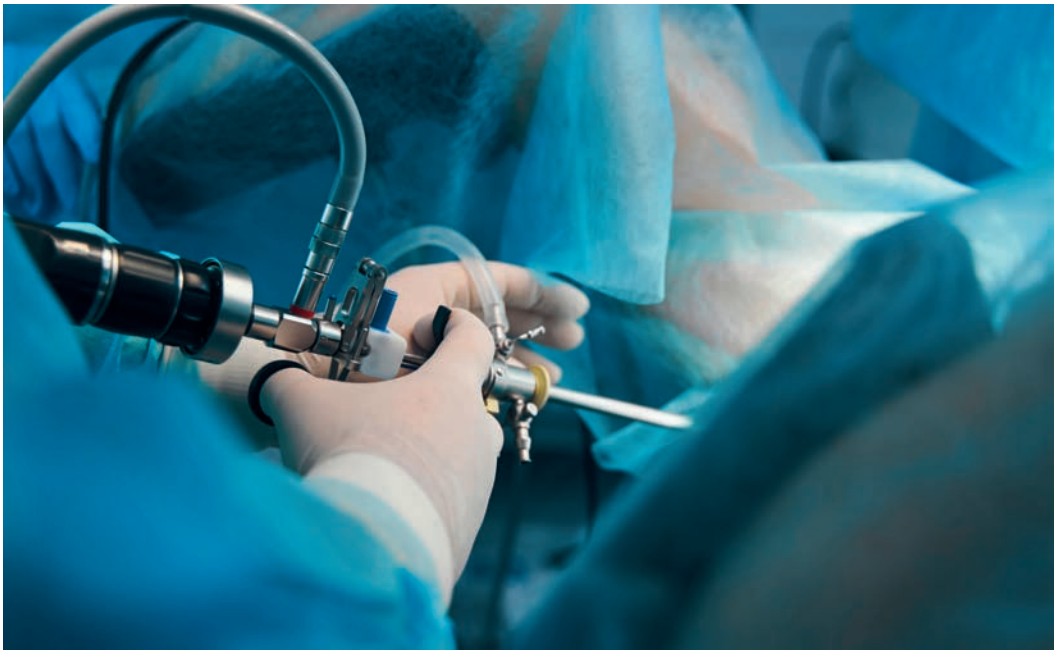
Tribologically Optimized Plastic Compounds without PTFE

PFAS-Free Performance

Can high-performance tribological plastics be implemented without PFAS? Various materials from the plastics manufacturer Lehvoss demonstrate that this is possible. These successfully combine functionality, sustainability, and application and future viability.



Fluoroplastics are widely used in medical technology, including sliding elements for invasive instruments. However, PFAS-free compounds are already available as replacements. ©Shutterstock; Svitlana Hulko

In technical applications with moving components, materials with good tribological properties, such as low friction and high wear resistance, are essential. For a long time, fluoropolymers, especially polytetrafluoroethylene (PTFE), were considered key elements for the tribological optimization of thermoplastic compounds. These compounds are currently indispensable for many applications such as plain bearings, pumps, and linear components. However, due to impending regulatory restrictions, environmental concerns, and growing customer awareness, compounds containing so-called per- and polyfluorinated alkyl compounds (PFAS) are increasingly being criticized. This group of substances also includes fluoroplastics such as PTFE. The Lehvoss Group has therefore developed PFAS-free alternatives that allow customers to avoid compromises in performance and processability.

Due to its unique, excellent properties, PTFE is currently used in tribological applications both on its own and in the form of plastic compounds. Its ability to significantly reduce sliding friction and wear in tribological systems through the formation of a transfer film leads to a self-lubricating effect. The challenge in developing PFAS-free compounds lies in achieving equivalent tribological effects through alternative additive systems that are simultaneously stable during processing and compatible with the polymer matrix, as well as environmentally safe.

Developers and designers currently face key questions:

- What alternatives are there to the currently used materials containing PTFE and PFAS?
- How can these materials be used to meet tribological requirements in components and assemblies?
- What mechanical properties are possible with them?
- How is the functionality of the parts ensured?
- How future-proof are the alternatives?
- What about processability and costs?

Multi-Stage Development Approach

The Lehvoss Group pursues a multi-stage development approach to replacing PFAS-containing compounds and fluoropolymers: First, existing formulations are analyzed, and the role of PTFE and other fluoropolymers is precisely identified – not only with regard to sliding behavior,

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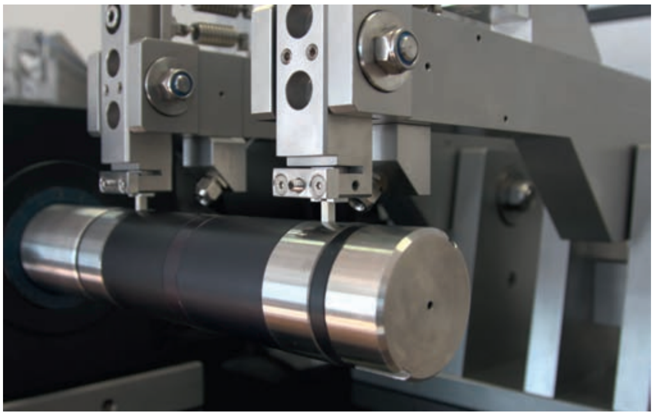

Fig. 1. Lehvoss uses, among other methods, the pin-on-roll method for tribological material testing. © Lehvoss

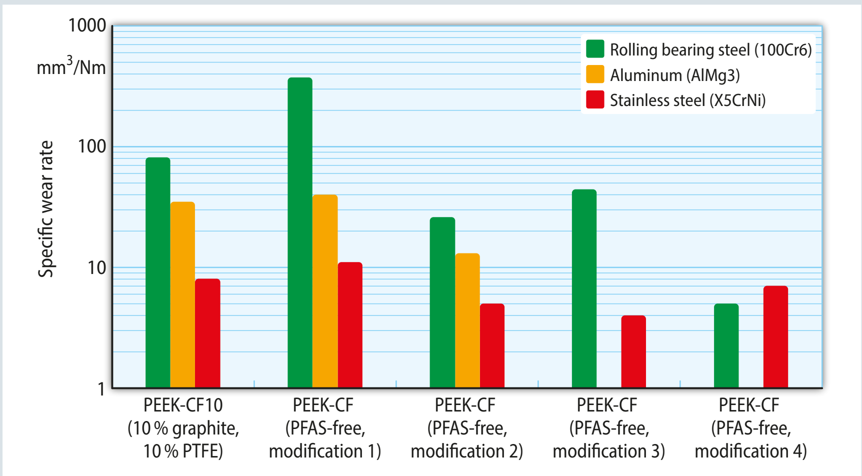

Fig. 2. Wear of PFAS-free Luvocom PEEK compounds with various metallic counterpart materials compared to the classic PEEK formulation with 10 % carbon fibers, 10 % graphite, and 10 % PTFE: The material testing was conducted using pin-on-roll. Source: Lehvoss; graphic: © Hanser

but also with regard to processing, mechanical properties, durability, and system compatibility. Based on this, alternative additive combinations are developed, for example, based on functional solid lubricants, ceramics, and high-performance polymers. These combinations make it possible to achieve – and in some cases even exceed – the tribological property range of fluoropolymers and PTFE-containing compounds. For example, PFAS-free Luvocom grades from Lehvoss demonstrate comparable or even significantly better friction and wear values, even under demanding conditions such as dry running, high surface pressure, or thermal stress. The company verifies this using its own tribology test benches, such as pin-on-roll (**Fig. 1**), SRV tribometers, and component tests at customers' sites.

Lehvoss has been offering PFAS-free tribological compounds for 25 years and has developed a comprehensive portfolio of PFAS-free high-performance thermoplastics. Based on polymer matrices such as POM, PA, PPA, PPS, PEEK, or LCP, these compounds offer tailored properties for tribological applications – from low-friction linear systems to highly loaded plain bearings.

Focus on Application Orientation

A key aspect in the development of PFAS-free materials is application orientation. The selection of the appropriate compound takes place in close cooperation with the customer. Environmental conditions such as temperature, pressure, running speeds, and media, as well as the component design, are all taken into account. This results in tailor-made materials for specific design goals – such as reducing costs, improving energy efficiency, and extending maintenance intervals.

One example of this is carbon fiber-reinforced PEEK compounds with tribologically active additive packages. Under dry-running conditions, they achieve comparable friction values and higher wear resistance to PTFE-containing systems (**Fig. 2**). At the same time, they have met the requirements for temperature resistance, dimensional stability, and chemical resistance in numerous applications for many years.

The Lehvoss product line includes PFAS-free tribological materials based on various thermoplastics:

- PA (PA6, PA66, PA410, PA12, PA610), POM, and PBT for applications with medium requirements
- PA46, PPS, and PEEK for high to extreme loads
- Additional customized compounds, tailored to friction coefficient, wear, temperature range, and media contact, based on all common thermoplastics and the use of short, long, or carbon fibers, in possible combination with other properties, such as electrical or thermal conductivity.

Advantages and Application Areas

PFAS-free tribological compounds offer numerous advantages – not only in terms of regulatory compliance. They often exhibit more stable mechanical behavior, better recyclability, and enable a broader range of functional combinations. For example, tribological requirements can be combined with electrical conductivity or even structural properties.

Advantages of PFAS-free compounds:

- **Improved long-term stability:** PTFE-containing compounds tend to excrete more PTFE from the polymer matrix as temperature increases.
- **Greater design freedom,** as these compounds are easier to process.
- **Easier processability:** No corrosion of tool steels and no deposit formation on tool surfaces.
- **Better compatibility** with electrical conductivity, flame retardancy, and structural reinforcement.
- **Better recyclability,** as fluoropolymer-free systems can be processed with greater thermal stability.

Typical applications for the compounds include:

- Plain bearings and bushings in the automotive and bicycle industries, for

Fig. 3. Plain bearings made of PFAS-free modified compounds: In some cases, the material alternatives even achieve better results than their PFAS-containing counterparts. © Lehvoss

energy systems, and in mechanical engineering
- Low-friction guides in medical technology
- Conveyor and handling elements in food technology
- Components in pumps, valves, and drive systems

Practical Examples from Typical Applications

A typical application area is plain bearings in valve trains or actuators, where a long service life without lubrication is required. In a practical example, a PEEK compound with a PFAS-free additive package was tested under endurance test conditions – with a consistently low coefficient of friction and at temperatures up to 200 °C – and approved for use (**Fig. 3**). The advantage of the PFAS-free solution is also evident in applications in the medical technology and food industries. In these areas, regulatory aspects are just as crucial as chemical resistance, cleanability, and reliability.

For designers, PFAS substitution means adapting existing and new designs to these materials. The following aspects are particularly relevant:
- **Material data and test series:** Validated tribological tests provide certainty in the selection process.
- **Component compatibility:** Processing parameters and dimensional behavior must be considered.
- **Future-proofing:** Designing PFAS-free now reduces future adaptation costs.
- **Cost reduction:** Costs are reduced through lower specific densities, easier processing, and reduced tool maintenance.

Conclusion: PFAS-Free Is Becoming the New Standard

With PFAS-free tribological compounds, Lehvoss offers a genuine and more sustainable alternative to PFAS-containing variants for the construction of functional plastic components. This is not only due to the elimination of this substance group, but also because materials based on recycled materials are used. The material systems meet high technical requirements – without regulatory risks – and offer additional advantages in terms of environmental compatibility, recyclability, and industrial sustainability. These are materials that have already proven their performance and practical benefits for years.

The development of PFAS-free tribological compounds is exemplary of the shift towards more sustainable and safer high-performance materials. Due to the impending PFAS ban or at least upcoming restrictions at the European level, this approach is not only technically sensible but increasingly required by law. The materials prove that uncompromising performance is also possible without PFAS – a step forward that combines functional excellence and responsibility. ■