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Control Leaks with Bearing Isolators

by **KwongVoon Wong (James), Project Lead**
Garlock Sealing Technologies
Palmyra, NY

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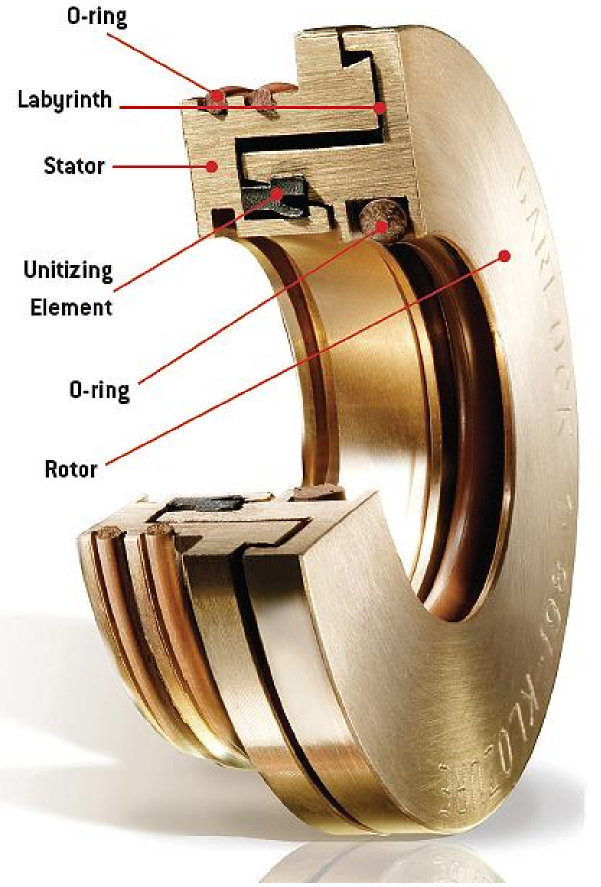
Today’s demanding applications call for other sealing methods. One alternative is the bearing isolator. Advances have created units with little frictional drag and a service life that is up to 65 times greater than that of a radial lip seal.



Although initially designed for electric motors, bearing isolators quickly gained acceptance for different applications and operating conditions. They consist of three key components—stator, rotor and unitizing element. They use a tortuous path, centrifugal force and drain ports to prevent contamination ingress and lubrication egress.

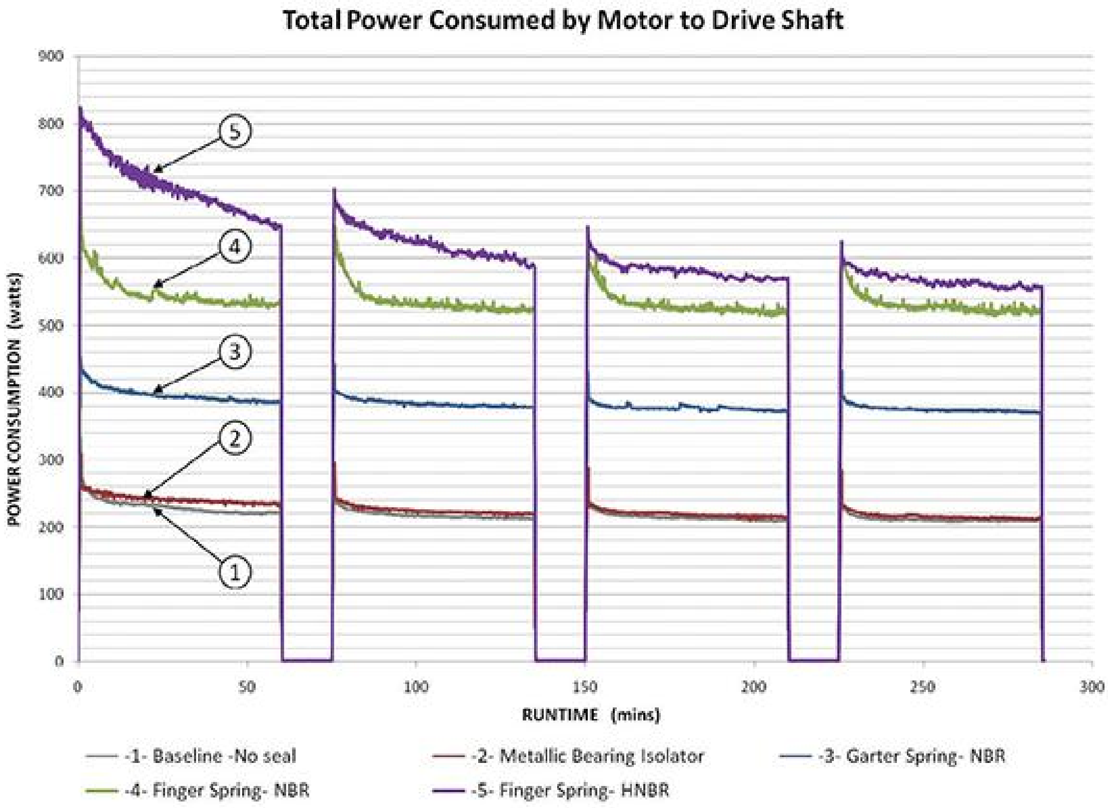
As radial lip seal technology evolves, new materials, geometries and configurations are being tested for their ability to reduce or overcome frictional drag between the lip and the shaft.

Because the hydrodynamic pumping action is not continuous, though, the lip can come in direct contact with the shaft, especially during the dry-running periods of startup and shut down. Dry running increases drag, the amount of force needed to overcome it, and increases the power needed to turn the shaft. Direct contact also causes grooving on the shaft and wear on the lip, shortening the service life of the seal. Repairing damaged shafts is both costly and time-consuming, so most radial seal manufacturers provide recommended shaft hardness, finish and surface texture to counter this problem.

Formation of the oil meniscus between the lip and shaft is subject to a combination of factors, most notably radial load. Also known as lip or contact load, it is the sum of all forces exerted by the lip 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. Lip load is controlled by lip material and geometry, spring type and seal interference, among other factors.

The angle of the lip and location of the spring play a critical role in seal design. Garter springs typically exert less load than molded-in finger springs, but snap-in-place garter springs can roll off the lip and enter the bearing chamber causing premature bearing failure. Interference is built into the lip design to develop pre-load on the shaft and provide greater misalignment capability. However excessive pre-load can cause shaft grooving and make a seal difficult to install. Harder elastomers such as hydrogenated nitrile butadiene rubber (HNBR) are more abrasion-resistant, but can create excessive lip load causing the seal to generate excessive heat.

Correctly determining the optimal amount of lip load without generating unnecessary drag and wear under varied conditions continues to challenge seal manufacturers.



This graph shows the total power consumed by motors for the duration of testing. Spikes reflect the power required to overcome startup torque.

Bearing isolators

Until about a decade ago radial lip seals were the sealing system of choice for rotating equipment, however more demanding operating conditions called for alternative sealing methods. Bearing isolators were developed in the late 1970s to meet these demands, to which have been added energy conservation and responsible environmental stewardship. Advances in this technology have led to development of bearing isolators to replace these traditional seals. With minimal dynamic contact, bearing isolators have little to no frictional drag, so less power is required to rotate the shaft. The average service life of a bearing isolator is up to 65 times greater than that of a radial lip seal.

NO.	TYPE	CATEGORY	MATERIAL	SPRING TYPE
1	Bearing isolator	Metallic	Bronze	n/a
2	Radial lip seal	General service	Nitrile (NBR)	Garter spring
3	Radial lip seal	High-performance	Nitrile (NBR)	Finger spring
4	Radial lip seal	High-performance	Hydrogenated nitrile (HNBR)	Finger spring

For a power consumption test, four different seals were used: a metallic bearing isolator, two high-performance radial lip seals of different materials, and a general service radial lip seal. They were tested using similar idle and startup cycles.

Controlled laboratory testing for power consumption of radial lip seals and bearing isolators indicates that bearing isolators use up to 99% less energy. This translates into 350 watts of power savings for a typical electric motor. Reducing energy consumption also yields a smaller carbon footprint, making bearing isolators the choice for green bearing protection.

Also referred to as labyrinth or non-contact seals, bearing isolators use a tortuous path, centrifugal force and drain ports to prevent contamination ingress and lubrication egress. They consist of three key components: stator, rotor and unitizing element.

Secured by an o-ring or by metal-to-metal press fitting, the stator remains static within the bearing housing. The o-ring design is preferred, facilitating installation, preventing bore damage, and acting as a secondary seal. The rotor is also secured to the shaft with o-rings. As with the stator, the o-rings both retain the rotor and seal the gap between its inner diameter and the shaft, preventing any contamination or lubricant from getting through the seal.

The unitizing element, as the name suggests, holds together the stator and rotor and prevents them from making contact, which would generate heat and cause the metal to expand and the bearing isolator to seize. Stator-rotor contact can also produce metal shavings, which could contaminate the bearing chamber.

Unitizing elements are machined from low-friction material, such as specially filled polytetrafluoroethylene (PTFE). Some bearing isolators also use o-rings to unitize the rotor and stator. All three components are engineered to create a tight path when assembled. The centrifugal force of the spinning rotor and shaft helps to fling contaminants away from the seal. Heavier particles on the rotor are flung radially outwards away from the labyrinth. The faster the rotation, the greater the centrifugal force will be.

When the rotor is in static position, slots and cutouts drain contaminants and lubrication away from the labyrinth. Bearing isolators typically have two sets of drain ports, an expulsion port in front and a drain-back port on the inboard side. These capture any lubricant or contamination and direct it back into the bearing chamber or expel it away from the labyrinth.

There are two primary types of bearing isolators. Made of bronze or stainless steel, metallic isolators include a unitizing element that creates a tighter labyrinth for higher performance. Non-metallic isolators are usually machined from filled PTFE, and are based on the same labyrinth and drain port configuration as metallic isolators. Due to the nature of the material, however, they are limited to lower-speed conditions but are well suited to applications where chemicals would attack metallic isolators.

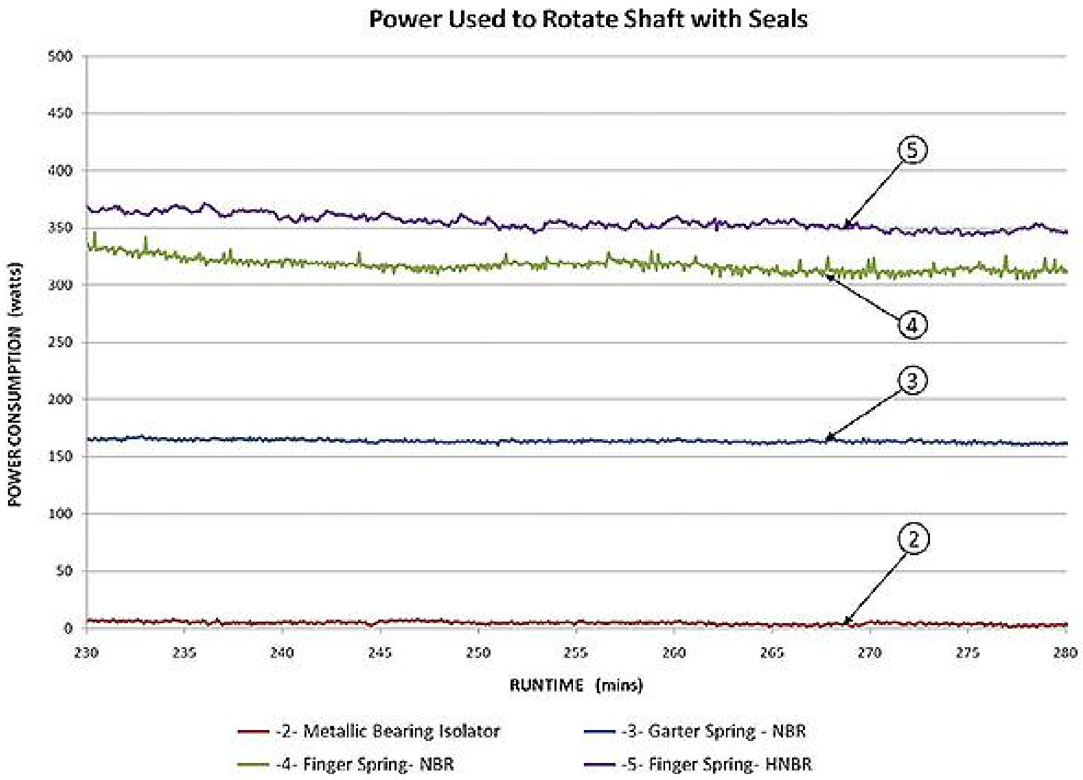
The ‘green’ aspect

Bearing isolators not only offer longer service life, they can also be used under dry running conditions such as those encountered in vertical top motors and tilted pumps. As long as lubrication does not submerge the seal, isolators are suitable for these type applications. Static o-rings on the inner and outer diameters of an isolator provide non-dynamic sealing, thereby eliminating the rubbing motion of lip seals and the cost of hardening or coating shafts to resist its damaging effects.

Besides their mechanical advantages, isolators have a “green” connection. In addition to preventing leakage of potentially harmful lubricants, more than 90% of the materials used in their construction are recyclable, including chips and scraps generated during the manufacturing process. However their biggest contribution to responsible environmental stewardship is reduced power consumption.

Power consumption test

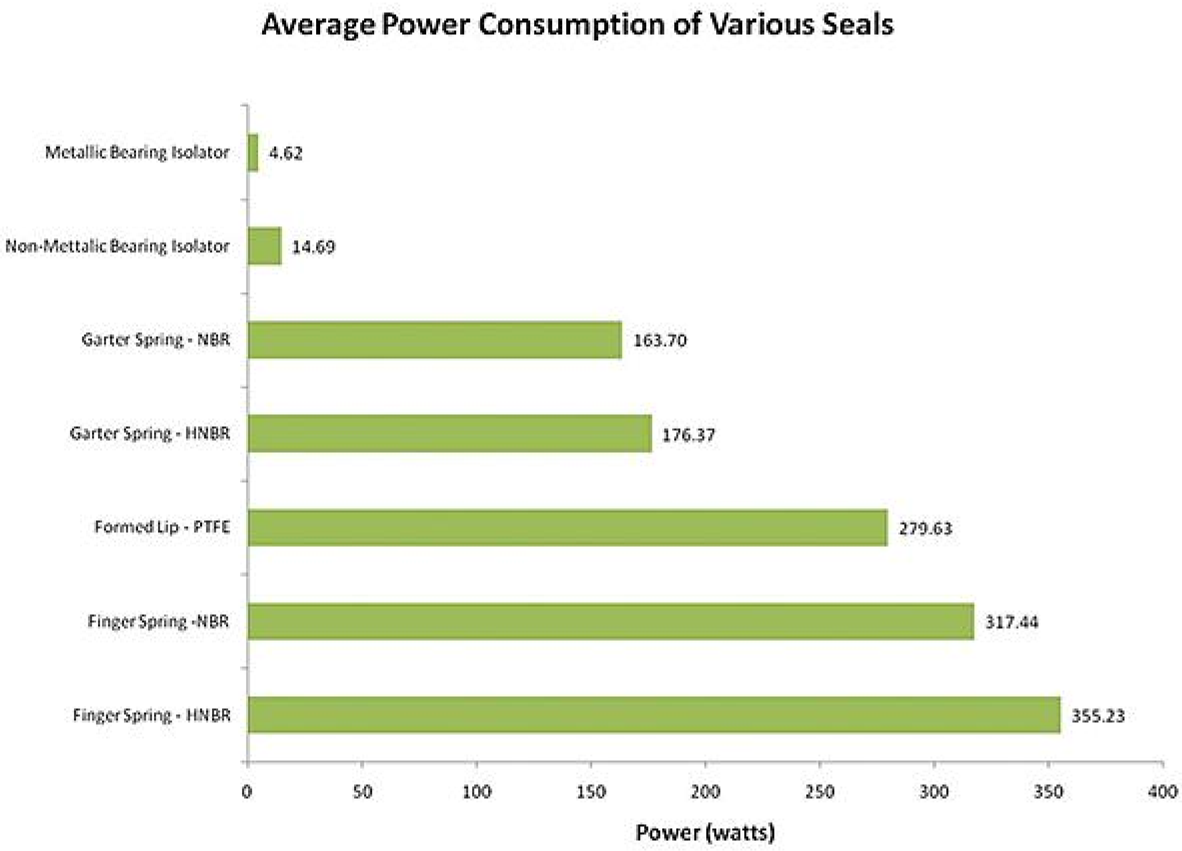
Controlled laboratory testing to compare the power consumption of radial lip seals and bearing isolators was conducted using a simulated shaft driven by a 3 hp motor with the power required to drive the shaft being the primary unit of measurement.



To accurately determine the power consumed to overcome the drag of the seals, the data in the chart were normalized by subtracting the power required to turn the shaft including startup torque; the data were from the fourth test cycle when the seals were broken in.

Four different seals were tested: a metallic bearing isolator, two high-performance radial lip seals of different materials and a general service radial lip seal. The test ran four similar idle and startup cycles.

The total power consumption for each type of seal was recorded and tabulated. Spikes reflect the power required to overcome startup torque.



Comparative power consumption of various other seals. From this chart, it can be seen that bearing isolators consume up to 99% less energy than radial lip seals.

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The seal that consumed the most power was the high-performance HNBR finger spring seal with an average consumption of 355 W. While the molded-in finger spring design yields better performance, it also consumes considerably more energy. By contrast the bearing isolator consumed an average of just 5 W of power, making it the most energy-efficient of the four seals tested.

Other types of seals also were tested and the results are tabulated in the chart. It can be seen that bearing isolators consume up to 99% less energy than radial lip seals.

Bearing isolators more than repay their initial higher cost by longer service life, improved performance and savings from reduced power consumption and maintenance. In addition they can be customized to meet the requirements of diverse operating conditions, and manufactured and delivered quickly to reduce downtime and increase production.

A quick look at Radial lip seals

Radial lip seals have evolved into various materials, sizes and configurations, each offering different temperature, chemical and abrasion resistance. They protect bearings in pumps, compressors, turbines and other rotating equipment by preventing lubricants from leaking or contaminants from entering the bearing chamber. Although cost-effective, they are at best a short-term solution because frictional drag from contact with rotating shafts reduces service life.

Made of elastomers molded into engineered angles and contours, radial lip seals are like micro-hydrodynamic wedges that raise the lip and recirculate lubricant under it creating a thin meniscus of oil on which the seal rides. This hydrodynamic action reduces friction between the lip and shaft.

There are three basic types of radial lip seals:

- General service seals are made of commodity grade elastomers and are suitable for most applications. They offer satisfactory performance at lower speeds and can handle misalignment.

- Snap-in garter springs are usually used to provide additional lip load.

- High-performance lip seals are molded from specially engineered synthetic rubber and incorporate molded-in spring technology for improved performance and service life. Specialty lip seals come in many custom engineered designs for pressurized, unlubricated, and other challenging applications.