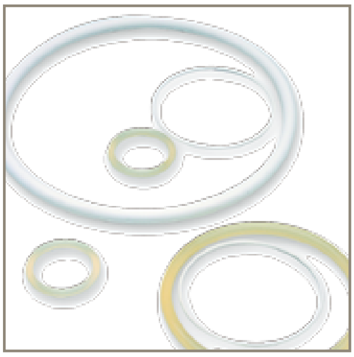




Parofluor® (FFKM)

Sealing compounds for extreme chemical and thermal requirements

aerospace
climate control
electromechanical
filtration
fluid & gas handling
hydraulics
pneumatics
process control
sealing & shielding

Parker Prädifa

ENGINEERING YOUR SUCCESS.

Parofluor® sealing compounds

for harshest process conditions

Continuous performance improvements are a hallmark of advanced industrial manufacturing processes. The resulting use of highly aggressive media and extreme process temperatures - in the chemical and related industries in particular – is making increasing demands on sealing compounds. Pharmaceutical and food industry regulations require materials to be pure and inert to the process media used. In addition to offering outstanding chemical and thermal resistance, compounds used in semiconductor manufacturing must conform to UHP (Ultra High Purity) standards in order to prevent process contaminations and reduce maintenance requirements. Parker's answer to these needs: Parofluor®.

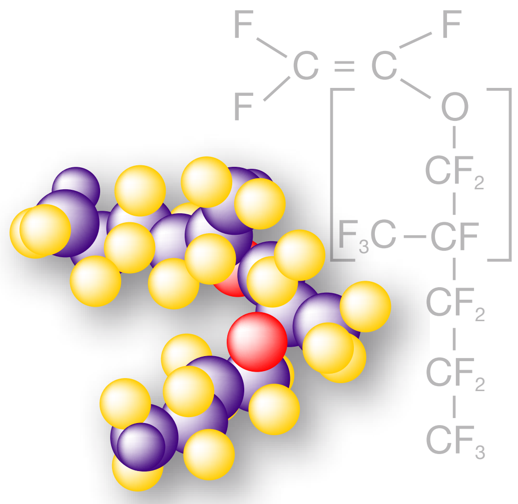
What is Parofluor®?

To combine the elastic properties of elastomer compounds with the excellent chemical and thermal resistance of PTFE, Parker has developed the Parofluor® compound family (FFKM). Compared to conventional perfluorinated elastomers, Parofluor® offers excellent permanent elasticity and is ideally suited for sealing applications involving highly aggressive media.

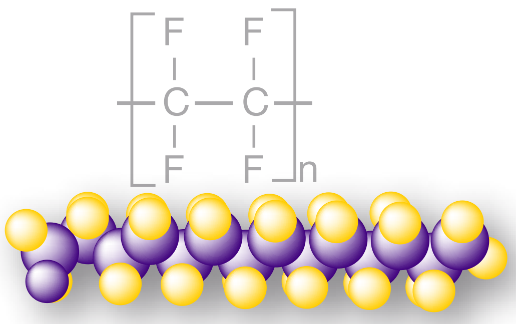
Parofluor® compounds are based on perfluorinated rubbers. Yet terms like "perfluorinated rubber" or "perfluorinated elastomer" are somewhat misleading.

A material that truly qualifies as a perfluorinated, highly molecular compound is PTFE, a polytetrafluoroethylene with the chemical formula "(CF_2)". Large fluorine atoms (shown in yellow) shield the carbon chain (shown in blue) against any attack by chemical action.

The composition of PTFE, i.e. 24 % carbon and 76 % fluorine, is a result of the chemical structure depicted. PTFE, however, is not an elastomer but a highly special thermoplastic compound. Elastomers are produced by copolymerisation of tetrafluoroethylene (TFE) and a perfluorinated ether such as perfluoromethylvinylether (PMVE).
Unlike PTFE, "perfluorinated elastomers" are not perfluorinated rubbers in the true sense of the word since they include a third element, i.e. the oxygen (shown in red) contained in the ether group. Depending on the type of ether used, marked by the length of the side chain, the nominal percentage of fluorine varies. While the use of ether gives elasticity, the perfect shielding of the chain in PTFE provided by the fluorine atoms is neutralised by the incorporation of the oxygen atoms.



FFKM molecule (perfluorinated elastomer)



PTFE molecule (polytetrafluoroethylene)

Typical applications

Parofluor® compounds are used for critical sealing applications, such as those found in semi-conductor manufacturing, aerospace, the chemical industry and the energy sector as well as in pharmaceutical and other processes involving aggressive fluids or gases. (For detailed information, please refer to Parker's Media Resistance List, Catalogue No. ODE 5703 GB).

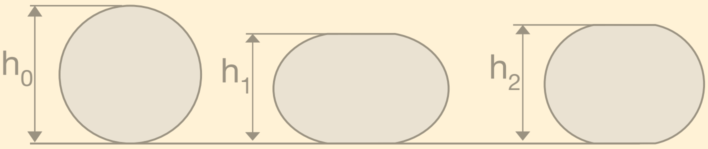
Thanks to their outstanding resistance to permanent deformation, exceptional temperature resistance and compatibility with a wide range of aggressive chemical combinations, Parofluor® compounds are ideally suited for sealing applications exceeding the performance capabilities of other high-performance elastomers.

Overview of Parofluor® benefits

- Reliable sealing performance in service with highly aggressive chemicals and at extreme temperatures
- Temperature resistance up to +320 °C
- Very low compression set
- Significant cost benefits thanks to longer servicing intervals and maintenance planning
- Clean room production (UHP/Ultra High Purity)
- In-house compound development and mixing, engineering design, tooling and production
- Computer-aided product development (finite elements analysis)
- Standard lead time: 1–2 weeks
- Quality management system according to DIN EN ISO 9001:2000 and ISO/TS 16949

Elasticity

Parofluor® compounds have a very low compression set and are therefore extremely reliable materials.
Compression set is the permanent deformation that remains after relieving the load from a standard sample or finished part that has been deformed under specified conditions. It is a measure for an elastic material's loss of resilience. In practical terms, a high compression set means a considerable loss of sealing force and increased risk of leakage.



Calculation of compression set

$$CS = \frac{h_0 - h_2}{h_0 - h_1} \cdot 100\ (\%)$$

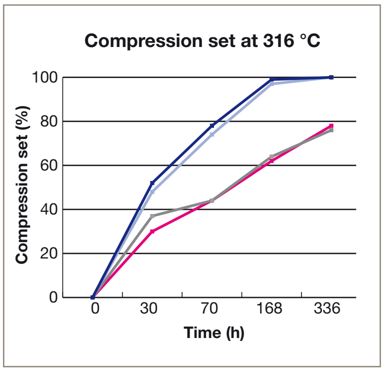
h_0 = O-ring cross-section or original height of test specimen

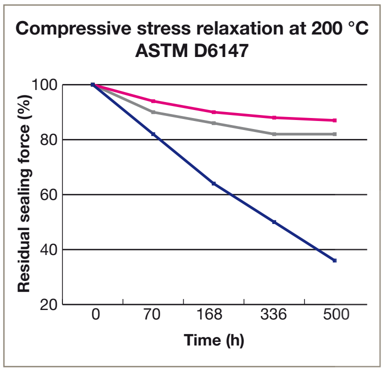
h_1 = Height of test specimen in deformed state

h_2 = Height of test specimen after a specified period of relaxation

Semiconductor production

In semiconductor production processes there is no place for “standard” sealing materials. Highly aggressive chemicals and gases, high temperatures, high vacuums and plasms are all part of modern chip manufacturing. In such processes any leakage or contamination results in costly downtimes or loss of productivity.
Thanks to their superior physical properties Parofluor® materials are ideally suited for use in plasma and gas as well as thermal and wet processes.
Specifically for use in the most advanced semiconductor processes (8’ and 12’ technology) Parker has developed the Parofluor ULTRA® and Parofluor MICRO® compounds. They withstand high temperatures as well as being highly resistant to process media. The production of these seals conforms to special requirements, including the use of clean room technology.
During final inspection the parts are cleaned separately and subsequently packed in clean room conditions. These procedures assure that the seals meet UHP (Ultra-High-Purity) standards.





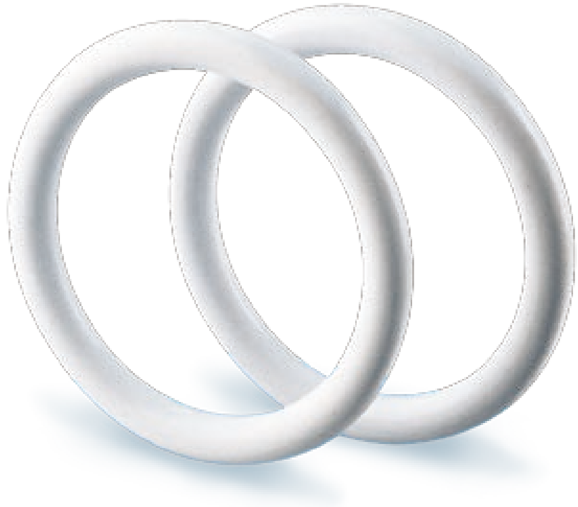
FFKM1
FFKM2
Parofluor® Ultra FF200-75
Parofluor® Ultra FF350-75

Parofluor® Compound / Semiconductor Process Guide

	Process Type	Temperature Range	Requirements	Typical Applications	Suggested Compounds
Plasma and Gas	Etching	25 °C – 225 °C 77 °F – 437 °F	Fluorine/ Chlorine/O_2	**Static Seals:** Lids Endpoint Windows Chambers Gas Inlets KF Centering Rings Flanges **Dynamic Seals:** Slit Valve Doors Mass Flow Controls Throttle Valves Isolator Valves Exhaust Valves Fittings	**Best:** **FF370-75 Ultra®** **V8801-75 Micro®** **FF350-75 Ultra®** **FF356-75* Ultra®** Alternative: V8581-90 Parofluor®
	Ashing	25 °C – 250 °C 77 °F – 482 °F	O_2/O_3/ H_2O		
	HDPCVD/ PECVD/ CVD	25 °C – 250 °C 77 °F – 482 °F	TEOS/O_3, SiH_4/O_2, NF_3/C_2F_6/CF_4,		
	PVD	25 °C – 250 °C 77 °F – 482 °F	Air, High Vacuum		
	Metal CVD	25 °C – 250 °C 77 °F – 482 °F	TEOS/O_3, SiH_4/O_2, NF_3/C_2F_6/CF_4 WF_6/ClF_3		**Best:** **V8801-75 Micro®** **FF350-75 Ultra®** **FF356-75* Ultra®** Alternative: V8545-75 Parofluor® V8562-75 Parofluor® V8581-90 Parofluor®
	Copper	25 °C – 250 °C 77 °F – 482 °F	TEOS/O_3, SiH_4/O_2, NF_3/C_2F_6/CF_4 WF_6/ClF_3		
	ALD	25 °C – 250 °C 77 °F – 482 °F	O_2/O_3/H_2O NF_3/CF_4/ClF_3		
Thermal	Oxidation/ Diffusion	150 °C – 300 °C 302 °F – 572 °F	N_2/O_2/H_2O	**Static Seals:** Lids Endpoint Windows Chambers Gas Inlets KF Centering Rings Flanges Quartz Chambers Bell Jars **Dynamic Seals:** Slit Valve Doors Mass Flow Controls Throttle Valves Isolator Valves Exhaust Valves Fittings	**Best:** **FF200-75 Ultra®** **FF350-75 Ultra®** **FF356-75* Ultra®** **FF370-75 Ultra®** Alternative: V8545-75 Parofluor® V8581-90 Parofluor®
	LPCVD	150 °C – 300 °C 302 °F – 572 °F	NH_3		
	RTP	150 °C – 300 °C 302 °F – 572 °F	IR Resistance/ Low Outgassing/ Thermal Stability		
Wet	Surface Prep, Cleaning, Rinse	25 °C – 125 °C 77 °F – 257 °F	UPDI, SC-1, HF, HCL	**Static Seals:** Lids Chemical Containers Chemical Baths **Dynamic Seals:** Pumps Valves Connectors Flow Meters Filters Contact Rings Thrust Plates	**Best:** **V8712-75 Micro®** **V8801-75 Micro®** **FF370-75 Ultra®** Alternative: V8545-75 Parofluor®
	Wet Etching	25 °C – 180 °C 77 °F – 356 °F	UPDI, HF, H_2SO_4		
	Photolithography, Developing, Rinse	25 °C – 125 °C 77 °F – 257 °F	nMP, H_2SO_4, NaOH		
	Wet Strip	25 °C – 125 °C 77 °F – 257 °F	nMP, H_2SO_4, NaOH		
	Copper Plating	25 °C – 100 °C 77 °F – 212 °F	$CuSO_4$, H_2SO_4, UPDI		

* Ideal for use in composite (rubber-to-metal) sealing configurations

Foodstuffs



According to U.S. FDA (Food and Drug Administration) regulations materials used in food processing, biochemical, pharmaceutical and genetic engineering equipment may not contain any substances classified as toxic or carcinogenic.

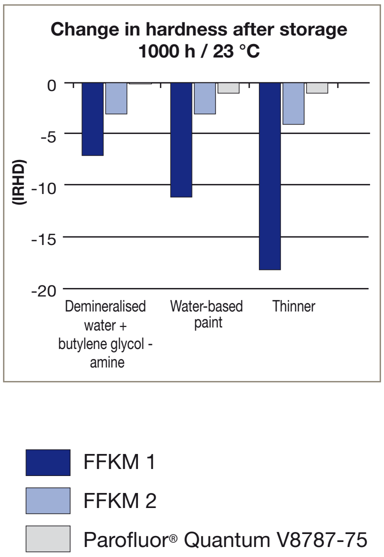
Parofluor® V8742-70 conforms to the requirements established in No. 177.2600, CFR 21 ("Rubber Articles Intended for Repeated Use"). This compound is particularly well suited for use with high processing temperatures and various aggressive media. Parofluor® V8742-70 thus provides higher operational reliability and allows maintenance intervals to be expanded.

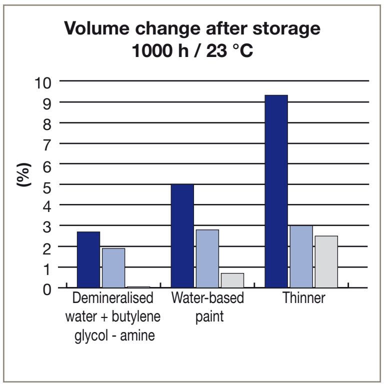
Parofluor® V8742-70 is our specialist for static sealing applications, in plumbing and production lines for example. Due to its white colour it is possible to visually check the cleanliness of the system.

For use in mechanical shaft seals we offer our black Parofluor® V8810-75 with optimised mechanical properties.

PAROFLUOR®
Perfluoroelastomer Seals

Paints, lacquers, solvents





By developing Parofluor Quantum® Parker has successfully addressed the wishes of numerous users in the paints, lacquers and solvents industry for a perfluorinated elastomer optimised to meet the particular requirements of this sector. Compared to standard FFKM compounds Parofluor Quantum® offers improved low-temperature flexibility. Permissible service temperatures range from –20 up to +230 °C. Compounds of the Quantum® family have been improved specifically for advanced, large-volume production processes, making them a particularly cost-effective choice.

Products for painting and printing

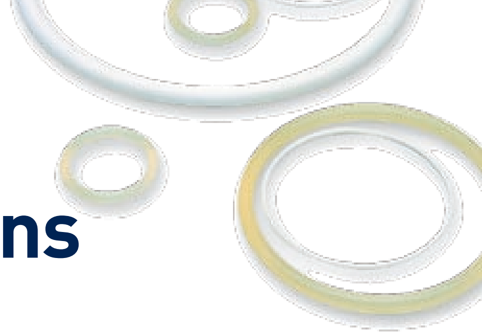
We offer finished products, such as sealing elements for printing presses and painting lines, which are free from any substances that inhibit paint or varnish wetting.

Clean room production

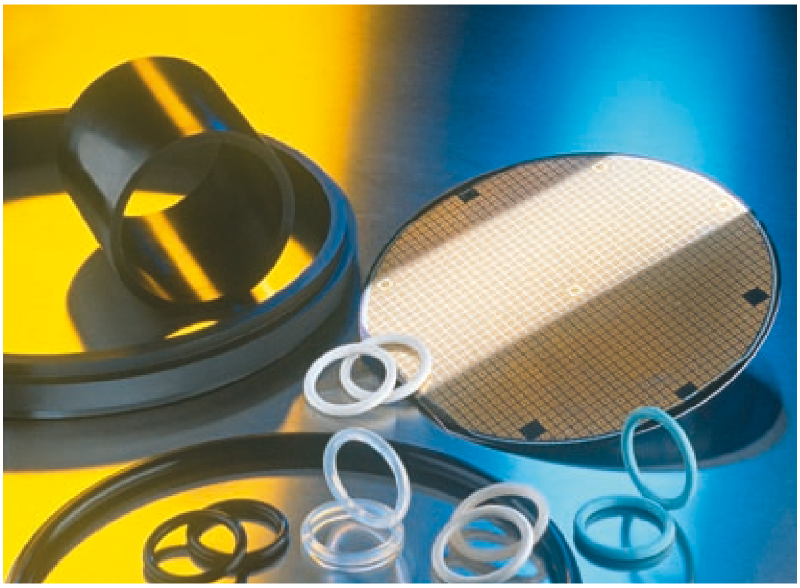
On request, we incorporate clean room production into our processes to manufacture UHP (Ultra High Purity) products for contaminationcritical applica-tions, such as medical technology, semiconductors and high-tech research.

Our UHP manufacturing process guarantees maximum purity across the whole process chain – from compounding through to packaging the finished seal.

- Exclusive use of selected, ultra-pure raw materials.
- Storage of raw materials in hermetically sealed containers.
- Cleaning of all machine components, moulds and tools having contact with the compound by means of fluids and special textiles typically used in the semi-conductor industry.
- UHP products are processed in special moulds, combined with stringent monitoring of processing parameters as well as optical and dimensional inspections.
- Moulding tools for UHP products are made from a special steel with an additional coating. Prior to start of production all moulding tools are carefully inspected. Data from all production process steps are recorded for each moulding tool. This enables Parker to consider the service life of the respective mould and to take appropriate action preventing the production of parts not conforming to required parameters.
- While processing UHP products critical manufacturing data (dimensional and process data) are recorded and evaluated, using statistical process control (SPC).
- UHP products are subject to 100 % inspections based on tolerances smaller than those specified by DIN 3771. This standard defines the permissible deviations for o-rings regarding dimensions, shape and surface.
- Prior to being approved for packaging, all UHP products are routinely subjected to final optical and dimensional inspections.
- Various grades of packaging are available for UHP products: combined packs, single packs, cleaning with an isopropanol-water mixture, all the way to packing in a class 100 clean room.



Parofluor® product solutions



Parofluor® offers versatile application solutions in all industrial disciplines – from the conventional o-ring in standard dimensions (imperial or metric), available at short notice, to diaphragms and engineered components based on customer drawings.
Parofluor® compounds can be processed in rubber-metal composites as well. Composites can be created with a wide range of metals.

Our in-house tooling and prototyping department assures flexible sampling of pre-production parts with short lead times.

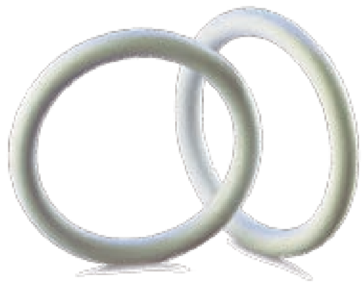
Engineering design instructions

Assembly recommendations for high-temperature applications

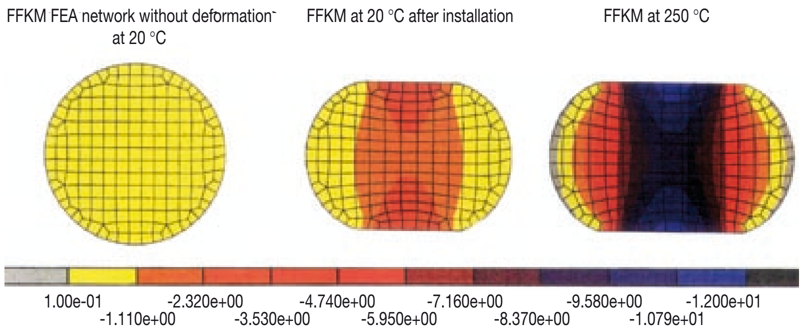
The thermal expansion of perfluorinated elastomers exceeds that of other sealing elastomers such as NBR or FKM considerably. When designing o-ring seals for high-temperature applications it must be assured that the groove will accommodate the thermal expansion of the o-ring. If not, the elastomer may generate levels of mechanical stress which – in extreme cases – would damage the seal or contacting parts.

The figure shows an FEA diagram (radial stress distribution) of a compressed Parofluor® o-ring cross-section at room temperature and after heating to 250 °C.

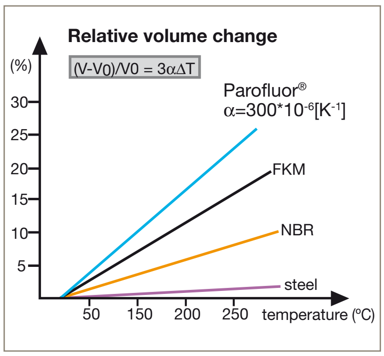
This analysis provides an impression of the volumetric increase and the levels of stress that may be generated in perfluorinated elastomers as a result of thermal expansion at high temperatures.



Radial Tension (MPa)



The figure below shows the volumetric thermal expansion of various elastomers compared to steel. For example, the volumetric expansion of a perfluorinated elastomer heated from 20 °C to 250 °C is approximately 22 %. For a seal made from this material the groove filling, i.e. the ratio between o-ring volume and groove volume, should never exceed 75 % at room temperature to assure that sufficient space is available for thermal expansion of the o-ring, thus avoiding the risk of gap extrusion due to high mechanical stress.



Type of compound		Parofluor®							Parofluor Quantum®		Parofluor Ultra®			Parofluor Micro®	
	Compound reference	V3862-75	**V8545-75**	V8581-90	**V8588-90**	V8742-70	V8800-75	V8810-75	**V8787-75**	V8844-75	FF200-75	**FF350-75**	FF370-75	V8712-75	**V8801-75**
	Nominal hardness (Shore A)	75	**75**	90	**90**	70	75	75	**75**	75	75	**75**	75	75	**75**
	Colour	black	**black**	white	**black**	white	black	black	**black**	black	black	**white**	translucent black	translucent	**white**
	Temperature Range (°C)	-15/260	**-15/300**	-15/300	**-15/280**	-15/300	-15/320	-15/300	**-20/230**	-20/230	-15/320	**-15/316**	-15/275	-15/250	**-15/250**
	Application:														
Chemical processing	Mechanical Seals	x	**x**		**x**		x	x			x				
Chemical processing	Pumps	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Valves	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Instrumentation	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Flow control elements	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Food applications (acc. to FDA CFR21 NO.177.2600)					x		x				**x**			
Chemical processing	Meters	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Mixers	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Reactors	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Conveyors	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Tank systems	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Chemical processing	Inspection glasses	x	**x**	x	**x**	x	x	x	**x**	x	x	**x**	x	x	**x**
Semiconductor	Plasma processing		**x**	x								**x**	x		x
Semiconductor	Gas processing		**x**									**x**	x		**x**
Semiconductor	Ion Implantation		**x**									**x**			
Semiconductor	Thermal processing		**x**	x			x				x	**x**	x		
Semiconductor	Wet processing		**x**										x	x	**x**
Semiconductor	UPDI-Water													x	**x**
Energy	Oil wells (sour gas)	x	**x**		**x**		x				x				
Energy	High pressure gas applications (ED)				**x**										
Energy	Mud drilling	x	**x**	x	**x**		x		**x**	x	x				
Energy	Amine-based fluids	x	**x**	x	**x**		x	x	**x**	x					
Energy	Hot water/steam systems		**x**	x	**x**		x	x							
General Industrial	Varnish production and handling	x	**x**	x	**x**				**x**	x					
General Industrial	Ink/printing systems	x	**x**	x	**x**				**x**	x					
General Industrial	Solvents	x	**x**	x	**x**	x	x	x	**x**	x	x	x	x	x	**x**
General Industrial	Fluid applications	x	**x**	x	**x**	x	x	x	**x**	x	x	x	x	x	**x**
General Industrial	Rubber-metal bonded parts	x	**x**	x	**x**	x	x	x			x		x		**x**
General Industrial	High purity processes					x						x		x	**x**

Standard compounds printed in bold

PAROFLUOR®
Perfluoroelastomer Seals

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