

# Troubleshooting Of Dry Gas Seals Repeat Failure In A Centrifugal Compressor

Raghuveer Harsha Vardhan

Engineer- Maintenance-Rotary

Hindustan Petroleum Corporation Limited

Visakh Refinery

**Abstract**—Centrifugal compressors in process gas service require shaft sealing to prevent the process gas escaping the compressor casing into the atmosphere. Most centrifugal compressors use dry gas seals for the purpose of sealing of gas leakage between shaft and stuffing box. Dry gas seals are basically non-contacting type mechanical seals consisting of a mating (rotating face) ring and a stationary face. Contamination is a leading cause for the failure/decreased reliability of these seals. Case study of repeat failure of dry gas seal of a centrifugal compressor and the sequence of trouble shooting is discussed in this paper

**Key words:** Centrifugal compressor, Dry gas seal, Repeat failure, Troubleshooting

## Introduction

In a centrifugal compressor, energy is transferred from a set of rotating impellers to the gas. Energy transfer is caused by a change in the centrifugal forces acting on the gas. Each impeller in the compressor imparts the kinetic energy to the gas which is converted to pressure energy in the diffuser. The gas then enters the next impeller suction and the final discharge pressure is attained at the last stage of the compressor.

## DRY GAS SEAL:

For centrifugal compressors, the leakage of the gas between the shaft and stuffing box is arrested by the usage of Dry gas seals. The seal consists of a rotating face running very close to a stationary face. The rotating face consists of special grooves that generate an “axial lift” during rotation. The stationary face is backed by a series of springs which force it against the rotating face when the compressor is at rest. The lift force compresses the springs slightly resulting in very small running clearances in the order of 3-10 microns. This small clearance effectively limits

the gas leakage from the seal. The small amount of residual leakage from the seal is routed through the seal piping either to flare or to any other recovery system.

## CASE STUDY:

Equipment No: 60K02

Service : Hydrogen Recycle gas Compressor

Make : M/s BHEL

Stages : 2 stage (LP and HP)

Type : Barrel Type (2BCL 407)

No. of Dry gas seals : 4

## SEAL GAS SYSTEM:

The compressors LP and HP are provided with Tandem dry gas seals with inter-stage labyrinth. Each seal assembly consists of a primary and secondary sealing stage arranged in series. The seal closest to the compressor impeller is primary seal and the seal closest to the bearing is the secondary seal. The primary seal is injected with clean process gas (seal gas) picked up from the compressor discharge after getting filtered in the duplex filters. When the compressor is in operation, the pressure of the gas is adjusted such that it is slightly higher than the system pressure in the casing. The residual leakage is collected in the cavity in front of the inter-stage labyrinth. This is vented to flare. Inert gas (Nitrogen) is injected through the connection between secondary seal and inter-stage labyrinth at a slightly higher pressure than the flare pressure. Part of residual leakage goes to the flare and the remaining part is vented to atmosphere. Along with these two seals, a barrier seal is also provided which acts as a barrier between bearing

housing and secondary seal which ensures that the lubricant doesn't enter the secondary and primary seals. Instrument air is injected into this seal and the leakage is vented to atmosphere.

### PRECAUTIONS DURING OPERATION of a DRY GAS SEAL:

Liquid or dirt should not enter the dry gas seal for proper working and reliability. To ensure this, the following precautions are to be followed at all times.

1. Positive differential pressure should be maintained across the seal faces so that clean filtered gas enters between them.
2. Liquid carry over from the process gas needs to be eliminated by draining the filter housing frequently depending on the amount of condensate collected in the housing
3. Instrument air to the barrier seal is to be maintained always at the set pressure so that the lubricant does not enter the secondary and primary seals
4. During shut down of the compressor, the barrier air is to be maintained at least for 12 hours so that lubricant seepage into the seals is avoided.

### HISTORY:

The compressor was overhauled during the Turnaround maintenance of the process plant and all the four seals (LP inboard, LP outboard, HP inboard, HP outboard) were replaced with new refurbished seals. After one month of continuous service, one of the seals (LP outboard) was reported with higher leakage rate (10 Nm<sup>3</sup>/hr. and 4 kg/cm<sup>2</sup> against normal flow & pressure of 6 Nm<sup>3</sup>/hr and 1 kg/cm<sup>2</sup>). The compressor was taken for outage and the seal was replaced with a new one. The old removed seal was sent to the Seal OEM for inspection. After the new seal was installed, the leakage was observed right during the pressurization of the compressor.

### OBSERVATIONS:

1. Black color fine color powder was identified on the seal outer surface near the primary vent port.
2. Lot of liquid was found accumulated in the primary filter housing.

3. Primary vent lines were inspected & found that the lines were in wet condition (supposed to be in dry condition).

### VI. TROUBLESHOOTING & MODIFICATION ACTIVITIES CARRIED OUT

1. Previously, the liquid condensate collected in the filter housing could not be drained completely as the housing drain line was open to the atmosphere. The drain line was modified and was connected to the closed blow down system where all the process related fluids are being drained. This ensured complete draining of liquid condensate thereby eliminating one of the reasons for liquid entry into the dry gas seal. The primary seal gas lines were provided with steam tracing to reduce the formation of condensate in the seal gas lines.

2. During startup, while pressurizing the compressor, chances of dirty gas (Gas from the compressor casing) entering the seals is very high as the positive differential pressure could not be maintained across the seal faces in stationary condition. This chance of dirty gas entering the seal was eliminated by providing clean (filtered), high pressure (higher than the compressor casing pressure) gas from an external source.

3. Drain points were provided to all the primary seal gas lines at the bottom most point to drain the condensate, if any, during the startup of the compressor. Even after the above modifications, the dry gas seal leakage was observed during Compressor pressurization.

Fig 1: Schematic diagram of Dry gas Seal

### SEQUENCE OF ACTIVITIES FOR IDENTIFYING CAUSE OF REPEATED SEAL FAILURES

1. LP Compressors, Drive end seals removed
2. The compressor housing and shaft area of the compressor were thoroughly cleaned
3. Static testing of DGS was conducted by pressurizing compressor casing initially by nitrogen @ 7 Kg/cm<sup>2</sup> and subsequently by Hydrogen @ 34.5 Kg/cm<sup>2</sup>. Leakage through

primary vent @ LP-NDE was observed at pressure of 5.5 Kg/cm<sup>2</sup> @ flow of 12 Nm<sup>3</sup>/hr

4. It was decided to check the seal supply system instruments of seal supply systems stuffing box ports and bore details at primary seal locations.

5. Inspection of compressor stuffing box at dry gas seal seating area through Bore scope revealed that the seal primary inlet flushing hole was found punctured inside the stuffing box. Hence, seal inlet was passing directly to the Primary vent area and resulting in heavy leakage.

6. Internal puncture in the Stuffing box was temporarily arrested by applying metallic putty and was welded later on taking planned outage of the unit.

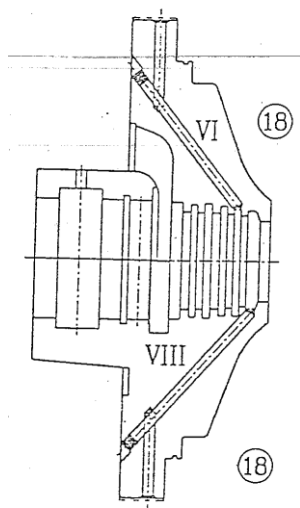
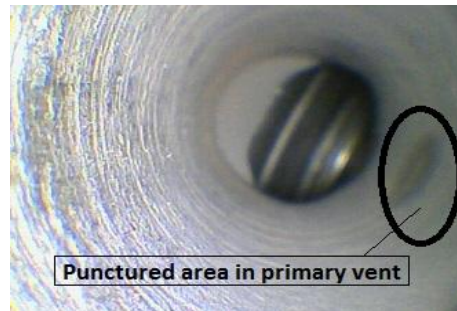


Fig 2: Compressor End cover



Fig 3: Puncture in the stuffing box



### VIII. Final Recommendations

1. All required dimensions & Fits in the compressors with respect to Dry Gas seal seating area to be maintained precisely.
2. Change the existing seal supply systems to latest design for more reliability of DGS Parameters
3. Change the existing Seal leak off flow Rota meters to Transmitters for ease in data monitoring

### References

- [1] Centrifugal Compressor manual by M/s. BHEL
- [2] Dry gas seal Manual by M/s. Eagleburgmann