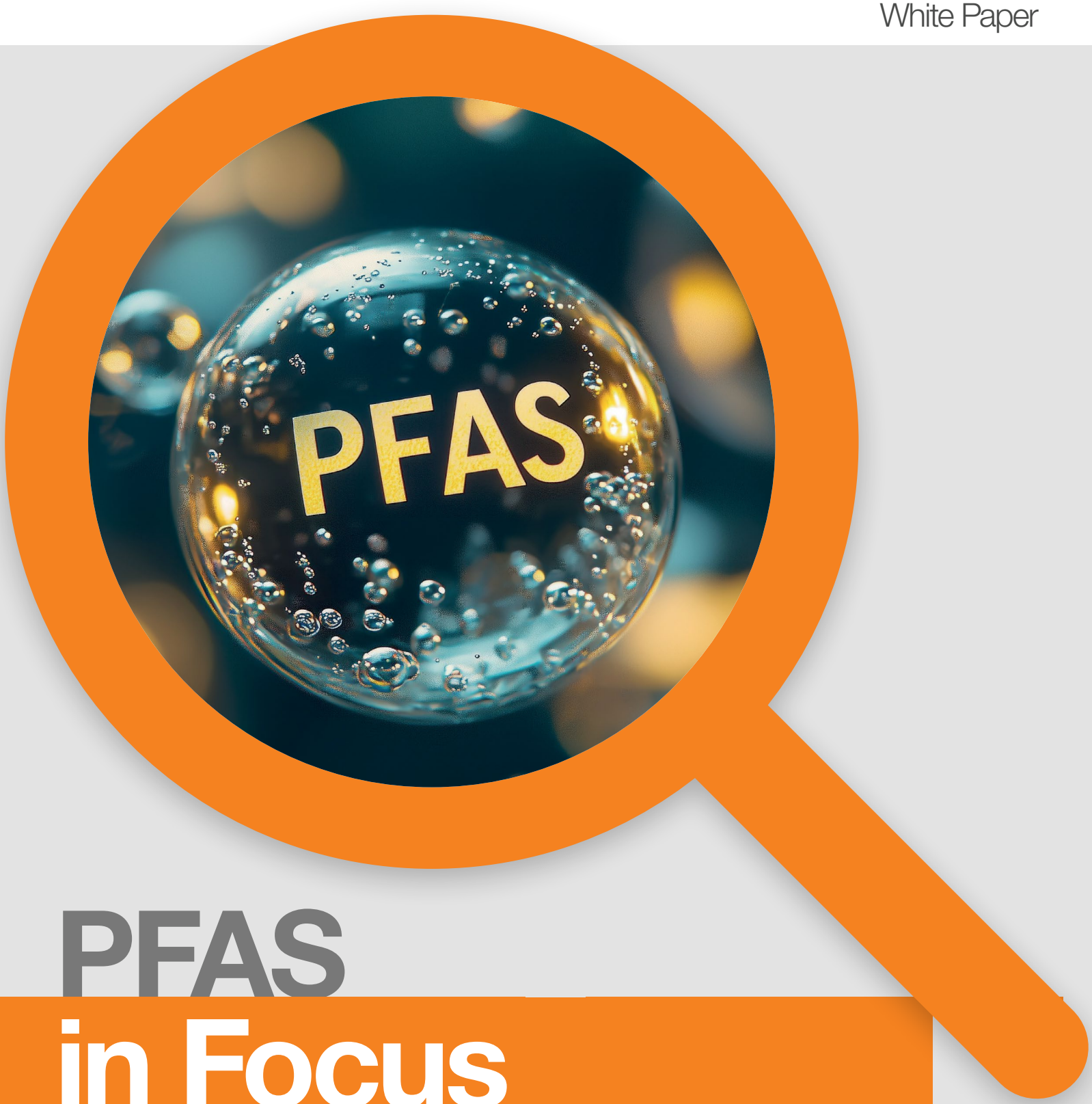


PFAS in Focus

Planned restrictions, challenges and solutions for the industry

Introduction & background

Technological developments have always left their mark on world history. Dynamite or nuclear fission are just two examples that show how close good and bad were in the past. The present has another problem child: organic fluorine compounds. Colloquially known as PFAS, they pollute soil and water across regional, national, and international borders. This is reason enough for the EU to take action: The European Chemicals Agency (ECHA) has published a proposal to ban the production, use, and marketing of PFAS.

This poses challenges not only for industrial manufacturers in the automotive, aviation, and automation industries, but for all sectors without exception. From agricultural technology, renewable energies and intralogistics to the life sciences industry, medical technology, the offshore sector, the oil and gas industry and the packaging industry — they all use PFAS in some way or another.

The problem is that research still knows too little about PFAS. It is known that short-chain PFAS in particular are absorbed by plants and can thus enter the food chain. The still insufficiently known ecological and human toxicological effects of most PFAS are therefore forcing legislators to take precautions. The aim is to reduce the release of PFAS into the environment.

This white paper provides engineers and developers, as well as managing directors and technical purchasers, with an initial overview of PFAS, their properties and their occurrence in the industrial sector. It also demonstrates how igus, as a plastics processor, can counter the impending ban on PFAS at an early stage and offer customers PTFE-free and PFAS-tested alternatives.

What are PFAS
& why are they so popular in the industrial sector?

In simple terms, PFAS are industrial chemicals that comprise a very large number of substances. They are organic compounds in which hydrogen atoms are replaced by fluorine atoms. This can be done in two ways:

Perfluorinated ▶ complete replacement
Polyfluorinated ▶ partial replacement

PFAS have no natural origin, but have been produced industrially since the 1950s. There are several thousand different PFAS substances, each with different properties; they can be gaseous, liquid or solid. There are different figures on the number: according to the OECD database, there are over 4,700; according to the EPA about 9,000; and according to the EU Commission there are even more than 10,000.

PFAS are initially divided into two groups: Non-polymers, the best known of which are PFOS (perfluorooctane sulfonic acid) and PFOA (perfluorooctanoic acid), and polymers.

Fluoropolymers, which consist of a carbon chain with directly attached fluorine atoms and of which there are a total of 38 substances, form a subgroup of polymer compounds. The most prominent and economically significant representative of fluoroplastics is PTFE (polytetrafluoroethylene), also known under the brand name Teflon®.

The extremely strong bond and semi-crystalline structure are the basis for polymers with the following positive properties:

Enormous temperature resistance
(-200°C to 250°C)

Resistant to weather influences

High chemical resistance

Excellent insulating properties

Stable and durable

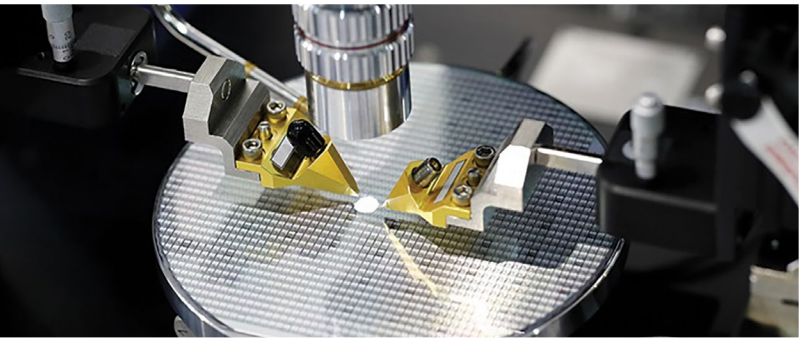
Very low coefficient of friction

Water and grease repellent

Popular in the industrial sector

These properties make it clear that plastics become high-performance plastics through the use of PFAS. This is also the reason why polymers or fluoropolymers containing PFAS are so popular with designers in all branches of the industrial sector. Some of the ways they are used are as follows:

- As a solid lubricant in plastics
- As a component of lubricants
- As a recipe component in fluoropolymer production
- In electronic components
- In membranes for fuel cells
- In the manufacture of semiconductors
- As an aid in electroplating
  (Surface treatment: hard chrome plating, bright chrome plating and plastic electroplating, zinc chrome plating, copper plating, nickel plating, gold plating)
- In paints, leather, and textile coatings
- In packaging, films, and adhesive tapes
- In tubes
- In sealing tapes
- In floor and car care products
- As an auxiliary agent for coating paper with dirt, grease, and water-repellent properties
- As an aid in the production of formulations
- As an aid for photographic processes







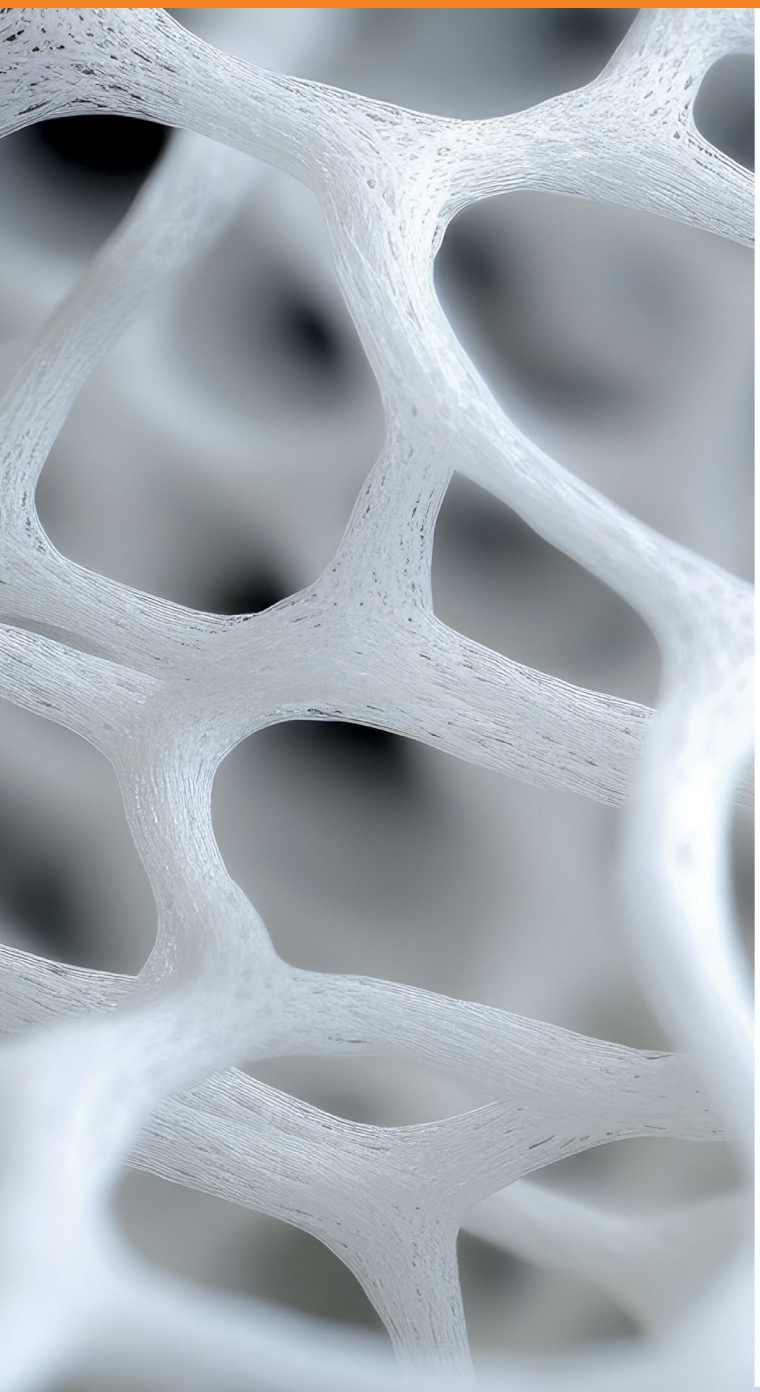




Widely used in the consumer sector

PFAS have also established themselves in the consumer sector due to their many positive properties. They can be found in upholstered furniture, carpets, tablecloths, and bed linen, where they protect against moisture and dirt. They are also frequently used as non-stick coatings in pans, waffle irons, baking tins, and baking foils. PFAS are also often found in grease-repellent fast food packaging (e.g. chip bags or microwaveable popcorn packaging). Another popular area of application is clothing: PFAS are used here to protect textiles and leather against moisture, oil, and dirt. PFAS can also be found on glasses or optics, where they serve as anti-fogging agents.

- Dental floss
- Paints and varnishes with special properties
- Photo papers, paper for adhesive labels and printing inks
- Waxes and lubricants for skis and boards
- Climbing ropes
- Plant protection products
- Fire extinguishing foams
- Electronic devices



Why are PFAS **problematic**

The longevity of PFAS, which makes them so popular in industrial and consumer products, also has its downsides, as the substances are extremely difficult to break down and remain in the environment for a very long time. This is why PFAS are also known as forever chemicals. There are four negative properties that characterize some PFAS:

Persistent

difficult to degrade

Bio-accumulative

can be absorbed by organisms and accumulate there

Toxic

highly harmful to health

Mobile

does not bind to surfaces, enters groundwater

Forever chemicals

Chemicals enter the environment via numerous routes. In industry, for example, this happens during oil extraction and mining; when contaminated sewage sludge is reused as fertilizer; when fire extinguishing foams containing PFAS are used; or through emissions into the air from industrial production facilities, which are then deposited on soil and water. Remediation measures are extremely complex, and the costs are difficult to estimate.

Some PFAS accumulate in plants, animals, and humans. Science describes the negative effects as follows: “In the human body, long-chain PFAS can bind to proteins in the blood, liver, and kidneys. Compared to other chemicals, long-chain PFAS are excreted very slowly and can therefore accumulate in the body. The transfer of long-chain PFAS from mother to child during pregnancy and breastfeeding is also particularly critical.

Elevated concentrations of PFAS in human blood can reduce the effectiveness of vaccinations, increase susceptibility to infections, lead to increased cholesterol levels, and cause lower birth weight in offspring. Long-chain PFAS are detectable in breast milk and in human blood in the general population. According to the European Chemicals Regulation REACH, some of these compounds are considered to be of ‘very high concern’.”[1]

These particularly worrying compounds include, for example, the non-polymers PFOA and PFOS, which, along with a few other PFAS compounds, have been well studied. However, little is known about the ecological and human toxicological effects of most PFAS.

1 Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection: “Guidelines for PFAS assessment” (Recommendations for the nationwide assessment of soil and water contamination and for the disposal of PFAS-containing soil material), as of February 21, 2022

What is the Specific Situation with **PTFE & Other Fluoropolymers?**

Although they are persistent, they are not bioaccumulative and not mobile. And they are not toxic, because the strong carbon-fluorine bond makes them so stable that they cannot decompose into toxic substances. The OECD classifies fluoropolymers as “products of low concern”.

There is a risk in cases where PFAS-based processing aids (emulsifiers) are used during production. However, this problem can be solved thanks to the development of alternative, PFAS-free manufacturing processes.

Phases of restriction

The restriction of the manufacture, marketing or use of substances comprises the following phases:

What is the legal situation in the EU?

The use of two PFAS chemicals is already largely banned in the EU due to their negative effects on humans and the environment: PFOS since 2006 and PFOA since July 2020. On March 7th, 2023, the ECHA published a proposal for the general restriction of PFAS submitted by five countries: Germany, the Netherlands, Denmark, Sweden, and Norway.

This proposal is the first step (Phase I) in a long regulatory process. The subsequent six-month public consultation phase by all stakeholders (Phase II-A) ran until September 22, 2023. In Phase II-B, two committees prepare their opinions within twelve months: the Scientific Committee for Risk Assessment (RAC) and the Committee for Socio-Economic Analysis (SEAC). The former examines whether the proposed restriction is suitable for reducing the risks to human health and the environment, while the latter assesses the costs and benefits for society. On the basis of opinions, the European Commission and the member states vote in Phase III on whether the restriction proposal should be accepted.

The proposed PFAS regulation would probably come into force in the EU member states in 2026 at the earliest. From this date, possible transition periods of up to 13 years are possible.

(Status: April 2024)

I Preparation & submission of a restriction proposal

- Initiation of the restriction procedure
- Notification of intent to submit a restriction proposal
- Registry of Intentions
- Preparation of the restriction dossier
- Submission and conformity check

II-A Consultations

- Consultations on the restriction report
- Consultation on the SEAC's draft opinion

II-B Preparation of the opinions

- Advice from the forum
- Statement of the RAC
- Statement of the SEAC

III Decision & follow up

- Commission's decision on restriction
- Compliance with the restriction
- Enforcement of the restriction

Source: ECHA (European chemicals agency)

Outcome
open

It is uncertain how far the restrictions will go or whether there will be a blanket ban on all PFAS substances, including fluoropolymers. The following scenarios are possible:

- A complete ban of all substances currently declared as PFAS by the ECHA, including many (e.g. PTFE) with a certain transitional period
- A far-reaching ban on certain PFAS substances that have not yet been narrowed down, with exemptions for certain substances that are extremely difficult to substitute and at the same time harmless, such as PTFE
- Restricting the bans to the relatively few PFAS substances that are currently classified as harmful to health and the environment and are comparatively easy to detect, with or without sanctions. Additionally, regulations for substances such as PTFE

Challenges
for the industry

What does igus® do?

What can industrial companies do in view of the PFAS restrictions? The following measures are possible:

- R&D receives enormous budgets to develop or find suitable substitutes for affected components until a law is passed and PFAS are banned.
- The design replaces PFAS-contaminated components with PFAS-free components that are already available
- Those responsible submit an application for an extension of the deadline and put PFAS substitution on the long-term agenda with the corresponding budget.

Solution
approaches

acheiving partial goals quickly & pragmatically

As a plastics processor and manufacturer of high-performance polymers for motion, igus has been researching PFAS-free products in our in-house laboratory for some time. Today, igus already offers solutions for our customers — for example in the automotive industry, medical technology, and packaging machine construction — with which those responsible at all levels can replace PFAS-contaminated products with uncontaminated polymer components. The best example: bearings. Wherever components move on a machine, a medical device, or in a vehicle, bearings with a long service life and high mechanical, thermal, and chemical resistance are used. With regard to PFAS relief, igus products prove to be doubly useful, as they do not require external lubricants, which are largely enriched with PFAS.

Insight into material development

The current debate about the ban on PFAS in plastics poses two challenges for material development at igus.

First off, a comprehensive evaluation of existing materials and manufacturing processes is required to determine the extent to which PFAS are used. This is a complex task, as the substances are used in many plastics due to their chemical stability and superior properties. In addition, according to the current state of the art, only around 100 PFAS substances can be detected by measurement. We invest considerable effort in testing our materials and in exchanging information with our suppliers about the ingredients of the components we purchase.

The other challenge is the development of alternatives that have similar properties without polluting the environment. Intensive research and development is needed to find or produce materials that meet both technical and ecological requirements.

igus is well positioned to overcome these challenges. We invested in the research and development of alternative materials right at the start of the Europe-wide discussion about a possible ban on various PFAS and are working closely with suppliers. Regardless of the outcome of the political and public debate on the PFAS ban, we will be able to offer our customers a large number of products in which we do not use PFAS, which are measurable and ecologically questionable.

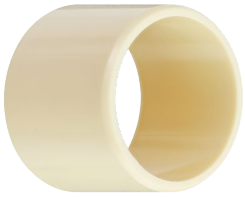
With in-house material development and compounding, igus can react quickly to changes and enable our experienced team to develop innovative solutions. This combination of expertise, resources, and agility makes igus a valuable partner for manufacturers who need to implement PFAS-free moving parts.

PTFE-Free & PFAS-Tested products

"PFAS-tested": This is how igus labels all materials that have been tested for the approximately 100 PFAS substances considered critical for the environment and health according to the SQP M1227 test method (LC-MS/MS and GC-MS). Excluded are ubiquitous traces that cannot be completely removed due to external influences, as well as substances from the group of fluoropolymers.

PTFE, which is considered a harmless chemical, is also a popular solid lubricant at igus and is contained in many bearing materials. In addition, igus already has numerous materials without PTFE in our range and continue to develop others. Here are some product examples:

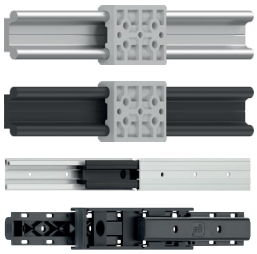
PFAS TESTED



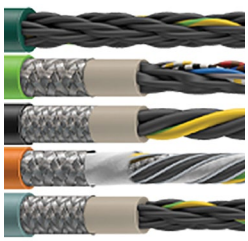
iglide® JPF
Based on the tried and tested endurance material iglide® J, the PTFE-free iglide® JPF offers comparable properties.

iglide® FPF
The new PTFE-free variant of the conductive iglide® F material, particularly suitable for applications with ESD requirements.

iglide® A500
Universal food material with very high temperature and chemical resistance, compliant with the specifications of FDA, EU 10/2011, 3-A, GB4806.1, Food Sanitation Act



drylin® linear technology
The maintenance-free alternative for lubricated linear recirculating ball bearings and guides. Various linear rails, carriages, and plastic sliding elements made from PTFE-free and PFAS-tested materials.



chainflex® cables
Control, bus, data, motor, fiber optic cables, and more. 95% of igus cables are free of PTFE and other PFAS chemicals.

In exchange with various industries

Today, igus supports 188,000 companies from over 80 countries and more than 50 different industries. Our industry managers are in constant contact with customers and know their concerns. Four of them have their say here and answer the question:

What relevance do PFAS and the planned restriction have in your industry?

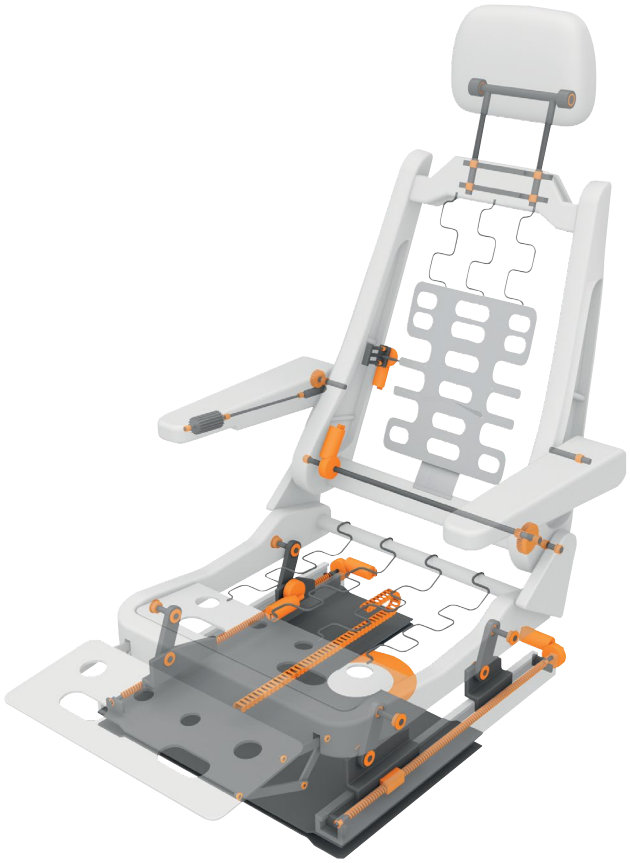
Automotive

PFAS play a very important role in the automotive industry, especially in future technologies such as electromobility and networked automated driving. Because they are needed for cathodes in lithium-ion batteries, fuel cells, and power electronics (especially in semiconductor production), the industry believes that progress in decarbonizing the transport sector would be jeopardized if a blanket ban on PFAS were to be introduced. PFAS and especially PTFE are used in countless other automotive applications due to their outstanding lubricity and high temperature and chemical resistance, for example in seals, hoses, or as dry lubrication in various bearings.

At least in the latter case, we at igus can help, because we can offer PFAS- or PTFE-free bearings for many applications. Compared to metal bearings that are coated and lubricated with PTFE, our products, which do not require external lubrication, score twice as well. It is not possible to say in general terms which PFAS-free igus material is the right one — we do not have a universal automotive bearing material.

We talk to our customers on a case-by-case basis, assess the most important application parameters and then recommend the right material. Together with them, we are also constantly developing new product and material solutions to meet the latest requirements.

-Dirk Tietz, Automotive Industry Manager

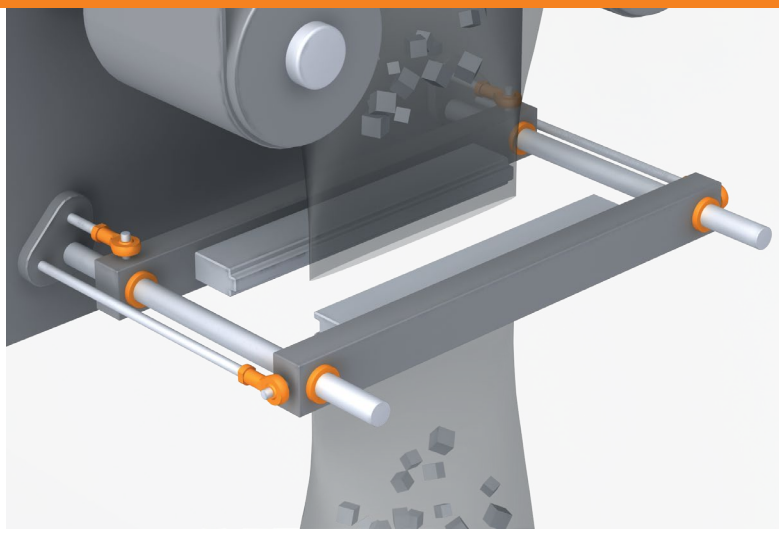


Medical technology

A general ban of PFAS, including fluoropolymers, would hit medical technology particularly hard. Due to their inert, insulating, and non-bioactive properties, fluoroplastics such as PTFE are excellently suited to ensure sliding functions, whereby they are not absorbed in the body and — according to the current state of the art — do not overcome body barriers. They are used as coatings or materials in countless applications, for example in catheters, endoscopes, joints, prostheses, pacemakers, ventilators, incubators, syringe pumps, and imaging systems. In the absence of alternatives available in the short term for very sensitive applications, the medical technology industry assumes that the EU will adopt longer transitional periods and/or substance exemptions.

However, when it comes to bearings, cables, and cable carriers in particular, we can already offer our customers PTFE/PFAS-free alternatives that can replace current applications on a one-to-one basis, or even exceed their performance. We invite all manufacturers to contact us if they want to re-evaluate their motion elements, check igus components for possible future conformity, or discover a new development without PFAS- or PTFE-containing components.

-Ulf Hottung & Elif Teper, Medical Technology Industry Managers



Packaging technology

PFAS compounds and PTFE in particular have a major influence in the packaging industry. They are not only contained in numerous packaging materials, but are also very important for many processes.

In the beverage industry, for example, they are used in filling valves, in process technology, and in a variety of other applications. Here, the liquid product (water, juice, beer) sometimes comes into direct contact with PTFE and other engineering plastics. They are also often essential for processes in the packaging and food industries. Excellent sliding properties, high temperature resistance and high chemical resistance are often necessary to ensure an optimal process. PTFE tape is used in the sealing bar and longitudinal sealing of a tubular bag machine, for example, to prevent the sealed packaging film from sticking. In bakery technology or fish and meat processing, the open product also usually comes into direct contact with plastics such as belts, knife edge rollers, or sliding strips. Particularly in moving applications, care must be taken to ensure that any abrasion does not contaminate the open food.

We can offer our customers several food-grade materials for plain bearings, semi-finished products, sliding foils, and 3D printing filaments that are PFAS-tested, including those that do not require PTFE.

-Lars Braun, Packaging Technology & Food Industry Manager

Conclusion

Perfect is the enemy of good: the large number of annual patent applications worldwide shows that people's inventive spirit remains unbroken to this day — including at igus. For more than a year, our team of plastics engineers has been working on the topic of PFAS and, together with the product managers, has been developing solutions that are closely aligned with the needs of the customers.

Whether automotive suppliers, medical device manufacturers, packaging machine manufacturers, or other branches of industry; a possible PFAS ban can already be dealt with quickly and unbureaucratically in some areas.

In the igus plastics experts, companies not only find a strategic partner with product and industry know-how, but also experienced engineers and technicians who have in-depth knowledge of standards and regulations, such as the FDA or the Medical Devices Directive.