DESCRIPTIONS OF PTFE ROTARY BAL SEAL® SPRING-ENERGIZED SEALS

Factors That Affect Seal Performance

Technical Report

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1.0 SUMMARY

This report provides general guidelines for BAL™ Seal selection for rotary service. The seals press-fit into the housing, requiring relatively low force. The seals also come in small diameters and small cross-sections. They are suitable for use in most chemical environments and dry applications and are available in various styles and sizes.

This report also discusses various hardware considerations, factors that affect seal performance, seal installation/removal and engineering support.

2.0 ADVANTAGES OF PTFE ROTARY BAL™ SEALS

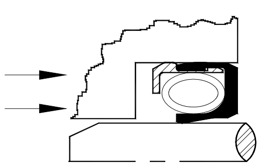
- Available in small cross sections and small diameters for minimum package requirements
- Made from PTFE and PTFE compositions for low friction and long seal life
- High compatibility to solvents, chemicals and other materials
- Operates in dry environments
- Wide range of temperatures from –70 to 450 F (-57 to 232 C)
- Locking ring design prevents seal rotation and seal shrinkage at thermal cycling
- BAL Seal's patented canted-coil spring energizer

3.0 PTFE ROTARY BAL™ SEAL TYPES

Rotary BAL Seals are divided into four groups as shown below. Each group has its unique advantages and seal design features.

3.1 Spring-energized seals with metal locking rings

KSS/KS series; K31/KF31 series

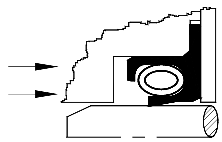


KS Series

The locking ring press-fits in the housing so it is securely retained. The unique design of BAL Seal's patented metal ring design prevents the seal jacket from rotating and shrinking under thermal cycling. The canted-coil spring provides a positive, constant seal energizing force. Those seals may be used at speeds to 2000 ft/min (610 meters/min) at low pressures depending on media, shaft diameter and seal material.

3.2 Spring-energized seals with seal material as holding means

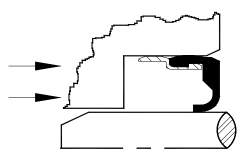
S31 & RS31 series; 71 series


RS31 Series

The interference-fit, O-ring, or flange design retain the seal. The flange design prevents seal rotation and eliminates one potential leak-path on the outside perimeter of seal ring. The canted-coil spring provides positive, constant seal energizing.

3.3 Memory lip seal types—with and without metal locking rings

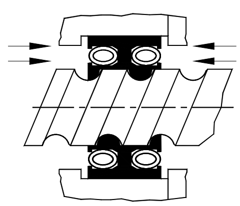
KP/KPF series; PB series


KP Series

The memory lip is designed for high-speed and low-pressure applications. The seal is retained by either locking ring or press-in. A spring is not required for seal energizing due to the memory lip design. These seals may be used at speeds to 3500 ft/min (1067 meter/min) at very low pressures depending on media, shaft diameter and seal material.

3.4 Customized seals

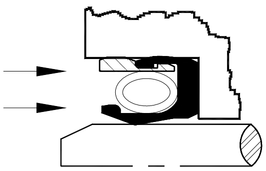
Special designs
(Sealing ball screws)


Ball Screw Seal

Bal Seal Engineering offers exclusive seal designs for special applications – heavy-duty service, unusual gland configurations and special customer requirements. The customized seal designs include tandem or double cartridge seal designs with backup rings. Bal Seal Engineering also offers clearance seals, ball-valve seals, ball-screw seals, butterfly anti-blowout seals and bearing-seal packages. Suitable as an environmental seal.

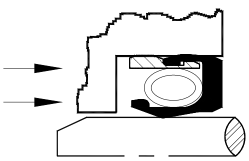
4.0 HARDWARE DESIGN CONSIDERATIONS

4.1 Gland configurations



KF31 Series Captivated

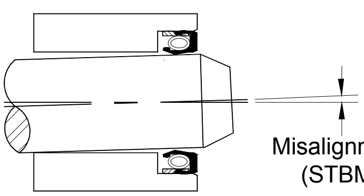
BAL Seals for rotary service press into the housing in a captivated or uncaptivated groove. Captivated seal glands are used under a wide range of pressures [vacuum to 3000 psi (211 kg/cm^2)]. Speed is dependent on the media, shaft diameter and seal material.



KF31 Series Uncaptivated

Uncaptivated grooves are suitable for low pressures less than 15 psi, requiring relatively low force to retain the seal into the housing. Suitable for use at speeds to 2000 ft/min (610 meters/min) depending on media, shaft diameter and seal material.

4.2 Shaft/Bore tolerances, shaft runout, STBM



The seal performance can be substantially improved by minimizing variables on the shaft, such as tolerance, shaft runout and misalignment between the shaft and bore. An excessive radial shaft/bore movement can cause shaft fretting and excessive leakage at the seal lip, which can considerably reduce seal life and performance. See page 6 of the BAL Seal DM-5 catalog for the recommended tolerances for the shaft/bore.

4.3 Shaft/Bore surface finish

Rotary seal performance is governed to a great extent by the finish of the mating surface over which the seal rotates. The surface finish has a significant effect on friction, wear and sealing ability. The better the surface finish, the lower the seal wear. A smoother finish creates greater sealing contact between the seal and mating surface, thus improving sealing ability. A surface finish of 4 to 8 Ra is generally recommended for most rotary applications. Request Technical Report 78 for complete technical data on surface finish.

4.4 Shaft/Bore chamfers

To avoid seal damage during installation, use chamfers on both the shaft and the bore. Glands should be fabricated per the dimensions indicated on page 7 of the DM 5 Catalog. They should be free of burrs, sharp edges and nicks. Lubricating the seal and gland will ease installation. If the gland does not have chamfers, use the assembly tools to reduce the chance of damaging the seal during installation.

4.5 Shaft materials

Generally, the harder the material, the lower the molecular adhesion that occurs between the seal and the sealing surface. Therefore, harder materials are always preferred for a long seal life. However, customer should also consider the chemical compatibility when they decide what material to use for their applications. See Technical Report 15 and Technical Report 78 for information on the different shaft materials and their applications.

4.6 Shaft/Bore hardness

As mentioned above, the hardness of the surface in contact with a rotary seal has a significant effect on seal wear. Adhesion is lower between a soft PTFE seal and a hard mating surface, resulting in reduced friction. Higher hardness reduces wear and increases seal life. The shaft hardness of Rockwell C 58 to 62 is recommended for medium- to high-speed rotary applications.

4.7 Shaft plating

Some of the stainless steels, such as types 304, 316, and 316, provide good chemical compatibility but only a moderate degree of hardness. These materials are often chrome or electroless nickel plated to provide an added degree of hardness.

4.7.1 Dense chrome plating

Use for general-purpose applications; very thin layers from 0.0002 to 0.0006 inch per side; good surface finish; good resistance to wear; good corrosion resistance; Rc 70. Request Technical Report 14 for more information.

4.7.2 Electroless nickel plating

Use for general-purpose applications; good surface finish; good resistance to wear; excellent chemical compatibility; for bores; Rc 50 as plated; Rc 62 after heat-treating. Request Technical Report 16 for more information.

4.8 Radial clearance (E-gap)

The radial clearance, or E-gap (extrusion-gap), between the shaft and bore has a significant effect on seal performance at medium to high pressures. As system pressure and temperature increase, the clearance must be reduced to minimize the possibility of extrusion. Extensive testing conducted by Bal Seal Engineering, we have established recommended clearances based on pressure, temperature, seal diameter, seal cross section and other factors. See page 7 of the DM-5 Catalog for a list of suggested radial clearances.

5.0 FACTORS THAT AFFECT SEAL PERFORMANCE

The performance of a rotary BAL Seal is not dependent on just one or two operating conditions, but on a variety of factors working simultaneously. Selection of a rotary BAL Seal for a particular application requires a complete understanding of media, speed, pressure and temperature.

5.1 Seal operating conditions—media, speed, pressure and temperature

Media

The fluid media has a substantial effect on seal wear. Gases have the highest wear for the same PV values, followed by water and oil. Therefore, the media is one of the most important factors in seal jacket material selection. Liquids around the lip dissipate heat from the seal interface and reduce temperatures. Reducing interface temperatures improves seal performance. Some liquids also provide a lubricating film, which tends to reduce friction and improve seal performance.

Speed

Surface speed is one of the most important determining factors in seal performance. Rotary lip seal life is directly proportional to the rate at which the seal absorbs the effects of frictional heat. Therefore, the seal life is a direct function of the rotational speed of the shaft. The higher the surface speed at which the seal operates, the higher the temperature at the seal underlip, and the shorter the seal life.

Pressure

The pressure also has a significant affect on seal life. The pressure acting on the seal is a combination of forces derived from the interference between the seal and the shaft due to a residual stress developed by the sealing lips. Also, any spring force that may be applied on the seal and the applied media pressure affects seal life. As pressure increases, the force pressing the seal against the mating surface increases. This results in greater friction, which may produce increased seal wear. The system pressure should be maintained at the lowest possible level to reduce the PV values and obtain optimum BAL Seal performance. Higher pressures require special seals with a thicker back wall or backup rings.

Temperature

The temperature at the seal underlip is always the most significant factor that affects seal life. The temperature at the underlip may be derived from the fluid temperature or the combination of speed, pressure, seal material or seal design. The rapid transfer of heat away from the seal also plays a major role in enhancing seal life. The cooler the seal can run, the longer the seal life.

5.2 Seal materials

Rotary seal life is substantially affected by proper selection of the seal jacket material. Friction, a measurement of the resistance to sliding between a seal and hardware surface, is directly related to seal material coefficient of friction and total load. PTFE has one of the lowest coefficients of friction of any solid. Certain materials substantially improve wear resistance than others materials, and the fluid media in which it is being used affects such materials.

5.3 Seal designs—spring-energized and memory lip

Rotary PTFE BAL Seals operate on the same principle as elastomeric seals. There are certain limitations inherent in the material, such as less flexibility and higher material price. Also, the material needs to be machined instead of molded, which limits the shapes into which the material can be made. To overcome the limitation and lack of flexibility, sealing lips are made substantially thinner, spring-energized and, in some cases, with radial or helical grooves to permit lubrication at the seal contact points. PTFE rotary lip seals are used in those applications where elastomeric seals cannot perform, usually due to lower friction, chemical compatibility, extreme temperatures and ability to operate in non-lubricated applications. Bal Seal Engineering offers excellent seal designs that solve numerous application problems and provide outstanding seal performance. Please see Section 3.0 "PTFE Rotary BAL™ Seal Types" of this report for detailed design features.

5.4 Hardware conditions

As mentioned in Section 4.0 “”Hardware Design Considerations,” existing hardware conditions for “change-out” seal designs are an important consideration. Generally, for new applications, the customers are open to Bal Seal Engineering’s recommendations for their hardware designs, such as dimensions, tolerances, shaft runout, STBM, surface finish, and surface hardness. However, for existing applications, many times the seals failed prematurely and were sent back to Bal Seal Engineering for seal failure analysis. In most of the cases, we discovered that the seal prematurely failed because of the improper hardware conditions – too much tolerances, rough surfaces, too soft piston material or misalignment of the shaft. To achieve the most optimum sealing solution possible, submit all current hardware information to obtain the most optimum sealing solution possible. Sometimes, the conditions of the hardware are upgraded to correct the cause of seal failure.

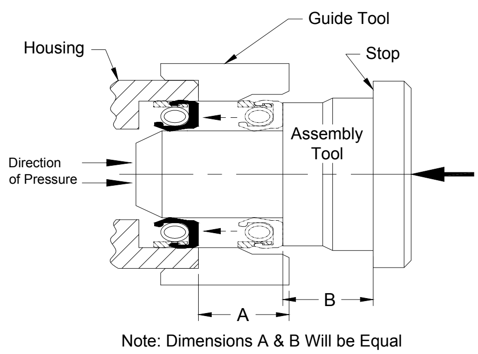
5.5 Seal cross-section vs. seal diameter

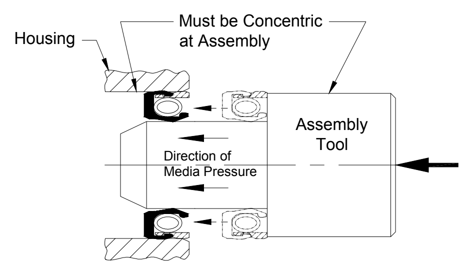
For optimal performance, match the seal cross-section to the corresponding seal diameter to achieve the best sealing stability with minimum frictional force or torque. A small seal cross-section develops less pressure sealing force, which may promote longer seal life. However, a large diameter in relation to the seal cross-section may create instability, leakage and reduced seal life. Variations may be made depending on conditions. For example, at high speeds and in conditions of high eccentricities and angular misalignment, a larger cross-section may be more suitable. If low friction is desirable with long seal life, then a small cross section may be more suitable. Consult our Technical Sales Department for assistance.

5.6 Seal installation

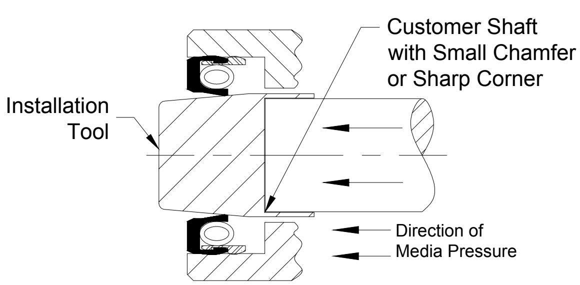
Improper installation is one of the main causes of premature seal leakage and failure. Rotary BAL Seals are precise components that must be assembled properly to obtain the reliability expected for the application. Fluoroplastics have less elasticity than elastomers, so stretching or manipulating the seal into the gland can reduce seal performance. Seal assembly into the housing should be done **straight** using assembly tools (shown) to avoid cocking the seal. Whenever possible, lubricate the seal and the housing prior to assembly. Make sure that components have proper lead chamfers, smooth edges and smooth surfaces.

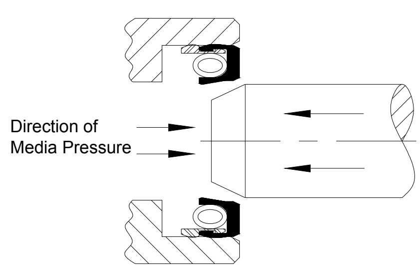
Note: 1. Dimensions A and B will be equal.
2. Guide and pusher diameters to be concentric within 0.002 in (0.051 mm) to the housing's seal bore. (See form 0-993 for more detailed information.)





5.7 Shaft Assembly





Assembly of customer shaft into the seal with no chamfer on the seal or shaft

Assembly with chamfer on the customer shaft and seal. Note: Chamfers must be per Bal Seal specification (Refer to DM-5 catalog

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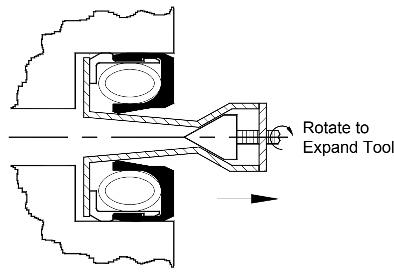
5.8 Seal removal

To avoid damaging the seal and the housing, use method shown below. For additional information, refer to page 8 of our DM-5 catalog and technical report, TR-97, for assembly and disassembly methods.



Removing a Bal Seal

6.0 ENGINEERING SUPPORT

Bal Seal Engineering Company is committed to providing high-quality service and high-quality products that customers deserve. We are a customer-centered company that strives for excellent customer service and satisfaction. Bal Seal has experienced sales representatives, design engineers and R&D engineers available to provide answers to your questions and solutions to your specific applications.

Proposals

Bal Seal Engineering will provide you with proposals for your specific applications. The proposals include the actual seal design, dimensions, tolerances; seal design descriptions, hardware recommendations and quotations.

Technical Reports and Product News

Bal Seal Engineering Company focuses on innovative product technologies and ongoing research and development of PTFE rotary seals. Technical reports (TR's) and Product News (PN's) are regularly issued and updated. They are provided to give you the latest and most accurate information.

Please call Bal Seal Engineering's Technical Sales Department with any questions or inquiries.

Reference:

DM-5 Catalog	621-5	Solutions for rotary applications
TR-4A	100-54-1	The influence of surface finish on Bal Seal performance
TR-7	100-66	Use of Non-Ferrous metals in contact with Bal Seals in Dynamic Service
TR-8A	100-30-9	Properties of Bal Seal PTFE Materials. Physical Properties Definitions
TR-10	47-9/100-41	The effect of wet lubrication on Bal Seal performance
TR-14	100-48/100-49/100-49-1	Chrome Plating
TR-17	48-7-3	Hard anodizing of aluminum alloys and its effect in Bal Seal performance
TR-24	45-6-1	Ion Implantation, PVD and CVD andits effects on Bal Seal performance
TR-29	100-45	Methods of obtaining surface finishes
TR-97	50-608	Suggested tools or disassembling 'K' series Rotary Bal Seals from housing-bore

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