The performance of a bearing is influenced by the conditions of speed, mating materials, clearances, temperature, lubrication, type of loading, etc. Of primary importance, is the maintenance of an oil film between the bearing surfaces to reduce friction, dissipate heat and retard wear by minimizing metal to metal contact. The most critical periods of operation are during starting and stopping, when the load may cause the bearing surfaces to come into contact with each other. For these reasons it is not practical to predict the wear rate of bronze bearings.

The selection of the best bearing for an application can be a very complicated problem because the combined influence of the many factors affecting the operation is difficult to predict.

The following information may be used as a guide for selecting a Bronze sleeve bearing which should satisfy the requirements.

For practical reasons, the length of the bearing should normally be between one and two times the shaft diameter and the O.D. approximately 25% larger than the shaft diameter.

Starting and Stopping/Oscillatory Motion/Cyclical Overload conditions mean a full film of oil cannot be maintained. When this happens, metal-to-metal contact occurs and causes bearing wear. Because of the continual interruption of the oil film, a larger safety factor is required when designing bearings for applications of this type. A lower permissible PV factor must be considered.

Speed/Oil Viscosity must also be considered. The proper viscosity oil must be selected for each particular speed application, to achieve optimum bearing operation.

For high speed applications, a light oil (150 SUS at 100°F) is required to keep internal oil friction at a minimum and assure proper metering of the oil to the bearing/shaft surface.

For moderate speeds, a medium-viscosity oil (400 SUS at 100°F) is required.

For very low shaft speeds under moderate or heavy loads, a heavier oil with an extreme pressure additive may be required to prevent complete oil film rupture and give sufficient lubrication for proper operation.

**Shaft Consideration** is extremely important in bearing applications. For optimum operation the shaft must be of proper material, hardness, surface finish, roundness and dimensions. Experience indicates that carbon steels, and preferably C1137, offer the best operating results. If stainless steel shafts are to be used, 400 Series is recommended. Austenitic 300 Series stainless steel tends to gall, which results in extreme wear and shortened life. If 300 Series stainless is required for its non-magnetic qualities, it is strongly recommended that shafts be work-hardened or chrome-plated for satisfactory operation.

For best results, a shaft surface finish of 4 to 12 RMS is recommended. Nicks, gouges, and burrs should be avoided because they rupture the oil film and cause metal-to-metal contact.

Shaft roundness and dimensions also contribute greatly to bearing life. The more round the shaft, the less the bearing and shaft wear, with longer life resulting. Dimensions also play an important role in operation and should always be in accord with the recommended bearing clearance charts.

As stated, for practical reasons the bearing length should normally be between one and two times the shaft diameter. However, the recommended practice is by using the PV factor. PV is a means of measuring the performance capabilities of bearings. P is expressed as pressure or pounds per square inch on the projected area of the bearing. V is velocity in feet per minute of the wear surface (surface feet per minute). "PV" is expressed by the following:

\[
P V = \frac{W \times \pi d n}{12 L} = \frac{W n}{12 L} = .262 W n \quad \text{Ld} 12 12L L
\]

\[
P = \frac{W}{A \text{ (Brg. I.D. x Length)}}
\]

\[
V = \text{Surface velocity of the shaft, ft./min.} \quad \text{(.262 x RPM x Shaft Dia.)}
\]

\[
W = \text{Bearing load in pounds}
\]

\[
L = \text{Bearing length in inches}
\]

\[
d = \text{I.D. of bearing in inches} \quad \text{(cancels out of formula)}
\]

\[
n = \text{Shaft speed, RPM}
\]
SLEEVE BEARING SELECTION (CONTINUED)

Each material has a specific maximum PV rating, as shown in the following Table. In addition, it also has a maximum pressure (P) and velocity (V) limitation. These values should not be exceeded. At no time can all maximum values be utilized.

All values based on 72°F ambient temperature and standard lubricant, when required.

NOTE: Above figures should be considered maximum and not to be exceeded.

**EXAMPLE**

Select a BOST-BRONZ (oil impregnated) bearing to satisfy the following conditions.

**Known—**

5/8" Shaft Diameter

\[ n = 500 \text{ RPM} \]

\[ W_1 = \text{Load Bearing I} = L_1 = 52.5 \text{ Lbs.} \]

\[ W_2 = \text{Load Bearing II} = L_2 = 157.5 \text{ Lbs.} \]

\[ L = \text{Length of Bearing} \]

**For Bearing I—**

\[
PV = \frac{.262 \times W_1 \times n}{L \text{ (In. of Lgth.)}} = \frac{.262 \times 52.5 \times 500}{1} = 6877
\]

With the calculated PV of 6877, Bearing I, and 20,632, Bearing II, it can be seen from the Table, that a BOST-BRONZ bearing, one inch long, will not exceed Maximum PV.

**NOTE:** An increase in L will decrease the value of PV; conversely, a shortening of L increases the value of PV.

A check of PV calculations should now be performed to assure that Max. “P” and Max. “V” is not exceeded.

PV Max. = \( P \text{ Max.} \times V \text{ Max.} \)

\[ V = .262 \times \text{Shaft Dia.} \times n = .262 \times .625 \times 500 = 81.9 \]

Bearing I \[ P = \frac{PV}{81.9} = 6877 = 83.9 \]

Bearing II \[ P = \frac{PV}{81.9} = 20632 = 251.9 \]

As can be seen, we have not exceeded any maximum values. We can now select an actual Bost-Bronz bearing.

Knowing:

Shaft Dia. 5/8" = Bearing I.D. 5/8"

Bearing O.D. should be approximately 25% larger than I.D.

Bearing O.D. = \( .625 \times 1.25 = .781" \)

Referring to Bost-Bronz listings, Page 12, we find 5/8" I.D. bearings listed with O.D.’s from 3/4 to 1" and lengths from 1/2 to 2".

From this selection of bearings, we may choose a bearing to fit the requirements.

Since Bearing I is lightly loaded, for practical reasons, we select a bearing length of one times bearing I.D. We select a B1013-5 (5/8" I.D. x 13/16 O.D. x 5/8" long).

**Material** | **Max. PV** | **Max. P** | **Max. V**
---|---|---|---
BEAR-N-BRONZ | 75,000 | 3,000 | 750
BOST-BRONZ | 50,000 | 2,000 | 1,200
BOST-BRONZ (Thrust Washers) | 10,000 | 2,000 | 1,200
F1 | 20,000 | 1,000 | 400
TN | 10,000 | 800 | 300
AF | 8,000 | 750 | 300
GS | 4,000 | 500 | 300
D | 3,000 | 480 | 300
N | 3,000 | 480 | 300
UHMW-PE | 2,300 | 1,400 | 100
Nylon | 16,000 | 2,000 | 400
UHMW-PE with Internal Wear Strip | 4,000 | 1,400 | 100
Nylon with Internal Wear Strip | 16,000 | 2,000 | 400
SLEEVE BEARING SELECTION

EXAMPLE (Continued):

For Bearing II we will select a length of two times bearing I.D. — B1013-10. (In actual practice, it may be more suitable to select one common size — B1013-10.)

For a double-check of PV, we should use actual bearing selected:

\[
PV_{Actual} = \frac{PV}{L \text{ (Actual Bearing)}}
\]

Bearing I PVA = \( \frac{6877}{.625} = 10043 \)

Bearing II PVA = \( \frac{20632}{1.25} = 16505 \)

Actual PV values are below Maximum PV values shown in Table.

SLEEVE BEARING WEAR LIFE

Wear life cannot be applied to BOST-BRONZ (oil-impregnated) or BEAR-N-BRONZ (SAE CA932/660) bearings. Under ideal conditions the shaft rides on a film of oil, and will give almost infinite life. If this film of oil is disrupted, intimate metal-to-metal contact results leading to eventual failure.

NON-METALLIC AND NON-LUBRICATED BEARINGS

Wear rate is generally defined as the volumetric loss of material over a unit of time. Several mechanisms operate simultaneously to remove material from the wear interface, however, the primary mechanism is adhesive wear which is characterized by fine particles of polymer being removed from the surface. The presence of this powder is a good indication that the rubbing surfaces are wearing properly. The presence of melted polymer or large gouges or grooves at the interface is normally an indication that the materials are abrading and wearing and/or the pressure velocity limits of the materials are being exceeded.

Once a Wear Rate factor (K) has been established it can be used by the engineer to calculate wear rates of bearings, gears, etc. However, because wear rates is affected by material types, finishes and hardness as well as environmental temperature and part design, large errors may result as end use variables begin to differ from those selected for the test procedure.

As a relative measure of the performance of one composite vs. another at the same operating conditions, the K factors have proven to be highly reliable.

\[
t = K (PVT)
\]

K = Wear rate factor

\[
P = \frac{W \text{ (Total Load)}}{A \text{ (Brg. I.D. x Lgth.)}}
\]

V = Velocity in ft. per minute \( \times \frac{.262 \times \text{RPM} \times \text{Shaft Dia.}}{1000} \)

\[
T = \frac{t}{KPV}
\]

T = Running time in hours

Values for plastic resins assume no trace of lubricant present.

A simple calculation could be made as follows:

Assumptions: 1. 1616D-1/2 Delrin Roll End Bearing
2. .020 inch allowable wear limit
3. 50 lbs. load on roll (25 lbs. per bearing)
4. 100 RPM
5. Normal environment with no lubrication

Problem: Find estimated wear life

Solution:

\[
PV = \frac{\pi Wn}{12L} = \frac{\pi \times 25 \times 100}{12 \times 1} = 655
\]

\[
t = K (PVT)
\]

\[
T = \frac{t}{KPV} \quad \text{or} \quad \frac{.020}{50 \times 10^{-10}} \times 655
\]

T = 6100 hrs.

The use of low viscosity lubricant applied initially and/or periodically during operation of the bearing would extend the life several times.

BostonE F-1 material is generally limited to a bearing maximum of 1,000 p.s.i. For more detailed design calculations Fig. 2 shows actual deformation values as a function of temperature and load.

The coefficient of friction of BostonE F-1 varies with changes in load and speed when operated dry. Figure 3 shows the variation with load and Figure 4 shows the variation with speed.
For optimum performance of BostonE F-1 bearings, the mating surface should be as hard as possible. Mild steel, however, will give satisfactory results.

A surface finish range of 8-16 micro-inches is preferred; however, good results will be obtained with finishes to 32 micro-inches.

Figures 1 through 6 apply to BostonE F-1 material only.
LUBRICATION—BOST-BRONZ

All standard BOST-BRONZ bearings, bars and plates are impregnated with a high grade, oxidation-resistant mineral oil of SAE30 (ISO 100) viscosity. If properly stored, BOST-BRONZ parts retain their oil supply indefinitively. To prevent loss of lubricant, BOST-BRONZ should be stored in non-absorbent materials (metal, plastic, or suitably lined containers, etc.) The bearings should be covered to keep out dirt and dust.

REMOVING LUBRICANT: If it becomes necessary to remove the oil from BOST-BRONZ, for example to replace with another type or viscosity of lubricant, the following procedure may be used:

Immerse parts in a good grade of oil solvent, such as lead-free gasoline, naptha, carbon tetrachloride or alcohol. Change solvent often, until solvent appears clear. Agitation will hasten the process.

RE-OILING: BOST-BRONZ parts may be re-impregnated by submerging in oil (pre-heated to about 150°F) for approximately 30 minutes. More time should be allowed for larger parts.

SUPPLEMENTARY LUBRICATION

The following designs illustrate simple, effective arrangements for providing supplementary lubrication.

LUBRICATION—BEAR-N-BRONZ

The maintenance of an oil film between the shaft and bearing surfaces is extremely important, serving to reduce friction, dissipate heat, and retard wear by minimizing any metal to metal contact.

Lubricant is usually supplied into the bearing from an oil cup or fitting through an oil hole.

The drawings below illustrate two typical methods.

A. Oil Cup
Oil is fed from the oil cup to the bearing by gravity.

B. Oil or Grease Fitting
Lubricant is fed through the fitting under pressure and distributed through grooves by the rotation of the shaft.
GROOVING

1. An oil feeder hole is normally sufficient for small bearings under light loads.

The oil hole should be in a position to introduce the lubricant to the non-loaded area of the bearing. The lubricant will then normally be carried to the loaded area by the rotation of the shaft.

For larger bearings under heavy loads, it may be desirable to facilitate the flow of lubricant to the pressure area by means of grooves machined into the bearing surface.

2. Type I or Type II grooves have proven adequate for most applications requiring an oil groove. In either case, the oil feed hole introducing the lubricant should always be located in the unloaded bearing area.

3. Very long bearings may require two feeder holes connected by one straight (axial) groove.

4. Oil grooves should stop short of the bearing ends to minimize oil leakage.

5. Grease lubricants are normally restricted to applications subjected to heavy loads at low speeds. Grease should be distributed under pressure along oil grooves to the loaded area. Type VI or Type VII grooves may be used for grease lubrication.

Below are illustrations of some popular styles of oil grooves:

Depth of oil groove is 1/8” max. if wall permits. On thin wall bearings depth of groove is normally less than 1/2” wall thickness. When applicable groove is located 1/8” from ends.
SHFT CLEARANCES

The following graphs may be used as a guide to determine shaft clearance for proper running fit.

BOST-BRONZ

BEAR-N-BRONZ

PLASTICS
PRESS FIT ALLOWANCES

The allowance for press fit into a housing will vary depending upon bearing size, wall thickness, housing material, and housing construction. The accompanying graphs will be a useful guide in determining allowances for press fits.

**BEAR-N-BRONZ**

When a BOST-BRONZ bearing is pressed into a housing, the inside diameter (I.D.) will close-in (becoming smaller). The amount will depend upon the same factors influencing the Press Fit, but will average approximately 75% of the Press Fit allowance.

**PLASTICS**

Due to normal variations in molded bearings, practicality dictates the measuring of actual bearing O.D. and adjusting bore size accordingly.

For this reason, the minimum required press fit depicted in graph, for F-1 material and other plastic material is approximate and may be used as a guide.
MACHINING

In cases where it is desired to alter a standard stock bearing or to manufacture parts from a bronze bar or plate stock, the following machining practices are suggested.

BOST-BRONZ

BOST-BRONZ may be readily machined. For best results, use carbide tools. For finishing cuts on bearing surfaces, the cutting tool should be extremely sharp. Use feeds and speeds that are normal for machining regular bronze. Finish with a light cut (up to .005”). This method avoids the pulling or spreading of metal over the surface pores. Cutting oils or coolants should not be used. After machining, parts should be reoiled, using a good grade of oxidation-resistant mineral oil of about SAE20 (ISO 68) viscosity. For re-oiling procedure, see lubrication, Page 51.

BEAR-N-BRONZ

The use of carbide tools or high speed tools is recommended for machining Bear-N-Bronz. Carbide tools should be used at speeds of 500 to 1000 surface feet per minute. High speed steel tools should be used to 200 to 500 surface feet per minute. Either tool should be held to a minimum clearance angle for best results. Cutting solutions are not required.

ASSEMBLY AND SIZING—BOST-BRONZ

In most instances, sizing the bore of BOST-BRONZ bearing is not necessary. The desired inside diameter will be obtained by proper press fit (and close-in) at assembly. In applications where sizing is necessary, it may be accomplished during assembly by the use of a shouldered sizing arbor, as illustrated in Figure 1. The arbor should be ground and lapped to a size slightly larger (.0002” to .0003” approx.) than the hole desired. A multiple step burnishing tool (see Figure 2) may also be used to size the hole in BOST-BRONZ bearings after assembly.

ASSEMBLY—BEAR-N-BRONZ

BEAR-N-BRONZ can be easily assembled by using a shouldered arbor, as illustrated, to maintain proper bearing alignment. A steady, even pressure should be applied. The arbor diameter should be of a size to allow for close-in of bearing I.D. at assembly. The surface of the arbor should be lightly oiled to facilitate withdrawal after assembly.