LIPS OR ISOLATORS?

Keep bearing lubricant in and external contaminant out

By Karyn Caverly, Garlock Sealing Technologies

Shaft seals not only retain lubricant but also protect it from contaminants. Whether contact lip seals or non-contact bearing isolators, the best solution for a given application depends on service conditions, desired performance, and value, or cost plus delivered performance.

Contact lip seals are available in a variety of materials, sizes, and configurations. Made of elastomers molded into angles and contours, these seals act as micro-hydrodynamic wedges that raise the lip and recirculate lubricant to form a thin meniscus of oil on which the seal rides. This reduces friction between the lip and shaft (Figure 1).

There are three basic types of lip seals. General-service seals, using snap-in springs to provide lip load, are made of commodity-grade elastomers that offer satisfactory performance at lower speeds and can accommodate misalignment. High-performance lip seals are made of specially engineered synthetic rubber and incorporate molded-in springs for improved performance and service life. Specialty lip seals are custom-engineered for demanding conditions.

THE ANGLE OF THE LIP AND LOCATION OF THE SPRING PLAY A CRITICAL ROLE IN SEAL DESIGN.

As contact lip seal technology evolves, new materials, geometries, and configurations are being tested for frictional drag between the lip and the shaft. Because hydrodynamic pumping isn't continuous, the lip can come in contact with the shaft, especially during startup. Dry running increases drag and the power required to turn the shaft.

Direct contact also causes grooving on the shaft and wear on the lip. Repairing damaged shafts is costly and time-consuming; seal manufacturers recommend ranges for shaft hardness and surface finish. The oil meniscus is subject to a combination of factors, but mostly radial load, which is the sum of the forces the lip exerts on the shaft.

The greater the load on the lip, the harder it is for the oil to lift it; too little load and the oil will leak past the lip. Radial load mainly is a function of lip material and geometry, the type of spring used, and seal interference. The angle of the lip and location of the spring play a critical role in seal design. Interference is built into the design to develop preload on the shaft and provide greater mis-

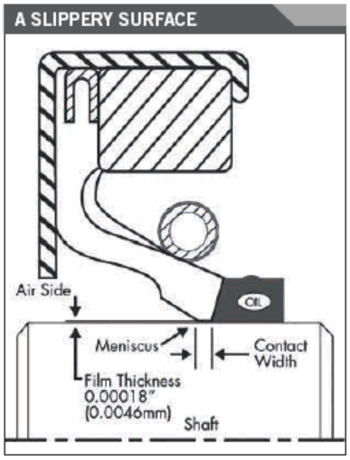

Figure 1. A seal should be riding on thin meniscus of oil.

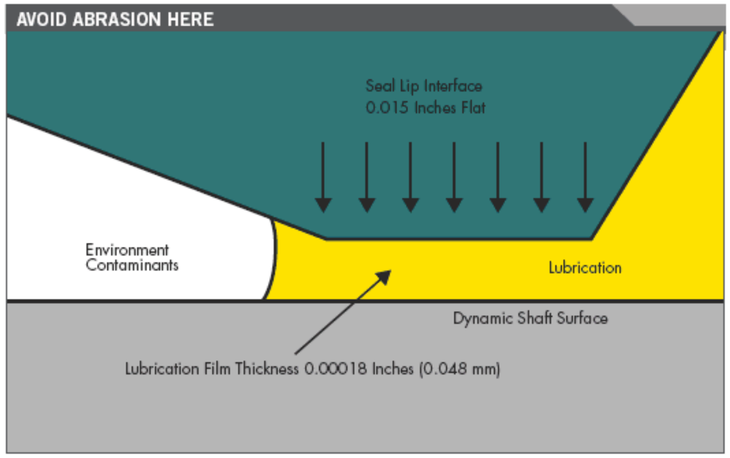

Figure 2. It's critical to know how a seal is going to be used, whether to retain lubricants, prevent contamination, or both.

alignment tolerance. Excessive preload, however, can cause shaft grooving and make a seal difficult to install. Harder elastomers are more abrasion-resistant but can generate too much load, thereby generating heat.

Lip seal performance depends on application requirements. A number of factors affect performance, and taking them into account helps ensure selecting the optimal seal.

It's critical to know how a seal is going to be used, whether to retain lubricants, prevent contamination, or both (Figure 2). If solely for lubricant retention, the lip should be directed toward the lubricant. If it's to exclude contamination, it should point toward the contamination. If you require both, use either a dual-lip seal or two back-to-back single-lip seals.

NON-CONTACT SEALS

The media also might determine seal type. Dry-running applications might require bearing isolators, which need lubrication to prevent wear. Standard bearing isolators also can be used in oil mist or splash applications when the lubricant surface is below the seal. Unlike lip seals, isolator seals are a non-contact means of retaining lubricants and excluding contaminants. Standard labyrinth seals have close tolerances and intricate, circuitous paths with abrupt directional changes to prevent leakage.

Bearing isolators are more energy-efficient than lip seals. With minimal dynamic contact, they present little to no drag. (Figure 3) As a result, they reduce power consumption by as much as 99% and can last 65 times longer than lip seals (Figure 4). The power savings from a single seal might not be impressive, but it's significant when multiplied by the hundreds of pieces of rotating equipment in a typical plant.

APPLICATION DATA

The acronym, STAMPS, provides a guide to selecting the seal. The input needed includes size (shaft, housing bore, and bore depth), temperature (continuous/maximum), application variables (equipment, constant or intermittent rotation, shaft misalignment, dynamic run-out), media (type and level of lubrication), pressure (continuous/maximum), and shaft speed (continuous/maximum).

The size and surface finish, particularly the shaft, can affect lip seal performance. The correct amount of interference is important for proper sealing. Too much results in premature wear; not enough prevents following shaft irregularities, causing a leak. The shaft and bore should fit within the recommended tolerance for the seal. Because the shaft and the sealing element are a primary sealing system, it's important that the shaft surface finish be one that's within the proper range.

A rough shaft finish can cause leakage. Conversely, if too smooth, the sealing element won't form a lubricating film (meniscus), thereby resulting in premature lip degradation. Most seal manufacturers suggest plunge grinding rather than machining, which can form small screw-like trenches that pump lubricant out of the seal and might produce a direct leak path. In addition, shaft and bore chamfers should be machined to prevent damage during installation.

If these factors are within specifications, shaft rotation will produce the hydrodynamic action as microasperities on the lip act as small lube pumps.

Operating temperatures also can affect seal performance. The maximum temperature to which the seal will be exposed should be known to select the correct elastomer material. In oil-lubricated applications, add 50 °F to the maximum process temperature to account for frictional heat at the lip. For

NO CONTACT ON THIS ONE

Figure 3. With minimal contact, a bearing isolator presents little to no drag.

limited grease-lubrication, add 100 °F. A sealing element exposed to temperatures beyond its material rating might harden or crack, resulting in leakage through the cracks themselves or because the hardened material can no longer conform to the shaft surface.

THE ACRONYM, STAMPS, PROVIDES A GUIDE TO SELECTING THE SEAL.

Other application variables include misalignment and runout conditions. Shaft-to-bore misalignment is a static condition whereby the shaft is off-center relative to the bore. Run-out is a dynamic misalignment condition in which the shaft doesn't rotate about its true center (Figure 5).

Excessive misalignment can cause uneven wear and reduce seal life. The degree of misalignment becomes increasingly important as shaft surface speed increases. Most seals can accommodate as much as 0.015 in. of misalignment, but some can accommodate as much as 0.125 in. Seals with high misalignment capabilities are designed to conform to shaft eccentricities without leakage or damage to the seal.

Lubrication conditions also might determine the type of seal that's selected. Dry-running applications might require labyrinth technology (bearing isolators) instead of contact lip seals, which need lubrication to prevent premature lip wear. Table 1 summarizes the differences between lip seals and isolators.

POWER DRAINS

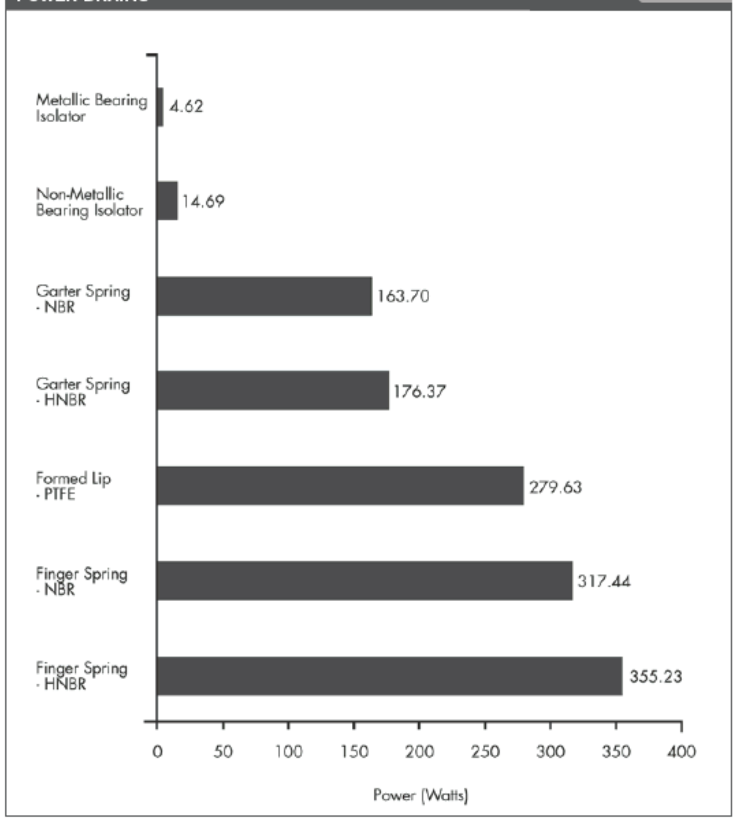

Figure 4. Test results show the power consumption of lip seals and bearing isolators tested on a 3-hp motor.

In addition to lubricants, lip seals might come into contact with other chemicals with which they must be compatible to prevent attack, degradation, and leakage. If the application includes external contaminants, a dual-lip seal might be more effective than a single-lip seal.

Application pressure could be critical because most oil seals are rated at 3 psig to 7 psig, depending on shaft speed. Pressure capability is inversely related to shaft speed — as the speed increases, the pressure rating decreases. High-pressure seals are available, but if exposed to higher than specified pressures, can leak or blow out from the bore housing, posing a significant safety concern.

Different seal types have varying speed ratings. The shaft surface speed can be calculated easily if the shaft size and rpm are known. If surface speed exceeds seal specifications, the temperature at the lip will increase, possibly causing premature degradation, especially under limited lubrication conditions.

SEALS VS. ISOLATORS

Variable	Contact lip seals	Bearing isolators
Temperature	-40 °F to 400 °F (depending on elastomer)	PTFE: -40 °F to 400 °F, metal -30 °F to 400 °F
Equipment	Rotating (constant/ intermittent)	Rotating (constant/ intermittent)
Fluids	Determines elastomer used, specific information needed	Accommodates broad range of media, check compatibility of O-ring material
Pressure	3 psig to 7 psig (depending on shaft speed)	None; oil sump needs to be vented
Shaft	≥ Rockwell C 30-40 hardness, 10-20 micro-inch Ra with no machine lead; plunge grinding required, no surface defects	Maximum 32 micro-inch Ra
Dry running	Not recommended; seal will wear, damage shaft, and fail	Can run dry
Lubrication level	Minimum: Splash lubrication Maximum: Oil level above seal	At or below bottom of the seal
Dynamic shaft run-out/shaft-to-bore misalignment	0.015 in. maximum not to exceed 0.010 in. total, some good to 0.125 in. total, speed dependent	0.040 in. total, axial to 0.050 in. total
Shaft surface speed	1,000 fpm to 7,000 fpm (depending on elastomer and seal design), high-speed applications require frequent replacement because of wear	PTFE: to 4,500 fpm, metal: to 12,000 fpm

Table 1. Lip seals and bearing isolators affect various aspects, such as pressure and temperatures, in different ways.

RELIABILITY / SEALS

STAY CENTERED

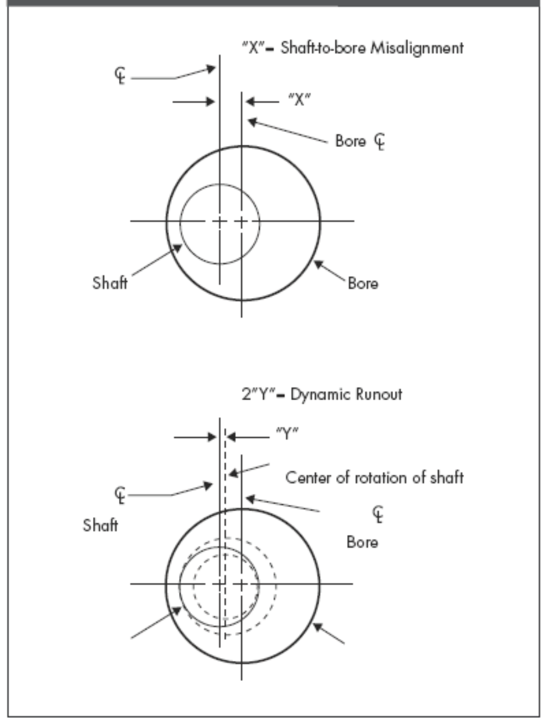

Figure 5. Excessive misalignment can cause uneven wear and reduce seal life.

In addition to the above variables, take into account the performance of the seal being replaced and expectations for the new seal. If the current seal is deemed unsatisfactory, there's little point in replacing it with the same thing. If it leaks, it's helpful to know where and how much. If it shows signs of thermal or chemical degradation, a different seal material might be called for. Application pressure exceeding that for which the seal is rated might require a different type of seal.

A split seal might be the answer if a quick fix or ease of installation is the objective. Dirty, dusty environments such as those encountered in steel mills might call for seals with secondary lips. A bearing isolator or more abrasion-resistant seal might be specified to reduce maintenance and unscheduled downtime.

And, of course, cost always is a consideration. Taking these factors into account, particularly the quantitative STAMPS data, can help to ensure the seal selected will meet or exceed users' expectations.

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