



DIAPHRAGMS

Freudenberg-NOK
Sealing Technologies

The background of the page is a photograph of an industrial facility. It features a complex network of large, light-colored metal pipes and valves. Some valves are painted blue, while others are grey. The pipes are connected by flanges and bolts. The scene is brightly lit, suggesting an indoor or well-lit outdoor environment. The overall color palette is dominated by greys, blues, and whites.

Freudenberg–NOK Sealing Technologies

Freudenberg–NOK Sealing Technologies is one of 16 global subsidiaries of the Freudenberg Group. In 2011, Freudenberg combined the activities of the previously named Freudenberg Seals and Vibration Control Technology Europe and the Freudenberg–NOK Sealing Technologies in the Americas into one organization.

With its partners NOK Corporation, Japan, Sigma Freudenberg NOK, India, and NOK–Freudenberg Group China, Freudenberg provides customers with high quality, standard or custom-engineered products that consistently meet or exceed exacting industry standards. Freudenberg is a leading producer of elastomeric materials and precision molded products for a variety of markets, including aerospace, automotive, building engineering, fluid handling, fluid power, food and beverage, health and safety, plant equipment, power generation, and truck and bus.

FREUDENBERG

YOUR SPECIALIST FOR DIAPHRAGMS

Diaphragms made from elastomeric materials provide specialized sealing solutions for virtually any industrial sector and can fulfill the following basic functions:

▶ **Control or switching function**

Diaphragms may be used in an array of applications, including pumps, actuators, hydro-accumulators, valves, and regulators.

any application. Our teams have been directly involved in the development and growth of the diaphragm industry, and we bring that expertise to every customer collaboration.

▶ **Accumulation or separation function**

Freudenberg has the expert engineering and materials expertise to provide the high performance diaphragms your equipment demands, in standard or custom-designed sizes and formats for

Trust Freudenberg for the complete range of products plus the global service and expertise your business deserves.

▶ **Pump function**

Count on Freudenberg for quality, reliable solutions in nearly every application, everywhere in the world. The Freudenberg brand leads the industry, because our customers trust us to provide:

The world's largest product range

Comprehensive solutions from a single source save you time and assure integrated solutions to meet your demands.

Continuous innovation

Our expertise and new products are your competitive advantage.

DIAPHRAGM EXPERIENCE

Expert diaphragm design and engineering

Freudenberg puts the best engineers in the industry to work for you, with more than 50 years of experience in designing and manufacturing elastomer diaphragms with fabric reinforcement, different types of inserts, and PTFE foil coating. From our leadership at the emergence of the diaphragm industry through our continued growth and experience, Freudenberg has become the market leader in Europe for diaphragms. We offer extensive design support and extensive testing facilities to ensure high quality, reliable diaphragms for your applications.

Leadership in design

Freudenberg excels in diaphragm design, with engineers experienced in designing the optimum part for the application and selecting the diaphragm styles and materials that will work best. We also offer the opportunity for you to collaborate directly with Freudenberg experts at your site at any point during the product development process, enabling you to gain competitive advantages from our expertise. These interactive events, or "Tech Days," are tailored to the needs and interests of your research and development teams. Freudenberg experts can discuss innovations, products, and advancements, and will share their insights on mechanical seal considerations, rubber and fabric selection, diaphragm styles and construction, and other factors specific to your custom diaphragm needs.

An excellent example of Freudenberg sealing solutions is contained in a case study of Flotronic's successful project in collaboration with Freudenberg-NOK Sealing Technologies.

To download the pdf, please visit:

<http://www.simritna.com/news/brochures/Simrit-Case%20Study-Flotronic.pdf>, or simply scan the code below.



In-house testing and validation

At our in-house application test facility, we are able to design and test custom diaphragms, accurately assessing and verifying product behavior during the development. We offer a range of comprehensive tests including flow tests, consumer good life-cycle testing, and heat age or accelerated life-cycle testing, and we custom-design tests to meet customer specifications. That information provides you with the economic advantages of decreased time-to-market cycles, as well as outstanding functional reliability and quality.

Expertise in materials and quality

Our materials expertise, paired with certified quality processes, assures you of the safest, most effective seals for every application.

Integrated services

Count on Freudenberg support at every stage, from specialized product development through deployment and maintenance.

Globality

Rely on our global network for consistent quality and support everywhere in the world, with solutions tailored to local market requirements.

GLOBAL MANUFACTURING

Global manufacturing with quality assurances

Freudenberg brings you the advantage of global manufacturing operations with an array of expertise and equipment that protects the quality of your parts from design to delivery. We engage in global best practices in manufacturing, backed by extensive research and development into materials and design for every application, and common design standards across all our facilities. Our production facilities around the world ensure that manufacturing is close to customer locations.

These facilities include:

- ▶ Reichelsheim, Germany (south of Frankfurt)
- ▶ Mullutu, Estonia
- ▶ Morristown, Indiana, USA. (near Indianapolis)
- ▶ Changchun, in northeast China (turbocharger actuator diaphragm manufacturing only)



MARKETS

Solutions for Industrial Markets

With the Freudenberg material expertise, you are certain to receive the right material choice for your application. We have application experience and material certifications to design and manufacture diaphragms for many different industries including:



Fluid Handling

FLUID HANDLING

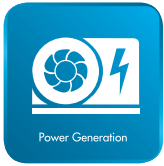
- ▶ Dosing pumps
- ▶ Feeding pumps
- ▶ Vacuum pumps
- ▶ Metering pumps



Building Engineering

BUILDING ENGINEERING

- ▶ Refrigeration and air-conditioning
- ▶ Heating regulation valves
- ▶ Water control valves
- ▶ Pressure regulator—water systems
- ▶ Pressure regulator—gas systems
- ▶ Sanitary installations



Power Generation

POWER GENERATION

- ▶ Pneumatic actuators, e.g., turbochargers, EGR valves
- ▶ Regulator valves, e.g., CNG/propane fuel delivery systems
- ▶ Carburetors



Automotive Tier

AUTOMOTIVE TIER

- ▶ Hydromounts
- ▶ SCR systems (AdBlue®)
- ▶ Crankcase ventilation systems
- ▶ Emission control systems



Fluid Power

FLUID POWER

- ▶ Accumulators
- ▶ Bladders
- ▶ Micro valves, e.g., medical applications
- ▶ Hydraulic hammer drills, e.g., rock breakers



Truck & Bus

TRUCK AND BUS

- ▶ Pneumatic brake systems
- ▶ Trailer management



Food & Beverage

FOOD AND BEVERAGE

- ▶ Food and beverage device valves



Health & Safety

HEALTH AND SAFETY EQUIPMENT

- ▶ Firefighter respirators
- ▶ Volume compensator medical devices



Aerospace

AEROSPACE

- ▶ Fuel pump
- ▶ Engine starting systems
- ▶ Safety valve
- ▶ Cabin pressure regulating system



Plant Equipment

PLANT EQUIPMENT

- ▶ Gas transportation and regulation systems

DIAPHRAGM STYLES

Every diaphragm is a tailor-made solution

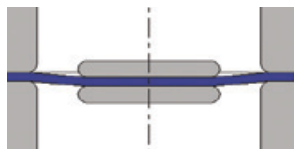
Important differences distinguish diaphragms used for control, switching, accumulation, or pumping. In addition, the operating conditions and media inherent in these various applications have a direct impact on the design of a functional diaphragm and housing. At the initial design stage, it is necessary to consider design-related conditions such as:

- ▶ Pressurization on one or both sides of the diaphragm
- ▶ Ratio stroke to diameter
- ▶ Variations of effective pressure area during stroke
- ▶ Need for an insert and/or covering using reinforcement material

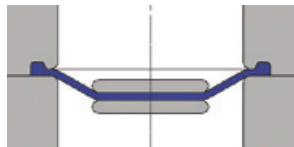
For these reasons, we develop every diaphragm in consultation with you according to the defined function.

Based on the following four fundamental shapes, we design the best configuration for your application.

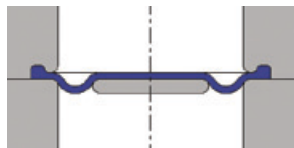
FLAT DIAPHRAGM



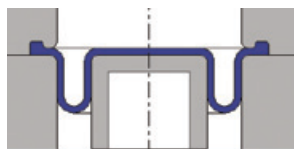
DISHED DIAPHRAGM



CONVOLUTED DIAPHRAGM



ROLLING DIAPHRAGM



DIAPHRAGM DESIGN

Fabrics and foils improve diaphragm performance

Modern technology makes use of diaphragms made solely of elastomer, as well as elastomers in combination with:

- ▶ Metal or plastic inserts for the transmission of power/stroke and support
- ▶ Fabrics for reinforcement
- ▶ PTFE foils to protect against attack from chemicals

With Freudenberg you have a partner that can offer exemplary know-how for the optimum combination of these various components to form a robust diaphragm.

Diaphragm inserts

Bonded to the diaphragm during the molding process, diaphragm inserts provide enhanced connectivity, facilitating the assembly process and conserving costs.

Benefits of inserts include:

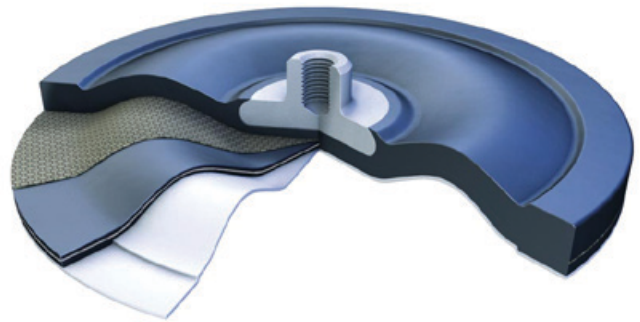
- ▶ Ease of assembly of the diaphragm
- ▶ Built-in piston-area support
- ▶ Reduction in the number of purchased parts
- ▶ A well-centered attachment point

Typical insert materials:

- ▶ Metals: stainless steel, aluminum, and brass
- ▶ Plastics: fiberglass-filled polyamide and PEEK

Fabric reinforcement

The mechanical properties of a diaphragm can sometimes be optimized with fabric and other types of reinforcement materials. To extend diaphragm life, and ultimately reduce the life-cycle costs of your products, we use fabric reinforcement made of polyester, polyamide, and aromatic polyamide. The position of the fabric reinforcement is matched to the operating conditions not only in relation to the diameter of the diaphragm but also within the layer structure.



Optimum protection through PTFE foil covering

Pure or modified PTFE foil coverings permanently affixed to the diaphragm have proven to be highly effective for shielding aggressive media, common in diaphragm pump applications. With foils made of electrically conductive material, we can supply components for ATEX-compliant units.

The case study of Polaris's project in partnership with Freudenberg–NOK Sealing Technologies provides an informative demonstration of Freudenberg sealing solutions.

To download the pdf, please visit:

<http://www.simritna.com/news/brochures/Simrit-Case%20Study-Polaris.pdf>,

or simply scan the code below.



MATERIALS

Largest choice of materials

With more than 600 conventional elastomer blends, we provide one of the world's largest materials offerings, covering virtually all standard elastomers, including:

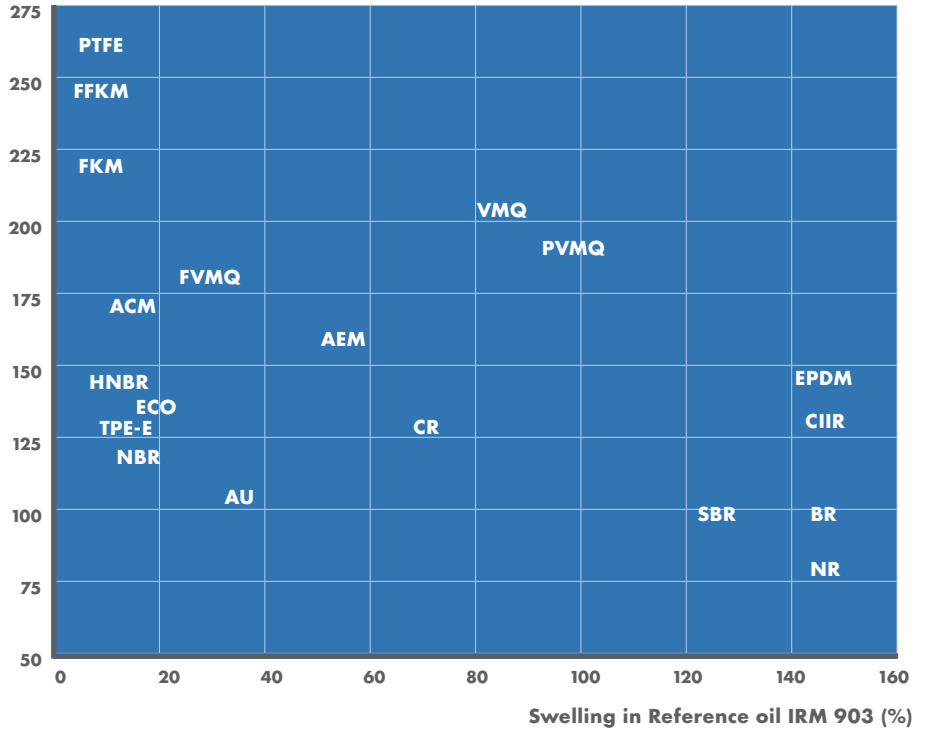
- ▶ NBR
- ▶ CR
- ▶ VMQ
- ▶ EPDM

We also utilize high-performance elastomers such as:

- ▶ CIIR
- ▶ ECO
- ▶ FKM
- ▶ CSM
- ▶ HNBR
- ▶ FVMQ
- ▶ FFKM

We have materials which conform to industry-specific application standards or are approved by original equipment manufacturers (OEMs).

Maximum Operating Temperature (°C)



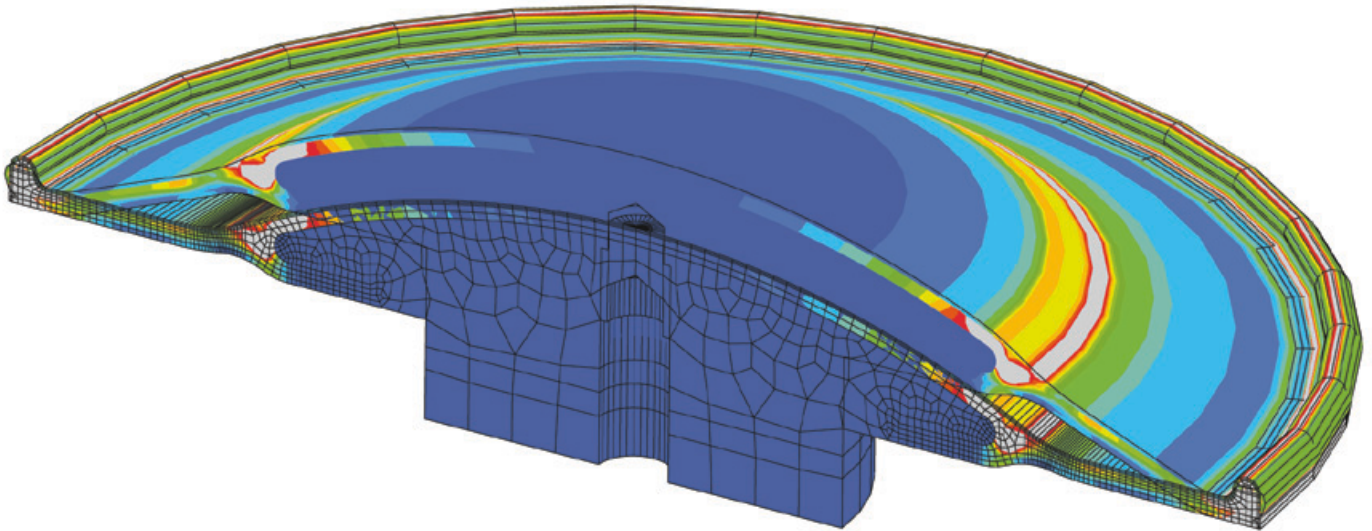
MATERIALS CERTIFICATION

Freudenberg diaphragms are manufactured from compounds certified for use in specific applications, helping to ensure that your products will comply with local, national, and international standards.

Certifications include:

FDA, KTW, ACS, USP Class VI, UL157, NSF 51, 3A (Sanitary), DVGW (German Technical and Scientific Association for Gas and Water) approval according to the norm DIN EN 549 for elastomers and fabric (NBR and FKM for gas applications in combination with different types of fabric).





FEA diagrammatic models like these provide important data for product design.

EXPERTISE

Freudenberg holds quality management certifications from international, national, and industry-specific standard-setting organizations. These include ISO/TS 16949 and ISO 9001.

Product design and validation

Freudenberg experts design every custom diaphragm to your precise specifications, and validate the design before manufacturing begins. Validation includes Finite Element Analysis (FEA) with proprietary material models and a unique Freudenberg material model for elastomers (FEA/AUTO FEA).

These rigorous procedures give you the benefits of:

- ▶ Exact product design from the beginning
- ▶ Shorter development times, which helps to lower costs
- ▶ An early start on your product simulations and developments

Our worldwide teams use the same design tools around the globe, which facilitates a quick data exchange between production partners and customers, enables simulations of tool process and potential loads, and ensures process reliability for a higher quality product.

With our engineering expertise and precision equipment, Freudenberg has diaphragms as small as 5.4 millimeters (0.2 inches) and as large as 1.1 meters (42 inches).

TESTING CAPABILITIES

Testing to validate in-use performance

Freudenberg offers a range of testing to validate that the diaphragms you order will perform to the highest standards under actual in-use stresses. Testing includes:

TEST

DESCRIPTION

HOT ENDURANCE TESTING

- ▶ Diaphragms mounted in your component
- ▶ Continuous temperature recording in hot ovens
- ▶ Climate chambers suitable for most applications
- ▶ Maximum 300°C (572°F)
- ▶ Minimum -70°C (-94°F)

HOT STEAM

- ▶ Your components mounted onto a hot steam circuit to test the diaphragms
- ▶ Up to 150°C (302°F)
- ▶ Maximum 5 bar pressure.

TENSILE STRENGTH

- ▶ Test slabs, including temperature testing
- ▶ Maximum 230°C (446°F)
- ▶ Minimum -40°C (-40°F)

COLD LIQUID

- ▶ Test bench with temperatures to -15°C (-59°F)

HYSTERESIS

- ▶ Dynamic recording for pneumatic actuators

BENDING FATIGUE STRENGTH

- ▶ Testing similar to DeMattia Flexing Fatigue Test

PERMEATION

- ▶ Testing with nitrogen performed on test slabs

CUSTOMER-SPECIFIC APPLICATION TESTS

- ▶ Ad-Blue® applications
- ▶ Dosing and feeding pumps
- ▶ Pneumatic actuators

PRESSURE PEAK SIMULATIONS

- ▶ Simulation of pressure peaks in water circuits

Freudenberg–NOK Sealing Technologies
Plymouth, Michigan, USA
Phone +1 734 451 0020
information@simrit.us

Freudenberg Sealing Technologies GmbH & Co. KG
Weinheim, Germany
Phone +49 6201 80 6666
info@simrit.de

NOK–Freudenberg Group Trading (China) Co. Ltd.
Shanghai, China
Phone +86 21 5036 6900
simrit@nfgc.com.cn