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Technical Article

Power Transmission Engineering:

Recommendations for Bearing Seals

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Recommendations for Bearing Seals

Abstract

Equipment downtime and reduced component life are a few of the consequences – and potential costs – of using the wrong seals on many types of industrial equipment including pump bearing frames, electric motors, fans, pillow blocks, gearboxes and more. However, if correctly specified and installed, seals can provide effective barriers that both retain lubricants as well as protect against water, corrosion, debris and other contaminants.

Simply put, seals are used on rotating shafts to form a barrier with two basic functions: retain lubricants and exclude contaminants. In a typical application, an oil seal – also known as a rotary shaft, grease, fluid or dirt seal – is usually located adjacent to the bearing on most equipment. To retain the lubricant and prevent leakage, oil seals are designed to seal the spaces between stationary and moving mechanical components, such as the housing and shaft, which are found in nearly every type of machine and vehicle in operation.

Standard bearing seals often can't stand up to the toughest conditions. Talk to an expert about specific application requirements before selecting an elastomer compound.

Selecting The Right Seal Elastomer Compound

For seals to perform adequately and prevent abrasives, corrosive moisture and other harmful contaminates from entering sensitive equipment, the selection of the seal elastomer compound is critical. The application parameters and external environment in which a seal will operate need to be closely considered before choosing a compound. For general industrial environments, the most widely used elastomer is nitrile, due to its excellent abrasion resistance properties. The second most common elastomer is fluoroelastomer, preferred for its chemical and heat-resistance capabilities.

Although two of the most important application parameters are temperature and lubricant type, it also is important to determine if any environmental contaminants will have an adverse chemical effect on the seal elastomer compound. Chemical compatibility tables are available from most seal suppliers but provide just a general guideline. For an in-depth analysis of elastomer compatibility, be sure to consult a seal engineer.

Other application parameters that must be considered are shaft run-out, shaft-to-bore misalignment, shaft speed and pressure. Bear in mind that these parameters may vary greatly from one application to another. While operating a seal at the extreme of just one parameter may have a small effect on its performance, operating it at multiple extremes in a system might have a much greater impact.

The temperature limitations and general fluid/lubricant compatibility for the most common and premium seal elastomer compounds are shown in Tables 1 and 2 on pages 3 and 4. It is important to note that since seal manufacturers each have their own proprietary elastomer formulations, the information in the following tables may vary from one manufacturer to another.

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Table 1:
Most common materials and compounds for sealing elements.

Elastomer Compound	Advantages	Disadvantages/ Limitations	Temperature Range
Nitrile	Low cost. Good low-temperature capability and abrasion resistance. Low swell in hydrocarbon fluids.	Does not have excellent heat resistance. Poor resistance to lubricants containing sulphur or EP additives, hydrocarbons/ oxygenate blends (gasoline/methanol). Poor ozone resistance.	-40° F to 225° F -40° C to 107° C
Polyacrylate	Resistance to EP lubricants. Higher heat capabilities than nitrile. Low swell in hydrocarbon fluids.	Limited to low-temperature capability. Poor dry-running capability. Subject to attack in aqueous media. Higher cost than nitrile.	-20° F to 300° F -29° C to 49° C
Silicone	Good dry-heat resistance. Excellent low-temperature capability. Good ozone resistance.	Easily damaged during installation. Poor chemical resistance to certain EP additives and oxidized oil. High swell, poor dry-running performance. Higher cost than nitrile.	-80° F to 350° F -62° C to 176° C
Fluoro-elastomer	Excellent high-temperature capabilities. Compatible with wide range of fluids. Very long life.	Poor resistance to basic (high pH>7) fluids. Attack by high-performance gear lubes. Expensive relative to other materials.	-30° F to 400° F -35° C to 204° C

Table 2:
Premium materials and compounds for sealing elements.

Elastomer Compound	Advantages	Disadvantages/ Limitations	Temperature Range
Ethylene-Acrylic (Vamac®)	Higher heat capabilities than nitrile or polyacrylate. Better low temperature performance than polyacrylate. Good abrasion and dry running capability. Intermediate cost.	High swell in hydrocarbon fluids. Limited capabilities to follow eccentric shafts or perform in high-frequency applications.	-30° F to 325° F -34° C to 163° C
Tetrafluoro-Ethylene Propylene (Aflas®)	Better chemical resistance to all hydrocarbon fluids, acids, bases and oxidizing agents than fluoroelastomers. Capable of performing in the complete range of hydraulic fluids.	Poor chemical resistance to hydrocarbon/oxygenate blends (gasoline/ methanol). Poor low-temperature capabilities. More expense than fluoroelastomers.	-30° F to 400° F -34° C to 204° C

Sealing System Preparation

Once the proper seal elastomer compound is selected, it is essential to determine if the equipment components are properly specified in order to ensure good seal performance. More specifically, the seal is only one part of a sealing system, and its performance is dependent on the proper shaft and bore specifications to function correctly.

According to the Rubber Manufacturers Association (RMA), several shaft requirements should be considered at the original equipment design stage or during any upgrades. These considerations include shaft finish, grinding lead, hardness, diameter tolerances, chamfer, material, potential shaft-to-bore misalignment and dynamic run-out. Of these, the most important are the shaft finish, grinding lead and hardness.

Shaft finish is a major factor in the proper function of a seal and should be specified as 10–25 microinches Ra (0.20–0.60 micrometers Ra) with zero grinding lead. Regarding shaft materials, seals will function satisfactorily on mild steel, cast iron or malleable iron shafts. Under normal operating conditions, the section of the shaft being contacted by the seal lip should be hardened to Rockwell C30 minimum. In applications where the shaft may be nicked or damaged during handling or assembly, or for shafts that operate in harsh abrasive environments, a Rockwell C45 minimum is recommended. Again, for a deeper analysis of the shaft chamfer, misalignment and other parameters, contact a seal engineer to discuss application details.

Meanwhile, in situations where the shaft does not meet the requirements for optimal seal operation, wear sleeves are typically available to provide the surface necessary for good seal performance. Not only does a wear sleeve provide the required surface, but it also offers a cost reduction to the alternative of refinishing the shaft to provide an adequate running surface for the seal lip.

Maintaining the proper bore specifications also is important to the integrity of the sealing system. To ensure proper fit of the selected seal, manufacturers' recommendations for bore tolerances and press fits should be followed closely.

Another characteristic to take into account is the bore configuration. The lead corner of the housing bore should be chamfered for ease of seal installation. It is important to take notice of rough corners or burrs that can scratch the seal outside diameter (O.D.) and cause potential leakage paths.

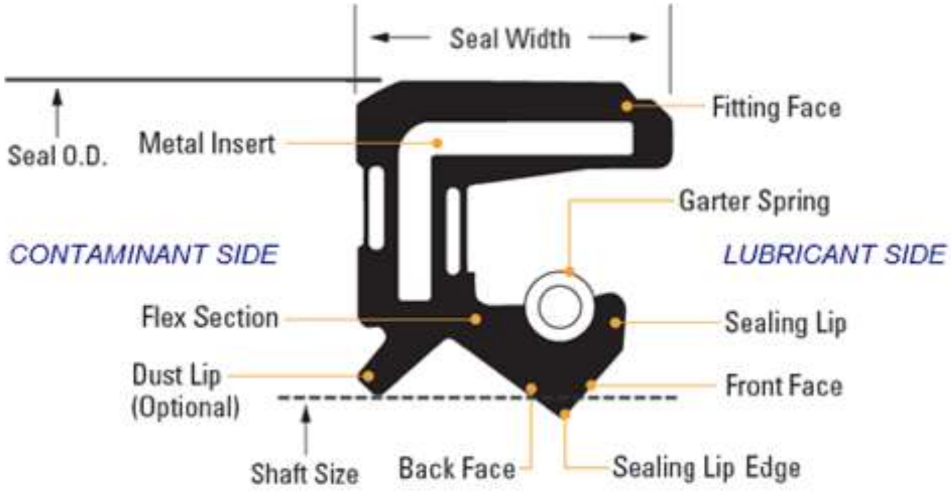

Figure 1:
Rubber O.D. dual lip seal nomenclature.

Basic Seal Design

The most widespread seal design in use today is shown in Figure 1 which is a typical rubber O.D. dual-lip seal. A garter spring is located behind the main seal lip which retains the lubricant. There is a secondary dust lip next to it that faces the opposite direction to exclude contaminants.

The four most popular seal designs are shown in Figure 2. The main difference is the O.D. of the seal. Metal O.D. seals typically provide slightly better retention in the housing bore than rubber O.D. seals. However, their

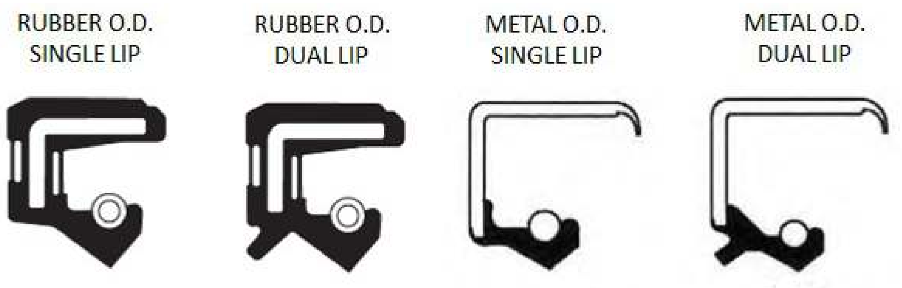

Figure 2:
Most widely used seal designs.

carbon-steel cases may rust depending upon the environment, while the rubber coating of the rubber O.D. seals provide additional protection to the metal insert. For many standard applications the seals may be considered interchangeable. Dual-lip seal designs have the optional dust lip and should definitely be used in contaminated environments. All of these types of seals are available in both metric and inch sizes.

Proper Installation For Maximum Performance

Even if the proper seal elastomer compound, seal type and equipment design are selected and verified, the reliability of the sealing assembly still relies heavily on successful installation. Proper installation steps include:

1. Inspect the housing bore to make sure it is clean and free of burrs that might distort the seal or scratch the O.D., leading to possible leaks. Check for roundness and make sure the leading edge is either rounded or chamfered.

2. Inspect the shaft for machining burrs, dirt or paint that might damage the seal-lip area, resulting in a leak path. If the previous seal being replaced has worn a groove into the shaft, then that area must either be refinished or covered with a shaft sleeve.

3. Inspect the end of the shaft and remove all burrs or sharp edges. The end also should be chamfered or have a radius to assure the seal lip is not damaged during installation. If not possible, consider protecting the seal lip with a tapered sleeve.

4. Inspect splines and keyways for sharp edges; if present they should be covered with a sleeve, shim stock or tape to protect the seal lip.

5. Inspect the seal itself for damage that may have occurred during shipping and handling, such as nicks, cuts, scratches or distortion.

6. Assure proper seal direction. The main seal lip usually faces the lubricant to be sealed in. If there is room for a second seal in the housing bore, its main seal lip may face outward to provide additional protection in harsh environments.

7. Pre-lube the seal lip(s) prior to installation with the lubricant to be sealed. It is not necessary to lube the O.D. of metal seals, but a very light film of oil should be applied to the O.D. of rubber-coated seals to aid in the installation process and reduce stress during installation. This pre-lube should reduce or eliminate the possibility of a rubber O.D. seal backing out of the bore immediately after installation.

8. Select an installation tool appropriate for the application. The best tool will have a diameter slightly smaller than that of the housing bore and will apply force only on the seal case. Bearing races may be used as an installation tool adapter when "approved tools" are not available.

9. Never hammer directly on the seal. Screwdrivers, drift pins or punches should not be used as installation tools. Steel hammers also are not recommended for use with approved installation tools; the shock of the hammer can potentially dislodge the garter spring. After the seal has started to enter the bore, the seal should be driven or pushed in evenly with only enough force to seat it.

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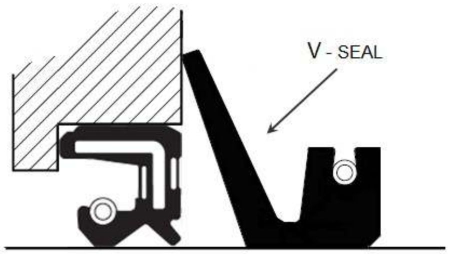

Figure 3:
V-seal.

Additional Options For Harsh Environments

For the most challenging conditions, oil seals are available in a variety of styles, including multi-lip designs. A standard double-lip design, made of nitrile or fluoroelastomer, can be used as a primary sealing element. However, in extremely harsh environments, an optional V-seal should be added outside the oil seal on the shaft to act as a contaminant excluder or back-up seal for additional protection as shown in Figure 3.

Another benefit of the V-seal is its elasticity, which enables ease of installation on a broader range of shaft sizes. V-seals can also be used on eccentric or misaligned shafts.

For more information or expert advice on seals, compounds, preparation or installation, contact The Timken Company or visit www.timken.com/seals.