The BlueSeal is one design suited for future engine dynamic sealing.

This patented Simmerring® shaft seal technology offers weight savings of 40 percent compared to a conventional seal, and it requires only half as much installation space.

A specific design has been developed to be mechanically resistant to high pressures, while the PTFE material of the seal lip stands up to aggressive substances.

VALUES FOR THE CUSTOMER

The BlueSeal technology has been developed specifically to achieve the following advantages:

- PTFE chemical inertia
- Low-friction POP® lip design
- Axial space reduction which allows for downsizing the engine or could also be used for additional functional space
- Weight reduction
## FEATURES AND BENEFITS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effect</th>
<th>Result for customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE as single material</td>
<td>• Use of all PTFE advantages</td>
<td>• Full compatibility with oils and fuels</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fits with a global use in different regions of the world</td>
</tr>
<tr>
<td>Low friction (PTFE POP® lip design)</td>
<td>• Small dissipation loss</td>
<td>• Mass production with PTFE POP lip</td>
</tr>
<tr>
<td></td>
<td>• Temperature reduction in the contact area</td>
<td>• Higher efficiency</td>
</tr>
<tr>
<td></td>
<td>• Good performance in engine conditions</td>
<td>• Reduction of shaft wear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduction of oil carbonization</td>
</tr>
<tr>
<td>Downsized design</td>
<td>• Minimum height required for a BlueSeal –50% compared to traditional seals</td>
<td>• More compact than solutions available on the market</td>
</tr>
<tr>
<td>Weight reduction</td>
<td>• Reduction down to –40% compared to traditional seals</td>
<td>• Contribution to CO₂ emission reduction</td>
</tr>
<tr>
<td>Pumping effect</td>
<td>• Seal lubrication</td>
<td>• Increased sealing system durability</td>
</tr>
<tr>
<td></td>
<td>• Perfect sealing behavior</td>
<td></td>
</tr>
<tr>
<td>Specific design</td>
<td>• Higher resistance to pressure</td>
<td>• Robust design for applications like injection pumps</td>
</tr>
</tbody>
</table>

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www.fst.com
Energy saving up to 70% on your engine seals

CASCO cassette-type seals generate a much lower friction compared to other lip-design engine seals, due to the specific design of its “axial” sealing lip.

Endurance over 1,000,000 miles (1.6 million kilometers)

CASCO seals have been continuously tested in our labs for over 25,000 hours—equals almost 1 million miles—and show a negligible wear after testing. These results are confirmed by testing on light- and heavy-duty vehicles, now exceeding 310,000 road miles.

Reliability in the most extreme working conditions

CASCO cassette seals successfully passed a number of tests representing polluted environments: in used oil containing high percentages of carbon deposits; in low-temperature conditions; as well as with high eccentricity and axial play of the engine crankshaft. CASCO demonstrates superior performance even in the most difficult conditions.

VALUES FOR THE CUSTOMER

- Given an average of 100,000 km/year for a Light Commercial Vehicle (LCV) and 200,000 km/year for a Heavy Duty Truck (HDT), the energy savings generated in one year by each engine equipped with CASCO seal at the crankshaft (front and rear) can then be calculated approximately in 800 KWh for the LCV and 1500 KWh for the HDT, or 2300 KWh in total. This means saving almost 227 liters of diesel each year.

- Each gallon of diesel pollutes the atmosphere with 9.8 kilograms of CO₂.

- Taking into account the current volume supplied for the two vehicles considered above, CASCO seals will contribute a reduction of about 50,000 tons (45,360 metric tons) per year in CO₂ emissions.
FEATUERS AND BENEFITS

- A tailor-grooved, axially-loaded, rubber sealing lip, with combined pump and centrifugal effect for enhanced sealing performance, and a "hovercraft effect" between the sealing lip and working counter-surface results in very low wear.

- CASCO cassette seal power loss level is unchanged when increasing shaft diameters (Graphs 1 and 2), while other crankshaft seal designs show increasing power loss behavior.

- CASCO is less sensitive to negative oil ageing effects (Graph 3). Power loss level remains stable, providing beneficial effects throughout the entire lifetime of the seal while carbon residuals are “pumped away” from the sealing lip area, preventing stacking and leakages.

Graph 1. Power loss vs rpm (shaft Ø 85 mm)

Graph 2. Power loss vs rpm (shaft Ø 135 mm)

Graph 3. Power loss vs oil aging (shaft Ø 85 mm)

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www.fst.com
New powertrain modules, with a focus on lightweight designs and reduced material usage, are challenging the limitations of traditional press-in-place (PIP) gaskets.

The Freudenberg Sealing Technologies’ Curve Gasket with greater stability, lower reaction forces and wider compression ranges supports the trend of using thermoplastic engine covers over other materials. The innovative geometry supports engine weight reduction by minimizing the amount of structural plastic required at the cover flange.

The design principles used to stabilize metallic sheets with corrugated waves are applied to the design of the Curve Gasket. These corrugated waves on the gasket provide stability against buckling.

The patented* Curve Gasket uses a combination of constant and undulated cross-sections to achieve dimensional stability and lower reaction forces, while maintaining the highest standards of sealing performance and durability required for all Freudenberg Sealing Technologies gaskets in extreme conditions.

Combinations of cross-sections are fine tuned to optimize the gasket performance depending on the sealing application.

VALUES FOR THE CUSTOMER

The Curve Gasket helps overcome the design challenges for PIP gaskets, especially for thermoplastic covers.

- Curve Gasket meets all the new design requirements for these applications:
- Extends the engineering specifications for PIP gaskets in a groove
- Increases the sealing performance under low compression level
- Provides a better use of material
- Curve Gasket allows smaller grooves and achieves perfect sealing while supporting our customers efforts to use less material on their components.

* Patent pending

**Freudenberg Sealing Technologies**

**Innovating Together**
FEATURES AND BENEFITS

The Curve Gasket design comprises at least one portion with a constant section and at least one portion with an undulated, continuously variable section.

- **Void Volume** — even at elevated temperatures that typically cause gasket expansion issues, the Curve Gasket design prevents the gasket from exceeding the void volume limit.

- **Reaction Forces** — the Curve Gasket’s unique design produces lower reaction forces even at extreme compression levels (e.g., MMC, Maximum Material Condition) and consequently reduces any potential deformation of the mating components.

- **Compression Set Lifetime** — the Curve Gasket design allows a shift of compression range to a higher level while reducing reaction forces, allowing selection of the most suitable material for a longer lifetime.

The Curve Gasket’s undulated cross-section achieves lower reaction forces while maintaining the highest standards of sealing performance and durability required for all Freudenberg Sealing Technologies gaskets in extreme conditions.

The Curve Gasket offers our customers more press-in-place gasket solutions than ever before.
Oversized flat flange elastomeric gaskets are used to seal large perimeters in applications such as battery enclosures and oversized covers or pans. This type of gasket presents specific challenges for cost effective design, tooling, and production processes.

Freudenberg Sealing Technologies’ Deformed Large Format Gasket (DLFG) uses a patented* design and molding process to enable injection molding of oversized flat flange gaskets on conventional-sized presses.

**Design principle**—straight sections of the gasket are shaped around corners in the mold layout. To allow these curved sections to straighten for use in the application, parts of the gasket design are cut away.

The patented Deformed Large Format Gasket design* uses cut-outs in only the areas of the gasket that do not affect the sealing function.

The Deformed Large Format Gasket’s patented design reduces development time and allows cost effective manufacturing of oversized flat flange elastomeric gaskets.

**VALUES FOR THE CUSTOMER**

- The deformed molding design saves on both the press and tooling costs by fitting the gasket shape into a smaller area. It also helps to reduce gasket development time.
- The patented deformation design allows bending of straight sections so the gasket fits a standard sized molding tool.
- Once in the final application, there is no loss of durability or gasket sealing performance in the sections deformed during manufacture.

FEATURES AND BENEFITS

The DLFG design process is for flat flange elastomeric gaskets. To fit the gasket into the usable area of a standard mold, cut-outs are used in areas of the gasket design that do not affect the sealing function.

- **Applications**— flat flange gaskets for sealing large perimeters such as battery enclosures and oversized covers or pans.
- **Typical Size**— the DLFG process allows molding of gaskets up to 100% larger than with conventional non-deformed gaskets.
- **Materials**— standard compound options include ACM, EPDM, HNBR, and FKM.
- **Performance**— the cut-outs do not affect the gasket sealing function in the application.

With our patented design* the DLFG maintains the highest standards of sealing performance and durability required for all Freudenberg Sealing Technologies gaskets in extreme conditions.

With the Deformed Large Format Gasket, you have more gasket solutions than ever before.

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www.fst.com
Made of PTFE, Duo Forseal U-packings are pressurized and feature metallic pretension springs. These rings seal both statically and dynamically at temperatures ranging from –200 °C to 260 °C.

**Ultimate Design for any application**, the standard PTFE compound is resistant to hydraulic fluids, oil, water, steam, air, solvents, and all media that do not attack PTFE and stainless steel. A broad range of PTFE compounds and spring material is offered to ensure the ultimate design for your specific application.

**Duo Forseals are highly resistant to aggressive media**, thermal influences, friction, and wear. Commonly used for stroke movement, rotations, as well as for purely static sealing solutions.

**Freudenberg Sealing Technologies** automatic inspection system provides flexible testing for standard and enhanced product. This dedicated, specially developed equipment, inspect both measured and visual characteristics.

**VALUES FOR THE CUSTOMER**

**Standard sizes plus customized solutions** make Duo Forseal U-packings ideal for many applications, such as direct injection high-pressure fuel pumps, EGR valves, brake and suspension systems.

**CUSTOM**

- Customized solutions for individual applications
- Fast prototyping
- Test bench available for pre-validation test

**GENERAL**

- Highly automated mass production
- Net-molding possible option for high-volume applications
- High-performance PTFE compound
- Latest CNC technology
- Fully automatic machining process
- Sophisticated spring production
- Automatic spring assembly
FEATURES AND BENEFITS

Application Example: High-pressure fuel pumps

- Double acting, media separation of oil and fuel
- Easy assembly due to symmetric design
- Universal resistance to all fuel types including 100% ethanol (E100)
- Reliable radial forces due to stainless steel spring
- Good wear resistance to the DLC-coated plunger
- 3-5 strokes/camshaft revolution
- >200 Hz frequency
- Durability expected > one billion strokes
- Seal-pressure up to 30 bar (pump 300 bar)
- Low leakage rate
- Usable for gasoline and diesel applications.
- State-of-the-art for all European GDI-pumps
- Most common stem size 6 mm for gasoline applications
- Most common stem size 6.5 mm for diesel applications
Freudenberg Sealing Technologies manufactures multipole encoders that are used in wheel bearings, drive shafts, gear shafts, crankshafts, and camshafts of internal combustion engines, axial piston engines, wind turbines, and other applications.

Our encoders have a magnetized rubber exterior consisting of alternating north and south poles. Our encoder compounds can be tailored to particular application needs. Both the magnetic strength and pole size can also be customized to fit your exact specifications. The encoder’s magnetic field extends out of the body to the sensitive element within the sensor (diagram below). From a quality standpoint, the multipole encoder is perfectly defined because it gives a part’s characteristics at the exact position where the signal is measured by the sensing element, providing an ideal technical interface.

Due to its high accuracy, narrow design, and robust construction, the multipole encoder delivers key advantages over mechanical transmitter wheels in radial and axial signal detection. The detection of rotation angle positions is also possible. Whether custom-made or standard (in sizes 40 mm to 200 mm), our multipole encoders have an impressive track record with automotive and general industry customers worldwide.

The invisible magnetic field (yellow wave) can be customized to particular specifications.
FEATURES AND BENEFITS

- Our multipole encoders are available with radial or axial signal detection
- Standard dimensions available from 40 mm to 200 mm
- These products are part of a system consisting of the multipole encoder, magnetic field sensor, and evaluation unit
- Our experts assist in sensor selection
- A magnet in the sensor is eliminated
- Our encoders come with compounds tailored to the specific application, consisting of an elastomer and magnetic hard filler material
- Our experts assist in sensor selection

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Freudenberg Sealing Technologies radial shaft Energy Saving Seals (ESS™), demonstrate significant reduction of power loss in drive assemblies as opposed to standard sealing elements. By combining a special elastomer and a revolutionary new design, this shaft seal is able to maintain the pressure force at a consistently low level over a wide range of RPM, even at a higher sealing operating temperature. The low radial force of the main lip ensures the optimization of sealing function, abrasion resistance, and friction.

Features of Energy Saving Seals:

- High performing FKM rubber provides resistance to extreme engine conditions which include large temperature fluctuations and aggressive synthetic oil
- Optimized sealing design to reduce the friction up to 40% compared to a conventional PTFE lip
- Outer diameter in full rubber or half metal/rubber to ensure a safe assembly and proper retention over all engine conditions and application parameters

VALUES FOR THE CUSTOMER

The Energy Saving Seals (ESS) technology has been developed specifically to achieve the following advantages:

- Increases engine efficiency, reducing power consumption and improving fuel economy
- Significantly reduces friction between the seal lip and shaft
- Lowers seal lip temperature
- Virtually eliminates coked oil failure mode
- Reduces heat aging (hardening) of rubber
- Maintains sealing performance at large shaft to bore misalignments

Freudenberg Sealing Technologies superior customer service in all customer contact areas provides consistent and excellent service starting with the engineering team’s commitment to design and validation support, through all aspects of production quality checks, order scheduling, and safe assembly.

Our world-class manufacturing processes achieve consistent quality control in the production of ESS, Energy Saving Seals, and all our products.
ENERGY SAVING SEALS—ESS™

**FEATURES AND BENEFITS**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effect</th>
<th>Result for customer Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimized sealing design, fewer components</td>
<td>Sealing lip geometry creates reduced radial load that does not require a spring to provide consistent sealing as the seal ages. This reduced radial load coupled with helix geometry results in low friction sealing.</td>
<td>Reduced CO₂ emissions and increased sealing system durability</td>
</tr>
<tr>
<td>Rubber sealing lip contact</td>
<td>Best-in-class performance for air leak test</td>
<td>Reduces &quot;false failures&quot; due to the air leak test on assembly lines</td>
</tr>
<tr>
<td>Rubber lip geometry and flexibility</td>
<td>Optimal lip contact on the shaft even in conditions that exceed manufacturing and assembly tolerances</td>
<td>Superior dynamic sealing in extreme running conditions</td>
</tr>
<tr>
<td>FKM rubber material</td>
<td>Best-in-class compression set allowing long running duration</td>
<td>Increased sealing life time</td>
</tr>
</tbody>
</table>

**Power conservation with ESS, Energy Saving Seals**

![Graph showing power loss vs. shaft diameter for different seals.]

- Standard FKM Seal
- Standard PTFE Seal
- PTFE POP® Seal*
- ESS, Energy Saving Seal

*Please refer to our PTFE POP® Seal datasheet

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www.fst.com
FLUOROXPRENE® MATERIALS

Processes like a plastic, behaves like rubber. FluoroXprene materials have nearly the chemical resistance of PTFE but perform almost like a rubber. FluoroXprene fluorinated thermoplastic elastomers are unique materials that bridge the technology gaps between PTFE and rubber.

Two phase morphology allows for customization by adjusting the ratio of fluoro thermoplastic and fluoro elastomer.

FluoroXprene materials compounding allows for a change of characteristics. By changing the ratio of plastic to rubber (or the type of plastic and/or type of rubber) its characteristics can be changed or modified for specific applications.

VALUES FOR THE CUSTOMER

FluoroXprene materials demonstrate a number of important characteristics that make it superior to other elastomeric and thermoplastic materials.

- Improved creep resistance versus traditional thermoplastics
- High temperature and chemical resistance
- Higher flexural strength versus traditional elastomeric material
- Unmatched fuel permeation resistance compared to FKM rubber
- Allows, for the first time, a thermoplastic elastomer material to be used in demanding applications regarding chemical and thermal resistance
- Ease of processing
- Recyclable

AFM micrograph of FluoroXprene showing the unique two-phase morphology
FEATURES AND BENEFITS

A comparison of FluoroXprene to both PTFE and standard rubber demonstrates the clear advantage of FluoroXprene.

<table>
<thead>
<tr>
<th></th>
<th>PTFE</th>
<th>Rubber</th>
<th>FluoroXprene</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High chemical resistance</strong></td>
<td>Limited chemical resistance</td>
<td>High chemical resistance</td>
<td></td>
</tr>
<tr>
<td><strong>Complex process: heat, pressure, time (hours)</strong></td>
<td>Net shape molding: heat, pressure, time (minutes)</td>
<td>Net shape molding: pressure, time (seconds)</td>
<td></td>
</tr>
<tr>
<td><strong>Not recyclable</strong></td>
<td>Limited recycling possible</td>
<td>100% recyclable</td>
<td></td>
</tr>
<tr>
<td><strong>Concerns with dimensional stability under load; creep</strong></td>
<td>Dimensional stability is function of crosslink density and chemical/thermal environment</td>
<td>More dimensionally stable than conventional plastics due to ability to radiation treat causing cross linking of the elastomer phase to the plastic phase</td>
<td></td>
</tr>
<tr>
<td><strong>Simple modifications possible</strong></td>
<td>Substantial variations possible through compounding</td>
<td>Substantial variations possible through compounding</td>
<td></td>
</tr>
<tr>
<td><strong>No elastic behavior</strong></td>
<td>Highly elastic</td>
<td>Highly elastic</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of physical properties for FluoroXprene and FKM elastomer

<table>
<thead>
<tr>
<th></th>
<th>FKM control</th>
<th>FluoroXprene</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardness (Shore A)</strong></td>
<td>80 ~ 95</td>
<td>80 ~ 100</td>
</tr>
<tr>
<td><strong>Tensile strength (MPa)</strong></td>
<td>6.0 ~ 12.0</td>
<td>2.0 ~ 25.0</td>
</tr>
<tr>
<td><strong>Elongation at break (%)</strong></td>
<td>100 ~ 300</td>
<td>10 ~ 350</td>
</tr>
<tr>
<td><strong>Compression set (70 h @ 150 °C in air)</strong></td>
<td>15 ~ 50</td>
<td>27 ~ 55</td>
</tr>
</tbody>
</table>

Comparison of fuel permeation resistance for FluoroXprene and FKM (ASTM D-814, CE10 Fuel, 30 days @ 40 °C)

<table>
<thead>
<tr>
<th></th>
<th>Permeation rate (g/m²/day)</th>
<th>Permeation constant (g-mm/m²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FKM (Ter-polymer)</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>FKM (Co-polymer)</td>
<td>29</td>
<td>55</td>
</tr>
<tr>
<td>FluoroXprene</td>
<td>1 ~ 4</td>
<td>2 ~ 8</td>
</tr>
</tbody>
</table>

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www.fst.com
The Freudenberg Hydraulic Piston Accumulator consists of two components: a gas chamber and a fluid chamber, with a gas-proof piston seal separating the components.

The fluid chamber is directly connected to the hydraulic circuit within the application. When the pressure in the hydraulic circuit rises, the accumulator stores the hydraulic fluid and the nitrogen-filled gas chamber becomes compressed.

Minimizing the loss of hydraulic pressure is the primary benefit and the reason for using hydraulic accumulators within a hydraulic circuit. Hydraulic accumulators also decrease the consumption values and reduce CO₂ emissions.

VALUES FOR THE CUSTOMER
Customized solutions enable the hydraulic piston accumulator to become an excellent component in a variety of product applications, such as automated control gears, dual clutch transmissions, and start-stop systems.

Customer-Specific Benefits
- Customizable designs
- Rapid production of prototypes
- Test stand for pre-validation tests available
- The engineering process is optimized to meet the specific requirements of the given application

General Product Information
- High-quality seal material with low permeation
- Fully automatic assembly procedure
- Possibility of a high piston speed
- Small hysteresis
- High durability and low maintenance
- Compact design
The LEVITEX seal is a cost-optimized, dry gas seal, which can be assembled on a combustion engine crankshaft in place of a conventional oil seal. This concept of dry gas sealing is already in mass production in many different applications, e.g., steam turbines, turbochargers, and compressors.

It operates with two interacting surfaces containing high precision micro-structures. This basic function generates a very stable gas film in the magnitude of a few micro meters, which prevents oil leakage.

The low viscosity in the gas film leads to a friction close to zero. The high rigidity of this gas film guarantees a safe function under all conditions. Additionally, running in this mode without rigid body contact, the LEVITEX seal has virtually no wear.

Compared with friction-optimized Simmerring shaft seals, there is an emissions reduction potential of approximately 0.5 to 1.0 g CO₂/km. Considering future development in global emissions regulations, OEMs can take a great step towards the specified aims.

VALUES FOR THE CUSTOMER

Energy Efficiency by Friction Reduction
CO₂ emissions caused by main oil seal inefficiency in a 1.6 liter engine with a double-clutch transmission

Friction Comparison: LEVITEX versus standard PTFE shaft seals
FEATURES AND BENEFITS

- Dry gas seal for crankshaft applications
- Shaft speeds of 8,000 rpm and higher are possible
- Higher pressure and underpressure stability and performance than standard oil seals
- Coated sealing surfaces
- Operating temperatures –40 °C to 150 °C
- CO₂ emission reduction of between approximately 0.5 and 1.0 g CO₂/km at NEDC
- Minimized friction torque due to optimized design typically < 5W friction power @ 2000 rpm
- Wear resistant (also with Start-Stop)
- No lubrication is needed
- Reduction of shaft surface finishing compared to standard oil seals
- Dry-sump lubrication is possible because there are no issues with boundary lubrication and under-pressure

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FREUDENBERG-NOK
SEALING TECHNOLOGIES

FREUDENBERG-NOK
INNOVATING TOGETHER
LOW FRICTION SIMMERRING® SHAFT SEALS

VALUES FOR THE CUSTOMER

- ACM 380 DF: better relaxation characteristics and bigger temperature range (–40 °C to 175 °C) compared to classic ACM
- Lower friction compared to conventional sealing lip profile: 15 to 20%
- Lower price compared to FKM seals due to special ACM for high temp
- Higher ability for high speed and high temp applications
- Less sensitivity during assembly compared to ESS

NEW HIGH TEMPERATURE ACM

Advantages of high temperature ACM 380 DF compound:

- Better relaxation characteristics and bigger temperature range (–40 °C to +175 °C)
- Excellent compatibility with the additives of the new generation of oils for gearboxes and axles
- Inline with the current environmental protection requirements such as EU regulations and REACH

LOW FRICTION SIMMERRING Shaft Seals

Standard Simmerring shaft seal

Low Friction Simmerring shaft seal (LFS)

Energy Saving Simmerring shaft seal (ESS)
Low Friction Simmerring Shaft Seals

FEATURES AND BENEFITS

Comparative features of the LFS and ESS versus the standard Simmerring® shaft seal

<table>
<thead>
<tr>
<th></th>
<th>Standard Simmerring shaft seal</th>
<th>LFS, Low Friction Seal</th>
<th>ESS, Energy Saving Seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction</td>
<td>good</td>
<td>very good</td>
<td>outperforming</td>
</tr>
<tr>
<td>High Speed/High Temp</td>
<td>good</td>
<td>very good</td>
<td>outperforming</td>
</tr>
<tr>
<td>Dirt</td>
<td>very good</td>
<td>very good</td>
<td>inferior</td>
</tr>
<tr>
<td>Assembly</td>
<td>outperforming</td>
<td>outperforming</td>
<td>inferior*</td>
</tr>
<tr>
<td>Air Leakage (end of line test)</td>
<td>outperforming</td>
<td>outperforming</td>
<td>inferior*</td>
</tr>
</tbody>
</table>

*Only for input seal with specified assembly line

The Low Friction Simmerring shaft seal demonstrates 15-20% lower friction in comparison to the conventional sealing lip (AT vs LFS)

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FREUDENBERG SEALING TECHNOLOGIES
Plug & Seal Connectors

Plug & Seals are rubber-coated pipe sections that create a safe, leak-free connection between housings. A secure, low-cost solution for the transport of air, water, and oils, they can combine several functions in a single component and compensate for conduit misalignment and tolerance variations. Plug & Seals are available in a wide variety of elastomer coatings.

Plug & Seals are useful in a wide range of applications including:

- Water and oil circuits
- Air routing systems of internal combustion engines
- Ancillary engine components such as superchargers, turbochargers or intake manifolds
- Automatic and manual transmission systems
- Valve and pipework systems
- Heating and air-conditioning systems

VALUES FOR THE CUSTOMER

Plug & Seal plug connections from Freudenberg Sealing Technologies provide many technical and cost benefits:

- Create a reliable seal even in high-pressure applications
- Give simple, secure, and low-cost fitting
- Ensure acoustic and mechanical decoupling
- Minimize maintenance costs due to greatly improved service life
- Compensate for misalignment and permit greater tolerances on installation
- Reduce logistics costs
- Combine several functions in a single component
- Offer clear benefits through lower total cost
- Design development according to customer-specific requirements
Plug & Seal Connectors

FEATURES AND BENEFITS

FLEXIBLE COMPONENTS

Selection of materials
Rubber coatings and shock absorption are available with modern elastomer materials—for a range of different physical requirements. Customers are also free to choose the base material of the pipe section: steel, aluminium or plastic. Thanks to the flexible range of materials the plug connections can be used in virtually all sectors of fluids and gas transport.

Plug & Seal Connectors are designed according to customer specifications and are also available in standard dimensions for quick sampling.

Dimensions available for quick sampling in bold:

<table>
<thead>
<tr>
<th>External diameter* [mm] Plug &amp; Seal (A)**</th>
<th>Locating bore [mm] (acc. to H8) (B)***</th>
<th>Internal diameter pipe [mm] (R1)</th>
<th>Plug &amp; Seal Length [mm] (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.5</td>
<td>15</td>
<td>10</td>
<td>20 25 30 40 50 60</td>
</tr>
<tr>
<td>20.7</td>
<td>20</td>
<td>14</td>
<td>20 25 30 40 50 60</td>
</tr>
<tr>
<td>25.9</td>
<td>25</td>
<td>18</td>
<td>20 25 30 40 50 60</td>
</tr>
<tr>
<td>30.9</td>
<td>30</td>
<td>22</td>
<td>20 25 30 40 50 60</td>
</tr>
<tr>
<td>40.9</td>
<td>40</td>
<td>32</td>
<td>20 25 30 40 50 60</td>
</tr>
</tbody>
</table>

Wall thickness of base part (b):
1.0 mm (Plug & Seal for locating bore 15, 20, 25 mm)
1.5 mm (Plug & Seal for locating bore 30, 40 mm)

*Not all dimensions available
**Minimum compression of 15%
***Recommended values, depending on elastomer base material: steel (bonderised)

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www.fst.com
The Freudenberg Sealing Technologies PTFE POP Seal is designed for reduced friction in automotive drive assemblies as opposed to standard sealing elements. Especially in turbocharged combustion engines the seal proves robustness against the pressure conditions that are considerably different to those in naturally aspirated engines.

The surface structure of the contact area of the sealing lip made of polytetrafluoroethylene has an optimized helix to provide a micro pump effect, ensuring perfect sealing behavior and—due to the lubrication—a minimized power loss.

Freudenberg Sealing Technologies’ superior customer service in all customer contact areas provides consistent and excellent service starting with the engineering team’s commitment to design and validation support, through all aspects of production quality checks, order scheduling, and safe assembly.

Our world-class manufacturing processes achieve consistent quality control in the production of PTFE POP Seals, and all our products.

VALUES FOR THE CUSTOMER

The PTFE POP technology has been developed specifically to achieve the following advantages:

- Dynamic sealing efficiency improved (micro pump principle)
- Friction reduction = power consumed = reduction of the fuel consumption
- Reduction of the temperature in the contact area
- No oil carbonization
- No shaft wearing

Features of PTFE POP Seal

- Material provides resistance to extreme engine conditions which include large temperature fluctuations and aggressive synthetic oil
- Optimized sealing design to reduce the friction up to 30% compared to a conventional Simmerring shaft seal lip
- Outer diameter in full rubber to ensure a safe assembly and proper retention over all engine conditions and application parameters
- Also optional as modules in a variety of housing materials
- Available in integrated thermoplastic housing with static seal, reducing overall weight and installation complexity
FEATUR ES AND BENEFITS

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Effect</th>
<th>Result for Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low friction PTFE lip</td>
<td>• Reduced power loss</td>
<td>• Reduced CO₂ emissions</td>
</tr>
<tr>
<td></td>
<td>• Temperature reduction in the contact area</td>
<td>• Reduction of shaft wear</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduction of oil carbonization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compatibility with oils and fuels</td>
</tr>
<tr>
<td>Sealing lip contact</td>
<td>• Good performance in specific engine</td>
<td>• Improved dynamic sealing efficiency</td>
</tr>
<tr>
<td></td>
<td>conditions</td>
<td>• Reliable sealing durability</td>
</tr>
<tr>
<td></td>
<td>• Better resistance under pressure in the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>engine</td>
<td></td>
</tr>
<tr>
<td>Pumping effect</td>
<td>• Seal lubrication</td>
<td>• Increased sealing system durability</td>
</tr>
<tr>
<td></td>
<td>• Perfect sealing behavior</td>
<td>• Reliable sealing durability</td>
</tr>
</tbody>
</table>

Power conservation with PTFE POP Seals

- Standard FKM Seal
- Standard PTFE Seal
- PTFE POP® Seal
- ESS™, Energy Saving Seal*

*Please refer to our ESS™ Seal datasheet

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PROFILE TO GASKET: P2G

PRODUCT DESCRIPTION

Housings—Sealing with Extruded Profiles

Whether they are stationary or portable, housings must be sealed reliably to protect gearboxes, motors, batteries, or transformers properly and keep them operating reliably. The housing’s gasket plays a critical role in achieving this goal.

Freudenberg Sealing Technologies’ newly developed product, Profile to Gasket (P2G), offers an extremely economical and technically efficient solution. The gasket profile, which is manufactured as a linear extrusion and is fabricated via water-jet cutting, can be custom-cut to match the various corners and straight runs in the installation space.

Fabrication of the entire profile extrusion in a single piece avoids unnecessary joints, even with very large and complex housings, creating a sealing system that is reliable with long service life. Materials expertise that Freudenberg has built up over decades helps to achieve dependable performance: P2G solutions can be implemented using materials that are ideally suited for specific applications.

Very low tooling costs make P2G especially suitable for low-volume production. Production and delivery lead times are short, providing quick response to customer requests. And there are also environmental advantages. Compared with conventional frame-type gasketing systems, almost no waste occurs in the P2G manufacturing process. That all adds up to making P2G the solution tailor-made for housings and containers.

Functional Areas:

1. Sealing area (has just one seam, which is closed when the ends are bonded together)
2. Transition area (protects the gasket from tearing)
3. Cutting and punching area for fixing the position of the profile in the installation space. Limits displacement and serves as an abutment to protect the sealing area.
FEATURES AND BENEFITS

- High recovery
- High impermeability to gases
- Long service life
- Can be installed in force-fit connections
- Excellent seal at a single adhesively bonded joint
- Less waste ("more sustainable") compared with a punched gasket
- Mounting system is integrated into the gasket
- Low tooling costs
- Virtually no size limitations
- Highly flexible with regard to changes in housing geometry

P2G compared with other methods:

<table>
<thead>
<tr>
<th>Function/Process</th>
<th>Flat gasket</th>
<th>P2G</th>
<th>Tooling-specific molded gasket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tooling costs</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Material consumption</td>
<td>– –</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Flexibility</td>
<td>+</td>
<td>++</td>
<td>– –</td>
</tr>
<tr>
<td>Functionality (tolerance compensation)</td>
<td>–</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Installation</td>
<td>+</td>
<td>–</td>
<td>++</td>
</tr>
<tr>
<td>Maximum size</td>
<td>–</td>
<td>++</td>
<td>– –</td>
</tr>
</tbody>
</table>

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Freudenberg sealing modules provide a solution for any engine configuration. Composite seal modules can be produced in a wide variety of materials and they may contain a bore or retainer.

Our best-in-class sealing modules can be customized to meet customer demands and requirements. Our vast sealing experience with FEA tools allow Freudenberg to deliver innovative sealing solutions for your application needs.

VALUES FOR THE CUSTOMER

- Fully integrated solutions, with one component and one development, makes possible a safe and easy assembly
- Contributes to reduction in CO₂ emissions
- Fits every type of engine with a large choice of retainer materials and lip technologies
- Very efficient design-to-cost approach

<table>
<thead>
<tr>
<th>Sealing Module</th>
<th>Effect</th>
<th>Results for Customers</th>
</tr>
</thead>
</table>
| CS             | • Integrated sealing (static and dynamic) system with retainer | • Integrated static and dynamic sealing  
• Robust design and increased lifetime  
• Reduction of assembling and logistic costs  
• Weight reduction (plastic-, aluminum-stamped) |
| CSWS           | • Dynamic sealing of the crankshaft  
• Static sealing of the flange integrated  
• Speed and crank position measurements | • Reduced space requirements  
• Weight reduction (plastic materials)  
• Very accurate signal  
• Rotation direct detection  
• Less parts provide for a reduced assembling effort  
• Integrated solution  
• Robustness  
• Design-to-cost consideration |
| RWDS®          | • Integrated system for engines with a bore  
• Dynamic sealing of the crankshaft  
• Combined solution of sealing and sensing functions | • Downsized design  
• Weight reduction  
• Very accurate signal  
• Dynamic seal |
Many traditional radial shaft seals are used in hybrid and purely electric vehicles. However, in the transmission or E-drive unit of an electrically powered vehicle, the input shaft may become electrically charged resulting in a positive charge travelling through various components in the gear box damaging the gears and other moving components.

The Simmerring shaft seal with electrically conductive nonwoven fabric eliminates this risk through a fleece ring glued onto the air side of the seal. Because the carbon fiber-PTFE nonwoven material contacts both the shaft and the housing, the design forms a conductive bridge which grounds the gear box preventing mechanical system damage.

By adding this function to the Simmerring it is possible to eliminate additional components used to ground the unit, saving costs.

In addition to the conductive bridge, the fleece ring also excludes contamination from the primary sealing lip.

**VALUES FOR THE CUSTOMER**

The Simmerring shaft seal with integrated electro conductive bridge:

- Provides a cost-efficient alternative compared to traditional solutions
- Is a more compact solution, saving space and weight
- Delivers extended service life due to the mechanical properties of the electrically conductive fleece
- Offers additional contamination protection

**ADVANTAGES OF THE ELECTRICALLY CONDUCTIVE NONWOVEN MATERIAL**

- Special mechanical properties
- Excellent electrical conductivity (resistance value <10 Ohm)
- Very wide temperature range (−40 °C to +250 °C)
- Nearly temperature-independent electrical conductivity
- Good air permeability prevents vacuum build up under sealing lip at high speed

**FREUDENBERG SEALING TECHNOLOGIES**

**FREUDENBERG INNOVATING TOGETHER**
**FEATURES AND BENEFITS**

Compare these important features between traditional solutions versus Simmerring with electrically conductive nonwoven material

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Simmerring® with Electrically Conductive Nonwoven Material</th>
<th>Carbon Brush</th>
<th>Jumper Ring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Space-saving in the unit</td>
<td>++</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Service life</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conductivity</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Contamination due to abrasion of the component and the opposing surface</td>
<td>++</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Friction</td>
<td>++</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Temperature coefficient of the electrically conductive nonwoven material:** Constant resistance values over a wide temperature range

**Comparison of friction torque:** Simmerring® with and without electrically conductive nonwoven material

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FREUDENBERG SEALING TECHNOLOGIES
Freudenberg Sealing Technologies valve stem seals control leak rate for the life of the engine to assure correct guide lubrication while avoiding excessive oil consumption.

Prevent any flow of blow-by gas from the manifold to the engine head with: special metal case for improved seal retention, special lip geometry to further increase Lip Opening Pressure (LOP).

Freudenberg Sealing Technologies valve stem seals are produced from high-performance materials which lead to increased lifetime and lower wear. They are supplied in a variety of geometries to satisfy different assembly needs. Different valve stem seal types are also available to match customers’ application requirements.

VALUES FOR THE CUSTOMER

Freudenberg Sealing Technologies valve stem seals offer premium service capabilities:

Engine performance benefits

- Improve engine (mechanical) performance
- Constant performance over life of the engine
- Reduced valve train wear rate
- Increased engine efficiency

Freudenberg–NOK also promotes:

- Product development for customers’ specific requirements and needs
- State-of-the-art manufacturing process with “global footprint” technology
- Continuous technical support and expertise throughout the project lifetime, established by a strong, cooperative partnership with our customer
FEATURES AND BENEFITS

OIL METERING

“Controlled leakage” concept
Avoid inadequate oil flow and its effects

- Increased valve train wear rate
- Premature valve train failure
- Increased valve train noise
- Higher local temperature

Avoid excessive oil flow and its effects

- High oil consumption
- Lower engine efficiency
- Poor catalyst performance

BLOW-BY CONTROL

Prevent exhaust gases passing through the seal
Avoid inadequate control and its effects

- Insufficient lubrication causes:
  - Increased valve train wear rate
  - Premature valve train failure
  - Increased valve train noise
  - Higher local temperature

- Engine oil contamination
- Power loss
- VSS damage

Metal case is uniquely shaped to improve retention performance and assure optimal assembly

Gas-lip allows the oil lip to work in a stable pressure zone, assuring lubrication against high back pressure (avoiding excessive blow-by gases)

“Wave-shaped rubber support” assures flexibility while maintaining the adequate integrity of the gas-lip