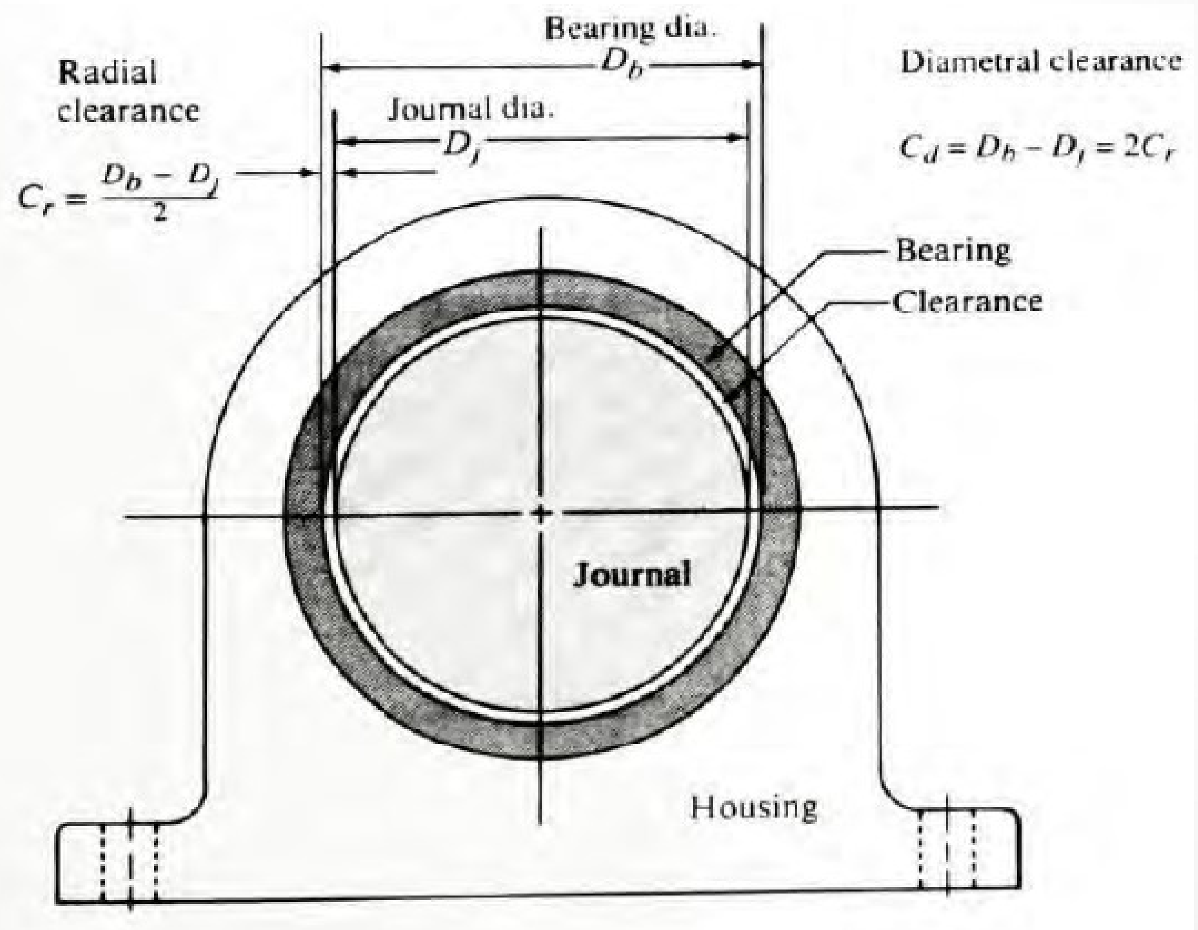
Plain Surface Bearing Geometry



Plain Surface Bearing Short Description

Bearing Type	Description	Friction	Bearing Stiffness	Velocity	Life Span
Plain Bearing	Rubbing surfaces, usually with lubricant; some bearings use pumped lubrication and behave similarly to fluid bearings.	Depends on materials and construction e.g., PTFE has coefficient of friction ~0.05-0.35, depending upon fillers added	Good, provided wear is low, but some slack is normally present	Low to very high	Low to very high - depends upon application and lubrication

Lubrication Mechanisms

A given bearing system can operate with any of three types of lubrication:

- ***Boundary lubrication:***

- ***Mixed-film lubrication:***

- ***Full-film lubrication:***

Bearing Requirements

- Magnitude, direction, and degree of variation of the radial load.
- Magnitude and direction of the thrust load, if any.
- Rotational speed of the journal (shaft).
- Frequency of starts and stops, and duration of idle periods.
- Magnitude of the load when the system is stopped and when it is started.
- Life expectancy of the bearing system.
- Environment in which the bearing will operate.

Design Decisions

- Materials for bearing visa vis shaft
- Diameter & tolerances
- clearance
- R_a of Journal and Bearing
- Length of the bearing
- Method of manufacturing the bearing system
- Type of lubricant to be used and the means of supplying it
- Operating temperature of the bearing system and of the lubricant
- Method of maintaining the lubricant cleanliness and temperature

Analyses Required

- Type of lubrication: boundary, mixed-film, full-film
- Coefficient of friction
- Frictional power loss
- Minimum film thickness
- Thermal expansion
- Heat dissipation required and the means of accomplishing it
- Shaft stiffness and slope of the shaft in the bearing

BEARING MATERIALS

- Bronze (88% copper & 12% tin)
- Babbitt
- Aluminum
- Zinc
- Porous metals: Sintered from powders of bronze, iron and aluminium; some mixed with lead or copper.
- Plastics (nylon, TFE, PTFE, phenolic, polycarbonate, filled polyimide)

Design requirements

- *Compressive Strength*
- *Fatigue Strength*
- *Embeddability*
- *Compatibility*
- *Corrosion resistance*
- *Conformability*
- *Wettability*

Properties Continued…

- *High thermal conductivity*
- *Low thermal expansion*
- *Low coefficient of friction*
- *Relative hardness*
- *Availability*
- *Cost*
- *Elasticity*
- *Availability*

Commonly used Bearing Materials & their Properties

Material		Load Capacity	Maximum Operating Temperature	Compatibility	Conformability	Embedability	Corrosion Resistance	Fatigue Strength
Tin Based Babbit		5.5 to 10.3	149⁰C	1	1	1	5	5
Lead Based Babbit		5.5 to 8.3	149⁰C	1	1	3	5	5
Copper Lead		10.3 to 17.2	177⁰C	2	2	5	3	3
Lead Bronze		20.7 to 27.6	232⁰C	3	4	4	2	2

1 = Highest Range
5 = Lowest Range

Applications of different materials of plain bearing

- **Cast Bronze:** It possesses a good combination of properties for such uses as pumps, machinery, and appliances.
- **Babbitt:** Because of their softness, babbitts have outstanding embeddability and resistance to seizure, and are often applied as liners in steel or cast iron housings.
- **Aluminum:** With the highest strength of the commonly used bearing materials, aluminum is used in severe applications in engines, pumps, and aircraft.

Continued….

- **Zinc:** Used during operation on steel journals, a thin film of the softer zinc material is transferred to the steel to protect it from wear and damage. It performs well in most atmospheric conditions except for continuously wet environments and exposure to seawater.
- **Porous Metals:** Such bearings are particularly good for slow-speed, reciprocating, or oscillating motions.

Design of Boundary Lubricated Bearings

The factors to be considered when selecting materials for bearings and specifying the design details include the following:

- *Coefficient of friction:* Both static and dynamic conditions should be considered.
- *Load capacity, p:* Radial load divided by the projected area of the bearing (Pa).
- *Speed of operation, v:* The relative speed between the moving and stationary components, m/s.
- *Temperature at operating conditions.*
- *Wear limitations.*
- *Producibility:* Machining, molding, fastening, assembly, and service.

PV Factor

The product pv between the load capacity(p) and speed of operation(v) is an important performance parameter for bearing design when boundary lubrication occurs.

Therefore, pv can be thought of as the rate of energy input to the bearing per unit of projected area of the bearing if the coefficient of friction is 1.0.

•In SI units,

$$pv = kPa.m/s$$

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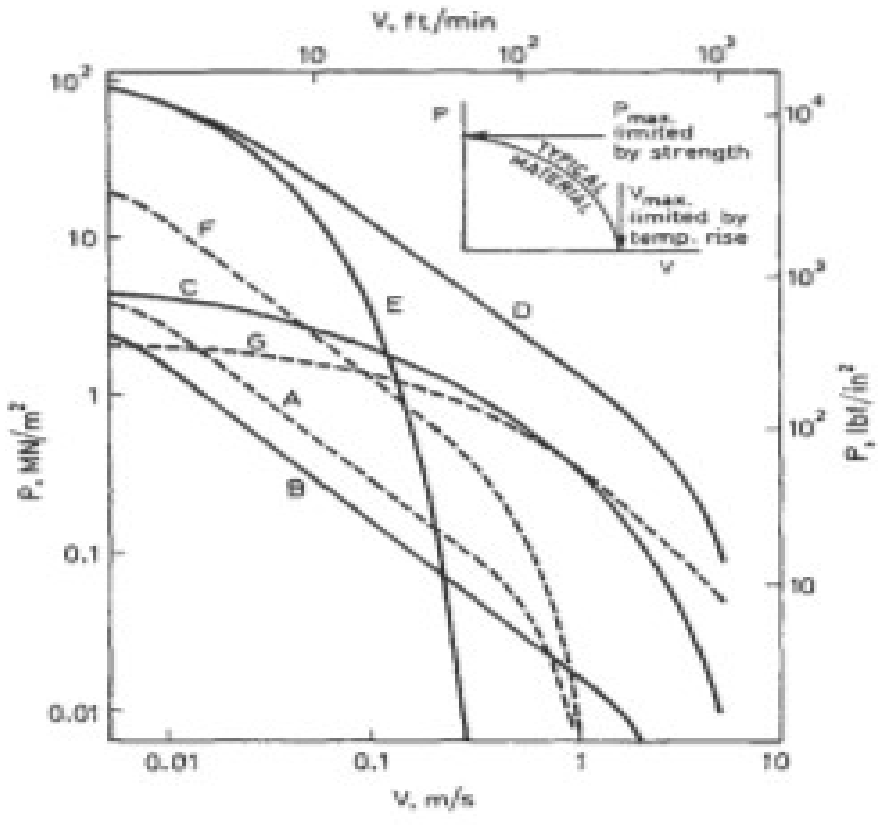
PV chart

A Thermoplastics
B PTFE
C PTFE + fillers
D Porous bronze + PTFE + Pb
E PTFE-glass weave + thermoset
F Reinforced thermoset + MoS_2
G Thermoset/carbon-graphite + PTFE



Operating Temperature

Most plastics are limited to approximately 200°F (93°C). However, PTFE can operate at 500°F (260°C). Babbitt is limited to 300°F (150°C), while tin-bronze and aluminum can operate at 500°F (260°C). A major advantage of carbon-graphite bearings is their ability to operate at up to 750°F (400°C).

Wear Factor

The wear factor **K** is measured under fixed conditions with the material loaded as a thrust washer. When equilibrium is reached, wear is measured as a volumetric loss of material as a function of time. The load and the velocity affect wear, thus **K** is defined as

K=W/FVT

Where, W= Wear, volume of material lost

F= Applied load

V= Linear velocity

T= Time

Note that the K factor and the above equation may not be used to predict actual wear in the application. The K factor only allows the comparison of relative wear among alternative materials

Design Procedure for BL Plain Surface Bearings

Given Information: Radial load on the bearing, F (N); speed of rotation, n (rpm); nominal minimum shaft diameter, D_{min} (in or mm)

Objectives of the design process: To specify the nominal diameter and length of the bearing and a material that will have a safe value *of pv*.

•Step 1: Specify a trial diameter, D, for the journal and the bearing.

•Step 2: Specify a ratio of bearing length to diameter, L/D, typically in the range of 0.5 to 2.0. For non-lubricated (dry-rubbing) or oil-impregnated porous bearings, $L/D = 1$ is recommended. For carbon-graphite bearings, $L/D = 1.5$ is recommended.

- Step 3: Compute $L = D(L/D)$ = *nominal length of the bearing.*
- Step 4: Specify a convenient value for *L*.
- Step 5: Compute the bearing pressure (N/m2 =Pa):

  $p = F/LD$
- Step 6: Compute the linear speed of the journal surface:

  In SI metric units: $V = \pi Dn/(60\ 000)$ *m/s*
- Step 7: Compute *pv (Pa.m/s)*.
- Step 8: Multiply *2(pV) to obtain a design value for pv.*
- Step 9: Specify a material with a rated value *of pv equal to or greater* than the design value.

Complete the design of the bearing system considering diametrical clearance, lubricant selection, lubricant supply, surface finish specification, thermal control, and mounting considerations.

Example Problem :A bearing is to be designed to carry a radial load of 667N from a shaft having a minimum acceptable diameter of 38mm and rotating at 500 rpm. Design the bearing to operate under boundary-lubrication conditions.

Solution:

- *Step l.* Trial diameter: Let $D = D_{min}$ = 38mm = 0.038 m
- *Steps 2-4.* Let $L/D = 1$, Then $L = D$= 0.038m
- *Step 5.* Bearing pressure: $p = F/LD$ = (667N)/(0.038m)(0.038m)

  = 461911.36 N/m2

- *Step 6.* Journal speed:

  $V = \pi Dn/(60\ 000)$ m/s = π(0.038)(500)/60000 = 9.94×10-4 m/s

- *Step 7.* pv factor:

  pv= (461911.36)(9.94×10-4) = 459.139Pa-m/s

- *Step 8.* Design value *of pv* = 2(459.139) = 918.279 Pa-m/s

Problem Continued…

- *Step* 9. From Table below, we could use a bearing made from high tin babbit having a rated value *of pv* of 1050kPa-m/s.

Material	pV psi-fpm	pV kPa-m/s	
Vespel® SP-21 polyimide	300 000	10 500	Trademark of DuPont Co.
Manganese bronze (C86200)	150 000	5250	Also called SAE 430A
Aluminum bronze (C95200)	125 000	4375	Also called SAE 68A
Leaded tin bronze (C93200)	75 000	2625	Also called SAE 660
KU dry lubricant bearing	51 000	1785	See note 1
Porous bronze/oil impregnated	50 000	1750	
Babbitt: high tin content (89%)	30 000	1050	
Rulon® PTFE: M-liner	25 000	875	Metal backed
Rulon® PTFE: FCJ	20 000	700	Oscillatory and linear motion
Babbitt: low tin content (10%)	18 000	630	
Graphite/Metallized	15 000	525	Graphite Metallizing Corp.
Rulon® PTFE: 641	10 000	350	Food and drug applications (see note 2)
Rulon® PTFE: J	7500	263	Filled PTFE
Polyurethane: UHMW	4000	140	Ultra high molecular weight
Nylon® 101	3000	105	Trademark of DuPont Co.

Problem Continued…

- *Steps 10-11.* Nominal diametrical clearance:

From Figure below, we can recommend a minimum C_d = 0.002 in based on D = 38mm and *n* = 500 rpm. Other design details are dependent on the details of the system into which the bearing will be placed.