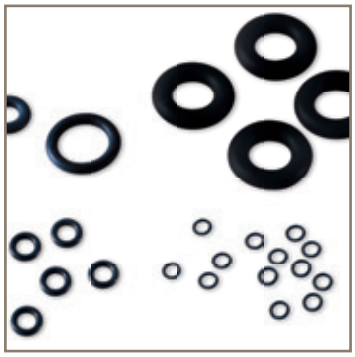
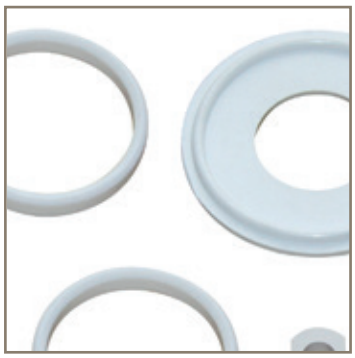




Parofluor® (FFKM)

Sealing Compounds for Extreme Chemical and Thermal Requirements

Parker Prädifa

ENGINEERING YOUR SUCCESS.

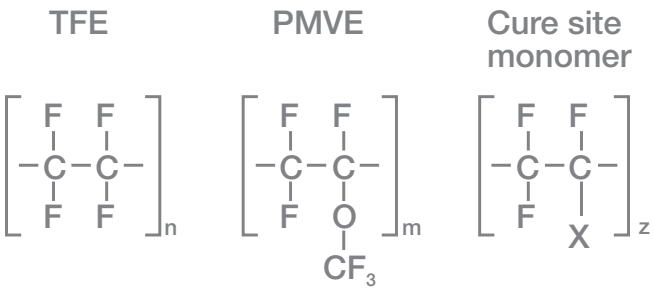
Parofluor® (FFKM)

For Harshest Process Conditions

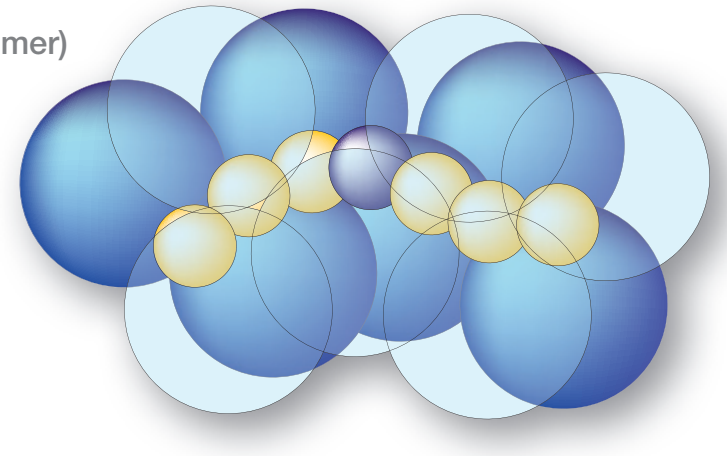
Continuous performance improvements are a hallmark of advanced industrial manufacturing processes. The resulting use of highly aggressive media and extreme process temperatures – in the chemical and related industries in particular – is making increasing demands on sealing compounds. Pharmaceutical and 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®.

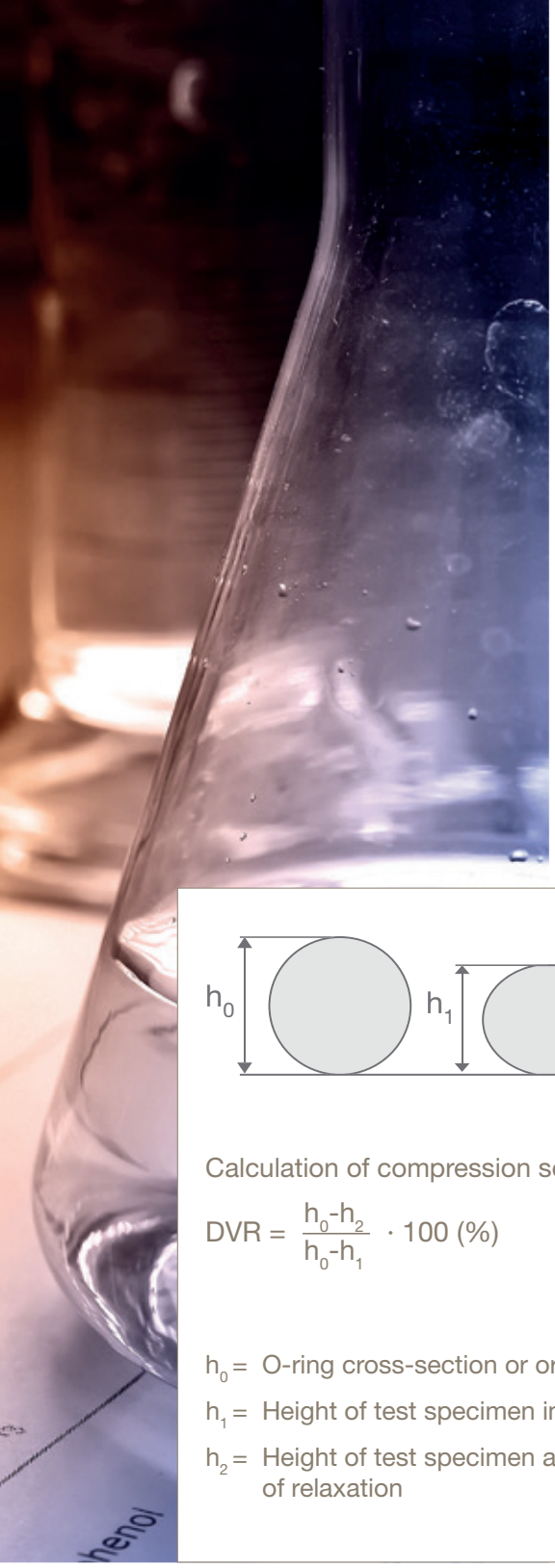
What Is Parofluor®?

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. They typically consist of three monomers: tetrafluoroethylene (TFE) as the basic structure, perfluoromethylvinylether (PMVE) for elasticity and a cure site monomer (CSM). Like PTFE, none of these monomers include hydrogen atoms anymore, which gives Parofluor® excellent and universal media resistance.



FFKM molecule (perfluorinated elastomer)



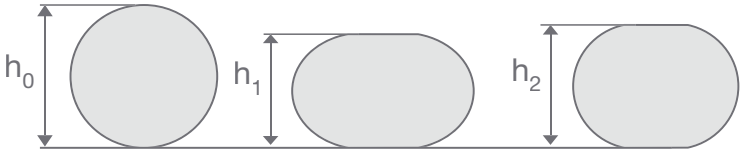


Typical Applications

Parofluor® high-performance compounds are used for critical static and dynamic sealing applications, such as those found in the chemical industry, in oil and gas applications, in semiconductor manufacturing, aerospace as well as in pharmaceutical and other processes involving aggressive fluids or gases.

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.

For detailed information, please refer to the Media Resistance List in Parker Prädifa's O-Ring Handbook:



Calculation of compression set:

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

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

Overview of Parofluor® Benefits

- Reliable sealing performance in service with highly aggressive chemicals and at extreme temperatures
- Temperature resistance up to +325 °C
- Longer service life due to very low compression set
- Significant cost benefits thanks to longer servicing intervals and maintenance planning
- Approvals and conformities for numerous industries
- Cleanroom production (UHP / Ultra High Purity)
- Complete traceability due to in-house compound development and mixing, engineering design, tooling and production
- Computer-aided product development (Finite Elements Analysis)
- Expert technical application consulting support
- 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.

Chemical / Process Engineering

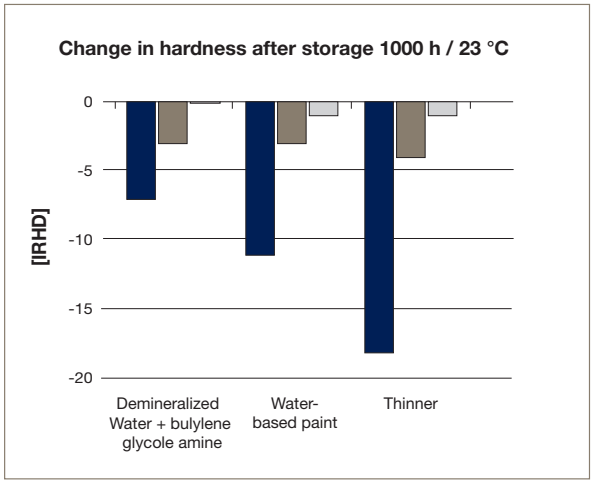
Continual adjustments of chemical processes in terms of output volume, production efficiency and downtimes change the requirements profile of sealing components in pumps, valves, mechanical seals or analytical equipment with a bias toward high-performance materials such as Parofluor®. Due to the very good chemical resistance of Parofluor® sealing elements used in aggressive media and at high temperatures, maintenance intervals are extended and the productivity of manufacturing equipment is clearly enhanced.

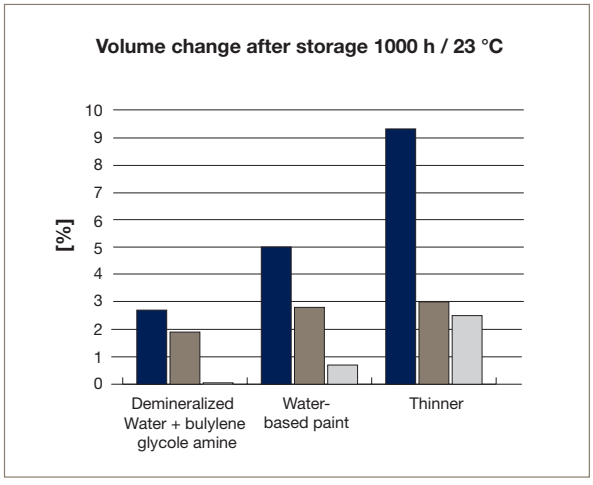
Paints, Lacquers, Solvents

By developing Parofluor Quantum® Parker has successfully addressed the wishes of numerous users in the paints, lacquers and solvents industry for perfluorinated elastomers optimized to meet the particular requirements of this sector. Compared to standard FFKM compounds Parofluor Quantum® offers improved low-temperature flexibility and mechanical resistance. Permissible service temperatures range from –20 up to +230 °C, short-term up to 240 °C. Compounds of the Quantum® family have been optimized specifically for advanced, large-volume production processes, making them a particularly cost-effective choice.

PWIS-Free Production

... guarantees finished products which are free of paint-wetting impairment substances, which is specified particularly for printing presses or painting lines. The quality inspection for paint-wetting impairment substances is performed according to international automotive standards.





FFKM 1 FFKM 2 Parofluor® Quantum V8787-75

Natural, Bio and Liquid Gas Applications

With natural, bio and liquid gas applications a distinction is made between elastomer materials for seals and membranes in gas equipment and gas installations according to DIN EN 529 and materials for seals in DN 682 supply lines for gas and liquid hydrocarbons.

As natural gas itself is odorless, odorants are added as a warning odor so that an equipment defect or leakage can be immediately detected. Normally, organosulfur compounds such as tetrahydrothiopene (THT) which are highly volatile and have a typical odor are used. Sulfur-free odorants such as those sold under the trade name Gasodor® S-Free have more aggressive properties than those based on sulfur. Therefore, we recommend Parofluor® compounds. In applications with liquid Gasodor® S-Free, sealing elements made of the Parofluor® V8910-75 compound have been delivering outstanding performance. The material was tested against the requirements of the German Technical and Scientific Association for Gas and Water (DVGW) according to DIN EN 549:1994. The sealing elements are suitable for trouble-free utilization in odorizing systems, process and metering pumps, valves, tanks and containers, and in measurement and control technology using Gasodor® S-Free.

Oil and Gas

Parofluor® sealing elements from Parker Prädifa are successfully used in the challenging applications of the global oil and gas industry with diverse contact media, some of which are highly aggressive and corrosive, at high pressures and in extreme temperature conditions. They are resistant against explosive decompression as well.

Resisting Salt Water, Sour Gas and Steam

The industry has established specific testing and qualification standards to ensure that materials used in the harsh Oil and Gas drilling and production environments meet the critical demands of these applications.
For applications in the oil and gas industry, special Parofluor® compounds are available which meet the following requirements and standards.

- ISO 23936-2:2011 describes the requirements and procedures for qualification of elastomeric materials in contact with media related to oil and gas production. H_2S testing in accordance with the specification enables lifetime prediction of compounds.
- NORSOK M-710 defines the requirements for critical non-metallic (polymer) sealing, seat and anti-extrusion ring materials for permanent subsea use, including well completion, Christmas trees, control systems and valves as well as topside valves in critical gas systems.
- API 6A is the specification for drilling and production, Wellhead and Christmas tree equipment.
- Total GS EP PVV142 defines the requirements for non-metallic sealing materials concerning elastomers in pipeline valves.

Food and Pharmaceuticals

Purity and reliability are of paramount importance in the production of food, beverages and pharmaceuticals. To ensure maximum safety of products intended for human consumption, the production processes and equipment of the food and pharmaceutical industries have to meet a large number of national, European and international regulations. Most of these legal requirements and recommendations concern ingredients and additives, residues, contamination and permissible migration and leaching levels in products of the food and pharmaceutical industries.

For applications in the food and pharmaceutical industries, special Parofluor® compounds with the required approvals and conformances are available. As a result, our production process delivers maximum levels of safety and durability.

European Regulation **(EC) No. 1935/2004** says that, according to good manufacturing practice, sealing elements shall be produced so that under normal or foreseeable conditions of use they will not transfer any substances to food that endanger human health or bring about an unacceptable change to the composition or deterioration of the organoleptic properties of food. We guarantee complete traceability from the individual raw materials to the finished sealing element.

Regulation **(EC) No. 2023/2006** establishes GMP (Good Manufacturing Practice) rules for all materials listed in Regulation **(EC) No. 1935/2004,** Annex I.

In Regulation **(EC) No. 1907/2006** (Registration, Evaluation, Authorization and Restriction of Chemicals – REACH), chemicals are registered, evaluated, approved and limited in order to minimize the potential risk, such as the utilization of lead, to the end user.

The American Food and Drug Administration (FDA) defines ingredients and mass contents with extraction limits in a White List. Materials marked FDA meet the requirements of

FDA 21 CFR 177.2600 (e,f) ("rubber articles intended for repeated use") and the limits for extractable substances according to **FDA 21 CFR 177.2400** (d).

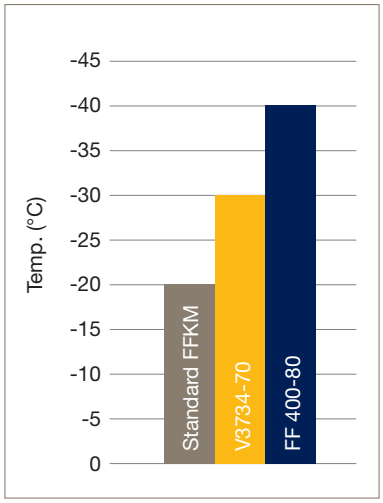
Specifically for the pharmaceutical industry, Parker has developed materials and sealing elements that fully meet the exacting operating conditions and, at the same time, support the hygienic and aseptic processes so that no process contamination or no catalytic technical process change takes place. These pharmaceutical applications require **USP** (United States Pharmacopeia) **Class VI** (Parts 88 and 87 according to ISO 10993-1) approval confirming the biological compatibility with living organisms and thus the harmlessness of sealing materials to human health.

Aerospace

The Parker Engineered Materials Group develops and produces Parofluor® sealing elements and Parofluor® metal composite parts for extreme temperatures and aggressive media such as those used in aerospace applications like lubricants for jet aircraft engines, hydraulic fluids, rocket propellants, solvents and degreasing agents.

Additionally, a large number of actions must be taken in the manufacturing process to comply with the aerospace industry's stricter safety requirements. Parker has implemented the relevant organizational and quality assurance measures and is therefore an approved manufacturer for military and civil aviation.

Special materials from the Parofluor® family meet the exacting requirements. The Parofluor® compound V3734-70, in addition to very good chemical resistance, has very good cold flexibility in application temperatures from -25 °C to 240 °C. For a low-temperature range of -40 °C, Parofluor® FF400-80 is successfully used around the globe. In gas turbines with very high temperatures, Parofluor® V8930-75 is the suitable material because its exceptional thermal and oxidative resistance have a positive impact on total system costs.



Cold flexibility comparison

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.

Specifically for use in the latest semiconductor processes such as oxygen plasma, ozone, tetrafluoromethane, nitrogen trifluoride and fluorine-based plasmas, ultra-pure Parofluor® high-performance compounds have been developed. They withstand high temperatures as well as being highly resistant to process media. The production of seals from selected, high-purity raw materials conforms to special requirements including the integration of cleanroom techno-logy. In the final inspection process, the parts are cleaned separately and subsequently inserted in cleanroom-conformant double packaging in a class 7 cleanroom according to ISO 14644-1 (U.S. Federal Standard 209d 10,000). These procedures assure that the seals meet UHP (Ultra High Purity) standards.

Thanks to their superior physical physical properties, Parofluor® materials materials are ideally suited for use in plasma, CVD (Chemical Vapor Deposition), as well as thermal and wet processes, like

- Etching, ashing, HDPCVD (High-Density Plasma Chemical Vapor Deposition), PECVD (Plasma Enhanced Chemical Vapor Deposition)
- Diffusion, LPCVD (Low-Pressure Chemical Vapor Deposition), RTP (Rapid Thermal Processing)
- Wet etching, cleaning, photoresist stripping, copper processes

Vacuum Technology

For special chemical processes in high-vacuum technology at temperatures from 200 °C to 250 °C and up to a pressure range of $1*10^{-10}$ mbar O-rings and molded parts made of Parofluor® high-performance compounds are used. They meet the demands of minimal outgassing and low permeation made on the material. The O-ring should fill the groove nearly 100 %. This results in larger contact areas and the diffusion time through the perfluoroelastomer increases. All sealing areas, including the groove edges, are provided with a clearly better surface quality than those of standard industrial applications.

Parofluor® Product Solutions

Parofluor® high performance materials offer versatile application solutions in all industrial disciplines – from the conventional O-ring in standard dimensions (imperial or metric), available on 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.

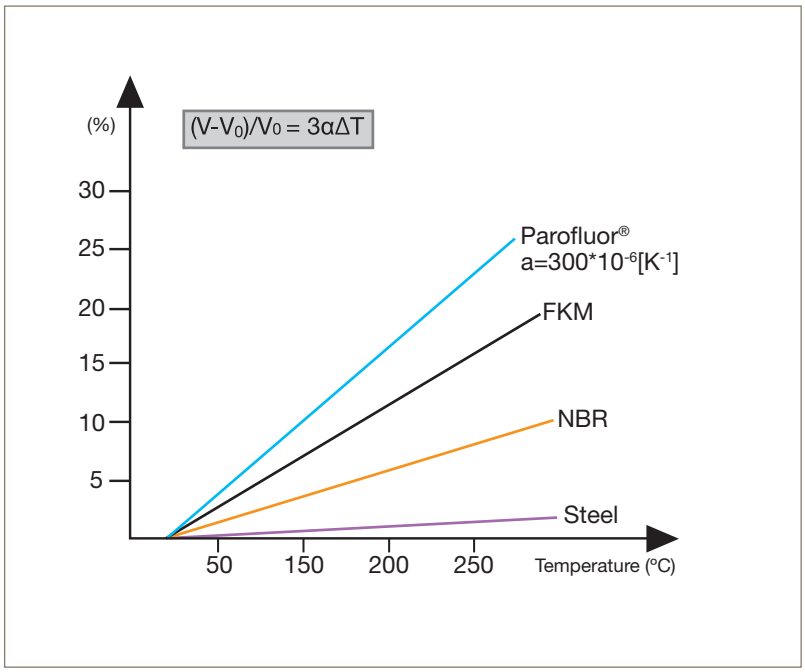
Our in-house tooling and prototyping department assures flexible sampling of pre-production parts with short lead times.

Engineering Design Instructions

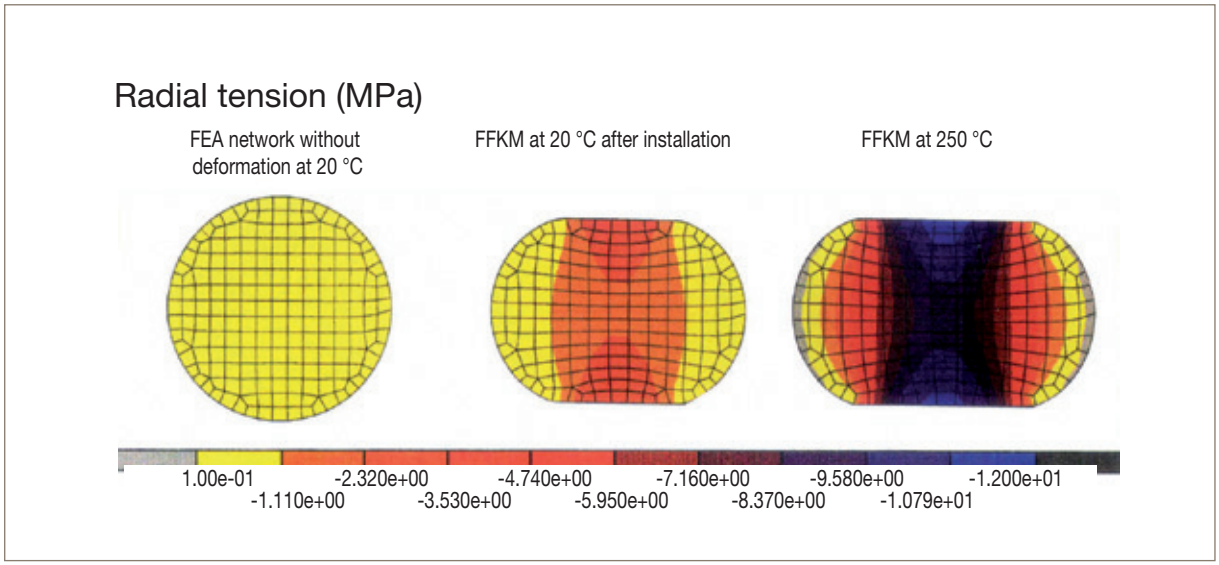
Assembly recommendations for high-temperature applications

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 belows shows the results of a Finite Elements Analysis: 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. The figure 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.



Relative Volumen Change



Compound Table

Type of compound					
Compound reference		V3734-70	V8545-75	V8562-75	V8588-90
Nominal hardness (Shore A)		70	75	75	90
Color		black	black	white	black
Temperature range (°C)		-25 / 240	-15 / 300	-15 / 300	-15 / 260
	Application				
Chemical processing	Mechanical seals		x		x
	Pumps & valves	x	x	x	x
	Instrumentation	x	x	x	x
	Meters & dosing	x	x	x	x
	Mixers	x	x	x	x
	Reactors	x	x	x	x
	Conveyors		x		x
	Tank systems		x	x	
	Varnish production and handling				
	Ink/printing systems				
	Solvents				
	Inspection glases				
Food & Pharma	Seals in contact with media in food applications (conform FDA CFR21 No. 177.2400)				
	High purity processes			x	
	Seals in contact with media in pharma applications (USP Cl. VI)				
	Hot water/steam systems (CIP/SIP)	x	x		
	Rubber-metal bonded parts		x		
Oil and Gas	Oil wells (sour gas)		x		x
	High pressure gas applications (ED)				x
	Mud drilling	x	x		x
	Amine-based fluids	x	x		x
	Hot water/steam systems	x	x		x
Semiconductor	Plasma processing			x	
	Gas processing		x		
	Ion Implantation		x		
	Thermal processing		x		
	Wet processing		x		
	UPDI-Water			x	
Aero-space	Fuel systems		x		
	Steering systems	x			
	Turbines				
Approvals/ conformitites	FDA CFR21 no. 177.2400				
	USP class VI				
	Norsok M-710, API 6A				x
	ISO 23936-2: 2011				
	(EU) No. 1935/2004				

Standard materials in gray

Parofluor®							Parofluor Quantum®	
V8920-75	V8921-75	V8930-75	V8800-75	V8950-75	V8951-70	FF400-80	V8910-75	V8911-75
75	75	75	75	75	70	80	75	75
black	white	black	black	black	white	black	black	white
-15 / 260	-15 / 260	-15 / 325	-15 / 300	-15 / 240	-15 / 240	-40 / 275	-20 / 220	-20 / 220
x		x		x	x	x	x	
x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x
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