INTERNATIONAL

Designation: B438 – 17

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

This standard is issued under the fixed designation B438; 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 porous metallic sleeve, flange, thrust and spherical bronze-base bearings that are produced from mixed metal powders 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 bronze-base PM materials that have been developed and standardized specifically for use in the manufacture of these self-lubricating bearings.

1.3 This specification is applicable to the purchase of bronze-base bearings (oil-impregnated) that were formerly covered by military specifications and are intended for government or military applications. Those additional government requirements that only apply to military bearings are listed in the Supplementary Requirements section of this specification.

1.4 This specification accompanies Specification B439 that covers the requirements for Iron-Base Powder Metallurgy (PM) Bearings, (Oil-Impregnated).

1.5 Typical applications for bronze-base bearings are listed in Appendix X1.

1.6 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, ISO 5755 and the technical literature.[2]

1.7 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 values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *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.*

1.9 *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
B439 Specification for Iron-Base Powder Metallurgy (PM) Bearings (Oil-Impregnated)
B939 Test Method for Radial Crushing Strength, ***K***, of Powder Metallurgy (PM) Bearings and Structural Materials
B946 Test Method for Surface Finish of Powder Metallurgy (PM) Products
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

[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.

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[2] *Machine Design Magazine*, Vol 54, #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.

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

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:*
MPIF Standard 35 Materials Standards for PM Self-Lubricating Bearings[4]
2.3 *ISO Standard:*[5]
ISO 2795 Plain Bearings Made from Sintered Material—Dimensions and Tolerances
ISO 5755 Sintered Metal Materials - Specifications
2.4 *Government Standards:*
MIL-PRF-6085 Lubricating Oil: Instrument, Aircraft, Low Volatility[6]
QPL-6085 Lubricating Oil Instrument, Aircraft, Low Volatility[6]
MIL-PRF-17331 Lubrication Oil, Steam Turbine and Gear, Moderate Service[6]
QPL-17331 Lubricating Oil, Steam Turbine and Gear, Moderate Service[6]

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 This specification uses the established three-part alphanumeric PM Material Designation Code to identify the nonferrous materials used for self-lubricating PM bearings. The complete explanation of this classification system is presented in Annex A1.

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

4.2.1 *Prefix CT—Bronze (Low Graphite):*

CT-1000-K19
CT-1000-K26
CT-1000-K37
CT-1000-K40

4.2.2 *Prefix CTG—Bronze-Graphite (Medium Graphite):*

CTG-1001-K17
CTG-1001-K23
CTG-1001-K30
CTG-1001-K34

4.2.3 *Prefix CTG—Bronze (High Graphite):*

CTG-1004-K10
CTG-1004-K15

4.2.4 *Prefix CTG-MOD—Bronze-Lead-Graphite (Military Grade):*

CTG-1001-K23-MOD

4.2.5 *Prefix CFTG—Bronze (Diluted):*

CFTG-3806-K14
CFTG-3806-K22

5. Ordering Information

5.1 Purchase orders or contracts for bronze-base, oil-impregnated 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 Standard, including date of issue,

5.1.3 Identification of bearing material by the PM Material Designation Code (Section 4.2),

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 (Section 6.2 or S2.2),

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

5.1.7 Chemical composition limits (Sections 7.2 and 13.2) if required,

5.1.8 Sampling lot size (Section 12) if required,

5.1.9 Testing procedure and strength requirement for the flanges of flanged oil-impregnated bearings (Section 13.4.1.2) if required,

5.1.10 Bearing breaking load (Section 13.4.2) if required.

5.2 Those additional government requirements necessary on orders for military bearings are prescribed in the Supplementary Requirements section.

6. Materials and Manufacture

6.1 *Porous Metallic Bearing:*

6.1.1 Sintered bronze-base bearings shall be produced by first compacting pre-alloyed bronze or elemental copper and tin powders and any other additives appropriate for the composition to the proper density and bearing configuration.

6.1.2 The green bearings shall then be sintered in a protective atmosphere furnace for a time and temperature relationship that will produce the required sintered bronze-base PM material.

6.1.3 After sintering, the bronze-base bearings are normally sized to achieve the density, dimensional characteristics, concentricity and surface finish required of the 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 normally 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.

[4] Available from Metal Powder Industries Federation (MPIF), 105 College Rd. East, Princeton, NJ 08540-6692, http://www.mpif.org.
[5] ISO standards are available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[6] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil. Electronic copies of military specifications may be obtained from http://assist.daps.dla.mil/.

TABLE 1 Specifications for Bronze-Base Materials used in PM Bearings

Material Designation Code	Chemical Requirements						Physical Requirements		Mechanical Requirements	
									Radial Crushing Strength, K	
	Copper mass %	Tin mass %	Lead mass %	Graphitic Carbon mass %	Iron mass %	All Others mass %	Impregnated Density g/cm^3	Oil Content vol %	10^3 psi	(MPa)
Bronze (Low Graphite)										
CT-1000-K19	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	6.0-6.4	24 min^{A,G}	19 min	(130 min)
CT-1000-K26	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	6.4-6.8	19 min^{G}	26 min	(180 min)
CT-1000-K37	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	6.8-7.2	12 min^{G}	37 min	(260 min)
CT-1000-K40	bal	9.5-10.5	—	0.3 max	1.0 max	1.0 max	7.2-7.6	9 min^{G}	40 min	(280 min)
Bronze (Medium Graphite)										
CTG-1001-K17	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	6.0-6.4	22 min^{B,G}	17 min	(120 min)
CTG-1001-K23	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	6.4-6.8	17 min^{G}	23 min	(160 min)
CTG-1001-K30	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	6.8.7.2	9 min^{G}	30 min	(210 min)
CTG-1001-K34	bal	9.5-10.5	—	0.5-1.8	1.0 max	1.0 max	7.2-7.6	7 min^{G}	34 min	(230 min)
Bronze (High Graphite)										
CTG-1004-K10	bal	9.2-10.2	—	2.5-5.0	1.0 max	1.0 max	5.8-6.2	11 min^{G,I}	10 min	(70 min)
CTG-1004-K15	bal	9.2-10.2	—	2.5-5.0	1.0 max	1.0 max	6.2-6.6	^{C,G}	15 min	(100 min)
Bronze-Lead-Graphite (Military Grade)										
CTG-1001-K23-MOD^{D}	bal	9.5-10.5	2.0-4.0	0.5-1.75	1.0 max	0.5 max	6.4-6.8	17 min^{G}	23 min	(160 min)
Bronze (Diluted)										
CFTG-3806-K14	bal	5.5-6.5	—	^{E}	36.0-40.0^{F}	2.0 max	5.6-6.0	22 min^{H}	14-35	(100-240)
CFTG-3806-K22	bal	5.5-6.5	—	^{E}	36.0-40.0^{F}	2.0 max	6.0-6.4	17 min^{H}	22-50	(150-340)

^{A} For an oil content of 27% min, density range will be 5.8-6.2 g/cm^3 and radial crushing strength will be 15 000 psi (100 MPa) minimum.
^{B} For an oil content of 25% min, density range will be 5.8-6.2 g/cm^3 and radial crushing strength will be 13 000 psi (90 MPa) minimum.
^{C} At maximum graphite (5%) and density (6.6 g/cm^3), this material will contain only a trace of oil. At 3% graphite and 6.2-6.6 g/cm^3 density, it will contain 8 vol % (min.) of oil.
^{D} Additional chemical requirements are: Zinc–0.75% max, Nickel–0.35% max, Antimony–0.25% max.
^{E} Graphitic carbon content is typically 0.5-1.3%; total carbon shall be 0.5-1.3%.
^{F} The iron portion may contain 0.5% max metallurgically combined carbon.
^{G} Minimum oil content will decrease with increasing density. Those shown are valid at the upper-limit of the density given.
^{H} These data are based on material in the finished condition.
^{I} At 3% graphite, it will contain 14% min oil content.

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 a general purpose lubricating oil.

7. Chemical Composition

7.1 *Chemical Composition Specifications*—Each bronze-base PM bearing material shall conform to the chemical requirements prescribed in Table 1 when determined on a clean test sample 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 1.

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 prescribed 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 standard is applicable to bronze-base PM sleeve and flange bearings having a 4 to 1 maximum length to inside diameter ratio and a 24 to 1 maximum length to wall thickness ratio.

10.2 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 tolerance limits shown on the bearing print accompanying

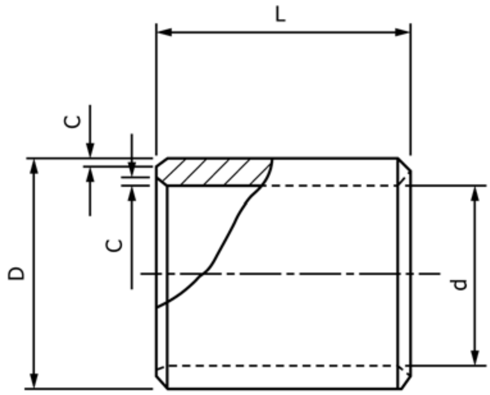

FIG. 1 Standard Sleeve Bearing

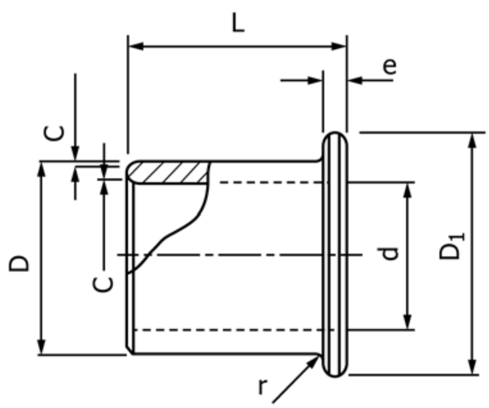

FIG. 2 Standard Flange Bearing

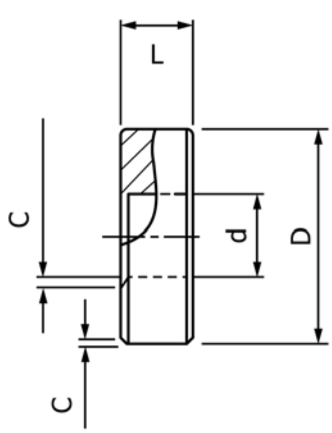

FIG. 3 Standard Thrust Bearing

the order or shall be within the limits specified in the purchase order or contract. Dimensional tolerances of bearings for military or government applications shall meet the requirements specified in the Supplementary Requirements section.

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

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

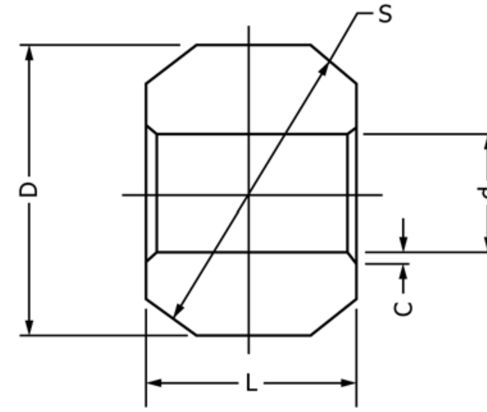

FIG. 4 Standard Spherical Bearing

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 of the bearings should exhibit a uniform visual appearance.

11.3 If metallographic examination is performed to determine degree of sintering, it should be done at 200-400X magnification. In 90Cu-10Sn bronze bearings, the microstructure should be alpha bronze with no silver-gray tin-rich copper compounds and with a minimum of reddish copper-rich areas. The structure should have a very minimum number of original particle boundaries. Diluted bronze material should show a bronze phase with no visible free tin, dispersed throughout an iron matrix.

11.4 To verify that oil is present, heat the bearing to about 300 °F (150 °C) for 5 minutes. If oil is present, the bearing surfaces exhibit beads of oil being exuded from the pores.

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 operation. It is important that the Oil Content test (13.3.2) 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 (Terminology B243).

12.2 *Sampling Plan*—The number of sample bearings, agreed to between the producer and the purchaser, to be used for inspections 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 must be dry and free of oil before running chemical tests. To remove oil, a Soxhlet Apparatus as specified in Test Method B963 may be used. 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 inert atmosphere may be used to volatilize any lubricant that may be present.

13.2.2 *Metallic Elements*—The chemical analysis of metallic elements shall be performed on an oil-free sample 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.

13.2.3 *Combined Carbon*—To determine the amount of carbon metallurgically combined with the iron in the diluted bronze materials, a metallographic estimate may be made.

13.2.4 *Graphitic Carbon*—Determine the total carbon content in accordance with Test Method E1019 with the exception that a sample as small as 0.25 g may be used upon agreement between purchaser and producer. With the exception of diluted bronze, the graphitic carbon provides an estimate of the total carbon. For diluted bronze, the graphitic carbon is approximately equal to the total carbon minus the combined carbon as determined in 13.2.3.

13.3 *Physical Properties:*

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

13.3.2 *Impregnation Efficiency*—The efficiency of the oil-impregnation process in volume percent units shall be calculated following the procedure for *Oil-Impregnation Efficiency* in Test Method B963.

13.3.3 *Impregnated Density*—The impregnated density of the sample bearings in g/cm^3 units, measured after they have been fully impregnated, shall be determined following the procedure for *Determination of 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 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 1 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 1. 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 1 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 minimum (maximum) breaking load, $P_{min,}$ (P_{max}) required for acceptance of any specific plain sleeve or thrust bearing is calculated using the breaking load formula:

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

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 Use the minimum (maximum) radial crushing strength value specified for the oil-impregnated bearing material from Table 1 for K, use the actual D, d and L dimensions of the as-received bearing and solve for $P_{min,}$ (P_{max}). This calculated value will be the minimum (maximum) acceptable breaking load for that specific plain bearing. Using the allowable print dimensions that minimize (maximize) the volume of the bearing for the calculations will result in a breaking load specification(s) that will be applicable to any lot of that specific bearing.

13.4.2.3 The minimum (maximum) acceptable breaking load for a specific flanged bearing shall be calculated by first cutting off the flange and measuring the D, d and L of the body. Then, using the minimum (maximum) radial crushing strength for the oil-impregnated bearing material in Table 1 for K in the breaking load formula and the measured dimensions of the body, a $P_{min,}$ (P_{max}) value may be calculated. This will be the minimum (maximum) bearing breaking load required for the body of that specific flanged bearing. The test procedure and breaking load requirements for the flange shall be a matter of agreement between purchaser and producer.

13.4.2.4 For acceptance testing of whole spherical bearings, a minimum (maximum) bearing breaking load specification, $P_{min,}$ (P_{max}) may be established on a specific whole spherical oil-impregnated bearing. First, the radial crushing strength, K_a, is determined on that specific spherical bearing machined to a plain cylinder as in 13.4.1.3. Second, whole spherical bearings from the same lot are crushed, keeping their axes horizontal, to determine the breaking load of the whole bearing. Then, using the correlation formula, the specifications for the breaking load, $P_{a,}$ of that whole spherical bearing are calculated as follows:

$$P_{min,}\,(P_{max}) = \frac{K \times P_a}{K_a} \tag{2}$$

where:

$P_{min,}$ (P_{max}) = specification for the minimum (maximum) bearing breaking load of a specific whole spherical bearing, lbf (N),
K_a = radial crushing strength of the machined test spherical bearings according to 13.4.1.3, psi (MPa),
K = minimum (maximum) radial crushing strength for the bearing material, (Table 1), psi (MPa), and
P_a = breaking load of whole test spherical bearings, lbf (N).

13.5 *Conformance:*

13.5.1 *Dimensional Measurements*—For purposes of determining conformance with the dimensional specifications, the tolerance limits specified on the bearing print are considered absolute limits as defined in Practice E29.

13.5.2 *Chemical, Physical, Mechanical Test Results*—For purposes of determining conformance with these specifications, an observed value or calculated value 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.

13.5.3 *Measurement Uncertainty*—The precision and bias of the test result values shall be considered by the purchaser and producer in determining conformance.

14. Inspection

14.1 The producer has the primary responsibility to conduct the necessary measurements and tests to ensure that the bearings meet the requirements of the purchase order or contract and this specification before they are shipped to the purchaser.

14.2 Provided the producer notifies the purchaser, all or a portion of the required conformance tests may be contracted to a qualified third party.

14.3 Upon receipt of the shipment, the purchaser may conduct whatever quality control inspections that he feels are necessary to confirm compliance to the purchasing requirements.

15. Rejection and Rehearing

15.1 Rejection based on tests made in accordance with this specification shall be reported in writing to the producer within 30 days of receipt of the shipment; the rejected bearings, however, shall not be returned or disposed of without written authorization from the producer.

15.2 In case of dissatisfaction with the test results, either the purchaser or producer may make a claim for rehearing.

16. Certification and Test Report

16.1 The purchaser may require in the purchase order or contract that the producer shall supply a Certificate of Compliance stating that the bearings were produced and tested in accordance with this specification and met all requirements.

16.2 In addition, when required by the purchase order or contract, the producer shall furnish a Test Report that lists the results of the chemical, physical, mechanical and functional tests performed on the sample bearings.

16.3 Unless otherwise agreed upon between the purchaser and the producer, the Certificate of Compliance, the Test Report, or both will be transmitted by electronic service.

17. Packaging

17.1 Unless specific packaging requirements are included in the purchase order or contract, the finished oil-impregnated PM bearings shall be packaged and shipped in containers of a nonabsorbent material to prevent loss of lubricating oil.

18. Keywords

18.1 bearing breaking load; bronze bearings; impregnated density; interconnected porosity; oil content; oil-impregnated bearings; open porosity; porous metallic bearings; radial crushing strength; self-lubricating bearings; PM bearings; PV Factor; PV Limit

SUPPLEMENTARY REQUIREMENTS

MILITARY BEARINGS, SINTERED BRONZE, OIL-IMPREGNATED

The following supplementary requirements shall apply to purchase orders or contracts from all agencies of the United States Government or where specified by a purchaser as part of the purchase order or contract with a government agency.

S1. Introduction

S1.1 The B438 purchasing specification incorporates and updates the applicable portions of specifications from four now-cancelled military standards, bringing the military requirements into alignment with the rest of this consensus specification. The type and grade designations from four now-cancelled military standards have been converted to the industry accepted material designation codes from MPIF Standard 35 (Bearings) (see Table A2.1 for conversion information). In addition to meeting the primary specifications, the purchaser of bearings for military or government applications must comply with additional specific requirements. This Supplementary Requirements section details those additional governmental requirements.

S1.2 The bearings referred to within this specification are not intended for reaming on assembly.

S1.3 The bearings referred to within this specification are not recommended for military airframe applications.

S2. Government Requirements

S2.1 *Chemical, Physical and Mechanical Requirements*—Refer to Section 1 and Table 1 for the specifications for bearing materials that shall conform to material designation codes CTG-1001-K23 (sleeve, flange and thrust washer) or CTG-1001-K23-MOD (sleeve and flange only). The contractor shall furnish a chemical composition analysis on an oil-free basis for each lot showing the weight percentage for each element as specified in Table 1. Bearings shall conform to this specification.

S2.1.1 *Compressive Yield Strength*—The yield strength in compression shall be 11 000 psi (75 MPa) (minimum) for 0.1 percent permanent offset in accordance with section X3.2.1.

S2.1.2 *Surface Finish*—For thrust washer bearings, all surfaces shall have a surface finish of 125 µin. maximum except as noted on a print or drawing. Surface finish shall be measured in accordance with Test Method B946.

S2.2 *Oil-Impregnation*—High-grade non-gumming petroleum lubricants purchased in accordance with the applicable Qualified Products Lists (QPLs), such as MIL-PRF-17331 (Military Symbol 2190–TEP, NATO Code O-250 and QPL-17331) for sleeve and flange bearings and MIL-PRF-6085 (Military Symbol OAI, NATO Code No. 0-147 and QPL-6085) for thrust washer bearings, or as specified on referenced military standard specification sheets shall be used to impregnate the bearings.

S2.3 *First Article Tests (FAT)*—When specified in the contract, FATs shall be performed on a number of samples (four minimum). The tests performed shall conform to 12.2, Sampling Plan and shall include testing for interconnected porosity. Testing shall be as specified within this specification, Test Method B963 or in another document as specified in the contract. Any defect or failure shall be cause for rejection of the lot. Waivers for minor defects may be addressed to the contracting officer.

NOTE—In order to perform all the tests on a single bearing, the following order of tests is suggested: dimensional, impregnated density, interconnected porosity, oil content, oil exudation, radial crushing strength and chemical analysis.

S2.4 *Oil Exudation Test*—During the test period for oil exudation, beads shall exude from the bearing surface. Lack of appreciable sweating of the lubricant on the bearing surface will be cause for rejection (see 11.4).

S2.5 *COQC*—When procured from a dealer or distributor versus the actual producer, a certificate of quality conformance (COQC) supplied by the producer of the bearing may be furnished in lieu of actual performance of such testing by the dealer or distributor, provided lot identity is traceable, has been maintained and can be demonstrated to the Government. The certificate shall include the name of the dealer or distributor, dealer or distributor number, name of producer, national stock number (NSN), item identification, name of the component or material, lot number, lot size, dimensions, date of testing, test method, individual test results, and specification requirements.

S2.6 *Records*—Records of examination and tests performed by or for the contractor shall be maintained and made available to the Government by the contractor for a period of three years after delivery of the products and associate material.

S2.7 *Inspection*—Unless otherwise specified, the producer is responsible for testing. The producer may use their own or any other suitable facility for the performance of testing and inspection, unless an exception is stated. The Government reserves the right to perform an inspection as set forth herein to assure supplies and sources conform to the prescribed requirements.

S2.8 *Packaging*—Special packaging and marking requirements shall be included in the contract or will conform to Section 17, Packaging.

S2.9 *Requirements*—All requirements shall be as specified herein. Referenced military standard specification sheets shall take precedence unless otherwise specified in the purchase order or contract.

S3. Ordering Information

S3.1 *Purchase Order or Contract*—Ordering information shall be in accordance with Section 5 of this specification and shall also include:

S3.1.1 PIN from S3.3, Table S3.1, Table S3.2 or Table S3.3,

S3.1.2 National Stock Number (NSN),

S3.1.3 Quantity,

TABLE S3.1 MS17795 Bronze Sleeve Bearings—Dimensions and Dash Numbers

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
1	97	3⁄32	1⁄8	0.127	0.1905
2	129	1⁄8	1⁄8	0.127	0.1905
3	194	3⁄16	1⁄8	0.127	0.1905
4	258	1⁄4	1⁄8	0.127	0.1905
5	129	1⁄8	1⁄8	0.127	0.253
6	194	3⁄16	1⁄8	0.127	0.253
7	258	1⁄4	1⁄8	0.127	0.253
8	323	5⁄16	1⁄8	0.127	0.253
9	193	1⁄8	3⁄16	0.1895	0.253
10	290	3⁄16	3⁄16	0.1895	0.253
11	387	1⁄4	3⁄16	0.1895	0.253
12	483	5⁄16	3⁄16	0.1895	0.253
13	580	3⁄8	3⁄16	0.1895	0.253
14	677	7⁄16	3⁄16	0.1895	0.253
15	290	3⁄16	3⁄16	0.1895	0.3155
16	387	1⁄4	3⁄16	0.1895	0.3155
17	483	5⁄16	3⁄16	0.1895	0.3155
18	580	3⁄8	3⁄16	0.1895	0.3155
19	677	7⁄16	3⁄16	0.1895	0.3155
20	774	1⁄2	3⁄16	0.1895	0.3155
21	386	3⁄16	1⁄4	0.252	0.378
22	516	1⁄4	1⁄4	0.252	0.378
23	645	5⁄16	1⁄4	0.252	0.378
24	773	3⁄8	1⁄4	0.252	0.378
25	902	7⁄16	1⁄4	0.252	0.378
26	1031	1⁄2	1⁄4	0.252	0.378
27	1289	5⁄8	1⁄4	0.252	0.378
28	386	3⁄16	1⁄4	0.252	0.4405
29	516	1⁄4	1⁄4	0.252	0.4405
30	645	5⁄16	1⁄4	0.252	0.4405
31	773	3⁄8	1⁄4	0.252	0.4405
32	902	7⁄16	1⁄4	0.252	0.4405
33	1031	1⁄2	1⁄4	0.252	0.4405
34	1289	5⁄8	1⁄4	0.252	0.4405
35	1547	3⁄4	1⁄4	0.252	0.4405
36	645	1⁄4	5⁄16	0.3145	0.4405
37	806	5⁄16	5⁄16	0.3145	0.4405
38	967	3⁄8	5⁄16	0.3145	0.4405
39	1128	7⁄16	5⁄16	0.3145	0.4405
40	1289	1⁄2	5⁄16	0.3145	0.4405
41	1611	5⁄8	5⁄16	0.3145	0.4405
42	1934	3⁄4	5⁄16	0.3145	0.4405
43	773	1⁄4	3⁄8	0.377	0.503
44	967	5⁄16	3⁄8	0.377	0.503
45	1160	3⁄8	3⁄8	0.377	0.503
46	1354	7⁄16	3⁄8	0.377	0.503
47	1547	1⁄2	3⁄8	0.377	0.503
48	1934	5⁄8	3⁄8	0.377	0.503
49	2320	3⁄4	3⁄8	0.377	0.503
50	2707	7⁄8	3⁄8	0.377	0.503
51	3094	1	3⁄8	0.377	0.503
52	773	1⁄4	3⁄8	0.377	0.628
53	967	5⁄16	3⁄8	0.377	0.628
54	1160	3⁄8	3⁄8	0.377	0.628
55	1354	7⁄16	3⁄8	0.377	0.628
56	1547	1⁄2	3⁄8	0.377	0.628
57	1934	5⁄8	3⁄8	0.377	0.628
58	2320	3⁄4	3⁄8	0.377	0.628
59	2707	7⁄8	3⁄8	0.377	0.628
60	3094	1	3⁄8	0.377	0.628
61	3867	1-1⁄4	3⁄8	0.377	0.628
62	1354	3⁄8	7⁄16	0.439	0.565
63	1579	7⁄16	7⁄16	0.439	0.565
64	1805	1⁄2	7⁄16	0.439	0.565
65	2256	5⁄8	7⁄16	0.439	0.565
66	2707	3⁄4	7⁄16	0.439	0.565
67	3158	7⁄8	7⁄16	0.439	0.565
68	3609	1	7⁄16	0.439	0.565
69	4512	1-1⁄4	7⁄16	0.439	0.565
70	1547	3⁄8	1⁄2	0.502	0.628
71	1805	7⁄16	1⁄2	0.502	0.628
72	2063	1⁄2	1⁄2	0.502	0.628

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
73	2578	5⁄8	1⁄2	0.502	0.628
74	3094	3⁄4	1⁄2	0.502	0.628
75	3609	7⁄8	1⁄2	0.502	0.628
76	4125	1	1⁄2	0.502	0.628
77	5156	1-1⁄4	1⁄2	0.502	0.628
78	1547	3⁄8	1⁄2	0.502	0.753
79	2063	1⁄2	1⁄2	0.502	0.753
80	2578	5⁄8	1⁄2	0.502	0.753
81	3094	3⁄4	1⁄2	0.502	0.753
82	3609	7⁄8	1⁄2	0.502	0.753
83	4125	1	1⁄2	0.502	0.753
84	5156	1-1⁄4	1⁄2	0.502	0.753
85	6188	1-1⁄2	1⁄2	0.502	0.753
86	2320	1⁄2	9⁄16	0.565	0.695
87	2900	5⁄8	9⁄16	0.565	0.695
88	3480	3⁄4	9⁄16	0.565	0.695
89	4061	7⁄8	9⁄16	0.565	0.695
90	4641	1	9⁄16	0.565	0.695
91	5801	1-1⁄4	9⁄16	0.565	0.695
92	6961	1-1⁄2	9⁄16	0.565	0.695
93	2578	1⁄2	5⁄8	0.627	0.753
94	3223	5⁄8	5⁄8	0.627	0.753
95	3867	3⁄4	5⁄8	0.627	0.753
96	4518	7⁄8	5⁄8	0.627	0.753
97	5156	1	5⁄8	0.627	0.753
98	6445	1-1⁄4	5⁄8	0.627	0.753
99	7734	1-1⁄2	5⁄8	0.627	0.753
100	2578	1⁄2	5⁄8	0.627	0.879
101	3223	5⁄8	5⁄8	0.627	0.879
102	3867	3⁄4	5⁄8	0.627	0.879
103	4518	7⁄8	5⁄8	0.627	0.879
104	5156	1	5⁄8	0.627	0.879
105	6445	1-1⁄4	5⁄8	0.627	0.879
106	7734	1-1⁄2	5⁄8	0.627	0.879
107	9023	1-3⁄4	5⁄8	0.627	0.879
108	3094	1⁄2	3⁄4	0.752	0.879
109	3867	5⁄8	3⁄4	0.752	0.879
110	4640	3⁄4	3⁄4	0.752	0.879
111	5414	7⁄8	3⁄4	0.752	0.879
112	6188	1	3⁄4	0.752	0.879
113	7734	1-1⁄4	3⁄4	0.752	0.879
114	9281	1-1⁄2	3⁄4	0.752	0.879
115	10828	1-3⁄4	3⁄4	0.752	0.879
116	3094	1⁄2	3⁄4	0.752	1.004
117	3867	5⁄8	3⁄4	0.752	1.004
118	4640	3⁄4	3⁄4	0.752	1.004
119	5414	7⁄8	3⁄4	0.752	1.004
120	6188	1	3⁄4	0.752	1.004
121	7734	1-1⁄4	3⁄4	0.752	1.004
122	9281	1-1⁄2	3⁄4	0.752	1.004
123	10828	1-3⁄4	3⁄4	0.752	1.004
124	12375	2	3⁄4	0.752	1.004
125	4512	5⁄8	7⁄8	0.877	1.004
126	5414	3⁄4	7⁄8	0.877	1.004
127	6316	7⁄8	7⁄8	0.877	1.004
128	7219	1	7⁄8	0.877	1.004
129	9023	1-1⁄4	7⁄8	0.877	1.004
130	10828	1-1⁄2	7⁄8	0.877	1.004
131	12633	1-3⁄4	7⁄8	0.877	1.004
132	6188	3⁄4	1	1.003	1.129
133	7219	7⁄8	1	1.003	1.129
134	8250	1	1	1.003	1.129
135	10313	1-1⁄4	1	1.003	1.129
136	12375	1-1⁄2	1	1.003	1.129
137	14438	1-3⁄4	1	1.003	1.129
138	16500	2	1	1.003	1.129
139	6188	3⁄4	1	1.003	1.254
140	7219	7⁄8	1	1.003	1.254
141	8250	1	1	1.003	1.254
142	10313	1-1⁄4	1	1.003	1.254
143	12375	1-1⁄2	1	1.003	1.254
144	14438	1-3⁄4	1	1.003	1.254
145	16500	2	1	1.003	1.254

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
146	18563	2-¼	1	1.003	1.254
147	20625	2-½	1	1.003	1.254
148	9281	1	1-⅛	1.128	1.378
149	11602	1-¼	1-⅛	1.128	1.378
150	13922	1-½	1-⅛	1.128	1.378
151	16242	1-¾	1-⅛	1.128	1.378
152	18563	2	1-⅛	1.128	1.378
153	20883	2-¼	1-⅛	1.128	1.378
154	23203	2-½	1-⅛	1.128	1.378
155	10313	1	1-¼	1.2535	1.504
156	12891	1-¼	1-¼	1.2535	1.504
157	15469	1-½	1-¼	1.2535	1.504
158	18047	1-¾	1-¼	1.2535	1.504
159	20625	2	1-¼	1.2535	1.504
160	23203	2-¼	1-¼	1.2535	1.504
161	25781	2-½	1-¼	1.2535	1.504
162	28359	2-¾	1-¼	1.2535	1.504
163	30938	3	1-¼	1.2535	1.504
164	11344	1	1-⅜	1.378	1.629
165	14180	1-¼	1-⅜	1.378	1.629
166	17016	1-½	1-⅜	1.378	1.629
167	19852	1-¾	1-⅜	1.378	1.629
168	22688	2	1-⅜	1.378	1.629
169	25523	2-¼	1-⅜	1.378	1.629
170	28359	2-½	1-⅜	1.378	1.629
171	31195	2-¾	1-⅜	1.378	1.629
172	34031	3	1-⅜	1.378	1.629
173	12375	1	1-½	1.504	1.755
174	15469	1-¼	1-½	1.504	1.755
175	18563	1-½	1-½	1.504	1.755
176	21656	1-¾	1-½	1.504	1.755
177	24750	2	1-½	1.504	1.755
178	27844	2-¼	1-½	1.504	1.755
179	30938	2-½	1-½	1.504	1.755
180	34031	2-¾	1-½	1.504	1.755
181	37125	3	1-½	1.504	1.755
182	21656	1-½	1-¾	1.753	2.005
183	25266	1-¾	1-¾	1.753	2.005
184	28875	2	1-¾	1.753	2.005
185	32484	2-¼	1-¾	1.753	2.005
186	36094	2-½	1-¾	1.753	2.005
187	39703	2-¾	1-¾	1.753	2.005
188	43313	3	1-¾	1.753	2.005
189	28875	1-¾	2	2.004	2.38
190	33000	2	2	2.004	2.38
191	37125	2-¼	2	2.004	2.38
192	41250	2-½	2	2.004	2.38
193	45375	2-¾	2	2.004	2.38
194	49500	3	2	2.004	2.38
195	57750	3-½	2	2.004	2.38
196	66000	4	2	2.004	2.38
197	37125	2	2-¼	2.254	2.631
198	46406	2-½	2-¼	2.254	2.631
199	55688	3	2-¼	2.254	2.631
200	64969	3-½	2-¼	2.254	2.631
201	74250	4	2-¼	2.254	2.631
202	41250	2	2-½	2.505	3.006
203	51563	2-½	2-½	2.505	3.006
204	61875	3	2-½	2.505	3.006
205	72188	3-½	2-½	2.505	3.006
206	82500	4	2-½	2.505	3.006
207	323	5⁄16	⅛	0.127	0.1905
208	387	⅜	⅛	0.127	0.1905
209	451	7⁄16	⅛	0.127	0.1905
210	516	½	⅛	0.127	0.1905
211	387	⅜	⅛	0.127	0.253
212	451	7⁄16	⅛	0.127	0.253
213	516	½	⅛	0.127	0.253
214	161	⅛	5⁄32	0.158	0.253
215	242	3⁄16	5⁄32	0.158	0.253
216	322	¼	5⁄32	0.158	0.253
217	403	5⁄16	5⁄32	0.158	0.253
218	483	⅜	5⁄32	0.158	0.253

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
219	564	7⁄16	5⁄32	0.158	0.253
220	645	½	5⁄32	0.158	0.253
221	774	½	3⁄16	0.1895	0.253
222	967	⅝	3⁄16	0.1895	0.253
223	1160	¾	3⁄16	0.1895	0.253
224	967	⅝	3⁄16	0.1895	0.3155
225	1160	¾	3⁄16	0.1895	0.3155
226	1354	⅞	3⁄16	0.1895	0.3155
227	1546	1	3⁄16	0.1895	0.3155
228	1547	¾	¼	0.252	0.378
229	1805	⅞	¼	0.252	0.378
230	2063	1	¼	0.252	0.378
231	2320	1-⅛	¼	0.252	0.378
232	2578	1-¼	¼	0.252	0.378
233	1805	⅞	¼	0.252	0.4405
234	2063	1	¼	0.252	0.4405
235	2320	1-⅛	¼	0.252	0.4405
236	2578	1-¼	¼	0.252	0.4405
237	3094	1-½	¼	0.252	0.4405
238	2256	⅞	5⁄16	0.3145	0.4405
239	2578	1	5⁄16	0.3145	0.4405
240	2900	1-⅛	5⁄16	0.3145	0.4405
241	3223	1-¼	5⁄16	0.3145	0.4405
242	3867	1-½	5⁄16	0.3145	0.4405
243	645	¼	5⁄16	0.3145	0.503
244	806	5⁄16	5⁄16	0.3145	0.503
245	967	⅜	5⁄16	0.3145	0.503
246	1128	7⁄16	5⁄16	0.3145	0.503
247	1289	½	5⁄16	0.3145	0.503
248	1611	⅝	5⁄16	0.3145	0.503
249	1934	¾	5⁄16	0.3145	0.503
250	2256	⅞	5⁄16	0.3145	0.503
251	2578	1	5⁄16	0.3145	0.503
252	2900	1-⅛	5⁄16	0.3145	0.503
253	3223	1-¼	5⁄16	0.3145	0.503
254	3867	1-½	5⁄16	0.3145	0.503
255	3480	1-⅛	⅜	0.377	0.503
256	3867	1-¼	⅜	0.377	0.503
257	4641	1-½	⅜	0.377	0.503
258	3480	1-⅛	⅜	0.377	0.628
259	4061	1-⅛	7⁄16	0.439	0.565
260	5414	1-½	7⁄16	0.439	0.565
261	4641	1-⅛	½	0.502	0.628
262	6188	1-½	½	0.502	0.628
263	6703	1-⅝	½	0.502	0.628
264	4641	1-⅛	½	0.502	0.753
265	6703	1-⅝	½	0.502	0.753
266	7219	1-¾	½	0.502	0.753
267	8250	1-⅞	½	0.502	0.753
268	5221	1-⅛	9⁄16	0.565	0.695
269	5801	1-⅛	⅝	0.627	0.753
270	5801	1-⅛	⅝	0.627	0.879
271	8379	1-⅝	⅝	0.627	0.879
272	9668	1-⅞	⅝	0.627	0.879
273	10313	2	⅝	0.627	0.879
274	6961	1-⅛	¾	0.752	0.879
275	10055	1-⅝	¾	0.752	0.879
276	6961	1-⅛	¾	0.752	1.004
277	10055	1-⅝	¾	0.752	1.004
278	11602	1-⅞	¾	0.752	1.004
279	13922	2-¼	¾	0.752	1.004
280	15469	2-½	¾	0.752	1.004
281	8121	1-⅛	⅞	0.877	1.004
282	11730	1-⅝	⅞	0.877	1.004
283	9281	1-⅛	1	1.003	1.129
284	13406	1-⅝	1	1.003	1.129
285	15469	1-⅞	1	1.003	1.129
286	9281	1-⅛	1	1.003	1.254
287	13406	1-⅝	1	1.003	1.254
288	15469	1-⅞	1	1.003	1.254
289	22681	2-¾	1	1.003	1.254
290	24750	3	1	1.003	1.254
291	6188	¾	1	1.003	1.379

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
292	7219	⅞	1	1.003	1.379
293	8250	1	1	1.003	1.379
294	9281	1-⅛	1	1.003	1.379
295	10313	1-¼	1	1.003	1.379
296	12375	1-½	1	1.003	1.379
297	13406	1-⅝	1	1.003	1.379
298	14438	1-¾	1	1.003	1.379
299	15469	1-⅞	1	1.003	1.379
300	16500	2	1	1.003	1.379
301	18563	2-¼	1	1.003	1.379
302	20625	2-½	1	1.003	1.379
303	22681	2-¾	1	1.003	1.379
304	10441	1-⅛	1-⅛	1.128	1.378
305	15082	1-⅝	1-⅛	1.128	1.378
306	17402	1-⅞	1-⅛	1.128	1.378
307	25523	2-¾	1-⅛	1.128	1.378
308	27800	3	1-⅛	1.128	1.378
309	11602	1-⅛	1-¼	1.2535	1.504
310	16758	1-⅝	1-¼	1.2535	1.504
311	19336	1-⅞	1-¼	1.2535	1.504
312	10313	1	1-¼	1.2535	1.630
313	11602	1-⅛	1-¼	1.2535	1.630
314	12891	1-¼	1-¼	1.2535	1.630
315	15469	1-½	1-¼	1.2535	1.630
316	16758	1-⅝	1-¼	1.2535	1.630
317	18047	1-¾	1-¼	1.2535	1.630
318	19336	1-⅞	1-¼	1.2535	1.630
319	20625	2	1-¼	1.2535	1.630
320	23203	2-¼	1-¼	1.2535	1.630
321	25781	2-½	1-¼	1.2535	1.630
322	28359	2-¾	1-¼	1.2535	1.630
323	30938	3	1-¼	1.2535	1.630
324	12762	1-⅛	1-⅜	1.378	1.629
325	18434	1-⅝	1-⅜	1.378	1.629
326	21270	1-⅞	1-⅜	1.378	1.629
327	13922	1-⅛	1-½	1.504	1.755
328	20109	1-⅝	1-½	1.504	1.755
329	23203	1-⅞	1-½	1.504	1.755
330	12375	1	1-½	1.504	1.880
331	13922	1-⅛	1-½	1.504	1.880
332	15469	1-¼	1-½	1.504	1.880
333	18563	1-½	1-½	1.504	1.880
334	20109	1-⅝	1-½	1.504	1.880
335	21656	1-¾	1-½	1.504	1.880
336	23203	1-⅞	1-½	1.504	1.880
337	24750	2	1-½	1.504	1.880
338	27844	2-¼	1-½	1.504	1.880
339	30938	2-½	1-½	1.504	1.880
340	34031	2-¾	1-½	1.504	1.880
341	37125	3	1-½	1.504	1.880
342	23461	1-⅝	1-¾	1.753	2.005
343	27070	1-⅞	1-¾	1.753	2.005
344	30938	1-⅞	2	2.004	2.380
345	28875	1-¾	2	2.004	2.505
346	30938	1-⅞	2	2.004	2.505
347	33000	2	2	2.004	2.505
348	37125	2-¼	2	2.004	2.505
349	41250	2-½	2	2.004	2.505
350	45375	2-¾	2	2.004	2.505
351	49500	3	2	2.004	2.505
352	57750	3-½	2	2.004	2.505
353	66000	4	2	2.004	2.505
354	41766	2-¼	2-¼	2.254	2.631
355	51047	2-¾	2-¼	2.254	2.631
356	60328	3-¼	2-¼	2.254	2.631
357	69609	3-¾	2-¼	2.254	2.631
358	46406	2-¼	2-½	2.505	3.006
359	56719	2-¾	2-½	2.505	3.006
360	67031	3-¼	2-½	2.505	3.006
361	77344	3-¾	2-½	2.505	3.006
362	49500	2	3	3.006	3.507
363	55688	2-¼	3	3.006	3.507
364	61875	2-½	3	3.006	3.507

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Outer Diameter, D (in.)
365	68063	2-¾	3	3.006	3.507
366	74250	3	3	3.006	3.507
367	80438	3-¼	3	3.006	3.507
368	86625	3-½	3	3.006	3.507
369	92813	3-¾	3	3.006	3.507
370	99000	4	3	3.006	3.507

S3.1.4 Requirements for testing including FAT,

S3.1.15 COQC if required, and

S3.1.6 Packaging requirements, if different from Section 17.

S3.2 *PIN*—The military PIN shall consist of the letters and numbers representing the old MS documents and taken from the titles of Table S3.1 (for sleeve), Table S3.2 (for flange) or Table S3.3 (for thrust washer), a dash number from either Table S3.1 (for sleeve), Table S3.2 (for flange) or Table S3.3 (for thrust washer) and a suffix of Y or Z representing the material designation code.

$$\text{Example: MS17796} - 104 - \text{Y}$$

where:

MS17796 = the number from Table S3.1 or Table S3.2 or Table S3.3 representing the old MS document,
104 = Dash number, from Table S3.1 or Table S3.2 or Table S3.3,
Y = Material Designation Code:
Y = CTG-1001-K23 and
Z = CTG-1001-K23 MOD

Note—The MS17796–104–Y part identification number (PIN) equates to the old MS17796-104 designation where the MS17796 represented the military standard number for flange bearings (sleeve and thrust bearings are described in MS17795 and MS21783 respectively), the 104 was the dash number; as for the suffix Y, it is new; in MS17796, the material designation code was called out separately as a Grade and Type and was not a part of the PIN but was part of the required ordering information. The dash numbers themselves remain unchanged from those in MS17795, MS17796 and MS21783.

S3.3 *Dimensions and Dash Numbers:*

S3.3.1 *Sleeve Bearings*—Refer to Fig. 1 and Table S3.1—Standard Military Bronze Sleeve Bearings–Dimensions and Dash Numbers.

S3.3.2 *Flange Bearings*—Refer to Fig. 2 and Table S3.2—Standard Military Bronze Flange Bearings–Dimensions and Dash Numbers.

S3.3.3 *Thrust Washer Bearings*—Refer to Fig. 3 and Table S3.3—Standard Military Bronze Thrust Washer Bearings–Dimensions and Dash Numbers.

S3.4 *Tolerances*—Refer to Table S3.4—Required Dimensional Tolerances.

S3.5 *Chamfers*—Refer to Table S3.5—Chamfers.

S3.6 *Documents*—Referenced documents shall be of the issue in effect on the date of invitations for bids or request for proposals, except that referenced, adopted industry documents shall give the date of the issue adopted. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence.

TABLE S3.2 MS17796 Bronze Flange Bearings—Dimensions and Dash Numbers

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Radius, r (in.) (max)	Outer Diameter D (in.)	Flange Outer Diameter, D_1 (in.)	Flange Thickness, e (in.)
1	75	1⁄8	3⁄32	0.095	1⁄32	0.159	3⁄16	1⁄32
2	125	3⁄16						
3	175	1⁄4						
4	96	1⁄8	1⁄8	0.127	1⁄32	0.1895	1⁄4	
5	160	3⁄16						
6	222	1⁄4						
7	65	1⁄8				0.253	3⁄8	1⁄16
8	130	3⁄16						
9	193	1⁄4						
10	255	5⁄16						
16	290	1⁄4	3⁄16	0.1895	1⁄32	0.3155	7⁄16	1⁄16
17	385	5⁄16						
18	485	3⁄8						
19	580	7⁄16						
20	675	1⁄2						
21	387	1⁄4	1⁄4	0.252	1⁄32	0.378	1⁄2	1⁄16
22	516	5⁄16						
23	645	3⁄8						
24	773	7⁄16						
25	902	1⁄2						
26	1160	5⁄8						
27	387	1⁄4	1⁄4	0.252	1⁄32	0.440	9⁄16	1⁄16
28	516	5⁄16						
29	645	3⁄8						
30	773	7⁄16						
31	902	1⁄2						
32	1160	5⁄8						
33	485	1⁄4	5⁄16	0.3145	1⁄32	0.440	9⁄16	1⁄16
34	645	5⁄16						
35	805	3⁄8						
36	970	7⁄16						
37	1130	1⁄2						
38	1450	5⁄8						
39	405	1⁄4	5⁄16	0.3145	3⁄64	0.503	11⁄16	3⁄32
40	570	5⁄16						
41	730	3⁄8						
42	890	7⁄16						
43	1060	1⁄2						
44	1375	5⁄8						
45	580	1⁄4	3⁄8	0.377	3⁄64	0.503	5⁄8	1⁄16
46	775	5⁄16						
47	965	3⁄8						
48	1160	7⁄16						
49	1355	1⁄2						
50	1740	5⁄8						
51	2125	3⁄4						
52	580	5⁄16	3⁄8	0.377	3⁄64	0.628	7⁄8	1⁄8
53	775	3⁄8						
54	965	7⁄16						
55	1160	1⁄2						
56	1545	5⁄8						
57	1920	3⁄4						
58	1130	3⁄8	7⁄16	0.4395	3⁄64	0.565	3⁄4	1⁄16
59	1360	7⁄16						
60	1585	1⁄2	7⁄16	0.4395	3⁄64	0.565	3⁄4	1⁄16
61	2035	5⁄8						
62	2490	3⁄4						
63	1290	3⁄8	1⁄2	0.502	3⁄64	0.628	3⁄4	1⁄16
64	1550	7⁄16						
65	1810	1⁄2						
66	2325	5⁄8						
67	2840	3⁄4						
68	3355	7⁄8						
70	1550	1⁄2	1⁄2	0.502	3⁄64	0.753	15⁄16	1⁄8
71	2070	5⁄8						
72	2580	3⁄4						
73	3100	7⁄8						
74	3615	1-0						
80	1935	1⁄2	5⁄8	0.627	3⁄64	0.879	11⁄8	1⁄8
81	2580	5⁄8						
82	3220	3⁄4						

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Radius, r (in.) (max)	Outer Diameter D (in.)	Flange Outer Diameter, D_1 (in.)	Flange Thickness, e (in.)
83	3865	7⁄8						
84	4510	1-0						
85	5155	1 1⁄8						
86	5800	1 1⁄4						
87	2320	1⁄2	3⁄4	0.752	3⁄64	0.941	1 3⁄16	1⁄8
88	3080	5⁄8						
89	3865	3⁄4						
90	4645	7⁄8						
91	5415	1-0						
92	6180	1 1⁄8						
93	6960	1 1⁄4						
94	2325	1⁄2	3⁄4	0.752	1⁄16	1.003	1 1⁄2	1⁄8
99	6195	1 1⁄8						
103	10065	1 3⁄4						
104	3610	5⁄8	7⁄8	0.877	1⁄16	1.004	1 1⁄4	1⁄8
105	4510	3⁄4						
106	5415	7⁄8						
107	6315	1-0						
108	8120	1 1⁄4						
109	9925	1 1⁄2						
110	11730	1 3⁄4						
117	4640	3⁄4	1-0	1.003	3⁄64	1.379	1 3⁄4	3⁄16
118	6705	1-0						
119	8760	1 1⁄4						
120	10730	1 1⁄2						
121	12895	1 3⁄4						
122	14995	2-0						
123	8380	1-0	1 1⁄4	1.2535	1⁄16	1.504	1 3⁄4	3⁄16
124	10960	1 1⁄4						
125	13540	1 1⁄2						
126	16121	1 3⁄4						
127	18695	2-0						
128	23850	2 1⁄2						
129	17015	1 1⁄2	1 1⁄2	1.504	1⁄16	1.755	2-0	1⁄8
130	23200	2-0						
131	29390	2 1⁄2						
132	21660	1 3⁄4	1 3⁄4	1.754	3⁄32	2.254	3-0	1⁄4
133	25270	2-0						
134	32485	2 1⁄2						
135	39705	3-0						
136	97	3⁄16	3⁄32	0.095	1⁄32	0.159	1⁄4	1⁄16
137	145	1⁄4						
138	193	5⁄16						
139	322	3⁄8	1⁄8	0.127	1⁄32	0.253	3⁄8	1⁄16
140	201	3⁄16	5⁄32	0.158	1⁄32	0.253	3⁄8	1⁄32
141	282	1⁄4						
142	363	5⁄16						
143	443	3⁄8						
144	195	3⁄16	3⁄16	0.1895	1⁄32	0.253	5⁄16	1⁄16
145	290	1⁄4						
146	385	5⁄16						
147	485	3⁄8						
148	580	7⁄16						
149	675	3⁄8	1⁄4	0.252	1⁄32	0.378	1⁄2	3⁄64
150	725	3⁄8	5⁄16	0.3145	1⁄32	0.440	9⁄16	3⁄32
151	1045	1⁄2						
152	1690	3⁄4						
153	805	3⁄8	5⁄16	0.3145	3⁄64	0.503	1 1⁄16	1⁄16
154	965	13⁄32	3⁄8	0.377	3⁄64	0.503	5⁄8	3⁄32
155	965	3⁄8	3⁄8	0.377	3⁄64	0.503	1 1⁄16	1⁄16
156	1355	1⁄2						
157	2125	3⁄4						
158	870	3⁄8	3⁄8	0.377	3⁄64	0.503	1 1⁄16	3⁄32
159	1255	1⁄2						
160	2030	3⁄4						
161	965	3⁄8	3⁄8	0.377	3⁄64	0.628	7⁄8	1⁄16
162	1355	1⁄2						
163	2125	3⁄4						
164	1585	1⁄2	7⁄16	0.4395	3⁄64	0.565	1 1⁄16	1⁄16
165	2490	3⁄4						
166	1030	3⁄8	1⁄2	0.502	3⁄64	0.628	7⁄8	1⁄8
167	1290	7⁄16						

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Radius, r (in.) (max)	Outer Diameter D (in.)	Flange Outer Diameter, D_1 (in.)	Flange Thickness, e (in.)
168	1545	½						
169	2060	⅝						
170	2580	¾						
171	3095	⅞						
172	3610	1-0						
173	1550	½	½	0.502	3⁄64	0.753	1-0	⅛
174	2070	⅝						
175	2580	¾						
176	3100	⅞						
177	3615	1-0						
178	1935	½	⅝	0.627	3⁄64	0.753	1-0	⅛
179	2580	⅝						
180	3220	¾						
181	4510	1-0						
182	5155	1⅛						
183	2705	½	¾	0.752	3⁄64	0.879	1-0	1⁄16
184	4255	¾						
185	2320	½	¾	0.752	3⁄64	0.941	1¼	⅛
186	3865	¾						
187	5415	1-0						
188	6960	1¼						
189	2320	½	¾	0.752	3⁄64	0.941	15⁄16	⅛
190	2705	9⁄16						
191	3865	¾						
192	5415	1-0						
193	6960	1¼	¾	0.752	3⁄64	0.941	15⁄16	⅛
194	1935	½	¾	0.752	3⁄64	1.004	1¼	3⁄16
195	3480	¾						
196	5415	1-0						
197	6575	1¼						
198	4060	¾	⅞	0.877	3⁄64	1.004	1¼	3⁄16
199	5865	1-0						
200	4510	¾	⅞	0.877	3⁄64	1.129	1½	⅛
201	6315	1-0						
202	8120	1¼						
203	9925	1½						
204	11730	1¾						
205	5155	¾	1-0	1.003	3⁄64	1.254	1½	⅛
206	7220	1-0						
207	9280	1¼						
208	11345	1½						
209	7220	1-0	1-0	1.003	3⁄64	1.254	1⅞	⅛
210	4640	¾	1-0	1.003	3⁄64	1.379	1⅝	3⁄16
211	6705	1-0						
212	10730	1½						
213	12895	1¾						
214	14955	2-0						
215	8380	1-0	1¼	1.2535	3⁄64	1.504	1¾	3⁄16
216	10960	1¼						
217	13540	1½						
218	16121	1¾						
219	8380	1-0	1¼	1.2535	3⁄64	1.630	1¾	3⁄16
220	13540	1½						
221	13150	1½	1½	1.504	3⁄64	1.755	2-0	3⁄16
222	13150	1½	1½	1.504	3⁄64	1.880	2-0	3⁄16
223	25525	2¼						
224	30935	2-0	2-0	2.004	1⁄16	2.254	2½	⅛
225	47440	3-0						
226	28875	2-0	2-0	2.004	1⁄16	2.505	3-0	¼
227	45375	3-0						
228	38675	2-0	2½	2.505	3⁄32	3.006	3¼	⅛
229	59295	3-0						
230	79920	4-0						
231	36095	2-0	2½	2.505	3⁄32	3.006	3½	¼
232	56720	3-0						
233	77345	4-0						
234	55685	2½	3-0	3.006	3⁄32	3.507	3¾	¼
235	68060	3-0						
236	80435	3½						
237	92810	4-0						
238	105185	4½						
239	117560	5-0						

TABLE *Continued*

Dash No.	Static Capacity (lb)	Length, L (in.)	Nominal ID (in.)	Inner Diameter, d (in.)	Radius, r (in.) (max)	Outer Diameter D (in.)	Flange Outer Diameter, D_1 (in.)	Flange Thickness, e (in.)
240	4645	7⁄8	3⁄4	0.752	3⁄64	0.941	15⁄16	1⁄8

TABLE S3.3 MS21783 Bronze Thrust Washer Bearings—Dimensions and Dash Numbers

Dash Number	Inside Diameter, d (in.)			Outside Diameter, D (in.)			Thickness, L (in.)		
	Nom size	Actual size		Nom size	Actual size		Nom size	Actual size	
02062	1⁄8	0.130	+0.010 -0.002	3⁄8	0.370		1⁄16	0.062	±0.002
03082	3⁄16	0.192	+0.010 -0.002	1⁄2	0.495		1⁄16	0.062	±0.002
04102	1⁄4	0.255	±0.005	5⁄8	0.625	+0.005 -0.010	1⁄16	0.062	+0.002 -0.005
05122	5⁄16	0.315		3⁄4	0.750	+0.005 -0.010	1⁄16	0.062	
05A123	5⁄16	0.318		3⁄4	0.745		3⁄32	0.093	
06122	3⁄8	0.377		3⁄4	0.750		1⁄16	0.062	
06A144	3⁄8	0.380		7⁄8	0.870		1⁄8	0.125	
06B122	3⁄8	0.390		3⁄4	0.750		1⁄16	0.062	
07122	7⁄16	0.439		3⁄4	0.750		1⁄16	0.062	
08146	1⁄2	0.505		7⁄8	0.875		3⁄16	0.187	
08A186	1⁄2	0.505		1-1⁄8	1.125		3⁄16	0.187	
08B122	1⁄2	0.507		3⁄4	0.750	+0.005 -0.010	1⁄16	0.062	
08C162	1⁄2	0.510		1	1.000	±0.010	1⁄16	0.062	
08D163							3⁄32	0.093	
08E164							1⁄8	0.125	
09202	9⁄16	0.565		1-1⁄4	1.250	±0.015	1⁄16	0.062	
09204							1⁄8	0.125	
10162	5⁄8	0.627		1	1.000		1⁄16	0.062	
10163							3⁄32	0.093	
10164							1⁄8	0.125	
10192	5⁄8	0.627		1-3⁄16	1.187		1⁄16	0.062	
10193							3⁄32	0.093	
10196							3⁄16	0.187	
10204				1-1⁄4	1.250		1⁄8	0.125	
10244				1-1⁄2	1.500		1⁄8	0.125	
12202	3⁄4	0.753		1-1⁄4	1.250		1⁄16	0.062	
12204							1⁄8	0.125	
12222				1-3⁄8	1.375		1⁄16	0.062	
12A253	3⁄4	0.765		1-9⁄16	1.562	±0.010	3⁄32	0.094	
12A254							1⁄8	0.125	
12A256							3⁄16	0.187	
12A284				1-3⁄4	1.750	±0.010	1⁄8	0.125	
14244	7⁄8	0.890		1-1⁄2	1.500	±0.010	1⁄8	0.125	
14344				2-1⁄8	2.125	±0.010		0.125	
16244	1	1.003		1-1⁄2	1.500	±0.015	1⁄8	0.125	
16A282		1.012		1-3⁄4	1.750	±0.015	1⁄16	0.062	
16A284							1⁄8	0.125	
16A324				2	2.000	±0.015	1⁄8	0.125	±0.010
20284	1-1⁄4	1.253		1-3⁄4	1.750	±0.015	1⁄8	0.125	±0.010
20324				2	2.000	±0.015	1⁄8	0.125	±0.010
20A284	1-1⁄4	1.265		1-3⁄4	1.750	±0.015	1⁄8	0.125	±0.010
20A322				2	2.000	±0.015	1⁄16	0.062	
20A324	1-1⁄4	1.265		2	2.000	±0.015	1⁄16	0.125	±0.010
24404	1-1⁄2	1.510		2-1⁄2	2.500	±0.015	1⁄8	0.125	±0.010
24406							3⁄16	0.187	±0.010
24564				3-1⁄2	3.500	±0.015	1⁄8	0.125	±0.010
24566							3⁄16	0.187	±0.010
28424	1-3⁄4	1.765	±0.010	2-5⁄8	2.625	+0.020 -0.015	1⁄8	0.125	±0.010
32484	2	2.001	+0.010 -0.000	3	3.000	±0.020	1⁄8	0.125	±0.010
32488							1⁄4	0.250	±0.010

TABLE S3.4 Required Dimensional Tolerances

NOTE 1—For thrust washer bearings, dimensional tolerances for inside diameter (d), outside diameter (D), and thickness (L) shall be ±0.005 except as otherwise indicated in Table S3.5.

NOTE 2—For thrust washer bearings, the inside diameter (d) and outside diameter (D) shall be in 1⁄16 th of an inch increments; the thickness (L) shall be in 1⁄32 nd inch increments.

Dimensions	Bearing Size, in.	Tolerance, in.
(sleeve and flange)	Up to 1.510 d incl.	+0.000
Inside diameter, d		–0.001
and	1.511 to 2.510	+0.0000
Outside diameter, D		–0.0015
	2.511 to 3.010	+0.000
		–0.002
	3.011 to 3.507	+0.000
		–0.003
(thrust washer)		±0.005
d and D		
Flange outside	Up to 1.510	±0.005
diameter, D_1	D incl.	
	1.511 to 3.010	±0.010
	3.010 to 3.750	±0.025
Flange thickness, e	Up to 1.510	±.005
	flanged D	
	1.511 to 3.010	±.010
	flanged D	
	3.011 to 3.750	±.015
	flanged D	
(thrust washer)		±0.005
Thickness, L		
(sleeve and flange)	Up to 1.495 incl	±0.005
Length, L	1.496 to 2.990	±0.0075
	2.991 to 4.000	±0.010
	(sleeve)	
	2.991 to 4.985	±0.010
	(flange)	
Concentricity	Outside diameter, D	Tolerances
full indicator	(sleeve)	0.003
movement (FIM)	up to 1.379	0.004
	1.380 to 2.005	0.005
	2.006 to 3.507	
	(flange)	0.003
	up to 1.510	0.004
	1.511 to 2.010	0.005
	2.011 to 3.507	
	(thrust washer)	0.003
Parallelism full indicator movement (FIM)	(thrust washer)	0.003

TABLE S3.5 Required Chamfers

Bearing Size Range	Chamfer Size
Wall thickness up to and including 3⁄32 in.	Break corners
Wall thickness greater than 3⁄32 in. up to 3 in. outside diameter	(sleeve and flange) 1⁄64 in. × 45 degrees
All bearings over 3 in. outside diameter	(sleeve and flange) 1⁄32 in. × 45 degrees
Wall thickness greater than 3⁄32 in. up to 2 in. outside diameter	(thrust washer) 1⁄64 in. × 45 degrees

ANNEXES

(Mandatory Information)

A1. PM MATERIAL DESIGNATION CODE

A1.1 Introduction

A1.1.1 The PM Material Designation Code is a three-part alphanumeric array developed by the Metal Powder Industries Federation (MPIF) to identify any powder metallurgy material and present fundamental chemical and strength requirement information and is used herein with their permission. It is applicable to all standardized powder metallurgy structural and bearing materials. The array consists of a one to four letter prefix code identifying the base material, a four or five digit chemical composition code giving numeric information about the composition and a suffix code that specifies the minimum strength of the material. The identification system defines a specific standard PM material.

A1.1.2 This system offers a convenient means of designating both the chemical composition and the mechanical strength requirements of any standard PM material. For oil-impregnated bearings, the mechanical strength is listed as the minimum radial crushing strength in 10^3 psi (6.895 MPa) units and the value is preceded by the letter "K" to distinguish bearing materials from structural materials.

A1.1.3 Physical properties are not indicated within the PM Material Designation Code. Rather, the material specifications for oil content, interconnected porosity and impregnated density are listed in the "Physical Requirements" table shown for each standardized material.

A1.1.4 Code designations in this specification and revisions thereof apply only to PM materials for which specifications have been formally adopted. In order to avoid confusion, the PM designation coding system is intended for use only with such materials, and it should not be used to designate nonstandard compositions. The explanatory notes, property values and other contents of this specification have no application to any other materials.

A1.2 Prefix Material Letter Code

A1.2.1 In this PM coding system, the prefix letters denote the elements or alloy of the bearing material with the first letter always designating the dominant metallic element present. The code for any copper-base material always begins with the letter (C). For bronze-base bearing materials, the prefix used is (CT). This represents copper (C) as the basic element and tin (T) as the major alloying constituent that becomes bronze when alloyed. The letter codes used in the prefix for PM bearing materials are listed in Table A1.1.

A1.3 Four-Digit Chemical Composition Code

A1.3.1 All bronze-base PM bearing materials use a four digit chemical composition code following the prefix letter code to define the primary chemical composition of the material.

TABLE A1.1 Prefix Material Code

Letter Code	Material
C	Copper
F	Iron and Iron-Carbon or Steel
T	Tin
P	Lead
G	Free Graphite
CT	Copper-Tin or Bronze
CTG	Bronze with Graphite
FC	Iron-Copper and Iron-Copper-Carbon
CFTG	Copper-Base Diluted Bronze with Graphite
FCTG	Iron-Base Diluted Bronze with Graphite.
FG	Iron-Graphite

A1.3.2 In nonferrous bearing materials, the first two numbers in the four-digit series designate the percentage of the first or major added alloying constituent.

A1.3.3 The last two numbers in the four-digit series for any nonferrous PM material designate the percentage of the secondary added alloying constituent. The percentages of other minor alloying elements are excluded from the code but are included in the "Chemical Composition" column which appears with each standard material.

A1.3.4 The percentage of the base element is not shown in the code but is listed in the "Chemical Composition" column as "balance."

A1.3.5 An illustration of a bronze-graphite PM bearing material designation code is shown in Fig. A1.1.

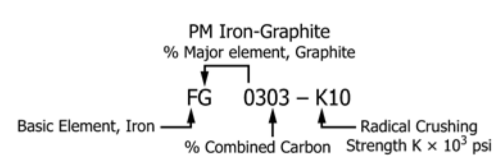

FIG. A1.1 Illustration of a Bronze-Graphite PM Bearing Material Designation Code

A1.4 Minimum Strength Suffix Code

A1.4.1 The suffix code designates the minimum mechanical strength of the PM material. For PM bearing materials the suffix starts with the letter "K" to designate radial crushing strength. The two digits that follow indicate the minimum radial crushing strength in 10^3 psi (6.895 MPa) that the user can expect from the finished oil-impregnated bearing material.

A1.5 Data Source

A1.5.1 Information used in compiling this specification was contributed by the membership of the Standards Committee of the Metal Powder Industries Federation (MPIF) and the ASTM

Committee B09 on Metal Powders and Metal Powder Products. The MPIF technical data are reproduced in this specification with the permission of the MPIF, Princeton, NJ 08540.

A2. CROSS INDEX OF BEARING MATERIALS

A2.1 Cross Reference

A2.1.1 *Cross Reference*—The bearing designation information presented in Table A2.1 permits cross-reference between the former ASTM material designations and the replacement PM Material Designation Code identifications for standard bronze-base bearing materials.

APPENDIXES

TABLE A2.1 Bearing Material Designation Cross-Reference

Previous ASTM / MIL Designation	New PM Material Code
Bronze	
B438 Grade 1, Type 1, 5.8 to 6.2 g/cm^3 impregnated density	CT-1000-K19
B438, Grade 1, Type 2, 6.4 to 6.8 g/cm^3 impregnated density	CT-1000-K26
B438, Grade 1, Type 3, 6.8 to 7.2 g/cm^3 impregnated density	CT-1000-K37
B438, Grade 1, Type 4, 7.2 to 7.6 g/cm^3 impregnated density	CT-1000-K40
Bronze-Graphite	
B438, Grade 2, Type 1, 5.8 to 6.2 g/cm^3 impregnated density	CTG-1001-K17
B438, Grade 2, Type 2, 6.4 to 6.8 g/cm^3 impregnated density	CTG-1001-K23
MIL-B-5687, Type 1, Grade 1	CTG-1001-K23
B438, Grade 2, Type 3, 6.8 to 7.2 g/cm^3 impregnated density	CTG-1001-K30
B438, Grade 2, Type 4, 7.2 to 7.6 g/cm^3 impregnated density	CTG-1001-K34
Bronze-High Graphite	
B438, Grade 3, Type 1, 5.8 to 6.2 g/cm^3 impregnated density	CTG-1004-K10
B438, Grade 3, Type 2, 6.2 to 6.6 g/cm^3 impregnated density	CTG-1004-K15
Bronze-Lead-Graphite (Military Grade)	
B438, Grade 4, Type 2, 6.4 to 6.8 g/cm^3 impregnated density	CTG-1001-K23-MOD
MIL-B-5687, Type 1, Grade 2	CTG-1001-K23-MOD

(Nonmandatory Information)

X1. BRONZE-BASE PM BEARINGS—APPLICATIONS

X1.1 Introduction

X1.1.1 Historically, bronze is the oldest and most universally accepted metal used for bearings that rely on oil or grease for lubrication. Bronze is a soft but strong alloy, has a low coefficient of friction and is resistant to seizure with an iron or steel shaft. PM oil-impregnated bronze-base materials have an advantage over wrought alloyed bronze because of the ability to tailor the composition to the need, to incorporate nonmetallic additives for performance enhancement and to control the open porosity for an integral supply of oil.

X1.1.2 Each PM composition is available in a range of densities. The strength, ductility, oil capacity and operating characteristics are directly related to density.

X1.1.3 The lowest density materials have lower strength and ductility and less shaft support but have greater open porosity and are able to contain more oil. They are selected where maximum oil content is of primary importance.

X1.1.4 Bearings of 6.4 to 6.8 g/cm^3 impregnated density are the first choice for general applications as they have the desired combination of mechanical properties and bearing performance capabilities.

X1.1.5 The highest density bearing materials have the highest strength but minimum oil capacity. At densities over 6.8 g/cm^3, the material can function as a combination structural part and bearing.

X1.1.6 When additional lubrication is required for longer life, the housing can be fitted with oil-impregnated felt wicks, grease pockets, oil grooves or other lubricant reservoir designs.

X1.2 Bronze Materials

X1.2.1 Bronze of 90Cu–10Sn composition is the base alloy for nonferrous PM bearings. This is the same alloy, (Tin bronze "D"), that is used for many solid bronze bearings. Porous bearings produced from 100% bronze exhibit the highest strength and greatest ductility of the PM nonferrous bearing materials.

X1.2.2 This material adapts easily to press fitting and at the higher densities can readily be staked into the housing. It has the best corrosion resistance of the nonferrous compositions.

X1.2.3 It is the classic bronze self-lubricating bearing material. Bearings of medium density bronze are the first choice for fractional horsepower motors used in business machines, vacuum cleaners, cake mixers, consumer electronics, air conditioners and small appliances.

X1.3 Bronze-Graphite Materials

X1.3.1 Adding up to 1% of graphitic carbon to the bronze reduces starting friction and improves running lubricity. The presence of graphite results in a small decrease in ductility.

X1.3.2 Bronze-graphite material of medium density is a general purpose material and is the most widely used of any of the bronze-base compositions. These porous metallic materials are the first selected when a balance of bearing properties and structural strengths is desired. The composition is reasonably tolerant to unhardened shafts.

X1.3.3 They are used extensively in fractional horsepower motors for machine tools, garden and farm equipment, automotive accessories and appliances in moderately abrasive conditions.

X1.4 Bronze-High Graphite Materials

X1.4.1 PM bronze with 3 to 5% graphitic carbon is a bearing material that relies more on graphite for lubricity but has relatively low strength and ductility. At higher densities it will contain very little oil.

X1.4.2 The graphite will help resist wear at startup when liquid lubricants are not fully effective. This material produces a very quiet running bearing. The presence of graphite keeps metal-to-metal contact to a minimum and requires less field lubrication.

X1.4.3 Its relatively lower strength makes it best for lighter loads and slower speeds. This material is used for oscillatory or intermittent operations and can be run at somewhat higher temperatures. At the higher densities, it contains very little oil and is good in environments where product dust or lint may be present such as the textile industry.

X1.5 Bronze-Lead-Graphite Material (Military Grade)

X1.5.1 The presence of 3% lead and 1% graphitic carbon lowers the hardness of the basic bronze. This material exhibits reduced starting and running friction.

X1.5.2 Leaded bronze resists seizing and scoring, is soft and conforms readily to the shaft. It is beneficial where full-film lubrication is not always present or metal to metal contact is frequent. It produces low start-up torque and has advantages where service is difficult and where motors may be idle for periods of time.

X1.5.3 The major use of this self-lubricating material is for bearings for fractional horsepower motors used in military field equipment and other government applications. Because of the toxicity of lead, this composition is no longer used for non-military applications.

X1.6 Bronze-Iron-Graphite Materials

X1.6.1 More commonly referred to as "Diluted Bronze," this material looks similar to bronze-graphite. The presence of 40% iron somewhat increases the strength and hardness.

X1.6.2 It is mostly considered as a low cost alternative to bronze-graphite and is only available as a porous metallic material.

X1.6.3 It is used for bearings having the same applications as bronze-graphite but in situations where bronze-graphite may be over-engineered or in applications where the cost savings are of major consideration. Toys, games, inexpensive home appliances, portable power tools and garden equipment are common applications. It is good for oscillatory applications and can carry higher loads than bronze-graphite. Diluted bronze has lower corrosion resistance and should not be used in highly corrosive conditions.

X2. BRONZE-BASE PM BEARINGS—COMMERCIAL TOLERANCES

X2.1 Introduction

X2.1.1 The dimensional accuracy of bronze-base PM bearings requires control of all processing steps from raw material to secondary operations. Dimensions critical to control with the PM process are the wall thickness and the length of the bearing. Wall thickness should be a minimum of one-eighth of the inside diameter. Normal production practice involves sizing after sintering to achieve the tolerances shown. Bronze bearings can be held to somewhat closer tolerances than iron-base bearings. As-sintered bearings have broader tolerances and are used for applications having less demanding dimensional requirements.

X2.2 Sleeve Bearings

X2.2.1 *Sleeve Bearing Tolerances*—The recommended commercial tolerances for standard plain sleeve bearings, as-sized, (Section 10, Fig. 1) are shown in Table X2.1. A listing of standard sleeve bearing sizes is shown in Table X2.2.

X2.3 Flange Bearings

X2.3.1 *Flange Bearing Tolerances*—The recommended commercial tolerances for the inside and outside diameters of the body of flange bearings, (Section 10, Fig. 2), are the same as for sleeve bearings. Commercial flange diameter and flange thickness tolerances are shown in Table X2.3. Normally, flange tolerance are not critical, therefore they should only be specified as close as is required for the application.

X2.4 Thrust Washers

X2.4.1 *Thrust Washer Tolerances*—The commercial inside diameter tolerances recommended for thrust washers, (Section 10, Fig. 3), are the same as those for plain cylindrical bearings. The outside diameter tolerances are the same as those for the flange diameter of flanged bearings. The commercial tolerances for thickness and parallelism are shown in Table X2.4.

TABLE X2.1 Recommended Tolerances for Bronze-Base PM Sleeve Bearings

Inside and Outside Diameter Tolerances[A]			
Inside, d, and Outside, D, Diameters		Total Diametrical Tolerances	
in.	(mm)	in.	(mm)
up to 0.760	(up to19)	0.001	(0.025)
0.761 to 1.010	(19 to 25)	0.001	(0.025)
1.011 to 1.510	(25 to 38)	0.001	(0.025)
1.511 to 2.010	(38 to 50)	0.0015	(0.038)
2.011 to 2.510	(50 to 63)	0.0015	(0.038)
2.511 to 3.010	(63 to 75)	0.002	(0.050)
3.011 to 4.010	(75 to 100)	0.003	(0.075)
4.011 to 5.010	(100 to 125)	0.004	(0.100)
5.011 to 6.010	(125 to 150)	0.005	(0.125)
Length Tolerances			
Length of Bearing, L		Total Length Tolerances	
in.	(mm)	in.	(mm)
1.496 to 1.990	(38 to 50)	0.015	(0.38)
1.991 to 2.990	(50 to 75)	0.015	(0.38)
2.991 to 4.985	(75 to 125)	0.020	(0.50)

Concentricity Tolerances[B]					
Outside Diameter, D		Wall Thickness, t		Concentricity Tolerance, (TIR)	
in.	(mm)	in.	(mm)	in.	(mm)
up to 1.000	(up to 25)	up to 0.255	(up to 6)	0.003	(0.075)
1.001 to 1.510	(25 to38)	up to 0.355	(up to 9)	0.003	(0.075)
1.511 to 2.010	(38 to 50)	up to 0.505	(up to13)	0.004	(0.100)
2.011 to 3.010	(50 to 75)	up to 0.760	(up to 19)	0.005	(0.125)
3.011 to 4.010	(75 to 100)	up to 1.010	(up to 25)	0.005	(0.125)
4.011 to 5.010	(100 to 125)	up to 1.510	(up to 38)	0.006	(0.150)
5.011 to 6.010	(125 to 150)	up to 2.010	(up to 50)	0.007	(0.175)

[A] Values are for bearings up to 2 in. (50 mm) in length. For greater lengths increase the diametrical tolerances by 0.0005 in. (0.013 mm) for each 1 in. (25 mm) of added length.
[B] Values are for bearings up to 1 in. (25 mm) in length. For greater lengths, increase the concentricity tolerance by 0.0005 in. (0.013 mm) for each 1 in. (25 mm) of added length.

X2.5 Spherical Bearings

X2.5.1 *Spherical Bearing Tolerances*—The commercial tolerances recommended for bronze-base spherical bearings, (Section 10, Fig. 4), are shown in Table X2.5.

TABLE X2.2 PM Sleeve Bearings

Shaft Diameter	Bearing Inside Diameter, d		Wall Thickness, t	Bearing Outside Diameter, D			Bearing Length, L	
Nominal, in.	Decimal		Nominal, in.	Nominal, in.	Decimal		Decimal	
	in.	(mm)			in.	(mm)	in.	(mm)
1/8	0.127	(3.23)	1/32	3/16	0.1905	(4.83)	0.250	(6.35)
1/8	0.127	(3.23)	1/16	1/4	0.253	(6.43)	0.250	(6.35)
5/32	0.158	(4.01)	3/64	1/4	0.253	(6.43)	0.312	(7.92)
3/16	0.1895	(4.80)	1/32	1/4	0.253	(6.43)	0.375	(9.525)
3/16	0.1895	(4.80)	1/16	5/16	0.3155	(8.01)	0.375	(9.525)
1/4	0.252	(6.40)	1/16	3/8	0.378	(9.60)	0.500	(12.70)
1/4	0.252	(6.40)	3/32	7/16	0.4405	(11.19)	0.500	(12.70)
5/16	0.3145	(7.99)	1/16	7/16	0.4405	(11.19)	0.562	(14.275)
5/16	0.3145	(7.99)	3/32	1/2	0.503	(12.78)	0.562	(14.275)
3/8	0.377	(9.58)	1/16	1/2	0.503	(12.78)	0.625	(15.875)
3/8	0.377	(9.58)	3/32	9/16	0.5655	(14.36)	0.625	(15.875)
1/2	0.502	(12.75)	1/16	5/8	0.628	(15.95)	0.750	(19.05)
1/2	0.502	(12.75)	1/8	3/4	0.753	(19.13)	0.750	(19.05)
5/8	0.627	(15.925)	1/16	3/4	0.753	(19.13)	0.750	(19.05)
5/8	0.627	(15.925)	1/8	7/8	0.879	(22.33)	0.937	(23.80)
3/4	0.752	(19.1)	1/16	7/8	0.879	(22.33)	1.125	(28.575)
3/4	0.752	(19.10)	1/8	1	1.004	(25.50)	1.125	(28.575)
1	1.003	(25.48)	1/8	1 1/4	1.254	(31.85)	1.500	(38.10)
1	1.003	(25.48)	3/16	1 3/8	1.379	(35.03)	1.500	(38.10)
1 1/4	1.2535	(31.84)	1/8	1 1/2	1.504	(38.20)	1.500	(38.10)
1 1/4	1.2535	(31.84)	3/16	1 5/8	1.630	(41.40)	1.875	(47.625)
1 1/2	1.504	(38.20)	1/8	1 3/4	1.755	(44.58)	1.500	(38.10)
1 1/2	1.504	(38.20)	3/16	1 7/8	1.880	(47.75)	2.250	(57.15)
2	2.004	(50.90)	1/4	2 1/2	2.505	(63.63)	2.000	(50.80)
2 1/2	2.505	(63.63)	1/4	3	3.006	(76.35)	2.500	(63.50)
3	3.006	(76.35)	1/4	3 1/2	3.507	(89.08)	3.000	(76.20)

TABLE X2.3 Recommended Tolerances for Bronze-Base PM Flange Bearings

Flange Diameter Tolerances					
Flange Diameter, D_1		Flange Diameter Tolerances			
		Sized		As-Sintered	
in.	(mm)	in.	(mm)	in.	(mm)
0 to1.5	(0 to 38)	±0.0025	(±0.06)	±0.005	(±0.13)
1.5 to 3.0	(38 to 75)	±0.005	(±0.13)	±0.010	(±0.25)
3.0 to 6.0	(75 to 150)	±0.010	(±0.25)	±0.025	(±0.63)
Flange Thickness Tolerances					
Flange Diameter, D_1		Flange Thickness Tolerances			
		Sized		As-Sintered	
in.	(mm)	in.	(mm)	in.	(mm)
0 to1.5	(0 to 38)	±0.0025	(±0.06)	±0.005	(±0.13)
1.5 to 3.0	(38 to 75)	±0.007	(±0.18)	±0.010	(±0.25)
3.0 to 6.0	(75 to 150)	±0.010	(±0.25)	±0.015	(±0.38)
Flange Parallelism Tolerances					
Flange Diameter, D_1		Maximum Parallelism of Faces			
		Sized		As-Sintered	
in.	(mm)	in.	(mm)	in.	(mm)
0 to 1.5	(0 to 38)	0.002	(0.050)	0.003	(0.075)
1.5 to 3.0	(38 to 75)	0.003	(0.075)	0.004	(0.100)
3.0 to 6.0	(75 to 150)	0.004	(0.100)	0.005	(0.125)

TABLE X2.4 Recommended Tolerances for Bronze-Base PM Thrust Washers

Thrust Washer Thickness Tolerances					
Thrust Washer Thickness, L		Thickness Tolerance for All Diameters			
		Sized		As-Sintered	
in.	(mm)	in.	(mm)	in.	(mm)
0 to 0.25	(0 to 6)	±0.0025	(±0.06)	±0.005	(±0.13)
Thrust Washer Parallelism Tolerances					
Thrust Washer Diameter, D		Maximum Parallelism of Faces			
		Sized		As-Sintered	
in.	(mm)	in.	(mm)	in.	(mm)
0 to 1.5	(0 to 38)	0.002	(0.050)	0.003	(0.075)
1.5 to 3.0	(38 to 75)	0.003	(0.075)	0.004	(0.199)
3.0 to 6.0	(75 to 150)	0.004	(0.100)	0.005	(0.125)

TABLE X2.5 Recommended Tolerances for Bronze-Base PM Spherical Bearings

Inside Diameter Tolerances			
Inside Diameter, d		Total Diametrical Tolerance	
in.	(mm)	in.	(mm)
0 to 1.00	(0 to 25)	0.0010	(0.025)
1.00 to 2.00	(25 to 50)	0.0015	(0,038)
2.00 to 3.00	(50 to 75)	0.0020	(0.051)
Outside Diameter Tolerances			
Outside Diameter, D		Total Diametrical Tolerance	
in.	(mm)	in.	(mm)
0 to 4.00	(0 to 100)	0.02	(0.50)
Sphere Diameter Tolerances			
Sphere Diameter, S		Total Diametrical Tolerance	
in.	(mm)	in.	(mm)
0 to 1.00	(0 to 25)	0.006	(0.15)
1.00 to 1.50	(25 to 40)	0.008	(0.20)
1.50 to 3.00	(40 to 75)	0.014	(0.36)
3.00 to 4.00	(75 to 100)	0.018	(0.46)
over 4.00	over 100	0.025	(0.63)
Length Tolerances			
Length of Bearing, L		Plus or Minus Tolerance	
in.	(mm)	in.	(mm)
0 to 2.50	(0 to 65)	0.02	(0.5)

X3. BRONZE-BASE PM BEARINGS—ENGINEERING INFORMATION

X3.1 Introduction

X3.1.1 This section contains some basic engineering information concerning the design, installation and operating limits of bronze-base PM bearings that is important to their successful use. It does not purport to be all-inclusive and is only included as a helpful guide.

X3.2 Bearing Loading and Speeds

X3.2.1 *Compressive Yield Strength*—The load carrying capacity of a bearing is directly related to the compressive yield strength of the bearing material. Yield strength is determined by testing cylindrical specimens 0.375 in. (9.5 mm) in diameter and 1.05 in. (26.7 mm) in length as determined in accordance with Test Methods E9 (section on cemented carbide specimens).

X3.2.2 *Operating Factors*—There are two crucial factors that must be considered when engineering a bearing application. Both strongly influence the selection of the bearing material and in many cases the load can control the required length of the bearing.

X3.2.2.1 *Shaft Speed*—The shaft velocity is one important factor. It is expressed as *V*, the circumferential surface speed (rpm × πD) of the shaft in ft/min (m/min).

X3.2.2.2 *Bearing Loading*—The load on the bearing is also a major factor and is expressed as *P*, the pressure in psi. (N/mm^2 or MPa). It is calculated by dividing the load in lbf (N) by the projected bearing area ($d \times L$).

X3.2.3 *Static Loads*—The maximum static load-carrying capacity is primarily a function of the strength of the material. It is recommended that the static pressure on the bearing not exceed 75% of the compressive yield strength of the PM bearing material. The compressive yield strength (0.1% permanent offset) of bronze-base bearing materials range from 10 000 to 35 000 psi (70 to 240 MPa) depending upon composition.

X3.2.4 *Operating Speeds*—Bronze-base bearings may be used at higher speeds than iron-base bearings. Industrial experience with commercial applications has shown that bronze-base bearings operate most successfully at shaft speeds between 100 and 400 ft/min (30 to 120 m/min.), but can be used at higher shaft speeds up to 2000 ft/min (600 m/min) if lightly loaded.

X3.2.5 *Operating Loads*—Bronze-base bearings usually carry lighter operating loads than iron-base bearings. Pressures up to 300 psi (2 MPa) have been found to be most successful, but greater loads up to 600 psi (4 MPa) can be accommodated at slower shaft speeds. The maximum permissible operating load is a function of the composition and density of the bronze-base bearing material.

X3.2.6 *Technical Support*—For detailed information concerning the strength of specific compositions, safe operating speeds and loads, and for assistance on bearing design and material selection for new or unusual applications, the purchaser is strongly urged to contact the engineering department of the PM bearing producer.

X3.3 Pressure/Velocity (PV) Factor

X3.3.1 The design of any type of bearing and the selection of a bearing material may also be based on a term called the PV Factor. This engineering guideline defines the load carrying capacity of a bearing as measured by a friction and wear criterion that is an index of the heat generated in the bearing. The PV Factor is the product of P, the bearing load divided by the projected bearing area ($d \times L$) expressed in psi and V, the circumferential surface velocity of the shaft in ft/min. [In SI units, P is measured in N/mm^2 (MPa) and V is in m/min.] PV factor can be calculated using the following formula:

$$PV = \frac{\pi W n}{12L} \quad \text{(X3.1)}$$

where:

P = pressure on the projected bearing area (d × L), psi (MPa),
V = surface velocity of the shaft, ft/min (m/min),
W = bearing load, lbf (N),
L = length of bearing, in. (mm),
d = inside diameter of bearing, in. (mm), and
n = speed of shaft, rpm (rpm).

X3.3.2 Most bearing handbooks list an upper limit for PV, a value based on the type of bearing and the bearing material, which, under ideal conditions, should not be exceeded for satisfactory performance. For oil-impregnated bronze-base sleeve bearings, this published value is from 40 000 to 60 000 psi. However, the working PV Limit is a function of the bearing material, the operating conditions and the external environment and many factors can cause a reduction in the usable PV value.

X3.3.3 Detailed information on PV calculations and influences is available from PM bearing producers. This may be an involved calculation and the bearing purchaser is cautioned to consult with their technical service engineers with regard to the use of this procedure in the design of a PM bearing for a specific application. MPIF Standard 35 (Bearings) also contains information on external factors that influence the working PV Limit.

TABLE X3.1 Recommended Press Fits

Outside Diameter, D, of Bearing		Recommended Interference	
in.	(mm)	in.	(mm)
up to 0.760	(up to 19.31)	0.001 – 0.003	(0.03 – 0.08)
0.761 to 1.510	(19.32 to 38.36)	0.0015 – 0.004	(0.04 – 0.10)
1.511 to 2.510	(38.37 to 63.76)	0.002 – 0.005	(0.05 – 0.13)
2.511 to 3.010	(63.77 to 76.45)	0.002 – 0.006	(0.05 – 0.15)
over 3.010	(over 76.45)	0.002 – 0.007	(0.05 – 0.18)

TABLE X3.2 Minimum Running Clearance for Bronze-Base Bearings

Shaft Diameter		Minimum Running Clearance	
in.	(mm)	in.	(mm)
up to 0.250	(up to 6)	0.0003	(0.006)
0.251 to 0.760	(6.01 to 19)	0.0005	(0.013)
0.761 to 1.510	(19.01 to 38)	0.0010	(0.025)
1.511 to 2.510	(38.01 to 63)	0.0015	(0.038)
over 2.510	(over 63)	0.0020	(0.050)

X3.4 Installation

X3.4.1 Plain cylindrical PM journal bearings are commonly installed by press fitting the bearing into the journal housing with the use of an insertion arbor. The outside diameter of the insertion arbor must be precisely controlled to maintain the inside diameter tolerances of the bearing. For housings rigid enough to withstand the press fit without appreciable distortion and for bearings with a wall thickness approximately one eighth of the bearing outside diameter, the diametrical interference values shown in Table X3.1 are recommended.

X3.5 Running Clearance

X3.5.1 Proper running clearance for sintered bronze-base bearings depends to a great extent on the particular application. Therefore, only minimum recommended clearances are listed in Table X3.2.

X3.5.2 With good design practice, the maximum running clearances will automatically be held for normal operating conditions. It is assumed that hardened and ground steel shafts having a recommended surface finish of 4 to 16 µin. (0.1 to 0.4 µm) shall be used and that all bearings will be oil-impregnated.

X3.6 Bearing Life

X3.6.1 Oil-impregnated PM bearing are maintenance free and designed to last the life of the unit. Tests have shown that fractional horse power motor bearings in vacuum cleaners, small electric tools and household appliances will still perform satisfactorily after 10 000 hours of normal operation. Elevated bearing temperatures due to operating conditions or the external environment is the major cause of reduced bearing life.[7]

[7] Kindler, A. E., and Stein, H., "Determination of the Life of Sintered Bearings," *Metal Powder Report*, 1985, pp. 347-356.

X4. PM BEARINGS—ADDITIONAL INFORMATION

X4.1 MPIF Standard

X4.1.1 For more complete engineering information and detailed specifications regarding additional grades of iron-base and bronze-base oil-impregnated powder metallurgy (PM) bearing materials, refer to MPIF Standard 35, "Materials Standards for P/M Self-Lubricating Bearings."

X4.2 Metric Bearings

X4.2.1 For design information on self-lubricating PM bearings in standard metric sizes, refer to ISO 2795, "Plain Bearings Made from Sintered Metal—Dimensions and Tolerances." Any of the standardized PM materials covered by this ASTM specification may be used in the manufacture of metric bearings.

SUMMARY OF CHANGES

Subcommittee B09.04 has identified the location of selected changes to this standard since the last issue (B438 – 13) that may impact the use of this standard. (Approved April 1, 2017.)

(1) Removed Test Methods B966 and B970, MIL-B-5687, MS17795, MS17796, and MS21783 from the list of Referenced Documents.
(2) In subsection 6.2.1, replaced "interconnected and open porosity" with "surface-connected porosity."
(3) Replaced "supplier" and "manufacturer" with "producer" throughout.
(4) Replaced "customer" and "user" with "purchaser" throughout.
(5) Deleted subsections 13.3.4 and 13.3.5.
(6) Revised Section to remove cancelled military standards listed and replace with mention of their cancellation.