MATERIALS STANDARD and SPECIFICATIONS

for

POWDER METALLURGY MECHANICAL COMPONENTS, OIL IMPREGNATED BEARINGS

plus

CODING SYSTEM and CODE DESIGNATIONS

POWDER METALLURGY
PARTS MANUFACTURERS ASSOCIATION
trade division of the Metal Powder Industries Federation
60 East 42nd Street, New York 17, N. Y.

METAL POWDER
mpi
INDUSTRIES FEDERATION

CONTENTS AND SUBJECT INDEX

Price: $1.00

— Prepared and Published by the Powder Metallurgy Parts Manufacturers Association
A division of the Metal Powder Industries Federation
60 East 42nd Street, New York, N. Y. 10017

Metal Powder Industries Federation

POWDER METALLURGY PARTS MANUFACTURERS ASSOCIATION

MATERIALS STANDARD AND SPECIFICATIONS for POWDER METALLURGY MECHANICAL COMPONENTS AND OIL IMPREGNATED BEARINGS

MPIF Standard 35-61

Adopted October 1961

This Standard of the POWDER METALLURGY PARTS MANUFACTURERS ASSOCIATION is, under MPIF regulations, subject to periodic revision. Users of MPIF Standards are cautioned to secure the latest editions. Suggestions for revision should be addressed to the Metal Powder Industries Federation, 60 East 42nd Street, New York, N. Y. 10017.

1. Scope

This materials standard and specification chart covers mechanical components and oil impregnated bearings manufactured by the powder metallurgy process to produce cams, gears, levers, bearings, hardware, and other parts.

2. Purpose

Powder Metallurgy Parts Manufacturers Association Standards are adopted in the public interest and are designed to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper material for his particular product. Existence of a Powder Metallurgy Parts Manufacturers Association Standard does not in any respect preclude any member or non-member from manufacturing or selling products not included in this Standard.

A Standard of the Powder Metallurgy Parts Manufacturers Association defines a product, process or procedure with reference to one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing, and the service for which designed.

3. Specification Chart

(See page 4)

4. Ordering Data

The purchaser when ordering should specify the following information:

(a) PMPMA code designation number, in accordance with the specification chart—Section 3.

(b) Dimensions.

(c) Deviations, if any, from these specifications.

(d) The nature of manufacturer's warranty desired.

Note—Standard dimensional tolerances for plain bearings, flange bearings, and thrust washers are given in Tables IV and V of Appendix I.

5. Chemical Requirements

The material shall conform to the chemical composition set forth in the chart—Section 3.

6. Density

The density shall be in accordance with the limits set forth in the chart—Section 3. It shall be calculated in accordance with Section 14 (a) for mechanical components and Section 14 (b) for oil impregnated bearings.

7. Porosity

(a) *BEARINGS*—porosity, in terms of intercommunicating void space, shall be as set forth in the chart—Section 3.

(b) *MECHANICAL COMPONENTS*—porosity shall not be a consideration, unless specified by the purchaser. If specified, the porosity shall be as set forth in the chart—Section 3.

(c) The porosity shall be calculated in accordance with Section 15.

Additional copies of MPIF Standards may be obtained from the Metal Powder Industries Federation, 60 East 42nd St., New York, N. Y. 10017. A list of Standards and prices will be sent on request. The price of this Standard is $1.00.

The Powder Metallurgy Parts Manufacturers Association is a trade division of the Metal Powder Industries Federation, 60 East 42nd St., New York, N. Y. 10017.

Powder Metallurgy Parts Manufacturers Association
SPECIFICATION CHART
for
POWDER METALLURGY MECHANICAL COMPONENTS AND OIL IMPREGNATED BEARINGS

Code Designation(14)													
	Mechanical Components(1)			BT-0010-S	BZ-0218-T	BZ-0218-U	BZ-0218-W	F-0000-N		FC-0710-N	F-0010-P	FX-2000-T	FX-2010-T
	Bearings(1)	BT-0010-N	BT-0010-R	BT-0010-S				F-0000-N	FC-1000-N				
Material		Bronze	Bronze	Bronze	Brass	Brass	Brass	Iron	Iron-Alloy	Iron-Alloy	Iron-Carbon	Iron Metal Infiltrated	Iron-Carbon Metal Infiltrated
Type		Bearings	Bearings	Mechanical Components & Bearings	Mechanical Components	Mechanical Components	Mechanical Components	Mechanical Components & Bearings	Bearings	Mechanical Components	Mechanical Components	Mechanical Components	Mechanical Components
Composition—Per cent													
Copper		86.25-90.5	86.25-90.5	86.25-90.5	77.0-80.0	77.0-80.0	77.0-80.0		9.5-10.5	6.5-7.5		15.0-25.0	15.0-25.0
Iron		1.0 max	1.0 max	1.0 max	0.25 max	0.25 max	0.25 max	97.25 min	86.75 min	89.0 min	96.5 min	69.75-85.0	69.0-84.4
Lead					1.0-2.0	1.0-2.0	1.0-2.0						
Carbon		1.75 max (2)	1.75 max (2)	1.75 max (2)				0.25 max(3)	0.25 max (3)	0.0-1.0(3)	0.6-1.0(3)	0.25 max(3)	0.6-1.0(3)
Tin		9.5-10.5	9.5-10.5	9.5-10.5	0.1 max	0.1 max	0.1 max						
Zinc					remainder(4)	remainder(4)	remainder(4)						
Acid Insoluble, max (13)								1.0	1.0	1.0	1.0	1.0	1.0
Total Other Elements by Difference, max		0.5	0.5	0.5				1.5	1.5	1.5	1.5	4.0	4.0
Physical and Mechanical Properties (5)													
Density, gm per cu cm(6)		5.8-6.2	6.4-6.8	6.8-7.2	7.2 min	7.7 min	8.0 min	5.7-6.1	5.8-6.2	5.8-6.2	6.1-6.5	7.1 min	7.1 min
Allowable Density Variation, gm per cu cm(7)		———	———	0.3	0.4	0.4	0.4	0.3	———	0.3	0.3	0.4	0.4
Porosity, % by Volume(8)		25 min	18 min	7 min	7 min	———	———	18 min	18 min	18 min	7 min	———	———
"K" Strength Constant		15,000	26,500	30,500(9)	———	———	———	25,000(9)	40,000	———	———	———	———
Tensile Strength, psi (typical)		8,000	14,000	16,000-20,000	20,000	23,000	27,000	14,000-17,000	30,000	40,000-50,000	20,000-35,000	65,000	85,000
Elongation (in 1") % (typical)		1	1	2 — 3	9	10	13	1.5 — 3	0.5	0 — 0.5	0 — 0.5	1	1
Yield Strength in Compression 0.1% offset, psi (typical)		7,000	11,000	15,000-20,000	10,000	12,000	14,000	10,000-15,000	25,000	30,000-40,000	25,000-27,000	70,000	90,000
Comparable Specifications													
ASTM			B-202-60T Type I Class A	B-255-60 Class B(11)	B-282-60 Class A	B-282-60 Class B		B-310-58T Type I Class A(10) B-202-60T Type II Class A1	B-202-60T Type II Class B		B-310-58T Type II Class C	B-303-58T Class A	B-303-58T Class C
SAE	New	840	841	842	890	891		850	862		855	870	872
	Old		Type 1 Class A		Type 4 Class A	Type 4 Class B		Type 2 Class A	Type 5		Type 6 Class C	Type 7(15)	Type 7(15)
Military			MIL-B-5687-B Type I Comp A(12)		MIL-12128-A Comp. 3 Med Density	MIL-12128-A Comp. 3 High Density		MIL-B-5687-B Type II Comp. A1	MIL-B-5687-B Type II Comp. B				

[1] Unless otherwise specified by the purchaser, Mechanical Components are dipped in oil to inhibit rust formation, and bearings are impregnated with a high grade, non-gumming petroleum oil. The viscosity and type maye be agreed upon by the manufacturer and purchaser.

[2] Commonly graphite. A maximum of 1.75% of another type solid lubricant may be substituted when authorized by the purchaser.

[3] Combined carbon, on basis of iron only, may be a metallographic estimate.

[4] Remainder includes: Nickel 0.1% max, Antimony 0.1% max, and acid insoluble matter 0.1% max.

[5] Mechanical properties do not constitute part of the specification. They merely indicate to the purchasr values that may be expected from special subsize tensile and compression samples conforming to the chemical and *minimum* density requirements (in certain cases two values are given, the higher value corresponds to the upper density limit). It should be clearly understood that the values represent samples molded to size and not samples cut from commercial components or machined from blanks.

[6] Density of Bearings is on fully impregnated basis, Mechanical Components is on dry, unimpregnated basis.

[7] For Mechanical Components only, if the density varies from one section to another more than the stated allowable variation, the manufacturer and the purchaser shall agree upon a critical section of the component where the stresses are highest. The density of this critical section rather than the average density shall fall within the limits prescribed.

[8] Porosity in terms of intercommunicating void space. Porosity for Mechanical Components is not part of the specification unless requested by the purchaser.

[9] "K" Strength Constant is not part of the Mechanical Component specifications.

[10] ASTM B-310, Type I, Class A is for Mechanical Components, all others are for Bearings.

[11] ASTM B-255 is for Mechanical Components, there is no comparable specification for Bearings.

[12] MIL-B-5687-B, Type I, Composition A does not allow 1% max, iron.

[13] This commonly consists of the oxides of aluminum and silicon together with silicates, carbides, other oxides and so forth, which are normally insoluble in ordinary mineral acids.

[14] The coding system is detailed in Appendix III.

[15] SAE type 7 0.25-0.6% carbon.

8. Mechanical Properties

(a) *BEARINGS*—the radial crushing strength shall not be less than the value calculated as follows:

$$P = \frac{KLT^2}{D - T}$$

Where:

P = radial crushing strength, in pounds,

D = outside diameter of bearing, in inches,

T = wall thickness of bearing, in inches,

L = bearing length, in inches, and

K = strength constant as set forth in chart—Section 3.

(b) *Radial crushing strength* shall be determined by compressing the test bearing between two flat surfaces, the direction of the load being normal to the longitudinal axis of the bearing. The point at which the load drops due to the first crack shall be considered the crushing strength. This test shall be applied to plain cylindrical bearings. Flanged bearings shall be tested by cutting off the flange and compressing the two sections separately. Each section shall meet the minimum strength requirements prescribed in paragraph (a).

(c) *MECHANICAL COMPONENTS*—the manufacturer and the purchaser may agree on qualification tests for the determination of mechanical properties. These tests should be made on sample components and the tests should be determined after consideration of the function a component is to perform. Tensile or compressive strength and ductility can be determined by deforming or bending a component under compression and observing whether fracture occurs before the component has exhibited sufficient strength or ductility for its intended purpose.

Impact properties can be determined by dropping a weight upon a component to be tested. The weight, height of drop, point of impact, and the method of supporting the test sample should be prescribed.

The manufacturer and the purchaser should agree on limits for these qualification tests.

Note—The mechanical properties that may be expected are given in the chart—Section 3.

(d) After the first samples, on which the qualification test has been set up, both parties should agree as to conformance requirements for subsequent shipments.

9. Sampling

(a) *Lot*—Unless otherwise specified, a lot shall consist of pieces of the same form and dimensions made from powders of the same composition, manufactured under the same conditions, and submitted for inspection at one time. The number of pieces in a lot shall be as prescribed in Table I.

(b) *Samples for Chemical Analysis*—At least one sample for chemical analysis shall be taken from each lot. A sample shall consist of not less than 2 oz. of chips obtained by milling or drilling from at least two pieces with clean, dry tools without lubrication. In order to obtain oil-free chips, the parts selected for test shall be extracted in accordance with Section 14(b).

(c) *Samples for Physical and Mechanical Tests*—At least five samples from each lot of 10,000 pieces or less, and at least ten samples from each lot of over 10,000 pieces shall be selected for tests.

Table I

Maximum Number of Pieces in Lot

Weight of 1,000 pieces, lbs.	Maximum Number of Pieces in Lot
Up to 10, excl.	50,000
10 to 50, excl.	30,000
50 to 100, excl.	10,000
100 and over	5,000

10. Workmanship

Mechanical components and bearings shall be uniform in composition and free from defects which would affect their serviceability.

11. Variations in Dimensions

Variations in dimensions shall be within the limits specified on the drawings which describe the mechanical components and/or bearings, and which accompany the order; or variations shall be within the limits specified in the order.

12. Inspection

(a) *Inspection* — Unless otherwise specified, Inspection of mechanical components and/or bearings supplied on contract shall be made by the purchaser.

(b) *Certification* — A certification, based on manufacturer's quality control, that the material conforms to the requirements of these specifications, shall be the basis of shipment of the material. A certificate covering conformance of the material to these specifications shall be furnished by the manufacturer upon request of the purchaser.

13. Rejection

Unless otherwise specified, rejection based on tests made in accordance with these specifications shall be reported to the manufacturer within thirty days from receipt of the material by the purchaser.

METHODS OF TEST

14. Density

The density shall be calculated as follows:

(a) *MECHANICAL COMPONENTS*

$$D = \frac{A}{B\text{-}C}$$

(b) *OIL IMPREGNATED BEARINGS*

$$D = \frac{B}{B\text{-}C}$$

Where:

D = density, in gm per cu cm,

A = weight of the unimpregnated sample in air, in grams,

B = weight of the oil impregnated sample, in grams, and

C = weight of the oil impregnated sample immersed in water, in grams.

Note 1. Weights A, B and C shall be determined to within 0.1 per cent.

Note 2. When bearings are purchased impregnated, they should be weighed as received for determining weights of B and C.

Note 3. The effect of the surface tension of water in weighing the test sample may be minimized by the addition of a wetting agent to the water.

(c) When a sample is to be impregnated for the purpose of determining weights B and C, either of the following two procedures may be used, however, Procedure No. 1 is the preferred method and shall be used unless the manufacturer and purchaser agree to use Procedure No. 2. Procedure No. 2 might result in impregnation as much as 25% less than that obtained by Procedure No. 1.

(1) The pressure over the sample after immersion in oil (viscosity of approximately 200 sec. Saybolt Universal at 100 F., and/or as agreed between manufacturer and purchaser) at room temperature shall be reduced to not more than 2 in. of mercury pressure for 30 min. by a suitable evacuating method, after which the pressure shall be increased to atmospheric pressure for 10 min., with the sample immersed in the oil at room temperature during the entire period.

(2) The sample shall be immersed for at least 4 hrs. in oil, held at a temperature of 180 ± 10 F. and then cooled to room temperature by immersion in oil at room temperature.

(d) Samples that are to be freed of lubricant shall be extracted in Soxhlet apparatus using a suitable solvent, such as petroleum ether. After extraction residual solvent shall be removed by heating sample at 250 F. for 1 hr. Alternate extraction and drying shall be continued until the dry weight is constant to 0.1 per cent.

15. Porosity

MECHANICAL COMPONENTS AND OIL IMPREGNATED BEARINGS

(a) The porosity, in terms of intercommunicating void space, shall be calculated as follows:

$$P = \frac{B\text{-}A}{(B\text{-}C) \times S} \times 100$$

Where:

P = intercommunicating porosity by volume, in per cent.

A = weight of unimpregnated sample, in grams.

B = weight of oil impregnated sample, in grams.

C = weight of oil impregnated sample immersed in water, in grams, and

S = specific gravity of impregnant at the temperature of test.

Note 1. Weights A, B and C shall be determined to the nearest 0.1 per cent.

Note 2. When bearings are purchased impregnated they should be weighted as received for determining values of B and C.

Note 3. Samples that are to be freed of lubricant shall have the oil extracted in accordance with Section 14(b).

(b) Surface porosity of bearings may be determined by heating the sample as received to a temperature not exceeding 300 F. for a period of not more than 5 min., during which time oil shall exude uniformly from the bearing surface.

Appendix I

OIL IMPREGNATED BEARINGS

A. Design Information

In calculating permissible loads, the operating conditions, housing conditions, and construction should be considered.

B. Permissible Loads

Permissible loads for various operating conditions are shown in Table I. These are intended only as a general guide. It is recommended that all new applications be tested prior to establishing purchasing specifications.

Certain conditions will increase the permissible loads; such as additional lubrication, pressure lubrication, cooling, hardening or chrome plating the shaft, and loads of short duration.

Certain conditions tend to reduce the load carrying capacity of bearings regardless of type or make. Continual start-stop operation, oscillatory or reciprocating motion; high speeds; shock loading; extremely high or low temperatures; excessively close or loose bearing clearances; shaft run out, deflection or misalignment of shaft; dust, grit, moisture, corrosive fumes or poor shaft finish; oil breakdown.

To reduce the unit loading "P" on a bearing, the length must be increased (See Table IV for limits) because any increase in diameter is offset by an increase in the shaft velocity.

The permissible loading on THRUST BEARINGS is approximately 20% of that for plain bearings. An adequate oil film, as provided by immersion in oil or pressure lubrication, will increase the permissible loading.

C. Press Fits (Interference Fits)

Plain cylindrical journal bearings are commonly installed by press fitting the bearing into a housing with an insertion arbor. For housings rigid enough to withstand the press fit without appreciable distortion and for bearings with wall thickness approximately one-eighth of the bearing outside diameter, the press fits shown in Table II are recommended.

D. Running Clearance

Proper running clearance for bearings depends to a great extent on the particular application. Only minimum recommended clearances for oil impregnated bearing used with ground steel shafting are listed in Table III.

Table I
Permissible Loads

Shaft Velocity, ft. per min.	Permissible Loads, psi				
	BT-0010-N	BT-0010-R	BT-0010-S	F-0000-N	FC-1000-N
Static	5,500 max	8,500 max	11,250 max	7,500 max	15,000 max
Slow and intermittent	3,200	4,000	4,500	3,600	8,000
25	2,000	2,000	1,800	1,800	3,000
50 to 100	550	500	450	400	700
100 to 150	365	325	300	235	400
150 to 200	280	250	225	175	300
Over 200	$P = \frac{55,000}{V}$[1]	$P = \frac{50,000}{V}$	$P = \frac{45,000}{V}$	$P = \frac{35,000}{V}$	$P = \frac{40,000}{V}$

[1] For shaft velocities of 500 to 1000 ft. per min. $P = \frac{60,000}{V}$ (for BT-0010-N)

Where:
P = safe load in pounds per square inch of projected bearing area (length times inside diameter of bearing), and
V = shaft velocity in ft. per min.

Table II
Recommended Press Fits

Outside Diameter, in.	Press Fit, in.	
	min.	max.
Up to 0.760	0.001	0.003
0.761 to 1.510	0.0015	0.004
1.511 to 2.510	0.002	0.005
2.511 to 3.010	0.002	0.006
Over 3.010	0.002	0.007

Table III
Running Clearances

Shaft Size, in.	Clearance, min. in.	
	Bronze Base	Iron Base
Up to 0.760	0.0005	.001
0.761 to 1.510	0.001	.0015
1.511 to 2.510	0.0015	.002
Over 2.510	0.002	.0025

E. Dimensional Tolerances for Plain Cylindrical Bearings

The data in Table IV is intended for bronze base bearings with a 4 to 1 maximum length to inside diameter ratio and a 24 to 1 maximum length to wall thickness ratio, and for iron base bearings with a 3 to 1 maximum length to inside diameter ratio and a 20 to 1 maximum length to wall thickness ratio. Bearings having greater ratios than these are not covered by the table.

Table IV

Inside Diameter and Outside Diameter, in.	Total Diameter Tolerance, in. [1]			
	Bronze Base		Iron Base	
	Inside Diameter	Outside Diameter	Inside Diameter	Outside Diameter
Up to 0.760	0.001	0.001	0.001	0.001
0.761 to 1.010	0.001	0.001	0.0015	0.0015
1.011 to 1.510	0.001	0.001	0.0015	0.0015
1.511 to 2.010	0.0015	0.0015	0.002	0.002
2.011 to 2.510	0.0015	0.0015	0.002	0.002
2.511 to 3.010	0.002	0.002	0.003	0.003
3.011 to 4.010	0.003	0.003	0.004	0.004
4.011 to 5.010	0.004	0.004	0.005	0.005
5.011 to 6.010	0.005	0.005	0.006	0.006

Length, in.	Total Length Tolerance, in. [2]	
	Bronze Base	Iron Base
Under 1.495	0.010	0.010
1.496 to 1.990	0.015	0.015
1.991 to 2.540	0.015	0.020
2.541 to 2.990	0.015	0.020
2.991 to 3.985	0.020	0.030
3.986 to 4.985	0.020	0.030

Outside Diameter, in.	Wall Thickness, max., in.	Concentricity Tolerance, in. [3]	
		Bronze Base	Iron Base
Up to 1.010	Up to 0.255	0.003	0.003
1.011 to 1.510	Up to 0.355	0.003	0.003
1.511 to 2.010	Up to 0.505	0.004	0.004
2.011 to 3.010	Up to 0.760	0.005	0.005
3.011 to 4.010	Up to 1.010	0.005	0.005
4.011 to 5.010	Up to 1.510	0.006	0.006
5.011 to 6.010	Up to 2.010	0.007	0.007

[1] Total tolerance on the inside diameter and outside diameter is a minus tolerance only.
[2] Total tolerance is split into plus and minus.
[3] Total indicator reading.

F. Dimensional Tolerances for Flange Bearings and Thrust Washers

Table V

Flange Bearings: Flange Diameter, in.	Flange Diameter Tolerance, in.			
	Bronze Base		Iron Base	
	Class A	Class B	Class A	Class B
0 to 1½	±0.0025	±0.005	±0.0025	±0.005
1½ to 3	±0.005	±0.010	±0.005	±0.010
3 to 6	±0.010	±0.025	±0.010	±0.025

Note—Normally the outside diameter of the flange is not too critical; therefore, should not be held too close—unless required. Class A tolerances may require additional operations.

Flange Bearings: Flange Diameter, in.	Flange Thickness Tolerance, in.			
	Bronze Base		Iron Base	
	Class A	Class B	Class A	Class B
0 to 1½	±0.0025	±0.005	±0.0025	±0.005
1½ to 3	±0.007	±0.010	±0.007	±0.010
3 to 6	±0.010	±0.015	±0.010	±0.015

Note—Normally the thickness of the flange is not too critical; therefore, should not be held too close—unless required. Class A tolerances may require additional operations.

Thrust Washers: Thickness, in.	Thickness Tolerance, in. (for all diameters)			
	Bronze Base		Iron Base	
	Class A	Class B	Class A	Class B
0 to ¼	±0.0025	±0.005	±0.0025	±0.005

Flange Bearings and Thrust Washers: Diameter, in.	Parallelism on Faces, max., in.			
	Bronze Base		Iron Base	
	Class A	Class B	Class A	Class B
0 to 1½	0.002	0.003	0.003	0.005
1½ to 3	0.003	0.004	0.005	0.007
3 to 6	0.004	0.005	0.007	0.010

Note—Closer tolerances can be held, but may require additional operations.

Note—For flange bearings, the body tolerances—inside diameter, outside diameter, length and concentricity—are the same as for plain cylindrical bearings, Table V.

G. Removing Oil

For small quantities the procedure outlined in Section 14(d) of the Materials Standard may be used. For large quantities an active oil solvent such as lead-free gasoline or trichlorethylene may be used. The bearings are immersed for several hours, and the solvent is changed 2 to 5 times, as required, during this period. After extraction the bearings are allowed to dry by evaporation. (Caution—observe common safety rules for fire and health hazards.)

H. Re-impregnation

Bearings may be re-impregnated by following the procedure outlined in Section 14(c) of the Materials Standard.

I. Storage

Oil impregnated bearings should be stored in non-absorbent containers to prevent oil loss. They should also be protected from dirt and dust—especially close tolerance bearings.

J. Surface Finish

Where surface finish affects the function of a bearing, the purchaser may request a very smooth finish. However, due to the porous nature of powder metallurgy parts normal stylus measurements with tracer type instruments will not measure the true finish of the surface. This is because the surface porosity is deeper than surface irregularities in the metal particles.

The purchaser and manufacturer may agree on a surface finish specification and method of measurement.

Appendix II

MECHANICAL COMPONENTS

A. Mechanical Properties

The tensile data given in the specification chart was obtained from flat samples approximately ¼ x ¼ in. cross section with a gage length of 1 in. (Refer to MPIF Standard 10-50 and ASTM Designation E8 for additional details.) The compression data was obtained from samples with a diameter of 1⅛ in. and a length of 1 in. (Refer to ASTM Designation E9 for additional details.)

Hardness values have not been included in these specifications because the indentation hardness of powder metallurgy material is strongly affected by density. In lower density components the voids in the structure do not contribute to the support of the indenter. Thus, when hardness measurements are made on powder metallurgy materials, they are referred to as "apparent values". Apparent hardness values are often agreed upon between the manufacturer and purchaser for mechanical components that are heat treated. The effect of the density distribution within the component must be considered when establishing hardness limits.

B. Heat Treating

Metal infiltrated and high density mechanical components may be heat treated by conventional methods. Liquid carburizing of low density components should be avoided because of possible corrosion due to entrapment of salt within the pores.

When carburizing low carbon, low density components, no sharply defined case is formed, since the carbonaceous gas readily penetrates into the core through the inter-communicating porosity. To avoid the possibility of corrosion due to quenching media entering the pores, the use of oil is recommended.

Heat Treating is used primarily to increase hardness and wear resistance of powder metallurgy components.

C. Finishing

Infiltrated and high density parts are easily plated by standard procedures. In plating low density parts, special procedures must be observed, so that the plating salts are not entrapped in the pores of the components and cause eventual discoloration of the finish, internal corrosion or "flowering" of the plated surface. Techniques of burnishing, shot peening or resin impregnation have been developed to either close up the surface pores or fill all the pores, and thereby avoid these conditions. Mechanical components are being successfully plated with copper, nickel, chromium, cadmium, zinc and other metals.

Iron-base components may be economically finished by steam treating. This results in a black oxide finish which not only improves the corrosion resistance of the parts, but also makes them harder and more wear resistant.

Other oxidizing and phosphating treatments may also be used successfully.

D. Joining

With the exception of infiltrated or high density parts, conventional brazing or soldering techniques are not practical on powder metallurgy parts, since the brazing material is absorbed in the pores. Spot and projection welding have been used successfully, however it is recommended that the purchaser consult with the manufacturer in these cases. Infiltrated parts are readily joined because of their self-brazing characteristics.

E. Surface Finish

In addition to the notes in Section J, Appendix I, it should be pointed out that if machining operations are required on the component, the surface finish will be comparable to that obtained when machining similar wrought material.

Appendix III

CODING SYSTEM AND CODE DESIGNATIONS

This system is suggested as a convenient means for designating the type of material, composition and density of parts produced by the powder metallurgy process. It consists of a combination of letters and numerals arranged in sequence so as to designate the information desired.

The following three basic rules are applied:

Rule No. 1

Let prefix letters denote the general type of material. (See Table I.)

Table I

Prefix Letter Codes for General Materials

Material Code Letters	Material	Constituents
	Non-Ferrous	
BT	Bronze	Copper-Tin
BT	Bronze, leaded	Copper-Tin-Lead
BZ	Brass	Copper-Zinc
BZ	Brass, leaded	Copper-Zinc-Lead
	Ferrous	
F	Iron or Iron Carbon Alloy	Iron, (Iron-Carbon)
FC	Iron Alloy	Iron-Copper
FN	Iron Alloy	Iron-Nickel
FX	Iron Alloy	Iron-Copper Infiltrated (15-25%)

Note—Bronze type materials may contain up to 1.75% of a solid lubricant such as graphite.

Rule No. 2

Let the numbers which directly follow the prefix letters denote the percentage of the minor constituents. (See Table II.) Disregarding impurities, the percentage of the major constituent is easily determined by subtracting the sum of the minor constituents from 100 percent. Therefore, it is not necessary to designate it in the code.

(a) *Non-Ferrous Materials*

Use two digit numbers to show the minor constituents present.

The last two numbers in a series of four will designate the percentage of the major alloying constituent; tin for bronze, zinc for brass.

The first two numbers will designate the percentage of the other minor constituent.

If there is no other minor constituent present, place two zeros (i.e. 00) in the space for minor constituents.

(b) *Ferrous Materials*

Use two digit numbers to show minor constituent and carbon content.

The last two numbers in a series of four will designate the carbon content. A carbon content up to and including 0.25% will be regarded as zero carbon content.

The first two numbers will designate the percentage of the minor constituent.

If there is no minor constituent present, place two zeros (i.e. 00) in the space for minor constituents.

Table II

Composition Codes for General Materials

Material Code	Material	Composition	Code for Material and Composition
		Non-Ferrous	
BT	Bronze	Cu-90 Sn-10	BT-0010
BT	Bronze, leaded	Cu-87 Sn-10 Pb-3	BT-0310
BZ	Brass, leaded	Cu-80 Zn-18 Pb-2	BZ-0218
		Ferrous	
F	Iron	Fe (carbon 0.25 max.)	F-0000
F	Iron-Carbon	Fe & Carbon 0.5%	F-0005
F	Iron-Carbon	Fe & Carbon 1.0%	F-0010
FC	Iron-Copper Alloy	Fe & Cu 3.0%	FC-0300
FN	Iron-Nickel Alloy	Fe & Ni 2.0%	FN-0200
FX	Iron-Infiltrated	Fe & Cu 15/25%	FX-2000

Rule No. 3

Let a suffix letter denote the density range of the material. Use range in which MEAN density lies. (See Table III.)

Table III

Suffix Letter Codes for Density Range Classification

Code Letter	Density Range
K	For Future Expansion
L	For Future Expansion
M	For Future Expansion
N	6.0 gms/cc and less
P	6.0 to less than 6.4 gms/cc
R	6.4 to less than 6.8 gms/cc
S	6.8 to less than 7.2 gms/cc
T	7.2 to less than 7.6 gms/cc
U	7.6 to less than 8.0 gms/cc
W	8.0 or more gms/cc
X	For Future Expansion
Y	For Future Expansion
Z	For Future Expansion

Example showing how rules are applied

Rule No. 1	Rule No. 2	Rule No. 3
Let prefix letters denote the general type of material See Table I Example—Letters BT = Bronze	In the case of non-ferrous materials, the first two digit numbers designate the percentage of the minor constituent. The last two digit numbers denote the percentage of the major alloying constituent. See Table II, Item No. 1, Bronze Type Material Example—0010=10% Tin	Let a suffix letter denote the density of the material See Table III Example—Letter R = Density of at least 6.4 but less than 6.8 gms/cc
BT	**0010**	**R**

BT-0010-R therefore, represents the code designation for a bronze bearing material 90% copper and 10% tin in composition. The density of the material is 6.4-6.8 gms/cc, as represented by the letter "R" per Table III. It may also contain up to 1.75% of a solid lubricant such as graphite.

By combining the three rules set forth, the typical materials listed below may be coded as shown in Table IV.

Table IV
Code Designations for Typical Materials [1]

Material	Composition [2] (Constituents in percent)	Mean Density gms/cc	PMPMA Code
Non-Ferrous			
Bronze	Cu-90 Sn-10	6.6	BT-0010-R
Bronze, leaded	Cu-90 Sn-10 Pb-3	6.7	BT-0310-R
Brass, leaded	Cu-80 Zn-18 Pb-2	7.85	BZ-0218-U
Ferrous			
Iron	Fe (C 0.25 max.)	5.9	F-0000-N
Iron Infiltrated	Fe (C 0.25 max.) (Cu 15-25%)	7.35	FX-2000-T
Iron-Carbon	Fe & C 1.0%	6.3	F-0010-P
Iron-Carbon Infiltrated	Fe & C 1.0% (Cu 15-25%)	7.35	FX-2010-T
Iron Alloy	Fe & Cu-10.0% & C-.5%	6.0	FC-1005-N
Iron Alloy	Fe & Ni-3.0% & C-1.0%	6.0	FN-0310-N
Iron Alloy	Fe & Cu-7.0% & C-1.0%	6.9	FC-0710-S

[1] PMPMA has not established standards for all these typical examples.
[2] The compositions shown are expressed in percent and are those of the basic material before any oil impregnation, metal infiltration, heat-treatment, etc., has taken place.