Avoiding Compressor Dry Gas Seal Contamination

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Dry gas seals are a crucial part of today’s centrifugal compressors. With dry gas seals, machined-in lift profiles on one side of the seal face direct gas inward toward an extremely flat portion of the face. The gas flowing across the face generates a pressure that maintains a minute gap between the faces, optimizing gas film stiffness and providing the highest possible degree of protection against face contact. The seal’s film stiffness compensates for varying operations by adjusting the gap and pressure to maintain stability.

While dry gas seals are an effective, reliable and robust standard sealing solution for centrifugal compressors in all kinds of industry processes, they require a continuous supply of clean gas to ensure the seal faces are lifting off at optimal levels for the best possible gas leakage performance. Both pressurized and unpressurized dry gas seals utilize clean “seal gas” upstream of the dry gas seal to establish a barrier against the potentially contaminated process stream. Pressurized dry gas seals may use a different clean source to energize the seal faces, but a seal gas supply still acts upstream to protect against process contamination.

Under normal operating conditions, compressors can provide a constant supply of seal gas from a higher pressure level in the compressor. Dry gas conditioning systems receive this gas, filter and condition it, and then send it to the dry gas seals.
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The effects of dry gas seal contamination

Contamination is the leading cause of dry gas seal failures. It can be the result of a single event, such as during initial commissioning startup or system upset, or it can be cumulative over a period of time, resulting from lack of clean seal gas supply during frequent starts/stops, deposition of condensates from starts/stops, operating close to the dew point, or poor supply gas filtration.

Contamination occurs when liquid or particles enter the seal's cavity. The sealing gap between the rotating and stationary seal faces is only a few microns thick. Contaminants compromise the seal's reliability by clogging this gap, and as a result, disturbing the seal's lift-off capability, which leads to face contact and damage to the seal faces. The contaminants can further deposit in the area of the dynamic sealing element located behind the stationary seal face. The dynamic sealing element — typically an elastomeric O-ring or polymer shape — accommodates axial shaft movement of the compressor by sliding freely on a smooth cylindrical surface beneath the stationary seal face. Deposition of contaminants hinder free movement and can lead to hang-ups, i.e., the seal gap remains open and releases a high leakage flow or the seal gap is forced closed into rubbing contact.

However, during startup, pressurization, recycling, standstill and shutdown periods, differential pressure across the compressor drops, interrupting seal gas flow. When this occurs, it can lead to migration of unclean process gas, contamination and degradation of the seal's performance, which collectively cause downtime, higher maintenance costs and unsafe operating conditions.

Contamination occurs due to inadequate seal gas supply. Once a seal is compromised, it will eventually fail. The duration of time to failure depends on a variety of factors, making it impractical to predict how long a compromised seal will last.

Process contamination with liquids

Liquid presents a particular challenge when it comes to dry gas seal contamination. The film of a liquid is considerably thicker than that of a gas. This can result in an immense and unstable gap between the rotor/stator interface. Liquid also has surface tension and tends to adhere to the face surfaces, allowing them to wring together. When faces are stuck together in a static condition, they can become damaged at the drive mechanism interface due to excessive torque when rotation forces are applied.

To evaluate whether a seal has been contaminated with liquids, analyze its leakage rate. One sign of contamination is continuously increasing leakage. Another is a lower than expected leakage rate, or one that is fluctuating from high to low in rapid succession. Sometimes it is described as having a spitting or sputtering leakage rate.
**Contamination with solids and particles**

Solids and particles can affect the performance of a dry gas seal in multiple ways. If they are small enough to enter the seal gap, soft and adhesive substances can deposit on the rotor and stator surfaces, affecting the seal’s lift-off capability. Hard and abrasive particles can cause scoring and wear. Both conditions result in reduced seal life and a higher probability that the seal faces will need to be replaced (rather than refurbished) at the next repair interval.

Particle contamination in the process can block or hang up the stator face at the dynamic sealing element. If this occurs, it cannot react to required axial movements, preventing the hydraulic balance principle between the rotor/stator interface.

This condition results in a widened seal face gap, causing a sudden increase in leakage. Often, the leakage value exceeds the trip level. Unsuccessful restart attempts and replacing the dry gas seals both cause unexpected downtime. On the dry gas seal located on the opposite side of the compressor shaft, blocking the movement of the dynamic sealing element can cause the seal faces to contact one another, creating friction, wear and seal face damage.

**Gas boosters protect against dry gas seal contamination**

Seal gas boosters are the preferred solution to avoid a lack of seal gas flow and unconditioned process gas migration into and around the seal faces.

Driven by air or an electric motor, gas boosters improve operational reliability during periods of low differential pressure across the compressor when the available seal gas supply is insufficient.

**Considerations when selecting a gas booster**

There are a variety of gas boosters available on the market today. When comparing these units, pay attention to the following capabilities:

- **High energy efficiency.** Boosters with a magnetic coupling acting through a non-metallic containment shell have zero eddy losses for the highest efficiency and achieve a mean time between repair greater than 24,000 operating hours.

- **Modular design.** Look for modular designs that can be installed into existing seal support systems and easily removed, inspected and repaired in the field. These lead to lower downtime and quick maintenance turnaround.

This graph illustrates the seal supply gas flow with and without the use of a gas booster. During the startup phases of a gas compressor, the gas booster delivers enough seal gas flow to protect dry gas seals from process contamination.

**Conclusion**

Dry gas seals are vital in oil and gas production and refinery operations. But they require a continuous flow of clean and dry gas from the compressor to maintain their reliability. Usually, the compressor provides gas to the seals, but during transient conditions, this process is interrupted — increasing the risk of contamination.

Gas boosters can maintain consistent flow whenever the differential pressure across the compressor drops. They can lead to higher dry gas seal reliability, less downtime and maintenance costs, and a safer operating environment. But it’s important to note that not all gas boosters have the same design features or achieve the same outcomes. Oil and gas and refinery operations should carefully consider the features and benefits of gas boosters to ensure they are implementing the proper solution for their specific needs.
Flowserve can help

Flowserve manufactures various booster models utilizing different technologies. Please contact your local Flowserve sales representative to learn how we can help make the selection process easier. Contact details can be found on Flowsrve.com.

About the authors

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Torsten Bernicke has been with Flowserve for 17 years in roles of increasing responsibilities in sales and product management. He has been the product manager for different product lines, including compressor seals and systems since 2005, specializing in product lifecycles.

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Michael Schiller has more than 30 years of experience in compressor seal and system technology. He has held different positions within Flowserve such as design engineer, manager of testing and development, and manager of repair and customer service. Michael has co-authored numerous papers on compressor seals and systems, which have been presented at international conferences.