ISOLAST® perfluoroelastomer seals

Busak+Shamban

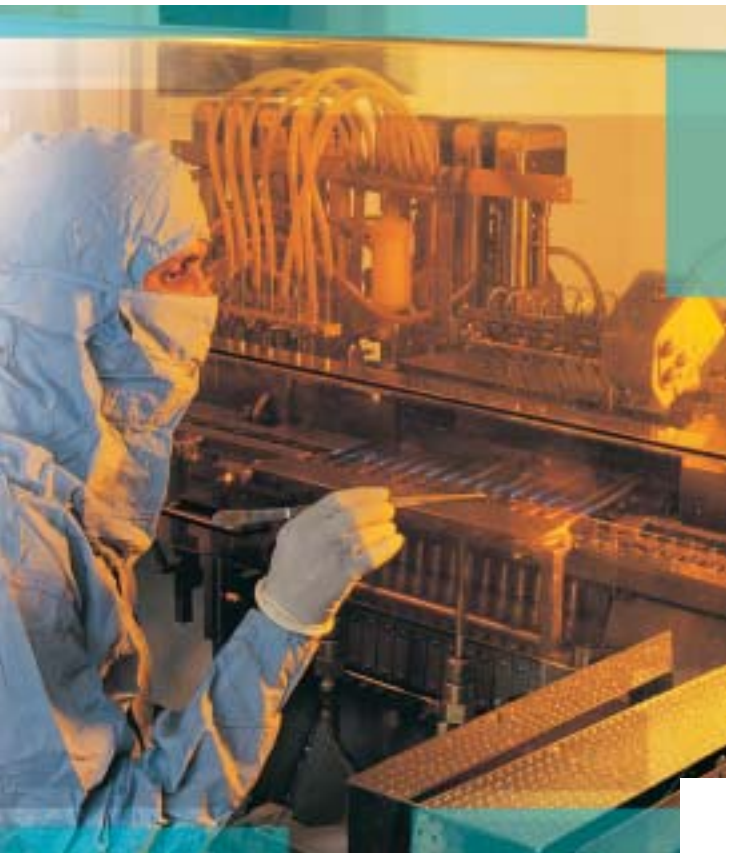
Isolast® perfluoroelastomer seals

Introduction

Material performance and seal design are both critical to effective sealing. Equipment manufacturers and end users expect a sealing system to operate leak free and to maintain long service life. Reliability is crucial to effective low maintenance cost operations.

To meet these demands in extremely hostile environments, with temperatures often in excess of 300°C, **Isolast®** perfluoroelastomers offer exceptional chemical and thermal resistance without sacrificing the essential performance of elastomeric seals.

Typically **Isolast®** is used in process applications such as chemical, semiconductor, pharmaceutical and hydrocarbon industries and is offered in a full range of products including O-Rings, gaskets and custom parts.



General perfluoroelastomer properties

Isolast® is a member of the perfluoroelastomer family (ASTM D1418: FFKM). Perfluoroelastomers are terpolymers of monomers in which all hydrogen atoms have been replaced by fluorine. The absence of hydrogen in the molecular chain dramatically increases both the chemical and thermal resistance of perfluoroelastomers. The cross-linked molecular chains enable perfluoroelastomers to combine the resilience and sealing force of an elastomer with the chemical inertness and thermal stability of PTFE.

Isolast® perfluoroelastomer compounds, developed by our specialists, comprise a range of materials which offer exceptional chemical resistance over a wide band of temperatures from –25°C to +325°C.

Benefits

The **Isolast®** combination of high performance and quality with state of the art sealing design provides a wide range of customer advantages:

- Superior reliability cutting planned and unplanned maintenance cost
- Longer service life reducing costs and driving up productivity
- Greater safety and reliability reducing wastage and contamination
- More opportunities for standardisation and inventory reduction
- Optimised seal solutions cutting the risk of failure

Applications

Isolast® perfluoroelastomer sealing products bring all these benefits to a wide range of applications for equipment manufacturers and end users in many industry sectors:

- Chemical processing
- Pharmaceutical and food industries
- Oil and gas
- Hydrocarbon processing
- Semiconductor fabrication
- Lacquer, print and coatings
- Aerospace
- Power generation

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The Isolast® product range

O-Rings

O-Rings offer engineers a high performance sealing element in a wide range of static and dynamic applications.

- AS 568A — American Norm
- DIN 3701 — German Norm
- BS 1806 / BS4518 — British Norms
- JIS B2401 — Japanese Norm
- NFT47-501 — French Norm
- SMS 1586 — Swedish Norm
- ISO 3601 — International Norm
- Moulded O-Rings to non-standard sizes - available to customer specification

Custom parts

Specific parts can be designed, developed and produced in conjunction with customers to ensure that all requirements are satisfied. The physical characteristics of perfluoroelastomers require careful design input from Busak+Shamban engineers. Inflatable seals, diaphragms and composite material products are typical areas of proven success in even the most hostile environments.

Gaskets: Moulded, punched or laser-cut to intricate patterns to suit customer specific requirements.

Bonded Gaskets: For leakproof flange gaskets with stainless steel or alternative metal compression retainer.

Bonded Products: In a variety of geometries, material grades and metals.

V Rings: For effective axial 'dirt' sealing in static and dynamic environments particularly for additional protection in hostile environments.

Moulded Parts: Custom moulded parts in virtually any shape

Specialty Seals: Homogeneous and layered diaphragms, inflatable seals, bellows, T Seals, valve seals amongst others.

General advice on issues concerning specifications, applications, installations or developments is available through our global organisation.

For personal service consult your local technical support office (see backcover)

The Isolast® material range

• Grade J9503	The classic material offering the most comprehensive chemical resistance including organic and inorganic oxides, amines and steam with an operating temperature range of –25°C to +240°C.	
	Hardness 75 IRHD	Colour – Black
• Grade J8325	The high temperature material which operates in applications up to +325°C whilst maintaining broad chemical resistance and excellent retained sealing force.	
	Hardness 75 IRHD	Colour – Black
• Grade J9501	A special material designed for applications in strong oxidising mediums such as halogens, ozone or hot oxidising acids. Also suitable for applications where cleanliness is required.	
	Hardness 80 IRHD	Colour - White
• Grade J9505	A general purpose, low compression set material designed for clean applications. Also suitable for strong oxidising mediums.	
	Hardness 70 IRHD	Colour – White
• Grade J9509	A material developed from J9503 but with increased hardness for use in high pressure applications.	
	Hardness 90 IRHD	Colour – Black
• Grade J9510	An approved explosive decompression resistant (EDR) (Shell Test) grade specifically developed for the Oil and Gas industry. In addition, compatible with, oils, steam, sour gas and amine based corrosion protection chemicals, amongst many others.	
	Hardness 95 IRHD	Colour - Black
• Grade J9512	'Heavy Duty' material suitable for extremely strong acids and bases (e.g. caustic soda) and steam applications whilst maintaining good compression set characteristics.	
	Hardness 85 IRHD	Colour - Black
• Grade J9515 *plus*	A material compliant with FDA requirements and meeting the high cleanliness standards typical in the pharmaceutical, food and biotechnology industries.	
	Hardness 75 IRHD	Colour - Black
• Grade J9516 *plus*	A white material meeting the same qualifications as J9515 *plus*, including FDA requirements.	
	Hardness 75 IRHD	Colour - White

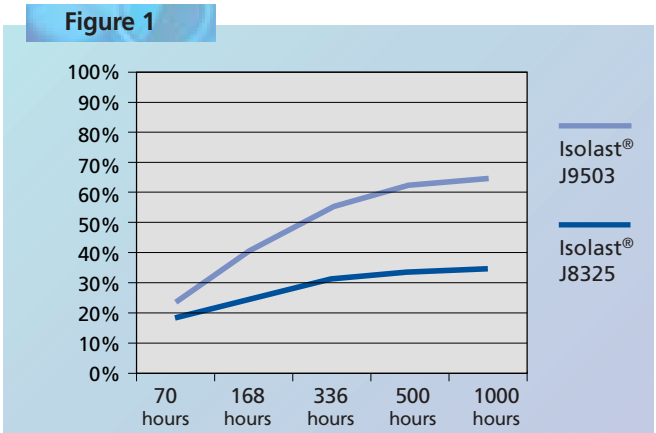
Isolast® perfluoroelastomer seals

Applications

The **Isolast®** range of outstanding material grades has been developed to ensure optimal performance and maximum mean time between failure through:

- Outstanding chemical resistance
- A wide temperature range from –25°C up to +325°C
- Very low outgassing at high temperatures and in vacuum applications
- Exceptional hysteresis properties ensuring high elasticity and dynamic recovery
- Excellent compression set characteristics giving the best possible leak-proof seals (*see figure 1*)
- High quality surface finish further enhancing sealing performance

Figure 1

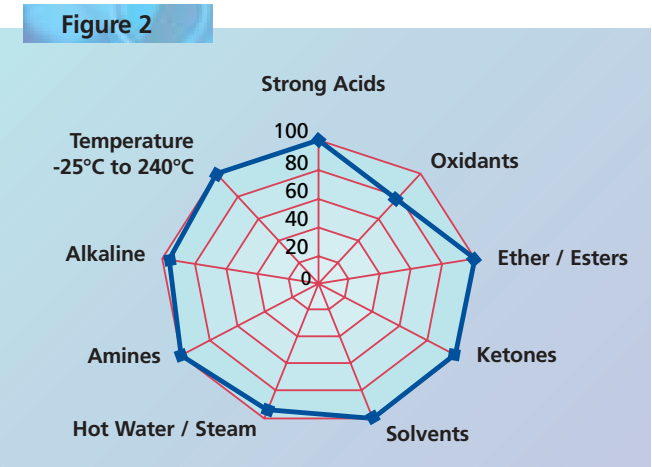


Long term compression set at 204°C

Aggressive Chemical Environments

In hazardous applications involving aggressive chemicals, high temperatures and long service life requirements, the **Isolast®** range offers the best solution. **Isolast®** *classic* material J9503 covers the widest range of chemicals from acids through to alkalis and amines to esters.

Figure 2



Isolast® J9503 radar chart for chemical resistance

In tests, **Isolast®** J9503 has shown considerably better compatibility over comparable competitor products, as seen in *figures 3-5*.
All tests were carried out on standard O-Rings size 214 (*24,99 x 3,99mm*) and in accordance with test procedure DIN 53521.

Figure 3

Immersion in nitric acid at 98°C

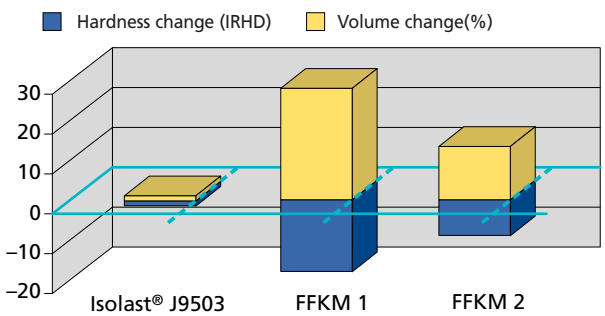
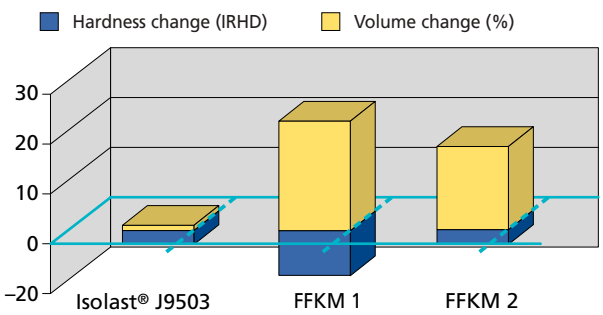


Figure 4

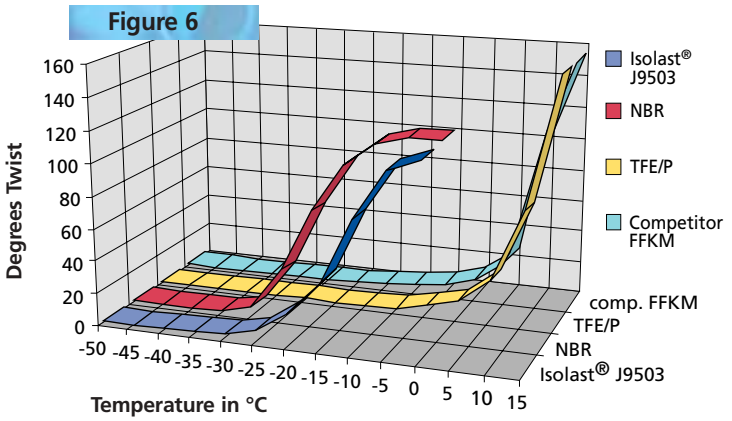
Immersion in acetic acid at 98°C



Low Temperature Applications

At lower temperatures, below -20°C for example, retained flexibility to maintain sealing force is critical. The glass transition temperature (*Tg*) of **Isolast®** J9503 is -19°C which is key to excellent low-temperature capability as the molecular backbone remains flexible.

Figure 6

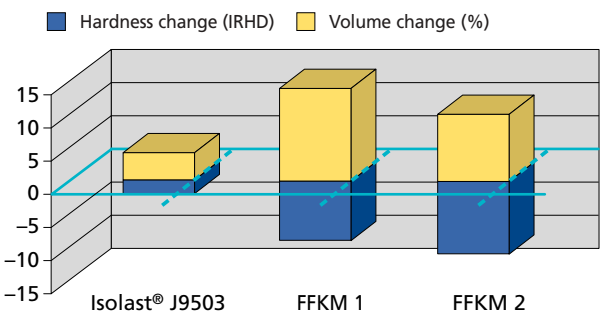


Low-temperature properties measured using a Gehman torsional test (BS 903: Part A 13, DIN 53548 and ASTM D 1053)

Figure 6 reflects the results of a Gehman test conducted with **Isolast®** and three other elastomers. As expected, NBR rubber shows the best low-temperature capabilities but it is followed by **Isolast®** J9503 which is effective down to -25°C. Tetrafluorethylene propylene (*TFE/P*) and a competitive perfluoroelastomer illustrate the exceptional performance of **Isolast®** J9503.

Figure 5

Immersion in pressurised steam at 200°C

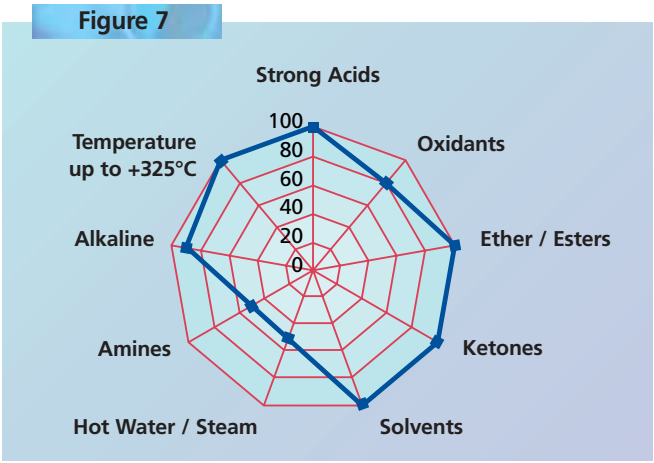


High Temperature Applications

To meet high temperature requirements in aggressive chemical environments, **Isolast®** J8325 has been designed to run at continuous operating temperatures up to +325°C. Even at these elevated temperatures, **Isolast®** maintains outstanding chemical resistance, as seen in *figure 7*.

Additionally **Isolast®** J8325 high temperature material has excellent retained sealing force which makes it suitable for applications with high temperature cycles.

Figure 7



Isolast® J8325 radar chart for chemical resistance

Specialised Applications

Additional **Isolast®** materials are continually being developed for specific customer applications, for instance **Isolast®** J9512 with excellent compression set features has been released for hot acid applications within the mining industries.

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Applications

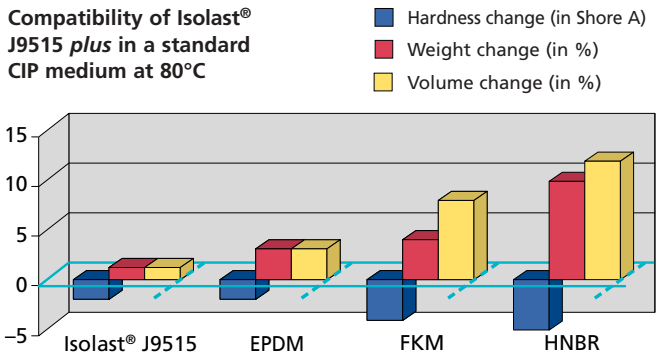
Pharmaceutical, Food and Beverage Applications

Sealing solutions in the pharmaceutical industry and also the food, beverage and biotechnology industries require cleanliness and high quality. To meet these special requirements a range of materials has been developed: **Isolast®** J9515 *plus* and the white **Isolast®** J9516 *plus*, both conform to the Food and Drug Administration (*FDA*) regulations set out in references 21 CFR 177.2600 (e,f) and 21 CFR 177.2400 (d) for perfluoroelastomers.

Isolast® J9515 and **Isolast®** J9516 are suitable for a wide range of pharmaceutical and food applications. Extensive tests demonstrated that the **Isolast®** *plus* range has excellent compatibility in the most widely used CIP cleaning mediums and can also be applied in Water-for-Injection (*WFI*) and steam sterilisation systems.

Figure 8

Compatibility of Isolast® J9515 *plus* in a standard CIP medium at 80°C



Oil and Gas Extraction and Processing

(High Pressure and Explosive Decompression Resistant Applications)

In oil and gas applications, traditional sealing solutions are limited due to extreme environments. Seals are not only in contact with aggressive mediums such as crude oil, natural gas, sour gases, carbon dioxide, acids, seawater, hydrogen sulphide and anti-corrosion chemicals but are also subject to damage caused through explosive decompression.

Isolast® J9510 material has been developed specifically to operate in the harsh environment of oil and gas processing.

The base polymer provides excellent chemical resistance and the specially developed density of the material makes it ideal in explosive decompression environments. An independent testing institute has certified **Isolast®** J9510 against the Shell Test.

Explosive decompression: ***an elastomer under high gas pressure absorbs gas which creates bubbles within the material. By controlled release of pressure, the elastomer expands and then contracts back to its original size as the gas permeates out. A sudden pressure drop within the system can lead to explosive decompression as high pressure gas expands within the elastomer before escaping, so destroying the surface and potentially the whole seal.***

O-Ring with explosive decompression damage

Semiconductor Application

Industry requirements for cleanliness and purity in both process and sealing products are high. Seals must perform in high vacuum environments and under pressure both in aggressive chemicals and at high temperatures. Neither must seals through particle generation create a potential contamination source for wafer processing. The expanding range of **Isolast®** semicon materials offer exceptional levels of purity, cleanliness and performance to seal current and proposed wet chemical and plasma applications.

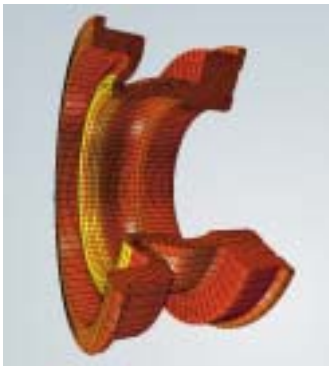
Lacquer and Paint Applications

To meet the aggressive nature of cleaning solvents and the requirement to be totally silicon-free, **Isolast®** offers materials ideally suited for paint, print and lacquer applications. For example in automotive paint lines, **Isolast®** has proven compatibility with the new cleaning solvents for hydro-lacquer while maintaining the highest quality surface finish from the initial filler coating to the final clear coat.

In-house Testing and Laboratory Capabilities

Material development and analysis in our modern elastomer laboratories, located in the United States and Europe, ensure that the **Isolast®** range meets current and future customer requirements. Tests carried out to DIN, ASTM or other industry standards include:

- Chemical compatibility testing
- High pressure and high temperature testing
- Dynamical mechanical analysis (*DMA*) - TR / TR10
- Thermogravimetric analysis (*TGA*)
- Modulus curve
- Low temperature flexibility testing
- Rheometer data



Non linear finite element analysis (NLFEA) is used to predict and optimise product performance. Taking comprehensive material test data from the material laboratories, accurate coefficients can be fed into the models. The availability of extensive test facilities permits validation of the models and benefits the customers.

Design Capability

For over 50 years, our design engineers have been producing sealing solutions for industries worldwide. The integration of **Isolast®** materials into the Busak+Shamban product range provides an unrivalled capability to exploit material performance and seal design.

Our Technology

We can offer the widest product range to meet both standard and speciality requirements with assurance helped by:

- State of the art Finite Element Analysis (*FEA*) and Non Linear FEA computer modelling
- Extensive test facilities
- Dedicated in-house tooling facilities
- Manufacture to zero defect standards in ISO9000 , QS9000 or AS9000 approved factories

Using a team approach, our application engineers, product designers and material technologists work with the customer to achieve optimum sealing performance with cost effective solutions.

Our international team of applications engineers and product designers are supported by 30 years experience of computer modelling. The benefits they offer, combined with data from our extensive test facilities include:

- Opportunity to optimise designs prior to prototyping and reduce lead times
- Indication of potential assembly problems and assessment of seal performance under complex loading profiles
- Assessment of seal performance over time
- Highlighting of tolerance problems
- Insight into operational effects of elastomeric seals

Technical data - Compound overview for Isolast®

Isolast®	Grade	Hardness ± 5 Shore A	Colour	Maximum service temperature °C	Minimum service temperature °C
Standard	J9503 - Classic	75	Black	240	-25
	J8325 - High Temperature	75	Black	325	-15
Special	J9501	80	White	240	-20
	J9505	70	White	240	-20
	J9509 - High Pressure	90	Black	240	-25
	J9510 - EDR[3]	95	Black	250	-15
	J9512	85	Black	260	-15
	J9515 - FDA	75	Black	250	-15
	J9516 - FDA	75	White	250	-15

Notes [1] BS 903 Part A2 [2] ASTM D1414 O-Rings [3] EDR - Explosive Decompression Resistant

For our semicon range of products - please refer to Isolast® semicon literature

Physical properties

Specific gravity	1.94 – 2.19 g/cm^3
Thermal conductivity of **Isolast®** J9503	33.1 x 10^{-4} W/(mK)

Gas permeation

Gas	Temperature in °C	rate*
Helium	25	2.5
Oxygen	25	0.08
Nitrogen	25	0.05
Hydrogen	90	113
Argon	90	6.2

* x 10^{-9}cm^3-cm/s-cm^2-cm △Hg

Key Chemical Resistance:

Detailed below are extracts from the **Isolast®** Chemical Compatibility Guide which is available from your local Busak+Shamban technical support office *(see backcover).*

Concentrated organic and inorganic acids
Strong alkalis and bases
Alcohols, aldehydes
Ketones, esters, ethers
Halogens and strong oxidising media
Hydraulic and fuel oils, fuels (e.g. Skydrol®, Pyrdraul®)
Most organic solvents
Hot water / steam*
CIP / SIP cleaning media
Aliphatic and aromatic amines
Ethylene oxide and propylene oxide

***Isolast®** J8325 is not suitable for steam temperatures greater than +150°C. Depending on application, **Isolast®** J9503, J9510 or J9512 is recommended.

Tensile strength[1]	Elongation at break	Compression set[2] 70 h at 204°C thermal expansion	Average linear coefficient of material	TR-10 values of **Isolast®**
MPa	%	%	(-25°C to 200°C)	°C
12.5	120	25	3.31 x 10^{-4}/°C	*-18*
20.0	190	19	2.82 x 10^{-4}/°C	*-5*
6.5	150	25	3.64 x 10^{-4}/°C	*-18*
6.5	200	20	3.52 x 10^{-4}/°C	*-19*
12.5	100	38	3.04 x 10^{-4}/°C	*-8*
22	80	30	3.01 x 10^{-4}/°C	*-5*
10	150	15	3.38 x 10^{-4}/°C	*-5*
11.7	182	16	3.48 x 10^{-4}/°C	*-2*
10	200	30	3.31 x 10^{-4}/°C	*-2*

Storage Conditions for Isolast® Perfluoroelastomer seals

Isolast® materials have a minimum 18 years' storage life providing the products are sealed in the original packing.
For further information regarding seal storage, please refer to the **Isolast®** Materials Guide.

General Design Considerations

Some important considerations when designing sealing systems with **Isolast®**:

1. Perfluoroelastomer has a higher volumetric coefficient of expansion than fluoroelastomers or other sealing materials. The volumetric expansion of warming the material from 20°C to 240°C is circa 25%. At room temperature the groove should be only 75% filled to avoid extrusion of the seal at higher temperatures.

2. For static applications the installation pressure should be between 12 - 18%. Larger pressures will over time increase the compression set and could lead to premature failure of the seal. When the operating temperature is under 0°C an installation pressure of 15 - 21% is recommended.

3. Elastomers will tend to act as a highly viscous fluid under pressure and require support or anti-extrusion devices where high pressures and/or temperatures are experienced. **Isolast®** perfluoroelastomer parts used in pressure applications exceeding 150 MPa require PTFE back-up rings.

4. When operating at below TR-10 values, shock loads should be avoided to maintain sealing integrity.

5. Care should be taken during installation of **Isolast®** materials to avoid over-stretching the seal (*max. 50%*).

*For further **Isolast®** details or general enquiries concerning the full range of Busak+Shamban sealing solutions please refer to your local technical support office (see backcover).*

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