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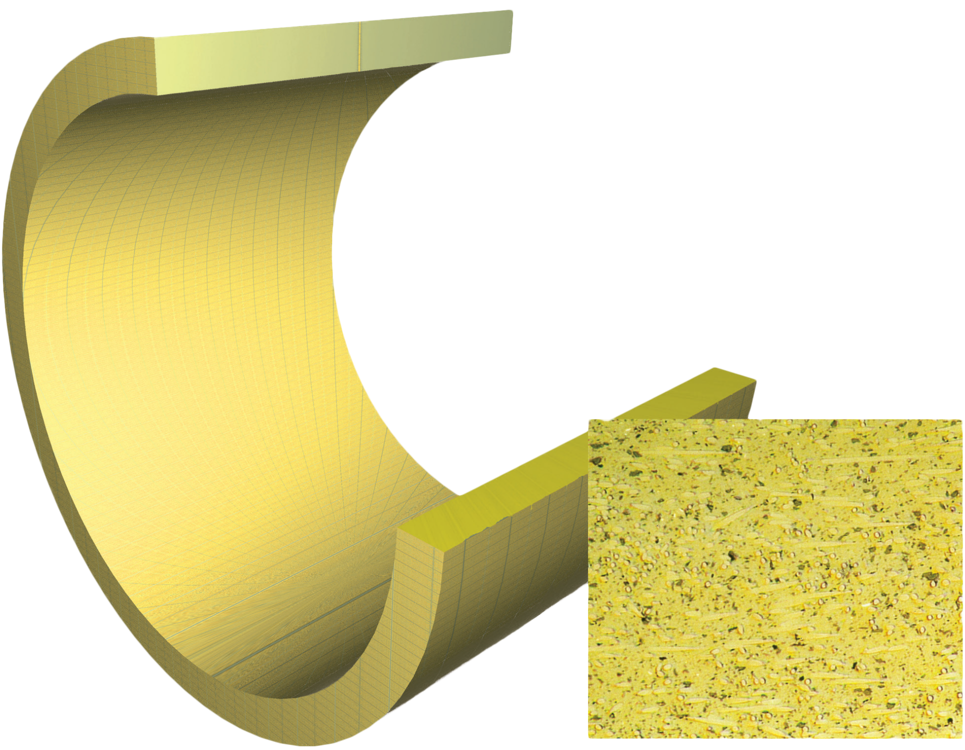
Advanced plastic bearing materials as replacement for metal

A rapidly growing number of industries have replaced traditional metal bearings with advanced plastic materials. However, some engineers lacking experience with these plastic materials may be reluctant to risk the operation of their machinery with an unfamiliar technology.

This Design Basics Guide will outline the material makeup of self-lubricating plastic bearings. It will also illustrate advantages over metal alternatives, common misconceptions about plastic bearings, how to properly select and install a plastic bearing and more.



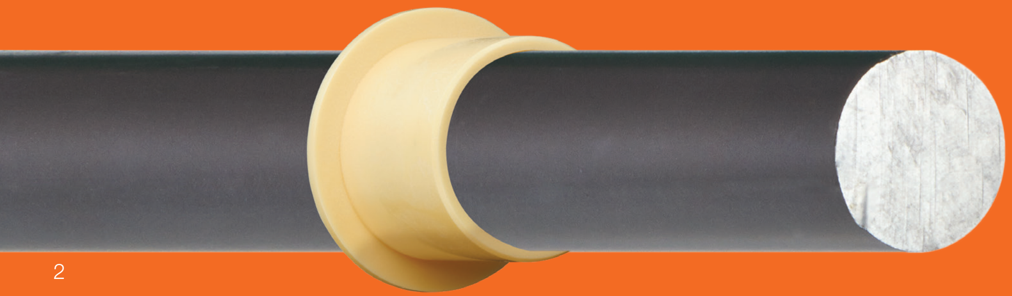
Material properties and advantages

Composite plastic bearings typically start out with a base polymer material, such as Acetal (POM) or PEEK. Fibers and filaments are then combined with the base material for added strength, and particles of solid lubricant are then homogeneously blended. These formulas create low friction, self-lubricating bearing materials which can be optimized for a variety of applications. In addition, this blend of materials offers exponentially higher service life than bearings with a very thin low-friction layer, such as a PTFE-lined metal bearing.

This formulation of base materials, strengthening fibers and filaments, and solid lubricants offers excellent wear-resistance and low-friction properties. When exposed to friction, this creates a self-lubricating effect critical at initial startup when a lubricant film has not yet formed.

As the loaded plastic bearings move, friction extracts microscopic particles of solid lubricant and thermoplastics, filling valleys on the shaft to provide an optimal sliding surface continuously throughout operation. This lubrication minimizes stick-slip and wear, minimizing (or in most cases, eliminating) the need for bearing maintenance or replacement when compared to metal bearing options.

For example, a sintered bronze bearing requires a lubricating film or coating that must be maintained or replaced regularly. Bronze bearings rely on capillary action to create a lubricated film on the shaft surface, which requires high speed rotational motion. Oscillating or linear motions, lower speeds, or intermittent use can all inhibit the bearing's ability to move freely, leading to higher friction, squeaking and eventually damage to the bearings and/or the shaft.



Worn sliding layer (top) and corrosion (bottom) of PTFE-lined metal backed bearings

Additionally, the film of lubricant on the shaft acts as a magnet for dirt, dust, and debris, and can cause contamination in cleanroom-type environments. Conversely, composite plastic bearing materials are able to "absorb" dirt/dust/etc., allowing the debris to becomes embedded within the plastic wall of the bearing with little to no effect of the bearing's performance.

When compared to metal, composite plastic materials can offer excellent vibration-dampening properties along with low-noise operation and ~80% lower weight than PTFE-lined metal bearings. With plastic bearings, the mechanical-loss factor, which indicated capacity to dampen vibrations, at approximately 250 times that of metal options.

Resistance to water, chemicals and extreme temperatures is also unmatched with composite plastics. Long term underwater operation of plastic bearings is possible, and plastic materials are available that can stand up to corrosives including biofuels, hydrocarbons, alcohols, and alkaline solutions. Even exposure to etching acids and other harsh chemicals is possible with the utilizing the appropriate plastic.

Did you know?
Thin vs. thick walled bearings

The wall thickness of a standard bronze bearing ranges from 0.0625 and 0.156 inches, compared to a composite plastic bearing's typical 0.0468 to 0.0625 inches, but what does that really mean?

1. Thin-walled bearings are just as durable and strong as thick-walled bronze bushings.
A bearing's wall thickness, whether it is metal or plastic, is not directly correlated to its strength. Instead, factors including the bearing's weight, coefficient of friction, and wear resistance should be considered.

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2. The wall thickness has zero effect on a bearing's surface pressure.
The surface pressure of a press-fit bearing is actually determined by the load divided by the surface area it acts on, giving wall-thickness no relation to surface pressure.

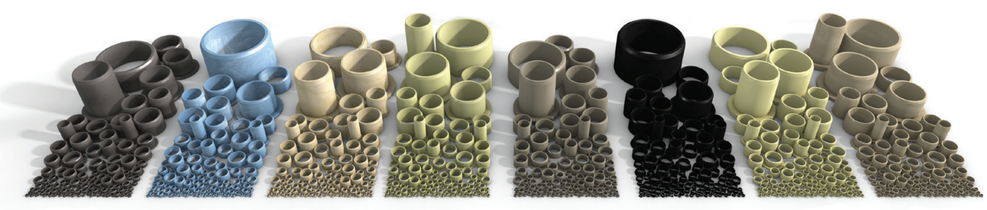
3. Wall service plays little to no part in a bearing's service life
While some metal bearings, such as sintered bronze, are designed with thicker walls to compensate for wear, oscillation and low-speed rotation may cause inordinate wear, even with adequate lubrication. This can lead to a number of problems, including lack of accuracy, higher friction, excessive noise and premature failure. Wear rates are largely dependent on the bearing material, not the wall thickness.

To determine a bearing's surface pressure (Ps) in psi, use the following formula:
Ps = L / (D * l),
where L= load, D = inner diameter, and l = bearing length (in inches).

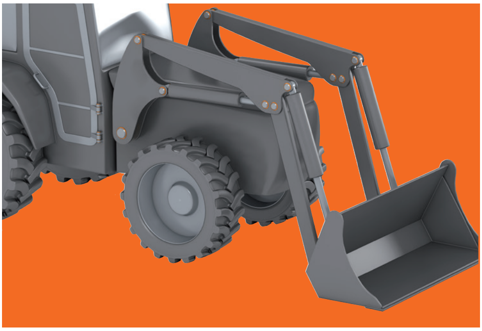
Successful applications

To date, composite plastic bearings are used in thousands of applications worldwide. Industries include, but are by no means limited to, laboratory equipment, pharmaceutical manufacturing, construction equipment, automotive applications, and 3D printers.

Engineers are turning more and more to composite plastic bearings, especially for applications that expose bearings to corrosion. Composite plastic bearings are also an ideal choice for applications in which access to lubrication points are limited, where equipment components must meet high regulations for hygiene, or where weight limits or magnetism restrictions come into play. Lubricant may also attract dirt/dust into the bearing system, causing binding and/or failure.

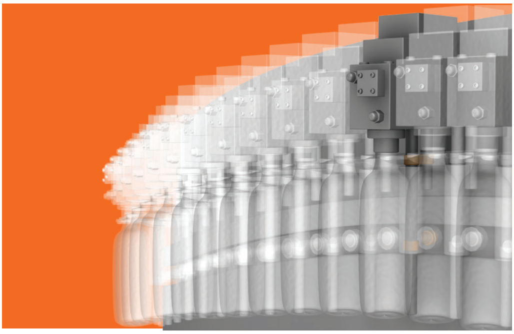


Example 1: An OEM implemented plastic bearings in their root-transplanter equipment. They had experienced failures as a result of soil penetrating lubricated machine elements. Extreme loads coupled with the unavoidable exposure to high levels of soil and a wide variety of temperatures was too much for lubricated metal, but plastic bearings were able to stand up to all of these challenges.



An added benefit to replacing metal with plastic in this application is the ecologically- conscious lack of lubricants, which can seep out of equipment and into the soil.

Example 2: A pasta manufacturer replaced track-guide rollers on its cartoning machines with plastic plain bearings. Despite 24/7 operation, rapid cycling, and extreme acceleration, the plastic bearings proved to last three times as long as the previous roller bearings, while reducing annual repair costs by $7,800. Replacement of plastic bearings is also exceptionally easier and more cost-effective than rebuilding a set of roller bearings, taking only 2 hours of downtime instead of a full day.



The plastic bearings reduced noise, dampened vibration issues, and eliminated the possibility of exposing food to contaminating grease and oil.

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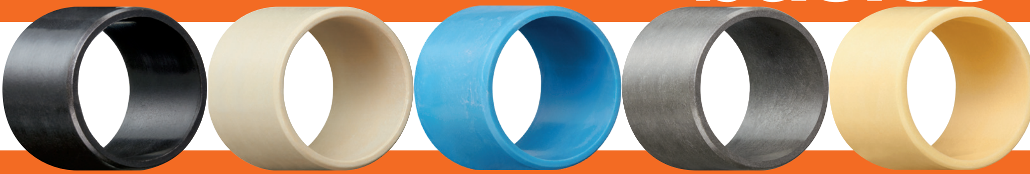


Selecting bearing and shaft materials

Considering the capabilities and limits of a bearing is imperative across all industries. The type of operation and motion, environmental factors, and required service life are all important to take into account during the selection process.

Speeds and operating motion: Oscillating, rotating and linear motion, as well as operating speeds, can have varying effects on plain bearings. Certain bearing materials respond more favorably to different types of motion, and the type of bearing material will determine the amount of wear that occurs.

Temperature: Most bearings have a higher wear rate as temperatures increase. Likewise, cold temperatures can cause certain materials to simply shatter under pressure. Some composite plastic bearing materials are able to withstand high temperatures of nearly 600° F, or as low as -148°F.

Load: Different loads and pressures can influence wear in different ways. Some plastic bearings are designed especially for high loads, and are able to withstand a maximum static surface pressure of up to 21,750 psi.

Media exposure: In applications where dirt, chemicals, water, UV rays, or other types of media can make contact with bearing points, care must be taken to select materials that are able to endure this exposure.

When pairing a bearing and shaft material, it is important to note that plastic bearings offer more options than metal bearings. For example, bronze bearings require a shaft material harder than the bearing itself, and ball bearings require a shaft that is both very hard and very smooth. This limits shafting options, and almost guarantees a high price tag. Plastic bearings allow for less expensive options, as they can operate on a wide variety of shafts. In fact, using smoother, more expensive shafts can actually be detrimental in some cases. While a very rough shaft acts as a file, causing excessive wear, a very smooth shaft can increase friction due to the shafting and the bearing surface adhering to one another.

This "stick-slip" phenomenon, characterized by a loud squeaking noise, can occur when there is a large difference between static and dynamic friction alongside adhesion between mating surfaces.

Some manufacturers of plastic bearings offer online tools to help select the most appropriate bearing for individual applications. Check with your bearing manufacturer for individual component limits and capabilities before installation.

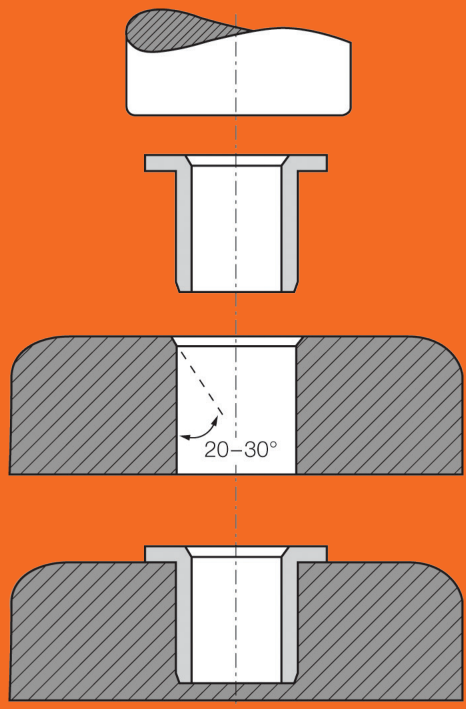
Installing and testing plastic bearings

The manner in which a bearing is installed and tested is essential to the success of any mechanical system. If installation is not done properly, or if testing methods fall short or are overlooked all together, a variety of problems can arise.

For installation, an arbor press is recommended for press-fitting bearings. This is usually the most efficient installation method, and also preserves the integrity of the bearing. Hammering, or other methods of press-fitting can damage the bearing, causing the surface to become uneven.

Next, ensure your bearing housing has a chamfer - ideally 20-30º. For sleeve bearings, confirm that the outside chamfer of the bearing is matched up with the lead-in chamfer of the housing.

Finally, ensure that your after-press-fit inner diameter (ID) matches your bearing manufacturer's recommended tolerances. Take note that the housing material can affect the after-press-fit ID.



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Now that your bearing has been properly installed, a quality check should be performed. A pin-gauge, or go/no-go, test is recommended. In this test, a pin plays the part of the shaft, and is placed inside the press-fit bearing. If the pin falls through the bearing under its own weight, the test is considered a pass, or a "go." A no-go occurs when the pin sticks, and does not fall through the bearing under its own weight.

This pin-gauge test is ideal, as it reveals the ID of the bearing's smallest points, which are critical to any application, and it proves the peaks and valleys of the bearing material are irrelevant as long as the recommended "shaft" is able to pass through.

To learn more about composite plastic bearings, visit the igus® plain bearings website, at www.igus.com/iglide
igus® also offers a series of online product selection and lifetime calculator tools, available at www.igus.com/onlinetools