white paper

drylin® E7 plastic linear plain bearings vs. PTFE-lined plain bearings

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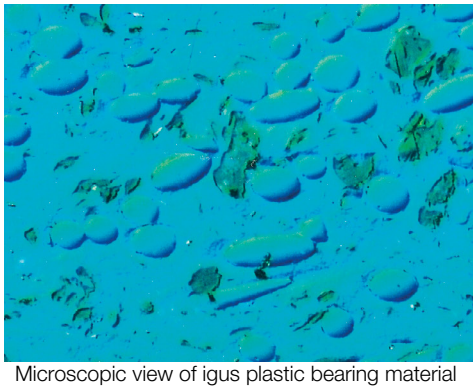
Linear plain bearings are becoming commonplace in today's manufacturing industry. As technologies and material sciences have advanced, so have the capabilities of linear plain bearings, particularly those made of plastic, such as the drylin® series of self-lubricating linear bearings from igus®. This whitepaper will compare how they outperform a competitive linear plain bearing technology, which uses a PTFE-based, bonded liner, in both wear and friction testing.

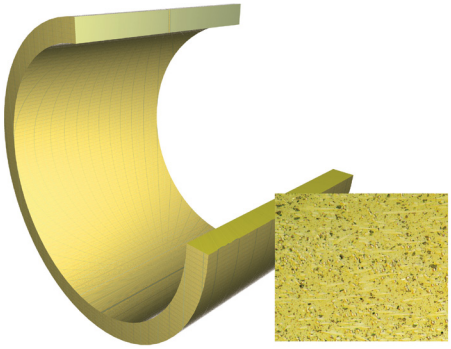
Originally, linear plastic plain bearings were developed to replace recirculating ball bearings. Unlike ball bearings, plastic plain bearings are designed to run without maintenance or external lubricants, like oil or grease. Not only is the upfront cost per bearing lower, so is the overall cost of ownership. There are also technical benefits to plastic bearings, the main advantage being that they are self-lubricating. Since they do not require any external lubrication they are well suited for dirty or wet environments, and are also ideal for sensitive food or laboratory applications, as they eliminate the risk of contamination. They are lighter weight, able to withstand higher static and shock loads, are corrosion-resistant, and perform better than ball bearings in applications with high accelerations.

drylin® Plastic Linear Bearing Design

drylin® linear bearings are designed using dry-tech plastic composites from igus®. These consist of a base polymer, reinforcing fibers, and particles of solid lubricants. The bearings are injection molded, homogenously blending the plastic material, and exhibit constant coefficients of friction and self-lubricating properties throughout their lifetime (see images below). As the bearing system begins to cycle, tiny deposits of solid lubricant are transferred into the microfinish of the shaft, lowering friction, increasing lifetime, and eliminating the need for additional external lubrication.



Microscopic view of igus plastic bearing material

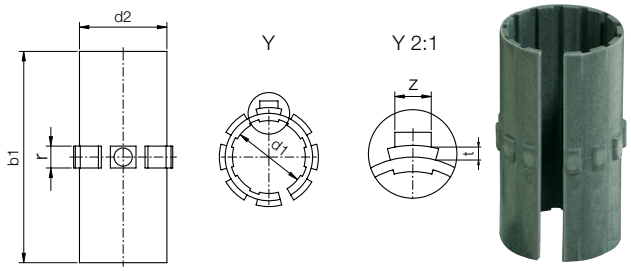


Cross section of igus plastic bearing

The geometry of drylin® linear plastic bearings also makes them unique. Grooves along the bearing's inner diameter serve two purposes. First, they minimize thermal expansion and result in a more tightly toleranced running clearance than a typical sleeve bearing. Additionally, they act as "dirt channels" in aggressive environments by allowing debris to pass easily through the system.

Debris passing through the bearing's dirt channels

The bearing liner is also molded with a lengthwise slit, enabling an easy, tool-free, “slip fit” installation into the housing bore. drylin® liners are molded with features on the outer diameter to allow for anti-rotation and to maintain axial security. The housing, or adaptor, is an aluminum sleeve, giving a bearing the same installation dimensions as standard recirculating ball bearings.



Images show the anti-rotation and axial fixation features

PTFE-Lined Bearings

Polytetrafluoroethylene (PTFE)-lined metal bearings are another option for linear bearing applications. A typical bearing of this type is made up of a thin, self-lubricating layer, sometimes gold in color, embedded with PTFE, which is permanently bonded to an aluminum housing. It should be noted that the liner is not replaceable. Just like drylin®, their outer shells are designed for dimensional interchangeability with linear ball bearings.

The Latest Self-Lubricating Liner Material: igus® E7

A new dry-tech material has been added to igus® linear technology, the E7 material. E7 was engineered for optimized service life and low friction on ferrous shafting; in particular, case-hardened steel or hardened stainless steel, which are common materials in the industrial marketplace. The E7 material is also effective on softer stainless alloys, such as 303/304/316, which offer superior corrosion resistance.

Laboratory Test Comparing E7 to PTFE-Lined Bearings

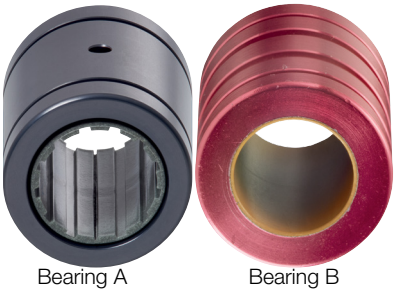
Testing was conducted to compare the friction and wear properties between the E7 material and PTFE-lined bearing technologies at the igus® test lab, located in Cologne, Germany.

Testing Information

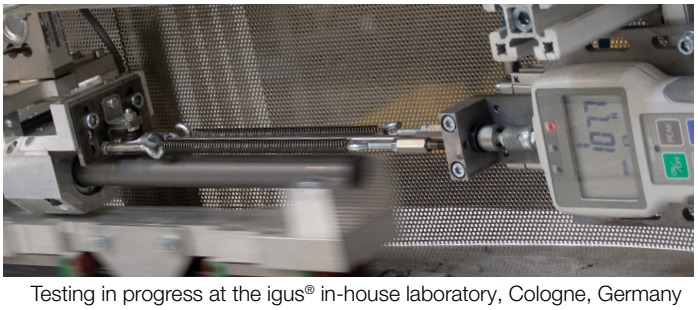
Bearing A: igus® E7 dry-tech plastic linear plain bearing – injection molded tribo-polymer bearing liner, clipped into an aluminum adaptor (shell). The outer diameter of this bearing liner is designed with structural features to keep it secured both radially and axially in the bearing adaptor. The inner diameter of the E7 liner has grooves, reducing thermal expansion and acting as channels for dirt or other debris.

igus E7 General Properties	
Density	1.05 g/cm^3
Color	dark grey
Moisture absorption (23ºC; 50% r.h.)	<0.1% of bearing wt.
Moisture absorption submerged in water	<0.1% of bearing wt.
Mechanical Properties	
Flexural modulus	1,477 MPa (214,220 psi)
Flexural strength	22 MPa (3,150 psi)
Max. permissible surface pressure (20ºC)	18 MPa (2,610 psi)
Shore D hardness	61
Thermal Properties	
Max. long-term service temperature	70º C (158º F)
Max. short-term service temperature	90º C (194º F)
Max. short-term ambient temperature	120º C (248º F)
Min. service temperature	-50º C (-58º F)
Electrical Properties	
Specific volume resistivity	>10^9 Ωcm
Surface resistivity	>10^9 Ω

Bearing B: Polytetrafluoroethylene (PTFE) impregnated bearing. This is comprised of a gold colored bearing liner incorporating PTFE as its primary tribological feature, which is permanently bonded into an aluminum housing.



Bearing A Bearing B



Testing in progress at the igus® in-house laboratory, Cologne, Germany

Test Parameters:
Both the igus® E7 bearing and the PTFE-lined bearing were tested for wear on a selection of common shaft materials, on a test stand with single bearings under a centric load. Tested shaft materials include case hardened stainless steel, 316 stainless steel, and hardened stainless steel. All shafts had a diameter of 20 mm, a 400 N (90 lbf) centric load, with a linear speed of 0.1 m/s (0.32 ft./s). The wear was calculated by measuring the mass of material lost after travel, with different material densities accounted for.*

Materials Tested	1. Case Hardended Steel (1050/1.1213) 2. 316 Stainless Steel (316/1.4571) 3. Hardened Stainless Steel (440c/1.4245)
Shaft Size	Diameter = 20mm
Centric Load	400N (90 lbf)
Linear Speed	0.1 m/s (0.32 ft./s)

Test Results:
The igus® E7 bearing material exhibited both lower friction and wear than the PTFE-lined bearing on each of the ferrous shaft materials tested in the igus lab. Details are available in the charts below. As noted above, material wear was calculated by measuring the mass of material lost using a precision analytical balance, with the differences in material densities being accounted for. This non-dimensional method is considered a more accurate way to measure wear when compared to measuring dimensional losses alone.

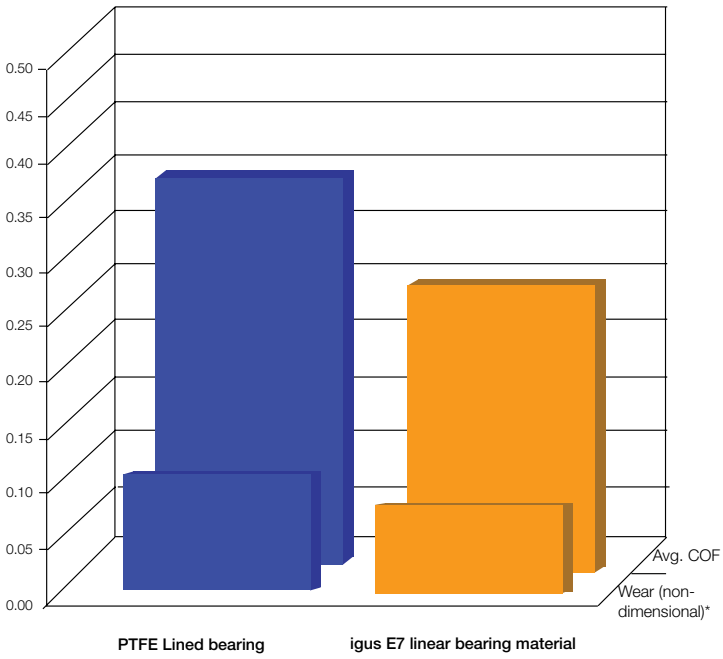
Case Hardened Shafting
E7 = 23% lower wear / 29% lower friction

440C Stainless Shafting
E7 = 51% lower wear /18% lower friction

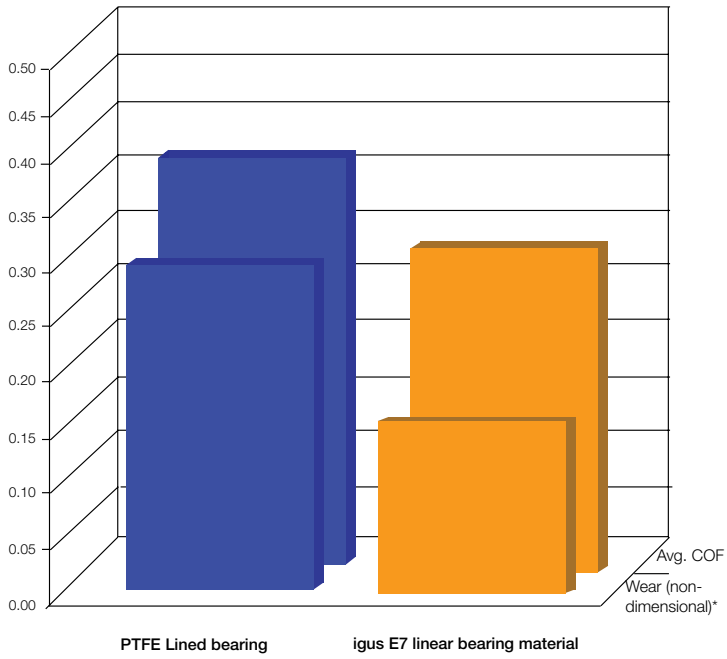
316 Stainless Shafting
E7 = 33% lower wear /24% lower friction

It is also important to note that the E7 liner is considerably thicker than the PTFE-lined bearing. The E7 liner thickness is nominally 1.4mm, and the PTFE lined bearing is 0.5mm. When this is factored in along with the 23-51% lower wear per kilometer of travel, the potential operating lifetime of the E7 material is far greater than the PTFE-based material. The main benefit of this would be seen in high cycle applications, where the need for replacement parts would be significantly lowered.

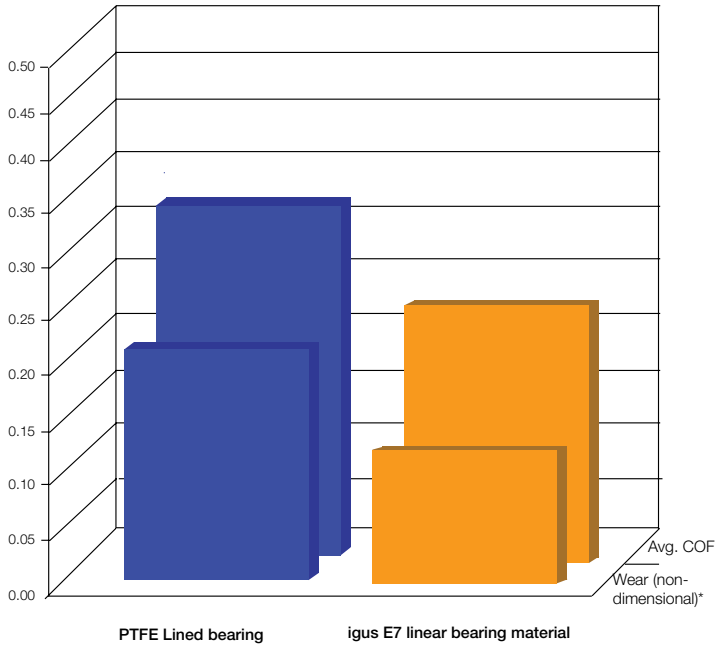
Linear bearing on case-hardened steel shaft (1050/1.1213)



Linear bearing on hardened stainless steel shaft (440c/1/4125)



Replacement Costs:

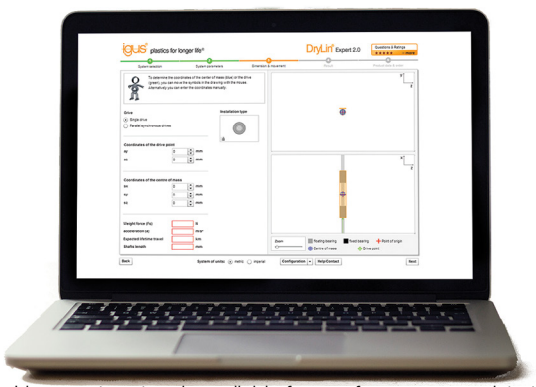


The igus® E7 material is able to slip-fit into the aluminum adaptor, allowing for re-use of the aluminum adaptor with the simple replacement of the liner if necessary. Conversely, the PTFE lined bearing is bonded to the adaptor, meaning the entire product must be replaced, as replacement of the liner itself is not a possibility. The ability to replace the bearing liner, as well as the reusability of the aluminum adaptor, mean that the overall cost to purchase and replace the igus® E7 bearing liner is significantly less than the bonded PTFE-lined bearing.

Conclusion:
The igus® E7 material is proven through this testing to be the optimal plain bearing material for higher lifetime, lower wear, and lower friction on ferrous shafting, when compared to PTFE-lined bearings. Not only is the wear rate lower per-distance traveled, at 23-51% lower wear per kilometer of travel, but the thicker liner material also offers a significantly longer lifetime.

Both the initial cost, as well as the total cost of replacement is reduced using the replaceable injection-molded E7 liner in the igus® product.

About dry-tech
igus® has been developing self-lubricating, maintenance-free plastic bearing material compounds since 1964, with the idea that plastics could not only offer technical advantages over ball and metallic bearings, but simultaneously offer a significant cost savings. Since its inception in a garage in Cologne, Germany in 1964, igus® now has 30+ offices worldwide. igus® engineers develop more than 100 new plastic compounds each year, which are then extensively tested in more than 5,000 individual experiments annually. Over the years, igus® has compiled the results of these tests into a comprehensive database on the tribological and wear properties of dry-tech bearings. This database has become an invaluable resource for specifying dry-tech bearings in specific applications.



The DryLin expert system is available for use for anyone, registration-free

Learn more at www.igus.com/drylin

Other bearing materials options

drylin® linear bearings are also available in these materials, each with their own specific characteristics:

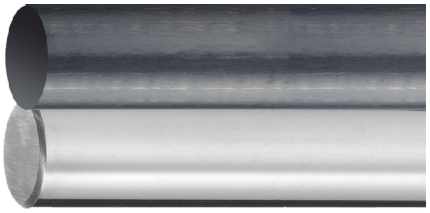
iglide® J, the original drylin® material achieves the best general results with all shaft materials, it is also available in special low-clearance versions for increased precision.

iglide® T500 is available for higher temperature applications, or those that require extreme chemical resistance.

iglide® J200 was developed for linear applications using hard-anodized aluminum shafts. Also available in low clearance geometries.

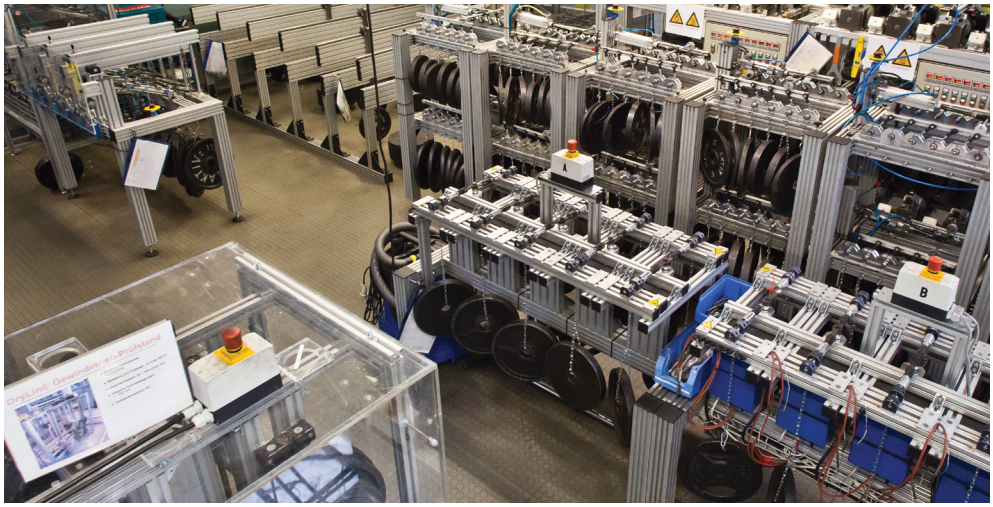
iglide® A180 is an FDA-compliant material for use in applications with direct food contact, such as food processing applications.

A number of different shaft materials and sizes are also available from igus, cut to your specific requirements.



Additional Information

Technical assistance is available over the phone from our in-house technical experts (1- 888-803-1895) from 8am-8pm ET, and on-site consultation is also offered by nearly 90 direct salespeople across North America. Online product selectors and application calculators are available with no registration required.These free tools allow engineers to model and calculate their particular application for lifetime, clearance, required drive force, and more. Free CAD files and catalogs of dry-tech products are also available online, and free samples for prototypes are available upon request.



The igus® bearings test lab, Cologne, Germany

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About igus®

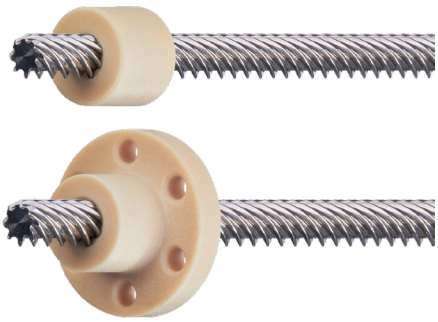
igus® develops industry-leading energy chain® cable carriers, chainflex® continuous-flex cables, drylin® linear bearings and linear guides, iglide® plastic bushings, and igubal® spherical bearings. These seemingly unrelated products are linked together through a belief in making functionally advanced, yet affordable plastic components and assemblies. With plastic bearing experience since 1964, cable carrier experience since 1971, and motion cables since 1989, igus® provides the right solution from over 100,000 products available from stock. No minimum order is ever required. For more information, contact igus at 800-521-2747 or www.igus.com.

Other drylin® products available from igus® include:

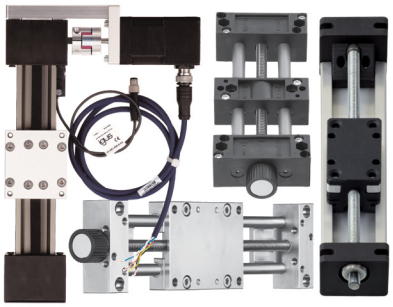
drylin® N
Low-profile linear guides

drylin® T
Linear profile guides and rails

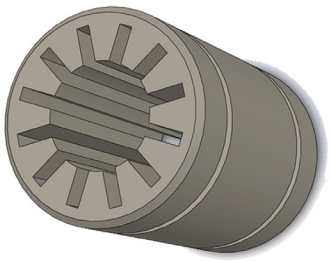
drylin® R
Round linear bearings



drylin® SD
Lead screws and drives



drylin® and drylin® E
Slide tables and motorized systems



drylin®
CAD files and technical data available registration-free