



PTFE Seals

Design Guide

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

Parker PTFE seals and sealing solutions are used in the more traditional sealing markets like pneumatics and hydraulics as well as in aerospace, energy, oil and gas, the life sciences sector and in the field of renewable energies.

PTFE seals are suitable for use in harsh environments with temperatures ranging from cryogenic to 300 °C in combination with highly aggressive media. Mixing virgin PTFE powder with different fillers gives PTFE specific properties.

For high-speed dynamic applications or extreme pressures, Parker's proprietary Polon® PTFE grades and special seal designs are used. Sealing elements or backup rings made from other engineering polymers such as PEEK, PAI or PI complement the product range for applications where combined pressure and temperature loads push the limits of PTFE-based seals. Continuous in-house research and development in the field of ultra-high-strength thermoplastic composite materials provides solutions for even the most demanding application requirements.

In-house machining technology enables the production of PTFE seals in diameters ranging from 0.5 mm all the way to 3.5 meters for very large cylinders. Clean-room manufacturing facilities are available as well for respective requirements, for instance in the medical and life sciences sector.

The three Parker Prädifa PTFE manufacturing locations in Denmark, Belgium and the Czech Republic specialize in different activities. The plant in Helsingør, Denmark, produces slipper seals and guiding tapes and houses the moulding department, with isostatic and compression moulding presses capable of producing PTFE tubes up to 2-metre diameters. The Belgian plant in Boom is the FlexiSeal® centre of excellence and home to the PTFE engineering team and sealing lab. The plant in Sadská, Czech Republic, is a high-volume manufacturing facility and specializes in products for the automotive market.

This design manual is intended as a guide. In case of special operating conditions or requirements, please contact our consultancy service or your local sales representative.

Engineering your success!



PTFE powder, semi-finished shape and final machined product

Parker's safety programme

Warning – user responsibility

This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product or system options for further investigation by users having technical expertise.

The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalogue and in any materials provided by Parker or its subsidiaries or authorized distributors. To the extent that Parker or its subsidiaries or authorized distributors provide component or system options based upon data or specifications provided by the user, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and responsibly foreseeable uses of the components or systems.

Range of application

Our seals may only be used within the application parameters stated in our documents as regards compatibility with contact media, pressures, temperatures and time of storage. Application or use outside of the specified application parameters as well as the selection of different compounds by mistake may result in damage to life, the environment and/or equipment and facilities.

The information contained in our publications is based on know-how developed over decades of experience in the manufacturing and application of seals. Despite this experience, unknown factors arising out of the practical application of seals may considerably affect the overall applicability of this information in such a way that the recommendations provided herein are not to be considered generally binding.

The data for operating pressure, operating temperature, and surface speed stated in the columns represent maximum values and are interrelated. Under extreme working conditions it is recommended not to use all maximum values simultaneously.

For special requirements (pressure, temperature, speed, etc.) please contact our consultancy service, so that suitable materials and/or designs can be recommended.

Compatibility of seals and operating media / cleaning agents

Due to the great diversity of operational parameters affecting fluidic devices and their impact on seals, it is absolutely imperative that manufacturers of these devices approve seals for functional and operational suitability under field conditions.

Furthermore, in view of the consistent increase of newly available media used as hydraulic oils, lubricants, and cleaning agents, special attention is invited to the aspect of compatibility with sealing elastomers currently in use.

Additives contained in base media in order to enhance certain functional characteristics may affect compatibility characteristics of sealing materials.

For this reason, it is imperative that any product equipped with our seals be tested for compatibility with operational media or cleaning agents ap-

proved or specified by you either at your plant or by means of field tests prior to any field use.

We kindly ask you to comply with this notice since, as a manufacturer of seals, we are not in a position, as a matter of principle, to perform simulations of any and all conditions present in the final application nor of knowing the composition of the operational media and cleaning agents used.

Design modifications

We reserve the right to make design modifications without prior notification.

Prototypes and samples

Prototypes and samples are produced from experimental moulds. The subsequent series production may differ in terms of production techniques from the prototype production unless specific agreement to the contrary was reached beforehand.

Delivery and services

The delivery guarantee (availability of moulds) for individual dimensions of our range of products is limited to a period of 7 years.

Damaged moulds, including standard items, can only be replaced in case of sufficient demand. Most of the dimensions stated in this catalogue are normally (but not as a matter of course) available ex stock.

For the production of smaller quantities, special compounds, and in case of special production procedures, we reserve the right of charging a pro-rated share of set-up costs.

All deliveries and services are subject to our terms.

Quality systems

Our manufacturing sites are certified according to ISO 9001 and/or ISO/TS 16949.

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Validity

This edition supersedes all prior documents.

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1 When to use PTFE seals

1.1 Characteristics of PTFE

Seals made from PTFE (Polytetrafluoroethylene) are used where many other sealing materials (like elastomers, PUR, fabric materials, etc.) fail to meet the required temperature range, chemical resistance or friction and wear requirements.

PTFE was discovered by accident in 1938 by Dr. Roy J. Plunkett of Du Pont's Jackson laboratory in New Jersey, USA. While investigating gases related to fluorinated refrigerants, he found that one sample left overnight in a pressurized storage cylinder had polymerised spontaneously to a white, waxy solid. This solid proved to have a unique composition with remarkable properties. The molecular structure of PTFE is based on a linear chain of carbon atoms which are completely surrounded by fluorine atoms. The carbon-fluorine bonds are among the strongest occurring in organic compounds. As a result, PTFE has

- **Thermal stability across a wide temperature range:** PTFE's high melting point (342 °C) and morphological characteristics allow components made from the resin to be used continuously at service temperatures up to 260 °C. Above this temperature the components' physical properties tend to decrease, causing heat-aging and material degradation. PTFE is used at cryogenic temperatures to seal critical media such as liquid nitrogen (-196 °C), liquid hydrogen (-253 °C) and liquid helium (-269 °C). PTFE has the unique ability to resist material degradation, heat-aging and alteration in physical properties during temperature cycling.
- **Low friction/dry running capability:** PTFE has the lowest friction coefficient of any known solid. It has self-lubricating capabilities, offering continuous dry running ability in dynamic sealing applications.
- **Extreme chemical resistance:** The intrapolymer chain bond strengths of PTFE preclude reaction with most chemicals, thereby making them chemically inert at elevated temperatures and pressures with virtually all industrial chemicals and solvents. Only a few media are known to react with PTFE: alkali metals, fluorine and a few fluoro-chemicals such as chlorine tri-fluoride and oxygen difluoride. PTFE is suitable for contact with food and satisfies FDA requirements.

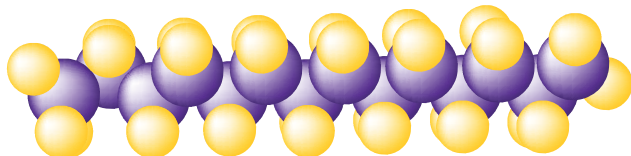


Fig. 1.1 Molecular structure of PTFE ($-\text{CF}_2-\text{CF}_2-$)

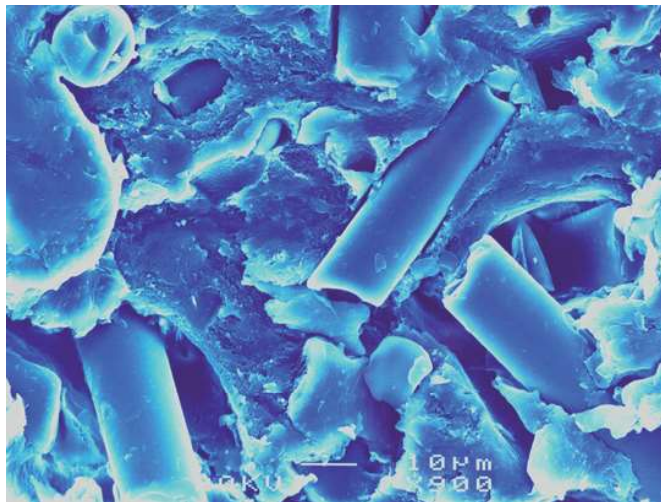


Fig. 1.2 Microscopic picture of fibre-filled PTFE

It is clear that from a sealing point of view, these unique characteristics give PTFE capabilities that exceed those of conventional elastomeric sealing materials. Other outstanding properties are:

- **Reduced stick-slip**
- **Unlimited shelf life:** PTFE does not age over time and is not affected by ultraviolet light.
- **No explosive decompression:** PTFE is not susceptible to saturation of high-pressure gas that can expand violently and cause explosion of the material when the pressure is suddenly removed.
- **No swelling due to moisture absorption.**
- **Safe for use in vacuum conditions.**
- **Excellent electrical properties:** High dielectric strength, low dielectric constant and very high electrical resistance.

1.2 The effect of fillers

In spite of its remarkable properties pure, unfilled or virgin PTFE is inadequate for a number of more demanding engineering applications.

In particular, its cold flow or creep behaviour precluded the use of PTFE in mechanical applications. Even at room temperature, PTFE experiences a significant deformation over time when it is subjected to a continuous load.

Also, virgin PTFE has hardly any resilience and wears quickly despite its low coefficient of friction.

In the 1960's, the addition of fillers was found to improve a number of physical properties, particularly creep and wear rate. Most

1 When to use PTFE seals

fillers are stable up to 400 °C, so they do not restrict use in high temperatures.

Listed below are some common filler elements and their effect on the physical properties of the PTFE compound.

Glass fibre

Glass fibre is a commonly used filler element with a positive impact on creep performance of PTFE, which is reduced at low and high temperatures. It also adds wear resistance and offers good compression strength. This additive is chemically inert except in the presence of hydrofluoric acid and strong bases. It has little effect on electrical properties.

Carbon and carbon-graphite

Carbon reduces creep, increases hardness and elevates the thermal conductivity of PTFE. Wear resistance of carbon filled compounds improves particularly in combination with graphite. Carbon is one of the most inert fillers except in oxidizing environments where glass performs better.

Carbon provides some electrical conductivity to PTFE. PTFE filled with carbon is typically used in pneumatic sealing applications.

Compounds with carbon in combination with graphite are the preferred materials for non-lubricated applications.

Carbon fibre

The addition of carbon fiber to PTFE changes its properties in the same way as glass fibre does. It lowers creep, increases flex and compressive modulus and raises hardness. In general, less carbon fibre than glass fibre is needed to achieve the same effect. The coefficient of thermal expansion is lowered and thermal conductivity is higher for compounds of carbon fibre filled PTFE. Wear rate decreases when carbon fibre parts are lubricated with water.

Carbon fibre is chemically inert and can be used in strong bases and hydrofluoric acid.

Graphite

Graphite is a crystalline modification of high-purity carbon. Graphite filled PTFE has one of the lowest coefficients of friction due to the low friction characteristics of graphite. It has excellent wear properties, particularly against soft mating surfaces and displays high load-carrying capability in high-speed contact applications. Graphite is chemically inert which enables its use in corrosive media.

Bronze

Bronze is a common metallic filler. Large quantities (40 to 60 % by weight) of bronze reduce deformation under load and raise the thermal and electrical conductivity of PTFE compounds. These two characteristics are beneficial to applications where a part is subjected to load at extreme temperatures.

Bronze filled PTFE offers excellent extrusion resistance characteristics. Bronze is an alloy of copper and tin and can be attacked by certain chemicals. Oxidation of the bronze can result in a discolouration of the finished part without impacting on the quality of the product.

PTFE filled with bronze is widely used in hydraulic rod and piston seal applications.

Molybdenum disulfide (MoS₂)

Molybdenum disulphide increases the hardness and stiffness of PTFE while decreasing friction. It has little effect on its electrical properties.

Chemically, is largely non-reactive and dissolves only in strong oxidizing acids.

It is normally used in small weight percentages and in combination with other fillers such as glass fibre.

Aromatic polyester

Aromatic polyester as a filler element raises the high temperature resistance of PTFE and is excellent for use with soft, dynamic mating surfaces.

Not recommended for sealing applications involving steam above 120 °C.

Colour additives

It is possible to pigment PTFE by using inorganic colour additives that withstand the sintering temperature of PTFE. Pigments do not significantly change the properties of PTFE. Combinations of pigments and other fillers are possible.

Proprietary fillers and filler combinations

Parker is continuously striving to search for and develop unique blends and formulations to enhance sealing performance in the most extreme applications.

1.3 Processing and machining of PTFE parts

Generally, PTFE is processed into semi-finished shapes with compression or iso-static moulding techniques. The PTFE resin in the form of a powder (pure or blended with fillers) is compressed into a preform mould at ambient temperature. After removal from the mold, the preformed rod or tube is heated in an oven and sintered. During this process it gains its cohesive strength for end use. For high-volume parts production, PTFE shapes are formed into continuous lengths by means of ram-extrusion. A hydraulic ram moves back and forth, pushing and compressing PTFE powder through an extrusion profile while it is being heated and sintered at the same time.

From the semi-finished rod or tube, the finished PTFE seals are produced by precision-machining.

1 When to use PTFE seals



Fig. 1.3 PTFE powder, semi-finished shape and final machined product

Polymer		Application
UHMW-PE	Ultra-high molecular weight polyethylene	• high wear resistance
PEEK	Polyetheretherketone	• high strength material for increased extrusion resistance
PCTFE	Polychlorotrifluoroethylene	• very low gas permeability
PI	Polyimide	• cryogenic environment • high temperature resistance

Tab. 1.1 Other typical polymeric materials and their application range

1.4 Comparison with other polymer materials

Despite the fact that PTFE has outstanding sealing properties, some other polymeric materials may perform better in specific application conditions.

Below is a summary of the most common alternative polymeric materials, their application range and some basic properties.

Tensile strength at break [MPa]

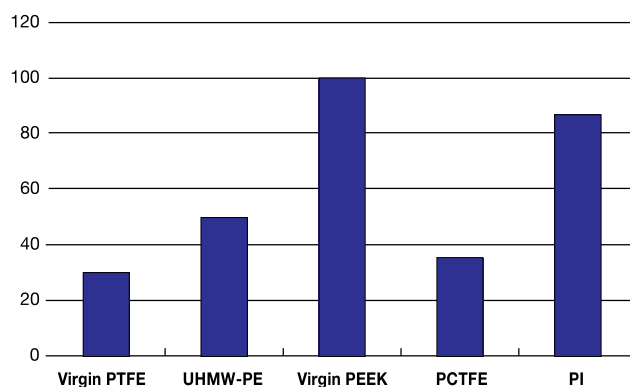


Fig. 1.4 Comparison of tensile strength between PTFE and other polymeric materials

Elongation at break [%]

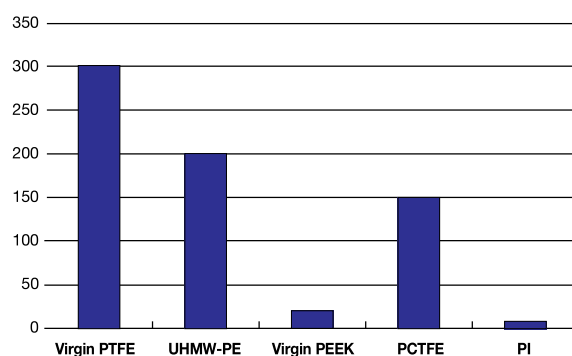


Fig. 1.5 Comparison of elongation properties between PTFE and other polymeric materials

Max. allowable service temperature in air, continuously [°C]

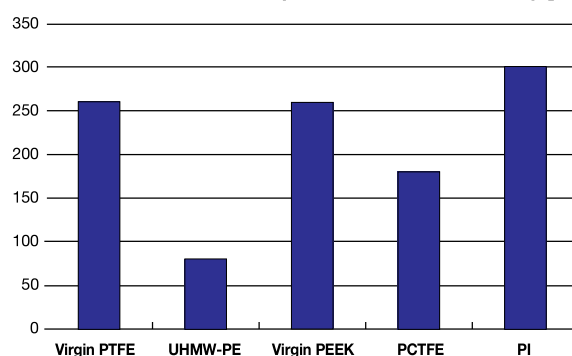


Fig. 1.6 Comparison of elongation properties between PTFE and other polymeric materials

1 When to use PTFE seals

2 PTFE product lines

2.1 Master decision tree

Depending on the type of application, Parker offers various PTFE standard product groups

- FlexiSeals®
- Slipper seals
- Anti-extrusion rings
- Guiding tapes

The master decision tree guides you to the standard profil product group that should be the best fit for your application. Just start at the left, begin answering the basic application questions and follow the tree until a standard product group is selected. It is to be used as an engineering guideline only. In many cases several other parameters need to be considered to optimize the seal design.

Please contact Parker's consultancy service or your local sales force for confirmation of your choice or further recommendations.

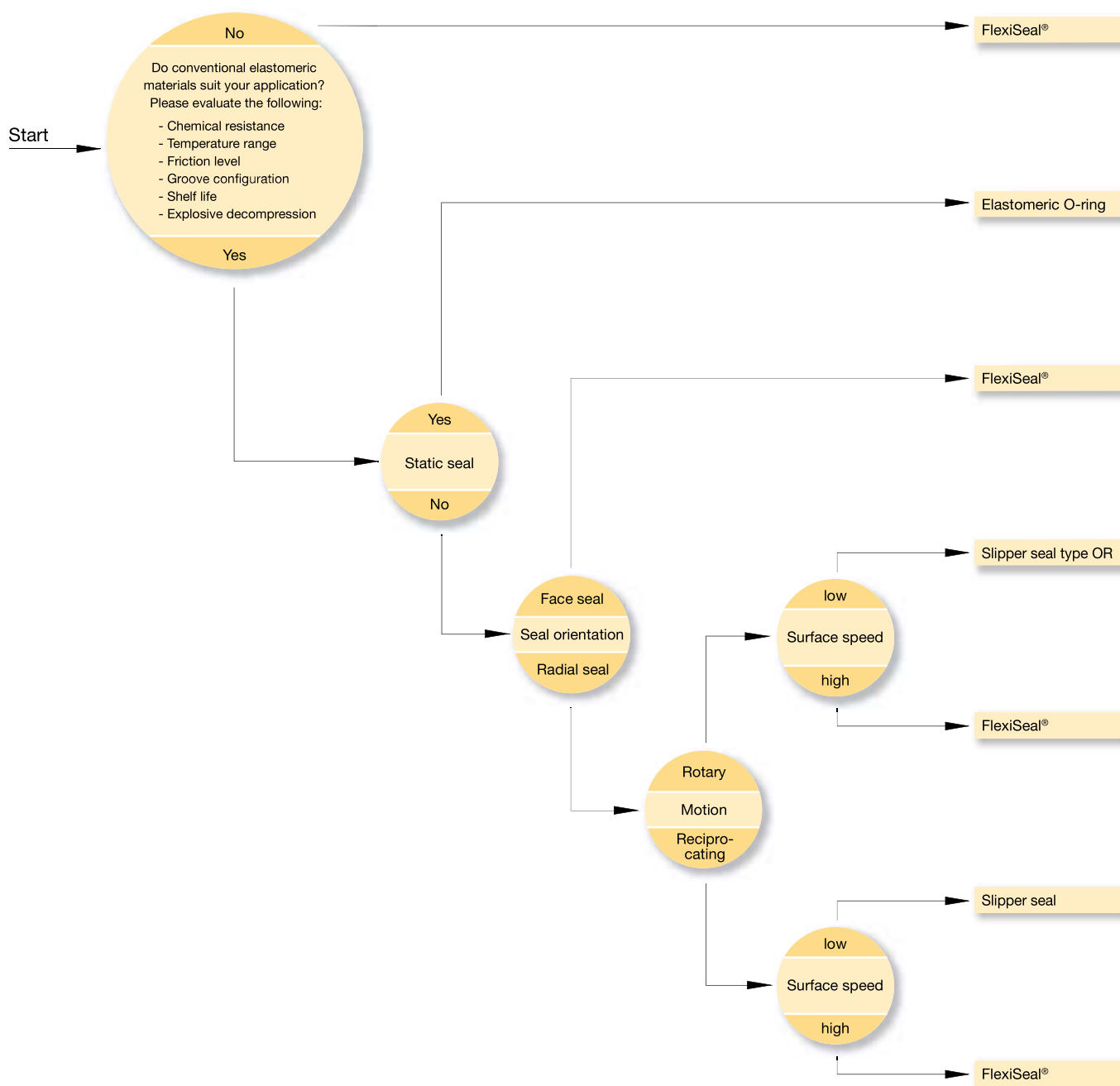


Fig. 2.1 Master decision tree for Parker PTFE standard product lines

2 PTFE product lines

2.2 FlexiSeals®



FlexiSeals® are used where conventional sealing materials (like elastomers, PUR, etc.) fail to meet the required temperature range, chemical resistance or friction requirements of the respective application.

The FlexiSeal® consists of a polymer jacket which is energized by a metallic spring.

FlexiSeals® are available in standard and custom sizes, in a wide variety of profiles, spring types and materials, in rod, piston and face seal configurations.

The use of a resilient spring element ensures positive sealing even at low-pressure and compensates for jacket wall reduction from cold flow, wear and thermal contraction.

The shape of the jacket allows the hydrostatic pressure to energize the seal and supplements the spring force which increases contact pressure and eliminates potential leakage.

Jacket profiles are made from PTFE-based and other high-performance polymer plastics.

Spring types are available in corrosion-resistant metal alloys including stainless steel, Elgiloy®, Inconel® and Hastelloy®.

Fig. 2.2 FlexiSeal®

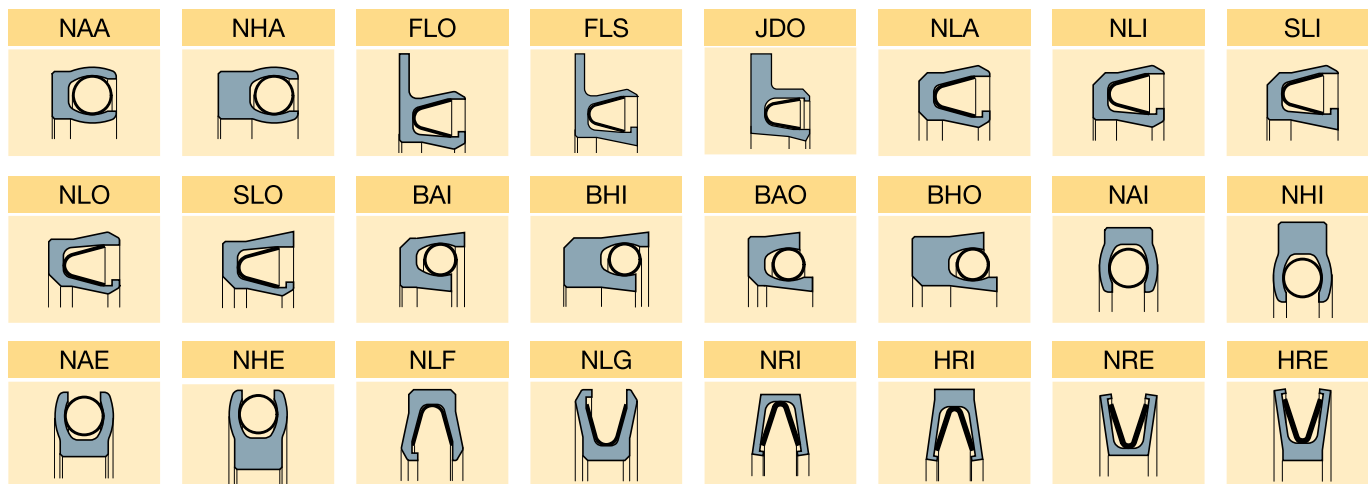


Fig. 2.3 Profile overview FlexiSeal®

2 PTFE product lines

2.3 Slipper seals



Slipper seals are radial seals that consist of a polymer ring and an elastomeric energizing element. They are typically used in general industrial pneumatic/hydraulic environments where a dynamic sealing element is required. The polymer ring faces the dynamic side of the application while the elastomeric element provides positive sealing at low-pressure and compensates for polymer thickness reduction from wear and cold flow.

A wide variety of profiles is available for reciprocating as well as for rotary applications, both in rod and piston configuration.

The polymer components are typically made of PTFE-based compounds and other high-performance plastic materials. The elastomeric energizer is available in a wide range of materials such as NBR, HNBR, EPDM and FKM.

Fig. 2.4 Slipper seal

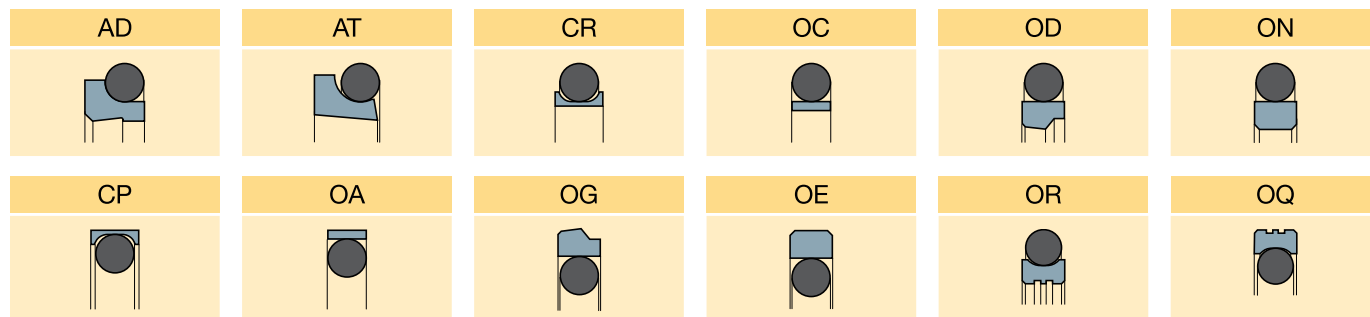


Fig. 2.5 Profile overview Slipper seals

2 PTFE product lines

2.4 Anti-extrusion rings



Fig. 2.6 Anti-extrusion ring

Anti-extrusion rings (or back-up rings) are non-sealing elements that prevent a softer sealing material to extrude in the downstream gap between adjacent hardware parts.

Anti-extrusion rings are typically made of polymeric materials such as filled PTFE, PEEK and reinforced PEEK that are resistant to high hydrostatic pressures.

They are machined with a tight groove fit and installed behind the seal, providing a smaller extrusion gap and allowing the seal to operate properly.

There are a variety of anti-extrusion rings available for use in various groove configurations and extrusion gap sizes together with elastomeric O-rings or FlexiSeals®.

IAA/IAI/IAO IBA/IBI/IBO	ICA/ICI/ICO IDA/IDI/IDO	XA/XB	XC

Fig. 2.7 Profile overview anti-extrusion rings

2 PTFE product lines

2.5 Guiding tapes



Fig. 2.8 Guiding tapes

Guiding tapes prevent metallic contact between reciprocating pistons and cylinders when forces act perpendicular to the direction of movement.

Guiding tapes are typically made from heavily filled PTFE-compounds and are available in configurations suited for pneumatic and hydraulic applications.

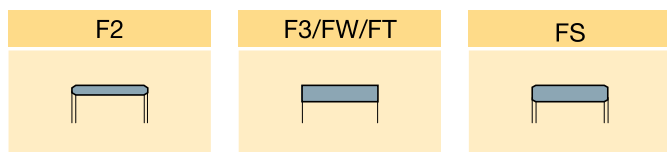


Fig. 2.9 Overview guiding tapes

2.6 Other PTFE products

2.6.1 PTFE chevron stacks



Fig. 2.10 PTFE chevron stack

For applications that make special demands in terms of sealing action and reliability, Parker has developed a chevron packing set which incorporates its proven FlexiSeal® design technology and PTFE-based materials as well as other high-performance polymer plastics.

A typical PTFE chevron stack consists of a radial FlexiSeal®, followed by several V-rings and an anti-extrusion ring.

The FlexiSeal® is the main sealing element. A pressurised FlexiSeal® automatically energises a series of V-shaped segments stacked behind it, pushing the lips outwards. The multiple sealing areas which are generated this way reduce the risk of leakage. Each V-ring responds to pressure shocks and even minor pressure changes by providing an immediate sealing effect.

The anti-extrusion ring prevents the softer PTFE elements from being extruded into the downstream hardware gap.

Advantages compared to conventional elastomer-based chevron stacks:

- Benefits of PTFE over elastomer materials.
- No special tooling required.
- Quick design and short manufacturing times.
- Simplified hardware and groove assembly as there is no need for a mechanical loading mechanism.

The chevron stack sealing elements are made from pressure- and wear-resistant PTFE compounds. The anti-extrusion ring is typically made from PEEK.

2 PTFE product lines

To satisfy the sealing needs of the Energy, Oil and Gas market, Parker offers a range of NORSOK and NACE approved materials. A dedicated list is available upon request.

Application range:

- Valve stems
- High-speed reciprocating equipment
- Forging presses
- Injection moulding machines
- Steel hydraulics
- Marine hydraulics

2.6.2 PTFE bearings

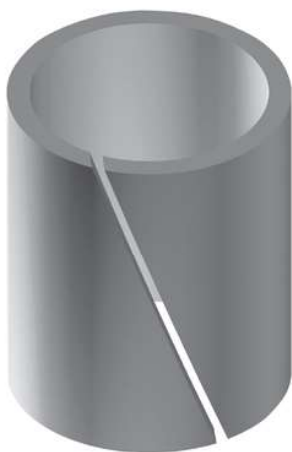


Fig. 2.11 PTFE bearing

Bearing arrangements made of PTFE offer many advantages over conventional metallic bearings such as

- Chemical resistance
- Thermal resistance
- Self-lubrication/low friction
- Reduced mass
- Non-magnetic
- Anti-static
- Reduced noise level

In addition to a wide range of filled PTFE compounds, Parker bearings are available in other high-performance polymeric materials such as PA, PEEK, PAI and PI.

2.6.3 PTFE bellows



Fig. 2.12 PTFE bellows

Bellows are expansion joints consisting of a series of convolutions that allow flexibility in the axial, radial and angular direction. They are typically used in piping systems to absorb thermally induced motion and vibrations.

Bellows made from PTFE are suitable for applications involving high temperatures and/or chemically aggressive media.

2.6.4 Custom shapes

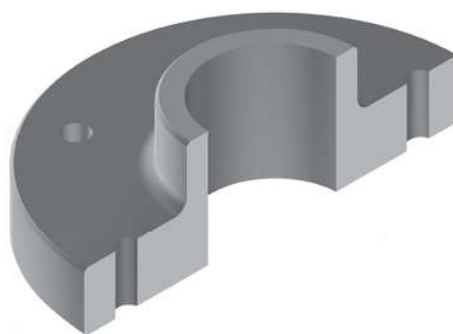


Fig. 2.13 Custom shape

Parker uses state-of-the-art machining facilities to manufacture custom sealing solutions or non-sealing parts according to customers' specifications and will also provide design assistance if desired.

In addition to seals, machined parts include valve seats, washers, threaded parts and other precision-machined items.

For additional information on these PTFE products, please contact our consultancy service.

3.1 What is a FlexiSeal® and how does it work



Fig. 3.1 FlexiSeal®

Jacket profiles are typically made from PTFE-based and other high-performance polymer plastics, often with special additives to enhance, for example, wear resistance or high-temperature strength. PTFE offers excellent inherent low friction characteristics and an outstanding high degree of chemical inertness. Additionally, polymers are less prone to some of the problems associated with elastomeric seals including explosive decompression and stick-slip.

FlexiSeals® are precision lathe-turned parts. Although Parker offers selected sizes to fit many popular international O-ring cavities, the fact is that the FlexiSeal® system can be tailored to any existing customer groove geometry.

3.2 FlexiSeal® standard part number nomenclature

The FlexiSeal® product line is available in a large variety of types, a virtually unlimited number of sizes and numerous jacket materials and energizers.

The FlexiSeal® standard range is defined by a standard part number which includes all key design elements.

XXX-M000000-00-000-0

XXX



FlexiSeal® type

(See section 3.3.1 to 3.3.3)

M



M for metric

000000



Groove diameter in millimetres specified to 2 decimal places (See section 3.3.4)

00



Cross-section code
(See section 3.3.4)

000



Jacket material
(See section 3.5.1)

0



Energizer material
(See section 3.5.2)

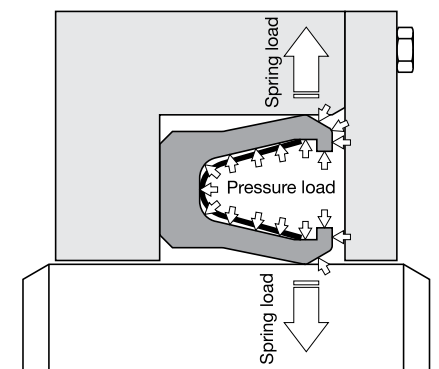


Fig. 3.2 FlexiSeal® operating principle

The FlexiSeal® consists of a polymeric jacket which is energized by a metallic spring when installed into a groove. It offers many of the well known advantages of the common elastomeric O-ring while avoiding many of its limitations.

The resilient spring element responds with constant force, pushing out the sealing lips, creating a tight seal against the groove mating surfaces. The open end of the jacket is orientated towards the highest pressure side and allows the hydrostatic pressure to energize the seal and supplement the spring force which increases contact pressure and eliminates potential leakage.

The use of a resilient spring element ensures positive sealing even at low-pressure and compensates for jacket wall reduction from cold flow, wear and thermal contraction. In conditions that see thermal cycling, the spring system continues to energize the seal lips without taking a compression set or becoming too soft or hard.

Many different spring designs are available in corrosion-resistant metal alloys including stainless steel, cobalt-chromium-nickel alloy, Inconel® and Hastelloy®.

3 FlexiSeal®

Ordering example

NAA-M010000-04-001-1

NAA	FlexiSeal® type (radial type NAA)
M	Metric
010000	Groove inner diameter (100 mm)
04	Cross-section code
001	Jacket material code (Reines PTFE)
1	Energizer material code (17/7 PH stainless steel)

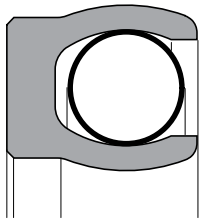


Fig. 3.3

3.3 How to select the FlexiSeal® type for your application

The following decision trees are designed to provide a clear path to the appropriate FlexiSeal® type choice for your application. The applications are divided into three basic categories.

The first category deals with static and intermittently dynamic applications both in radial and facial configurations.

The second one covers radial seals that experience regular dynamic rotary motion.

A third category deals with radial seals that see regular dynamic reciprocating motion.

The decision trees are to be used as an engineering guideline only. In many cases several other parameters have to be considered to optimize the seal design.

Please contact Parker's consultancy service or your local sales force for confirmation of your choice or further recommendations.

Static and intermittently dynamic applications

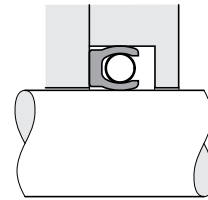


Fig. 3.4 Radial seal

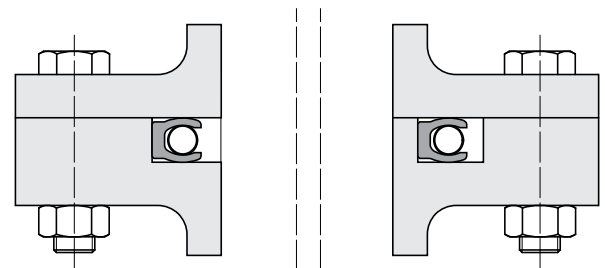


Fig. 3.5 Left: face seal internal pressure, right: face seal external pressure

Dynamic rotating applications

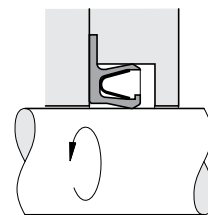


Fig. 3.6 Dynamic rotating

Dynamic reciprocating applications

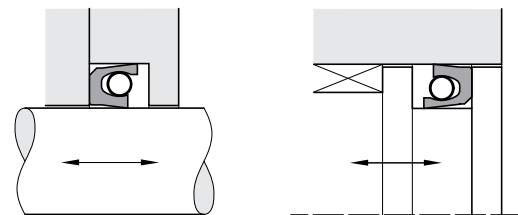


Fig. 3.7 Left: rod, right: piston

3.3.1 Static and intermittently dynamic applications

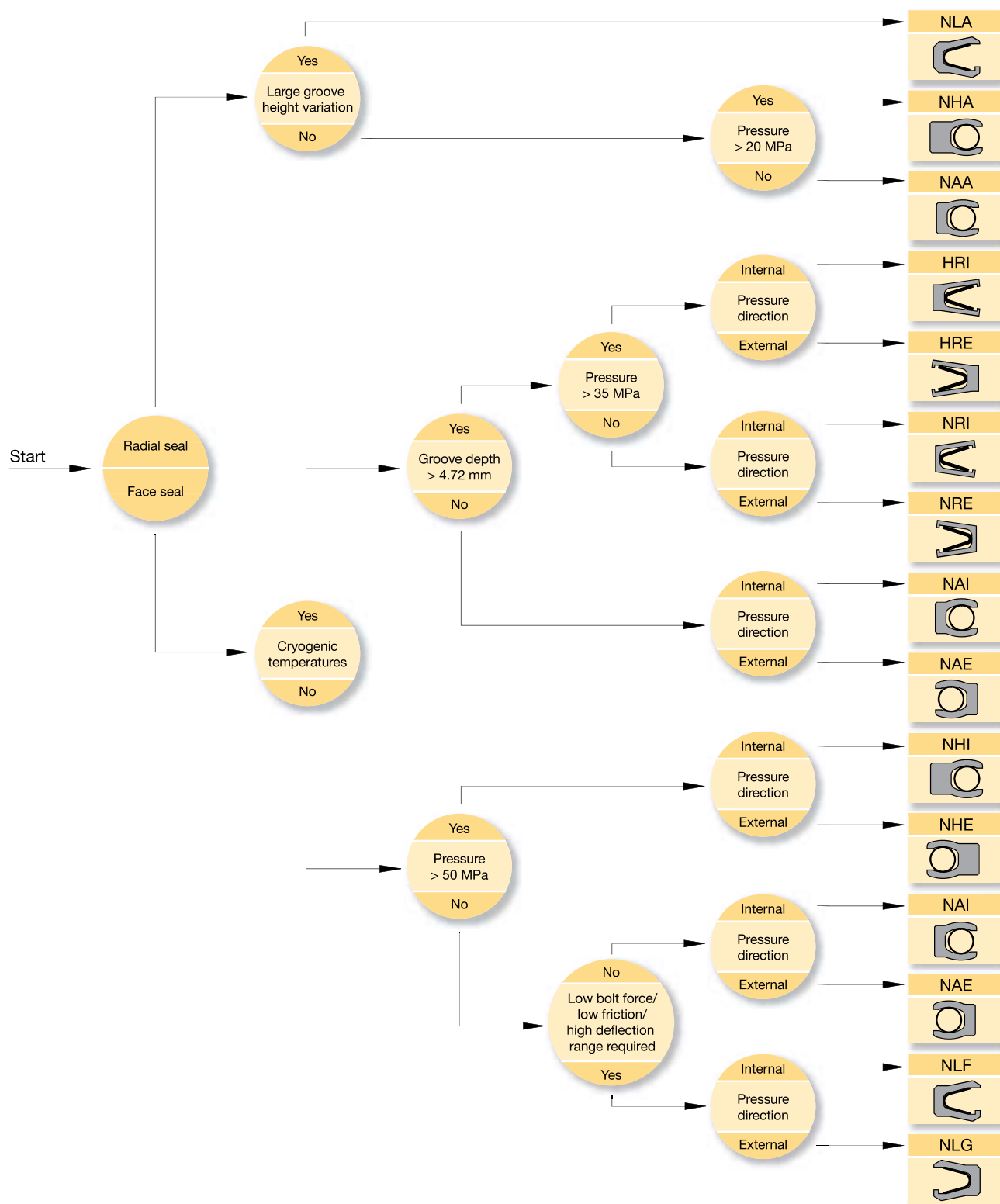
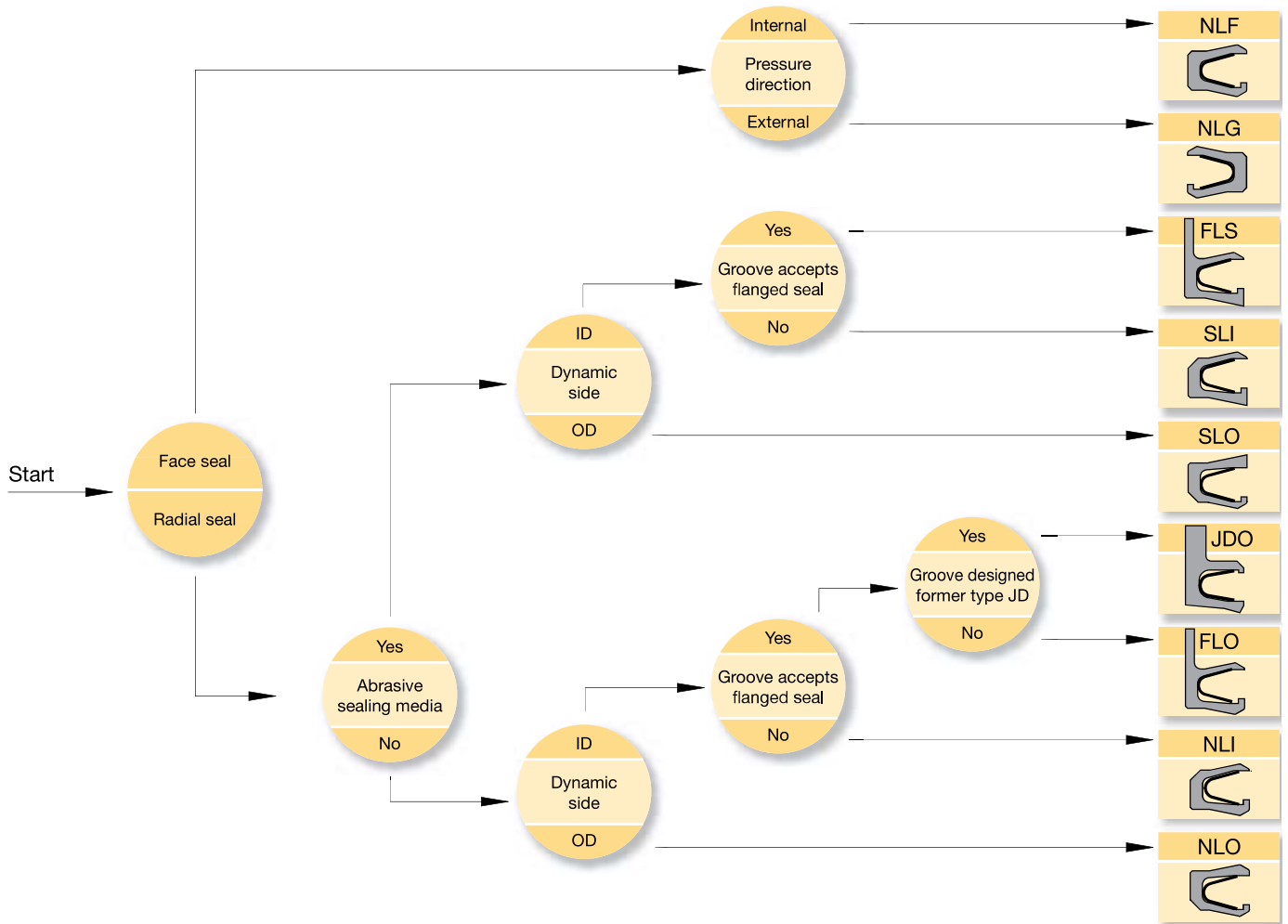


Fig. 3.8 FlexiSeal® decision tree for static and intermittently dynamic applications

3 FlexiSeal®

3.3.2 Dynamic rotating applications

When practical, a groove which accepts a flanged seal is preferred as this prevents seal rotation and resists thermally induced movement.



Note

The seal selection guidelines assume moderate temperatures and rotational velocities.

Refer to the pressure-velocity-temperature guidelines in chapter 3.6.6 of the Technical Information section to pre-qualify the seal for rotating applications.

Fig. 3.9 FlexiSeal® decision tree for dynamic rotating applications

3.3.3 Dynamic reciprocating applications

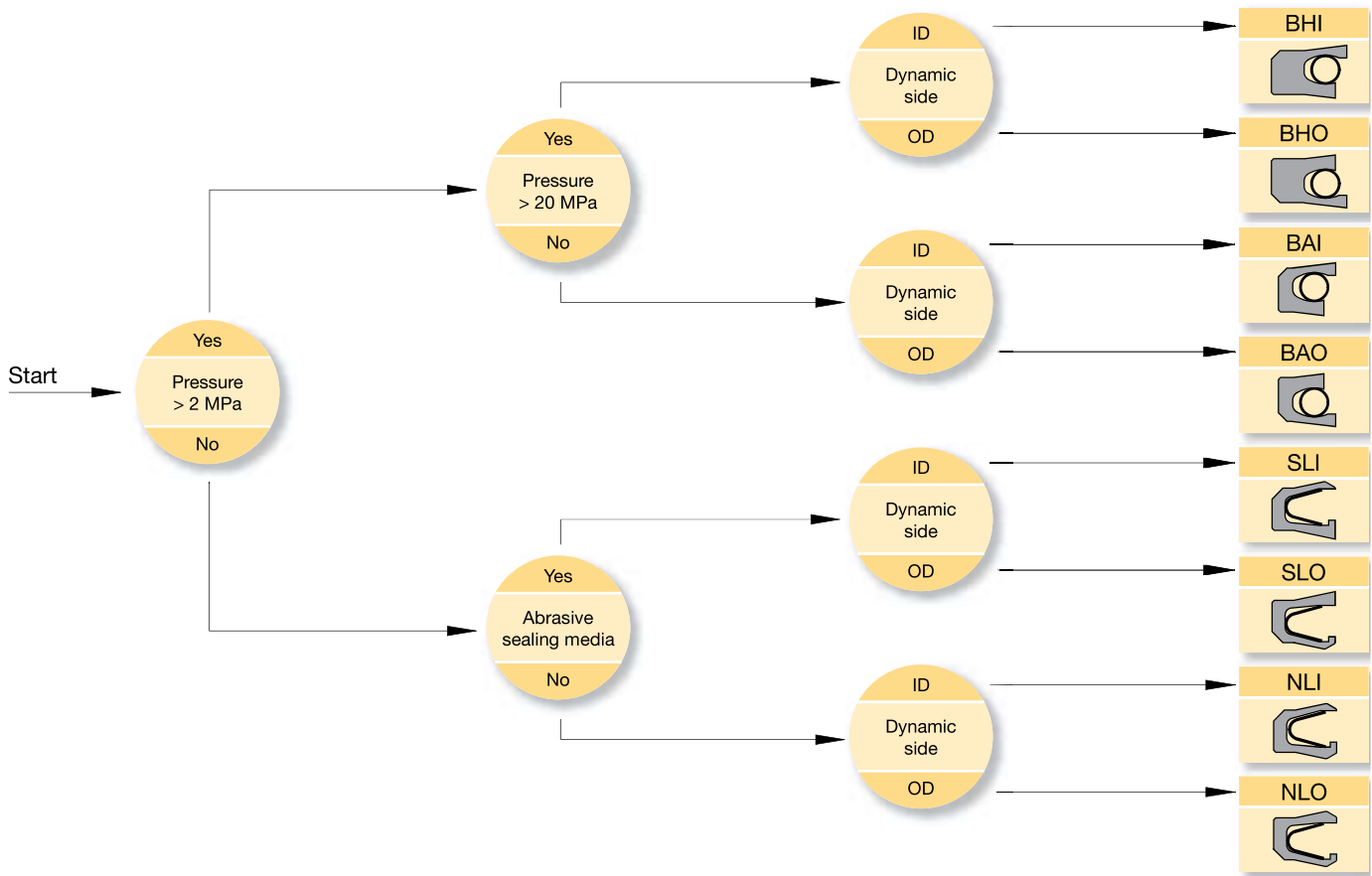


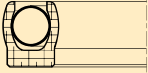
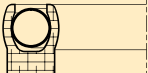
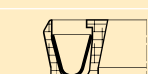
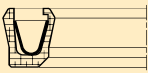
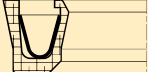
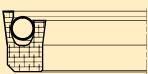
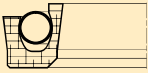
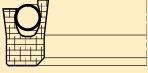
Fig. 3.10 FlexiSeal® decision tree for dynamic reciprocating applications

3.3.4 Selecting the FlexiSeal® size for your application

Standard FlexiSeals® are available in any diameter from 2.5 mm up to 3000 mm and a variety of cross-sections to fit the various groove sizes you may have. Refer to the page of the FlexiSeal® type selected for your application to determine the appropriate diameter, cross-section and housing dimensions.

Each selection outside this standard size range will result in a non-standard part generation and requires a filled out copy of the “Application data sheet” included in chapter 7 of this design manual. Please forward a completed form to our consultancy service or to your local sales force and we will come back to you with detailed recommendations.

3 FlexiSeal®

Profile cross-section	Profile reference	Page
Radial seals		
	NAA	23
	NHA	25
	FLO	27
	FLS	29
	JDO	31
	NLI	33
	SLI	35
	NLO	37
	SLO	39
	NLA	41
	BAI	43
	BHI	45
	BAO	47
	BHO	49

Profile cross-section	Profile reference	Page
Face seals		
	NAI	51
	NHI	53
	NAE	55
	NHE	57
	NLF	59
	NLG	61
	NRI	63
	HRI	65
	NRE	67
	HRE	69



- Rounded lip profile for easy installation and improved lubrication of a reciprocating sealing surface.
- Best choice for installation into non-split grooves: the short heel and helical spring stretch easily and the rounded lips will not hang up.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

The profile NAA is excellent for both static and intermittently dynamic applications. The seal can be used for reciprocating or rotating movements on either inner or outer diameter.

Profile NAA is particularly suitable for valve stems, secondary sealing in mechanical seals, connectors, pistons and swivel joints.

Features:

- Helical spring for high load and small deflection range.

Range of application

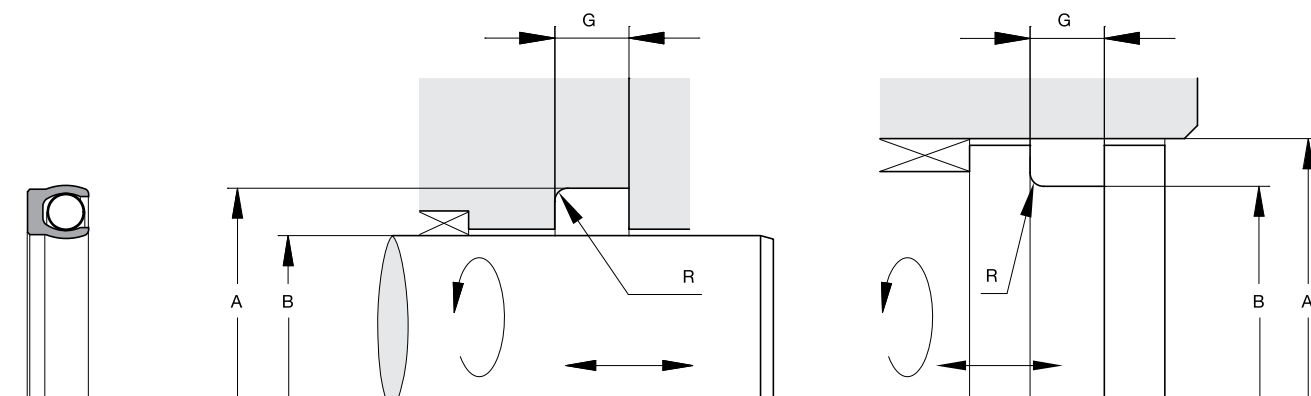
For static and intermittently dynamic sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NAA seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter	Groove width min.	Radius max.
		Tolerance h8		Tolerance H8		
		B (mm)		A (mm)	G (mm)	R (mm)
		≥	≤			
1/16"	01	7.5	75	B + 2.84	2.4	0.30
3/32"	02	5.5	180	B + 4.52	3.6	0.50
1/8"	03	6.0	250	B + 6.15	4.8	0.50
3/16"	04	12.5	300	B + 9.45	7.1	0.75
1/4"	05	50.0	500	B + 12.12	9.5	0.75
3/8"	06	150.0	1400	B + 18.75	13.3	0.75
1/2"	07	300.0	3000	B + 25.40	18.0	0.75

Ordering example

Shaft 70 mm
Cylinder bore 76.15 mm

NAA-M007000-03-XXX-Y

NAA Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile NHA is excellent for both static and intermittently dynamic applications at high pressures. The seal can be used for reciprocating or rotating movements on either inner or outer diameter.

Profile NHA is particularly suitable for high-pressure valve stems, connectors, pistons and swivel joints.

Features

- Extended heel that reduces effects of extrusion.
- Helical spring for high load and small deflection range.

- Rounded lip profile for easy installation and improved lubrication of a reciprocating sealing surface.
- Best choice for installation into non-split grooves: the short heel and helical spring stretch easily and the rounded lips will not hang up.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

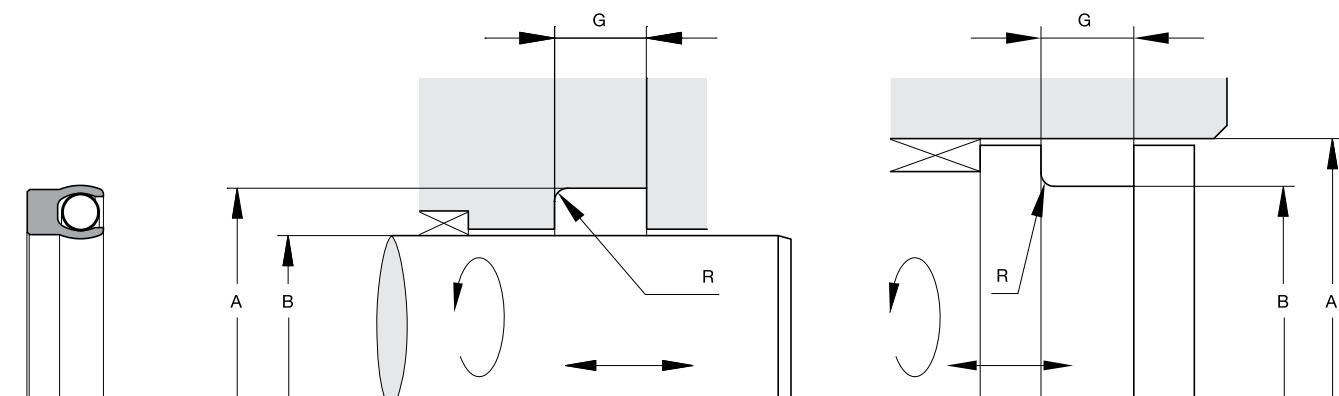
For high-pressure, static and intermittently dynamic sealing.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NHA seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter	Groove width min.	Radius max.
		Tolerance h8 B (mm)		Tolerance H8 A (mm)	G (mm)	R (mm)
		≥	≤			
1/16"	01	7.5	75	B + 2.84	3.8	0.30
3/32"	02	5.5	180	B + 4.52	4.6	0.50
1/8"	03	6.0	250	B + 6.15	6.0	0.50
3/16"	04	12.5	300	B + 9.45	8.5	0.75
1/4"	05	50.0	500	B + 12.12	12.1	0.75
3/8"	06	150.0	1400	B + 18.75	15.8	0.75
1/2"	07	300.0	3000	B + 25.40	20.5	0.75

Ordering example

Shaft 70 mm
Cylinder bore 76.15 mm

NHA-M007000-03-XXX-Y

NHA Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile FLO is the best choice for sealing rotating shafts such as in pumps, motors and rotary actuators.

Features

- Cantilever spring for low load-high compliance behaviour.

- Outside flange that stabilizes the seal, prevents seal rotation and resists thermally induced movement.
- Heavy dynamic lip (inside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.

Range of application

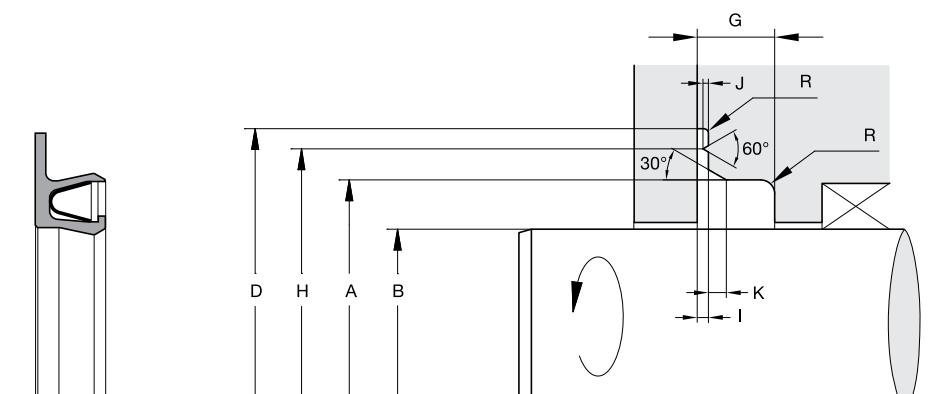
For rotating shaft sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 10 m/s

Compounds

The FLO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter	Groove width min.	Radius max.	Flange outer diameter	Nose Ø	Flange width	Nose width	Chamfer width
		Tolerance h10		Tolerance H8			Tolerance H11	Tolerance H11			
		B (mm)		A (mm)	G (mm)	R (mm)	D (mm)	H (mm)	I (mm)	J (mm)	K (mm)
		≥	≤								
1/16"	01	3.0	75	B + 2.84	2.4	0.30	B + 7.0	B + 5.0	0.56 ^{+0.08}	0.25 ^{+0.10}	0.4 - 0.5
3/32"	02	5.0	180	B + 4.52	3.6	0.5	B + 9.0	B + 7.0	0.56 ^{+0.08}	0.25 ^{+0.10}	0.8 - 1.0
1/8"	03	12.5	250	B + 6.15	4.8	0.5	B + 12.5	B + 10.0	0.66 ^{+0.08}	0.30 ^{+0.10}	1.0 - 1.2
3/16"	04	22.0	300	B + 9.45	7.1	0.75	B + 17.5	B + 13.5	0.96 ^{+0.08}	0.41 ^{+0.10}	1.3 - 1.6
1/4"	05	50.0	685	B + 12.2	9.5	0.75	B + 22.0	B + 17.0	1.16 ^{+0.08}	0.56 ^{+0.10}	1.7 - 2.0

Ordering example

Shaft 70 mm
Cylinder bore 76.15 mm

FLO-M007000-03-XXX-Y

FLO Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile FLS is the best choice for sealing rotating shafts with abrasive media such as in pumps, motors and rotary actuators.

Features

- Cantilever spring for low load / high compliance behaviour.

- Wiper-type dynamic (inside) lip.
- Outside flange that stabilizes the seal, prevents seal rotation and resists thermally induced movement.
- Heavy dynamic lip (inside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.

Range of application

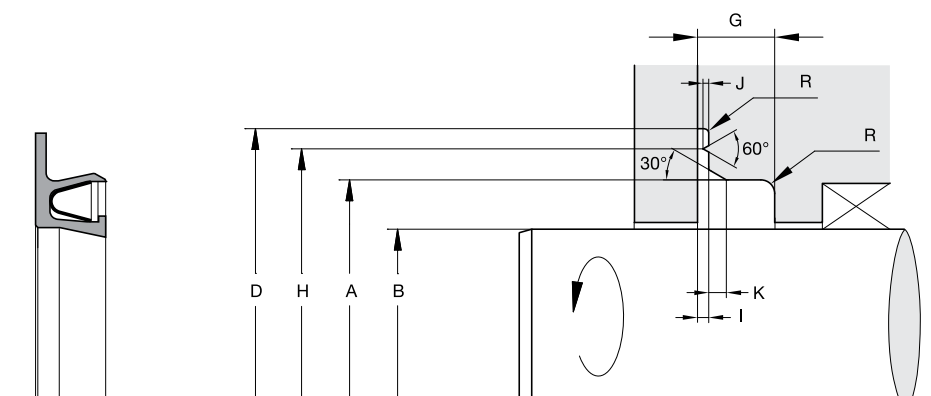
For rotating shaft sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 10 m/s

Compounds

The FLS seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter	Groove width min.	Radius max.	Flange outer diameter	Nose Ø	Flange width	Nose width	Chamfer width
		Tolerance h10		Tolerance H8			Tolerance H11	Tolerance H11			
		B (mm)		A (mm)	G (mm)	R (mm)	D (mm)	H (mm)	L (mm)	J (mm)	K (mm)
		≥	≤								
1/16"	01	3.0	75	B + 2.84	2.4	0.30	B + 7.0	B + 5.0	0.56 ^{+0.08}	0.25 ^{+0.10}	0.4 - 0.5
3/32"	02	5.0	180	B + 4.52	3.6	0.5	B + 9.0	B + 7.0	0.56 ^{+0.08}	0.25 ^{+0.10}	0.8 - 1.0
1/8"	03	12.5	250	B + 6.15	4.8	0.5	B + 12.5	B + 10.0	0.66 ^{+0.08}	0.30 ^{+0.10}	1.0 - 1.2
3/16"	04	22.0	300	B + 9.45	7.1	0.75	B + 17.5	B + 13.5	0.96 ^{+0.08}	0.41 ^{+0.10}	1.3 - 1.6
1/4"	05	50.0	685	B + 12.2	9.5	0.75	B + 22.0	B + 17.0	1.16 ^{+0.08}	0.56 ^{+0.10}	1.7 - 2.0

Ordering example

Shaft 70 mm
Cylinder bore 76.15 mm

FLS-M007000-03-XXX-Y

FLS Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile JDO is identical to the former profile JD and is the best choice for sealing rotating shafts as in pumps, motors and rotary actuators.

Features

- Cantilever spring for low load-high compliance behaviour.

- Outside flange that stabilizes the seal and prevents seal rotation.
- Heavy dynamic lip (inside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.

Range of application

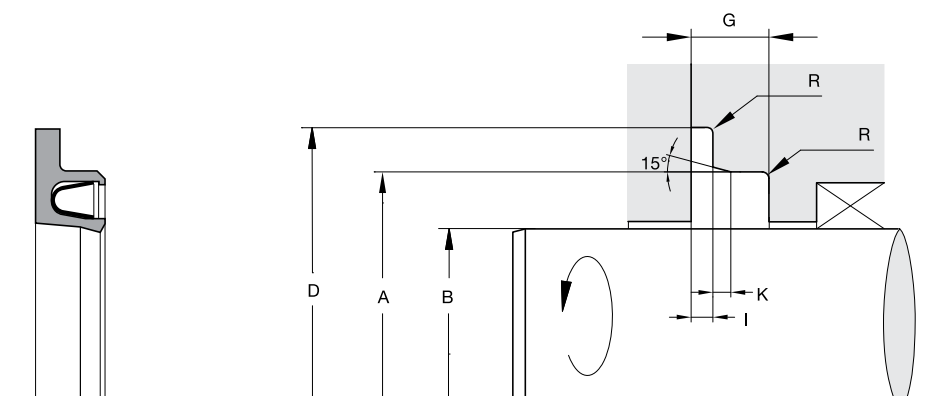
For rotating shaft sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 10 m/s

Compounds

The JDO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter	Groove width min.	Radius max.	Flange outer diameter	Flange width	Chamfer width
		Tolerance f7 B (mm)		Tolerance H9 A (mm)	G (mm)	R (mm)	Tolerance H11 D (mm)	I (mm)	K (mm)
		≥	≤						
3/32"	02	8	180	B + 5.0	3.6	0.3	B + 9.0	0.85 ^{-0.10}	0.8
1/8"	03	20	250	B + 7.0	4.8	0.4	B + 12.5	1.35 ^{-0.15}	1.1
3/16"	04	40	400	B + 10.5	7.1	0.5	B + 17.5	1.80 ^{-0.20}	1.4
1/4"	05	50	700	B + 14.0	9.5	0.5	B + 22.0	2.80 ^{-0.20}	1.6

Ordering example

Shaft 70 mm
Cylinder bore 77 mm

JDO-M007000-03-XXX-Y

JDO Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 3.07 mm groove height
XXX Jacket material
Y Spring-energizer material



- Heavy dynamic lip (inside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.
- Allows the integration of a stand-off ring to protect the sealing lips in case of reverse pressure.

The profile NLI is ideal for sealing rotating shafts without the possibility of a flange cavity in the groove. It can also be used in low-pressure reciprocating applications.

Profile NLI is particularly suitable for pumps, motors, rotary actuators and reciprocating stems.

Features

- Cantilever spring for low load / high compliance behaviour.

Range of application

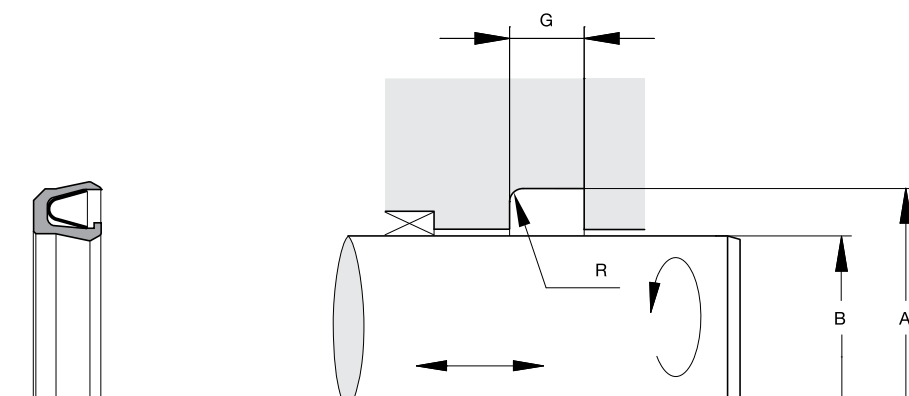
For inside dynamic sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The NLI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h8 B (mm)		Outer diameter Tolerance H8 A (mm)	Groove width min. G (mm)	Radius max. R (mm)
$\frac{1}{16}$ "	01	3.0	75	B + 2.84	2.4	0.30
$\frac{3}{32}$ "	02	5.0	180	B + 4.52	3.6	0.50
$\frac{1}{8}$ "	03	12.5	250	B + 6.15	4.8	0.50
$\frac{3}{16}$ "	04	22.0	300	B + 9.45	7.1	0.75
$\frac{1}{4}$ "	05	50.0	685	B + 12.12	9.5	0.75

Ordering example

Shaft or rod 70 mm
Cylinder bore 76.15 mm

NLI-M007000-03-XXX-Y

NLI Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



- Wiper-type dynamic (inside) lip.
- Heavy dynamic lip (inside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.
- Allows the integration of a stand-off ring to protect the sealing lips in case of reverse pressure.

The profile SLI is ideal for sealing abrasive media for rotating shafts without the possibility of a flange cavity in the groove. It can also be used in low-pressure reciprocating applications.

Profile SLI is particularly suitable for pumps, motors, rotary actuators and reciprocating stems.

Features

- Cantilever spring for low load / high compliance behaviour.

Range of application

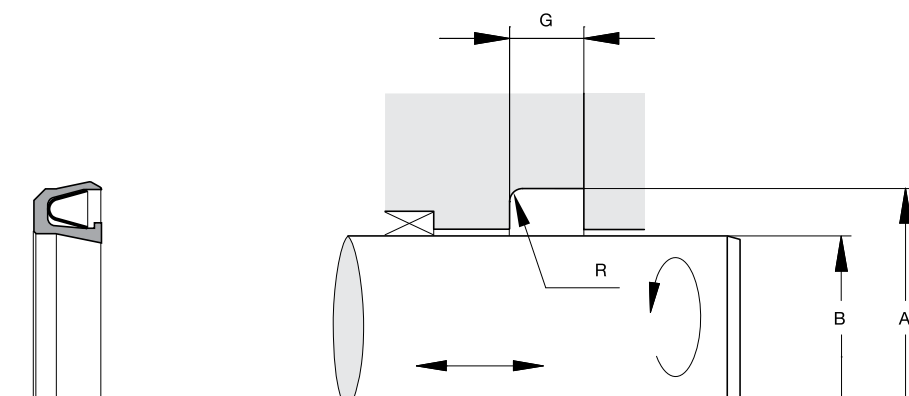
For inside dynamic sealing in abrasive media.

Operating pressure	≤ 20 bar
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The SLI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Outer diameter			Groove width min. G (mm)	Radius max. R (mm)
		Tolerance h8		Tolerance H8				
		B (mm)		A (mm)				
		≥	≤					
1/16"	01	3.0	75	B	+	2.84	2.4	0.30
3/32"	02	5.0	180	B	+	4.52	3.6	0.50
1/8"	03	12.5	250	B	+	6.15	4.8	0.50
3/16"	04	22.0	300	B	+	9.45	7.1	0.75
1/4"	05	50.0	685	B	+	12.12	9.5	0.75

Ordering example

Shaft or rod 70 mm
Cylinder bore 76.15 mm

SLI-M007000-03-XXX-Y

SLI Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile NLO is ideal for sealing outside rotating housings. It can also be used in low-pressure reciprocating piston applications.

Features

- Cantilever spring for low load / high compliance behaviour.

- Heavy dynamic lip (outside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.
- Allows the integration of a stand-off ring to protect the sealing lips in case of reverse pressure.

Range of application

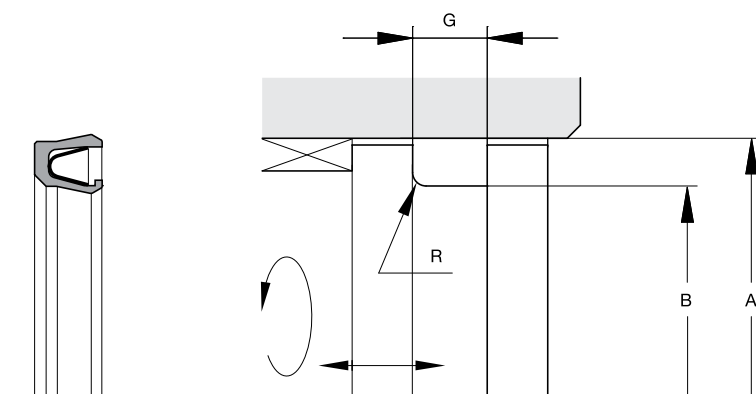
For outside dynamic sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The NLO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H8 A (mm)		Inner diameter Tolerance h8 B (mm)	Groove width min. G (mm)	Radius max. R (mm)
1/16"	01	≥ 6.0	≤ 75	A - 2.84	2.4	0.30
3/32"	02	≥ 9.5	≤ 180	A - 4.52	3.6	0.50
1/8"	03	≥ 19.0	≤ 250	A - 6.15	4.8	0.50
3/16"	04	≥ 31.5	≤ 300	A - 9.45	7.1	0.75
1/4"	05	≥ 63.0	≤ 685	A - 12.12	9.5	0.75

Ordering example

Piston groove 70 mm
Cylinder bore 76.15 mm

NLO-M007615-03-XXX-Y

NLO Profile
M007615 Outer groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile SLO is ideal for sealing abrasive media with outside rotating housings. It can also be used in low-pressure reciprocating applications.

Features

- Cantilever spring for low-load / high-compliance behaviour.

- Wiper-type dynamic (OD) lip.
- Heavy dynamic lip (outside) ensures longest life.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.
- Allows the integration of a stand-off ring to protect the sealing lips in case of reverse pressure.

Range of application

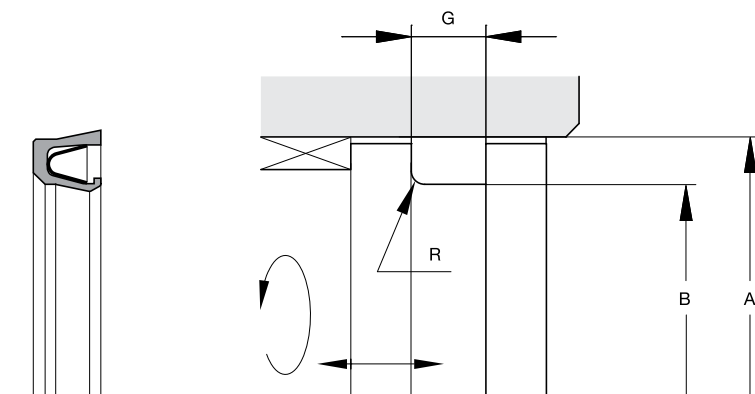
For outside dynamic sealing in abrasive media.

Operating pressure	≤ 20 bar
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The SLO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H8 A (mm)		Inner diameter Tolerance h8 B (mm)	Groove width min. G (mm)	Radius max. R (mm)
$\frac{1}{16}$ "	01	6.0	75	A - 2.84	2.4	0.30
$\frac{3}{32}$ "	02	9.5	180	A - 4.52	3.6	0.50
$\frac{1}{8}$ "	03	19.0	250	A - 6.15	4.8	0.50
$\frac{3}{16}$ "	04	31.5	300	A - 9.45	7.1	0.75
$\frac{1}{4}$ "	05	63.0	685	A - 12.12	9.5	0.75

Ordering example

Piston groove 70 mm
Cylinder bore 76.15 mm

SLO-M007615-03-XXX-Y

SLO	Profile
M007615	Outer groove diameter (mm; times 100)
03	Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX	Jacket material
Y	Spring-energizer material



The profile NLA is ideal for static applications where there is need for a higher deflection due to wider gland tolerance or excessive expansion and contraction. NLA can also be used for inside and outside dynamic applications.

Features

- Symmetric lip design.
- Cantilever spring for low load / high compliance behaviour.

- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.
- Allows the integration of a stand-off ring to protect the sealing lips in case of reverse pressure.

Range of application

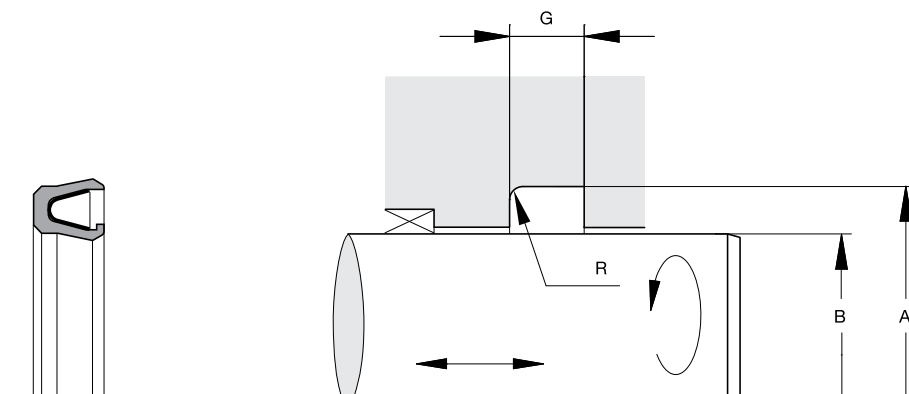
For inside dynamic sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The NLA seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h8 B (mm)		Outer diameter Tolerance H8 A (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	3.0	75	B + 2.84	2.4	0.30
3/32"	02	5.0	180	B + 4.52	3.6	0.50
1/8"	03	12.5	250	B + 6.15	4.8	0.50
3/16"	04	22.0	300	B + 9.45	7.1	0.75
1/4"	05	50.0	685	B + 12.12	9.5	0.75
3/8"	06	300.0	1400	B + 18.75	14.5	0.75
1/2"	07	300.0	3000	B + 25.40	18.0	0.75

Ordering example

Shaft or rod 70 mm
Cylinder bore 76.15 mm

NLA-M007000-03-XXX-Y

NLA Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile BAI is ideal for sealing reciprocating actuator rods.

Features:

- Helical spring for high load and small deflection range.

- Heavy dynamic lip (inside) ensures longest life.
- Short, wiper-type dynamic lip reduces frictional forces due to hydrostatic pressure.
- Squared, long static lip stabilizes the seal.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

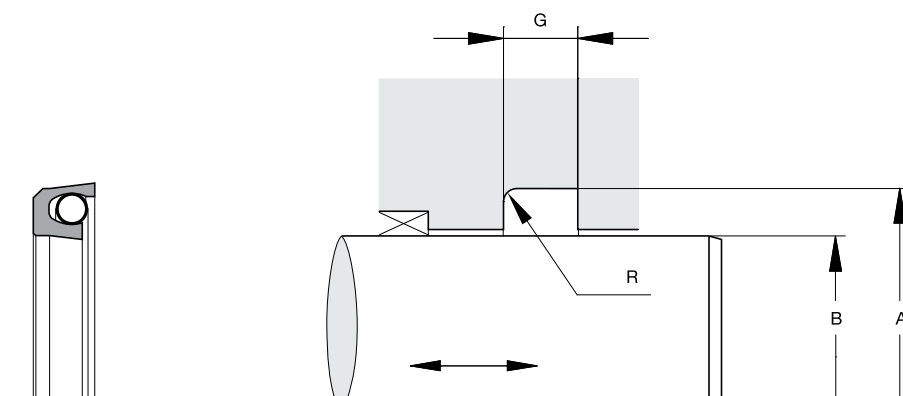
For reciprocating rod sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 15 m/s

Compounds

The BAI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h8 B (mm)		Outer diameter Tolerance H8 A (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	7.5	75	B + 2.84	2.4	0.30
3/32"	02	5.5	180	B + 4.52	3.6	0.50
1/8"	03	6.0	250	B + 6.15	4.8	0.50
3/16"	04	12.5	300	B + 9.45	7.1	0.75
1/4"	05	50.0	500	B + 12.12	9.5	0.75
3/8"	06	150.0	1400	B + 18.75	13.3	0.75
1/2"	07	300.0	3000	B + 25.40	18.0	0.75

Ordering example

Rod 70 mm
Cylinder bore 76.15 mm

BAI-M007000-03-XXX-Y

BAI Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile BHI is ideal for sealing high-pressure, reciprocating actuator rods.

Features

- Helical spring for high load and small deflection range.
- Extended heel reduces effects of extrusion.

- Heavy dynamic lip (inside) ensures longest life.
- Short, wiper-type dynamic lip reduces frictional forces due to hydrostatic pressure.
- Squared, long static lip stabilizes the seal.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

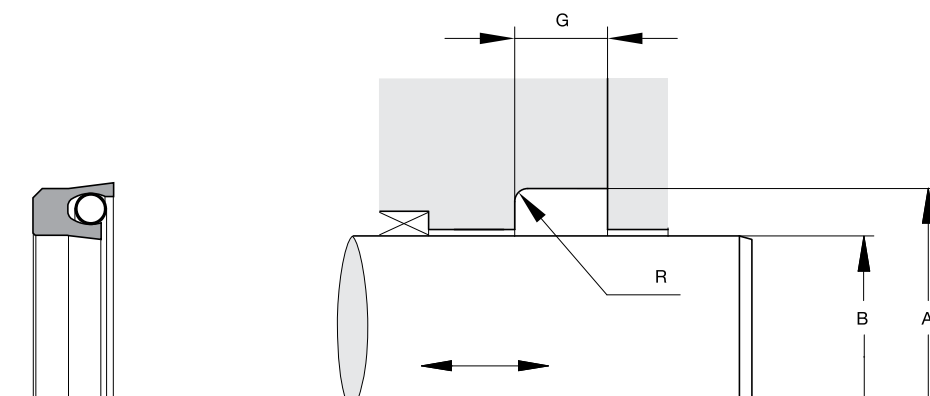
For high-pressure, reciprocating rod sealing.

Operating pressure	≤ 55 bar
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 15 m/s

Compounds

The BHI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h8 B (mm)		Outer diameter Tolerance H8 A (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	7.5	75	B + 2.84	3.8	0.30
3/32"	02	5.5	180	B + 4.52	4.6	0.50
1/8"	03	6.0	250	B + 6.15	6.0	0.50
3/16"	04	12.5	300	B + 9.45	8.5	0.75
1/4"	05	50.0	500	B + 12.12	12.1	0.75
3/8"	06	150.0	1400	B + 18.75	15.8	0.75
1/2"	07	300.0	3000	B + 25.40	20.5	0.75

Ordering example

Rod 70 mm
Cylinder bore 76.15 mm

BHI-M007000-03-XXX-Y

BHI Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile BAO is ideal for reciprocating piston sealing.

Features:

- Helical spring for high load and small deflection range.

- Heavy dynamic lip (outside) ensures longest life.
- Short, wiper-type dynamic lip reduces frictional forces due to hydrostatic pressure.
- Squared, long static lip stabilizes the seal.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

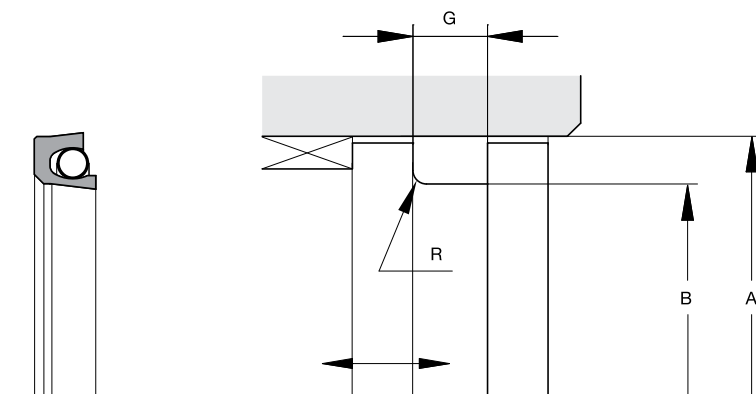
For reciprocating piston sealing.

Operating pressure	≤ 20 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 15 m/s

Compounds

The BAO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H8 A (mm)		Inner diameter Tolerance h8 B (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	10.0	75	A - 2.84	2.4	0.30
3/32"	02	10.0	180	A - 4.52	3.6	0.50
1/8"	03	12.5	250	A - 6.15	4.8	0.50
3/16"	04	22.0	300	A - 9.45	7.1	0.75
1/4"	05	63.0	500	A - 12.12	9.5	0.75
3/8"	06	170.0	1400	A - 18.75	13.3	0.75
1/2"	07	325.0	3000	A - 25.40	18.0	0.75

Ordering example

Piston groove 70 mm
Cylinder bore 76.15 mm

BAO-M007615-03-XXX-Y

BAO Profile
M007615 Outer groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile BHO is ideal for high-pressure piston sealing.

Features

- Helical spring for high load and small deflection range.
- Extended heel that reduces effects of extrusion.

- Heavy dynamic lip (inside) ensures longest life.
- Short, wiper-type dynamic lip reduces frictional forces due to hydrostatic pressure.
- Squared, long static lip stabilizes the seal.
- Widest range of cross-sections and diameters available, including sizes for upgrading standard O-Ring grooves.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

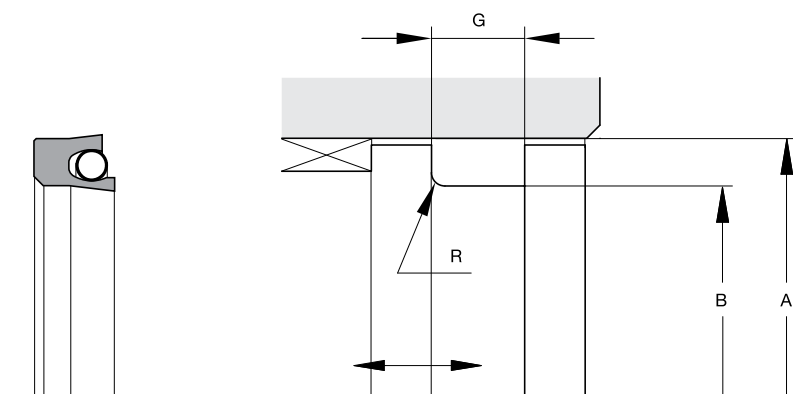
For high-pressure, reciprocating piston sealing.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 15 m/s

Compounds

The BHO seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H8 A (mm)		Inner diameter Tolerance h8 B (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	10.0	75	A - 2.84	3.8	0.30
3/32"	02	10.0	180	A - 4.52	4.6	0.50
1/8"	03	12.5	250	A - 6.15	6.0	0.50
3/16"	04	22.0	300	A - 9.45	8.5	0.75
1/4"	05	63.0	500	A - 12.12	12.1	0.75
3/8"	06	170.0	1400	A - 18.75	15.8	0.75
1/2"	07	325.0	3000	A - 25.40	20.5	0.75

Ordering example

Piston groove 70 mm
Cylinder bore 76.15 mm

BHO-M007615-03-XXX-Y

BHO Profile
M007615 Outer groove diameter (mm; times 100)
03 Cross-section code corresponding to a 6.15 mm groove diameter difference
XXX Jacket material
Y Spring-energizer material



The profile NAI is excellent for sealing internally pressurized static and intermittently dynamic flange applications.

Features

- Helical wound spring for high load and small deflection range.

- Resilient helical spring resists permanent set and maintains compliance to long-term flange separation.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

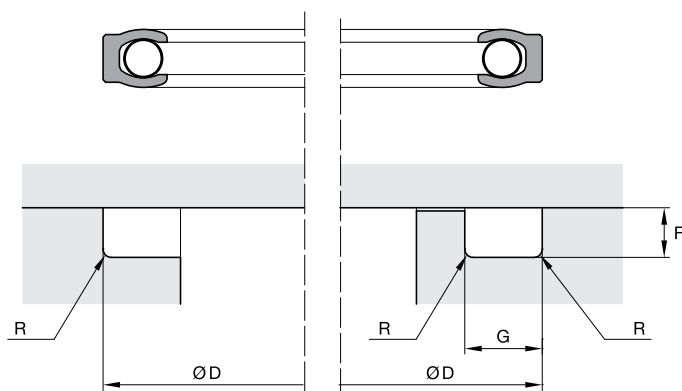
For internal static and intermittently dynamic flange sealing.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NAI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	10	65	1.42 - 1.47	2.4	0.30
3/32"	02	14	100	2.26 - 2.31	3.6	0.50
1/8"	03	25	200	3.07 - 3.12	4.8	0.50
3/16"	04	48	350	4.72 - 4.78	7.1	0.75
1/4"	05	115	400	6.05 - 6.12	9.5	0.75
3/8"	06	200	1000	9.47 - 9.58	13.3	0.75
1/2"	07	325	3000	12.70 - 12.80	18.0	0.75

Ordering example

Outside groove 70 mm

NAI-M007000-03-XXX-Y

NAI profile
M007000 Outer groove diameter (mm; times 100)
03 Cross-section code corresponding to a 3.07 mm groove height
XXX Jacket material
Y Spring-energizer material



- Resilient helical spring resists permanent set and maintains compliance to long-term flange separation.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

The profile NHI is excellent for sealing internally high-pressurized static and intermittently dynamic flange applications.

Features

- Extended heel reduces the effects of extrusion.
- Helical spring for high load and small deflection range.

Range of application

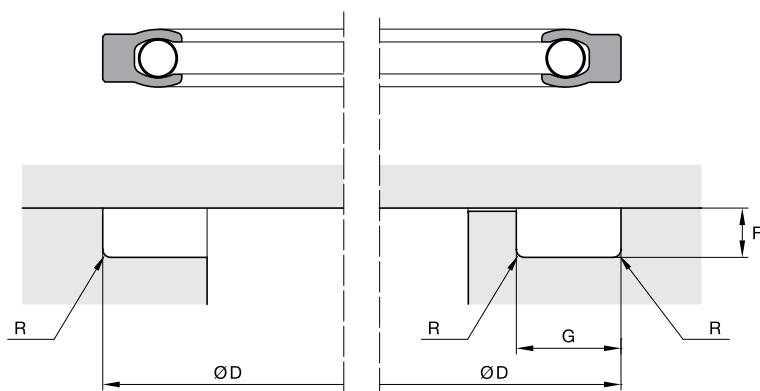
For internal static and intermittently dynamic flange sealing – high-pressure.

Operating pressure	≤ 140 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NHI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	11	65	1.42 - 1.47	3.3	0.30
3/32"	02	14	100	2.26 - 2.31	4.5	0.50
1/8"	03	25	200	3.07 - 3.12	6.5	0.50
3/16"	04	48	350	4.72 - 4.78	8.0	0.75
1/4"	05	115	400	6.05 - 6.12	11.3	0.75
3/8"	06	200	1000	9.47 - 9.58	15.8	0.75
1/2"	07	325	3000	12.70 - 12.80	20.5	0.75

Ordering example

Outside groove 70 mm

NHI-M007000-03-XXX-Y

NHI	Profile
M007000	Outer groove diameter (mm; times 100)
03	Cross-section code corresponding to a 3.07 mm groove height
XXX	Jacket material
Y	Spring-energizer material



The profile NAE is excellent for sealing externally pressurized static and intermittently dynamic flange applications.

Features

- Helical spring for high load and small deflection range.

- Resilient helical spring resists permanent set and maintains compliance to long-term flange separation.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

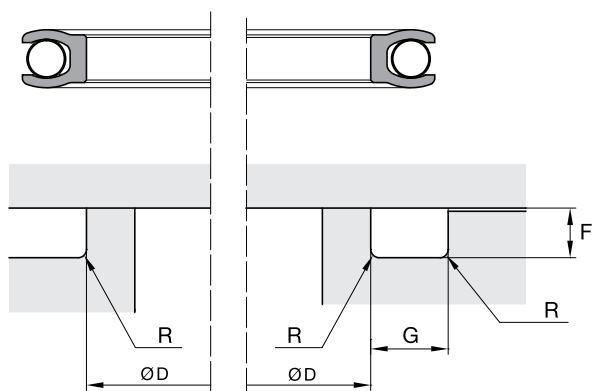
For external static and intermittently dynamic flange sealing.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NAE seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	5	65	1.42 - 2.84	2.4	0.30
3/32"	02	10	100	2.26 - 2.31	3.6	0.50
1/8"	03	20	200	3.07 - 3.12	4.8	0.50
3/16"	04	40	350	4.72 - 4.78	7.1	0.75
1/4"	05	90	400	6.05 - 6.12	9.5	0.75
3/8"	06	200	1000	9.47 - 9.58	13.3	0.75
1/2"	07	300	3000	12.70 - 12.80	18.0	0.75

Ordering example

Inside groove 70 mm

NAE-M007000-03-XXX-Y

NAE Profile
M007000 Inner groove diameter (mm; times 100)
03 Cross-section code corresponding to a 3.07 mm groove height
XXX Jacket material
Y Spring-energizer material

FlexiSeal® external high-pressure – static, intermittently dynamic **NHE**



The profile NHE is excellent for sealing internally high-pressurized static and intermittently dynamic flange applications.

Features

- Extended heel reduces the effects of extrusion.
- Helical spring for high load and small deflection range.

- Resilient helical spring resists permanent set and maintains compliance to long-term flange separation.
- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Low-cost elastomeric energizers available, all with excellent fatigue resistance.

Range of application

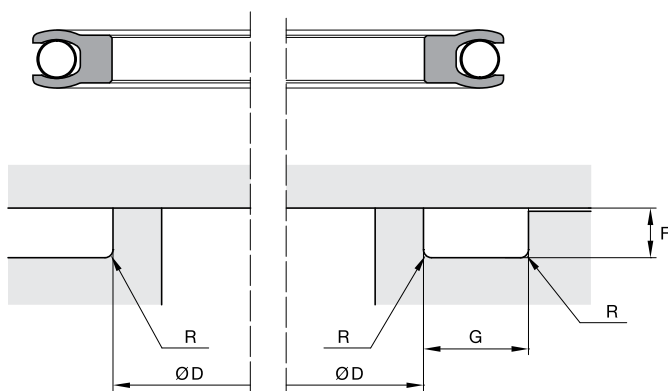
For external static and intermittently dynamic flange sealing – high-pressure.

Operating pressure	≤ 140 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.05 m/s

Compounds

The NHE seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	4.65	65	1.42 - 1.47	3.3	0.30
3/32"	02	10.00	100	2.26 - 2.31	4.5	0.50
1/8"	03	20.00	200	3.07 - 3.12	6.5	0.50
3/16"	04	40.00	350	4.72 - 4.78	8.0	0.75
1/4"	05	90.00	400	6.05 - 6.12	11.3	0.75
3/8"	06	200.00	1000	9.47 - 9.58	15.8	0.75
1/2"	07	300.00	3000	12.70 - 12.80	20.5	0.75

Ordering example

Inside groove 70 mm

NHE-M007000-03-XXX-Y

NHE	Profile
M007000	Inner groove diameter (mm; times 100)
03	Cross-section code corresponding to a 3.07 mm groove height
XXX	Jacket material
Y	Spring-energizer material



The profile NLF is excellent for sealing static and dynamic internally pressurized flange applications, in particular where bolt load and friction are limited or a higher deflection range is required.

Features

- Cantilever spring for low sealing load and high compliance to long-term flange separation.

- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.
- Available with silicone filling for food and drug applications.

Range of application

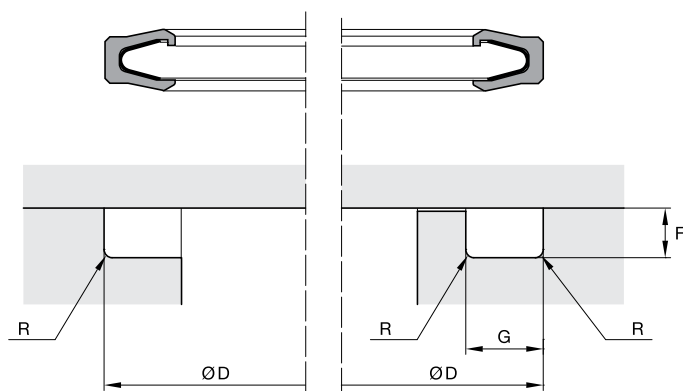
For internal static and dynamic flange sealing.

Operating pressure	≤ 35 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The NLF seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
1/16"	01	15	75	1.42 - 1.47	2.4	0.30
3/32"	02	20	180	2.26 - 2.31	3.6	0.50
1/8"	03	30	250	3.07 - 3.12	4.8	0.50
3/16"	04	50	300	4.72 - 4.78	7.1	0.75
1/4"	05	105	685	6.05 - 6.12	9.5	0.75
3/8"	06	300	1400	9.47 - 9.58	14.5	0.75
1/2"	07	300	3000	12.70 - 12.80	18.0	0.75

Ordering example

Outside groove 70 mm

NLF-M007000-03-XXX-Y

NLF	Profile
M007000	Outer groove diameter (mm; times 100)
03	Cross-section code corresponding to a 3.07 mm groove height
XXX	Jacket material
Y	Spring-energizer material



- Many high-resilience energizer options available, including choice of light, medium and heavy loads and NACE for oil field use.

The profile NLG is excellent for sealing static and dynamic externally pressurized flange applications, in particular where bolt load and friction are limited or a higher deflection range is required.

Features

- Cantilever spring for low sealing load and high compliance to long-term flange separation.

Range of application

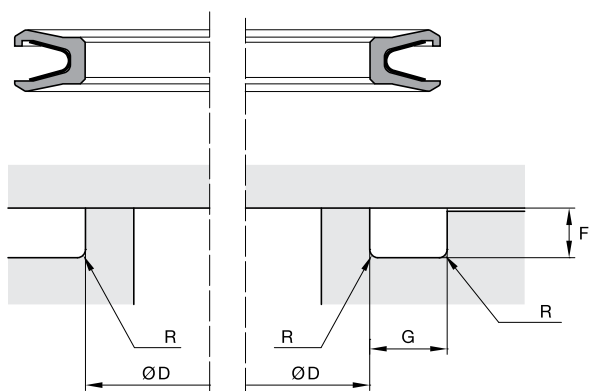
For external static and dynamic flange sealing.

Operating pressure	≤ 35 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 5 m/s

Compounds

The NLG seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range		Groove depth range	Groove width min.	Radius max.
		Tolerance H10				
		D (mm)				
		≥	≤		G (mm)	R (mm)
1/16"	01	10	75	1.42 - 1.47	2.4	0.30
3/32"	02	14	125	2.26 - 2.31	3.6	0.50
1/8"	03	25	400	3.07 - 3.12	4.8	0.50
3/16"	04	45	400	4.72 - 4.78	7.1	0.75
1/4"	05	85	450	6.05 - 6.12	9.5	0.75
3/8"	06	300	1400	9.47 - 9.58	14.5	0.75
1/2"	07	300	3000	12.70 - 12.80	18.0	0.75

Ordering example

Inside groove 70 mm

NLG-M007000-03-XXX-Y

NLG	Profile
M007000	Inner groove diameter (mm; times 100)
03	Cross-section code corresponding to a 3.07 mm groove height
XXX	Jacket material
Y	Spring-energizer material



- Wiper-type lips.
- Rigid spring acts as a control band to resist low-temperature shrinkage.
- Available in large cross-sections, ideal for large-diameter seals.
- NACE-approved energizers available for oil field use.

The profile NRI is ideal for sealing internally pressurized flanges, in particular cryogenic static and intermittently dynamic applications.

Features

- Cantilever spring with high-load / high-compliance to resist permanent set and long-term flange separation.

Range of application

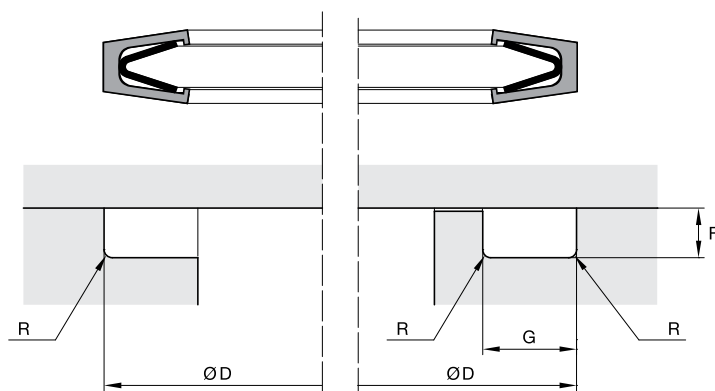
For internal cryogenic static and intermittently dynamic flange sealing.

Operating pressure	≤ 35 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NRI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
3/16"	04	50	300	4.72 - 4.78	9.0	0.75
1/4"	05	80	1000	6.05 - 4.78	10.0	0.75
3/8"	06	150	1200	9.47 - 4.78	13.5	0.75
1/2"	07	200	3000	12.70 - 4.78	18.5	0.75

Ordering example

Outside groove 100 mm

NRI-M010000-04-XXX-Y

NRI	Profile
M010000	Outer groove diameter (mm; times 100)
04	Cross-section code corresponding to a 4.62 mm groove height
XXX	Jacket material
Y	Spring-energizer material

FlexiSeal® internal high-pressure – high load/deflection – cryogenic HRI



The profile HRI is ideal for sealing internally high-pressurized flanges, in particular cryogenic static and intermittently dynamic applications.

Features

- Extended heel reduces effects of extrusion.
- Cantilever spring with high-load / high-compliance to resist permanent set and long-term flange separation.

- Wiper-type lips.
- Rigid spring acts as a control band to resist low-temperature shrinkage.
- Available in large cross-sections, ideal for large-diameter seals.
- NACE-approved energizers available for oil field use.

Range of application

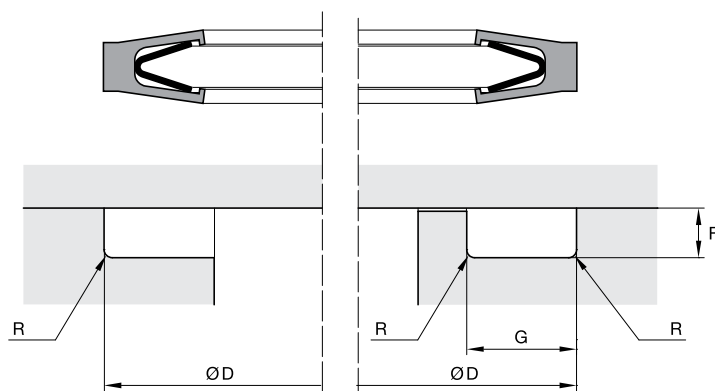
For internal cryogenic static and intermittently dynamic flange sealing – high-pressure.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The HRI seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended outer Ø range Tolerance H10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
3/16"	04	50	300	4.72 - 4.78	9.9	0.75
1/4"	05	80	1000	6.05 - 6.12	11.8	0.75
3/8"	06	150	1200	9.47 - 9.58	16.0	0.75
1/2"	07	200	3000	12.70 - 12.80	21.0	0.75

Ordering example

Outside groove 100 mm

HRI-M010000-04-XXX-Y

HRI	Profile
M010000	Outer groove diameter (mm; times 100)
04	Cross-section code corresponding to a 4.62 mm groove height
XXX	Jacket material
Y	Spring-energizer material



- Wiper-type lips.
- Available in large cross-sections, ideal for large-diameter seals.
- NACE-approved energizers available for oil field use.

The profile NRE is ideal for sealing externally pressurized flanges, in particular cryogenic static and intermittently dynamic applications.

Features

- Cantilever spring with high-load / high-compliance to resist permanent set and long-term flange separation.

Range of application

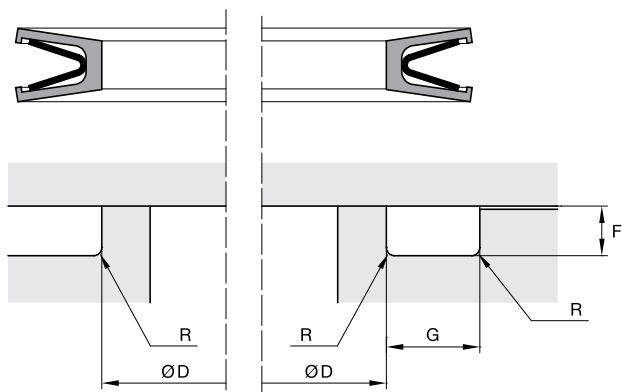
For external cryogenic static and intermittently dynamic flange sealing.

Operating pressure	≤ 35 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The NRE seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
3/16"	04	50	300	4.72 - 4.78	9.0	0.75
1/4"	05	80	1000	6.05 - 6.12	10.0	0.75
3/8"	06	150	1200	9.47 - 9.58	13.5	0.75
1/2"	07	200	3000	12.70 - 12.80	18.5	0.75

Ordering example

Inside groove 100 mm

NRE-M010000-04-XXX-Y

NRE	Profile
M010000	Inner groove diameter (mm; times 100)
04	Cross-section code corresponding to a 4.62 mm groove height
XXX	Jacket material
Y	Spring-energizer material



- Wiper-type lips.
- Available in large cross-sections, ideal for large-diameter seals.
- NACE-approved energizers available for oil field use.

The profile HRE is ideal for sealing externally high-pressurized flanges, in particular cryogenic static and intermittently dynamic applications.

Features

- Extended heel reduces effects of extrusion.
- Cantilever spring with high-load / high-compliance to resist permanent set and long-term flange separation.

Range of application

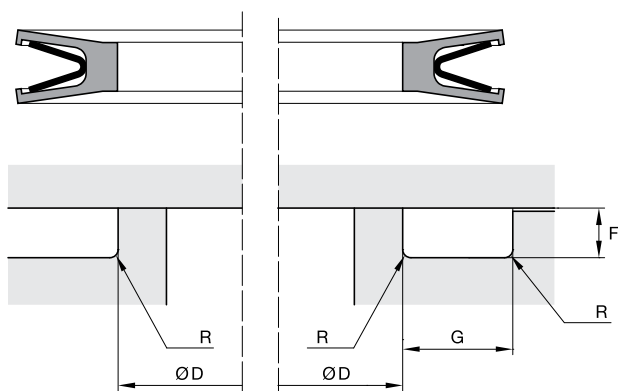
For external cryogenic static and intermittently dynamic flange sealing – high-pressure.

Operating pressure	≤ 55 MPa
Operating temperature	-260 °C to +315 °C
Sliding speed	≤ 0.005 m/s

Compounds

The HRE seal is available in a wide range of polymers. These include unfilled PTFE, filled PTFE, UHMW-PE, PEEK and many others. See the compound list for further information.

In case of special operating conditions (specific pressure loads, temperature, speed, use in water, HFA, HFB fluids etc.), please contact our consultancy service for a selection of the material and design best suited to your particular application requirements.



Housing dimensions

Nominal cross-section	Cross-section code	Recommended inner Ø range Tolerance h10 D (mm)		Groove depth range F (mm)	Groove width min. G (mm)	Radius max. R (mm)
		≥	≤			
3/16"	04	50	300	4.72 - 4.78	9.9	0.75
1/4"	05	80	1000	6.05 - 6.12	11.8	0.75
3/8"	06	150	1200	9.47 - 9.58	16.0	0.75
1/2"	07	200	3000	12.70 - 12.80	21.0	0.75

Ordering example

Inside groove 100 mm

HRE-M010000-04-XXX-Y

HRE	Profile
M010000	Inner groove diameter (mm; times 100)
04	Cross-section code corresponding to a 4.62 mm groove height
XXX	Jacket material
Y	Spring-energizer material

3.4 Non-standard FlexiSeal® types

Besides the standard range of FlexiSeals® there are many additional, non-standard types which have been developed, customized and proven over the years for specific applications in many different industries and final products. Our consultancy service will frequently recommend these for special requirements. Dimensional data has not been provided as many of these seal types are customized for specific applications and groove configurations which differ from the standard recommendations.

To order or request a quotation for a non-standard FlexiSeal®, please advise us of all your requirements by completing the “Application data sheet” included in chapter 7 of this design manual. Please forward the completed form to our consultancy service or to your local sales consultant. Our consultancy service will respond quickly with detailed recommendations.

Most non-standard FlexiSeal® types can be conveniently grouped within the following categories

- Radial seals for rotary, reciprocating and static sealing
- Radial wiper and wiper seals
- Radial flanged seals for high speed rotary sealing and cryogenic applications
- Radial seals to fit into standard lip seal grooves
- Double cavity seals to suit large groove sections
- Trapped anti-blowout seals
- Conical seals
- Closed seals for sanitary/food applications
- Double-acting seals
- Seals with canted coil spring
- Shaped seals
- FlexiSeals® for standard O-ring grooves

3.4.1 Radial seals for rotary, reciprocating and static sealing

3.4.1.1 Asymmetrical lip length

The long lip design serves as a lip protection device in low-pressure reciprocating applications or in case of reverse pressure difference (back-pressure).

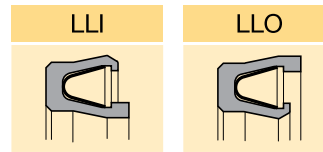


Fig. 3.11 FlexiSeal® types with asymmetrical lip length

3.4.1.2 Asymmetrical lip thickness

Seal designs with asymmetrical lip thickness can be used when additional wear resistance is required on the dynamic side of the application.

In cryogenic environments a thinner outer lip will help to restrict the shrinking forces on the spring element.

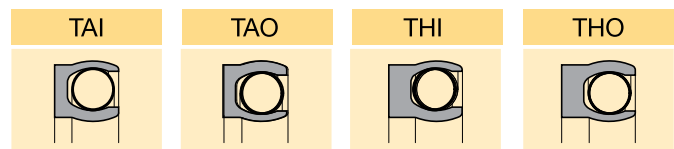


Fig. 3.12 FlexiSeal® types with asymmetrical lip thickness

3.4.1.3 Semi-exposed spring

A semi-exposed spring serves as a lip protection device in case of a reverse pressure difference (back-pressure). When the spring touches the front of the groove wall, an additional radial sealing force is generated.

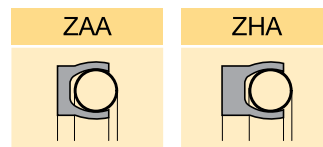


Fig. 3.13 FlexiSeal® types with semi-exposed spring

3.4.2 Radial wipers

These seal designs prevent abrasive particles from accumulating between the seal lip and the mating surface, which increases wear of the seal and the mating surface. The wiper feature is available with both helical and cantilever spring types.

FlexiSeal® profiles SAI and SAO are intended for intermittent or slow dynamic applications with wiper function on the inner or outer diameter. Their shorter dynamic lip reduces friction in pressurized conditions. Types SHI and SHO are high-pressure versions.

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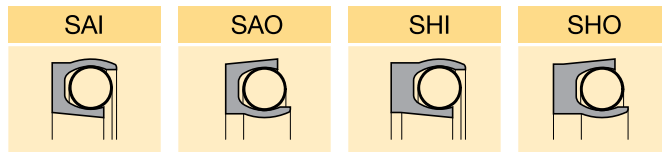


Fig. 3.14 FlexiSeal® wiper/wiper types with asymmetrical lip length

The profiles BAA, BHA and BLA have a symmetrical wiper lip design and can be used for reciprocating or rotating movements on either inner or outer diameter.

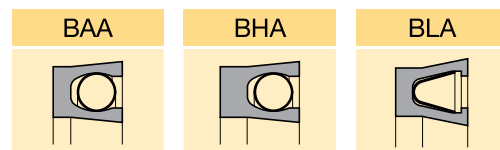


Fig. 3.15 FlexiSeal® wiper/wiper types with symmetrical lip

3.4.3 Flanged radial seals for high-speed rotary sealing and cryogenic applications

The flange feature prevents the seal from rotating within its groove as the high-speed hardware rotates against the seal's surface. In cryogenic environments or applications with large temperature variations a restrained outside flange minimizes seal shrinkage so that it maintains firm contact against the mating surfaces.

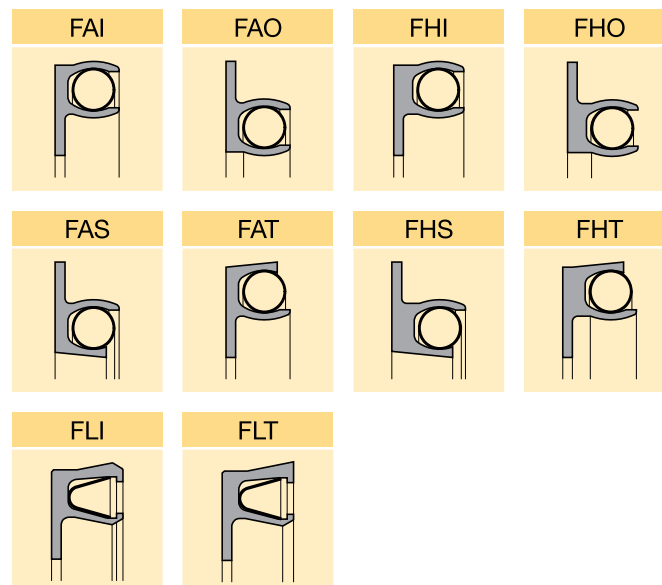


Fig. 3.16 Flanged FlexiSeal® types

3.4.4 Radial rotary seals to fit into standard grooves for elastomeric lip seals

These special seals are designed for high-speed applications and fit into existing standard elastomeric lip seal grooves. The elastomeric O-Ring prevents the seal from rotating with the dynamic side and provides a secondary sealing function at the static side.

An additional metal retainer ring (RRI) prevents thermally induced shrinkage in case of large-diameter seals and extreme temperatures.

All types are also available with a dynamic wiper lip.

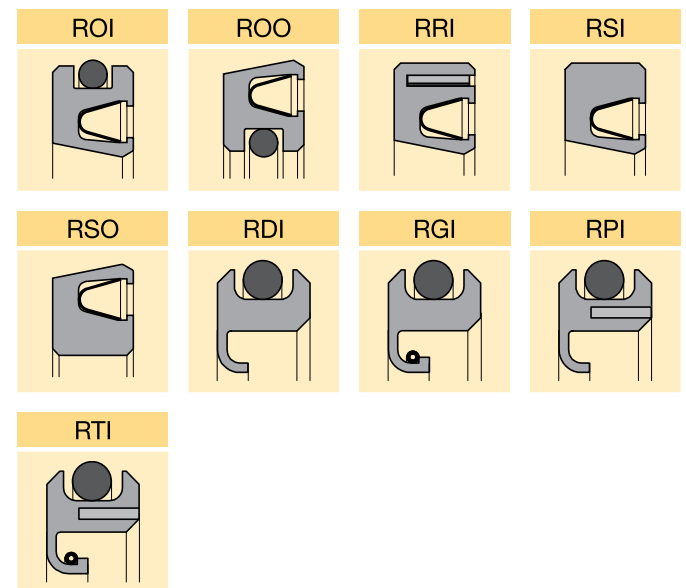


Fig. 3.17 Rotary FlexiSeal® types and lip seals to fit into standard grooves for elastomeric lip seals

3.4.5 Double-cavity seals to suit large groove sections

Double-cavity seals are available to fill large groove heights when the groove length is limited.

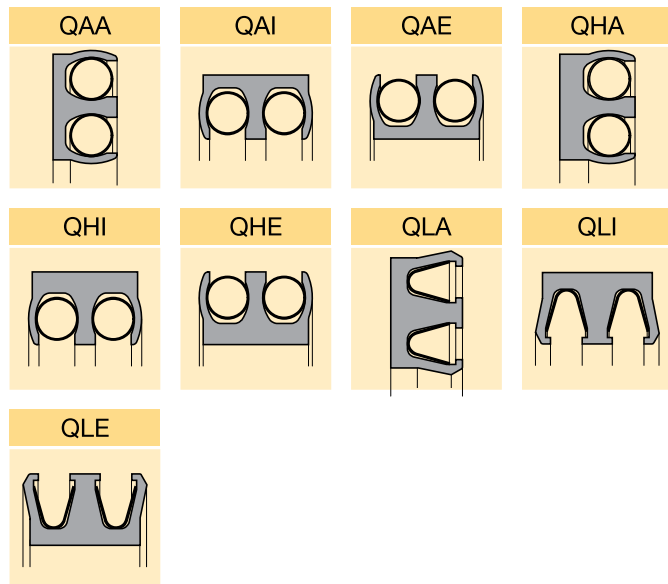


Fig. 3.18 FlexiSeal® types with double spring cavity

3.4.6 FlexiSeal® types with double spring cavity Trapped anti-blowout seals

These specific seal designs are used where rapid fluid flow may dislodge a non-trapped seal from its sealing groove. Constraint in a pocket also provides additional control over thermal movement of the seal.

A typical application is a butterfly valve where the AAI type is secured in its groove when exposed to high velocities when the pressurized valve is opened.

Anti-blowout designs are also used when the seal needs to pass port holes.

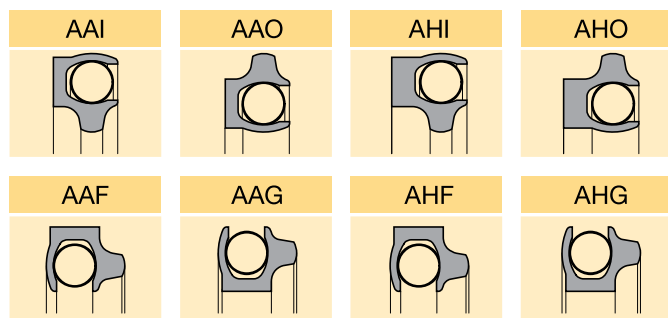


Fig. 3.19 Trapped anti-blowout FlexiSeal® types

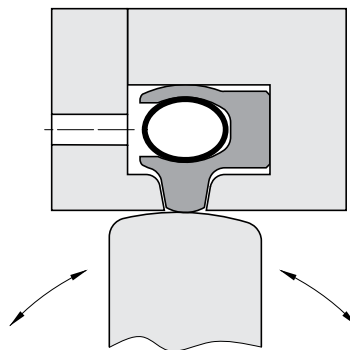


Fig. 3.20 Anti-blowout FlexiSeal® in a butterfly valve

3.4.7 Conical seals

These seals suit applications such as angular ball valves and poppet valves which have conical sealing surfaces. Conical seals in anti-blowout configuration are available as well.

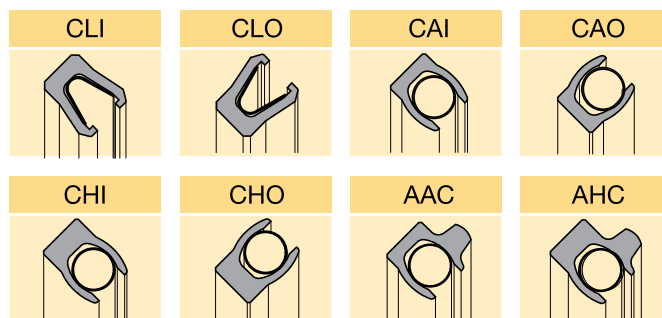


Fig. 3.21 Conical FlexiSeal® types

3.4.8 Closed seals for sanitary/food applications

A closed seal design prevents the medium from getting trapped in the spring and allows an easier cleaning process. It also protects the spring against chemical attack from the medium. Typical applications are food filling and other dispensing equipment.

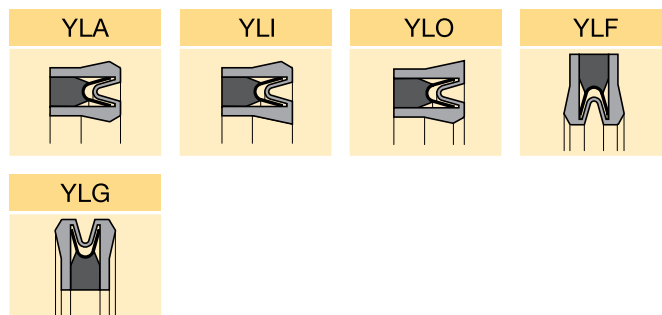


Fig. 3.22 Closed FlexiSeal® types

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3.4.9 Double-acting seals

Double-acting seals are designed for exposure in reversing system pressures. Only for low-pressures. Optional use of metallic stand-off rings for protection against collision of the lips with the groove front wall.

If the application conditions are less severe, please refer to our slipper seal section for additional double-acting seal types.

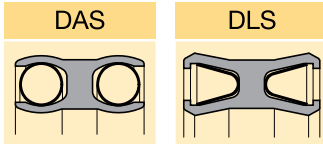


Fig. 3.23 Double-acting FlexiSeal® types

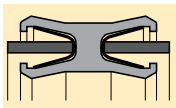


Fig. 3.24 Double-acting FlexiSeal® with stand-off rings

3.4.10 Seals with canted coil spring

These seal types feature a spring made from a round wire that is coiled into a canted or slanted shape. The result is a very flat load versus deflection curve, which makes them particularly suitable for sensitive friction applications where a low and constant load is required over a wide deflection range.

The canted coil design is intended for dynamic reciprocating and rotary applications but can also be used in static conditions when wide groove tolerance or misalignment is present.

The spring can be formed with extremely small coil diameters which lends itself for use in sealing applications with small cross-sections and small diameters. Available in radial and face seal configurations.

Refer to chapter 3.6.7 for more information on the canted coil spring design.



Fig. 3.25 Canted coil spring

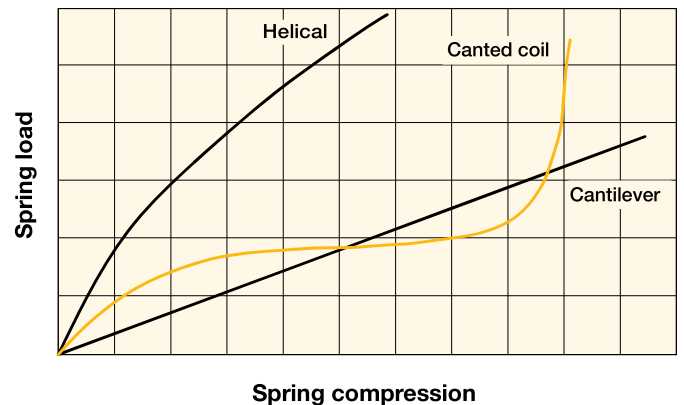


Fig. 3.26 Canted coil spring load curve

3.4.11 Shaped seals

Seal profiles with helical or canted coil springs can be formed into special, non-circular shapes.

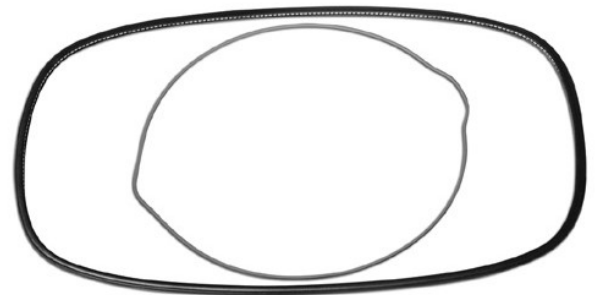


Fig. 3.27 Shaped FlexiSeal® types

3.4.12 FlexiSeals® for standard O-ring grooves

Standard grooves for elastomeric O-rings can also be used with FlexiSeals® when the operating conditions are too demanding. Parker offers FlexiSeals® in a complete range of sizes conforming to the following O-ring groove specifications

- MIL-G-5514 Standard Grooves
- Standard Industrial (Fractional) Grooves
- Aerospace Standard AS4716 Grooves
- Japanese Industrial Grooves JIS B-2406

Please contact our consultancy service or your local sales representative for more information.

3.5 FlexiSeal® material selection

3.5.1 Jacket material

Parker draws on hundreds of PTFE compounds and other polymeric materials to manufacture the FlexiSeal® jacket profile. Our material range includes unfilled PTFE, standard and speciality filled PTFE compounds, TFM blends, UHMW polyethylene, thermoplastics, PEEK, polyimide, ... Parker can meet your material requirements for polymer sealing in most environmental and operating conditions.

The FlexiSeal® jacket material is designated with a single code in the standard part number (see table 3.1)

XXX-M000000-00-000-0

Table 3.1 is a selection of our most popular jacket materials used for FlexiSeal®. Make an initial, possibly multiple, selection of all materials with appropriate application descriptions and service temperature ranges. The final selection may then be made using the performance rating values to choose a material with the best combination of characteristics for the intended service. For guidance on selection of a material other than the ones listed, please contact our consultancy service.



Fig. 3.28 FlexiSeal® raw material

Compound code	Elastomer base	Colour	Temperature range (°C) ¹⁾		Wear resistance ³⁾	Pressure / extrusion resistance ³⁾	Chemical compatibility ³⁾	FDA-compliant	NORSOK M-710 compliant	Min. recommended dyn. surface hardness (HRC)	Remarks
Polon® PS001	Virgin PTFE	white	-260	+260	1	1	5	•		25	• best for static applications requiring positive sealing • good in vacuum with low gas permeability • good for cryogenic service
Polon® PS002	PTFE + graphite	black	-260	+300	2	3	4		•	25	• much better temperature resistance than virgin PTFE • better extrusion resistance and higher wear resistance • excellent for corrosive service, steam and hot water applications • ideal for unlubricated service
Polon® PS003	PTFE + glas fibre/ MoS ₂	grey	-240	+300	5	4	4			60	• excellent wear resistance because of internal lubrication with MoS₂ • often used for high-pressure extrusion resistance or high speed, high-pressure rotary applications • only for use on very hard mating surface because of its abrasive properties
Polon® PS004	PTFE + bronze	bronze	-260	+300	5	5	2			45	• highly filled compound with excellent wear, temperature and pressure resistance • ideal for high-speed applications • limitations in use because of chemical incompatibilities

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Compound code	Elastomer base	Colour	Temperature range (°C) ¹⁾		Wear resistance ³⁾	Pressure / extrusion resistance ³⁾	Chemical compatibility ³⁾	FDA-compliant	NORSOK M-710 compliant	Min. recommended dyn. surface hardness (HRC)	Remarks
Polon® PS005	PTFE + aromatic polyester	cream	-260	+315	3	3	3		•	25	- a dynamic material for softer mating surfaces and a static material for high temperatures - excellent wear resistance without abrasion - not recommended for applications involving steam > 120 °C
Polon® PS006	UHMW-PE	translucent	-260	+80	1 ²⁾	5	1		•	35	- among the toughest, most wear-resistant materials but with limited temperature and chemical resistance - intended for reciprocating or very slow rotary applications - good lubricity in water - can serve in cryogenic conditions - higher coefficient of friction than PTFE
Polon® PS007	PTFE + carbon/graphite	black	-260	+300	4	4	4			50	- particularly suited for highly corrosive service - widely used in dynamic steam and water applications - excellent general purpose material and often used in rotary applications - performs well in non-lubricated systems
Polon® PS009	modified virgin PTFE	white	-260	+280	1	1	5		•	25	- similar to virgin PTFE but lower gas permeability, higher extrusion resistance and smoother surface on machined parts - can be used in slow, infrequent dynamics - good for cryogenic service
Polon® PS011	modified PTFE	turquoise	-260	+260	2	2	4			25	lower creep than virgin PTFE, good wear resistance
Polon® PS031	modified PTFE + glas fibre	ivory	-260	+300	4	5	4		•	60	- has positive impact on pressure resistance - improves wear resistance and offers good compressive strength - only for use on very hard mating surfaces - do not use with strong bases or hydrofluoric acid
Polon® PS045	PTFE + carbon fibre	black	-260	+300	4	4	4		•	50	- carbon fibre lowers creep, increases flexural and compressive modulus and raises hardness - thermal expansion is lower and electrical conductivity is higher - good for strong bases and hydrofluoric acids - excellent wear behaviour in aqueous environment
Polon® PS063	PTFE + proprietary carbon fibre	brown / red	-260	+300	4	4	3		•	50	- excellent all-purpose material - best for dynamic applications running on moderate to hard surfaces - high wear-rate material with low abrasion
Polon® PS0F5	FDA-compliant polymer-filled PTFE	cream	-260	+300	3	3	3		•	25	dynamic applications that require FDA approved material
Polon® PS0V6	Proprietary filled PTFE	dark brown	-260	+300	5	3	3		•	25	- best wear resistance among filled PTFEs - gentle to soft mating surfaces

Notes

¹⁾ High temperature end is subjected to extrusion gap guidelines.

²⁾ Not recommended in rotary applications due to frictional heat generation.

³⁾ 1 is lowest, 5 is highest rating.

We emphasize that this table should be used as a guide only. The data provided above is based primarily on laboratory and service tests, but does not take into account all variables that can be encountered in actual use. Therefore, it is always advisable to test the material under actual service conditions before specification. If this is not practical, tests should be designed in such a way that service conditions are simulated as closely as possible.

Tab. 3.1 FlexiSeal® jacket material selection

3.5.2 Energizer material

The FlexiSeal® energizer material is designated with a single code in the standard part number (table 3.3):

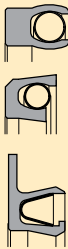
XXX-M000000-00-000-0

Refer to the tables 3.2 and 3.3 to select the spring energizer code for your seal type and application.

Energizer material	Application
300 series stainless steel (301, 302, 304)	• general-purpose spring material for most media up to 315 °C • recommended up to 200 °C in corrosive media • low-cost • standard material for cantilever springs
316 stainless steel	• 316 provides additional corrosion resistance due to its higher nickel and molybdenum content • typically used in food and sea water applications • limited availability in cantilever springs
17/7 PH stainless steel	• exhibits better retention of mechanical properties at temperatures above 200 °C than 300 series stainless steel • precipitation-hardenable • standard material for helical springs
Cobalt-chromium-nickel alloy	• originally developed as a spring material for watches • known for its excellent resistance to severe corrosive environments and use at temperatures above 260 °C • commonly used in oil industry applications • standard material for helical and cantilever springs • NACE-approved material in heat-treated condition
Inconel® X-750	• offers highest corrosive resistance • commonly used in high-temperature environments • NACE-approved material in heat-treated condition • limited availability in helical and cantilever springs
Hastelloy® C-276	• resistant in severely corrosive media when temperature exceeds 200 °C • limited availability in helical springs

Tab. 3.2 FlexiSeal® energizer material selection

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Seal profile	Spring type	Material	Standard code no.	Availability	Light / heavy versions ²⁾	Nace-compliant ¹⁾
	helical	17/7 PH stainless steel	1	standard	standard	
		Cobalt-chromium-nickel alloy	2	standard	standard	optional
		Inconel® X-750		optional	optional	optional
		Hastelloy® C-276		optional	optional	
	cantilever	Cobalt-chromium-nickel alloy	2	standard		optional
		Cobalt-chromium-nickel alloy+silicone filling	2S	standard		
		304 stainless steel	4	standard		
		304 stainless steel+silicone filling ³⁾	4S	standard		
		316 stainless steel		optional	optional	
		301 stainless steel		optional	optional	
		302 stainless steel		optional	optional	
		Inconel® X-750		optional	optional	optional
	heavy-duty cantilever	Cobalt-chromium-nickel alloy		optional		optional
		316 stainless steel		optional		
		301 stainless steel	4	standard		
		Inconel® X-750		optional		optional

Notes

¹⁾ For use in H₂S corrosive service per specification NACE MR-01-75/ISO 15156-3 (2003).

²⁾ To specify a light spring version to reduce sealing force, add Y to the energizer code (1Y, 2Y, etc.). To specify a heavy spring version to increase sealing force, add X to the energizer code (1X, 2X, etc.).

³⁾ An FDA approved silicone filling prevents the medium from getting trapped in spring cavity which may result in contamination. It thus allows the seal to be used in food processing applications.

Using an elastomeric O-Ring as an energizing element can be an alternative in case of high volumes and/or small diameters or to prevent medium to enter the seal cavity. Applicability is limited to the temperature and chemical resistance of the elastomer. A wide range of elastomeric materials is available:

NBR, EPDM, FKM, silicone, etc. Please contact our consultancy service for more details.

A seal with an optional spring energizer material will become a non-standard item and needs to be specified on the Application data sheet form (see appendix).

For additional energizer materials, please contact our consultancy service for assistance.

Inconel® is a registered trademark of the Special Metals Corporation. Hastelloy® is a registered trademark of Haynes International, Inc.

Tab. 3.3 FlexiSeal® energizer material availability

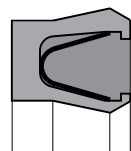


Fig. 3.29 Silicone-filled FlexiSeal®

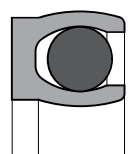


Fig. 3.30 FlexiSeal® with elastomeric O-Ring energizer

3.6 Technical information

3.6.1 Groove design and installation guidelines

3.6.1.1 Two-piece grooves or open groove configuration

Parker FlexiSeals® are rigid in comparison to seals made from elastomeric materials. They can be damaged if stretched or compressed beyond their material limitations. It is recommended that a two-piece, split-groove design be used whenever possible.

This allows easy installation or removal of the FlexiSeal® without the need for additional tooling and will greatly reduce the risk of damage to the seal.

It is necessary that all edges across which the seal might pass during installation are blended and very smooth to prevent damage to the seal.

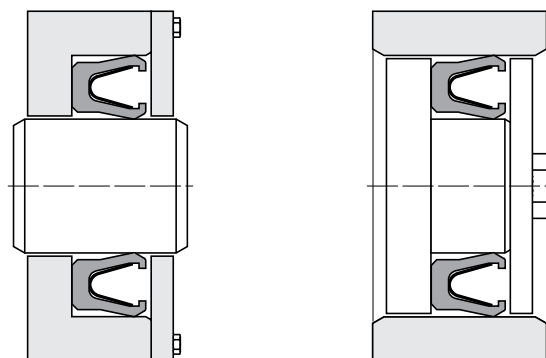


Fig. 3.31 Two-piece rod and piston grooves; left: rod, right: piston

3.6.1.1.1 Heel-first installation

When installing the FlexiSeal® with the heel or non-pressure side first, the lead-in chamfers may be smaller than for lips-first installation of the seal.

The FlexiSeal® is designed with a slight clearance at the heel diameter and is also chamfered. If lead-in chamfer angles cannot be made, a full polished radius may be used. Both designs must be very smooth and free from sharp edges which might damage the seal.

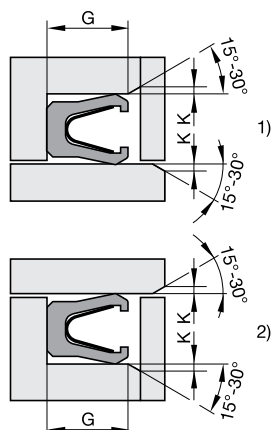


Fig. 3.32 Two-piece groove "heel-first" installation; 1) rod, 2) bottom: piston

Nominal cross-section	Cross-section code	Chamfer height K (mm)
1/16"	01	0.20
3/32"	02	0.30
1/8"	03	0.30
3/16"	04	0.40
1/4"	05	0.45
3/8"	06	0.60
1/2"	07	0.80

Tab. 3.4 Recommended "heel-first" lead-in chamfer

3.6.1.1.2 Lips-first installation

When installing the FlexiSeal® with the lips or pressure-side first, the lead-in chamfers must be longer than for heel-first installation. The FlexiSeal® is designed with pre-load interference on the lip diameters that require additional clearance to prevent damage during installation.

A stepped retention plate is required to provide a flat backed surface for the seal and to prevent extrusion into the lead-in angles. All chamfers must be very smooth and free from sharp edges which might damage the seal. If the necessary angles and retention plate cannot be accomplished, installation guiding tools are required.

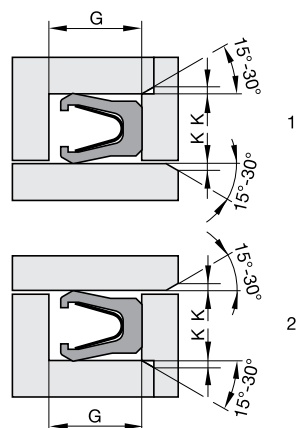


Fig. 3.33 Two-piece groove "lips first" installation; 1) rod, 2) piston

Nominal cross-section	Cross-section code	Chamfer height K (mm)
1/16"	01	0.90
3/32"	02	1.10
1/8"	03	1.25
3/16"	04	1.50
1/4"	05	1.75
3/8"	06	3.50
1/2"	07	4.00

Note

Sometimes a combination of heel-first and lips-first installation is required. When this occurs, match the appropriate table with the demands made on the chamfer.

Tab. 3.5

3.6.1.2 Step-cut grooves or partially closed-groove configuration

Sometimes, the use of the open groove configuration is not practical or possible. An alternative to the open groove is the step-cut or partially closed-groove configuration.

This solid one-piece design has a reduced wall on the pressure side of the groove. This allows the seal to snap into the groove without the need for a separate retainer or installation tools.

The step is designed to hold the seal in the groove during final assembly and under dynamic conditions such as low-pressure return strokes in reciprocating applications. In pressurized conditions, the FlexiSeal® is naturally held in the back of the groove.

The step-cut groove can be used for both rod and piston seals.

It is recommended that all edges across which the seal might pass during installation are blended and very smooth to prevent damage to the seal.

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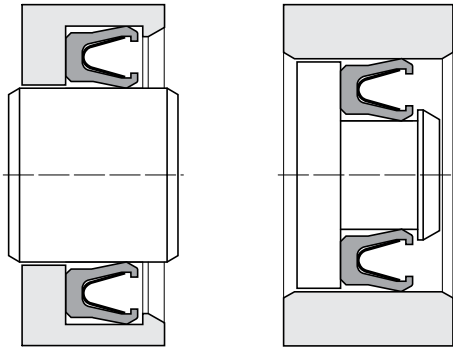


Fig. 3.34 Two-piece rod and piston grooves; left: rod, right: piston

The step-cut groove can only be used when the seal sees pressure from the open or spring side of the seal. This requires the seal to be installed heel or non-pressure side first, snapping the seal lips behind the retention step. After installing the seal in the groove, the assembly can be pushed into a piston bore or over a rod.

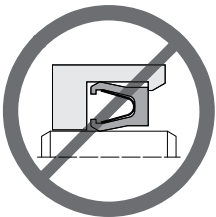


Fig. 3.35 Incorrect installation in step-cut groove

3.6.1.2.1 Step-cut groove in rod mode

The correct installation is achieved by first bending the FlexiSeal® into a slight elliptical shape and inserting one end into the groove followed by pressing the sides of the seal into the groove. The remaining portion of the seal is then pressed inwards to snap into the groove and complete the installation.

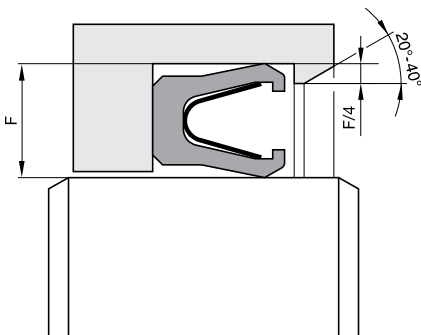


Fig. 3.36 Step-cut groove installation in rod mode

3.6.1.2.2 Step-cut groove in piston mode

Proper seal installation is accomplished by rapidly moving the seal over the retention step, minimizing seal distortion. A guide ramp tool may assist in the installation (see closed-grooves below).

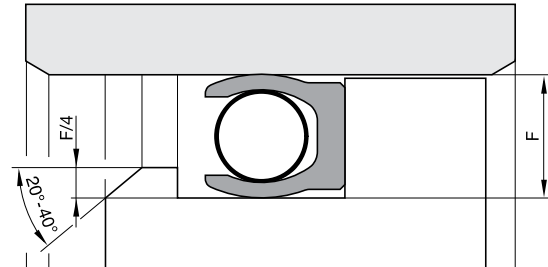


Fig. 3.37 Step-cut groove installation in piston mode

3.6.1.3 Closed-groove configuration

The least desirable groove design for the FlexiSeal® is the closed-groove design. It is strongly recommended to avoid this type of groove configuration if possible.

The seal cross-section, diameter and material are factors that determine whether the FlexiSeal® can be stretched into a solid piston groove or compressed into a rod seal housing. FlexiSeals® are more easily compressed into rod seal grooves than stretched into piston grooves.

FlexiSeals® with a helical spring element are more resistant to seal distortion than with a cantilever spring when installed in a closed-groove.

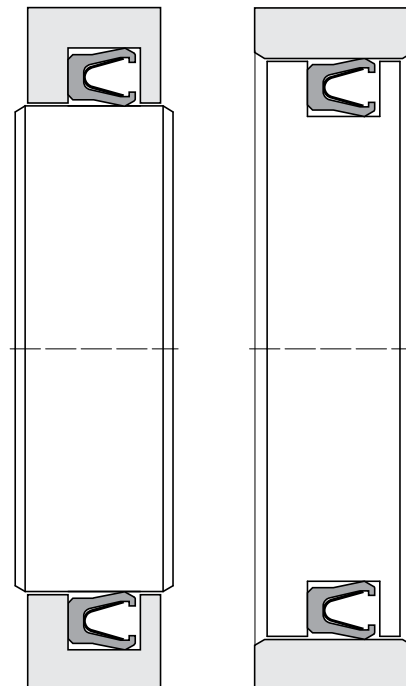


Fig. 3.38 Closed-groove configurations in rod and piston mode

3.6.1.3.1 Piston seal installation in closed-groove

A stretching guide ramp and resizing tool should be fabricated to assist in installing the FlexiSeal® in a fully closed-groove. Additionally, a flexible pusher tool may help in generating an equal pressure distribution over the seal circumference during the stretching process. As a general guideline, this type of installation should not be employed unless the inner diameter of the seal is at least 15 times its cross-section height. Otherwise permanent seal deformation may occur, affecting sealing integrity. Typical tool materials are POM or PVC.

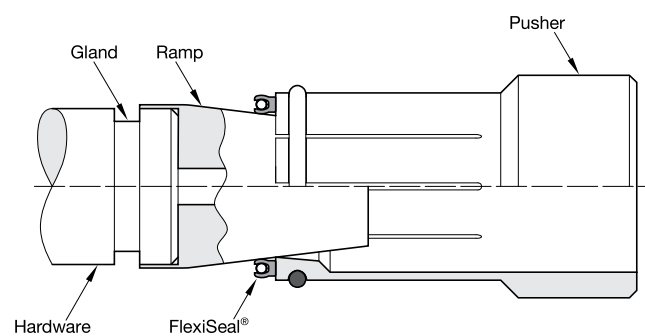


Fig. 3.39 Stretching guide ramp, pusher and resizing tool

Step 1 – Positioning

Place the seal on the guide ramp.

Optional preheating of the seal to as much as 150 °C in either oil, air or water will soften the jacket material and aid in stretching and installing the seal. Care must be taken not to damage the seal in the softened state and to prevent burns when using this option.

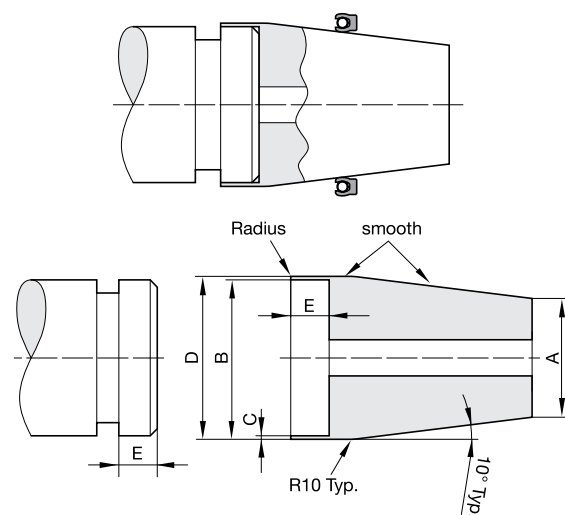


Fig. 3.40 Installation step 1: positioning of the FlexiSeal® on the guiding ramp

Dimension	Equals	Tolerance
A	minimum seal inner diameter – 2 × seal height	ref.
B	maximum hardware outer diameter + 0.05	+ 0.10 / - 0
C ¹⁾	0.30 if B ≤ 15 0.40 15 < B ≤ 35 0.50 35 < B ≤ 50 0.60 50 < B ≤ 80 0.75 80 < B ≤ 125 1.00 125 < B ≤ 175	± 0.03
D	B + (2 × C)	ref.

Note

¹⁾ If B > 175, please contact our consultancy service

Tab. 3.6 Installation step 1: positioning of the FlexiSeal® on the guiding ramp

Step 2 – Stretching

The FlexiSeal® is pushed over the guide ramp until it snaps into the groove. This sequence must be carried out rapidly to minimize seal distortion while stretching.

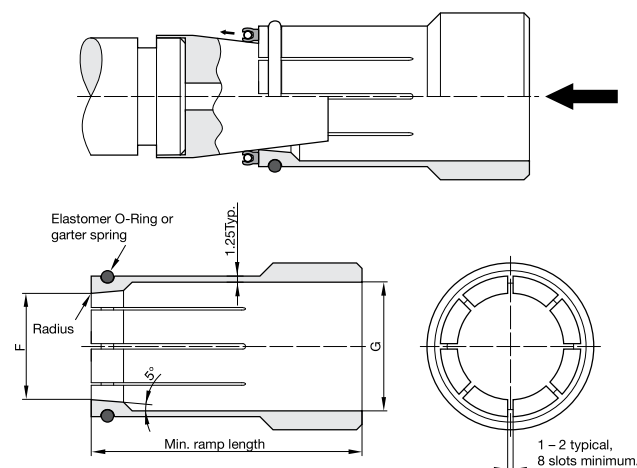


Fig. 3.41 Installation step 2: stretching of the FlexiSeal® into the groove

Dimension	Equals	Tolerance
F	smaller than seal inner diameter after installation of O-Ring or garter spring	ref.
G	maximum hardware outer diameter + 0.05	+ 0.20 / - 0

Tab. 3.7 Installation step 2: stretching of the FlexiSeal® into the groove

Step 3 – Resizing

Typically, a FlexiSeal® will not return to its initial diameter after the stretching sequence and therefore cannot be installed in the hardware bore without causing damage to the seal. Especially when dealing with smaller diameters, a resizing tool is slid over the in-

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stalled seal to compress it back to its original diameter. It is recommended that the compression on the seal is maintained for a few minutes to allow the material to recover.

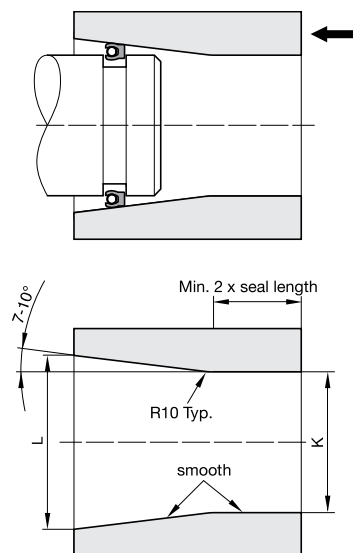


Fig. 3.42 Installation step 3: resizing

Dimension	Equals	Tolerance
K	groove inner diameter + 2 × seal height	+ 0.10 / - 0
L	max. hardware outer diameter + 2 × seal height	ref.

Tab. 3.8 Installation step 3: resizing

Seals with an inner diameter of at least 100 times the cross-section can be installed by hand only. Start by inserting one seal end into the groove and then gradually progress with the installation towards the other end until this remaining end snaps into the groove.

3.6.1.3.2 Rod seal installation in closed-groove

The FlexiSeal® is temporarily deformed into an elliptical shape as it is inserted in the bore until the trailing edge is seated in the groove. This type of installation should not be employed unless the inner diameter of the seal is at least 25 times its cross-section height. It is recommended to break or smooth sharp groove edges to avoid damage to the sealing surfaces.

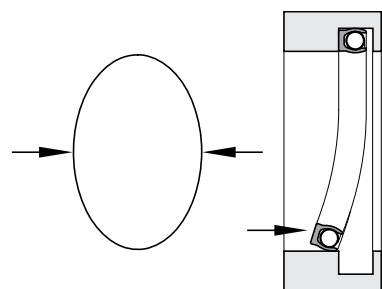


Fig. 3.43 Closed-groove installation in rod mode

Alternatively, a closed-groove with angled ramp feature makes installation possible from an inner seal diameter that is at least 15 times the cross-section height.

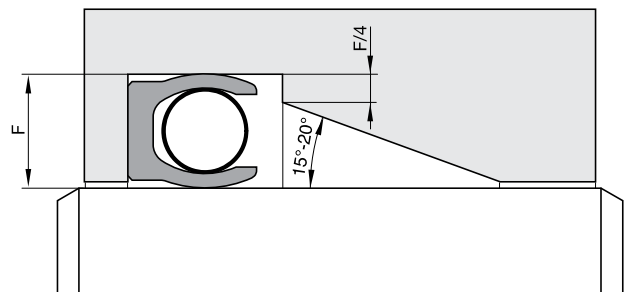


Fig. 3.44 Closed-groove installation in rod mode with ramp feature

3.6.1.4 Alternative grooves with snap ring retainer

For heel-first installation with a snap ring retainer, the snap ring groove is set into a reduced diameter to ensure that the seal does not pass over the edges. This design can be used for both rod and piston seals.

For lips-first installation with a support ring and snap ring retainer, the snap ring groove is also at a reduced diameter to prevent damage to the seal. The support ring must meet extrusion gap recommendations as outlined in this guide. Load ratings for snap rings must be considered to prevent fatigue or failure.

Note

It is the responsibility of the designer to test any alternate groove designs and/or components used to ensure that they meet all required operating conditions of their specific application.

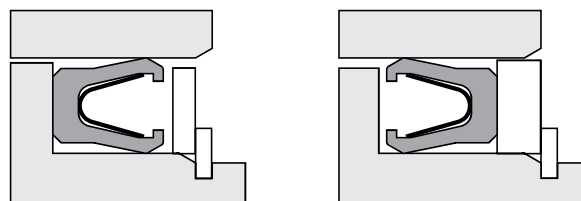


Fig. 3.45 Groove with snap ring retainer: "heel-first" and "lips-first" installation

3.6.2 Hardware surface finish and hardness

3.6.2.1 Mating surface finish recommendations

Proper surface finish of the seal groove is critical to ensure positive sealing and achieve the longest seal life possible in dynamic applications.

Mating surfaces that are too rough can create leak paths and be very abrasive to the seal. Unlike elastomeric contact seals, PTFE-based FlexiSeals® can run on very smooth surfaces with or without lubrication. Due to the toughness and low coefficient of friction of PTFE, FlexiSeals® slip over the high points of the mating

surface and resist abrasion. To maximize seal performance, the recommendations for surface roughness in the next table should be followed.

Dynamic surfaces with relatively rough finishes will result in higher wear rates which decrease seal life and may compromise performance.

Surface roughness R_a (μm)		
Media being sealed	Dynamic surfaces	Static surfaces
cryogenics	0.1 - 0.2	0.1 - 0.2
• helium gas	0.1 - 0.2	0.2 - 0.4
• hydrogen gas		
• freon		
• air	0.2 - 0.4	0.4 - 0.8
• nitrogen gas		
• argon		
• natural gas		
• fuel (aircraft and auto-motive)		
• water	0.2 - 0.4	0.4 - 1.6
• hydraulic oil		
• crude oil		
• sealants		

Tab. 3.9 Hardware surface roughness recommendations

Especially in dynamic reciprocating applications it is not sufficient to only indicate a maximum R_a -value to evaluate the suitability of a surface condition and how it will influence sealing performance and abrasion. As can be seen from fig. 3.46, significantly different surface textures can have similar R_a -values. It is clear that from a wear point of view, the surface roughness profile with plateau appearance from situation d) is preferred over a profile with peaks.

Table 3.10 shows Parker's recommended combination of surface roughness parameters to obtain the plateau profile.

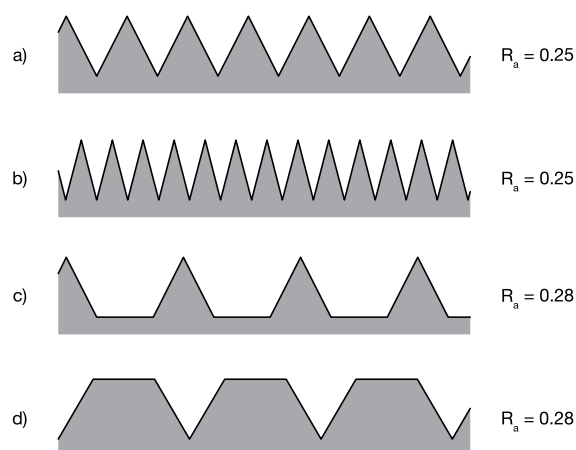


Fig. 3.46 Different surface roughness textures with similar R_a -values

Recommended surface roughness parameters

average roughness	(μm)	R_a	0.2 max.
average peak-to-peak height	(μm)	R_z	1.2 max.
maximum peak height	(μm)	R_p	0.2 max.
bearing ratio	(%)	t_p	60 % min. with reference line at 0.25 R_z if $R_z > 10.5 R_a$ if $R_z < 1$

Tab. 3.10 Recommended surface roughness parameters for dynamic reciprocating applications

3.6.2.2 Mating surface hardness recommendations

Most dynamic applications require a hard running surface on the dynamic portion of the hardware. The harder surface allows use of seal materials with higher reinforcements that will increase both the seal and hardware life. Softer running surfaces must use seal materials with higher reinforcements that will not damage the hardware but normally yield shorter seal life. A balance between seal material and dynamic surface hardness must be achieved to ensure that the seal remains the sacrificial component.

The hardness of the dynamic surface affects the wear rate of the seal. Additionally, some seal jacket materials are abrasive and will wear softer metal shafts or dynamic components. In general, higher surface hardness results in better overall seal and hardware performance. The ideal hardness of dynamic hardware surfaces is 50 to 60 Rockwell C.

Table 3.1 in chapter 3.5.1 includes minimum recommended surface hardnesses for Parker jacket materials in dynamic applications based on moderate temperature, motion and speed.

3.6.3 Friction information

Friction is the resistance to motion of one surface relative to another. In dynamic seal applications it is the resistance to rotation or reciprocation between the seal and the hardware mating surface. Frictional linear force – which resists reciprocating motion – and frictional torque – which resists rotating motion – are based on many factors. The key factors are:

- Diameter of the dynamic surface
- Coefficient of friction of the tribological couple FlexiSeal® jacket/mating hardware
- The coefficient of friction is defined as the dimensionless ratio between the friction force between two surfaces and the contact force normal to those surfaces. The coefficient of friction depends on many variables (material, speed, contact pressure, hydrostatic pressure, surface condition, lubrication, ...) and can therefore only be quantified by experiment, not through calculation.
- Medium system pressure
- Spring type and material
- Geometry of the FlexiSeal® jacket cavity. As the active length J of the jacket cavity increases, the load and thus friction due to the hydrostatic medium pressure rises proportionally.

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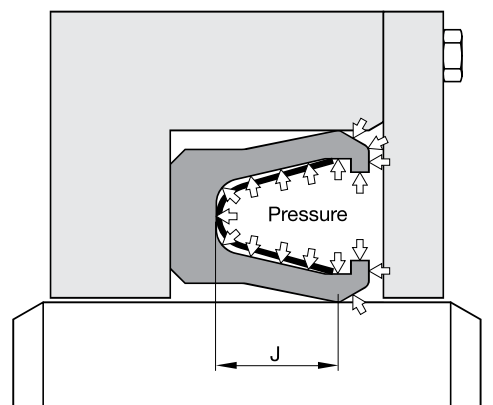


Fig. 3.47 Geometry factor for FlexiSeal® jacket

A first indicative value of the frictional force or torque between a FlexiSeal® and its dynamic mating surface can be calculated using the following equations

$$\text{Frictional linear force (N)} = \pi D \mu (pJ + S)$$

$$\text{Frictional torque (Nm)} = \pi D^2 \mu (pJ + S) / 2000$$

Where

- p Medium system pressure (MPa).
- D Dynamic mating surface diameter (mm). Use the rod diameter for rod seals and the groove bore diameter for piston seals.
- J Geometry factor of the jacket cavity (mm). Refer to table 3.11 for guideline values of standard FlexiSeal® types.
- S Spring factor (N/mm circumference). Check out the table 3.11 for reference values of standard FlexiSeal® springs in stainless steel.
- μ Coefficient of friction. Indicative values for some typical polymer materials in unlubricated conditions can be found in table 3.12.

Nominal cross-section	Section code								
		S	J	S	J	S	J	S	J
1/16"	01	5	0.7	2	1.2	5	1.0	-	-
3/32"	02	5	1.0	2	1.9	5	1.4	-	-
1/8"	03	5	1.5	2	2.7	5	2.2	-	-
3/16"	04	5	2.4	2	4.1	5	3.8	10	6.6
1/4"	05	5	3.2	2	5.0	5	4.8	10	8.2
3/8"	06	5	4.6	2	8.9	5	6.3	10	10.4
1/2"	07	5	5.4	2	8.5	5	7.8	10	15.0

Tab. 3.11 Spring and geometry factor for standard FlexiSeals®

Polymer	Coefficient of friction μ
PTFE	0.10
UHMW-PE	0.25
Virgin PEEK	0.35

Tab. 3.12 Indicative values for coefficient of friction (unlubricated against steel)

3.6.4 Pressure capability – battling extrusion gaps

The pressure capability of a FlexiSeal® is a function of temperature, seal material, seal design, time and extrusion gap.

An extrusion gap is the operational or manufacturing clearance between adjacent pressurized parts and is located on the low-pressure side of a seal.

Any seal subjected to hydrostatic loads will tend to be forced, or extruded, into such a gap. An excessive extrusion gap in the given application conditions will cause a polymer material to migrate towards the clearance until rupture in the jacket material and failure of the seal is inevitable.

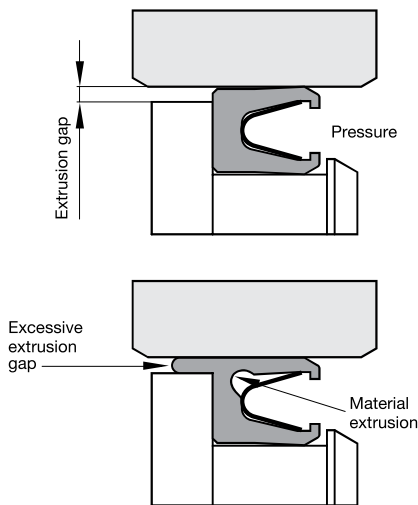


Fig. 3.48 Extrusion

The higher the temperature, the easier the seal jacket material will flow and extrude as the polymer material becomes softer. Some materials are more resistant to high-pressures than others because of their specific filler content or nature and are therefore less susceptible to extrusion and can accept larger gaps.

Radial FlexiSeals® with an extended heel design increase the pressure rating as they prevent extrusion with material added to the rear of the seal. This extra material acts as a built-in back-up device and fills the extrusion gap before damage is done to the rest of the seal.

Larger cross-section FlexiSeals® are more tolerant of larger extrusion gaps as they contain more material.

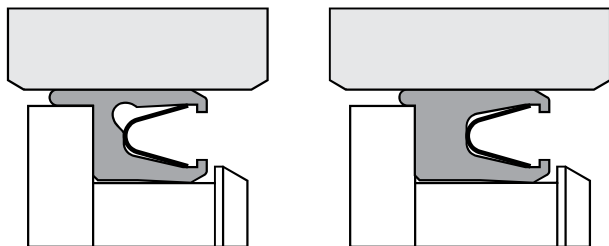


Fig. 3.49 Effect of an extended heel design on extrusion

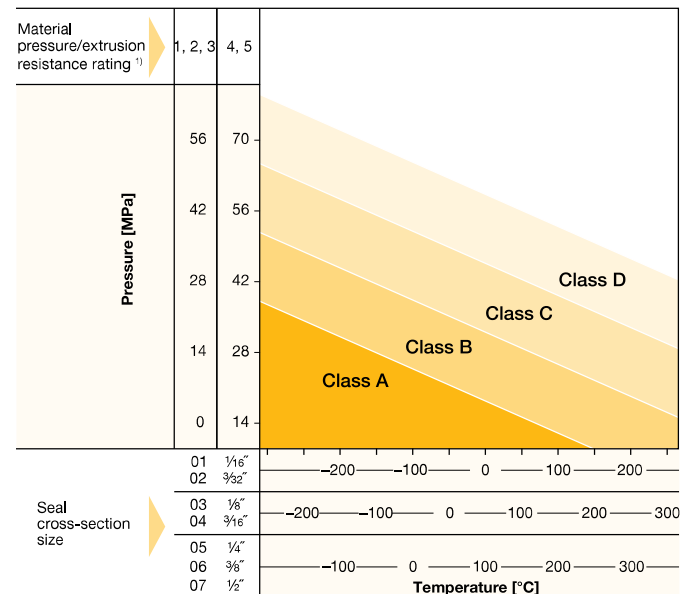
To determine the maximum recommended radial extrusion gap for a standard radial FlexiSeal®, refer to the graph and table 3.13 and go through the following steps:

1. Note the material pressure/extrusion rating from table 3.1
2. Locate the maximum pressure on the graph
3. Locate the maximum temperature for the appropriate seal cross-section
4. The intersecting point will determine the applicable extrusion gap class from the graph
5. From the table, determine the recommended extrusion gap for the various standard FlexiSeal® styles

For applications in which an extrusion gap below the maximum recommended values cannot be maintained, Parker offers a wide variety of separate back-up or anti-extrusion rings to reduce the seal's exposure to the gap.

Please refer to chapter 5 for more information on anti-extrusion rings or contact our consultancy service.

Eccentricity and shaft runout also affect the extrusion gap and should be considered in the seal design (see section 3.6.5).



¹⁾ Refer to table 3.1

Fig. 3.50 Extrusion gap class

Cross-section		Class A	Class B	Class C	Class D
	NAA	0.15	0.10	0.08	0.05
	NHA	0.25	0.20	0.10	0.08
	FLO	0.15	0.08	0.05	-
	BAI	0.25	0.20	0.10	0.08
	BHI	0.30	0.25	0.15	0.10

Tab. 3.13 FlexiSeal® maximum recommended extrusion gap

3.6.5 Shaft eccentricity and runout

Applications with rotating shafts come with their own set of common problems. Among these are those associated with the shaft not being aligned properly with the surrounding hardware. Misalignment most commonly manifests itself as eccentricity and runout.

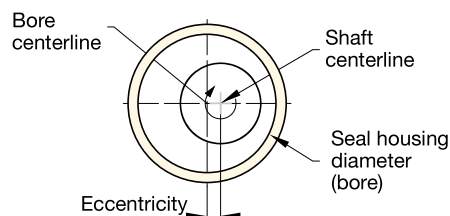
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Eccentricity of a rotating shaft creates two problems. One is that it forces the seal lip to follow a shaft that is not centered in the bore, wearing the lip more on one side. The second potential problem is that it enlarges the extrusion gap on one side, which could be detrimental when high-pressure is involved. With eccentricity, only a static radial deflection is imposed on the seal. Please refer to fig. 3.51 for a graphic representation.

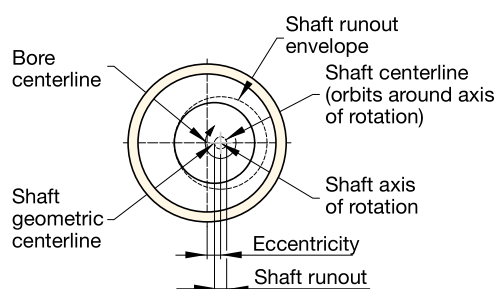
Shaft runout is when the shaft is spinning on an axis of rotation that is offset from the geometric centre of the shaft at the point of seal lip contact. Runout can be caused by a bent shaft or by whirling deflection while spinning. The seal must be sufficiently compliant to maintain contact with the shaft despite being compressed and extended in each revolution. It follows that shaft runout becomes more of a problem at high speeds. With runout, a cyclic radial deflection is imposed on the seal. See fig. 3.51 for a graphic representation.

Excessive runout may lead to wear and leakage problems (especially during cold-starting) and eventual fatigue failures.

When using a radial FlexiSeal® with a V-shaped cantilever spring, the combination of eccentricity and runout should be kept below the recommended guidelines shown in fig. 3.52. In addition, the total runout alone should not exceed the shaft runout limit to ensure seal performance. Radial FlexiSeals® with a round, helical spring are typically used in static and reciprocating applications. Therefore, only eccentricity guidelines apply.



With eccentricity, only static radial deflection is imposed on the seal.



In this case, cyclic radial deflection due to runout is superimposed on static radial deflection due to eccentricity.

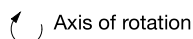


Fig. 3.51 Shaft eccentricity and runout

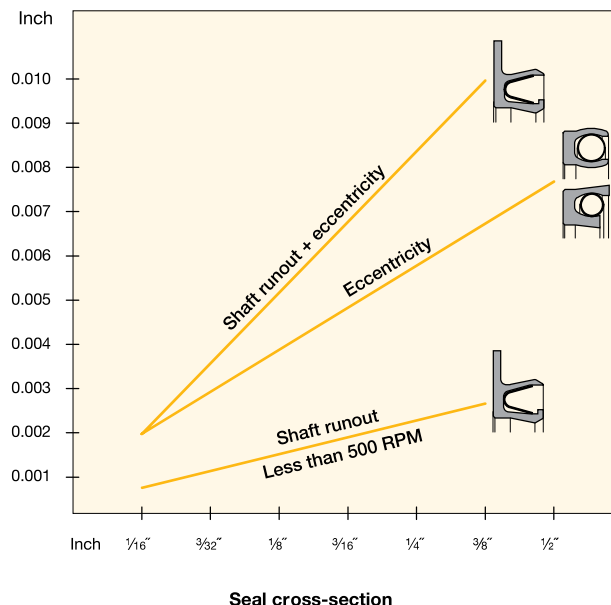


Fig. 3.52 FlexiSeal® eccentricity and runout limits

3.6.6 Pressure-velocity guidelines for rotary FlexiSeals®

Unlike in reciprocating applications, seals ride on a rotating shaft in only one small area where dynamic forces and energy are concentrated. In fact, much of the energy from the shaft is dissipated at the contact point in the form of frictional heat and wear, both of which are detrimental to seal life. This effect is accentuated by increasing the shaft speed or by increasing the perpendicular force holding the lip against the shaft.

As wear is proportional to pressure and velocity, one way to estimate exposure to these risks is to calculate the pv value: by multiplying the pressure p held by the seal by the surface velocity v of the shaft. Combinations of pressure and velocity are defined up to where a material can be used, thus a pv limit is established. Above the pv limit, wear increases exponentially because of the heat generated as a result of motion.

The $p \times v$ value provides the designer with a guide to aid in the choice of seal profile and material.

To calculate the surface velocity, use the following formula or fig. 3.53 for a graphical determination:

$$v = 52 \times 10^{-6} \times D \times n$$

Where

v : surface velocity (m/s)

D : shaft diameter (mm)

n : rotational speed (rpm)

Pressure p is expressed in MPa (N/mm²)

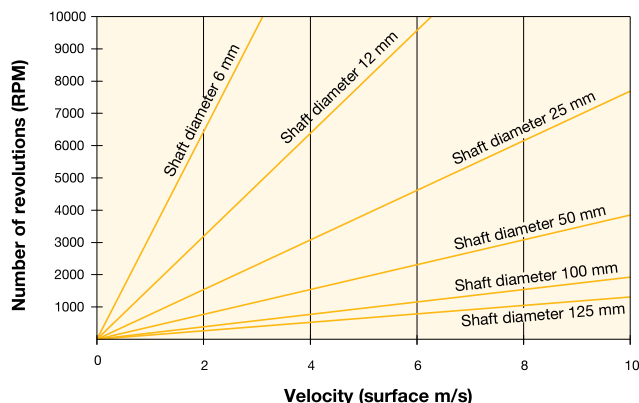


Fig. 3.53 Determination of surface velocity

The $p \times v$ graphs in fig. 3.54 apply to unlubricated rotary applications only using a stable rotary seal with a 4 or 5 wear resistance rating. If the point corresponding to the operating pressure and surface velocity falls on or below the appropriate temperature line the seal is an appropriate choice for your application.

These $p \times v$ curves are intended to be used as a guideline only since there are many other factors such as sealing media, groove material and surface finish, which affect the amount of heat generated and the performance of the seal.

While FlexiSeals® made of PTFE have a natural lubricity and can be used in unlubricated applications, it is always better to have lubrication present in rotary applications. A film of lubricant between the seal lip and the shaft reduces seal wear and frictional heat generation, makes higher surface speeds possible and helps to prevent the seal from wearing a groove in the shaft. When the lubricant splashes or flows past the seal area it acts as a coolant, prolonging seal life.

Anything that can be done to decrease the heat generation between the lip and the shaft will likely increase seal life. In cases where the medium being sealed is a lubricant continuous operation at $p \times v$ levels which are 20 times higher than those stated in these guidelines have been achieved.

Parker also offers a complete line of high-speed lip seals, high-pressure rotary seals and custom-designed seals for extreme operation. Refer to section 3.4, Additional FlexiSeal® types. Please contact our consultancy service or your local sales representative for assistance in selecting the seal for your extreme environment.

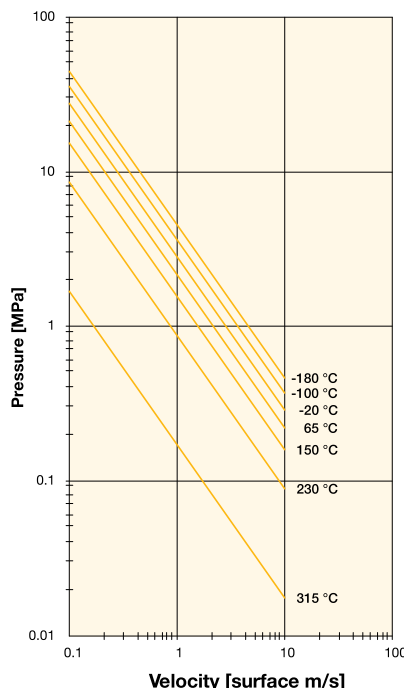


Fig. 3.54 Pressure-velocity curves at different temperatures

3.6.7 Spring design

The two elements to consider when selecting a FlexiSeal® spring design are its load value and its deflection range. The spring load affects the sealing ability, friction and wear rate. As the spring load is increased, the lips seal tighter, with friction and wear increasing proportionally.

The spring deflection range affects the seal's ability to compensate for normal seal wear, cold flow and variations in groove height. Each spring size has a specific deflection range. The available deflection increases as the seal and spring cross-section increases. This could be a deciding factor in selecting one cross-section over another.

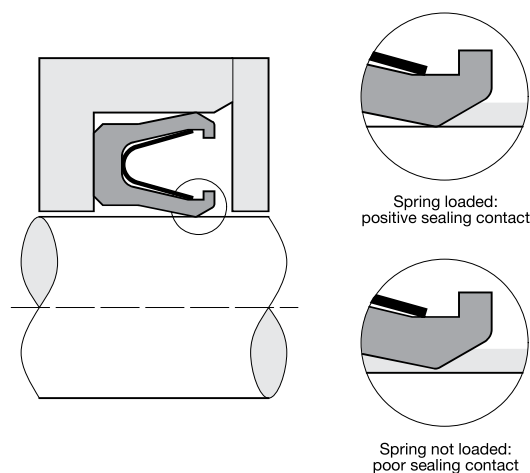


Fig. 3.55 Spring loading

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Fig. 3.56 shows a relative comparison of load versus deflection curves for four different spring types that can be used to energize the FlexiSeal® jacket: helical wound, cantilever, heavy-duty cantilever and canted coil.

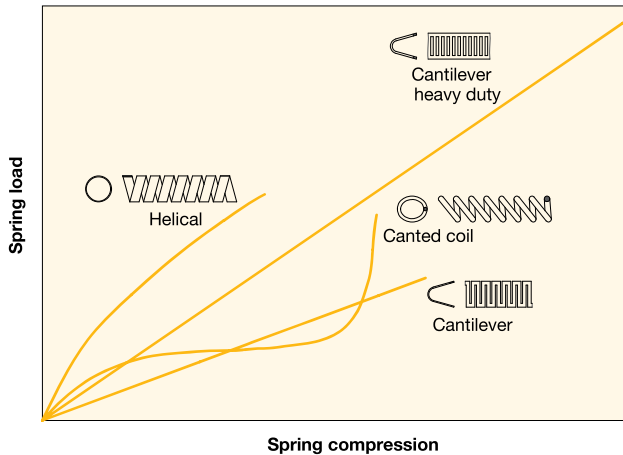


Fig. 3.56 FlexiSeal® spring comparison: load-deflection curves



Fig. 3.57 FlexiSeal® spring types

3.6.7.1 Helical springs

The helical spring is made from flat ribbon metal strip stock that is wound into a helix shape. The finished spring produces a high-load versus small-deflection curve as shown in fig. 3.56. The standard materials are 17/7 PH stainless steel and cobalt-chromium-nickel alloy, both available in light, medium and heavy versions.



Fig. 3.58 Helical spring

The helical spring design is intended for static applications due to the high unit load. It can be used in slow or infrequently rotary conditions and dynamic reciprocating applications when friction and wear are secondary concerns to positive sealing.

The helical spring produces an evenly distributed load across each individual band, with very small gaps between the coils. This tight spacing provides a nearly continuous load, reducing potential leak paths. This effect, combined with the high unit load, makes the helical spring well suited for vacuum and cryogenic applications or when pressure is too low to energize the seal.

The relatively small deflection range of the helical spring prevents it from being used in applications having wide groove tolerances, eccentricity or misalignment.

Features

- High load versus small deflection
- Standard 17/7 PH stainless steel and cobalt-chromium-nickel alloy springs
- Optional materials: Inconel® X-750 and Hastelloy® C-276
- NACE compliant cobalt-chromium-nickel alloy and Inconel® X-750 springs available
- Available in light, medium and heavy versions
- Available for external and internal face seals

Recommended applications

- Static rod, piston and face seal applications
- Slow rotary applications
- Reciprocating rods and pistons
- Vacuum, cryogenic sealing
- Applications where sealing ability is critical

3.6.7.2 Cantilever springs

The FlexiSeal® cantilever spring is made from flat metal strip stock of 304 stainless steel or cobalt-chromium-nickel alloy. The strip stock is punched into a serpentine pattern and formed into a rounded “V”-shape.



Fig. 3.59 Cantilever spring

The load deflection curve of a cantilever spring, as depicted in fig. 3.56 shows a light load versus a high deflection. It is intended for dynamic applications involving rotary or reciprocating motion. It can also be used in static conditions when there is a need for a higher deflection spring due to wide groove tolerance, excessive expansion and contraction or lift-off due to high-pressure.

Lighter and heavier loaded versions are optionally available. A light-load cantilever spring can be used if low friction is more important than sealability.

The geometry of the cantilever spring provides flexibility by using individual tabs, separated by small gaps. This shape allows the spring to flex into radial and face seal designs.

Features

- V-shaped spring shape for moderate load versus high deflection
- Standard 304 series stainless steel and cobalt-chromium-nickel alloy springs
- Optional materials: 301, 302 and 316 stainless steel, Inconel® X-750
- NACE-compliant cobalt-chromium-nickel alloy and Inconel® X-750 springs available
- Available in light and heavy versions (optional)
- Wiper lip designs for abrasive media
- Available for external and internal face seals

Recommended applications

- Reciprocating rod and piston applications (low friction)
- Rotary shafts
- Wide tolerance and misaligned grooves

3.6.7.3 Heavy-duty cantilever springs

The heavy-duty cantilever spring is made from flat metal strip stock of 301 stainless steel that is punched into a continuous, slotted pattern and formed into a rounded “V”-shape.



Fig. 3.60 Heavy-duty cantilever spring

The spring provides a continuous contact along the sealing lip. The absence of individual tabs and thus flexibility in the spring geometry limits its use in internal and external face seals. The result is a high-load versus high-deflection curve as shown in fig. 3.56, section 3.6.7.

The heavy-duty cantilever spring is typically used in extreme static sealing applications, involving cryogenic media, ultrahigh vacuum or helium.

In cryogenic conditions the rigid spring with high hoop strength acts as a control band and resists shrinkage of the polymer jacket. This spring can also be used when there is a need to compensate for extremely wide groove tolerances or lift off.

It can be employed in slow or intermittently rotary applications.

3.6.7.4 Canted coil springs

The canted coil spring is made from round wire that is coiled and formed into a canted or slanted shape.

The result is a radial compression spring with a very flat load versus deflection curve as illustrated in fig. 3.56, section 3.6.7.

The canted coil spring is not part of the Parker standard energizer range. It is only available on specific request. The respective FlexiSeal® is a non-standard item.

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Fig. 3.61 Cantilevered coil spring

The typical material is 302 stainless steel. Other possibilities are Hastelloy® C-276 and cobalt-chromium-nickel alloy, all available in light, medium and heavy versions.

The cantilevered coil spring is intended for use in dynamic reciprocating and rotary applications. The flat load curve makes it an excellent choice for friction-sensitive applications. It is also used in static applications with wide tolerances or misalignment.

The cantilevered-coil spring can be fit into small diameters without overlapping the individual spring coils. Because the coils on the inner diameter tend to butt up to each other the spring has very small gaps providing maximum spring contact.

Features

- Flat load versus deflection curve
- Standard 302 series stainless steel springs
- Cobalt-chromium-nickel alloy and Hastelloy® C-276 springs available
- Light, medium and heavy versions
- Available in radial and face seals

Recommended applications

- Friction-sensitive applications
- Wide-tolerance and misaligned grooves
- Applications where the seal section is subjected to fatigue loading
- Small-diameter radial seals

3.6.8 Lip design

3.6.8.1 Chamfered lip

The most common lip shape is the chamfered or backbeveled design. It is available with cantilever and cantilevered coil spring types. This design allows for ease of installation and permits lubrication to nest under the lip and feed through in reciprocating dynamic

applications. The result is a microscopic lubrication film that increases seal and hardware service life. Since the footprint (contact zone) of a chamfered lip is a single point all of the sealing force is concentrated on that point, resulting in highest sealability and lowest friction.

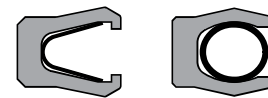
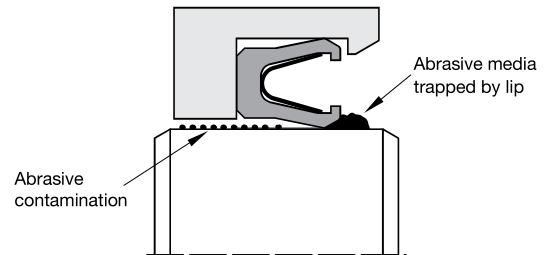


Fig. 3.62 Chamfered lip design

3.6.8.2 Wiper lip

Applications often involve media with abrasive particles that can get caught between the seal lip and the mating hardware. This increases wear on both the seal and the mating surface.

The wiper lip prevents particles from accumulating and is available with all four spring types. Its contact point is positioned closely to the load point of the spring for maximum scraping action.

The wiper lip can be positioned on the inner diameter, outer diameter or both or in a face seal configuration. The wiper lip stays in place better in a stepped groove where the step is not very large.

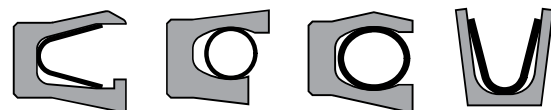
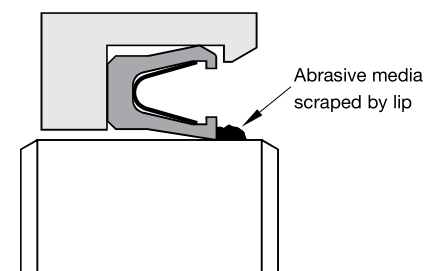


Fig. 3.63 Wiper lip design

3.6.8.3 Beaded lip

The beaded lip shape contacts the surface in much the same way as an O-ring does and is available with the helical spring type. Similar to the chamfered lip, it is easy to install and helps to lubricate the reciprocating sealing surface. In fact, the beaded lip provides an oil film that is slightly thicker than that of a chamfered lip, making it advantageous for applications with more rapid reciprocating motion.



Fig. 3.64 Beaded lip design

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