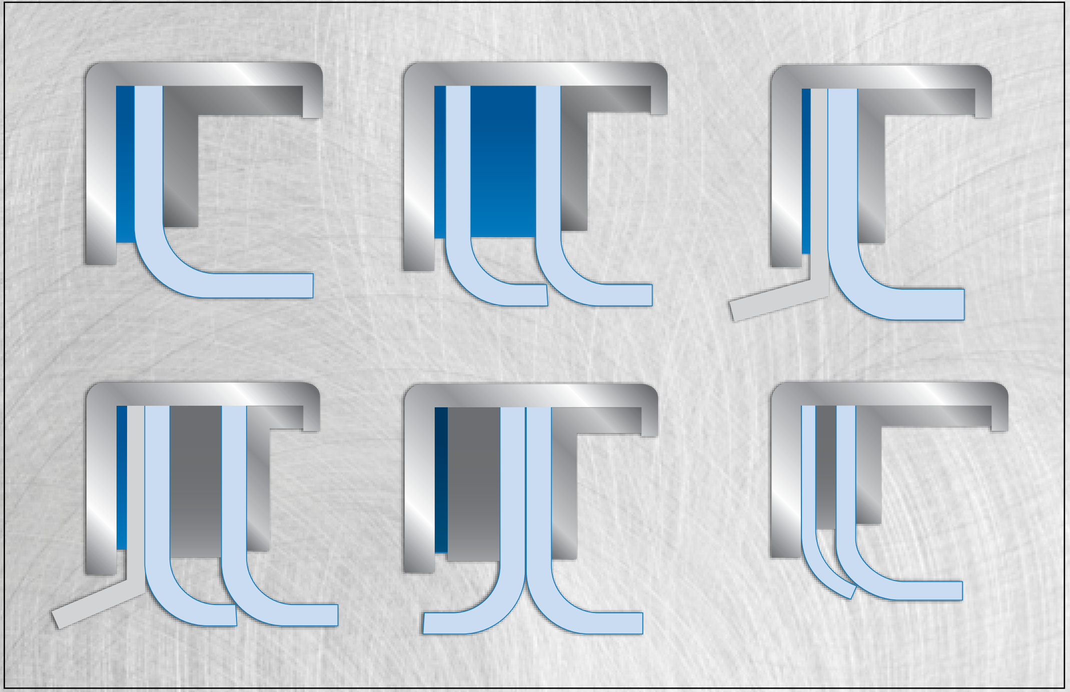
PTFE Rotary Lip Seal Guide



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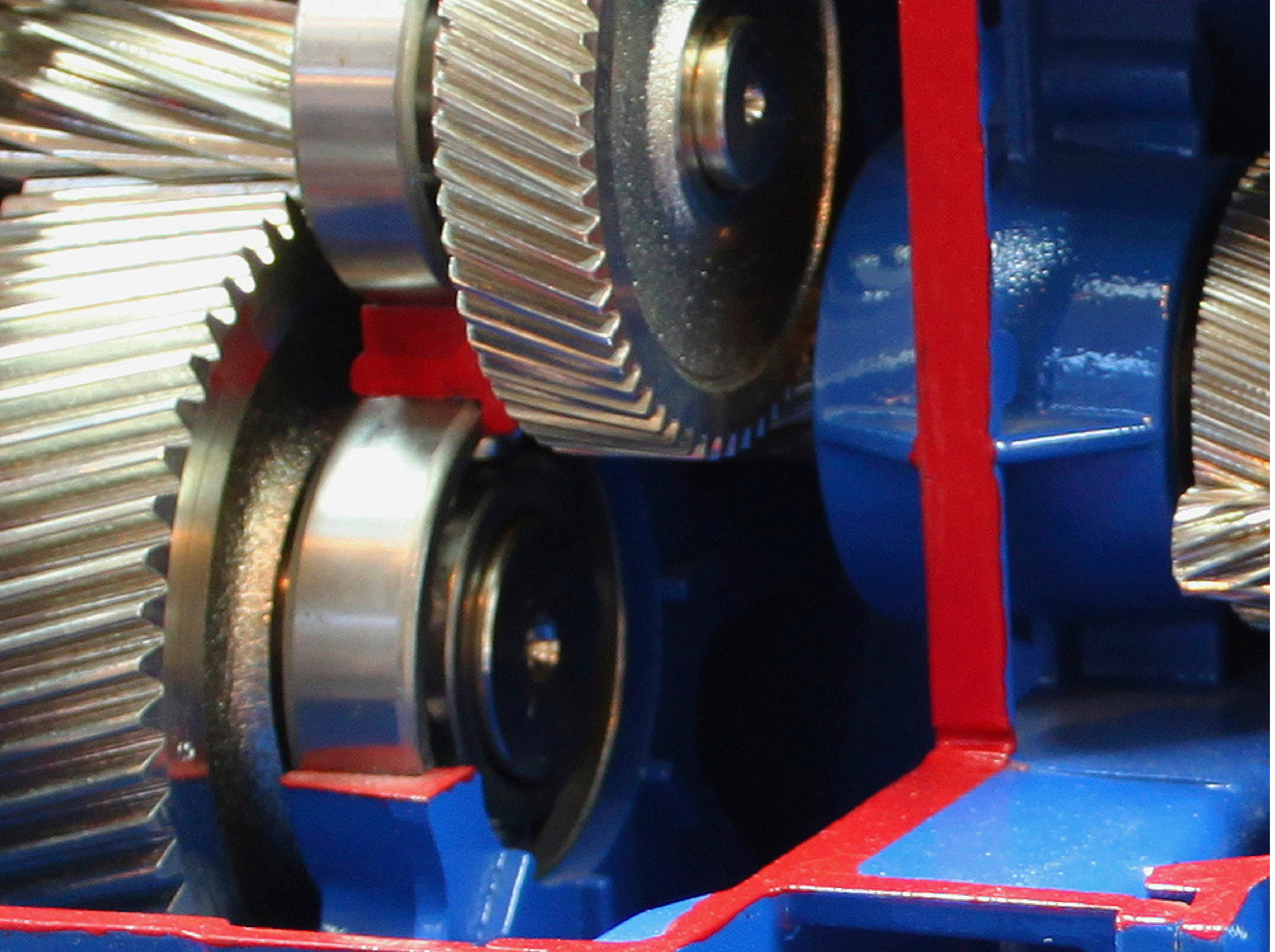
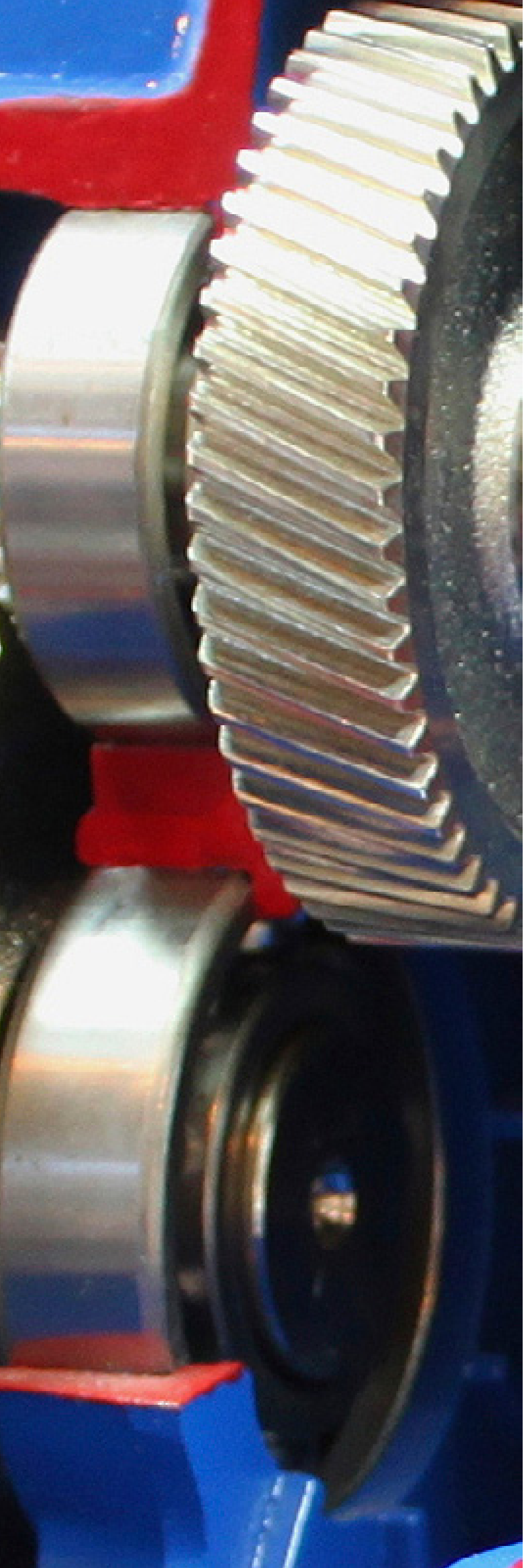


Rotary Seals Content



What is a PTFE Rotary Lip Seal and How Does it Work?

A PTFE Rotary Lip Seal is a seal that features a lip on the ID that seals dynamically on a shaft and metal casing on its OD to press-fit into a bore. A gasket is sandwiched between layers of sealing lips and the can to seal off the potential leak path. Since the lip is not spring-energized, the radial lip contact forces are lower than a rotary spring energized PTFE seal, which allows the seal to function at much higher surface speeds (up to 10,000 sfpm).

The seals are manufactured from a wide variety of PTFE composites and other machinable plastic materials. Standard gasket choices are fluorocarbon, nitrile, EPDM, and Armstrong reinforced paper.

Design Engineer can choose between stainless steel, cold rolled steel, zinc-plated cold rolled steel and aluminum. This broad foundation of standard gasket, metal and PTFE materials can be tailored to suit nearly all applications. Standard and Non-standard seal profiles are precision machined to fit inch and metric gland geometries. PTFE rotary lip seals are used in demanding applications where the operating conditions exceed the capabilities of elastomeric seals.

Features / Benefits

- Low friction – Long seal life with proper configuration
- Strong chemical resistance
- Surface speeds up to 10,000 feet per minute
- Wide temperature range: -65°F to 450°F (-53°C to 232°C)
- High pressure in excess of 500 psi (35 bar)
- Extended seal life in dry or abrasive media
- Unlimited shelf Life
- Large diameter capability
- Custom profile design

Applications

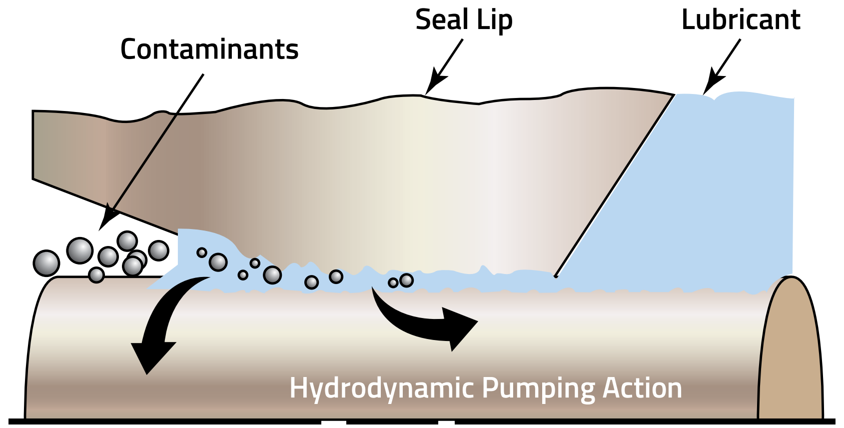
- Motors
- Gearboxes
- Pumps
- Bearings
- Compressors
- Cryogenics
- Extruders
- Valves
- Blowers
- Spindles
- Robotics
- Mixers

PTFE History

- The discovery of PTFE (polytetrafluoroethylene) resin dates back to 1938, but it was not until the 1950's that PTFE gained considerable attention as a possible material for rotary lip seals. Unfortunately, during the 1950's and 1960's PTFE seals proved to be inconsistent and unreliable performers in many applications. In more recent decades, however, there has been significant progress made in the areas of PTFE lip seal design and material processing.
- The following is aimed at providing the application engineer with a better understanding of PTFE as a material, some insight into the seal design and manufacturing practices, and a background on applications where PTFE has proved to be an excellent radial lip seal compound.
- The successful application of PTFE radial lip seals is dependent upon a thorough understanding of the basic properties and functional characteristics of PTFE resins, and in turn applying these criteria to the areas of product design and manufacturing methods.
- The PTFE lip seal provides to the end user; a sealing device that is compatible with virtually all fluids and additives, functional throughout a broad temperature range, and a low wear-rate enabling it to exceed today's required warranty periods.

How They Work

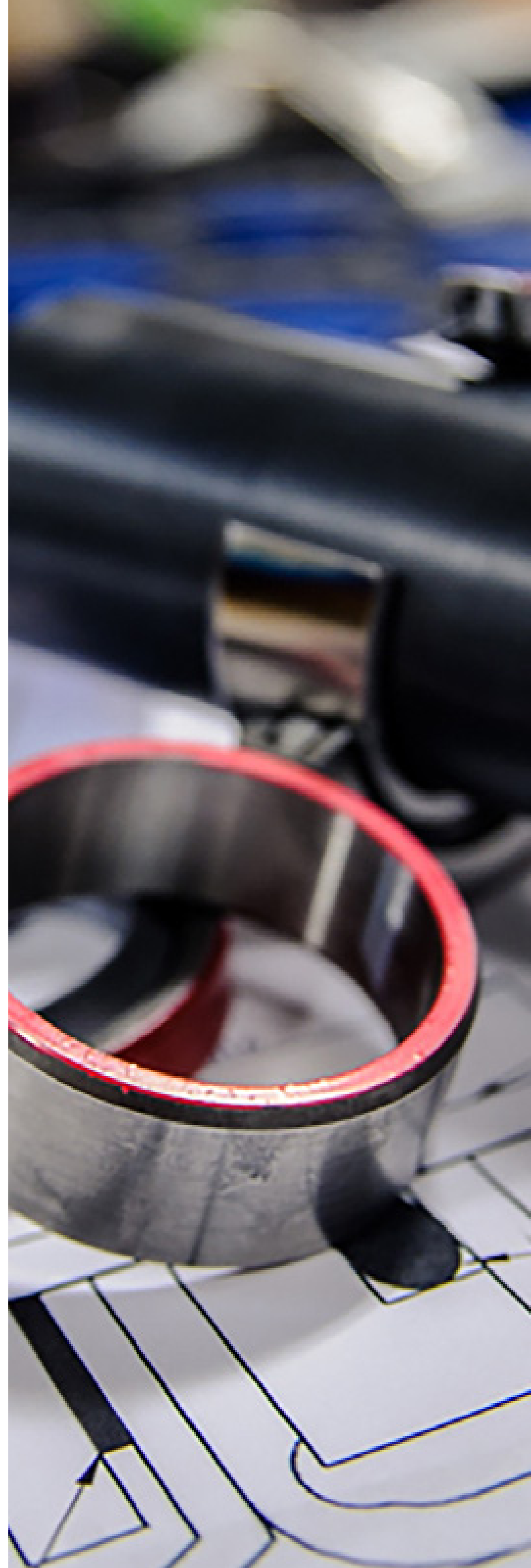
- Rotary shaft seals work by squeezing and maintaining the lubricant in a thin layer between the lip and the shaft. Sealing is further aided by the hydrodynamic action caused by the rotating shaft, which creates a slight pumping action
- Rotary shaft seals provide protection by performing two critical functions. In most applications the primary function of the seal is to retain the bearing or system lubricant. There are thousands of different types of lubricants available today, but in general bearings are either oil or grease lubricated.
- The second function of the seal is to exclude outboard material that can contaminate the system lubricant or directly damage the bearing. The type of contamination the seal will need to exclude is dependent on the application. The more common types are moisture, water, and dry materials including dust, sand, dirt or particulates such as those generated by manufacturing processes.
- The seal's ability to retain the system lubricant and exclude contaminants plays a key role in the service life of equipment components such as bearings, and gears and relies on the system lubricant. The seal can have a dramatic impact on the service life of the system lubricant, reducing exposure to excessive frictional heat and excluding foreign material.



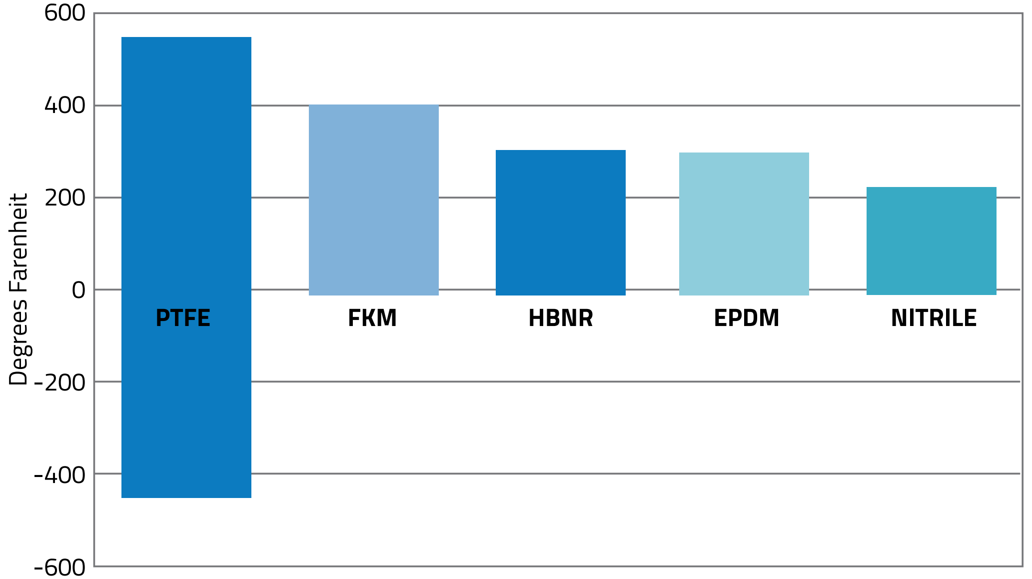
- Typical petroleum oil has a useful life of thirty years at 86°F (30°C) if it is not contaminated with water or particulate matter, but the same oil has a life of only a month at 212°F (100°C). As little as 0.002% water in oil lubrication can reduce ball bearing life by 50%, primarily through

hydrogen embrittlement. Solid particles cause more rapid damage to the bearing race through high-localized stresses and increased frictional heat.

- The sliding contact between the seal lip and the shaft will generate friction, increasing the contact temperature beyond the temperature caused by the bearings and other sources. Heat accelerates the breakdown of the oil and starts forming a varnish on the hot spots. Over time, the varnish changes to carbon and builds in thickness as the surrounding oil loses its lubricity. How quickly this happens is dependent on temperature. The deposit can leak and abrade the lip, causing leakage. The time to reach each stage is cut in half for each 18°F (10°c) increase in temperature.
- The amount of frictional heat that is generated is a combination of many operating parameters. Shaft surface, internal pressure, operating speed, lubricant type, lubricant level, lip geometry and lip material are just a few of the conditions that need to be considered. It is important to note that these conditions are very interactive. For example, an increase in shaft speed will increase the sump temperature. If not vented, the temperature rise will increase the pressure inside the housing. The internal pressure will push on the seal lip and create additional force between the seal lip and the shaft. In turn, the operating temperature under the seal lip will see a significant rise in temperature and can cause premature seal failure within hours.



Why PTFE?



PTFE has a much broader temperature service range than any standard elastomer material

Figure: 1

- Extreme temperature
  ->270°C (520°F)
  ->270°C (-450°F)
- Acids
- Chemicals
- Abrasive media
- PSI: UHV to 500+
- Low to High RPM

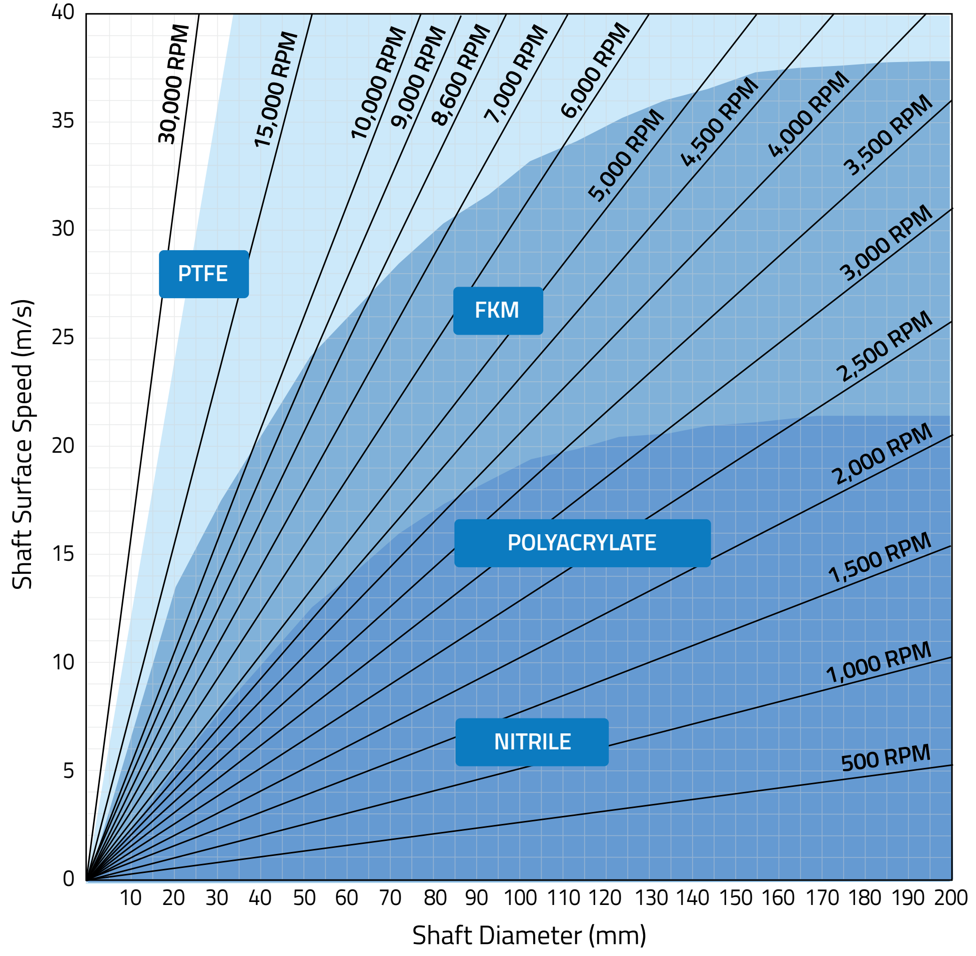
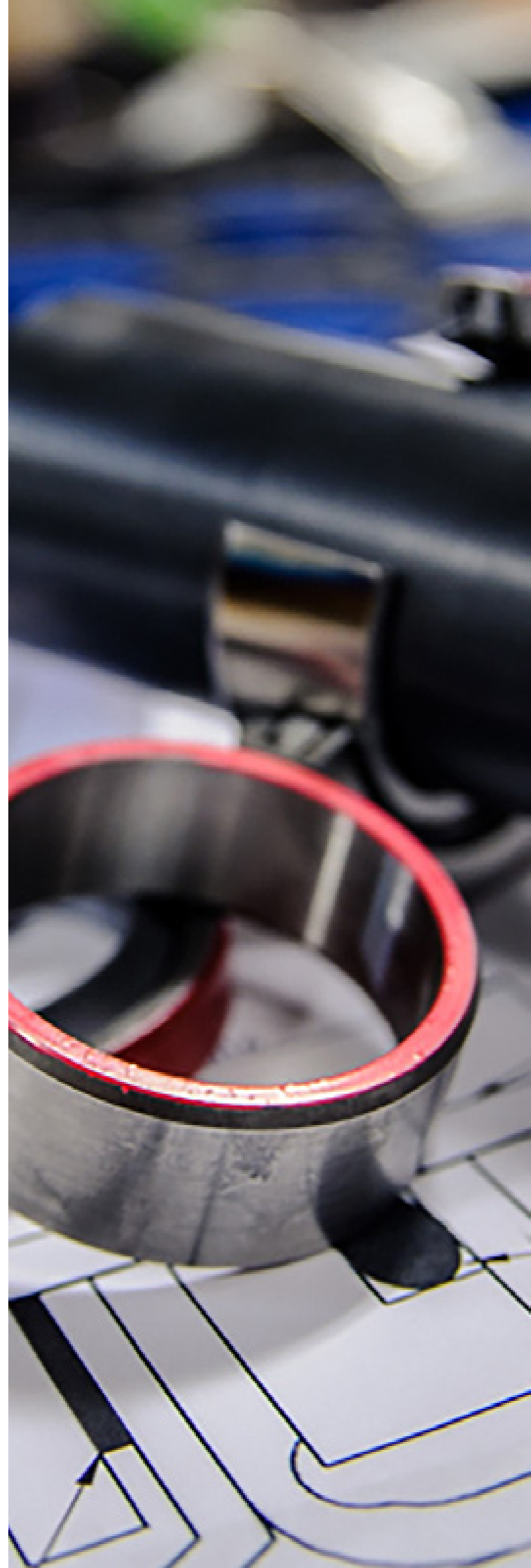


Figure: 2

- Used at greater extremes
  - Shaft OD, RPM, etc.
- Covers the same operating ranges as nitrile, polyacrylate, and FKM... combined



Fillers Employed in PTFE Resins

- PTFE Resin in its virgin form does not lend itself to being the most favorable sealing material for dynamic shaft applications. Therefore, various types of fillers are added to achieve the desirable end properties, The more common fillers employed in radial lip seal materials are fiberglass, graphite, molybdenum disulfide, carbon, and coke flour. However, any type of filler can be added to the virgin PTFE resin provided the filler can withstand the maximum sintering temperatures of 710-730 degrees F.

- In order to develop lip seal products properly from PTFE resins, it is extremely important that the engineer is aware of the unfavorable characteristics of the resin, as well as the favorable factors mentioned above. Improper seal design and lack of good control in material processing are perhaps the greatest cause for PTFE radial lip seal failures, but several characteristics and properties of the PTFE resin must be given considerable attention to fully realize a reliable product.

- **These are:**

  -High wear rate of the PTFE resin and/or mating surface is affected when improper fillers are used for a specific set of operations.

  -The high thermal expansion rate and compressive 'Creep' characteristics of PTFE resins tend to upset the desired contact pattern area of a seal when it is exposed to heat and/or load conditions.

  -PTFE's high flexural modulus results in a stiff sealing element when compared to present-day elastomer elements, and therefore PTFE's ability to follow eccentric shaft movement can be limited.

  -The stiffness and apparent hardness of PTFE resins to make seal elements vulnerable to damage in handling and at installation.

- The radial lip seal engineer can eliminate an/or offset these unfavorable characteristics by carefully establishing and applying proven PTFE seal design parameters, and incorporating rigid controls over the processing cycle of the PTFE material. However, the addition of the proper type and amounts of filler by itself can result in the following improvements:

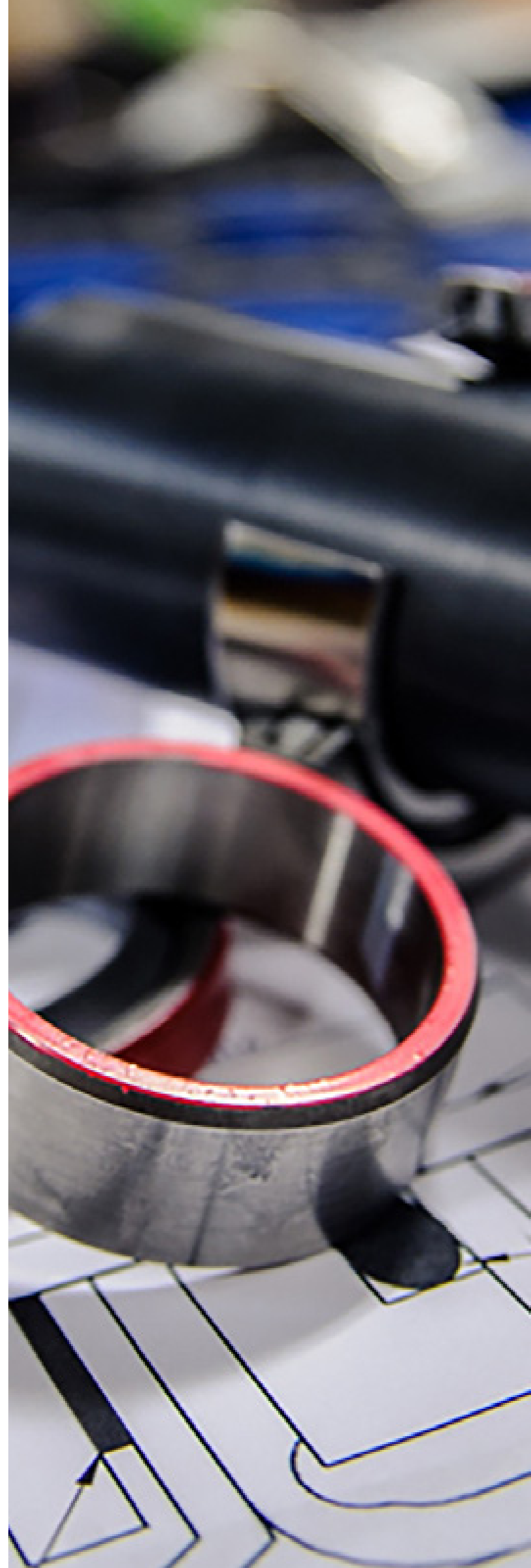
  -Thermal expansion reduced by factor of 5

  -Wear resistance is increased by a factor approaching 1,000

  -Resistance to 'Creep' is increased by a factor of 10

- It should be noted that many times the addition of a filler while improving some properties favorable to seal function, will also increase undesirable characteristics. As an example, the addition of glass fibers will improve both wear and 'Creep' resistance, but also tend to increase the stiffness and abrasive characteristics of the compound.

- Wear – Since wear rate is perhaps the most significant property of PTFE resin that is influenced by fillers, considerable testing has been performed on filled PTFE resins where rate of wear is the basic unit of measurement in determining functional acceptance of a compound.



- A great amount of literature has been printed by both PTFE resin suppliers and product fabricators regarding wear, and for most product applications this data will prove to be acceptable for usage in compound selection.
- However, for radial lip seal products, wear rate testing must also take into account the process cycle of the PTFE material, and final method of element fabrication. It is recommended that the test specimen for lip seal wear data closely resemble the final element configuration.
- To illustrate the wear performance of various filled PTFE compounds, five filled compounds were processed per the same molding pressure cycle, and sintered on the same time/temperature testing span. Identical conventional 'Wafer' elements were then machined from the billets of material and tested on a wear test fixture as shown in Table 1.

Physical Properties	ASTM Standard	Virgin	15% Glass	25% Glass	15% Graphite	5% Glass 5% Molybdenum	60% Bronze
Specific Gravity	D 1457-56T	2.18	2.21	2.24	2.14	2.22	3.68
Tensile Strength, PSI	D 1457-56T	4800	3500	2900	2800	4200	2000
Elongation, %	D 1457-56T	400	325	275	250	350	90
Flexural Modulus, PSI	D 747-61T	0.90 x 10^5	1.62 x 10^5	2.38 x 10^5	1.92x 10^5	-	1.97 x 10^5
Hardness, Durometer, D	D 1706-59T	58	64	66	64	62	70
Compressive Strength, PSI 1% Strain	D 695-54T	750	1250	1400	1200	1100	1700
Deformation at 78 F, 2000 PSI, 24 hours %	D 621-59 (ref.)	14.6	7.8	6.7	7.5	8.1	5.8
Coefficient Linear Expansion (per Deg f)	D 696-44	7.03 x 10^-5	3.12 x 10^5	4.10 x 10^5	4.67 x 10^-5	-	4.40 x 10^-5

Table: 1

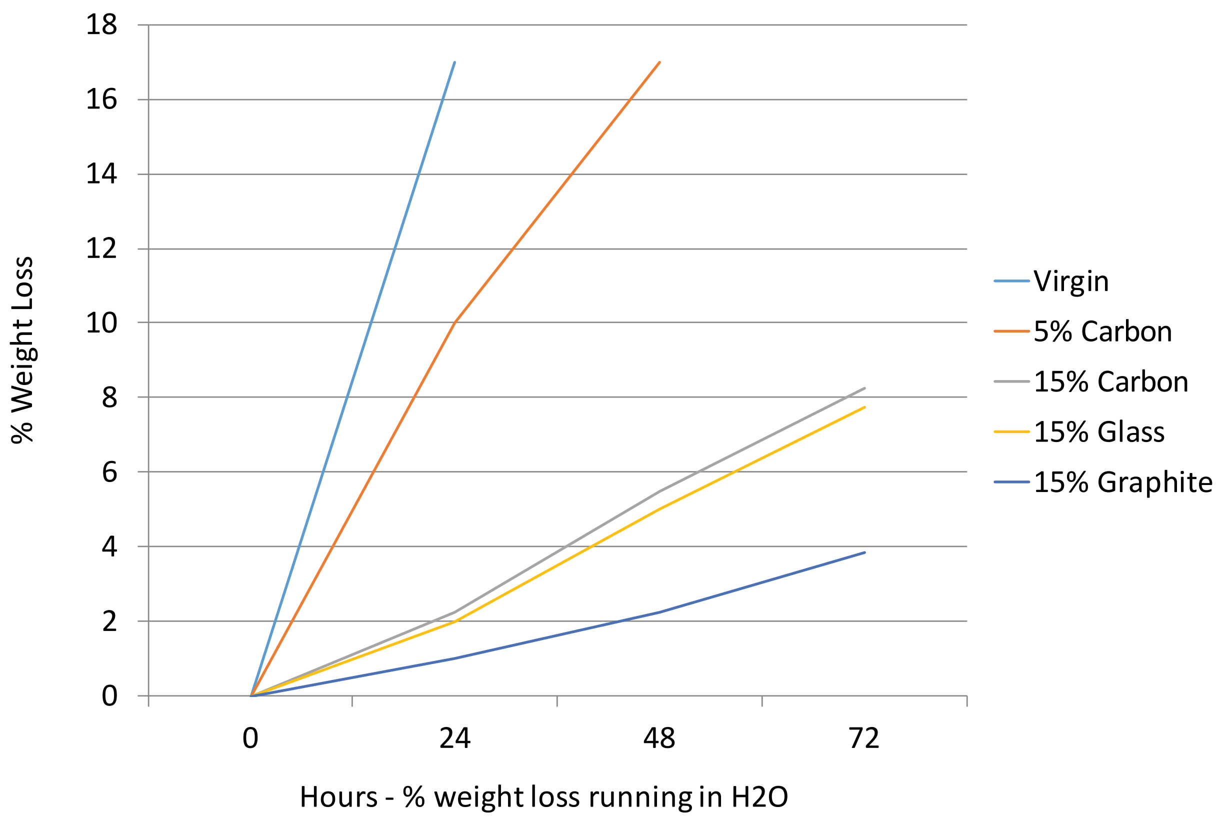


Figure: 3

- Figures 3 and 4 show the rate of wear by weight loss after 12, 24, and 72 hour running intervals. Note: unfilled virgin PTFE was also tested to illustrate effect of filler on wear rate.
- Wear data representing filled PTFE compounds in lubricating media is not shown, since the presence of lubricant extends the noticeable wear point to beyond 1000 hours, and even then the wear rate difference between compounds is minimal unless factors such as speed, pressure, and temperature are greatly increased.

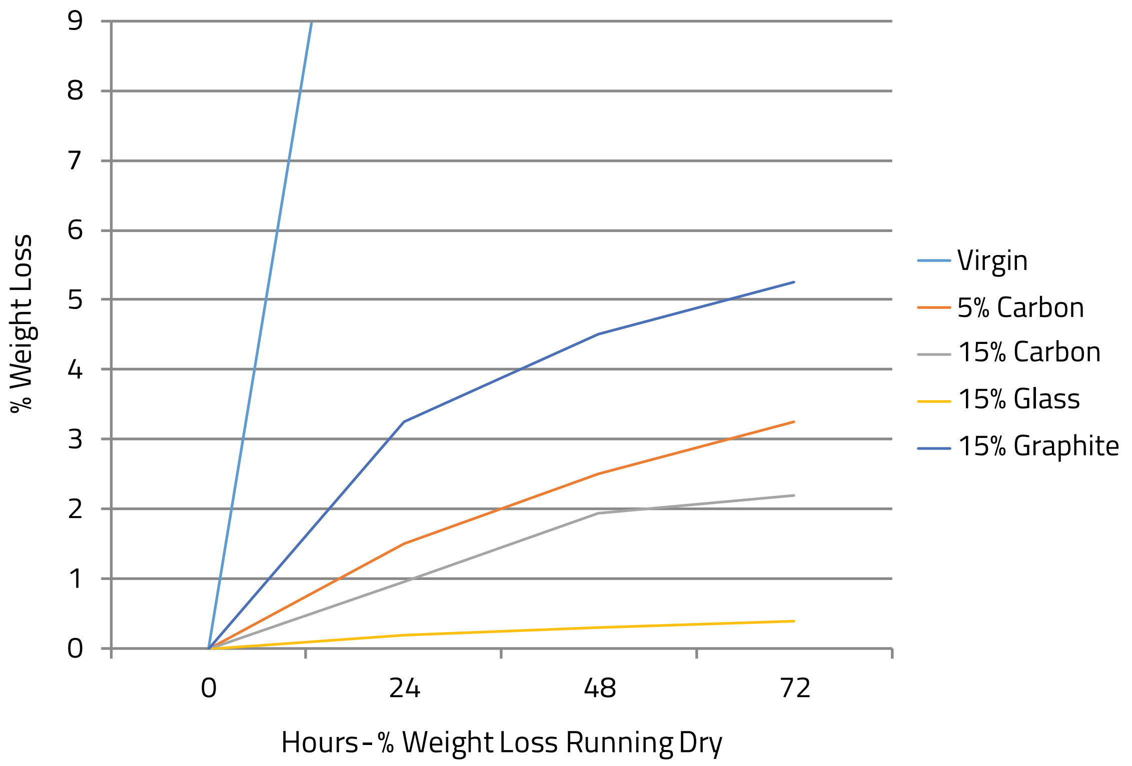


Figure: 4

- The choice of filler type and material processing cycle is still largely dependent upon the results obtained from empirical testing. Continued development and engineered approaches to PTFE lip seal design and manufacturing methods is establishing filled PTFE resins as an acceptable sealing element material.

PTFE Filler Chart

PTFE Desciption	Application	Temp Range °C	Temp Range °C
TP-3115	Light duty service, FDA approved, Excellent for cryogenic and low molecular weight gas service.	-195 to 232	Lowest
TP-3102	General purpose. Good wear in soft shaft applications. high speed & lower pressures.	-195 to 232	Low
TP-3100	Excellent resistance to heat and wear. Recommended for dry or semi-dry applications. Good in liquids and steam. Graphite added for lubricity.	-195 to 260	Low
TP-3113	Excellent wear and heat resistance. High pressure applications, good in hydraulic oil. Abrasive in rotary service against soft metals unless lubricated. Molybdenum added for lubricity.	-156 to 287	Moderate
TP-5114	FDA compliant. Exceptionally strong and prolongs life of the base PTFM. Abrasive in rotary service against soft metals.	-156 to 287	Moderate
TP-3105	Excellent in dry service with low wear rate in vacuum and inert gases. Very low abrasion to dynamic mating surface. Good in food applications and oil service. NOT good in water.	-267 to 260	Low
TP-5202	FDA compliant. Excellent wear and heat resistance. Excellent for high RPM applications. Good in both dry and liquid applications.	-195 to 260	Low
TP-XXXX	We will custom blend, sinter, and mold a filled PTFE compound to provide you with the best material available for your application!!	TBD	TBD

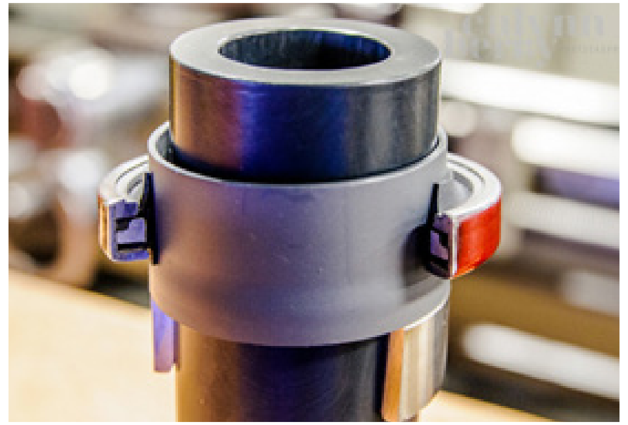
Table: 2

PTFE Radial Lip Seal Design

- Factors to consider regarding application of PTFE radial lip seals – Prior to the selection of seal type, and the filled PTFE compound to be utilized in a proposal, a thorough understanding of the operating conditions and how they affect PTFE lip seal performance is required. The following are the most important factors to consider:
- Temperature: This is perhaps the most critical factor to consider when designing a PTFE lip seal. Due to PTFE's high rate of thermal expansion, the pronounced change in flexural modulus at various temperatures, and the compressive 'Creep' characteristics, a controlled contact pattern and desirable radial loading on the shaft surface are difficult to control. To achieve a satisfactory seal, the design and material should be directed to the mean functional temperature range.
- Shaft Speed: As a factor by itself, shaft speed has little effect on the PTFE lip seals, unless speeds reach a level where severe temperature and wear are generated by the sealing element. Speed, however, is a critical factor in seal design when the application is one that has a high degree of shaft run-out, limited lubrication, or when a positive fluid pressure is present and the limiting PV range of the material is approached.

- Fluid Type and Fluid Level: These are determining factors that greatly influence seal design. Although PTFE is compatible with most lubricants and chemicals, careful selection of seal type and filler type are required for fluids that have no lubricant value. Since the majority of lip seal applications are involved with the sealing of lubricating oils, type of lubricant generally receives little attention. Experience with certain extreme pressure gear lubricants has shown a definite form of reversion and high wear rate when the EP fluid was exposed to temperatures beyond its recommended limit. Fluid level and/or amount of fluid in the adjacent seal area is a determining factor on usage of a spring or other means to increase radial load.
- Dynamic Shaft Run-Out: Shaft run-out is an operational condition that heavily influences the PTFE element design and method of processing the material. To offset the high flexural modulus and enable the element to follow the shaft movement, special design considerations and processing techniques are employed to obtain as flexible an element as possible.
- Shaft Material and Finish: These requirements are essentially the same as applied to elastomer seals. Because of PTFE's tendency to transfer a film onto the adjacent shaft surface, a finish of 16 Max rms is recommended for sealing lubricants. Applications in which water and chemicals are to be sealed require a smoother surface finish of 8-12 rms, since normally no transfer to PTFE is obtained. Steel and cast iron are the best shaft materials, and stainless steel is preferred over chrome plated materials. It is important that all finishes be produced by plunge grinding, or a process that will not produce a helical lead to the shaft surface. Helical leads on the shaft surface have a greater influence on PTFE than elastomers because of the low frictional hardness characteristics of PTFE resins.

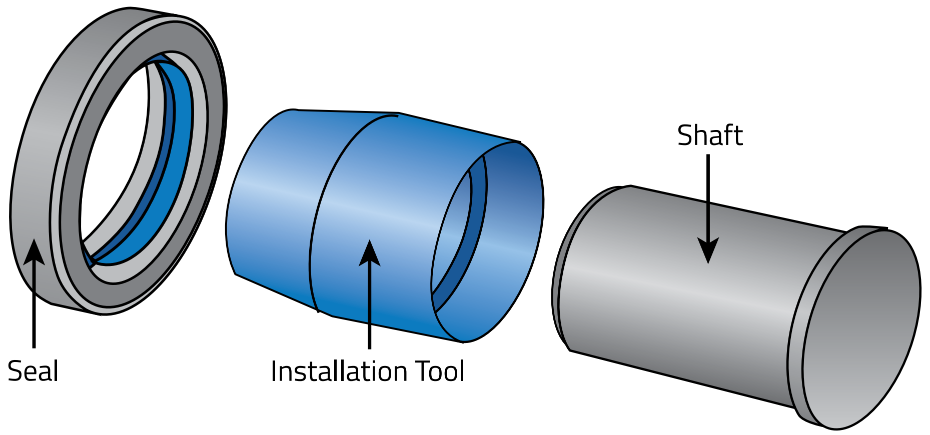
- Contamination: Contamination is less critical to PTFE resins than elastomer compounds. Whereas elastomer materials act like a grinding wheel when abrasive particles becomes embedded, PTFE allows the particles to penetrate and then transfers a film over the particles, therefore minimizing the abrasive action. PTFE radial lip seals have been used without excluder lip where contamination is light, but an excluder is recommended where heavy contamination is present.
- Installation: Installation of the PTFE radial lip seal is an area that requires attention by both the seal engineer and end user. Because PTFE is a stiff material and does not possess the elastic properties of elastomers, possible damage to the element from sharp edges and burrs on the shaft must be avoided. In most instances, installation problems can be overcome by proper seal design selection. If the application requires a element design with heavy interference, and installation onto the shaft is against the PTFE element, an installation tool should be considered.



Installation Tools

- Protect seal from damage caused by splines, keyways or shafts without a lead-in chamfer
- Properly aligns seal to shaft
- Typically made of plastic material

  -Nylon or PVC



Design Principles Employed in PTFE Radial Lip Seals

- The following will provide some insight into the basic design practices for PTFE lip seals
- PTFE radial lip seals generally incorporate a uniformly thin element cross section. The purpose of the thin section is to compensate for the high flexural modulus of PTFE and specifically in applications where severe shaft run-out is encountered. The thin sections also minimize the degree of thermal expansion and compressive 'Creep' and their effects on maintaining a controlled contact pattern on the shaft surface. The majority of PTFE seal constructions have the 'Body' portion of the element clamped between the two metal cases. To maintain proper retention pressure on the element, a thin element enables compression set and 'Creep' to be kept to a minimum. From a cost standpoint, it is desirable to keep material to a minimum and the element design as basic as possible. The only exception to thin element design is an application where lubrication is not present and high wear rates are predicted.
- The contact pattern area in many PTFE seal designs is wider than related elastomer seals. In some instances, the wide contact area was not intended, but due to the heavy interference on some non-spring activated elements to achieve a desirable radial load, the element produced this effect when it was positioned on the shaft.

The reasons for intentionally designing a wide contact into a sealing element are:

- PTFE when exposed to elevated temperatures experiences a significant reduction in radial load. Therefore, to maintain the fluid film between the shaft and element, a wide contact area is desirable to prevent leakage.
- Since PTFE is prone to damage on installation and handling, minor nicks in the extreme ID surface are offset with the wide contact area.
- In applications where fluid pressure is evident, the wide contact area enables the load to be distributed over a greater area, and therefore reducing both element and shaft wear. The wide contact area on the shaft surface also allows higher spring loads to be applied to the elements without increasing wear and/or shaft scoring.
- When the wide contact principle is employed in PTFE lip seal designs, and especially spring activated elements, the design parameters of the seal must not allow 'Bell Mouthing' to occur. This affect will create an oil wedge and produce high leakage rates.
- The amount of interference between the element ID and shaft OD may vary from one design to another. Heavy interference is normally associated with non spring-loaded element designs. This interference provides greater radial load and enables the element to follow shaft run-out. By incorporating a spring, the interference factor can be reduced. For designs that depend upon large running interferences, and this can apply to both spring and non-spring designs, the problem of installation damage becomes very critical. Although installation tools can be utilized, it is preferable to take advantage of the 'Heat-Set' characteristic of the PTFE material. Once the desired sealing interference has been determined and the element is machined or molded to this diameter, the element ID is then stretched over a predetermined diameter and the element is exposed to a 'Heat-Setting' operation. 'Heat-Set' is nothing more than applying a specific amount of heat to an element and allowing the element to cool on a mandrel of predeveloped size. After

'Heat-Set' the element ID is greater than the original fabricated dimension, and installation becomes less troublesome. After the 'Heat-Set' seal design is installed into the application, the initial heat generated from the friction will cause the element to attempt to return to its original ID.

- The employment of a spring to a PTFE element is normally determined by the seal engineer and their particular design practices. However, there are definite situations that will predict usage of a spring. These are:

  -Excessive amount of shaft run-out and/or shaft and bore misalignment.

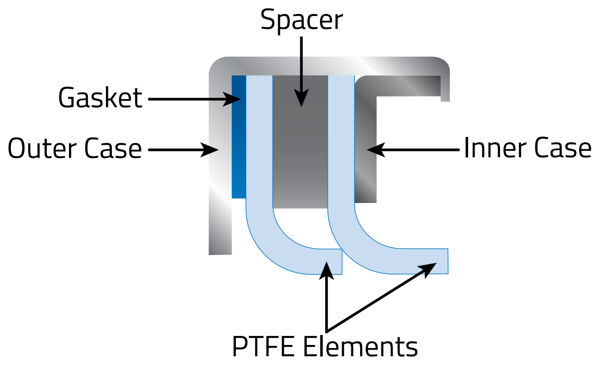
  -Pressure application where the element takes a compression set, and a spring is required to provide immediate response when pressure is suddenly reduced.

  -Where loss of radial load, due to high temperatures, will result in leakage

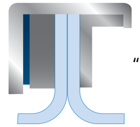
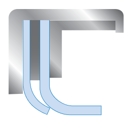
  -To offset the high flexural modulus in low temperature environment

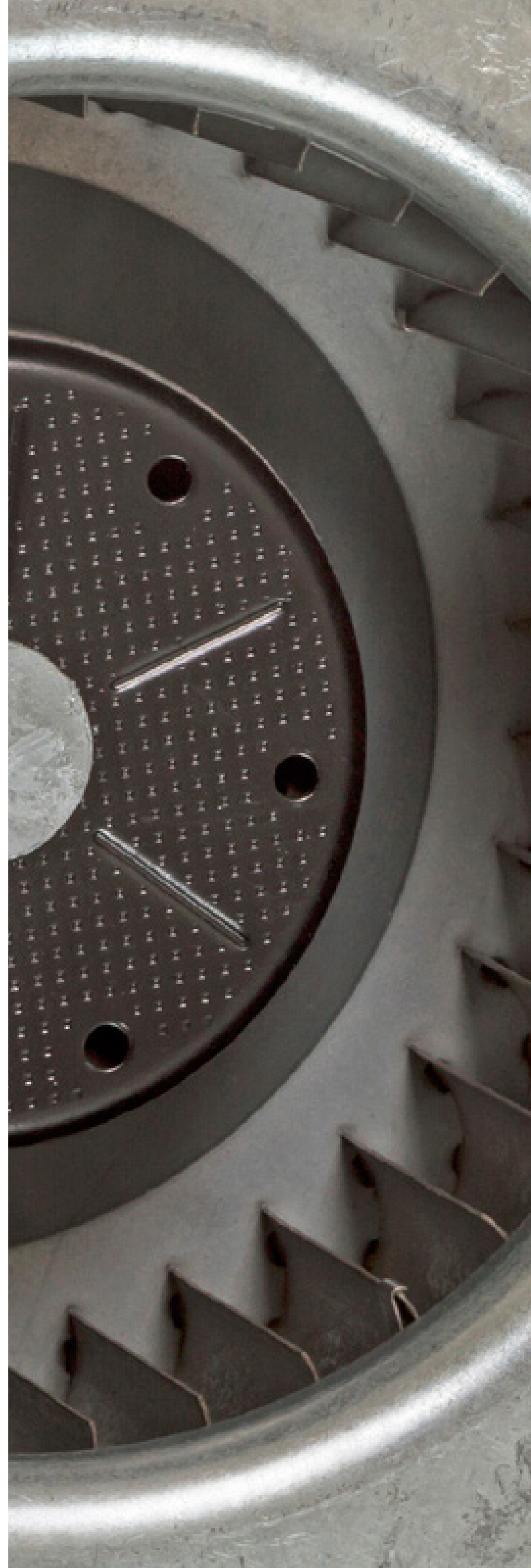
PTFE Rotary Lip Seal: *Definitions*

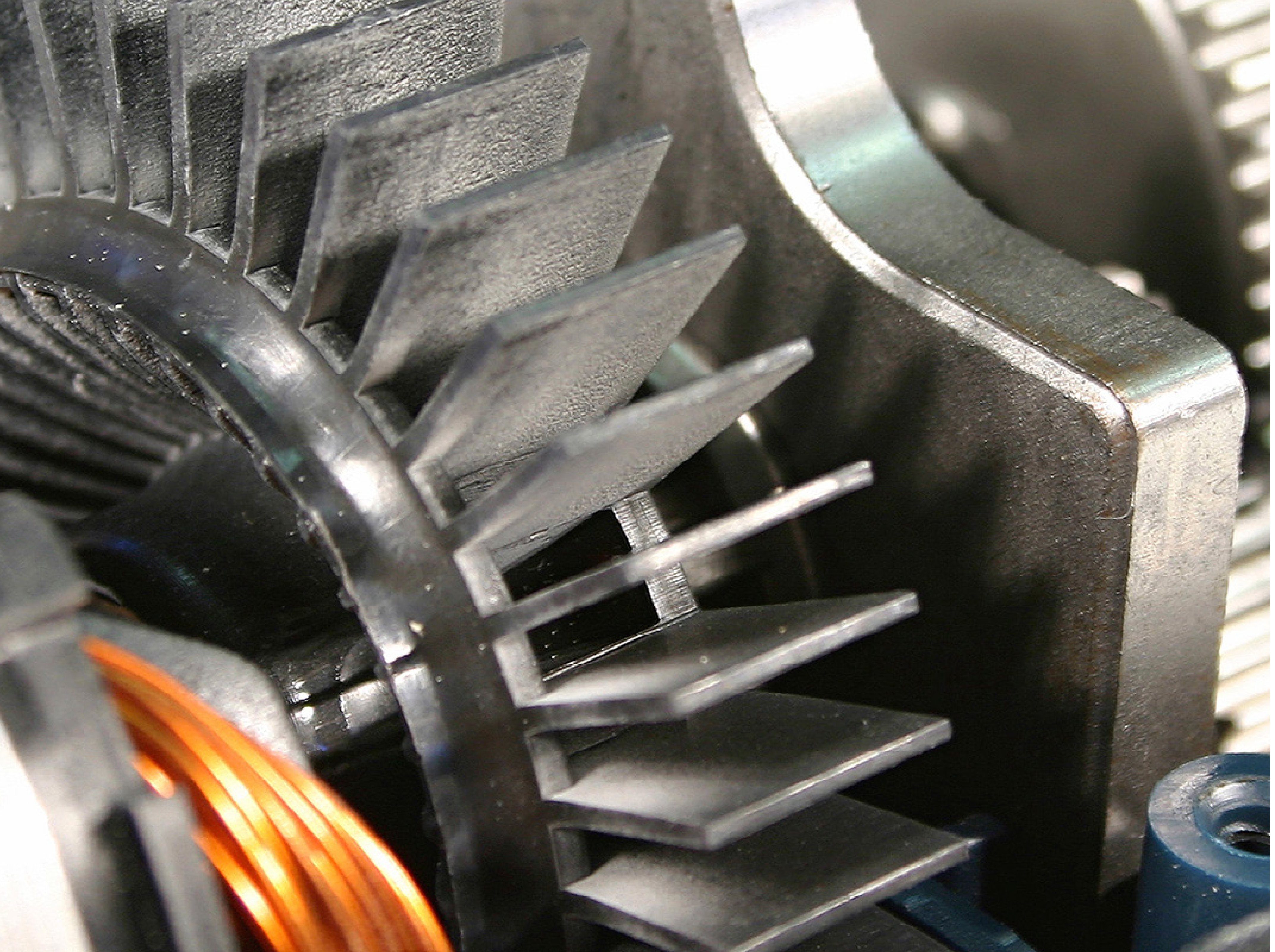
- Outer Case
  - -Houses all components of seal
  - -Press-fit into bore to prevent seal rotation
- Inner Case
  - -Compress internal components
  - -Locates bend point of element
- Gasket
  - -Helps prevent internal leakage
  - -Takes up tolerances in assembly
- Spacer
  - -Locates bend point of element
  - -Spaces multiple elements apart for ideal sealing
- PTFE element(s)
  - -Mechanically formed to a diameter smaller than shaft
  - -Takes advantage of hoop stress of PTFE



Factors Affecting PTFE Rotary Lip Seal Design

Cross-Section and "Series"		Style Description	Pressure Range	Temperature Range	Description / Application
	"100"	1 PTFE Element	60 psi (0.414 MPa)	-65° to 500°F (-54° to 260°C)	Rotary shaft seal designed for general purpose where application requires low friction, high pressure, and may contact harsh chemicals. Good or low pressure sealing as well.
	"200"	2 PTFE Elements Spaced Apart	250 psi (1.73 MPa)	-65° to 500°F (-54° to 260°C)	Designed with two elements spaced apart for enhanced sealing in one layout. Excellent for applications where sealing media can be a safety concern. Goodfor low pressure sealing as well.
	"300"	1 PTFE Element 1 "Wiper" Element (Opposite Direction)	40 psi (0.276 MPa)	-65° to 500°F (-54° to 260°C)	Designed for applications requiring sealing high pressure and/or caustic chemicals but also requires keeping dirt, water, or debris away from active sealing surface. Good for low pressure sealing as well.
	"400"	2 PTFE Elements Spaced Apart 1 "Wiper" Element (Opposite Direction)	150 psi (1.04 MPa)	-65° to 500°F (-54° to 260°C)	Combination of the dual design for enhanced sealing with the third element in the opposite direction to keep dirt and debris out. Good for low pressure sealing as well.
	"500"	2 PTFE Elements (Opposite Direction)	60 psi (0.414 MPa)	-65° to 500°F (-54° to 260°C)	Designed for bidirectional shafts. Uses two sealing elements facing opposite directions for active sealing on both sides of the seal. Good for low pressure sealing as well.
	"600"	2 PTFE Elements (Same Direction)	90 psi (0.621 MPa)	-65° to 500°F (-54° to 260°C)	Another variation of the dual element design. Elements are stacked together which allows sealing at higher pressures and high speeds in abrasive media. Excellent for low pressure sealing as well.





Shaft Considerations

- Proper surface finish is critical to ensure positive sealing, and achieve the longest seal life possible in rotating applications. Rotating surfaces that are too rough can create leak paths and can be very abrasive to the seal. Unlike elastomer contact seals, PTFE-based lips can run on very smooth surfaces with or without lubrication. Due to the toughness and low coefficient of friction or PTFE, PTFE lip seals, unlike seals made of other materials, slip over the high points of the mating surface and resist abrasion.
- The optimal surface finish for PTFE Lip seal applications is summarized in the Table 3.

Surface Finishes

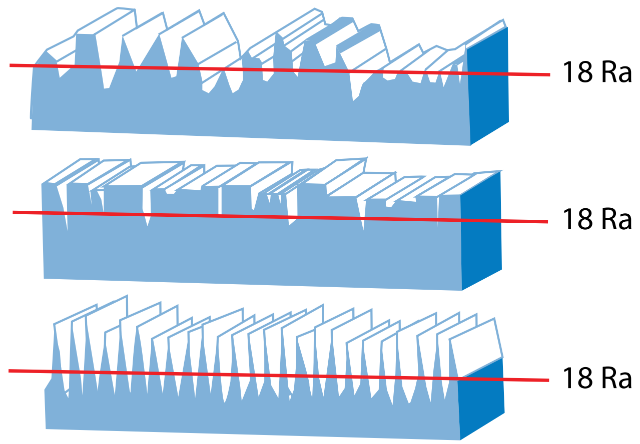
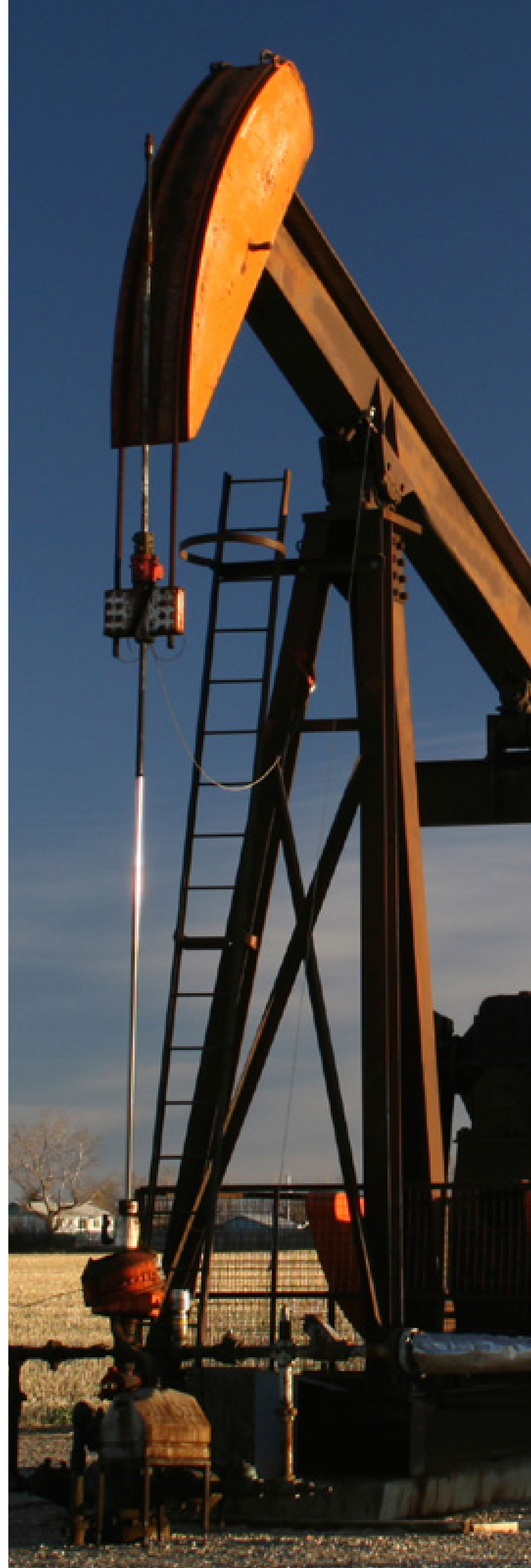
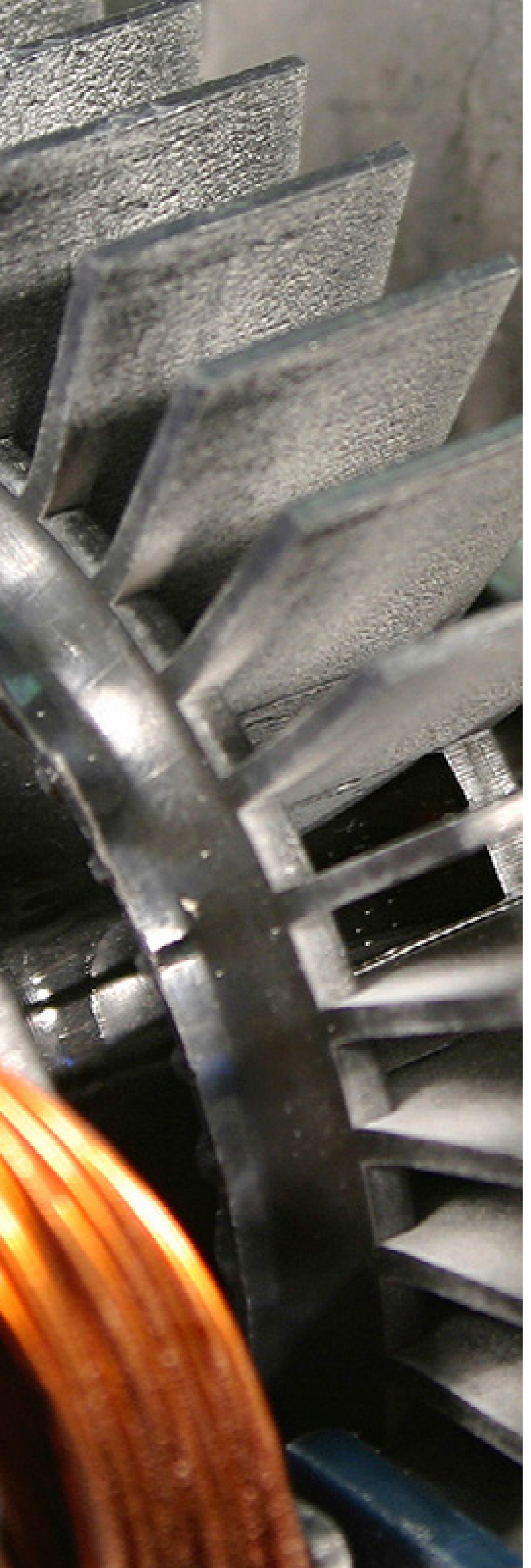


Table: 3

- Dynamic surfaces with relatively rough finishes will result in higher wear rates, which decreases the seal life and may compromise performance. Additionally, dynamic surfaces which have a finish smoother than recommended may also decrease the seals effectiveness. The optimum surface roughness allows a film of the fluid being sealed to flow between the seal and the mating surface, which effectively lubricates and extends the life of the seal.





- PTFE rotary seal applications require a hard running surface on the dynamic portion of the hardware. The harder surface allows the use of higher reinforced seal materials that will increase the seal and hardware life. Softer running surfaces must use lower wear resistant materials that will not damage the hardware and normally yield shorter seal life. A balance between seal material and dynamic surface hardness must be met to ensure that the seal remains the sacrificial component. Table 4 includes minimum surface hardness.

Recommended Minimum Hardness Values

Type of Motion	Surface Speed	Lubrication	Rockwell C Hardness				
			At 0 psi (0,0 Mpa)	150 (1,0)	500 (3,5)	1000 (6,9)	5000+ (34,5+)
Reciprocating	Up to 100 sfpm (0,51 m/s)	Good Poor	28 30	28 30	30 35	35 40	44 50
	Over 100 (0,51)	Good Poor	35 44	35 44	40 48	44 50	50 60
Rotary	Up to 150 (0,76)	Good Poor	35 44	44 50	50 55	65 70	70 70+
	Up to 500 (2,54)	Good Poor	55 60	58 65	65 70	70 70+	70+ Consult GFS
	Over 2500	Good	58	65	70	70+	Consult GFS Engineering

Table: 4

- When the dynamic surface hardness is below 45 Rc, most seal materials will polish the running surface of the hardware and the seal. This initial break-in period will cause seal wear to taper off over a period of time, depending on the seal material, surface finish and PV of the application.

When hardness exceeds 45 Rc, the initial surface finish is even more critical to seal life. The hardness of the dynamic hardware surface affects the wear rate of the seal. Additionally, some seal lip materials are abrasive and will wear softer metal shafts or dynamic components. In general, finer surface finish results in better overall seal and hardware performance. The ideal hardness of the dynamic surfaces of the hardware is 50 to 60 Rockwell C. The actual hardness used is normally a balance between the additional cost associated with finishing harder materials versus the maximum seal life that will be achievable.

- Shaft Tolerances: Shaft diameters should be held to the tolerances specified In Tables 5-6:

Shaft Tolerance for Inch Fractional

Shaft Diameter	Tolerance
Up to 4.000"	+/-0.003"
4.001" to 6.000"	+/-0.004"
6.001" to 10.000"	+/-0.005"
Over 10.000"	+/-0.006"

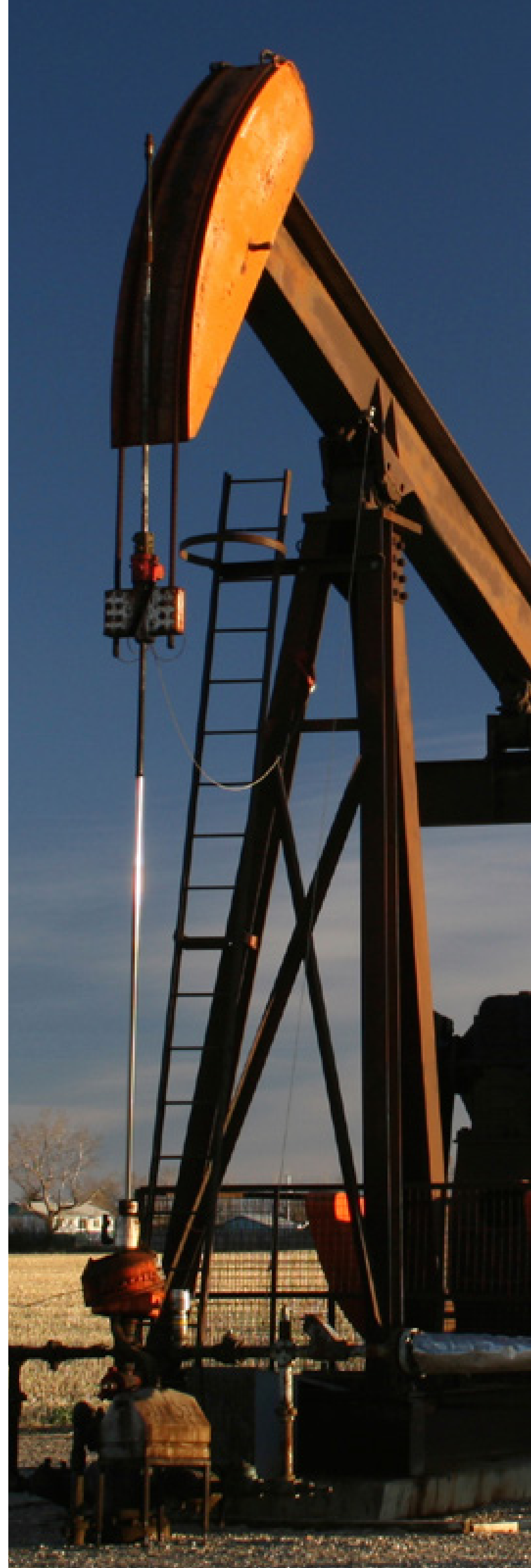
Table: 5

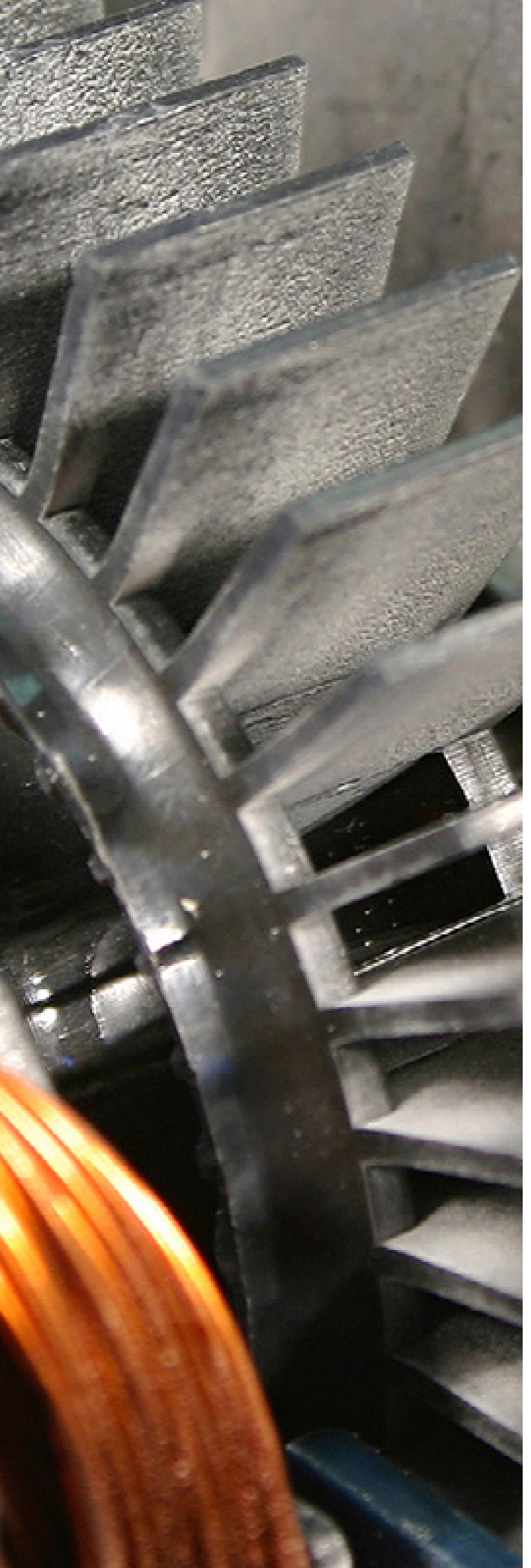
Shaft Tolerance for Metric

Shaft Diameter	Tolerance
Up to 10 mm	+0 to-0.09 mm
Over 10-18	+0 to-0.11 mm
Over 18-30	+0 to-0.13 mm
Over 30-50	+0 to-0.16 mm
Over 50-80	+0 to-0.19 mm
Over 80-120	+0 to-0.22 mm
Over 120-180	+0 to-0.25 mm
Over 180-250	+0 to-0.29 mm
Over 250-315	+0 to-0.32 mm
Over 315-400	+0 to-0.36 mm
Over 400-500	+0 to-0.40 mm

Table: 6

*ISO Standard 286-2, h11





Housing / Bore Considerations

- Typical PTFE rotary lip seals are pressed into the bore to assure proper OD sealing and seal retention in the housing. The most commonly used materials for seal housings are steel and cast iron. Care must be taken when softer materials such as aluminum, bronze or plastics are used for the housing material. Aluminum has a thermal expansion rate almost double that of steel. Metal case designs can lose the requires press fit in an aluminum housing when they go through thermal cycles due to the higher rate of thermal expansion of aluminum.
- A Finish range of 32 to 63 µin Ra (0.8 to 1.6µm Ra) is recommended for service pressures up to 3 psi (0.20 bar). If the fluid is thick, such as a grease, a 125 µin Ra (3.17 µm Ra) finish would be acceptable with no system pressure.
- A lead-in chamfer is highly recommended for all seal housings. The chamfer aligns the seal during installation and helps prevent the seal from cocking. Both corners of the chamfer should be free of burrs and sharp edges.
- For pressurized rotary applications, additional precautions are needed to ensure the seal is not pushed out of the housing.

Pressure and Shaft Velocity

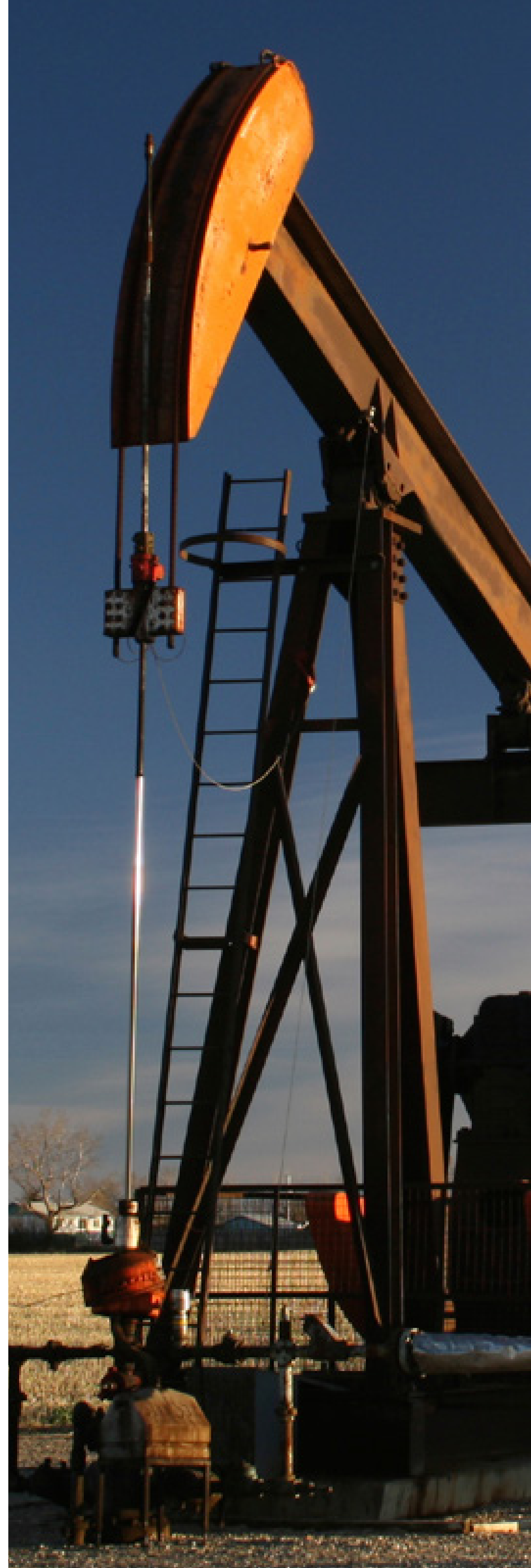
- Unlike reciprocating applications, seals that ride on a rotating shaft have a contact point that is localized in only one small area where dynamic forces and energy are concentrated. In fact, much of the energy from the shaft is dissipated at the seal in the form of frictional heat and wear, both of 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. Shaft speed can be measured in surface feet per minute and the lip force can be approximated by measuring the differential pressure across the seal in psi. Shaft velocity in surface feet per minute is calculated as follows:

Surface Velocity (In sfpm)	=	*Shaft Diameter (Inches)*	×	*Shaft RPM*	×	*0.262*

- One way to estimate the exposure to these risks is to calculate the PV-value by multiplying the pressure held by the seal (P in psi) by the surface velocity of the shaft (V in surface feet per minute). The product of the multiplication provides the designer with a guide to aid in the choice of seal profile and material. Below is an example:

Surface Velocity	=	*Shaft Diameter*	×	*Shaft RPM*	×	*0.262*
	=	*1.25" × 350 RPM × 0.262*				
	=	*115 sfpm*				

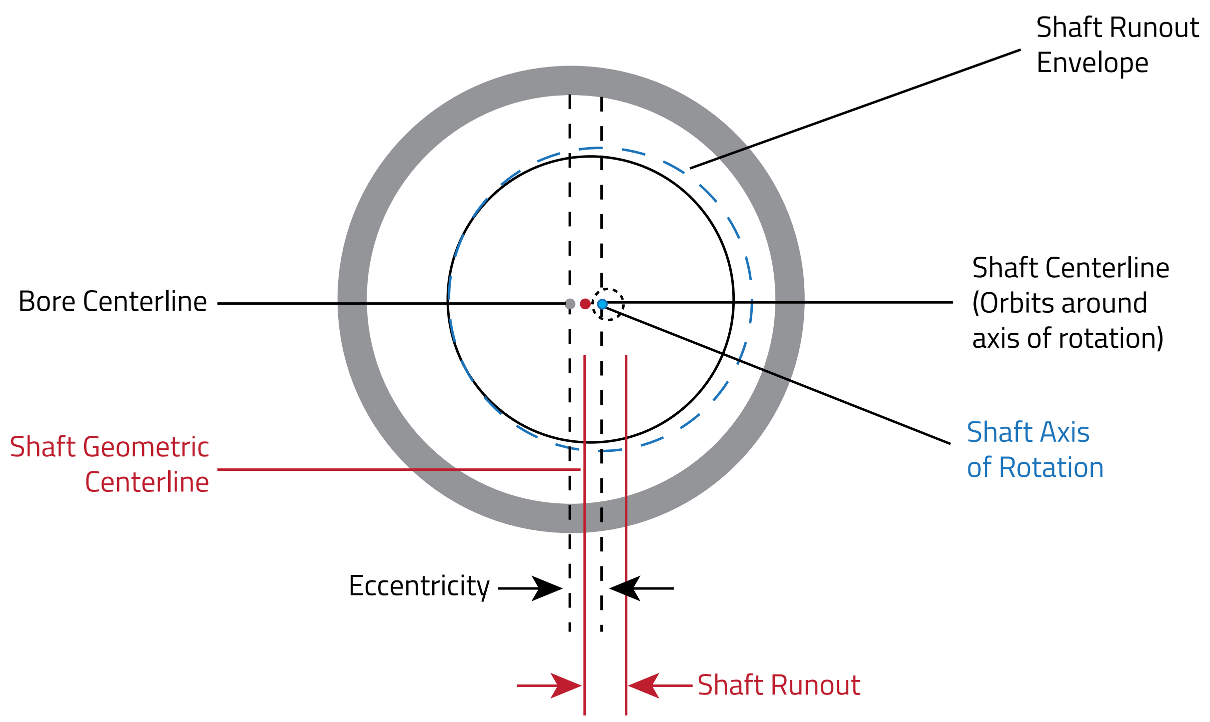
PV-Value	=	*Pressure*	×	*Shaft Velocity*
	=	*45 psl*	×	*115 sfpm*
	=	*5175 ft. lb./In^2 min.*		



Shaft Misalignment 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. Every shaft has some degree of both as described in Figure 5.
- 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. Because they are less elastic, PTFE seals are more susceptible to failure, misalignment and runout conditions than elastomeric lip seals. The second potential problem is that it enlarges the extrusion gap on one side, which could be detrimental if high pressure is involved.
- Shaft Runout is when the shaft is spinning on an axis of rotation that is offset from the geometric center 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 each revolution. It follows that shaft runout becomes more of a problem at high speeds.

Shaft Runout

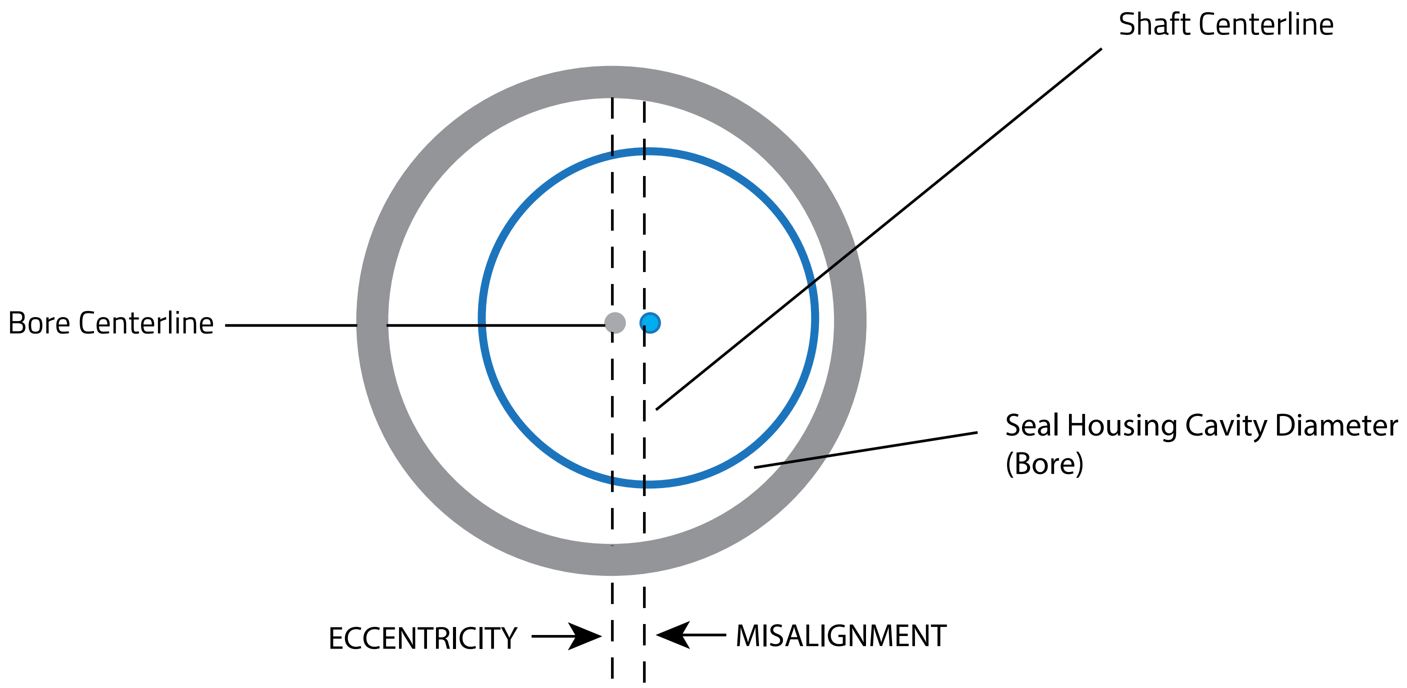


In this case, cyclical radial deflection due to runout is superimposed on static radial deflection due to eccentricity.

Figure 5

- All rotating shafts have eccentricity and runout to some degree. The risk of failure increases significantly if a system has a considerable amount of both.

Shaft Eccentricity



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

Figure 6

Application Areas for PTFE Radial Lip Seal

- Because of PTFE's superior physical and mechanical properties and its chemical resistance, the application areas where PTFE radial lips seals are being employed has increased rapidly. The only limiting factor to PTFE being used throughout the majority of applications is cost. The following are a few of the more popular applications for PTFE radial lip seals
- Diesel Engine Applications

  -These consist of the front and rear crankshaft, accessory drive, blower and thermostat seals. PTFE lip seals are being used and tested for these areas because of their ability to meet the performance and life requirements of today's engines. Minimum wear, performance at high temperatures with limited lubrication, resistance to abrasive contaminants, and fluid compatibility are the primary factors for PTFE's approval in the above applications.
- Hydraulic Applications

  -Applications such as motors, pumps, and hydrostatic transmissions are using PTFE lip seals at an increasing rate. It is not unusual to apply a PTFE lip seal in pressurized applications where the seal is exposed to pressure velocity values as high as 250,000 (250 psi and 1000 fpm) and achieve a seal life of 5000 hrs. Besides performance, PTFE lip seals normally are less expensive than the high pressure face seals currently being used, and can offer additional savings by the elimination of costly venting methods that are employed to reduce pressure in the seal area.
- Turbine Engines

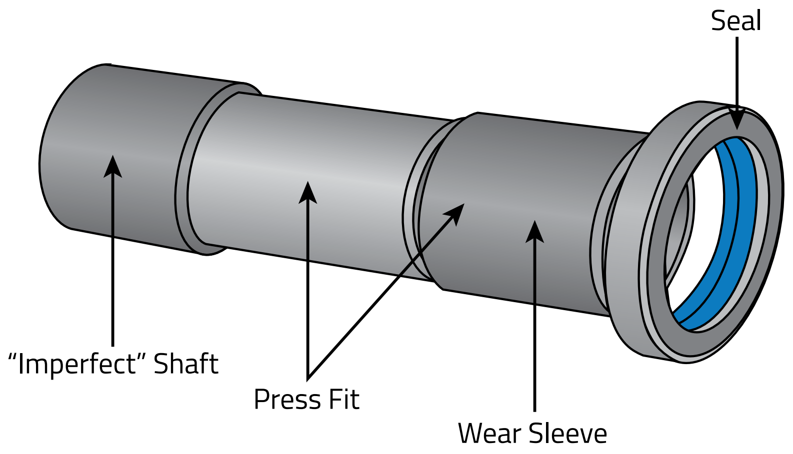
  -Turbines and their related gear box assemblies are presently incorporating PTFE lip seals because of life and minimum leakage rates achieved when these seals are exposed to shaft speed of 6000 ft/min and temperatures of 400F.

- Fractional Horsepower Motors
  - -Motors that require a seal in oil, or seal out contaminants are using PTFE lip seals because of their ability to perform with minimum torque being generated.
- The usage of PTFE radial lip seals continues to grow in other areas such as food processing equipment, chemical processing equipment, low-temperature environments, chemical processing equipment, and applications that require a seal to function in pressurized gases.

Wear Sleeves

- Used when ideal conditions are not met:
  - -Poor shaft surface or low hardness
  - -Damaged shaft
- Hardened running surface
- Controlled surface finish
- Less costly than replacing a damaged / worn shaft

Damaged / Worn Shaft

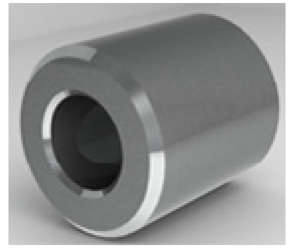


Wear Sleeves: *Surface Hardening Processes*

Wear Sleeve Materials & Recommended Surface Treatments

Treatment "Code"	Treatment Types	Description of Treatment Types	Sleeve Material & Available Treatment Types
A	Ceramic	Low Volume, Long Life, Abrasive Media, NoLube	4140 CRS (A, B, C, D)
B	ION Nitride	Good for low to medium corrosion resistance, no post-op grinding necessary	AR400 (B)
C	Thin Dense Chrome	Case hardened, .003" inexpensive vs hard chrome	300 Series SS (E)
D	Hard Chrome	Good corrosion resistance	0-1 Tool Steel (A, B, C, D)
E	Tri-Armor™	Achieve HRc of 70+, Ra of ~9, No surface change	17-4 PH (B)

Table: 7



Application Data Sheet

Application Data Form

Company Name: ____________________ Individual: ____________________

Street Address: ____________________ Title: ____________________

City: ____________________ Phone: ____________________

State & Zip: ____________________ Fax: ____________________

Type of Application: ____________________

Bore Dia: ____________ Bore Material: ____________ Bore Finish: ____________

Seal Width: ____________ Shaft Hardness: ____________ Method of Finish: ____________

Can above seal gland dimensions be changed?:____________ (How much?): ____________

Minimum life expectancy required (Hours): ____________________

Present seal type & element material: ____________________

Estimate of life with present seal (Hours): ____________________

Type of media to be sealed: ____________________

Amount of media in seal area: Full head ( ) Half Shaft ( ) Splash ( ) Mist ( )

Fluid Pressure: ____________________ Pressure Cycle: ____________________

Operational Temperature Range: ____________________

Shaft Speed: ____________________ Torque Requirements: ____________________

Direction of shaft rotation (Viewed from dry side of seal): CW ( ) CCW ( ) Both ( )

Bore / Shaft Misalignment: ____________TIR Dynamic Shaft Runout: ____________TIR

Direction of shaft entry into seal From rear of seal ( ) From Front of seal ( )

During installation, will element pass over keyway, spline, etc Yes ( ) No ( )

Type of evaluation: Bench ( ) Field ( ) Both ( )

Annual estimated usage: ____________________ Lot size purchase: ____________________

If possible, provide target price range expected: ____________________

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