Materials for the Chemical Process and Food Industries

Pure. Stable. Safe.

Parker Prädifa

ENGINEERING YOUR SUCCESS.

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Basic Prerequisites: Purity and Stability

The substances used in the food and in the chemical process industries are identical in many cases, whether they are of natural origin or synthetically produced. Irrespective of their type and occurrence – be it in process media, in raw materials for products or in finished products – the materials for seals and engineered components used in production equipment coming into contact with diverse chemical substances have to meet specific purity requirements and be resistant to chemicals under the given process conditions. Purity and stability are therefore basic prerequisites for materials in the chemical process industry and the food industry.

Top Priorities: Consumer Health and Safety

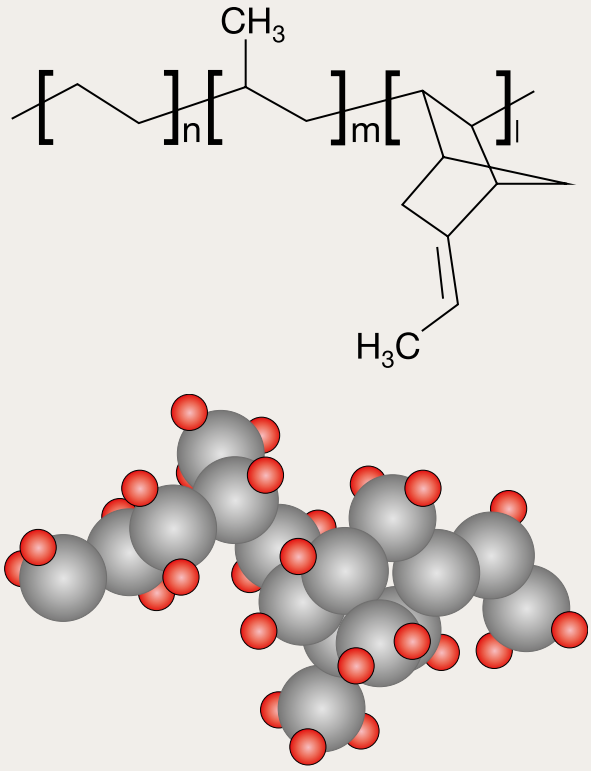
Consumer health and safety are of paramount importance in food, beverage and pharmaceutical production processes. To ensure that end products intended for human consumption are as safe as possible, the production processes and equipment have to meet a large number of national, European and global regulations and standards. These legal requirements and recommendations concern ingredients and additives, residues, contaminations and permissible migration levels (migration and leaching) in foodstuffs, pharmaceuticals and chemical products.

Parker Prädifa offers optimized special materials for any challenging requirement in sensitive processes.

Contents

Ethylene Propylene Diene Rubber (EPDM)

EPDM is a polymer produced from the monomers ethylene, propylene and a third monomor with a pendant double bond (diene). The properties profiles desired for the subsequent application result from the composition of the monomers and polymerization methods. For instance, ethylene content, diene content, molecular weight and molecular weight distribution, etc. determine important properties such as crystallinity or processability. EPDM can be crosslinked with sulphur or peroxides. In addition to the selection of the suitable polymer, the composition of the compound is decisive for the subsequent properties profile.



Properties

In addition to good thermal, aging and chemical resistance, EPDM exhibits high elasticity, good cold-temperature performance and good insulating properties. Hardness levels between 25 and 95 Shore A can be achieved, depending on the formulation. The resistance of EPDM compounds against ozone is equally excellent as their resistance to water, glycol-based brake fluids, detergents, caustic soda or potash lye, many organic and anorganic acids as well as polar pressure fluids and solvents (phosphorous acid esters, alcohols, ketones and esters). EPDM compounds are not resistant against aliphatic, aromatic and chlorinated hydrocarbons.

Range of Applications

In addition to the utilization of EPDM for seals or tubes and hoses in the automotive industry, which accounts for the largest quantities of these materials, EPDM is very well suited for applications in the food and beverage sector. Due to its excellent chemical resistance against detergents and cleaning solutions and its high abrasion resistance, EPDM is superbly suited

for use in domestic appliances. Furthermore, EPDM sealing solutions are important for the food and beverage industry because the material exhibits extensive compatibility even in CIP/SIP media. CIP (Cleaning in Place) media are cleaning fluids based on aqueous lyes and acids with washing additives, which are used in the cleaning processes of large-scale production equipment in the food and pharmaceutical industries. SIP (Sterilization in Place) refers to a cleaning process for the sterilization of large-scale equipment using disinfectants, superheated steam or oxydizing acids, etc.

From the Field

USP Class VI Materials for Food Applications and for Use in Medical Device Technology: E8924 and E8961

The ingredients of both materials conform to Chapter 21 CFR 177.2600 of the FDA white list and meet the required extraction limits in water and n-heptane. In addition, the materials meet the 3-A Sanitary Standard, 18-03 Class 2. Both materials have also been positively tested according to USP Class VI, Chapter 87 (in vitro) and Chapter 88 (in vivo), which is important for pharmaceuticals and medical technology devices.

Sealing elements made of Parker EPDM compounds E8924 and E8961 exhibit very good media resistance in hot water, water vapor, acids and alkaline solutions, and in polar CIP/SIP media. The temperature range is -50 to 150 °C, in water vapor up to a maximum of 180 °C. A wide variety of media has been tested

Approvals and Conformities at a Glance

- FDA-conformant acc. to Chapter 21CFR 177.2600
- USP Class VI, Chapters 87 and 88
- 3-A Sanitary Standard 18-03, Class II
- Regulation (EC) No.1935/2004
- Regulation (EC) No.1907/2006 (REACH)
- RoHS Directive 2011/65/EU
- Free of animal-derived ingredients (ADI-free)
- Free of polycyclic aromatic hydrocarbons (PAH-free)

Test	Standard	Unit	E8924	E8961
Elastomer base			EPDM	EPDM
Color			black	black
Hardness	DIN ISO 7619-1	Shore A	72	85
Density	DIN EN SIO 1183-1 A	g/cm³	1.18	1.31
Tensile strength	DIN 53504	N/mm²	13.1	15.3
Modulus 100 %	DIN 53504	N/mm²	6.2	10.9
Ultimate elongation	DIN 53504	%	176	139
Compression set 24 h / 150 °C	DIN ISO 815-1	%	9	15
TR10	ASTM D1329	°C	-47	-47
Aging in air, 168 h / 100 °C				
Hardness change	DIN 53508	Shore A	+1	+1
Dist. water, 22 h / 70 °C				
Volumetric change	DIN ISO 1817	%	0.3	0.9
Mass change	DIN ISO 1817	%	0.6	0.9
Hardness change	DIN ISO 1817	Shore A	0	-2
Nitric acid, 0.5 %, 22 h / 82 °C				
Volumetric change	DIN ISO 1817	%	2.3	3.1
Mass change	DIN ISO 1817	%	2.1	2.8
Hardness change	DIN ISO 1817	Shore A	-2	-2

E8924 and E8961 – Physical Data

Legal Requirements and Regulations

Specific requirements have to be met for the utilization of elastomers in the food industry. In addition to the selection of raw materials from the standard white lists issued by national authorities, it must be ensured that no substances are extractable from the material. For instance, in the case of seals used in beverage production equipment, it is of major importance that no chemicals migrate from the seal compound and, in the worst case, result in contaminations.

FDA
FDA conformity is an important requirement for materials used in the food and pharmaceutical sectors. The U.S. Food and Drug Administration (FDA) has issued a substance white list for elastomers in Chapter 21 (CFR 177.2600 – Rubber Articles Intended for Repeated Use). Only the polymers, fillers, crosslinking chemicals, etc. on this list may be used in the compound formulation. In addition, the FDA requires an extraction test in water and n-hexane. Global migration must not exceed a specified level. If both criteria, i.e. white list conformant raw materials and extraction, are met, the material is FDA-conformant. It should be noted that the FDA does not issue any approvals for elastomers (as is commonly the case for plastics) so that elastomers can only be FDA-conformant, but not FDA-approved.

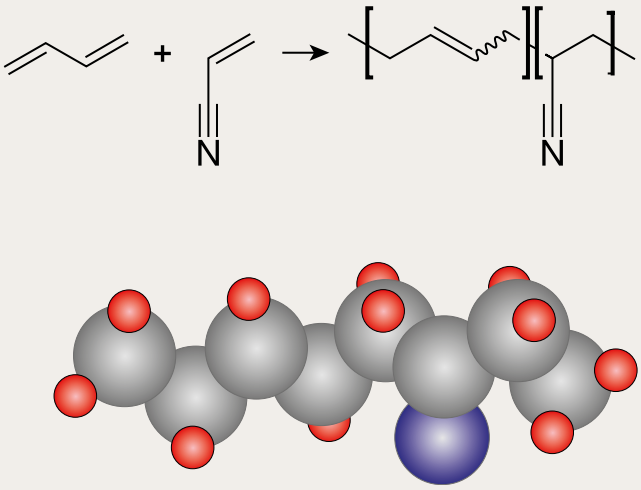
USP
Other requirements to be met are the current quality standards of the U.S. Pharmacopeial Convention (USP) for the use of elastomer components in pharmaceutical and biotechnology equipment. In addition, the classification of elastomer components for any type of hygienically designed equipment according to USP Class VI is highly useful. Suitable elastomers are classified according to USP Class VI, Chapter 87 in vitro) and Chapter 88 (in vivo), ensuring that there are no concerns regarding their use.

3-A
3-A Sanitary Standards Inc., a hygiene organization of the U.S. food industry, defines specifications and recommendations for the development, installation and utilization of hygienic equipment for dairy products. They prescribe tests with limits for volumetric and weight changes for EPDM seals. The tests include air aging, storage in grease (butter oil or milk fat), in distilled water, 0.5 % nitric acid, 1 % sodium hydroxide solution and in a hypochlorite solution. Due to their sensitivity to fat, EPDM compounds are classified in Class II.

National and EU Regulations
In addition, there are many other national and EU regulations. For instance, the German Federal Institute for Risk Assessment (BfR), like the U.S. FDA, has issued recommendations for elastomers (XXI. Commodities Based on Natural and Synthetic Rubber). However, it should be noted that the two lists do not match so that the formulation of a compound taking both of them into account poses a great challenge.

Nitrile Butadiene Rubber (NBR)

Nitrile rubber (NBR) is a polar rubber produced from two monomers: acrylonitrile and butadiene. The acrylynitrile content (ACN content) may vary between 18 and 50 % and has a major influence on cold resistance and media compatibility. The higher the ACN content the better the material's resistance in mineral oils while cold flexibility deteriorates at the same time. The intelligent selection of the polymer is made in consideration of the subsequent application. To achieve optimal mechanical properties, the utilization of fillers is indispensable. Sulphur is typically used for crosslinking, but organic peroxides may be used for crosslinking as well.



Properties

Due to the double bonds in the polymer chain, weather and ozone resistance is low and the utilization of suitable additives advisable. NBR compounds are heat-resistant up to 100 °C, short-term up to 120 °C. In cold conditions, depending on the composition, temperatures between -20 and -55 °C may be applied. Grades from 40 Shore A to hard rubber are possible, depending on the compound formulation. NBR has good mechanical properties and better abrasion behavior compared with other elastomers.
NBR compounds exhibit good resistance in gasoline, mineral oils and mineral greases, which can be improved by increasing the ACN content. NBR compounds have limited resistance in fuels with high aromatic content and aromatic or chlorinated hydrocarbons (e.g. benzene or toluene) and polar solvents (e.g. acetone).

Range of Application

NBR compounds are preferably used for sealing applications coming into contact with mineral oils, greases or waxes. Particularly for applications involving high dynamic loads and pressures, NBR is the material of choice.

From the Field

PAH-Free for the Food Industry: N9400

The NBR compound N9400 has been developed for the high demands of the food and chemical process industries. This compound is characterized by particular purity and intelligent formulation. In addition, N9400 is free of polycyclic aromatic hydrocarbons (PAH-free), nitrosamine-free and FDA-conformant. Besides the prescribed FDA extraction tests in water and n-hexane, N9400 meets the requirements of other extraction tests in media commonly used in the food and beverage industry. In migration tests in ethanol, acetic acid and MMPO (modified polyphenylene oxide) according to EU Regulation No. 10/2011, all limits were complied with as well. Furthermore, N9400 exhibits good aging resistance and compatibility in water.

Approvals and Conformities at a Glance

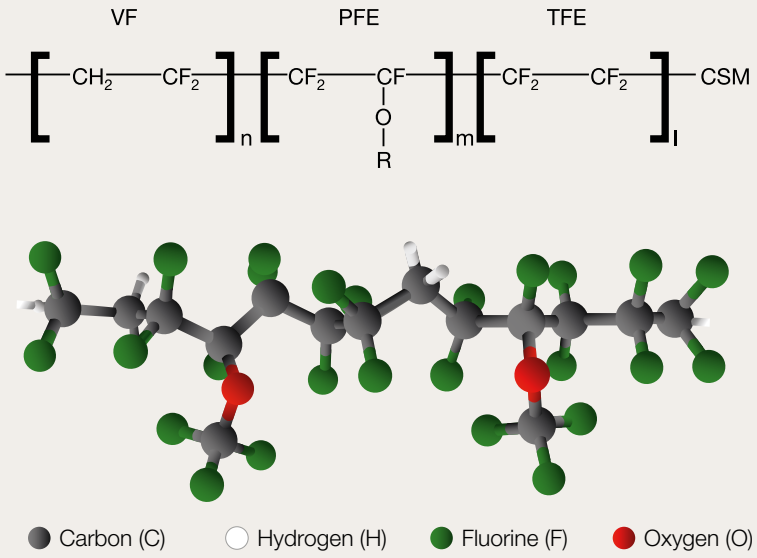
- FDA-conformant
- EC1935/2004
- PAH-free
- Nitrosamine-free
- Plasticizer-free
- REACH/RoHS-conformant

Test	Standard	Unit	Test specimen	Required range	N9400
Elastomer base					NBR
Color					black
Hardness	DIN ISO 7619-1	Shore A	Indenter > 6 mm	75 ± 5	76
Density	DIN EN ISO 1183-1 A	g/cm³	Method A	1.19 ± 0.02	1.19
Modulus 100 %	DIN 53 504	MPa	S2		3.8
Tensile strength	DIN 53 504	MPa	S2	> 15	16.4
Ultimate elongation	DIN 53 504	%	S2	> 300	406
Tear strength	DIN ISO 34-1	N/mm	Angle test w. incision	> 8	15.4
Compression set 24 h / 100 °C	DIN ISO 815-1	%	Test spec. B / Method A / 25 % deformation	< 30	22
Glass transition temperature T_g, DSC	DIN EN ISO 11537	°C		< -25	-32
Aging in air, 168 h / 100 °C					
Hardness change	DIN 53 508	Shore A		< +8	+4
Aging in water, 168 h / 70 °C					
Hardness change	DIN ISO 1817	Shore A		-10 / +2	+1
Volumetric change	DIN ISO 1817	%		0 / +10	+5

N9400 – Physical Data

Fluoroelastomers (FKM)

Fluoroelastomers (FKM) are characterized by a wide application range. They exhibit outstanding resistance against high temperatures, ozone, oxygen, mineral oils, aromatic compounds, many organic solvents and other chemicals. Gas permeability is low. By selecting a suitable polymer and appropriate formulation, resistance against acids, fuels, water and water vapor can be optimized.



Properties

Whenever seals have to deliver both excellent chemical and high temperature resistance, fluorelastomers are the materials of choice. Thanks to their very good chemical and temperature resistance, they are universally usable. Consequently, they rank among the most important sealing materials of all. With FKM elastomers there is normally no shrinkage in the application following exposure to media. Even in the case of heavily swelling mineral oils, volumetric increase will only be moderate. That is why fluoroelastomers are the optimal solution for many applications. FKM copolyymers are produced from two monomers, vinylidene difluoride (VF_2) and hexafluoropropylene (HFP), whereas terpolymers from VF_2, tetrafluoroethylene (TFE) and perfluorinated ethers (PFE) are used for low-temperature FKM compounds.

From the Field

The Pure Material for Hot Applications: V9196

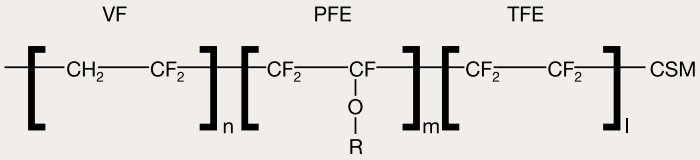
For challenging food and chemical process industry applications in high temperatures, the V9196 compound was developed. V9196 is free of polycyclical aromatic hydrocarbons (PAH-free), nitrosamine-free and FDA-conformant. The compound meets the prescribed FDA extraction test requirements in water and n-hexane and the extraction tests acc. to EU Regulation No. 10/2011 in ethanol, acetic acid and MMPO (modified polyphenylene oxide). In addition, V9196 meets the requirements of other extraction tests in media commonly used in the food and beverage industry. Due to the material's high purity, applications in baby food production is possible without any concerns as well.

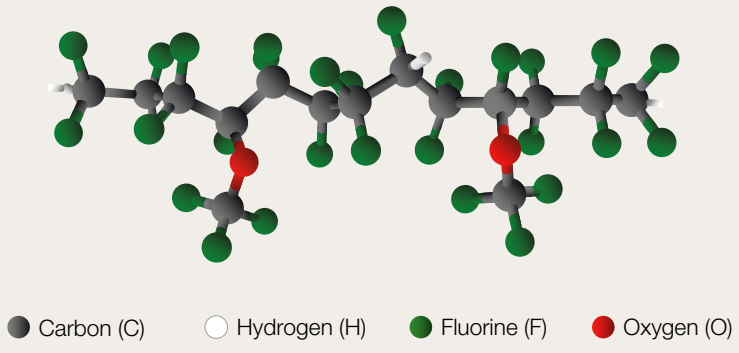
Test	Standard	Unit	Test specimen	Required range	V9196
Elastomer base					FKM
Color					black
Hardness	DIN ISO 7619-1	Shore A	Indenter > 6 mm	80 ± 5	80
Density	DIN EN ISO 1183-1 A	g/cm³	Method A	1.94 ± 0.02	1.94
Modulus 100 %	DIN 53 504	MPa	S2	> 5	9.0
Tensile strength	DIN 53 504	MPa	S2	> 15	24.8
Ultimate elongation	DIN 53 504	%	S2	> 180	268
Tear strength	DIN ISO 34-1 B	N/mm	Angle test with incision	> 10	16.4
Compression set 24 h / 200 °C	DIN ISO 815-1	%	Test spec. B / Method A / 25 % deformation	< 30	19
Glastransition temperature T_g, DSC	DIN EN ISO 11537	°C		< -15	-17
Aging in acetic acid (pH-value = 3), 500 h / 100 °C					
Hardness change	DIN ISO 1817	Shore A		-10/+2	-8
Volumetric change	DIN ISO 1817	%		< +10	+5

V9196 – Physical Data

Fluoroelastomers, highly fluorinated (FKM) – HiFluor®

Test results have shown that even fluoroelastomers (FKM) are not compatible with solvents such as methyl isobutyl ketone (MIBK) which, for instance, are used in the paint and varnish industry. By contrast, perfluoroelastomers (FFKM) offer chemical resistance against nearly all media, but their elastic properties in most cases are clearly inferior to those of FKM. The result for seals: relatively large permanent deformation and frequently inadequate low-temperature flexibility.
As an alternative Parker has developed unique high-performance elastomer materials which combine the elastic properties of FKM with a chemical resistance that nearly reaches the level of perfluorelastomers: HiFluor®. HiFluor® compounds owe their outstanding chemical and physical properties to a very flexible structural element that has been integrated into the backbone chain of the perfluoroelastomer polymer. The HiFluor® product family with its excellent chemical resistance, outstanding elastic properties and favorable price-performance ratio offers numerous application benefits.





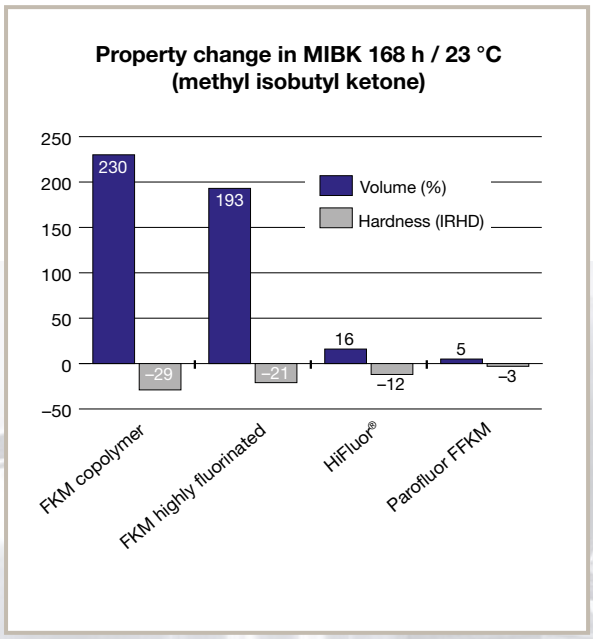
Properties

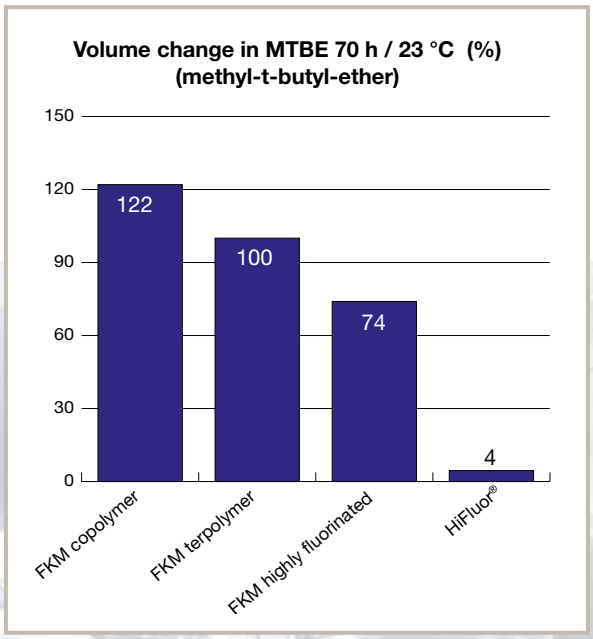
- Wide temperature resistance from -25 to 250 °C
- Long life due to very low compression set
- Large selection of special compounds for various pressure ranges and with various approvals or conformities

Chemical Resistance

In nearly all media, HiFluor® compounds offer chemical stability comparable to that of perfluoroelastomers. Particularly in polar solvents HiFluor® is superior to FKM compounds, even highly fluorinated variants.

The diagrams below show the results of comparative measurements between HiFluor® V3819, FKM and FFKM in methyl isobutyl ketone (MIBK) und methyl tert butyl ether (MTBE).





From the Field

The Specialist for the Food and Beverage Industry: HiFluor® FB V8991

Fluoroelastomeric compounds have been used with great success in chemical and food industry applications involving non-polar solvents, aliphatic hydrocarbons, fats, oils and aromatic substances whenever the resistance of standard materials such as HNBR and EPDM is no longer adequade.
A specialist from this HiFluor® FB compound family is the innovative, pure V8991 compound for static and dynamic sealing elements.

Properties of HiFluor® FB V8991

- Very pure material, free of phthalates and mineral oil based plasticizers
- Outstanding resistance in alkaline solutions, acids, greases, oils and aromatic substances
- Good resistance in CIP/SIP media, water vapor up to 150 °C
- Complete traceability due to in-house compound development and mixing, engineering design, tooling, production
- Wide application temperature range from -25 to 200 °C.

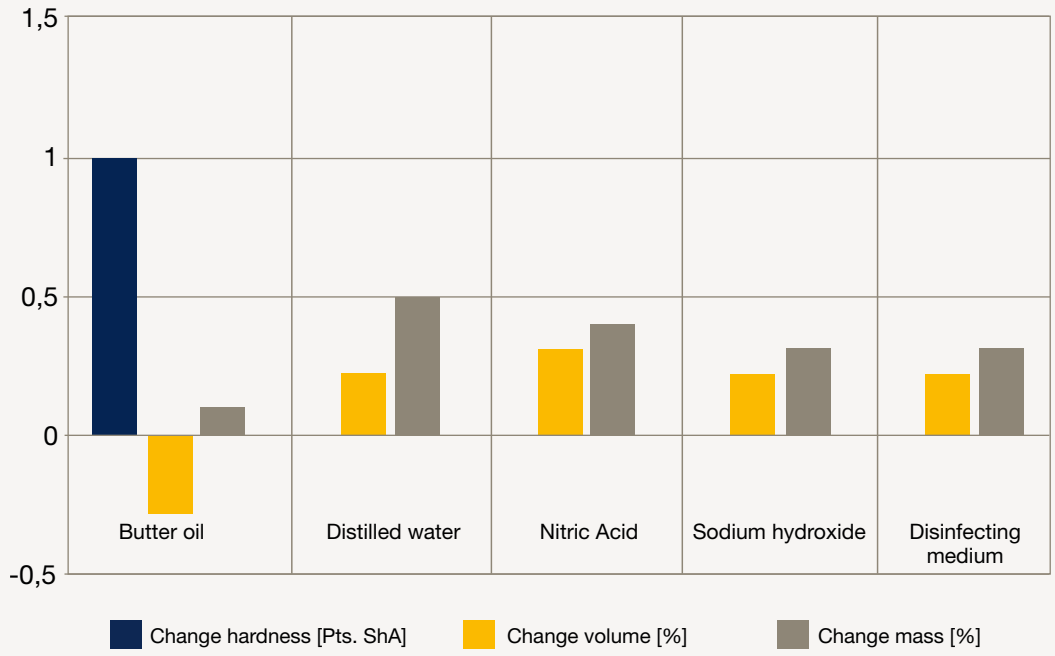
Thanks to its outstanding properties profile of mechanical strength and chemical resistance, the innovative HiFluor® FB V8991 high-performance compound is superbly suited for the challenges of the chemical and pharmaceutical industries.

Approvals and Conformities at a Glance

- FDA-conformant acc. to Chapter 21CFR 177.2600
- USP Class VI, Chapters 87 and 88
- 3-A Sanitary Standard 18-03, Class I + II
- Regulation (EC) No.1935/2004
- Regulation (EC) No.1907/2006 (REACH)
- RoHS Directive 2011/65/EU
- BNIC (Bureau National Interprofessionnel du Cognac)
- Free of animal-derived ingredients (ADI-free)
- Free of polycyclic aromatic hydrocarbons (PAH-free)

Test	Standard	Dimension	V8991
Elastomer base			FKM
Color			ocker
Hardness	DIN 53505	Shore A	75
Specific weight	DIN EN ISO 183-1	g/cm³	1.94
Tensile strength	DIN 53504	N/mm²	18.5
Ultimate elongation	DIN 53504	%	273
Modulus 100 %	DIN 53504	N/mm²	6.8
TR10 value	ASTM D 1329	°C	-7
Compression set (70 h / 200 °C)	DIN ISO 815	%	30

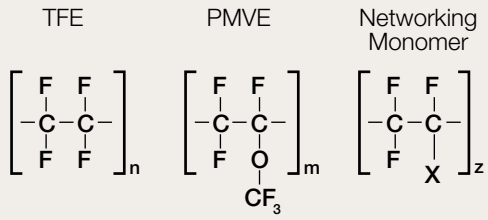
HiFluor® FB V8991 – Physical Data



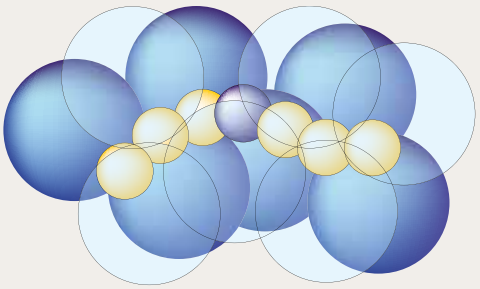
HiFluor® FB V8991 – changes after storage in
- Minimum 96 % butter oil after 22 h / 70 °C,
- Distilled water after 22 h / 70 °C,
- 0.5 % nitric acid after 22 h / 82 °C,
- 1% sodium chloride after 22 h / 82 °C,
- Disinfectant with 200 ppm chlorine after 22 h / 21 °C.

Perfluorinated Rubber (FFKM)
Parofluor®

All components – including seals and sealing systems – in processing equipment of the food and chemical industry must be reliable in processing without limitations. Yet increasingly aggressive and concentrated cleaning agents and high-temperature processes make higher and higher demands on the sealing compounds. In addition, legal and regulatory provisions require materials which are pure and inert in use with process media. Perfluoroelastomer materials or Parofluor® compounds are used in many industrial production processes whenever conventional elastomers due to a lack of chemical and temperature resistance are no longer adequate. Sealing elements made of these compounds exhibit outstanding permanent elasticity and wide resistance against aggressive acids, alkali, solvents, amines and many corrosive chemicals. In addition, they are characterized by exceptionally high temperature resistance of up to 325 °C.



FFKM molecule (perfluoroelastomer)



What Is Parofluor® ?

Parker has developed the Parofluor® compound family (FFKM) in order to combine the elastic properties of elastomer materials with the excellent chemical and thermal resistance of PTFE. Compared with conventional perfluoroelastomers, Parofluor® has excellent permanent elasticity and is superbly suited for sealing applications with very aggressive media. Parofluor® compounds build on perfluorinated rubbers. They typically consist of three monomers: tetra fluoro ethylene (TFE) as the basic structure, perfluoro methyl vinyl ether (PMVE) for elasticity and a cure site monomer (CSM). As in the case of PTFE, all of these monomers no longer contain any hydrogen atoms, which results in Parofluor® exhibiting excellent and universal media resistance.

Parker has developed Parofluor® compounds and sealing elements specifically for the food and chemical process industries which fully meet the demands of their challenging operating conditions while supporting the hygienic and aseptic processes so that no process contaminations or catalytic technical process changes occur. As a result, maximum safety, reliability and durability are achieved in the production process.

Properties

- Superior chemical resistance in aggressive and oxydizing media
- Very good resistance in hot water, steam, de-ionized and ozone-containing water and cleaning agents
- Outstanding temperature resistance from -20 to 300 °C
- Extended service life due to very low compression set
- Suitable Parofluor® compounds with required approvals and conformities

From the Field

Extreme High-Temperature Stability and Media Resistance: V8950 and V8951

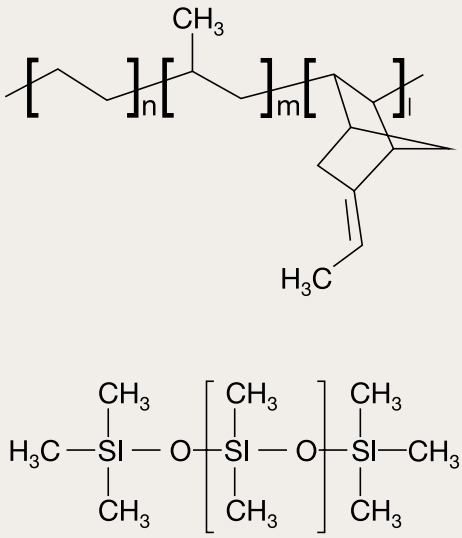
For hygienic applications in the food and process industries where defined approvals and conformities as well as outstanding chemical and thermal resistance are required, the Parofluor® compounds V8950 (black, FDA-conformant) and V8951 (white, FDA-conformant, USP Class VI, for oxydizing media) are on the short list of choices. Both are suitable for application temperatures of up to 240 °C .

Test	Standard	Unit	Test specimen	V8950	V8950
Elastomer base				FFKM	FFKM
Color				black	white
Hardness	DIN ISO 7619-1	Shore A	Indenter > 6 mm	75 +5/-3	70 +8/-5
Density	DIN EN ISO 1183-1 A	g/cm³	Method A	2.26	2.43
Modulus 100 %	DIN 53 504	MPa	S2	8.7	10.6
Tensile strength	DIN 53 504	MPa	S2	12.7	16.3
Ultimate elongation	DIN 53 504	%	S2	135	151
Compression set 70 h / 200 °C	DIN ISO 815-1	%	Test spec. B / Meth. A / 25 % deformation	18	
Compression set 70 h / 230 °C	DIN ISO 815-1	%	Test spec. B / Meth. A / 25 % deformation		34

V8950 und V8951 – Physical Data

Silicone (VMQ, LSR)

Silicone rubbers encompass a group of materials in which methyl vinyl silicone (VMQ) is the most frequently used one. Liquid silicone (LSR), which can be colored in nearly any desired way and can be processed as a 2-component compound, is part of this group as well. Due to their resistance against bacteria, mold and fungi, silicone compounds are ideally suited for use in biotechnology, in the food and beverage, and in the pharmaceutical industries. Excellent purity, which is evident in the material's transparency, is another striking argument for the utilization of silicone compounds in these applications. Due to the hygienic and purity requirements in the food, beverage and pharmaceutical industries, sterilization processes are inevitable. In applications with CIP/SIP media for continuously operating equipment, with the exception of steam sterilization, silicone (VMQ) exhibits very good properties.



Properties

- Heat resistance: up to approx 210 °C (special grades up to 230 °C)
- Cold resistance: up to approx -55 / -60 °C (special grades up to approx. -100 °C)
- Chemical resistance
  - Aliphatic-type engine and transmission oils (e.g. IRM 901)
  - Animal and vegetable oils and fats
  - Glycol-based brake fluids
  - Low-flammable hydraulic fluids HFD-R and HFD-S
  - Chlorinated aromatic hydrocarbons (e.g. clophene)
  - Chlorinated diphenyls (e.g. flame-resistant insulations, coolants for transformers)
  - Water up to 100 °C
  - Diluted saline solutions
  - Ozone, aging and weather resistance
- Not resistant against
  - Water vapor >120 °C
  - Acids and alkali
  - Silicone oils and greases
  - Low-molecular chlorinated hydrocarbons (e.g. trichloroethylene)
  - Aromatic mineral oils
  - Fuels
  - Aromatic hydrocarbon (e.g. benzene, toluene)

From the Field

Universally Usable in Food Processing: S3840 and S3698

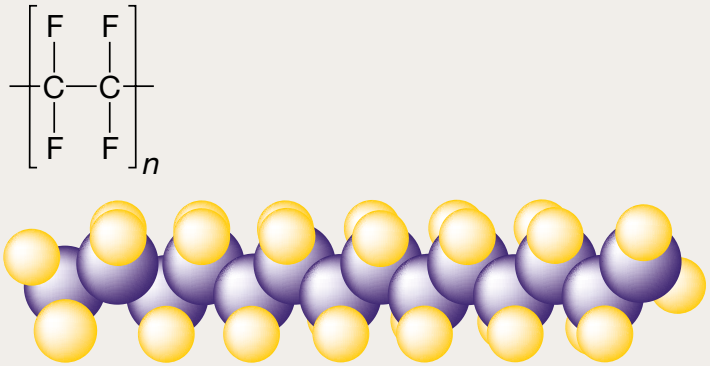
S3840 and S3698 are examples of Parker's silicone compounds for universal uses in food processing applications.
Thanks to their wide range of properties, silicone compounds are among the most frequently used materials in food processing applications. This applies to industrial processes as well as to equipment for domestic use and in the gastronomy business. Parker silicone compounds such as S3840 and S3698 can be used, for example, in deep freezers for ice cream processing, in coffee pad machines or in large industrial tunnel ovens in the form of seals, wipers or any type of molded components. Easy cleaning and disinfection of the components is no problem thanks to the compounds' good chemical resistance. Transparent compounds like S3840 are the materials of choice for visible components.

Test	Standard	Unit	S3840	S3698
Elastomer base			LSR	LSR
Color			transparent	reddish brown
Hardness	DIN ISO 7619-1	Shore A	70	70
Density	DIN EN SIO 1183-1 A	g/cm³	1.14	1.13
Tear strength	DIN 53504	N/mm²	9.0	8.4
Ultimate elongation	DIN 53504	%	312	350
Compression set, 24 h / 175 °C	DIN ISO 815-1	%	17	11
TR10	ASTM D1329	°C	-51	-51

S3840 und S3698 – Physical Data

Polytetrafluorethylen (PTFE)
Polon®

The molecular structure of PTFE is based on a linear chain of carbon atoms completely surrounded by fluorine atoms. The carbon-fluorine bonds are among the most stable organic bonds of all.



Thermal Stability across a Wide Temperature Range

Thanks to the high melting point (342 °C) and morphological characteristics of PTFE, the components made of this thermoplastic material are suitable for continuous use at operating temperatures of up to 260 °C. Above this temperature, the physical properties tend to degrade, resulting in heat aging and material decomposition.
PTFE is used in cryogenic temperatures to seal off critical media such as liquid nitrogen (–96 °C), liquid hydrogen (–253 °C) and liquid helium (–269 °C).
Under alternating temperature loads, PTFE has unique resistance against decomposition, heat aging and changes in physical properties.

Low Friction/Dry-Running Capability

PTFE exhibits the lowest friction coefficient of all known solids. Thanks to its self-lubricating properties, it is suitable for permanent operation in dry-running/low-lube conditions in dynamic sealing applications.

Extreme Chemical Resistance

The bonding stability of the intrapolymer chains of PTFE prevents reactions with most chemicals and thus makes them chemically inert at higher temperatures against practically all industrially used chemicals and solvents. There are only few media known that react with PTFE: alkali metals, fluorine and a few fluorine chemicals such as chlorine triluorine and oxygen difluoride.
PTFE is suitable for use in food applications and meets FDA requirements.

The Effect of Fillers

In spite of its remarkable properties, virgin PTFE is not suitable for a number of a more challenging applications involving high mechanical loads and wear. By adding fillers, various physical properties of PTFE, particularly creep and wear rates, and thus mechanical load resistance, can be improved. Due to the high temperature resistance of most fillers of up to 400 °C, there are no limitations for use in high-temperature applications.

Commonly used fillers are glass fiber, carbon and carbon-graphite, bronze, MoS_2, aromatic polyesters, etc.

Other Properties

- Reduced stick-slip tendency
- Unlimited shelf life: PTFE does not exhibit aging over time and is not impaired by UV light.
- No explosive decompression: PTFE harbors no risk of saturation of highly pressurized gases that may massively expand and cause the material to explode in the event of a sudden pressure drop.
- No swelling by moisture absorption
- Safe for use in low-pressure or vacuum applications
- Excellent electrical properties: high insulation strength, low K value and very high dielectric resistance (depending on fillers used).

From the Field

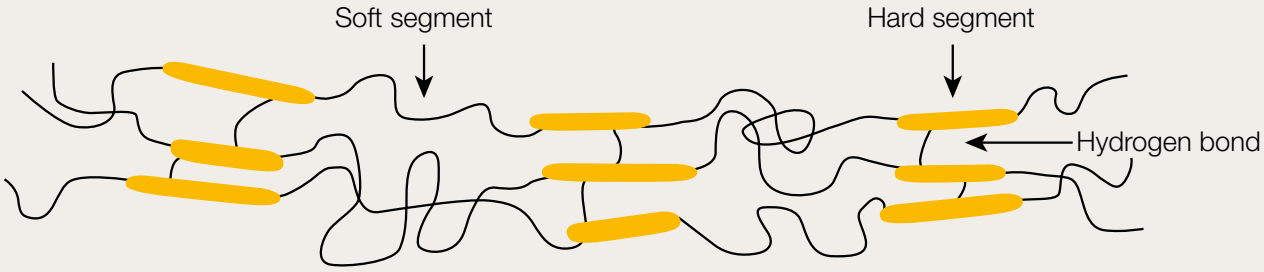
Wide Range of Designs and Special Compounds

Functional elements used in the food industry such as seals, wipers and molded parts not only have to be resistant against the foods passing through a filling line, but also have to exhibit extreme wear resistance, as most applications have to be run with no additional lubrication.
For this reason, Parker Prädifa offers a wide-ranging portfolio of PTFE seals and molded parts featuring special designs and made of materials specifically modified for applications in no-lube environments in the food industry. This ensures low wear and friction as well as long service life even in harsh conditions, which may, for instance, occur in shock-freezing or in industrial lines for baking products.

Due to their material properties, Parker Prädifa's special PTFE seals without undercuts are not only resistant against all commonly used cleaning processes such as CIP (Clean in Place) or SIP (Sterilization in Place), or non-standard cleaning agents like concentrated acids and alkaline solutions, but, due to their special design, enable easy cleaning in the area of the seal or wiper without the risk of contamination of the food products subsequently passing through the filling line.

Thermoplastic Polyurethanes (TPU)
Ultrathan®

Thermoplastic polyurethanes are partially crystalline materials and belong to the class of thermoplastic elastomers. Characteristic for polyurethane elastomers is the segmented structure of their macromolecules. Due to the varying cohesion energy densities of these segments, a phase separation into crystalline “hard” and amorphous “soft” segments ideally occurs. The resulting two-phase structure determines the properties profile of products made of these polyurethane systems.



Schematic composition of thermoplastic polyurethanes (TPU with hard and soft segments)

Properties

TPU compounds clearly differ from classic elastomers due to their clearly higher mechanical strength. Other outstanding material properties are high abrasion, wear and extrusion resistance, high elasticity, high pressure load resistance and high tear and tear strength.

Polyurethane materials exhibit good flexibility (also in the upper hardness range) in the temperature range from -50 to 120 °C (short-term up to 140 °C) as well as very good aging and ozone resistance. They are well-suited for use in mineral oils and lubricant greases with critical decomposition, H, HL, HLP hydraulic oils, silicone oils and greases, flame-retardent pressure fluids (e.g. HFA, HFC, HEES, HETG, HFB) and water up to 80 °C (special compound variants up to 100 °C) as well as pure aliphatic hydrocarbons. Special types are also resistant against aqueous media, including mineral oils, oil-water and water-oil emulsions or aqueous polyglycol solutions. Compared with the 90-Shore NBR rubber compound, abrasion and extrusion resistance is at least 4 to 5 times higher. The seals made of these compounds are resistant against various gases such as nitrogen or synthetic hydrocarbons and will not become brittle under the influence of oxygen or ozone. In mineral oil, hydraulic fluids or lubricant greases, swelling is minimal. Generally good chemical resistance and outstanding dynamic performance complement the product profile.

Range of Application

Applications for thermoplastic polyurethanes are found in mobile and industrial hydraulics, gas processing technology and gas spring engineering, pneumatics, valve technology, the chemical industry as well as in food and pharmaceutical process technology.

Ultrathan® Compounds by Parker Prädifa

In addition to the advantages mentioned above, Ultrathan® high-performance compounds are characterized by

- Good dynamic performance and long life
- Variable hardness, between 80 Shore A and 58 Shore D
- Flexibility across a wide temperature range
- Further improvement of dynamic load resistance and wear resistance compared with conventional TPU grades
- Tribological improvements such as low surface energy to prevent sticking and stick-slip
- High resistance against washing and cleaning processes
- Free of plasticizers
- Good resistance against high-energy radiation
- Very high resistance to reverse bending
- Thanks to very good adhesion to other thermoplastics (e.g. PA), the composite part can be produced in a single process step without requiring a primer.

Specially modified Ultrathan® compounds expand the range of applications for

- Low- or high-temperature applications (-60 to 140 °C)
- Higher hydrolysis requirements, e.g. in humid/moist environments, in cleaning cycles or when biodegradable service media are used
- Improved friction and stick-slip-free operation
- Applications involving high loads
- etc.

Parker Prädifa's in-house development and production ensures optimum monitoring of all process steps and additionally enables fast transfer of new compound developments into volume production.

From the Field

Fit for Food Contact: P5000, P5001

Parker Prädifa's Ultrathan® compounds P5000 and P5001 (on a polyester base) are suitable for use in production processes of food contact materials (FCM). They meet all the relevant FDA requirements, of European Regulation (EC) 1935/2004 and of Regulation (EU) 10/2011.

The materials are easy to clean and are characterized by good chemical, hydrolysis and aging resistance against aqueous media and by good microbial and good wear resistance. In addition, they exhibit good mechanical strength and outstanding elasticity (also in cold conditions).

Benefits of Ultrathan® Compounds in the Chemical Process and Food Industries

- Good resistance against animal fats and oils
- High chemical resistance against aggressive chemicals and cleaning methods
- Easy to clean contact area
- High temperature resistance in cleaning and sterilization processes
- Wear-resistant surface
- Improved tensile strength properties and improved elasticity
- Special shapes to avoid undercuts which are hard to sterilize and pose the risk of microbacterial contamination
- Microcrack-free TPU coating

Test	Standard	Unit	Test specimen	P5000	P5001
Elastomer base				TPU	TPU
Color				dark green	orange
Hardness	DIN ISO 7619-1	Shore A	Indenter > 6 mm	94 +/-5	94 +/-5
Density	DIN EN ISO 1183-1 A	g/cm³	Method A	1.2 +/-0.02	1.19 +/-0.02
Modulus 100 % (min.)	DIN 53 504	MPa	S2	13	11
Tensile strength (min.)	DIN 53 504	MPa	S2	50	50
Ultimate elongation (min.)	DIN 53 504	%	S2	350	400
Tear strength (min.)	DIN ISO 34-1 B	N/mm	Angle test w/incision	90	50
Compression set (max.) 70 h / 70°C	DIN ISO 815-1	%	Test spec. B / Meth. A / 25 % deformation	27	30
Glass transition temperature T_g, DSC	DIN EN ISO 11537	°C		-20	-40

P5000 and P5001 – Physical Data

Thermoplastic Compounds

Thermoplastic materials can be deformed in specific temperature ranges. This process is reversible with most thermoplastics. Thermoplastics are either partially crystalline or armorphous.

Parker Prädifa has a wide range of thermoplastic compounds that can be processed into both sealing and engineered elements. A combined application is possible to some extent and makes sense as well. In this case, energizer elements (e.g. elastomers or metal springs) are used, which ensure the required elasticity for the sealing application. Thermoplastic compounds from Parker Prädifa are characterized by excellent wear resistance and highest chemical and thermal resistance. They are suitable for the special requirements in sealing applications involving dynamic, mechanical loads.

Parker Prädifa offers one of the most extensive portfolios of thermoplastic compounds (e.g. PP, PE, PA, POM, PK, PEEK) in the industry for use in the chemical process and food sectors, which meet FDA and European requirements for contact with food (Regulation (EU) No. 10/2011). Before selecting the material, the customer's application is analyzed, followed by identifying the most economical solution that meets the technical and legal requirements.

The portfolio of thermoplastics ranges from polyethylene (W5040) to PEEK (W5052), from unfilled materials to compounds with 60% fillers (e.g. glass fibers), from friction-optimized grades to Parker's exclusive materials (nobrox®).

From the Field

Robust, Elastic and Food-Compatible nobrox® W6101

nobrox® W6101 is an evolution of nobrox® W6100 for which the additivation has been specifically adjusted to the needs of food applications. W6101 belongs to the family of modified aliphatic polyketones. In terms of media and hydrolysis resistance, it is comparable to PEEK and in terms of mechanical properties to POM or PA6. Its outstanding elasticity even at room temperature facilitates assembly and opens up new opportunities in product design.

nobrox® offers an alternative to the widely used materials PEEK and PTFE – frequently combined with attractive economic aspects. Compared with PTFE, processing of the material by injection molding makes cost-efficient production possible even for medium to larger volumes and compared with PEEK, nobrox® offers near-equal mechanical performance within a limited temperature range. Unless the utilization of PEEK is justified by high thermal loads in the application, nobrox® is a viable economical alternative.

Advantages at a Glance

- Mechanical properties comparable to PA 12 with approx. 40 K higher melting temperature of 220 °C
- Permanent service temperature of up to 150 °C
- Good resilience and low creep
- High chemical resistance / good barrier properties
- Very short cycle times (fast recrystallization)
- Low moisture absorption of 0.4 % at 23 °C, 50 % relative humidity
- Extremely high ultimate elongation
- Very good tribological properties / good sliding properties combined with low wear
- Good impact resistance at -40 °C
- Flame-protected without halogens and red phosphor
- Very good weldability (laser welding, vibration welding, etc.)
- Gamma sterilization possible
- Outstanding reproducibility of dimensions and tolerances

Test	Standard	Dimension	nobrox® W6100
Elastomer base			PK
Color			orange brown
Hardness	DIN 53505	Shore D	76 +/-3
Tensile strength	ISO 527	MPa	>60
Ultimate elongation	ISO 527	%	>300
Water absorption at 50 % rel. humidity	ASTM D 570	%	< 0.5
Izod notched impact strength	ISO 180/1A	kJ/m²	>15
Tensile modulus	ISO 527	GPa	>1.4

W6101 – Physical Data

nobrox® from Parker Prädifa is a prime example of a universally usable material. The combination of a seal and engineered element such as a piston or housing, offering a broad media resistance and robust mechanical performance offers a wide variety of new application possibilities.

Development of a Fully Integrated Brewing Piston Made of nobrox® for Professional Coffee Machines

The Challenge

The brew unit is the centerpiece of any fully automatic coffee machine. This is where the key parameters of the coffee's quality are determined, such as the compaction level of the grounds, water pressure and filtering of the coffee product.
The brewing chamber, the metallic micro-strainer and, last but not least, the brewing piston with the associated sealing and wiping system are the key components of the brew unit.

Conventional brewing piston systems in professional fully automatic coffee machines frequently consist of complex, metallic brewing pistons with sophisticated geometries and failure-prone sealing systems with an average expected lifetime of approximately 50,000 brewing cycles. Afterwards, the brewing piston and the related sealing system have to be exchanged in a time-consuming and costly process.
The sealing system not only has to withstand a pressure of up to 20 bar at temperatures of 95 °C, but also resist the highly abrasive coffee powder and the acidic coffee extract.

The Solution

- The newly developed brewing piston system features two major components: the brewing piston and the portafilter with integrated sealing, wiping and filtering function. Easy connection of the components can optionally be achieved by a threaded connection or snap fitting for ease of assembly and servicing.
- The fully integrated design of the nobrox® brewing piston reduces the geometric complexity and number of single componens while increasing ease of assembly and servicing.
- The piston attachment combines various functions, which helps reduce the complexity and component diversity of the brew unit. This where the non-reinforced nobrox® material can display its advantages. Its high wear resistance makes it possible to combine the sealing and wiping function in a dynamic sealing system. The sealing/wiping lip is preloaded by a TPU O-Ring and ensures consistently good sealing performance between the brewing piston and the brewing chamber across the entire lifetime.
- Service life extended on average by 50 to 100 % or to an average expected life of > 100,000 brewing cycles.
- Lower heat loss compared with metallic pistons saves heating elements.
- Manufacturing cost benefits due to injection molding technology compared with machining of metallic brew pistons.
- Unlike solution concepts that enclose the seals in a groove on the outer piston diameter the fully integrated system permits absolutely no dead space. This avoids coffee deposits that impair functionality or flavor.
Due to the outstanding tribological properties of the nobrox® material, there is no need for additional lubrication.

Free of Polycyclic Aromatic Hydrocarbons

Polycyclic Aromatic Hydrocarbons (PAHs) are risk-prone chemicals in many respects. Many PAHs have been rated as carcinogenic, mutagenic or toxic for reproduction by the European Union. A prominent example is benzo[a]pyrene. This substance is largely responsible for the carcinogenic effect of cigarette smoke. Additionally, PAHs can be toxic for humans or other organisms. If PAHs are released to the environment, they will accumulate in plants, soil and the air for an indefinite period of time, resisting degradation. Due to the combination of toxicity and persistence, PAHs are substances which are harmful to the environment.
Therefore, limiting the emission of PAHs and minimizing the use of PAH-containing chemicals is highly important and the utilization of sealing materials with low or no PAH content, particulary in the food industry, is a crucial step in the right direction.

PAH-Free Seals from Parker Prädifa

The PAH content of seals can be determined by means of analytical chemistry. Due to the large number and diversity of PAHs, the concentration of 18 chemical compounds is determined as a representative sampling. The measurement method of choice is GC-MS and the test procedure may be performed according to AfPS GS 2014:01 PAK / QMA 1284. When the sum of all 18 PAHs is below 0.2 ppm (i.e. less than 0.2 mg/kg) the seals are PAH-free. Concentrations of less than 10 ppm (10 mg/kg) are considered PAH-low. Additionally, since December 2015, a new EU Regulation (REACH VO (EC) 1907 Annex XVII, VO 1272/2013) has been in effect which provides for a limit of 1 mg/kg for 8 defined PAHs. So far, the restrictions of the regulation apply only to articles that come into direct as well as prolonged or short-term repetitive contact with the human skin or the oral cavity under normal or reasonably foreseeable conditions of use. In the future, further laws and regulations at country and EU levels can be expected to regulate the commercialization of PAH-containing products. Therefore, Parker Prädifa is aiming to offer PAH-free compounds for sealing solutions even before new restrictions come into effect. The table provides an overview of selected PAH-free compounds. The PAH content has been confirmed by an independent and accredited test laboratory of DEKRA.

Compound	Polymer base	Brand	Color	Hardness (Shore A)
N9400	NBR		black	75
N9192	HNBR		gray	80
V9169	FKM		black	80
V9196	FKM		black	80
E8924	EPDM		black	70
E8961	EPDM		black	85
V8991	FKM	HiFluor® FB	yellow	75
P5000	TPU	Ultrathan®	green	93
P5029	TPU	Ultrathan®	colorless	93
P5001	TPU	Ultrathan®	orange	93
P5600	TPU	Ultrathan®	ocher	93

PAH-free sealing compounds from Parker Prädifa

Polymer base	Prädifa Brand	Compound reference	Hardness (Shore A)	Color	Temperature range (°C)	Approvals and Conformities			
						FDA	USP Class VI	EU 1935/2004	Bfr
EPDM (Ethylene Propylene Diene Rubber)		E0540	80	black	-50/150				
		E8924	70	black	-50/150	•	•	•	
		E8961	85	black	-50/150	•	•	•	
NBR (Nitrile Butadiene Rubber)		N0674	70	black	-35/100				
		N8551	75	black	-35/100	•		•	
		N9400	75	black	-35/100	•		•	
HNBR (Hydrogenated Nitrile Butadiene Rubber)		N3824	70	black	-35/150	•		•	
		N8526	90	black	-35/150	•		•	
VMQ/LSR (Silicone Rubber)		S0604	70	red	-35/200				
		S3693	50	red	-35/200	•		•	•
		S3695	60	red		•		•	•
		S3840	70	transparent		•		•	•
		S3698	70	red		•		•	•
FKM (Fluoroelastomers)		V0747	70	black	-25/200				
		V8750	70	black	-25/200	•		•	
		V8722	70	black		•		•	
		V8836	75	green		•		•	
		V9169	80	black	-35/200	•		•	
		V9196	75	black	-25/200	•		•	
FKM (Fluoroelastomers, highly fluorinated)	HiFluor®	V8522	75	white	-25/260				
		V8991	75	ocher	-25/230	•	•	•	
		V8730	70	white	-25/250	•		•	
FFKM (Perfluoroninated Rubber)	Parofluor®	V8911	75	white	-20/220				
		V8950	75	black	-15/240	•		•	
		V8951	75	white	-15/240	•	•	•	
		V8921	75	white	-15/260				
		V8742	75	white	-15/300	•		•	
TPU (Thermoplastic Polyurethanes)	Ultrathan®	P5000	94	green	20/100	•		•	
		P5029	94	natural	20/100	•		•	
		P5001	94	orange	35/100	•		•	
		P5600	92	ocher	20/80	•		•	
PTFE (Polytetrafluorethylene)	Polon®	Polon® PS001	55 (Shore D)	white	-260/300	•		•	
		Polon® PS005	60 (Shore D)	natural white	-260/300	•	•	•	
		Polon® PS006	60 (Shore D)	natural white	-200/80	•		•	
		Polon® PS009	55 (Shore D)	white	-260/300	•	•	•	
		Polon® PS015	58 (Shore D)	natural white	-260/300	•		•	
		Polon® PS074	60 (Shore D)	gray	-260/310	•		•	
		Polon® PS007	61 (Shore D)	white	-260/300	•		•	
PK (Polyketone)	nobrox®	W6101	76 (Shore D)	natural	-40/80	•		•	
		W6100	76 (Shore D)	brown	-40/80			•	
PA (Polyamide)		W5051	232 (ball hardness)	black	-30/100			•	
PEEK (Polyether-Ether-Ketone)		W5082	250 (ball hardness)	gray	-65/260			•	

ADI-free	KTW	W270	PAH-free	3A	Media Compatibility + good ++ very good +++ excellent	Properties
					· CIP-/SIP cleaning fluids ++ · Lyes and acids ++ · Water ++ · Polar organic solvents (alcohols, ketones, esters) ++	· Very good abrasion resistance · Very good aging, ozone and light resistance · Good ultimate elongation and strength
•			•	•		
•			•	•		
					Plant- and animal-derived fats and oils +	· Very good low-temperature flexibility · High abrasion resistance · Approvals: DIN EN 549, VP 406
					Plant- and animal-derived fats and oils ++	· Very good low-temperature flexibility (terpolymer) · High abrasion resistance
			•		Plant- and animal-derived fats and oils ++	Ultra-pure NBR compound
					· Ozone + · Diluted acids, bases and saline solutions + · Plant- and animal-derived fats and oils +	Higher temperature resistance than NBR
					Suitable for coffee applications	High wear resistance (fiber-reinforced compound)
					Resistant to hot air up to 230 °C	· Good insulating properties · Inert · Odor- and tasteless · Bacteria- and fungus-resistant
•					· Wide range of chemicals · Oil-based fruit extracts ++	· Good thermal resistance · Approvals: BAM
				•	· Wide range of chemicals · Oil-based fruit extracts ++	Good thermal resistance
			•		· Acetic acid + · Superheated steam + · Polar solvents +	Low-temperature compound
			•			
•					· Wide range of chemicals · Polar solvents ++ · Lubricants ++ · Greases ++	Very good thermal resistance
•			•			
•						
					Widest range of chemicals	Excellent thermal resistance
•						
•						
			•		· Hydrolysis · NOT resistant to amines, glycole and chlorinated solvents	· Extrusion resistance · High tear resistance (> 60 MPa) · High ultimate elongation
			•			
			•			
			•			
				•	Widest range of chemicals	· Virgin PTFE · Low gas permeability (for vacuum applications) · Also for static applications
					Widest range of chemicals	· PTFE with aromatic polyester · For dynamic high-temperature applications
					· Widest range of chemicals · No moisture absorption	· UHMW PE · Very good wear and abrasion resistance · Self-lubricating properties
				•	Widest range of chemicals	· Virgin, modified PTFE · Reduced cold flow · Reduced permeation
					Widest range of chemicals	· PTFE, glass fiber filled · Pressure and wear resistant · No water absorption
					Widest range of chemicals	· PTFE with carbon fiber · Good wear coefficient, also in water · Higher thermal conductivity and lower thermal expansion than Polon® PS015
					· Widest range of chemicals · Steam and water	· PTFE with carbon/graphite · Self-lubricating properties
					· Aqueous and alkaline cleaning media · Steam cycles < 115 °C	· Extreme wear resistance · Robust against abrasive particles, rough surfaces etc. · High resilience
					Widest range of chemicals	· Stiff high-temperature glass-fiber-reinforced polyamide material · Excellent dimensional stability
					Widest range of chemicals	High-performance PEEK with glass-fiber reinforcement for higher stiffness and creep resistance

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