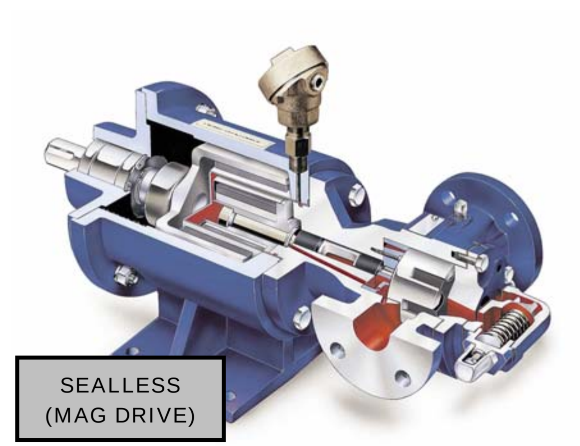
Liquid Containment

The Importance of Liquid Containment

In light of the increasing emphasis on decreasing leakage of pollutants in the industrial setting, there is a need to become informed about sealing equipment under our control. Because pumps are generally considered to be more expensive than the piping, valves, and related accessories surrounding them, pumps are higher profile when they leak. Seal manufacturers are gearing up to meet the challenge but have thus far focused on centrifugal pump principles because their numbers dominate the market. Positive-displacement (PD) pumps may pose special sealing problems because they have been designed to handle viscous, non-Newtonian, or other problem fluids under a wide range of physical conditions. Many factors must be considered in order to arrive at the proper sealing solution.

Types of Shaft Seals



Packing

Packing usually consists of braided or formed rings that are compressed in the stuffing box of the pump. As the packing is tightened, it compresses against the shaft and outer stuffing box bore to create the seal.

Packing is one of the oldest forms of shaft sealing and used to be made from leather, rope, and flax. Modern packing can be commonly found in inert materials such as expanded PTFE, compressed graphite, and granulated elastomers.

Packed pumps are typically the most economical and are common for thick, difficult to seal liquids such as chocolate, molasses, asphalt, resins, tar, and some adhesives. Packing seldom catastrophically fails, allowing for replacement at scheduled shut down dates.

Packing does have several drawbacks however. First of all, packing is a poor seal for thin liquids, especially at higher pressures. Secondly, packing requires lubrication either externally or by the liquid being pumped. As a result, packing must to allowed to leak slightly (weep). This can be messy and in the case of corrosive, flammable, or toxic liquids is unacceptable. Lastly, abrasive particulate has a tendency to embed in packing which can damage the pump shaft. Packing should not be used for handling abrasive liquids without use of a hardened or coated shaft.

Lip Seals

Lip Seals typically consist of a circular elastomeric seal element in a steel outer housing. The "lip" is often reinforced by a spring to help compress it to the shaft.

Lip Seals are common throughout the hydraulic industry and can be found on pumps, hydraulic motors, and actuators. They are typically limited to low pressures and as such, pumps that use them have to be unidirectional so that the seal can be vented to the low pressure inlet side. They are also poor for thin, non-lubricating liquids and abrasives, further limiting their usage.

Recently, multiple lipseals mounted in a gland on a sleeve have been applied successfully against a variety of viscous, nonabrasive liquids *(figure 1)*. Lip design and reinforcement allow operating at pressures to 150 PSI / 10 BAR without supporting fluid pressure behind the lips. Gland ports provide access to interior passages for cooling the lips or to pressurize internally.

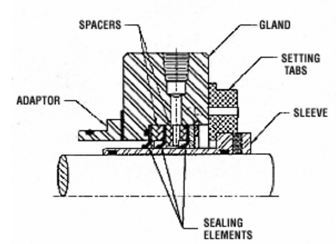


Figure 1
A Cross-Sectional View of a Triple Lip Cartridge Seal

Mechanical Seals

The topic of mechanical seals alone could run on for volumes. In brief, typical mechanical seals consist of highly polished faces (one stationary and one rotating) running against each other to form a seal. These seal faces are extremely flat, usually within about *33 millionths of an inch*. They are virtually leak-free and handle a wide range of liquids, viscosities, pressures, and temperatures. The faces are often lubricated by the liquid being pumped, but can be lubricated by external means. This lubricating liquid provides a thin, hydrodynamic film between the opposing seal faces. Mechanical seals come in a wide range of materials and types, including:

Single Component Seals - Single seals are classified as pusher or nonpusher types with single-spring or multiple-spring sub-classifications. They can be friction driven or positively driven.

Figure 2 is an example of a single nonpusher mechanical seal. Nonpusher seals are characterized by a shaft gasket or bellows that remains stationary with respect to the shaft. A tightly fitted rubber bellows is spring loaded against a soft face. All components are enclosed within a metal retainer and turn with the shaft against a stationary face. As the rotating face wears, the flexible rubber bellows extends to maintain sealing contact with the stationary face.

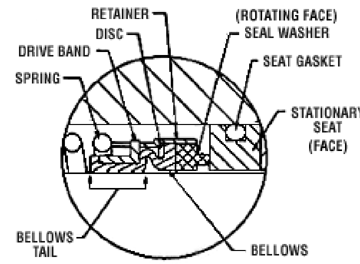


Figure 2
A Nonpusher Bellows Seal

Figure 3 is an example of a single pusher mechanical seal. Whereas in a nonpusher seal the shaft gasket does not move in relationship to the shaft, in a pusher seal, the shaft gasket must move. As the seal faces wear, mechanical and hydraulic forces push the shaft gasket forward to maintain contact with the faces. Pusher type seals can begin to leak when normal product leakage combined with face wear builds up to cause the shaft gasket to "hang up".

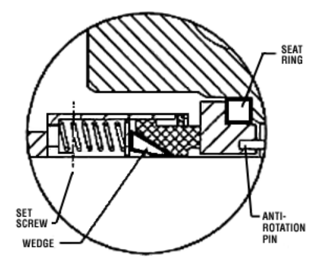


Figure 3
A Positive Drive, Pusher Seal

Figure 3 is also an example of a positive drive seal, which are locked to the shaft by setscrews. They utilize O-ring, Vee-ring, or similar configuration to seal along the shaft and against the rotating face. The stationary face is usually fitted with an anti-rotation device, depending upon face configuration and material of secondary seal. Mechanical links between the seal and the shaft, and among components of the rotating portion, put the seal in the positive drive classification. Frictionally driven seals like figure 2 can only be used in viscosities to 3,300 cSt (15,000 SSU). Setscrew drive can be used in viscosities to 5,500 cSt (25,000 SSU).

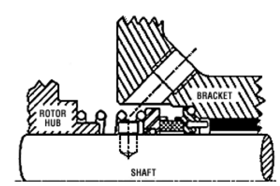


Figure 4
A Positive Drive, Pusher Seal for
Thick and/or Abrasive Liquids

Figure 4 is another positive drive, pusher seal, but utilizes a pin in the shaft to provide the driving means. This, combined with hardened seal faces makes this seal ideal for viscous liquids to over 16,500 cSt (75,000 SSU). It's also widely used for abrasive liquids as well such as paints, inks, and waste oils.

Double Seals - As the name implies, double seals utilize two sets of sealing elements. The seals in Figure 5 are identical to the seal in Figure 3, but are positioned back to back. The space internal to the two sets of seal faces must be hydraulically pressurized in order to close both sets of faces. For best results, the pressurized liquid must be a lubricant and compatible with the product. Internal pressure between the seals is normally maintained at 10 to 15 PSI (.7 to 1.0 BAR) higher than adjacent atmospheric or product side pressure. Thus, the film on the seal faces necessary for lubrication will be

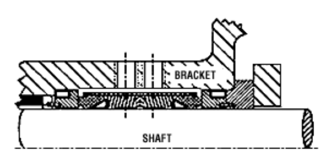


Figure 5
A Double, Pusher Seal

the barrier liquid, not the liquid being pumped. This arrangement can be used to seal noxious liquids, hazardous liquids, or those too viscous for a single seal to handle; because all the seal components are rotating in a "friendly" environment. The barrier liquid protects the seal faces while excluding product and atmosphere. Friction drive double seals have been successful in 33,000 cSt (150,000 SSU) viscosity liquid, and setscrew drive double seals can be applied to 55,000 cSt (250,000 SSU). Pressure on a good lubricating barrier liquid between the seals can be up to 250 PSI (17 BAR).

Tandem Seals - Like double seals, tandem seals utilize two seals, but are oriented in the same direction hydraulically rather than back to back. Both arrangements require the use of barrier/lubricants, but only the double must be pressurized. For tandem seals, only the product side seal rotates in the product, but product weepage across the seal faces will eventually contaminate the barrier lubricant (Figure 6). The consequences of this contamination upon the atmospheric side seal or the surrounding environment depend upon the nature of the product.

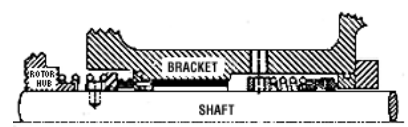


Figure 6
A Tandem Seal

Cartridge Seals - Cartridge seals are complete single, double, or tandem mechanical seals contained within a gland and built onto a sleeve *(figure 7)*. Single cartridge seals will operate within roughly the same physical parameters as component positive-drive mechanical seals. They can handle viscosities to 7,700 cSt (35,000 SSU), pressures to 300 PSI (20 BAR), and temperatures to 400°F (205°C).

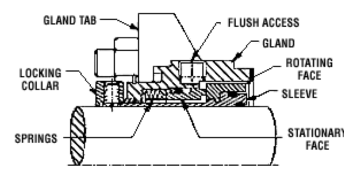


Figure 7
A Single Cartridge Seal

Most dual cartridge seals can be treated as either true double seals or as tandem seals, because each is a mathematically balanced seal *(figure 8)*. The use of a barrier lubricant between seals is required. Lubricant pressure applied internally dictates whether product or barrier liquid will be on the product side seal faces. Pressure is in general limited to 300 PSI (20 BAR). It is safe to assume that dual seals can be successfully applied to viscosities approaching 9,900 cSt (45,000 SSU) at reduced speeds and temperatures to 400°F (205°C). A review of components, secondary seals, and metals may allow application of the cartridge seal at higher temperatures; however, the proximity of antifriction bearings may call for cooling of the barrier/lubricant to assure acceptable bearing life.

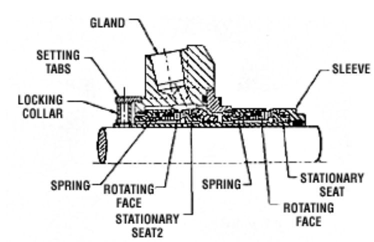


Figure 8
A Dual Cartridge Seal

Gas Barrier Seals - Gas barrier seals, the latest technology in mechanical face seals, are undergoing extensive lab and field testing. These are cartridge-style dual seals with faces especially designed to be pressurized using an inert gas as a barrier between product and atmosphere. The gas replaces traditional lubricating liquid.

In one version, the seal faces separate as soon as the pump shaft starts to revolve. The faces do not come in contact with each other again until the rotation stops. In another version, seal faces remain in light contact during normal operation. Current gas barrier seal designs allow a small amount of gas to escape in the product and for some to escape to atmosphere.

Sealless Pumps

Each of the previous sealing technologies utilizes dynamic sealing, whether it be a shaft rotating in stationary packing or a seal face rotating against a stationary face. Magnetically driven (Mag Drive) pumps use no dynamic seals. They have zero leakage and provide the most reliable seal for hazardous or difficult-to-contain liquids.

Magnets mounted radially around the pump drive shaft are surrounded by a close fitting canister which contains the product circulating through the pump. Magnets attached to the inside wall of a hollow cylinder affixed to the drive shaft and situated around the canister set up a magnetic field. When the drive shaft rotates, the field compels the pump shaft to rotate. The canister wall is not penetrated by either shaft and is statically sealed at its interface with the pump housing *(figure 9)*.

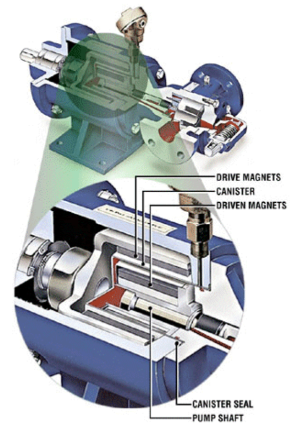


Figure 9
A Cutaway View of a Mag Drive Pump

Mag drive pump applications include corrosive liquids such as sodium hydroxide, hazardous liquids such as sulfuric acid, difficult to seal liquids such as isocyanate, and critical sealing applications such as pipeline sampling of oil. These certainly aren't the only applications however; sealless pumps once made up just a small fraction of the total pump market, but are now the fastest growing area across several markets.

Seal Selection

Packing?... Cartridge Seal?... Mag Drive?... It's difficult to know where to begin. The manufacturer's representative or local authorized pump distributor is a great place to start, but will need all of the pertinent information:

- What is the liquid being pumped?
- What is the temperature / viscosity range?
- What is the pressure range?
- Are any materials incompatible (elastomers or metals)?
- Where will the pump be located? Are there any environmental concerns?
- Past experiences (failed seals or unusual liquid characteristics)?

Even then, there are often several options available so seal selection may also be based on decisions regarding cost, frequency of maintenance, and local resources. After considering all factors involved and being educated as to your options you can be more confident that you've made the best containment decision for the application.