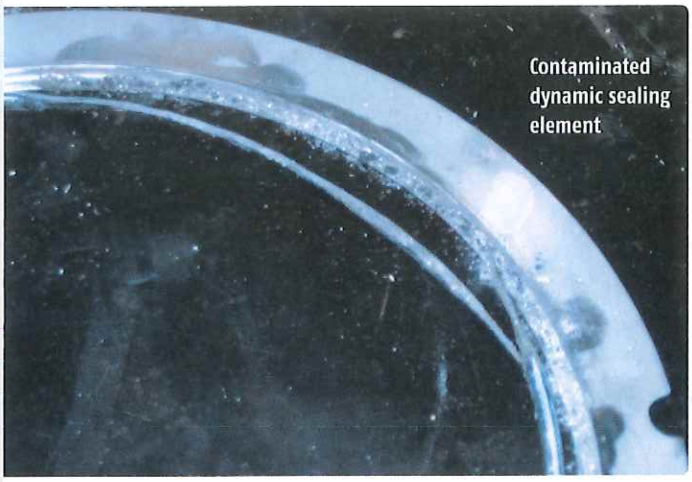
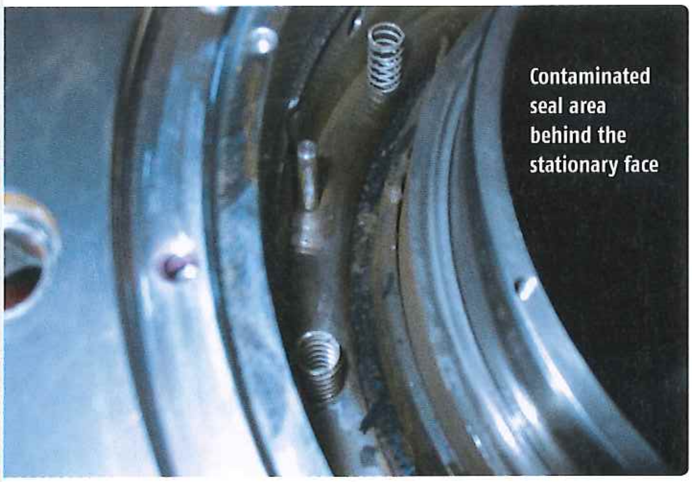
EVERYTHING MUST RUN SMOOTHLY



Contaminated dynamic sealing element



Contaminated seal area behind the stationary face

Damaged seal face

Pictures: Eagle Burgmann

Reliable gas supply solution for compressors to avoid seal contamination and failures — Process gas centrifugal compressors are typically equipped with gas seals to prevent gas from escaping between the stationary compressor body and the rotating shaft. Compressors are normally shut down when high seal leakage occurs, indicating a seal failure. Experience shows that the major root cause for high gas leakage is the contamination of the seal. How can it be avoided?

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The most common gas seal arrangements used in the industry for compressors are tandem arrangements, or tandem with intermediate labyrinth arrangements, which will be used as basis for this article. Tandem seals consist of two sets of sealing faces (see box on the right). The set closest to the process gas is known as the primary seal. The second set on the bearing side of the seal is known as the secondary seal. The secondary seal is a backup seal in case the primary seal fails. Contamination can enter the seal from the bearing or the process gas side of the seal. This describes the contamination of the primary seal here, as this is the major cause of seal failures or high seal leakage alarms during or after a long period of pressurized standstill of the compressor.

Gas seals are generally very robust and reliable seals. Ensuring the reliability of gas seals requires a supply of clean and dry gas (seal gas) at all times. Since process gas is a gas, how does it affect the operation of a gas seal? The gas leaking across the faces is low and should not have a detrimental effect on the seal. The quality of gas is the problem and the fact that not all components of a gas will stay in a gaseous phase when the gas temperature or pressure changes.

Contamination of the gas seal results when untreated process gas is allowed in and around the primary seal. A clean gas supply is provided to ensure that potential contamination—like particles or fluids—inside the process itself does not enter the seal.

Typically, process gas is taken from the discharge nozzle of the compressor. This gas is routed through a filter and regulated to a suitable pressure or flow to ensure clean seal gas supply to the primary seal. The majority of seal gas flows across the process labyrinth back into the process. A minimum

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This article is based on an White Paper, you can download at process-worldwide.com (see Process-Tip).

velocity of 5 m/s (16.4 ft/s)—at twice the nominal labyrinth clearance—should be maintained underneath the labyrinth towards the process to ensure no contamination enters the primary seal. An alternative to using process gas would be to use an external gas source.

The seal gas flows in two directions; a small amount flows between the seal faces as controlled leakage and is then routed to the primary vent together with the secondary seal gas. The majority of the seal gas flows underneath the process side labyrinth back into the process. Different scenarios that contaminate the gas seal are possible.

Contamination by Particles

Particles present in the process gas can contaminate the primary seal when the seal gas flow across the process side labyrinth is insufficient, or if the provided filtration or conditioning is inadequate for the seal gas to produce the required quality of gas. In consequence, particles can enter the gas grooves on the rotating face and the sealing gap. If the particles are small enough, they will blow through the seal. Larger particles will get trapped inside the grooves or gap, causing negative effects to the sealing behavior or seal reliability. In addition to the sealing gap, particles can also block the dynamic sealing element.

The dynamic sealing element is an O-ring or elastomer free sealing device between the non-rotating seal face and the balance sleeve. The non-rotating seal face must slide together with the dynamic sealing element on the balance sleeve, axially compensating for axial position or movements of the compressor shaft in relation to the seal housing. The non-rotating face must also move freely to adjust for any movements resulting from the normal seal behavior. If the dynamic sealing element is prevented from moving freely to adjust for axial movements, this will affect the seal gap and lead to high seal leakage if the faces are kept open, or will cause primary seal failure in case the faces stay in contact.

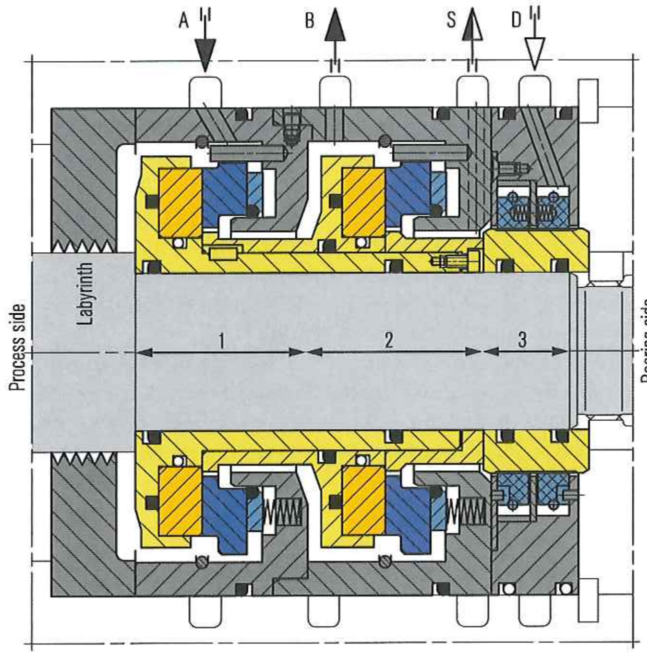
Technical Background

HOW A DRY GAS SEAL WORKS

The key elements within a Dry Gas Seal are the seal faces and secondary sealing elements. A shaft sleeve, which is fixed to the compressor shaft, holds the rotating seat. The rotating seat is sealed against the shaft sleeve with a secondary sealing element, which is a special O-ring or PTFE filled sealing device. The rotating seat has integrated gas grooves to generate an aerodynamic lift off and provide gas film stiffness during operation.

The non-rotating elements are a combination of the seal housing, which is fixed to the compressor casing, and the non-rotating seal face. The stationary elements are designed to compensate for axial movements of the compressor rotor in relation to the compressor case. The compressor shaft is exposed to axial movement caused by different loads and case expansion from heat and pressure or vibrations. Compensation for axial movements is achieved by allowing the non-rotating face to move along the balance sleeve (sleeve below the non-rotating face). The non-rotating face is sealed against the balance sleeve with a dynamic sealing element (O-ring or PTFE filled sealing device), which slides on the balance sleeve.

When pressure is applied to the seal or the compressor is rotating, the applied forces will hold the seal faces together and maintain the appropriate gap of 3 to 5 µ. When these conditions are not present, springs are required to hold the seal faces together. To avoid any wear on the sealing faces, Dry Gas Seals are designed to lift off when operated. This means the rotating seat and stationary face have no contact during operation. The lift off is mainly influenced by two differential pressures over the faces or by circumferential speed. The seal can lift off at a certain differential pressure, a certain speed or a combination of speed and differential pressure, depending on the specific operating conditions, such as gas type, and detailed seal design.



Tandem Dry Gas Seal (EagleBurgmann DGS): (A) Primary seal gas supply; (B) Primary vent; (S) Secondary vent; (D) Separation seal gas supply; (1) Primary seal; (2) Secondary seal; (3) Separation seal

To avoid the above-mentioned scenarios, a supply of clean gas must be provided to the primary seal whenever the compressor is pressurized or in operation. A reliable clean gas flow will prevent contamination from the process gas from entering the primary seal.

In the next steps, proper filtration must be selected. Typically, filter elements are selected to remove particles as small as 3 µm and sometimes even 1µm. This ensures the removal of particles that are larger than the seal gap can tolerate, producing a clean quality gas for the primary seal. Seal gas filters have high alarms on differential pressure to identify when filter elements require replacement. The use of dual filter housings means that filter elements can be replaced during compressor operation without interrupting the seal gas flow. Filters supplied with seal gas systems have limitations on the volume and size of the liquids and particles they can manage. Higher levels of contaminants in the seal gas will require additional filtration. This filtration pre-filters the gas and generally contains some type of liquid knock out.

PROCESS-Tip

- The **White Paper** "Reliable Gas Supply Solution for Compressors to Avoid Seal Contamination and Failures" you will find at process-worldwide.com **for free download.** Here also Eagle Burgmann's Rotech Booster is presented in detail.

Contamination by Liquids

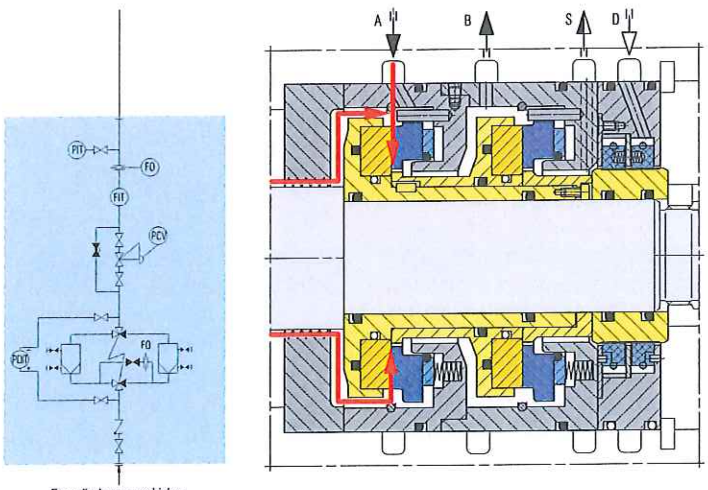
Many seals fail because of liquids in the gas during normal or transient conditions. This is usually the result of not considering the gas dew point—not completing a dew point analysis—or an inaccurate gas composition is used to complete a dew point analysis. Both of these can result in liquid forming in the seal gas and a system design that does not meet the needs of a dry gas seal.

Several steps must be taken to identify and provide the correct system to prevent liquids in seal gas. The first step is to accurately analyze the gas composition to identify all the components in the respective gases being used for seal gas supply. This includes any changes in the gas composition over time due to upset process conditions, and alternate gases used for seal gas. Most gas composition analyses do not include information on components higher than C5 or C6.

Process people are not concerned with trace components higher than C5 or C6. Some procedures also dry the gas sample before the analysis is completed. This eliminates components that turn to liquid and affect the operation of the gas seal. Another concern is when the composition of the process gas changes over time. Even minor changes in the gas composition can significantly change the dew point of a gas. It is therefore elemental to provide an accurate and complete gas composition when establishing the phase envelope to ensure a reliable result. Possible changes in gas composition over time must be considered as well.

Taking this information as basis, the second step is to produce the line for the seal gas dew point and to identify at what temperature and pressure the components in the gas will turn to liquids. Pressures and temperatures to the left of the dew line result in a dual phase gas; liquid in the gas. This is the area where the seal gas may not operate in. The third step is to plot the decompression curve with the minimum margin from the dew line (industry standards have identified the safety margin as 20 Kelvin).

The last step is to collect, analyze and plot all operating conditions; particularly conditions where the gas is at high pressure, such as settle out pressure and when the temperatures of the gas changes. Taking these measures will show what temperature the gas must be for a given pressure to prevent liquids from forming. This is critical to designing the correct seal gas supply system and preventing liquids from forming in a seal gas.



Process gas flow during pressurized stand still

From discharge or a higher stage of the compressor

Problems during Stand Still

Due to environmental concerns it is more difficult to vent compressors to the atmosphere. If compressors are stopped after a certain period of time they will be depressurized, sending the gas to flare or atmosphere, resulting in emissions penalties or fines. Some situations can also require a pressurized compressor which ensures a quick response to demand. Having a gas seal fail on a restarted compressor while supporting demands does not result in reliable production, profits or reduced environmental concerns. As identified above, particles in seal gas or primary seal cavity, or liquids that form in a seal gas are root causes for the majority of seal failures. To prevent these failures from occurring it is essential to ensure a clean and quality seal gas for the primary seal. This maintains a reliable seal that will not fail during standstill conditions and prevents failures when restarting or shortly after restarting a compressor.

During a pressurized stand still condition, seal gas flow, (clean and quality seal gas to the primary seal), is only present when an alternate supply or means of producing seal gas flow is provided. Seal gas flow during normal operation is generated by the discharge pressure, as indicated previously, which is higher than the pressure at the seal. If a higher pressure/flow cannot be provided during a pressurized hold, unconditioned process gas from the compressor flows into the primary seal cavity via the process labyrinth, when the seal gas flow is lost.

When the compressor is not or only slowly rotating but still pressurized, leakage still occurs through the gas seal. This means the gas leaking through the seal is

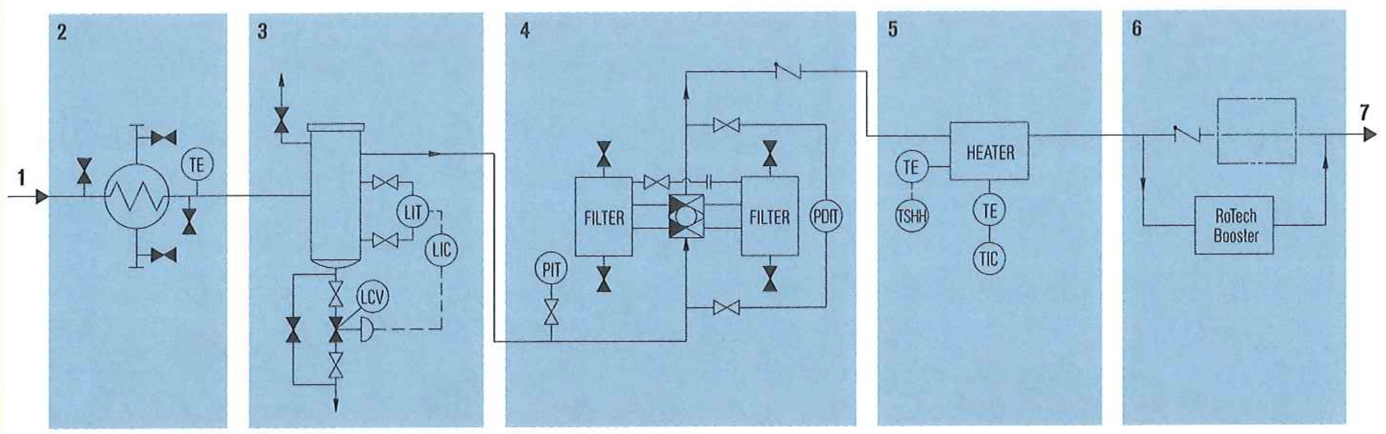


Diagram of a gas conditioning system: (1) Gas IN; (2) Cooler; (3) Separator; (4) Filter unit; (5) Heating; (6) Rotech Booster; (7) Gas OUT – to primary seal gas supply

unconditioned process gas from the compressor, allowing unconditioned gas to enter the primary seal cavity and contaminating the primary seal.

As stated above (contamination by liquids), the ambient temperature must be considered. The reason is that the compressor and seals will be at an ambient temperature during standstill conditions. If unconditioned process gas is exposed to these conditions, the gas drops in temperature and pressure when passing through the seal face liquid forms and contaminates the dry gas seal.

When liquids form between the seal faces while the compressor is not rotating, they may stick together. The flat surfaces of the stationary face and rotating seat are within two light bands of flatness. With such flat surfaces the liquid will create a bond between the stationary face and the rotating seat. This is good on the one hand because it will reduce or even totally eliminate the seal leakage. On the other hand, the downside is that the strength of the bond is so great when rotational force is applied to the seat that it will damage the drive pins and the stationary seat. This causes high seal leakage during the start or restart of a compressor, and identifies a seal failure with the requirement to replace the seal.

If the line represents pressure and temperature drops of the seal, then gas passes through or close to the dual phase envelope. There are a few possible solutions for this.

An outside source can be used, but the same analysis must be completed on an accurate composition of this gas. A concern with using an outside source is that gas volume is added to the compressor/process. This increases the pressure in the compressor/process. As the pressure builds in the system, the gas must be vented to maintain the clean flow of gas to the gas seal. Due to stricter environmental regulations this is becoming more difficult to do.

The ideal solution is to circulate the gas within the system. Dirty or wet gas is drawn out of the compressor through a conditioning system to bring it to the quality and temperature required for the gas seal and is pushed into the seal cavity. This ensures the gas seal is provided with a gas that does not allow liquid to form between the seal faces.

Conditioning a seal gas can require filtering the gas using coalescing filters. Or, conditioning can be as complex as cooling the gas to form the liquid, a liquid knockout to remove liquid, a heater to provide minimum dew point margin, heat trace for maintaining temperature, a booster to move the gas, and final filtration to ensure nothing passes through to the seal. Proper analysis of the dew point and operating conditions will define the required conditioning to ensure the right quality of gas is available for the gas seal.

The movement of the gas is one of the most important requirements for providing reliability for a dry gas seal: circulating seal gas from the compressor through the seal cavity. During normal operation there is sufficient differential pressure between compressor discharge and sealing pressure. When sufficient differential pressure is not present, usually during a standstill , a booster is required. A reliable booster, like an Eagle Burgmann Rotech Booster, delivers the recommended seal gas flow until the compressor is restarted to prevent failures in standby situations during or shortly after compressor restarts.

Learn more about the Rotech Booster in the White Paper this article is based on—see PROCESS-Tip.

Check List

WHAT TO CONSIDER

Contamination is the leading cause for dry gas seal failure. As identified in this article, if process gas or inadequately conditioned seal gas is provided to a dry gas seal, it will affect the reliability of the seal. To prevent this from occurring requires an

- accurate gas analysis,
- correct conditioning components,
- and seal gas flow whenever pressure is present in the compressor.
- When a compressor is in pressurized standby, using an alternative gas requires venting of gas pressure and leads to environmental concerns.
- Incorporating a booster in the system eliminates venting of process gas and prevents contaminated process gas from entering the primary seal.