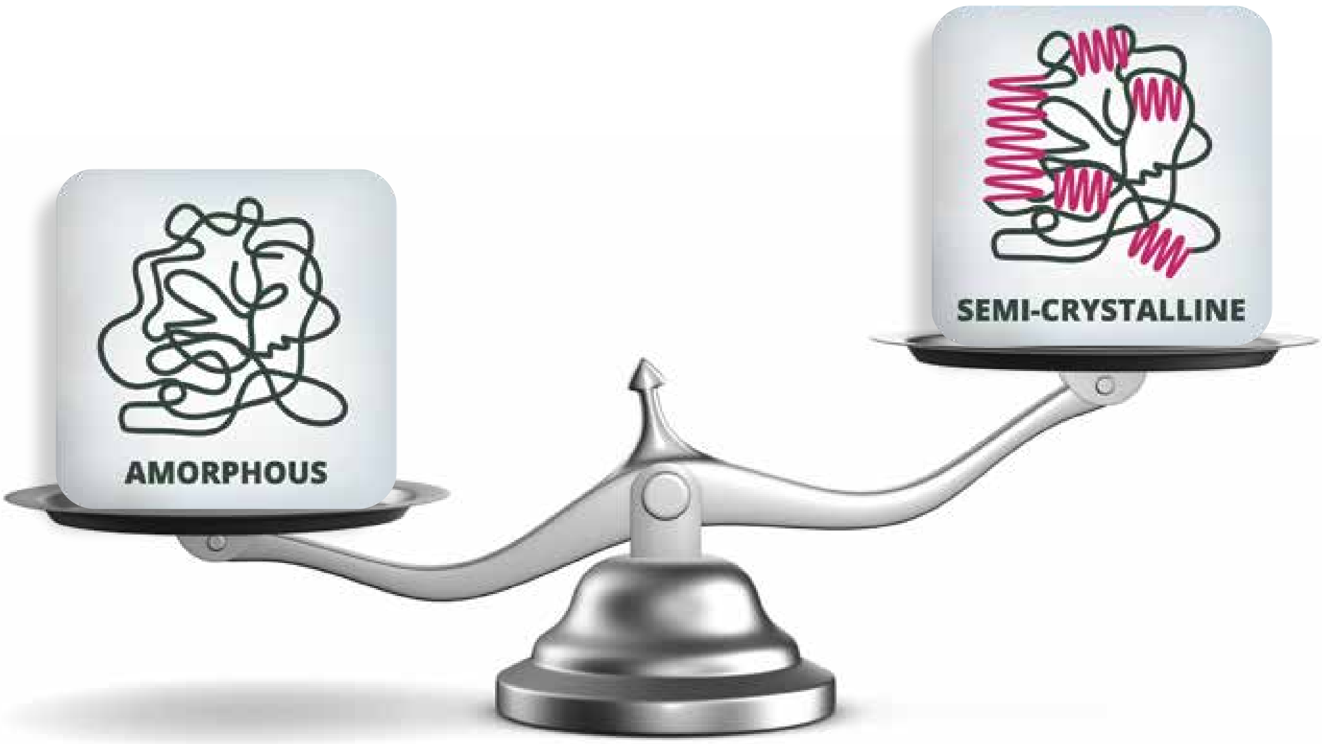


WHITE PAPER:

Plain bearing materials comparison: iglide® versus conventional plastics

igus®

CONTENTS

1 Starting situation: looking for the right plastic plain bearing

In contrast to a few years ago, people today ask themselves less and less whether they should replace a metal plain bearing with a plastic one. Plain bearings made of plastics or plastic compounds have long since taken root in almost all areas of industry and daily consumption. Plain bearings made of plastic ensure durable and high-quality door hinges in cars, regulate the flow of aggressive chemicals in industrial fittings, or support the loading area of dump trucks.

More and more often, construction engineers and buyers have to deal with the question of which plastic bearing should be planned and procured when designing the construction. The choice seems to be easy. Plastic bearings are cost-effective to procure, and can even be manufactured in-house. A wide range of different plastics tempts with a solution for every problem
The downside: even with plastic plain bearings, there are significant differences regarding performance and costs. Furthermore, the variety of plastic combinations is greater than that of other materials. Especially with plain bearings, a simple comparison of values in data sheets is often not sufficient. Frequently, a combination of different performance data plays an important part. In addition, cost pressure and standardization efforts combined with a consistent increase in quality requirements call for careful assessment.

In the thicket of brands, material designations, base polymers, compounds and blends, it can be a difficult choice. In this white paper, we would like to show you the differences between conventional plastics, how they affect the wear quality and how you can still find the most suitable plain bearing with ease.

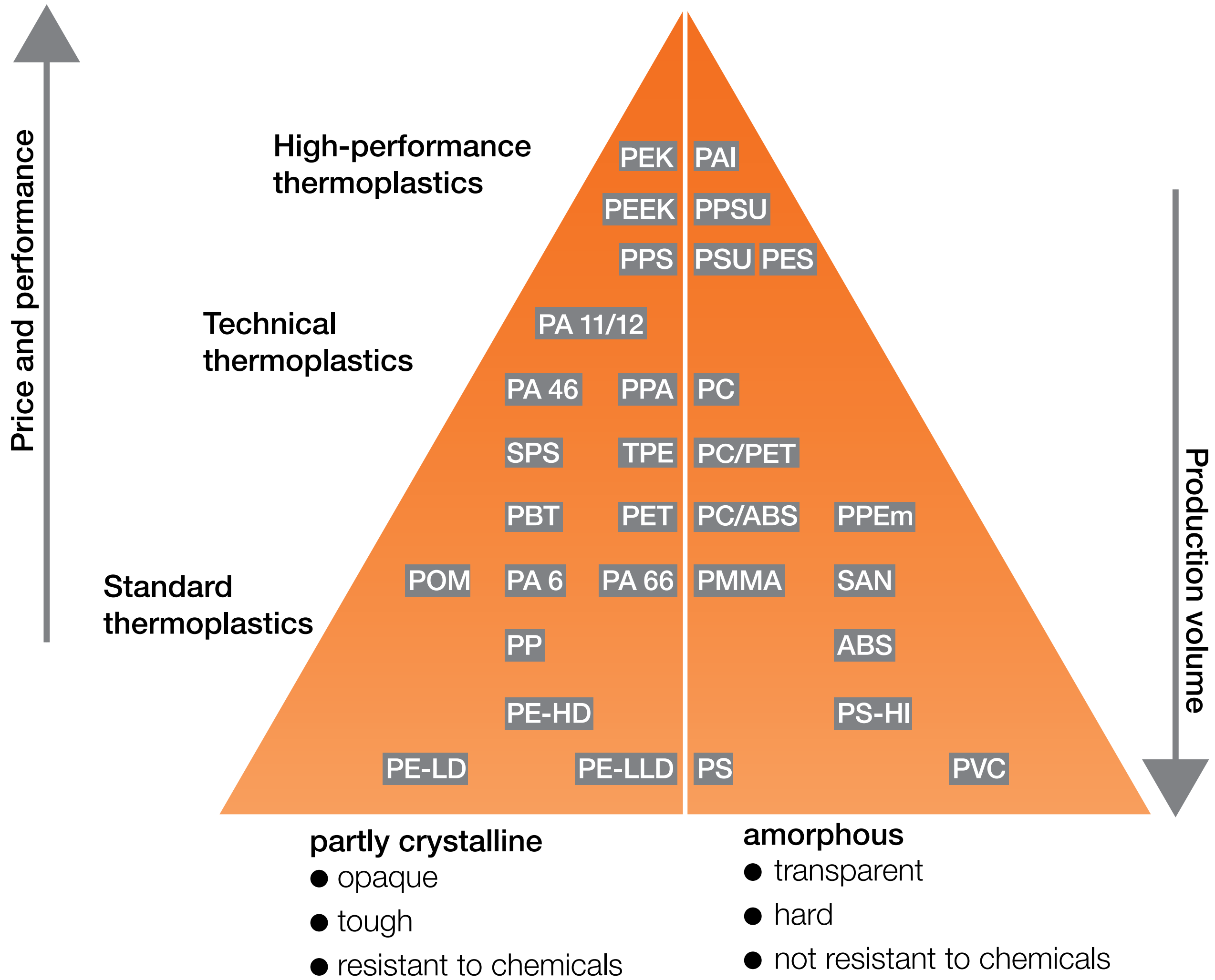
2 Classification: technical plastics for plain bearings

The group of plastics is no less diverse than that of metals. Plastics consist of molecules that are linked to each other, so-called macromolecules or polymers. Both the way of linking and the individual components result in different specifications. Generally, there are three groups of plastic polymers that have different physical properties: thermoplastics, Duroplasts and elastomers.

For plain bearings, thermoplastics and Duroplasts are most commonly used. This is due to the fact that elastomers are–as the name suggests–elastic. Thermoplastics and Duroplasts are dimensionally stable. They mainly differ in that Duroplasts cannot be deformed after hardening through heat or other measures. Thermoplastics, on the other hand, can be deformed. A quite well-known example of a Duroplast is epoxy resin, which is used for repairing stone chipping in windscreens. Typical thermoplastics are PE (polyethylene)–certain types of which are used in plastic bags–or PC (polycarbonate), from which spectacle lenses are manufactured.
While both thermoplastics and Duroplasts are used for plain bearings, thermoplastics are the more common choice. On the one hand, this is due to easier processing, since the material, for example in granur form, can be melted and injected or poured into prefabricated forms in order to reproduce almost any shape. At the same time, various additional materials can be added to these granules to improve the specifications of the future component. That way, added glass or carbon fibers improve the mechanical stability. Furthermore, solid lubricants and flame retardants can be added to improve fire resistance or sliding properties.

2.1 Thermoplastics

Thermoplastics and Duroplasts are again divided into different groups of materials with varying characteristics. As thermoplastics are used more often in the area of plain bearings, we will focus on them here.



The plastic pyramid shows materials depending on price and performance as well as production volume.

Usually, thermoplastics are presented in an overview as a pyramid, at the tip of which the relatively expensive high-performance polymers are shown. The base is formed by the commonly used more cost-effective and standardized thermoplastics. Furthermore, thermoplastics are divided into partly crystalline and amorphous materials. In brief, this can be translated with "tough" and "hard" or "brittle" respectively.

Generally, standard thermoplastics are used rarely for plain bearings. The requirements that plain bearings set for materials are too high. These requirements are mainly resistance to high temperatures and chemicals. Temperature resistance is especially crucial.

For plain bearings, it is less important from which temperature onwards a material begins to melt, than up to which temperature a material maintains the necessary hardness or toughness. Hence, plain bearings made of polyether ether ketone (PEEK) can be found in plain bearing applications with temperatures of more than 392°F, while plain bearings in less temperature-sensitive applications are more commonly made of POM or PA66.

2.2 Typical plastics for plain bearings

PA66 and POM (polyoxymethylene) are very popular for plain bearings. The reason is a simple one: due to their material specifications, they fit in well with many different applications. They are not suitable, however, for application areas with specific requirements for plain bearings.

POM is easy to process and work with and can therefore be used in a variety of ways. It is characterized by low wear and dimensional stability. However, it can only be used at temperatures up to about 100°C. This material also reaches its limits with heavy loads and high temperatures. On the other hand, POM is relatively creep-resistant and cost-effective compared to other materials.

Under certain circumstances, POM releases low amounts of unhealthy formaldehyde. This leads to problems when plain bearings made of POM are used in unventilated and small rooms where people are present. Therefore, POM is not used in the interior of vehicles. The emission of gases could jeopardize the health of vehicle occupants or lead to an unpleasant smell.

PA66 (polyamide) is often made stronger due to added carbon or glass fiber, and withstands significantly higher loads than POM. The temperature resistance of the material is also better. Disadvantage: machining and manufacturing large components is complicated. This material, too, is relatively cost-effective and hence very popular. PA66 shows all its strength in terms of wear resistance, friction behavior and mechanical strength.

Just like PPS, PPS-U or PAI, PEEK belongs to the materials that can be used for quite demanding applications. It is often used in plain bearings as the material withstands temperatures of more than 200°C. Furthermore, the material is resistant to chemicals, offers good strength values and has good tribological specifications. But the price is about 20 times higher than for PA66 and POM. PEEK is used for demanding applications in high-temperature areas or wherever it is complicated to protect metal bearings against corrosion and lack of lubrication.

2.3 Comparison of plastics for plain bearings

Polymer	Max. temp. (°C long-term)	Load (MPa)	Chemical resistance	Moisture absorption	Vibration dampening	Price* (€/kg)	Friction	Wear
PE	80	10	●●●●●	●	●●●●●	2.-	●	●●●
PA6	80	15	●●●	●●●	●●●	3.50	●●●●	●●●
PA66	100	18	●●●	●●●	●●●	5.-	●●●●	●●●
PA46	145	20	●●●	●●●●●	●●●	8.-	●●●●	●●●
POM	90	23	●●●●●	●●	●●●●●	4.-	●●●●●	●●
PBT	130	20	●●●	●	●	8.-	●●●●	●●
PPS	200	80	●●●●●	●	●	10.-	●●●●●	●●●●
PEI	290	100	●●●●●	●	●●●	80.-	●●●●●	●●●
PAI	250	150	●●●●●	●	●	90.-	●●●●●	●●●
PEEK	250	120	●●●●●	●	●	80.-	●●●●●	●●●
PTFE	200	4	●●●●●	●	●●	20.-	●	●●●●●

* Average German market price as of 2020

2.4 iglide® plastics

iglide® plastics are so-called polymer compounds. By mixing certain base polymers (such as PEEK, PA66, POM etc.) with fillers and additives, the different iglide® polymers can be optimized regarding different application areas. The base polymers are responsible for the iglide® materials' wear resistance. They ensure that the lubricants are not subjected to a surface pressure that is too high. Fibers and fillers strengthen the materials so that they withstand high forces or edge loads and can be used continuously. However, this can also have a negative effect. For instance, it can influence the moisture absorption of the chosen fiber.

Base polymers with fibers and solid lubricants, magnified 200-fold

Solid lubricants lubricate components made of iglide® materials independently and reduce friction. They are distributed in the entire material in the form of millions of microscopic particles.

Due to continuous research and development as well as thorough testing in the in-house test laboratory, a wide range of more than 60 different iglide® materials has been developed. Although iglide® plastics are finally based on a significantly lower number of base polymers, the wear results of the respective materials can differ heavily.

3 Wear quality of different plastics compared to iglide®

At first, it is necessary to determine the requirements for the plain bearing in as great a detail as possible. Here, the scope of the recorded requirements not only decides whether the future material is generally suited for the application. Often, the requirements define a range that makes many different plastics suitable for the application.

3.1 Test procedure - theory and practice

In tribology–the science of wear and friction–wear tests are often carried out by means of the pin-on-disk method. Here, a disk rotates on the sliding material that is tested under a pin that slides on it. This pin consists of the sliding partner that is to be tested (e.g. steel with a steel shaft). After the test, the amount of abrasion is analyzed.

The disadvantage of this standardized procedure is, in our view, the comparison to reality. In real conditions, various load and motion profiles influence a geometry that differs from the disk. To represent the characteristics of a bearing point as realistically as possible, igus® has developed several standardized test setups.

For decades, plain bearings from various materials have been pressed into bearing housings and tested in combination with different shafts in more than 10,000 tests per year. The tests were carried out under different temperatures and with different loads and motion profiles. The wear tests take place with the results measured by the loss of wall thickness. In real plain bearing applications, this is decisive for the clearance development and therefore the running performance of the bearing point.

In the following test series for analyzing the wear properties of the different plastics, two of our standard test setups were used:

Test of the wear rate rotating

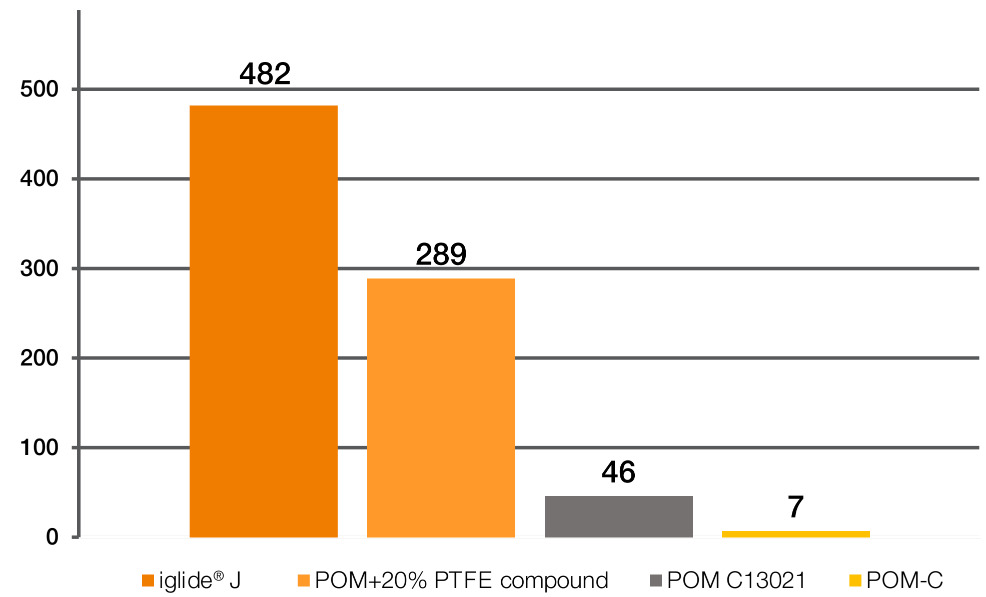
- Load per bearing point between 100 and 1,000N
- Surface speed between 100 and 1,300rpm
- Available shaft diameters:
  6, 8, 10, 12, 13, 14, 15, 16, 17, 18, 20mm
- Tests at room temperature and up to 150°C
- Underwater tests

Test of the wear rate pivoting

Load per bearing point between 25 and 300N
- Surface speed of 0.01m/s
  (with shaft diameter 10mm)
- Pivot angle of 60°
- Available shaft diameter: 10mm
- Tests at room temperature

All bearing materials have been tested under the same conditions and on the same shafts.

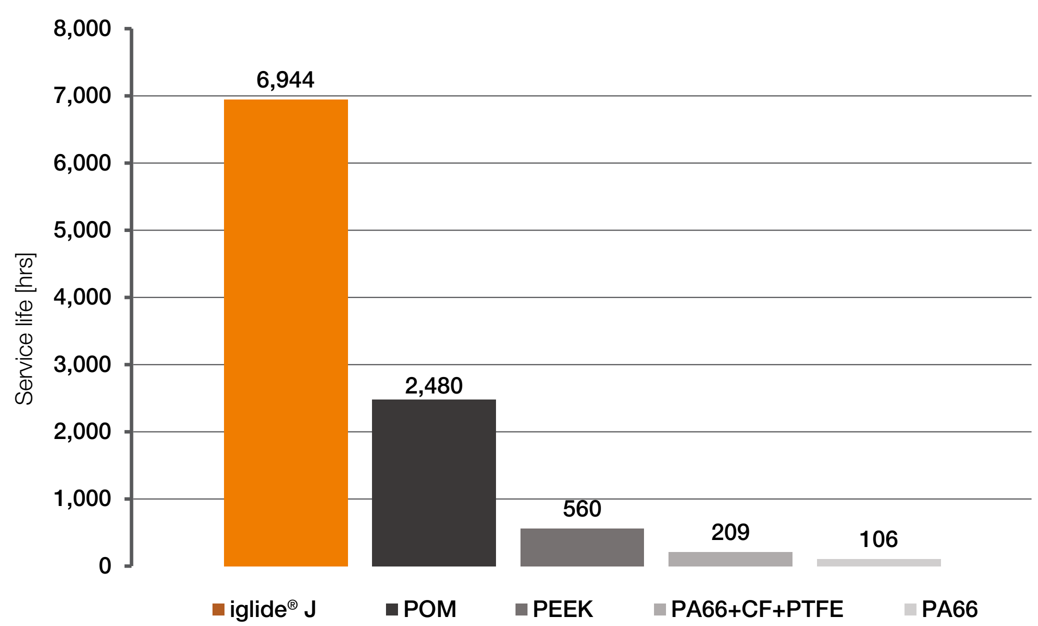
3.2 iglide® compared to different POM variations



Wear comparison: rotating, speed 59fpm, pressure 145psi, temperature 73°F, shaft 304 SS

All plain bearings were tested under the same conditions: shafts made of 304 SS, pressure 145 psi, 59 fpm running speed, at room temperature (73°F). We have defined the end of the service life with a wear loss limit of 0.25mm wall thickness. While the two POM variants without additional additives and fillers exit quite early with 7 and 46 hours, the POM with 20% PTFE achieved 289 hours. The exemplary matched iglide® material achieved a service life of 482 hours.

3.3 iglide® compared to other plastics



Wear comparison: rotating, speed 1.97 fps, pressure 290psi, temperature 73°F, shaft 304 SS

In the pivoting test, a 60° forwards and backwards movement that is typical for plain bearings was analyzed in continuous operation. The examined PEEK, PA66 and PA66 with carbon fiber reinforcement and added PTFE reached comparatively similar results. POM and the tested iglide® J achieved very good results, lasting 2,480 and 6,944 hours respectively.

3.4 Evaluation of the test results

On the one hand, we were able to determine that the wear results can differ significantly within the same group of polymers. This can be due to added reinforcing agents or solid lubricants.

On the other hand, comparisons with other plastics show that there does not have to be a connection between price and performance. The considerably more expensive PEEK achieved much worse results than POM.

All tested materials would have been suitable for the tested application parameters according to the technical data sheets. Choosing a material with the best price to service life ratio would be almost impossible without this test.

4 Conclusion

The iglide® J material achieves better results in the performed tests. While all other materials clearly over-delivered regarding the requirements defined by the application parameters, their results still differed strongly when it came to the running performance as a plain bearing.

Material data sheets are the most neutral and clear way of comparing plastics, considering the many different trade names and plastic mixtures. An analysis of price and performance, however, can only be carried out when taking into account representative wear tests. As dedicated test setups are often associated with high costs and a lot of time in advance, and field tests of new constructions are frequently not representative, test capacities offered by suppliers as well as existing test results offer great added value. Only that way can the right material be determined at an early stage of the development phase and possible additional costs due to later adaptions or need for testing be avoided.

If you require any further information, please do not hesitate to contact the igus® plain bearings department.
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