

PRODUCT CONCEPTS

Many process conditions have a decisive influence on the development times of new products, the production costs of prototypes, the minimum lot size and thus on the total costs of friction technology products. This is where the LIQFRIC® product concept comes in. It is intended to be used in the automotive, industrial, rail and prototypes sectors over the long term. Particularly for prototype construction, the product, thanks to its freedom of design, shows excellent starting conditions for disruptive manufacturing approaches as well as the possibility of utilizing batch size 1 to realize cost advantages in an unprecedented size.

The already developed **organic liquid two-component LIQFRIC® systems** have repeatedly been subjected to coefficient of friction tests among others and are available for testing and optimization by the customer. The required production capacities have been built up and can easily meet the initial demand. The freedom of design together with the simplified structure of the casting molds allows a fundamental redesign of the clutch geometry, as well as the production of thin-film materials in the range of 150 - 1000 µm.

FROM PROTOTYPE TO LARGE-SCALE PRODUCTION

LF GmbH & Co. KG develops tailor-made compounding solutions for you in a wide variety of areas of the friction lining industry. From brainstorming and compounding to the commissioning of complete systems, we are your reliable partner. Our core competencies lie in the development of liquid friction compounds - for clutches and brake linings, for example.

We have the expertise to optimize products specifically for the manufacturing processes during the development stage. The intelligent use of all resources enables us to break new ground and expand the limits of what is feasible. By combining the new LIQFRIC® technology with established solutions, we create sustainable and economical solutions for our customers over the long term.

Thanks to our partnership with a well-known system manufacturer in the friction lining industry, technology, process engineering and construction go hand in hand. For you, this means the highest level of innovation, reliability and quality in the development and manufacturing of your products.



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The **water-based compound product family LIQFRIC® HP** is in pre-series evaluation with various friction material-, brake- and vehicle manufacturers. The inorganic binder alone is thermally stable up to 1100 °C and in turn suitable for high temperature loads. The hardening process can be accelerated through the additional use of heat (<100° C). All LIQFRIC® material concepts allow a formulation based on customer requirements, which can be further developed in dialogue. It is possible for us to develop the finished friction material for you or, alternatively, for your company to purchase our basic compounds and optimize them independently. This ensures that only you know your development strategy.

We would like to identify together with you, how you can make use of the potential of our LIQFRIC® compounds for your company.

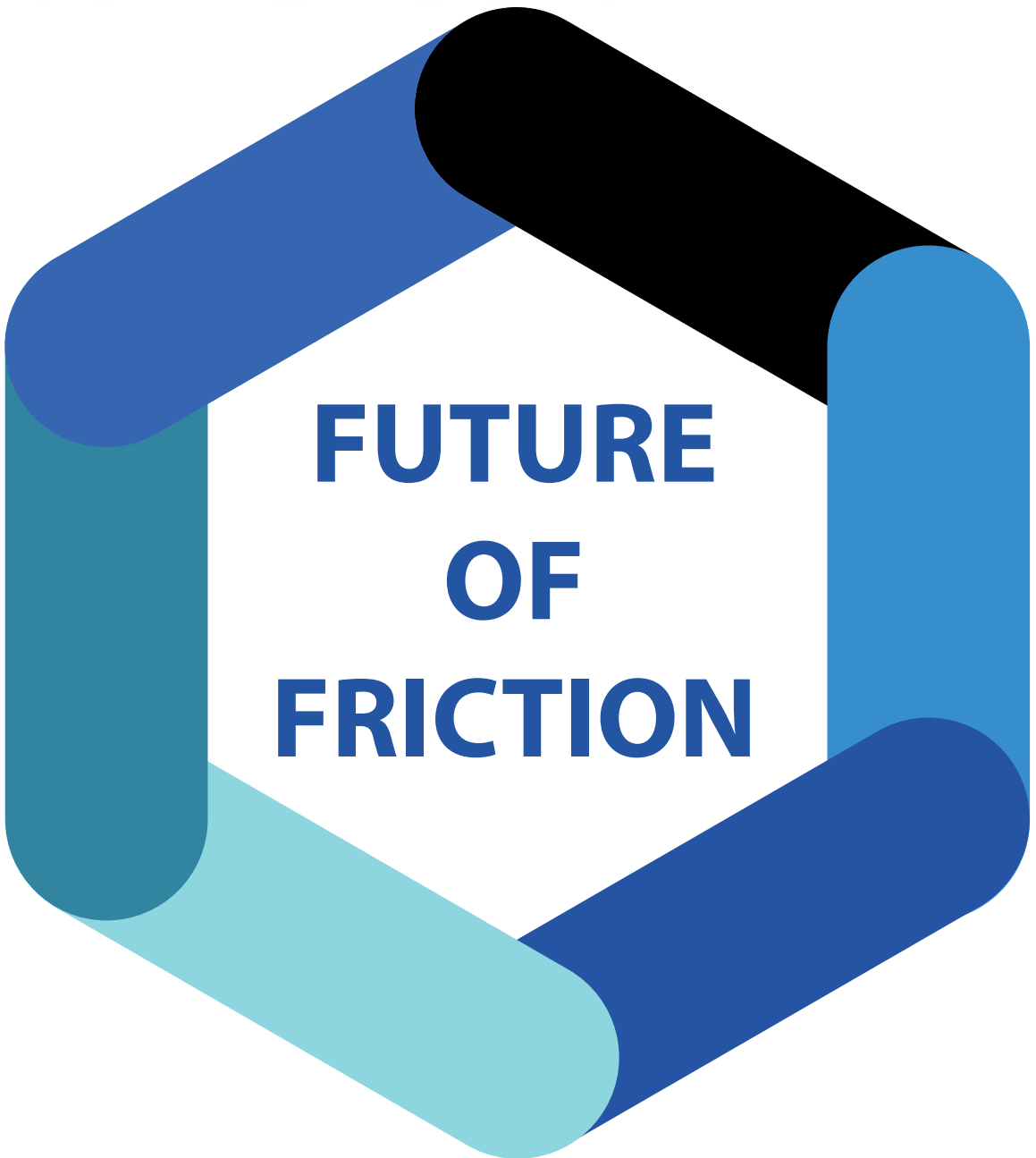
We look forward to your inquiry.

LIQFRIC®
Liquid intelligence friction compounds

5TH ANNIVERSARY
FROM STARTUP
TO SCALEUP

LF GmbH & Co. KG

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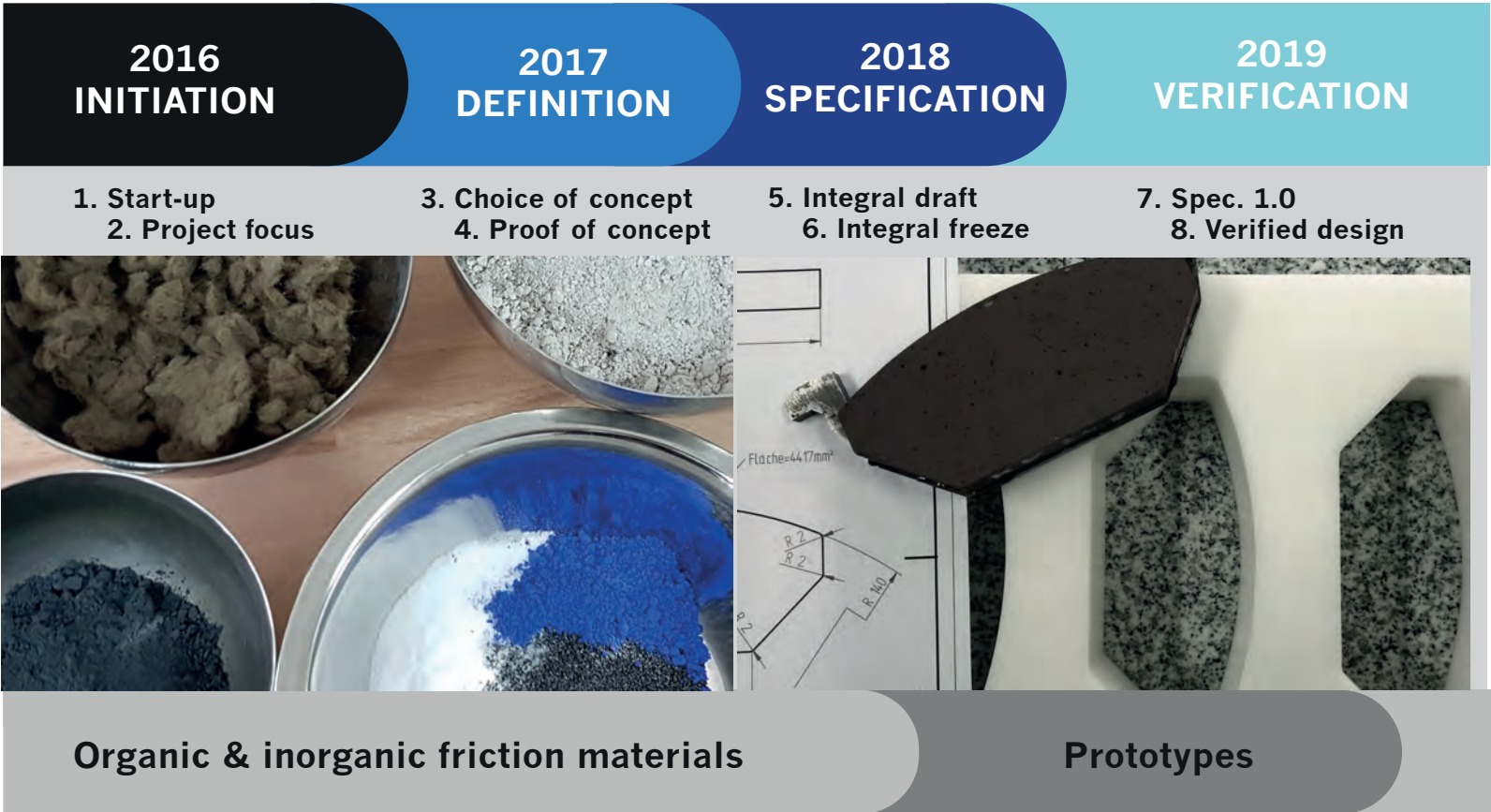
FROM LIQUID PHASE TO CO2 NEUTRALITY

LIQFRIC® - COMPETENCE IN LIQUID FRICTION COMPOUNDS

LF GmbH & Co. KG is a company founded in March 2016 with the first development objective of engineering, producing and marketing innovative friction materials for the application area of brake linings and clutches and initially reducing the thermal energy required by up to 85%. In the long term, we strive to completely eliminate any CO2 emissions in the manufacturing process.

The development strategy follows the founder's inventive idea that coating systems, especially friction materials, can be manufactured using a liquid phase and do not necessarily have to be manufactured from the original powdery state through the use of high pressures and temperatures. LF GmbH & Co. KG can produce pre-series parts and prototypes for the customer after prior agreement.

In the long term, the company plans to manufacture brake pads in large series itself or with an industrial partner.



LIQFRIC® PRODUCT INNOVATION PROCESS

A successfully carried out project requires a clearly defined starting point and a structured implementation. For this reason, we have developed an approach in which risks are analyzed and eliminated step by step. The product innovation process ensures that we can control product development.



CHIP-IN-PAD CONCEPT

Due to the systemically high pressures that occur in the production of brake linings, it has never been possible to integrate sensors into the friction lining matrix. However, the LIQFRIC® casting process allows sensors to be integrated and encased in the friction lining matrix. This makes it possible to control the condition and analyze the static and dynamic behavior of brake linings. For the first time, it is also possible to monitor lining wear in the sense of preventive maintenance. A large number of sensors can be integrated (Piezo, Gyro, NFC, ...).

Wireless communication between these sensors and the outside world is the next plausible development step in our strategy.



A LIQFRIC® chip-in-pad friction material conducting tests at the airport of Griesheim on a premium vehicle platform.



CO₂ REDUCTION

Production-related process temperatures and their sequence in the production of the linings require a high level of thermal energy for the manufacturing of the brake linings. The multiple heating- and cooling cycles of the linings in production, and especially the steel backing plates, require a lot of energy. Due to the low hardening and process temperatures, around 85% of the process energy currently required can be saved with phenolic bonded brake linings.

In the case of sinter metallic linings, this value improves considerably, since the process temperatures are significantly higher.



To achieve a production that is - at least mathematically – 100% free of CO₂ emissions, we at LIQFRIC® support the tree planting project "KultURwald" of the cultural initiative Kulturinitiative Windeck e.V.



LOT SIZE 1

Press tools for the production of friction lining materials and their rapid availability are another topic in which our LIQFRIC® technology can offer advantages. Thanks to the pressureless manufacturing process, for small series and prototypes we can dispense with the manufacturing of complex steel-based tools. The tools required can be manufactured from corresponding polymer blocks or by using a 3D printing process. This means that prototypical friction linings and their geometric variations can be made available much quicker.

Going from your DXF- or CAD file to the finished tool is only one button press away.



Our organic liquid two-component LIQFRIC® systems have repeatedly been subjected to coefficient of friction - and other tests.

MISSION STATEMENT: FUTURE OF FRICTION - FoF

The current status quo in the friction industry has been successfully developed over many decades. We identify with the topics of sustainability, zero CO₂, electromobility, sensor technology and autonomous driving, which will also change the approach of friction material manufacturing.



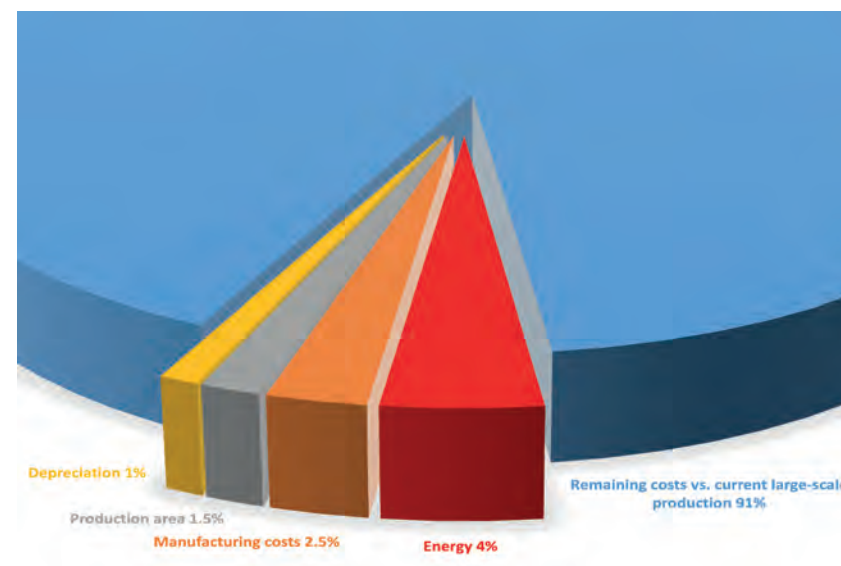
With our LIQFRIC® concept, we are setting new standards in terms of reducing CO₂ in the manufacturing process, increasing the critical temperature for fine particle emissions and integrating sensors in brake linings, in line with Industry 4.0. Our "Future of Friction" hexagon describes the areas of tension, but also our solution approaches in the best possible way.



The lab scale shows the direct comparison: Approx. 15% weight reduction for a standard brake pad with an identical steel backing plate.



You can request a copy of the PM10 study on our website.



Exemplary cost comparison with phenolic systems: Approx. 9% savings potential vs. current large-scale production.

Unsprung masses, e.g. in the brake, have been shown to have negative effects on driving behavior. The density of inorganic friction materials can be controlled by various process parameters. The mean density of the LIQFRIC® friction material lies between 1,7 -1,9 g/cm³ and thus well below the density of today's friction materials. This results in a geometry-dependent average weight saving of approx. 15% for the classic brake pad and backing plate combination. The savings are significantly higher for systems that do not have a backing plate.

In addition, we are working on metal-free friction linings, which should also be mentioned here in connection with the possible weight savings.

In the inner-city area, a significant part of the fine particle emissions is attributed to the operation of motor vehicles. The friction lining industry and its partners therefore use all available resources to reduce these emissions. As we were able to demonstrate with one of our project partners, the emission of fine dust particles with inorganic friction lining materials only begins at significantly higher temperatures than with phenolic resin-bound materials.

We want to investigate this phenomenon further in the future in order to be able to take advantage of these tremendous benefits.

Resource efficiency is an essential approach for the sustainability strategy and long-term cost reduction of industrially manufactured goods.

On the one hand, the use of energy for the manufacturing of the brake pad in large-scale production is significantly reduced through the savings in press hydraulics, the cross-linking temperatures and the process design.

On the other hand, the upstream mixing processes require less effort, so that overall lower production costs are incurred in the steady state.

We would be happy to show you which savings potential can be achieved with our LIQFRIC® process.



LIGHT-WEIGHT PAD



PARTICLE EMISSIONS



COST REDUCTION