Fluid Sealing Association FSA

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SEALING SENSE

5th Anniversary

What are the basics of gas lubricated seals? (Part One)

This month's *Sealing Sense* was prepared by FSA Member Tom Lai

The use of gas lubricated mechanical seals in pumps has increased for a variety of reasons. This two part article will address the principles of gas seals, some basic application questions, what to expect from seal performance and the environmental factors that may affect performance.

What Are Gas Lubricated Mechanical Seals?

Gas seals run in a clean, controlled fluid environment and are designed to remain non-contacting and non-wearing for the expected operating conditions. Seal faces operate on a barrier fluid film, typically in pressurized dual seal arrangements like in Figure 1.

Typical barrier fluids used in gas seals include nitrogen, steam, purified air or other inert gases. Each of the sealing end faces have some macro-topographic design pattern, are wider than plain face seals and are loaded with lighter spring force. These features enable generation of the hydrodynamic pressures that prevent contact of the seal faces.

Since they are non-contacting and do not wear, gas lubricated mechanical seals produce consistent seal performance, even in a widely varying duty cycle, and reduce power consumption at the seal faces. The seal generates little heat, and any gas leakage absorbs heat away through gas expansion. It is imperative that the seal faces are separated with a gas barrier film. If the faces contact, the seal will not last long running dry at typical pump speeds.

Why Gas?

Since gas has poor lubricity, why rely on it to "lubricate" the seal faces? The reason is that in some pump applications, the process fluid to be sealed can be volatile, non-lubricating and sensitive to heat. It can also polymerize to foul the seal face, corrode the seal parts or be hazardous to the environment.

Dual seal arrangements with liquid barrier fluid are commonly used to overcome the above problems. In situations where the liquid barrier fluid can contaminate the process, or it is cost prohibitive to add the circulating cooled barrier system, the gas barrier fluid can become a viable choice.

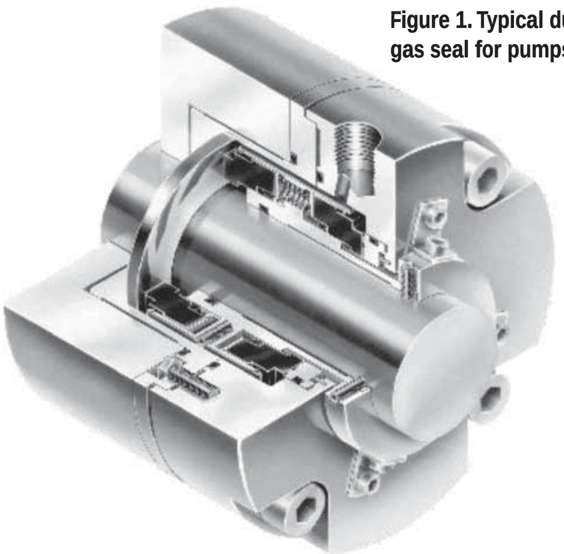

Figure 1. Typical dual gas seal for pumps

A seal support system (example in Figure 2) is usually installed, including a gas control panel with coalescing filter to minimize liquid contamination, ensure cleanness of the gas and monitor leakage flow rate.

What Keeps the Seal Faces Separated?

There are many methods for generating the gas barrier film. The underlying principle uses a shallow step height change on the face to squeeze the film and generate fluid pressure (see Figure 3). Design variations like those shown in Figure 4 include Rayleigh pad, spiral groove, wavy face and others. All demonstrate various capabilities to control the gas flow and generate the face separating pressure.

If the gas pressure generated depends on the relative sliding of the seal faces, it is called hydrodynamic pressure. If it depends only on the pressure differential and is effective even at standstill, it is called hydrostatic pressure. Depending on the operational requirements, typical gas lubricated mechanical seals use varying degrees of combinations of both

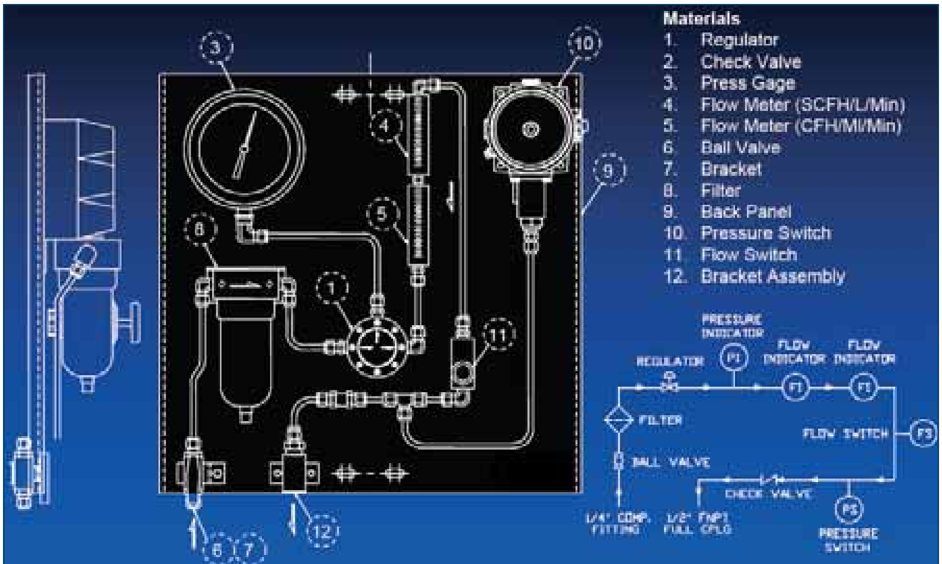

Figure 2. Typical gas seal support system

hydrodynamic and hydrostatic effects to maximize protection for the seal faces. They use carbon-graphite as the primary ring material to run against a silicon carbide or tungsten carbide mating ring, which helps the seal survive short durations of face contact in transient or emergency conditions. For higher pressure applications, carbide primary rings are used to take advantage of higher Young's Modulus and strength.

What Are Acceptable Leak Rates?

Gas leak rates are typically small, in the order of SCFH (standard cubic feet per hour). Predicting the actual leak rate from the theoretical rate is difficult since the leakage is sensitive to manufacturing variations and deviates from the idealized theoretical model. It is better to use the initial leak rate for any specific new seal installation as the baseline for future reference. If the operating leak rate exceeds 10 times the initial, contact the seal manufacturer to see if the seal needs to be repaired.

Barrier gas pressure is typically set at about 30 psi higher than the process pressure. As a rule of thumb, only about one-third of the total barrier gas flow leaks through the inboard seal into the process. Gas ingestion into the process is typically not an issue. The process fluid carries it through the system and vents it out at some stage. However, for a closed loop system, the user and seal manufacturer need to determine if the gas will accumulate and cause operational problem such as cavitation or vapor (gas) lock, which may starve the pump.

What Are the Other Performance Characteristics?

Gas film thickness will vary with the operating conditions. Users need to provide the details of expected duty cycles, not just the maximum pressure and speed conditions, so that seal engineers can ensure reliable seal operation through all phases. Since the seal does not wear, it will not have hysteresis behavior, i.e., the leak rate depends only on the current operating conditions and not on the operation history.

When the seal contacts and runs in dry condition, it generates carbon dust, which may be noticeable along the leakage path such as the gland bore area. High gland temperature may also indicate face contacting the outboard seal. If both signs show up, the pump most likely needs to be shut down and the seal repaired soon.

In an upset condition from too high process pressure or lost barrier gas pressure, most seals are designed to withstand the reversed pressure, but the seal face will contact to prevent the process fluid from leaking into the barrier and the atmosphere thereafter. After the cause of the upset is corrected, depending on the actual scenario, the seal may be able to resume normal operation. Consult with the seal manufacturer to see if the seal needs to be removed for refurbishment. Static leakage measurement can be helpful in assessing the severity of face damage, if any.

Watch For These Potential Problems

A common problem encountered is loss of barrier gas pressure. This can occur when the barrier pressure drops below the set point or the process pressure becomes higher than projected.

Since the seal is lightly loaded by a spring, too much drag on the primary ring may hang it up. The dynamic O-ring is critical to the seal reliability and has been carefully sized to ensure reliable performance. If it stays in a dirty fluid environment, the dirt accumulation will cause extra friction drag and cause the seal to fail. Solid exclusion devices should be incorporated to prevent the dirt from entering the dynamic O-ring area.

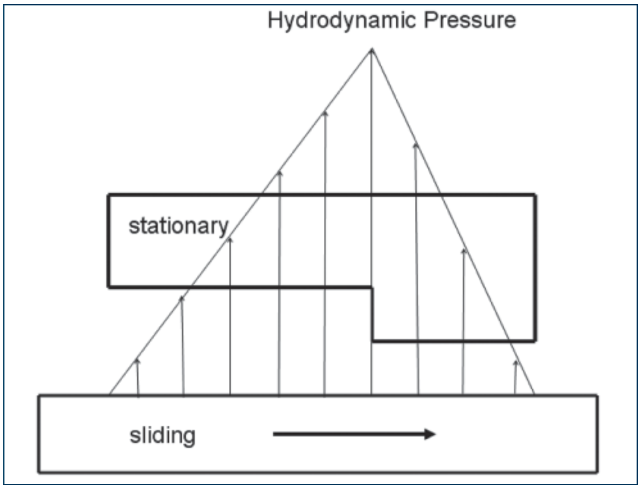

Figure 3. Hydrodynamic pressure generation in a step bearing

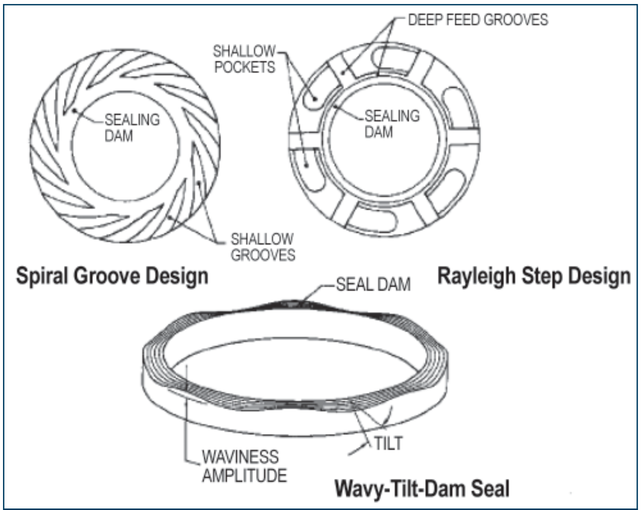

Figure 4. Typical gas seal face patterns

Elastomeric O-rings have relatively low temperature limits. Outside these temperature limits, other secondary seal materials and designs, such as metal bellows seal, should be considered.

Sometimes the metal bellows is used to avoid the seal hang up problem. Liquid contamination in the barrier gas, as can occur with steam, may cause a larger face separation than the seal was designed to handle. This will lead to a higher leak rate but should not damage the seal. After the liquid passes through the seal face, the seal should return to normal performance if the liquid does not leave any deposit on the face.

Conclusion

Gas lubricated seals are relatively recent developments in pump seal technology. They provide a new approach to double seals for controlling pump emissions, minimizing heat generation and reducing power consumption. A number of design combinations are available specific to application requirements. This *Sealing Sense* provided some design and functional principles, and Part Two will further address application issues and guidance.

Technology improvements are ongoing, so it is important to consult with a seal manufacturer to take advantage of the latest designs and application information.

Next Month: *What are the basics of gas lubricated seals? (Part Two)*

We invite your questions on sealing issues and will provide best efforts answers based on FSA publications. Please direct your questions to: sealingsensequestions@fluidsealing.com.

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