43rd Turbomachinery
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DRY GAS SEAL FAILURES IN A RECYCLE GAS CENTRIFUGAL COMPRESSOR, CAUSES & REMEDIAL ACTIONS

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Presenters

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Jim Demetriou *is a Consulting Engineer with Chevron Energy Technology Company in Richmond, California. During his 14 years with Chevron, he has provided machinery technical support for refining, chemicals and upstream business units including specification, selection, operation, root cause analysis and optimization of machinery systems. Prior to this, Mr. Demetriou was a machinery engineer with Exxon for 20 years, including assignments in corporate engineering in New Jersey and refining assignments in Texas and California. Mr. Demetriou has a B.E. degree (Mechanical Engineering, 1980) from Stevens Institute of Technology and is a registered Professional Engineer in the state of California. He is presently task force vice-chair on API 692 (Dry Gas Seal Systems) and on the API SOME steering committee.*

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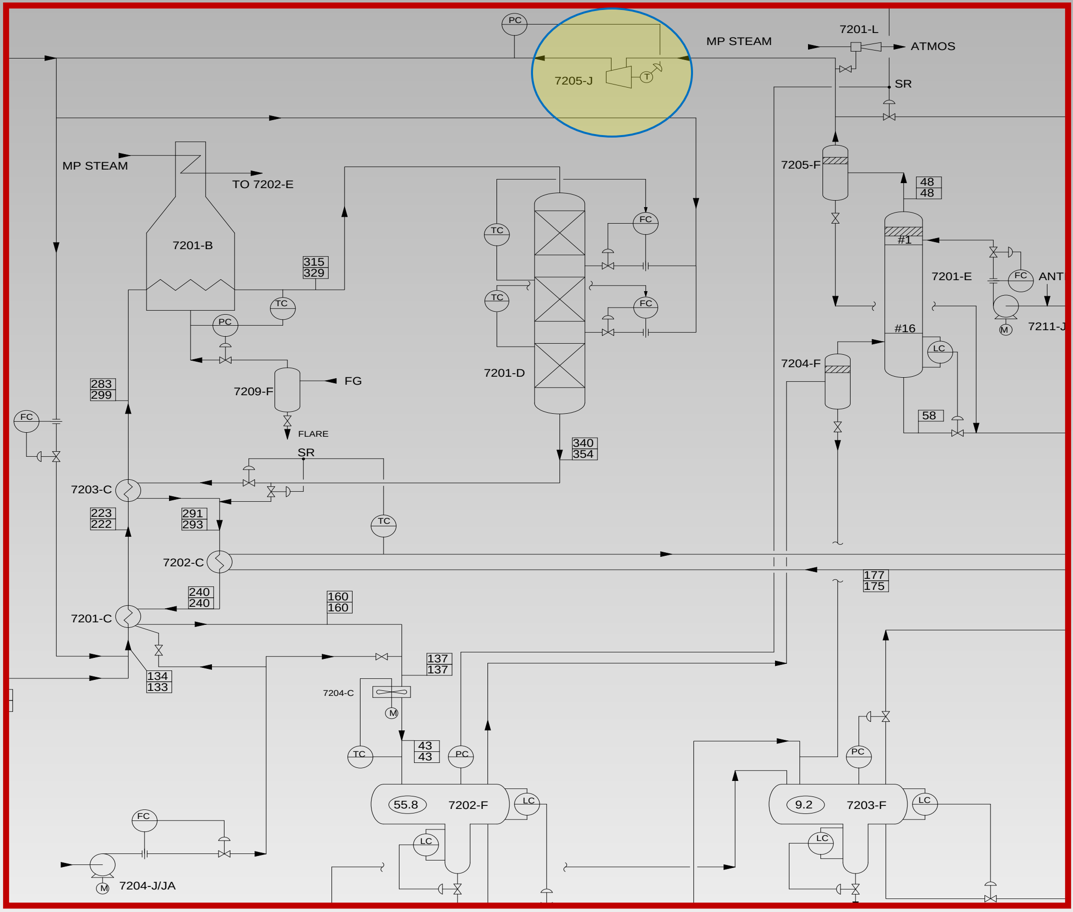
Introduction

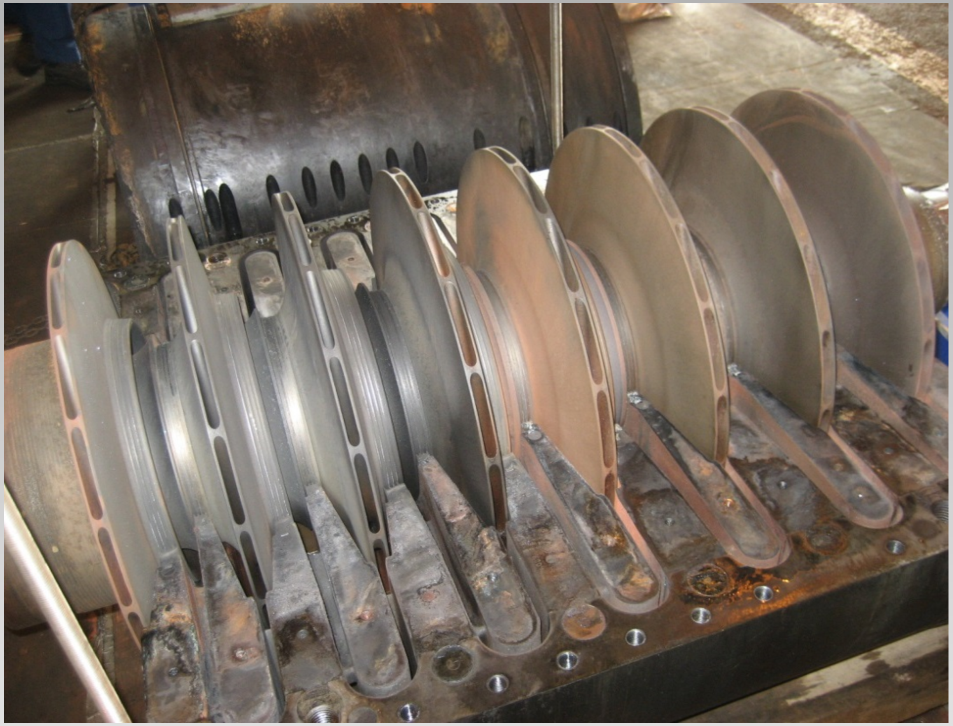


The recycle gas train is part of the Hydro-desulphurization Plant main reactor loop.

The steam turbine driven, single section barrel-type centrifugal compressor uses a dry gas seal system.

Compressor was commissioned in 1995 and had no failures prior to 2011.

Machine Details



- 8 stage compressor
- ~11,000 rpm
- Ps = 50 barg (725 psig)
- Pd = 80 barg (1160 psig)
- Tandem arrangement dry gas seals
- External seal gas from Hydrogen Make-up compressors (lubricated recips) as primary source, with the compressor discharge as back up in case of Make-up compressor trip.

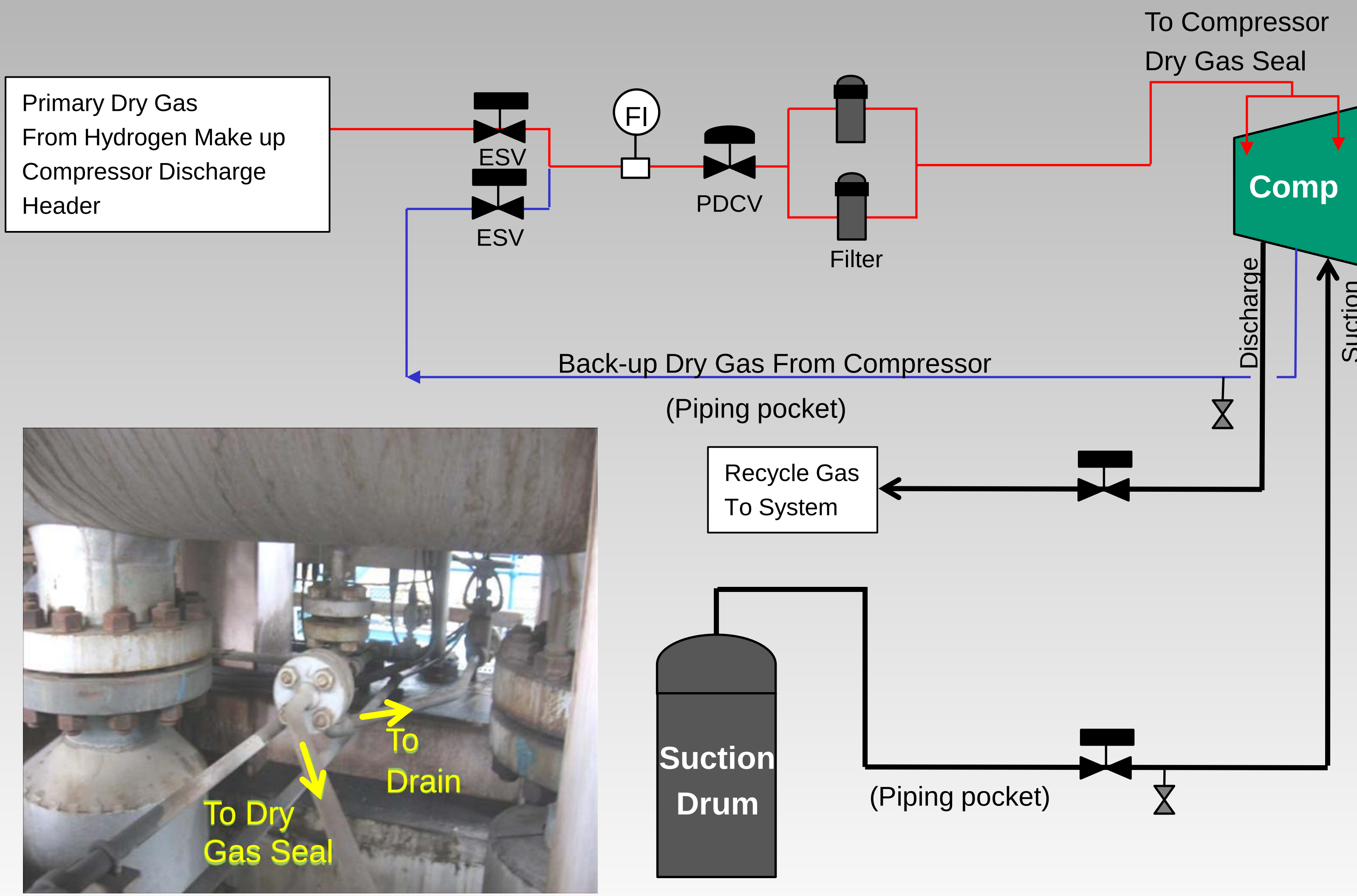
First Failure

- Compressor was started post turnaround.
- No compressor work was done during turnaround.
- After about 13 hours of running the compressor tripped on high primary vent pressure on the suction-side seal.

Causes of Failure

- Seal system found heavily contaminated with water-like liquid.
- Suction drum steaming for vessel entry during turnaround done with compressor suction and discharge ESVs left open resulting in condensate building up in the compressor and seal gas system.
- Seal gas take-off from casing bottom allowed for additional condensate to reach the dry gas seal, shattering the faces.

Compressor Flow Scheme



Challenges in restoration

- Dry gas seal rotating face fragments (WC) caused damage that impeded compressor disassembly.
- OEM’s previous experience with similar failure: 4 weeks to grind out the stuck sleeve with pencil grinder.
- Spare rotor allowed for partially destructive drilling method for sleeve removal. Rotor was removed within two days and compressor was restarted in 11 days.

Second Failure

- Compressor tripped on high primary vent pressure on suction side exactly one month after the first post-failure start up.
- Damage similar to first failure with shattered faces and seal stuck on the rotor.
- ***No liquid found.***

Causes of the Failure

- Presence of particulate contamination in the system due to improper cleaning following first failure.
- Seal gas system high flow excursion due to DP transmitter failure.
- Dry gas seal system vulnerabilities to contamination (both solids and liquids).

Restoration Challenges

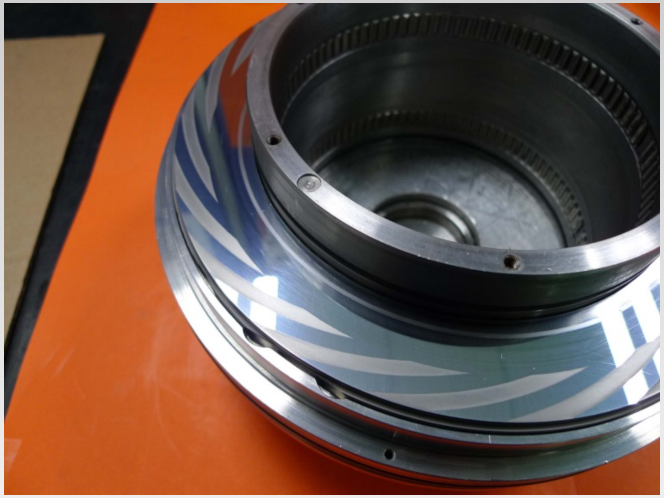
- No spare rotor & no spare seals.
- Sleeve was drilled using same technique as the last time but with added precaution to prevent damage to rotor.
- Rotor was repaired at the seal seating area using API recommended rotor repair techniques.
- The seal vendor was able to re groove the discharge end seal from first failure, test and return the seals within 4 days.
- Ensure the root cause is identified and mitigate risks by completing as many recommendations as practical.
- Compressor was restarted in 13 days from date of failure.

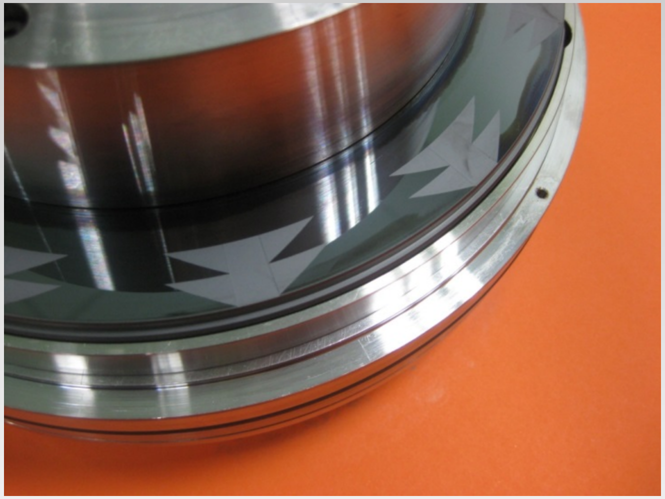
Post Failure Work

- Complete review of the compressor and dry gas seal system identified major gaps from evolving industry and company practices. New gas seal panel and system changes provide improvements and new capabilities:
  - Gas treating (separation, heating)
  - Filtration, coalescing, drainage
  - Seal gas supply availability (booster)

Post Failure Work

- Dry gas seal rotating face material changed to silicon carbide with bi-directional grooves to reduce post-failure damage and repair time, and also make spare seals compatible with either end of compressor.





Key Lessons Learned

- A machine without failures does not mean it has no gaps. Constant review of systems and latest industry practices helps to ensure equipment reliability. Dry gas seal system design has evolved to consider off-design and unanticipated conditions.
- Challenging situations like these are best overcome with strong partnerships with vendors who can provide unique and timely solutions.
- The need to ensure cleanliness of dry gas seal systems to the highest possible degree, especially during maintenance, is emphasized in these failures.
- *Success can be our worst enemy…if we allow it.*