PLAIN BEARINGS
BUSHINGS
BUYING GUIDE

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Plain Bearings (Bushings) are mechanical elements used to reduce friction between rotating shafts and stationary support members. Typically, a bushing relies on soft metal or plastic and an oil film to support the rotating shaft on the hardened shaft journal. Plain bearings (bushings) are used primarily in machinery that has a rotating or a sliding shaft component. Also called sleeve bearings, journal bearings, or sliding bearings, plain bearings have no rolling elements. Some are made of a relatively soft metal, such as babbit, to protect the shaft journals. They are made of other materials as well, depending on the application and load requirements. Other bushings may be used for alignment jigs in drilling operations.

Types of Plain Bearings

Hydrodynamic and Babbitted Journal Bearings

A common application of journal bearings is in supporting an engine crankshaft such as the one shown at right. The highly polished surfaces of the forging shown are the journals of both the main bearings and the connecting rod bearings. The main bearings themselves seat in the crankcase. The main bearings are made as lower and upper shells. They are installed into machined portions of the crankcase casting, as is being done in the photo at left. Main engine bearings operate mostly in what’s called the hydrodynamic regime, meaning that under normal conditions the journals and bearings are separated by an oil wedge formed as the shaft rotates. Oil is pumped into the bearing through feed holes which distributes oil to the main and connecting rod bearings.

Journal bearings are used in large industrial turbo-machines such as compressors and turbines. Many bearings in this service are hydrostatic, meaning that the shaft can be supported by an oil film even when
not rotating. Sometimes the bearings are segmented, as shown at right, and sometimes the bearings can tilt to suppress a phenomena know as shaft whirl or whip. A common form of the tilting pad bearing is used as a thrust bearing on large turbomachines. Generally, the surfaces of such bearings are babbitt-lined. Babbitt is a relatively soft white metal which supports fluid film lubrication while providing a forgiving surface if contacted by the hardened shaft journal. Automotive engine bearings are often bronze lined.

Journal bearings in these large sizes are often split designs similar to engine main bearings which permit removal of large rotors for maintenance.

### Sleeve Bearings

Although similar in principal to hydrodynamic and babbitted journal bearings, sleeve bearings are also used for linear motion with nearly the frequency they are used for rotary motion. The terms “bearing” and “bushing” are used interchangeably to describe these machine elements. And while hydrodynamic and babbitted journal bearings often connote a fairly elaborate system with lubrication systems and so forth, sleeve bearings can be relatively simple pressed-in devices used for a host of applications from guide post bushings to caster bearings. Sleeve bearings are often made of bearing bronze either sintered or cast and sometimes filled with plugs of lubricant such as graphite as with the bearings at left. Various plastics are also popular for sleeve bearings. Sleeve bearings are offered in two primary styles, a plain cylindrical version which is pressed flush into a component, and a flanged style which stands proud of the component into which it is pressed and provides a bearing surface for axial loads. Some manufacturers refer to the former type as “sleeve” bearings and the latter type as “flanged” bearings.

### Spherical Bearings

Spherical bearings allow angular rotation between linkages, control arms, etc. They are distinct from spherical roller bearings, which are rolling element bearings addressed in the family Bearings. Generally, for spherical bearings, the spherical inner race rotates angularly within limits in the outer race while grease, PTFE, etc. provides a lubricating layer between sliding surfaces. In very demanding applications such as
aerospace control linkages, small bearing balls roll between the inner and outer races, making for very low friction motion. Spherical bearings are not intended to handle rotation per se, though often as linkages move through their range the connected parts rotate and move angularly with respect to each other. Perhaps the most common application of spherical bearing is in rod ends.

Drill Jig Bushings
Drill jig bushings provide drill guidance during precision metal drilling operations and are ordinarily available as press-fit single parts or as two-piece renewable components that use replaceable liners. Bushings of this kind serve more for guidance than support and are often made from harder steels than bushings designed to function as bearings. They are usually very tightly tolerated to maintain the accuracy needed for machining operations.

Applications and Industries
Unlike rolling element bearings which are designed with finite lives in mind, plain bearings relying on full fluid lubrication are theoretically capable of running indefinitely and are used in very critical applications where failure of bearings might have severe consequences. Examples include many of the dozens of kinds of turbomachines, such as power plant steam turbines, compressors operating in critical pipeline applications, etc. Plain bearings are also frequently used in low speed shafting application such as ship propeller shafts. As mentioned, they are used almost exclusively in engines.

Plain bearings also excel at the other end of the spectrum due to their low costs and simplicity, and are also well suited to intermittent motion applications and, of course, to linear motion. For these bearings, materials play a wide role and can range from sintered bronze impregnated with oil to thermoplastic designs capable of running dry with the use of embedded lubricants. The latter are frequently applied in food processing where lubricants must be kept out of foods.

Plain bearings are often cast in bronze or pressed in powdered metal and impregnated with oil that provides film lubrication. Plastic bearings in nylon, PTFE, Vespel, etc. are available where the strength and performance of metal bearings are not needed.

Considerations
The design of hydrodynamic journal bearings takes into account the viscosities of oils, oil film thicknesses, coefficients of friction, oil flow rates, oil leakages, etc., in addition to the parameters of shaft load and speed. Thus hydrodynamic journal bearing design is heavily dependent on the makers of journal bearings who often provide journal bearings as housed units complete with seals and il lubrication. Oil lubrication is often provided by the use of oil rings.
Sleeve bearings are sized according to pressure and velocity considerations, which together determine the so-called PV limit. This represents the upper limit of the combined pressure and velocity for a given bearing material. The bearing is sized to operate below this threshold. The calculation involves projecting the area of the bearing based on its inside radius and length.

Some manufacturers identify maximum loads and speeds for their individual sleeve bearing sizes, relieving designers of the need to calculate them.

Fitting of plain bearings is critical as press fits are usually used to keep the bearing intact. Pressing a bearing into place can distort the geometry of the bore and cause problems in developing the fluid film profile, making the bearing wear out quickly. Manufacturers of plain bearings can offer guidance to fits to ensure the bearings run properly. Some bearings require a run-in procedure as well, especially some of the so-called dry-running plastic bearings.

Grooving of bearings is often done to add pockets for holding lubricant for bearings that run near speeds below the hydrodynamic regime. Many standard groove patterns can be machined into stock bearings, and these patterns range from the very simple circular, straight, or loop cuts to complex combinations and multiples of these simple shapes.

Spherical bearings are selected based on allowable loads and misalignment angles.

Drill jig bushings are more concerned with accuracy than load and are generally chosen based on these parameters.

**Important Attributes**

**Intended Application**
Because many plain bearings are specific to the applications—engine bearings is one example—intended application can be a good attribute to find bearings suited to a particular need. On the other hand, many plain bearings are general purpose, suited to a variety of bearing applications, in which case, searching by geometry, material, etc. may produce better results.

**Bearing Type**
If looking for spherical bearings, this is the place to select it. Likewise, choosing drill jig will return bushings of that variety. Selecting sleeve or journal as a type may give nearly identical results since the distinction made here between journal bearings and sleeve bearings is not necessarily an industry practice. Indeed, journal bushings, sleeve bearings, plain bearings, etc. can all mean much the same thing. A better choice for selecting a journal bearing of the full-fluid film variety is to pick the material value Babbitt (see below), which will return suppliers of the hydrodynamic bearing units.
Material
Material choice for plain bearings is far greater than for ball and roller bearings owing to the need to find material that can support oil film development, provide bases that are softer than shaft journals, provide porous structures that hold and release oils, etc. Load and speeds play a big role in determining materials, as do environmental conditions. Dry-running plastic bushings are favored in pharmaceutical and food packaging where oil and metal are considered potentially harmful it they can contaminate the products. Wood can sometimes be used in marine applications where water serves as a lubricant rather than oil. Babbitt is the traditional material for hydrodynamic bearings used in turbomachines. Materials for sleeve bearings are often composed of alloys of bronze, including aluminum nickel, phosphor, silicon, etc., which satisfy the various requirements of lubrication and resiliency.

Fabrication Process
Many plain Babbitt bearings are produced by centrifugal casting. Continuously cast rods are often used to machining bronze bearings. Sintered powder metal is another popular manufacturing method for producing oil-impregnated bronze bearings.

Related Product Categories
- **Shafts (Shafting)** are mechanical components, usually metallic, that typically rotate axially to transmit motion.
- **Lubricating Greases** are semi-solid mixtures of lubricants and thickeners usually made from minerals and soaps to produce a higher viscosity than oil and used to prevent wear on contact surfaces.
- **Lubricating Oil** is a slippery and viscous liquid made of any of numerous mineral, vegetable, animal, or synthetic substances. It is often a mixture of gaseous, liquid, and solid hydrocarbons used for lubricating. It is also available in synthetic and edible forms.
- **Bearings** are mechanical assemblies that consist of rolling elements and usually inner and outer races which are used for rotating or linear shaft applications.

Resources
General
Journal Bearings
http://www.kingsbury.com/index.shtml
Engine Bearings
http://www.aera.org/engine-professional/avoiding-failure/
Oil-Free Bearings
http://www.metcar.com/field-application.html
http://products.oiles.com/category/industrial-bearings
Spherical Bearings
http://www.radialbearing.com/engdata.html
Graphiting and Grooving

Trade Associations
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