**Self-Diagnosing Seal**

**Successful feasibility study: “Smart seals” offer significant data on the service life of the seal.**

**Weinheim (Germany), February 28, 2023. Freudenberg Sealing Technologies can now validate the superior performance capabilities of the intelligent seals it has under development. In addition to their core function, these seals can handle tasks such as sensor applications and monitoring their own state of wear. As a result, they enhance the reliability of machines and systems they help power by providing data about their state of performance and safety. That in turn helps eliminate mechanical failures and unanticipated downtime. A new feasibility study, conducted by Freudenberg Sealing Technologies, has verified the benefits of these sealing functions.**

Seals have several important functions: Preventing contamination, creating temperature and pressure safeguards, and protecting the external environment from accidental leaks and spills. By maintaining an impervious barrier between the external and internal environments in which they are placed, they serve a critical role protecting machinery and systems from temperature and pressure fluctuations and dirt and grime. They further prevent aggressive fluids and chemicals from polluting their surroundings. In the future, intelligent seals from Freudenberg Sealing Technologies can significantly expand this important core task: The seal itself is also a sensor and applies built-in functionality, via materials and design, to become a “smart seal”.

“We deliberately decided to take this route. It promises insights with considerably more information on the seal’s service life than we can get from modeling other usage data in the system,” says Dr. Boris Traber, Manager of the company’s global Materials Predevelopment. “We’re convinced that future seals will be able to provide us with accurate condition information in real time, which means they can be central elements in predictive maintenance and Industry 4.0 – the systematic digitalization of machines and plants.”

One of Freudenberg Sealing Technologies development efforts is the creation of an intelligent rod seal. This forms a capacitor with outer layers made of an electrically insulating elastomer and an inner layer of an electrically conductive elastomer with a metallic housing wall. If the successive abrasions of the insulating layer cause the seal to wear down, the distance between the electrically conductive layer to the metallic housing decreases while the capacitance rises. This makes it possible to get a condition measurement at any time which indicates the service life of the rod seal if the wear remains constant.

This offers considerable advantages: Maintenance times can be scheduled reliably in advance. Such predictions prevent follow-up costs caused by leakage damage and lower the risk of contaminating the whole batch. Another benefit: The seal is used throughout its entire service life without being replaced prematurely. This optimizes operating costs and provides a sustainable solution.

**The technical concept works**

Freudenberg Sealing Technologies has already developed both sealing materials and a smart rod seal that meet all the performance requirements of a conventional rod seal, including those that involve acid and base resistance, standards, service life and manufacturability.

The smart seal feasibility study conducted by Freudenberg Sealing Technologies offers proof to customers that the smart seal concept is valid and offers benefits. This comprehensive study confirms that the sensor concept works in real-life situations. The simulation of the capacitor principle already gave the developers important answers: “The change in capacitance informatively describes the wear of the seal lip. When the seal reaches the limit of its wear and tear, the capacitance increases significantly and approaches an exponential progression. A failure of the seal, and thus an imminent leakage, can be prevented in a timely manner,” explains Olaf Nahrwold, Development Engineer at Freudenberg Sealing Technologies. “To achieve this, we had to tackle several challenges, such as adapting the component geometries and developing the corresponding measurement software, which has proven to be very robust.”

Extensive tests in real application settings were key components of the feasibility study. In laboratory practice, they prove the full function of the innovative seal exactly as intended: Installed in a standard valve, it reliably seals the system in both dry and aqueous environments; at the same time, it continuously provides real-time measurement data about its own remaining service life.

The result is substantiated by comparing all capacitive measurements with a real mechanical leakage. To this end, overpressure is applied to the valve. As long as it remains constant, the system is free of leaks. All tests yielded a rise in capacitance before any measurable leakage: The system accurately captures the state of wear, which enables it to predict when the seal will fail.

“These positive results of the feasibility study are an important condition for the possible everyday use of intelligent seals in many application scenarios,” says Traber. “We also examined how this concept can be transferred to PTFE seals, such as those which are used in hydraulic applications with increased requirements for thermal and mechanical resistance at high pressures. These results are also highly encouraging.”

**Smart seals can create significant advantages**

The concept may sound simple, but experts have already performed considerable research and development work in recent years. The immense know-how is reflected in the materials and the fundamental structure of the intelligent seal. As to production-specific implementation, every seal made by Freudenberg Sealing Technologies is already a high-precision component. For smart seals in large-scale series production, this capability also makes it possible for the company to ensure the sensor quality required for the application.

The current status of this exciting technology? “Given that there are still various unanswered questions, it will probably still take some time before a specific practical application is identified,” Traber says. “The sensor information will also have to be implemented in the plant control systems so that actions can be triggered based on the data. The best way to clear up these questions is through application projects with their specific requirements. “We are absolutely convinced of the benefits of our concept in terms of data availability – and that smart seals can create significant advantages in many industrial processes.” Various customers have already indicated their interest.

***Image:*** *FST\_img\_SmartSealsStudy\_ENG.jpg / ©Freudenberg Sealing Technologies 2023*

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**About Freudenberg Sealing Technologies**

Freudenberg Sealing Technologies is a longstanding technology expert and market leader for sophisticated and novel applications in sealing technology and electric mobility solutions worldwide. With its unique materials and technology expertise, the company is a proven supplier for demanding products and applications, as well as a development and service partner to customers in the automotive industries and in general industries. In 2021, Freudenberg Sealing Technologies generated sales of about 2.2 billion euros and employed approximately 13,500 people. More information at [www.fst.com](http://www.fst.com).

The company is part of the global Freudenberg Group which has four business areas: Seals and Vibration Control Technology, Nonwovens and Filtration, Household Products as well as Specialties and Others. In 2021 the Group generated sales of more than 10 billion euros and employed more than 50,000 associates in around 60 countries. More information is available at [www.freudenberg.com](http://www.freudenberg.com).

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