OTTAWA March 23rd, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1187.

Comparison of Frictional Properties of P.M.G.2 Metal and PB-16 Metal.

(Copy No. 7.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Request and Object of Investigation:

On February 23th, 1942, the British Admiralty Technical Mission, Ottawa, Ontario, submitted samples of two bearing metals and requested an expression of opinion concerning their relative frictional properties. These metals were P.M.G.2 and PB-16. This work is authorized by a letter, dated February 25th, 1942, from Lt.-Commander (E) H. Greenwood, Inspector of Naval Gun Mountings for the British Admiralty

(Origin of Request and Object of Investigation, cont'd) -

Technical Mission, Ottawa.

Chemical Analysis of Samples:

Table I gives the chemical analysis of these two metals.

Table I. - Chemical Analysis.

		P.M.G.2	PB-16
		(Per cent)	
Copper	-	90.2	87.5
Tin	-	None	11.05
Zinc	-	3.02	None
Phosphorus	-	0.12	0.35
Lead	-	None	0.68
Silicon	-	4.37	None
Manganese	-	0.21	None
Iron	-	2.02	0.20
Nickel	-	None	0.07
Aluminium	-	None	0.22

Physical Properties:

The hardness values of the two metals, as determined with a 1/16" diam. ball and a 150-kilogram load, are:

P.M.G.2 = Rockwell B, 80
PB-16 = Rockwell B, 45

Friction Comparison:

Specimens 1" x 2" x 7/16" in size were obtained from the bushing castings submitted. These were pulled along a level smooth steel surface by a thread passing over a pulley at the end of the steel strip and carrying a pan on which weights could be placed.

The steel surface was rubbed down smooth with fine sandpaper and washed with ether and alcohol to remove all grease.

The bronze blocks were rubbed over the steel in order to wear-in matching surfaces.

Weights were added to the pan until the block

(Friction Comparison, cont'd) -

just started to slide. The equipment used was not sensitive enough to show any difference between the force required to start movement and the force required to sustain movement.

The force required to start movement was determined for three conditions;

1. To move the block only.
2. To move the block carrying a load of 50 grams.
3. To " " " " " " 100 grams.

The areas of the blocks in contact with the steel, the total forces acting to press the bronze against the steel, and the unit forces acting to press the bronze against the steel are given in Table II.

Table II.

	P.M.G.2	PB-16
Area of surface in contact with steel	- 1.98 sq.in.	2.02 sq.in.
Total interfacial pressure - no load	- 107 grams	103 grams
" " " , 50-gram load	- 157 "	153 "
" " ", 100-gram "	- 207 "	203 "
Unit interfacial pressure (grams per sq.in);		
No load	- 54	51
50-gram load	- 79.4	75.4
100-gram load	- 104.5 grams	100.5 grams

The forces required to start movement are given in Table III.

(See Table III on next page)

(Friction Comparison, cont'd) -

Table III.

Unit Interfacial Pressure, Grams per square inch.	Force Overcoming Friction, Grams P.M.G.2	Force Overcoming Friction, Grams PB-16	Ratio, Force: Unit Pressure P.M.G.2	Ratio, Force: Unit Pressure PB-16
51		20		0.392
54	23		0.426	
75.4		34		0.452
79.4	33		0.417	
100.5		52		0.517
104.5	50		0.478	

The relative areas of the actual contact surfaces were determined by the use of bluing. There was not 100 per cent contact but the areas in both cases appeared to be very nearly equal.

Discussion of Results:

The results obtained can not be considered as indicative of actual bearing behaviour.

The comparative data relative to the frictional properties of P.M.G.2 metal against steel and PB-16 metal against steel would appear to favour P.M.G.2 metal. It should be emphasized that these tests were carried out dry, using no lubricant.

The equipment used was not particularly sensitive and no consistent results could be obtained for the forces required to sustain motion.

Had the above tests been duplicated using oil to lubricate the surfaces, the results would have merely shown the lubricating properties of the oil since the actual metal surfaces would not have been in contact.

Finish, lubrication, bearing design, operating temperature and load are all equally as important as the coefficient of friction in determining the performance of

(Discussion of Results, cont'd) -

a bearing assembly. A bearing usually does not fail unless the lubrication either fails or is ineffective. This may be caused by any one of the following conditions:

1. Failure in supply of lubricant.
2. Puncture of oil film by rough bearing surface.
3. Dirt getting into bearing.
4. Failure of oil film due to heavy load.
5. Failure of oil film due to high temperature.
6. Improper grade of lubricant for specific bearing application.

One of the prime requirements of a good bearing is its ability to acquire a smooth surface.

The hardness of the metal will also have some effect on the performance of a bearing, particularly in running it in. When a relatively soft metal is used the alignment and tolerances required are not as critical as when a harder metal is used. It will deform and wear-in quicker. Therefore, with a hard metal a better finish, closer tolerances, and more accurate alignment are necessary.

The substitution of metals which do not contain tin in bearing applications is more fully dealt with in Report of Investigation No. 1172, "Some Suggestions for Tin Conservation in Certain Non-Ferrous Applications," being issued by the Ore Dressing and Metallurgical Laboratories, Ottawa.

Some comparative data on the bearing properties of P.M.G. metal vs. phosphor bronze are given by H. N. Bassett in his book, "Bearing Metals and Alloys," published by Edward Arnold & Co., London. On page 294 of

(Discussion of Results, cont'd) -

of this book the author states:

"Friction tests which were made compared P.M.G. metal with phosphor bronze, using half-bearings on a nickel steel shaft under a load of 435 lb. per square inch, the bearings being run-in before the test. The phosphor bronze alloy was made with 10 per cent of phosphor tin and the composition was approximately 90 copper, 8.5 tin and 1.5 phosphorus. The coefficient of friction for the P.M.G. metal was 0.0054 whilst that for the phosphor bronze was 0.0065. The temperature rise was practically the same, being 18° C. for the P.M.G. metal and 19° C. for the phosphor bronze. The latter showed signs of wear after 6 hours' running whilst the former was practically unchanged.

P.M.G. metal was substituted for phosphor bronze and gunmetal in the connecting-rod brass (big end) of a shunting locomotive and after six months' daily use showed no signs of wear, whereas the gunmetal was worn out at the end of that period and phosphor bronze only lasted a year."

In a paper entitled "Copper-Silicon-Iron Bronzes--Their Foundry Qualities and Physical Constants,"* by E. G. Jennings and Harold J. Roast, the authors state, in an addendum to Paragraph 44:

"Because of the following comparative test of Leaded Bronze versus Phosphor Bronze, Gun Metal, and P.M.G. Silicon Bronze, we do not recommend any but Leaded Bronze for high speed bearings with fine clearances with or without heavy loads.

Where the R.P.M. is not over 200 and the clearance is not less than seven thousandths, P.M.G., Gun Metal, and Phosphor Bronze should be satisfactory.

Description of Wear Test -

A revolving axle made of railway steel is used. Lubrication is the railway oil used for packing bearing boxes. Area of the specimen is 1" x ¼", or ¼ square inch, and the load is 190 pounds p.s.i. Speed of the revolving axle is 1750 R.P.M. All specimens are carefully ground in, cleaned, and weighed before the test is started.

Results -

In the case of Leaded Bronze, that is Lead 15%, Tin 7%, Zinc 3%, Copper balance, we were able to run a continuous twenty million revolution test, at the end of which period there was no sign of scoring of the axle. In the case of the other three alloys

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* Presented before a non-ferrous session at the 45th Annual A.F.A. Convention, New York City, N.Y., May 13, 1941. Copies available from Canada Bronze Co. Ltd., Montreal, Quebec.

(Discussion of Results, cont'd) -

referred to, Gun Metal (88% Copper, 10% Tin, 2% Zinc) started to score at 1,850,000 revolutions, Phosphor Bronze (10% Tin, 0.3% Phosphorus, balance Copper) started to score at 1,500,000 revolutions and P.M.G. No. 2 started to score at 1,650,000 revolutions while P.M.G. No. 6 started to score at 2,200,000 revolutions. As each of these three alloys started to score the shaft, we were not able to complete the twenty million wear test."

Conclusions:

1. The frictional properties of P.M.G.2 and PB-16 under the conditions of the test described in the report appear to be similar.

2. Pending further developments, in view of the research data at present available, it would be considered inadvisable to substitute P.M.G. metal for leaded bronzes in high speed bearings with fine clearances with or without heavy loads.

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