 (Bearings).

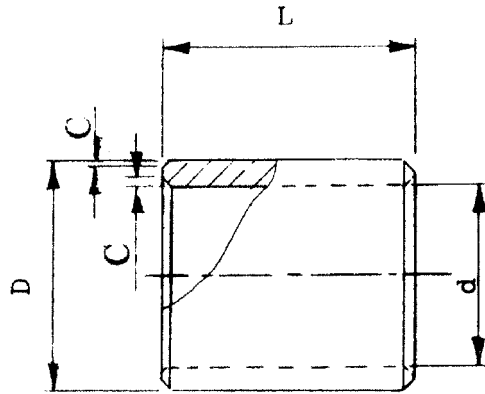


FIG. 1 Standard Sleeve Bearing

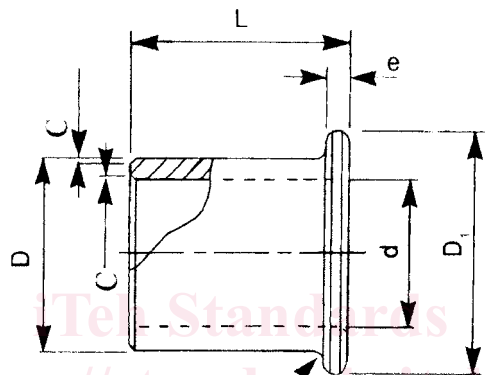


FIG. 2 Standard Flange Bearing

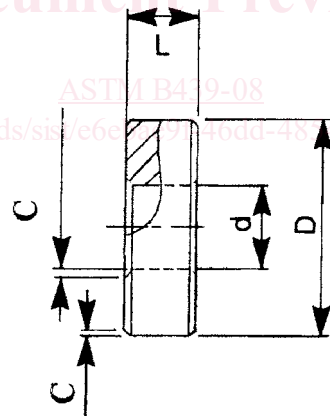


FIG. 3 Standard Thrust Bearing

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 \times 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 (13.3-213.3.1) be performed

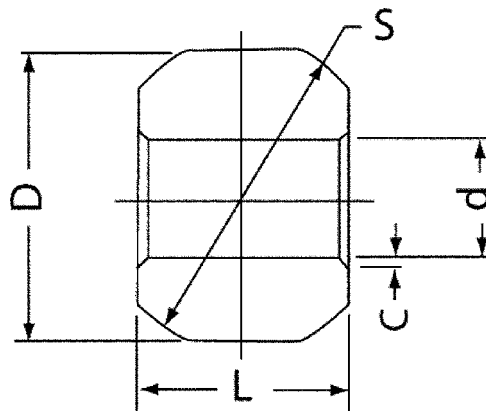


FIG. 4 Standard Spherical Bearing

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 user” (see Terminology B 243).

12.2 *Sampling Plan*— The number of sample bearings agreed to between the manufacturer 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 B 328. However, upon agreement between purchaser and supplier, 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 manufacturer 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 E 1019 with the exception that a sample size as small as 0.25 g may be used upon agreement between customer and supplier.

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 E 1019 (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 E 1019 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