

The 1st Middle East Turbomachinery Symposium (METS)

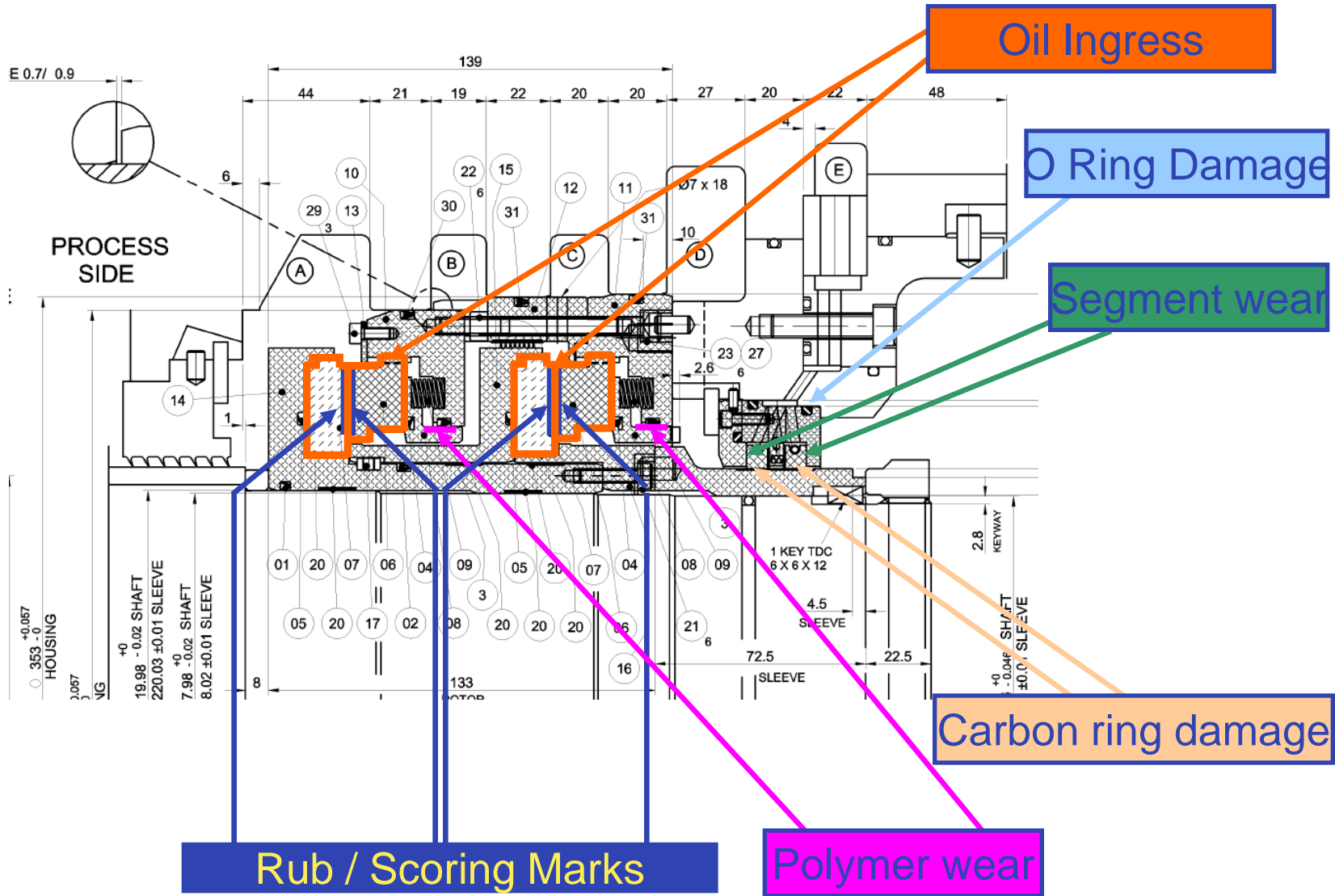
Trouble shooting the problems of Dry Gas Seals and Systems in Centrifugal Compressors

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Typical damage found on DGS

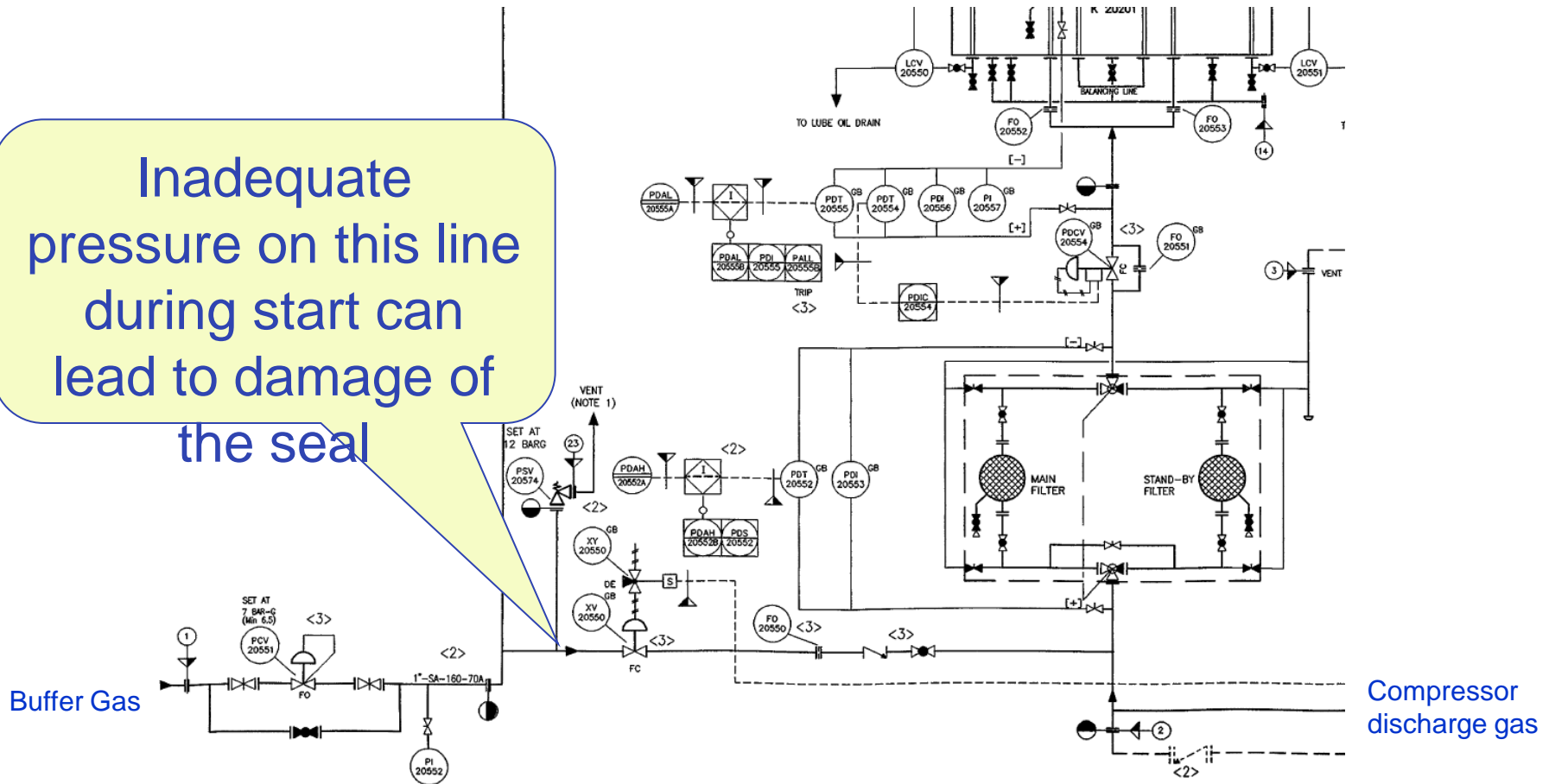


Different types of failures observed in DGS and its system and ways to mitigate the problem

1. Inadequate fuel gas pressure during start up
2. Failure of the oil traps on the barrier seal
3. Inadequate supply pressure of air/nitrogen into the seals
4. Presence of heavy hydrocarbons in the seal gas beyond design specs
5. Open rupture disc on the bypass of the primary vent PDT
6. Outboard seals instrumentation in Tandem seals arrangement
7. High process gas concentration systems on secondary vent
8. Inappropriate slow roll speed

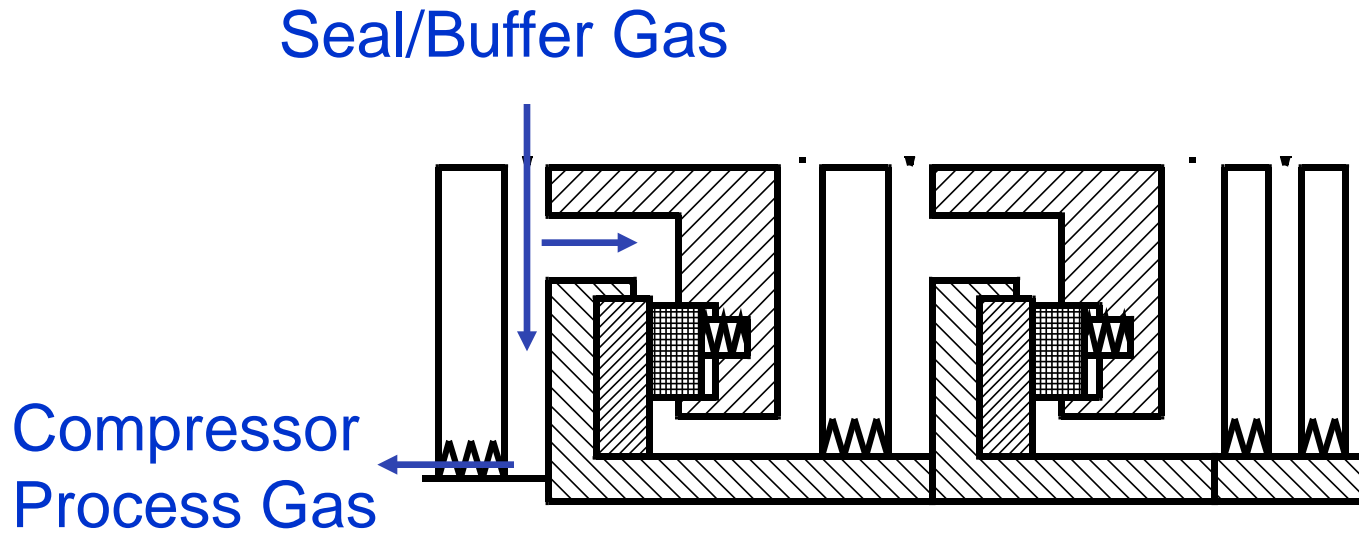
1a. Inadequate fuel gas pressure during start up

Inadequate pressure on this line during start can lead to damage of the seal



Typical seal gas scheme with provision for buffer gas during start up

1b. Inadequate fuel gas pressure during start up



Typical tandem dry gas seal with intermediate labyrinth

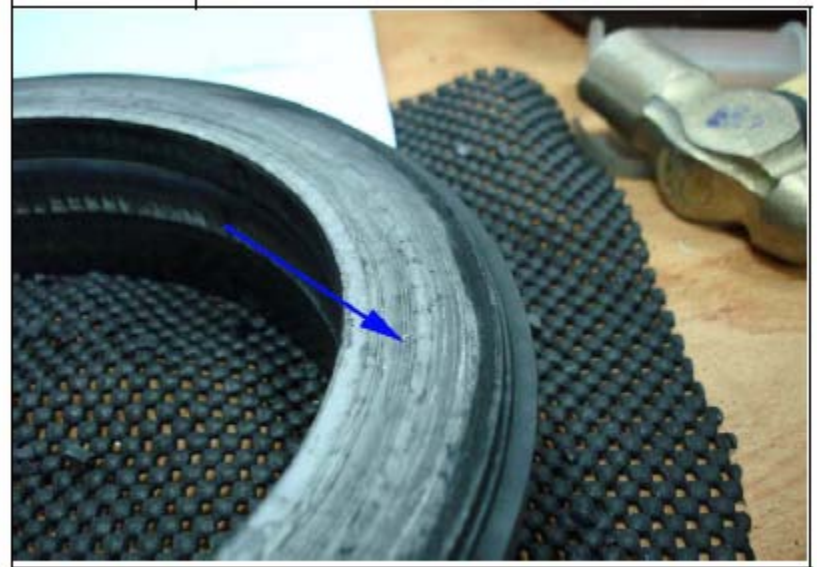
1c. Inadequate fuel gas pressure during start up

Typical conditions on Inboard/Outboard Seal

- Running marking on the seal
- Running/scoring marking on the face



(Courtesy: JC seal)



(Courtesy: JC seal)

1d. Inadequate fuel gas pressure during start up

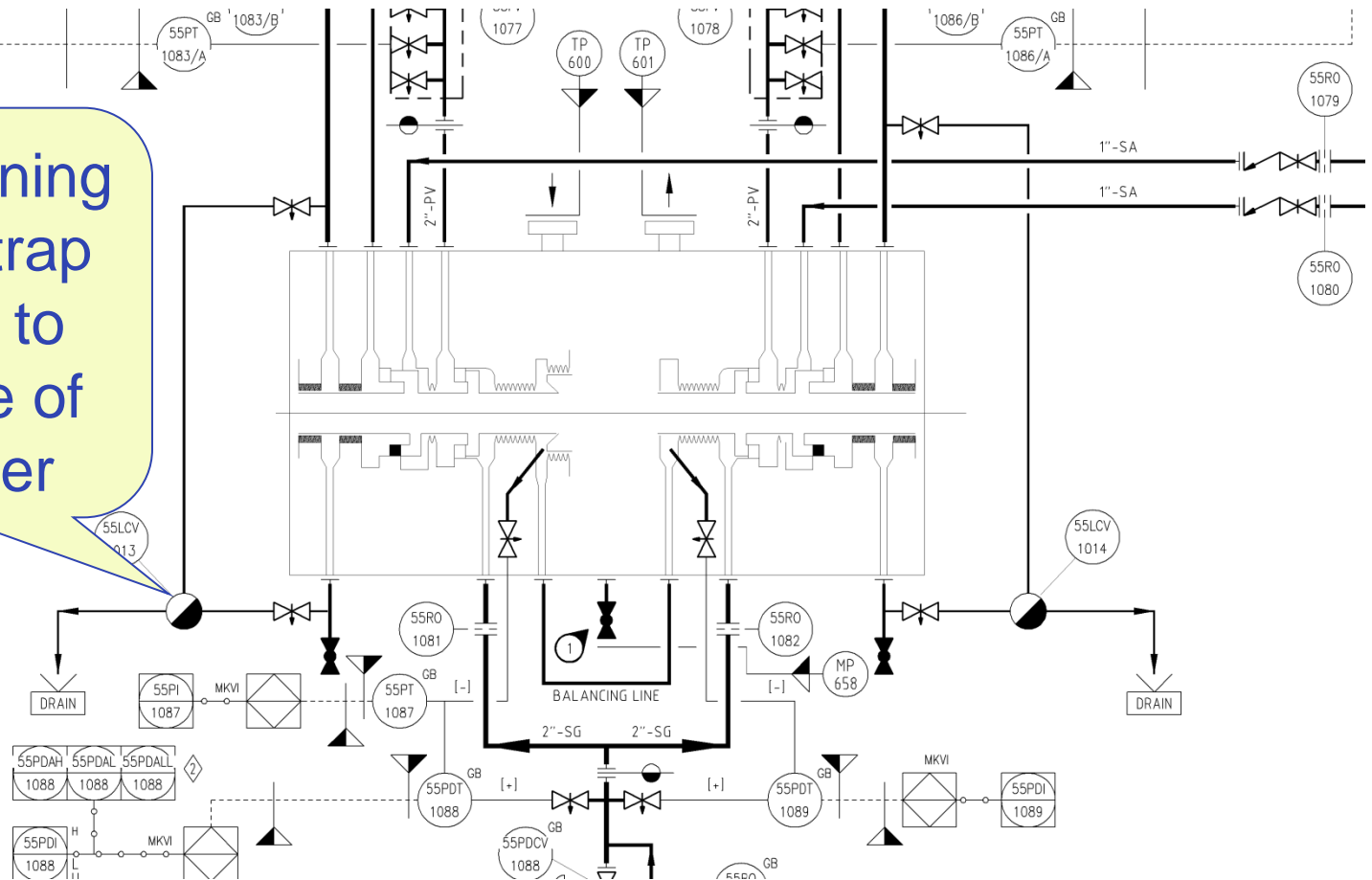
- Main buffer (fuel) gas is provided in the seal gas line if the compressor discharge pressure is not high enough or the process gas is not suitable to be used as seal gas.
- Insufficient pressure of the buffer gas during start up can cause the process (dirty) gas inside the compressor to go through the dry gas seal faces
- Exposure to the dirty gases will make the DGS groove ineffective causing the damage of the seal faces

Recommendations

1. Seal/Buffer gas Pressure > Max Process gas Pressure
2. Introduce a start up interlock

2a. Failure of the oil traps on the barrier seal

Malfunctioning of the oil trap can lead to the failure of the barrier seal



DGS system diagram with oil traps

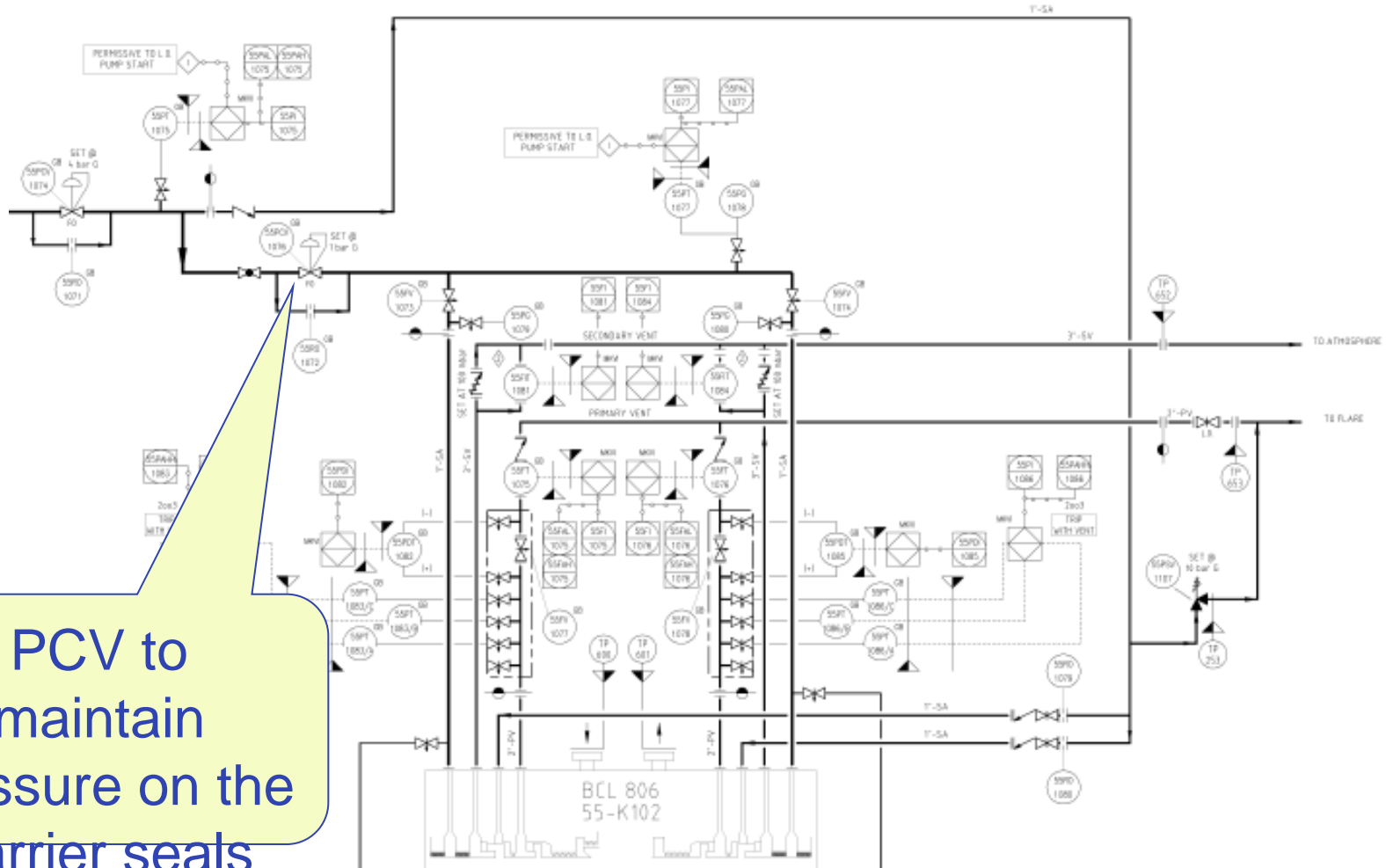
2b. Failure of the oil traps on the barrier seal

- The oil traps are provided in the drain of the buffer gas line to trap and drain the oil that could come into the barrier seal zone
- Failure of the trap will alter the pressure in the barrier seal zone. This leads to ineffectiveness of the barrier seals
- If oil is present in the barrier seal for an elongated period of time, the seals will eventually fail

Recommendations

1. Periodically check the functionality of the oil traps
2. If the PCV upstream of the barrier seals are not able to maintain the pressure on barrier seals, check the functionality of the oil traps

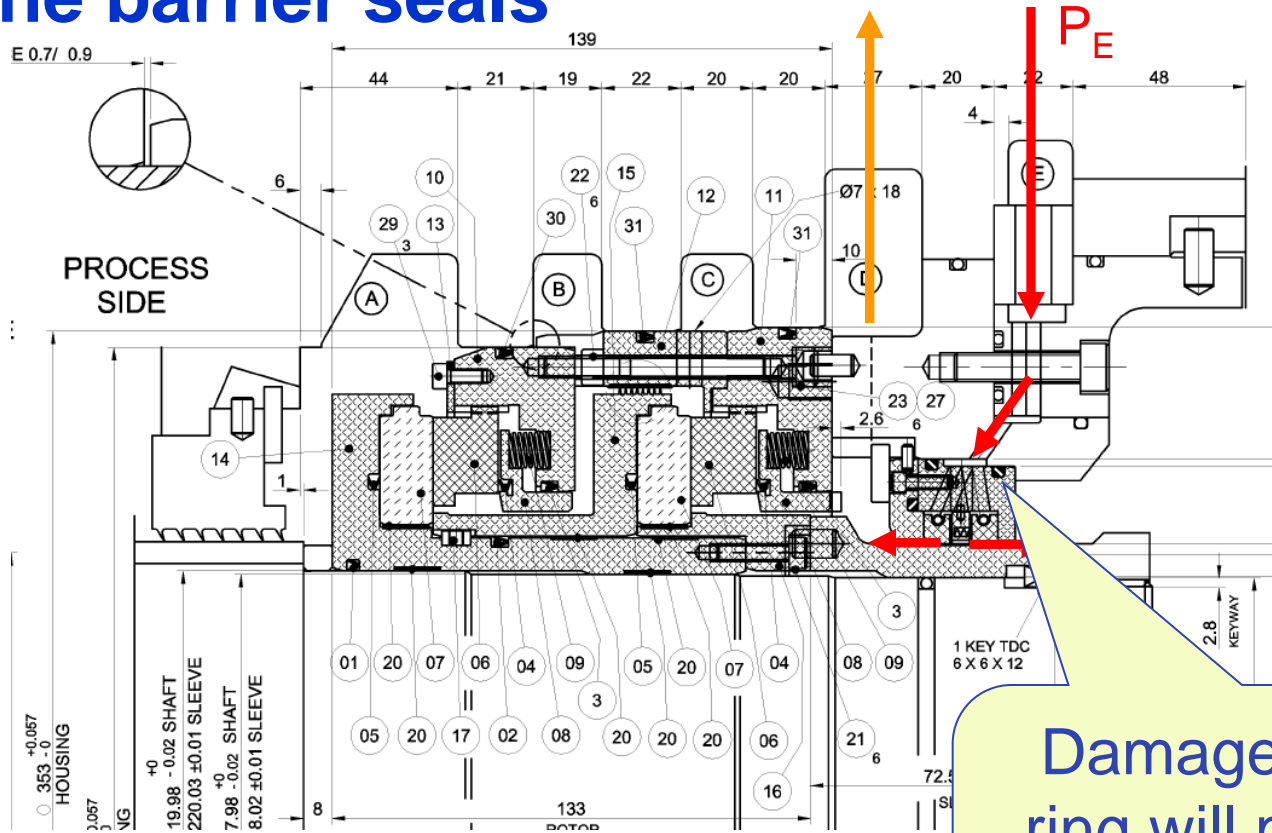
3a. Inadequate supply pressure of air/nitrogen into the barrier seals



PCV to maintain pressure on the barrier seals

DGS system diagram with PCV to maintain N2 pressure

3b. Inadequate supply pressure of air/nitrogen into the barrier seals



A = Clean buffer gas injection

B = Primary Vent (1st stage leakage)

C = N₂ Injection

D = Secondary vent (2nd stage leakage + Barrier seal inboard leakage)

E = N₂ / Air Injection

Damage of this O-ring will prevent the PCV from maintaining pressure P_E .

P_E .

3c. Inadequate supply pressure of air/nitrogen into the barrier seals

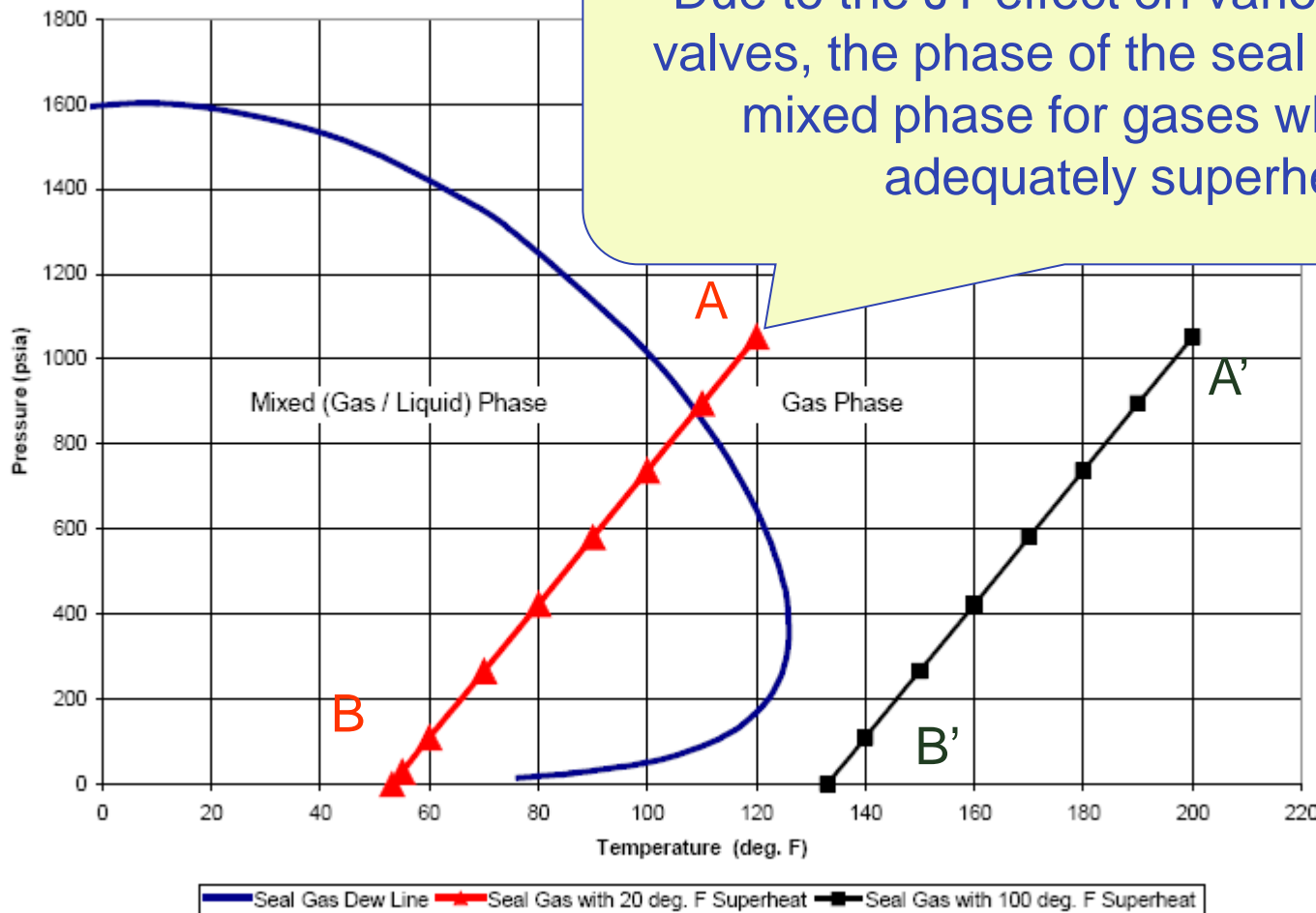
- Inadequate supply pressure on barrier seals can happen due to the following reasons
 - Failure of O-rings or carbon rings on the barrier seals
 - Failure of the PCV
 - Malfunctioning of the drain traps (if available) on the barrier seals
- Inadequate air/N₂ pressure at the tertiary seals can potentially allow lube oil carry over or process gas contamination

Recommendations

- Pay extra attention when replacing the barrier seal not to damage the O-ring
- Check the trends of the barrier seal header pressure.
- Check the functionality of the PCV

4a. Presence of heavy hydrocarbons in the seal gas beyond design specs

Due to the JT effect on various orifices and valves, the phase of the seal gas changes to mixed phase for gases which are not adequately superheated



Gas Phase Diagram

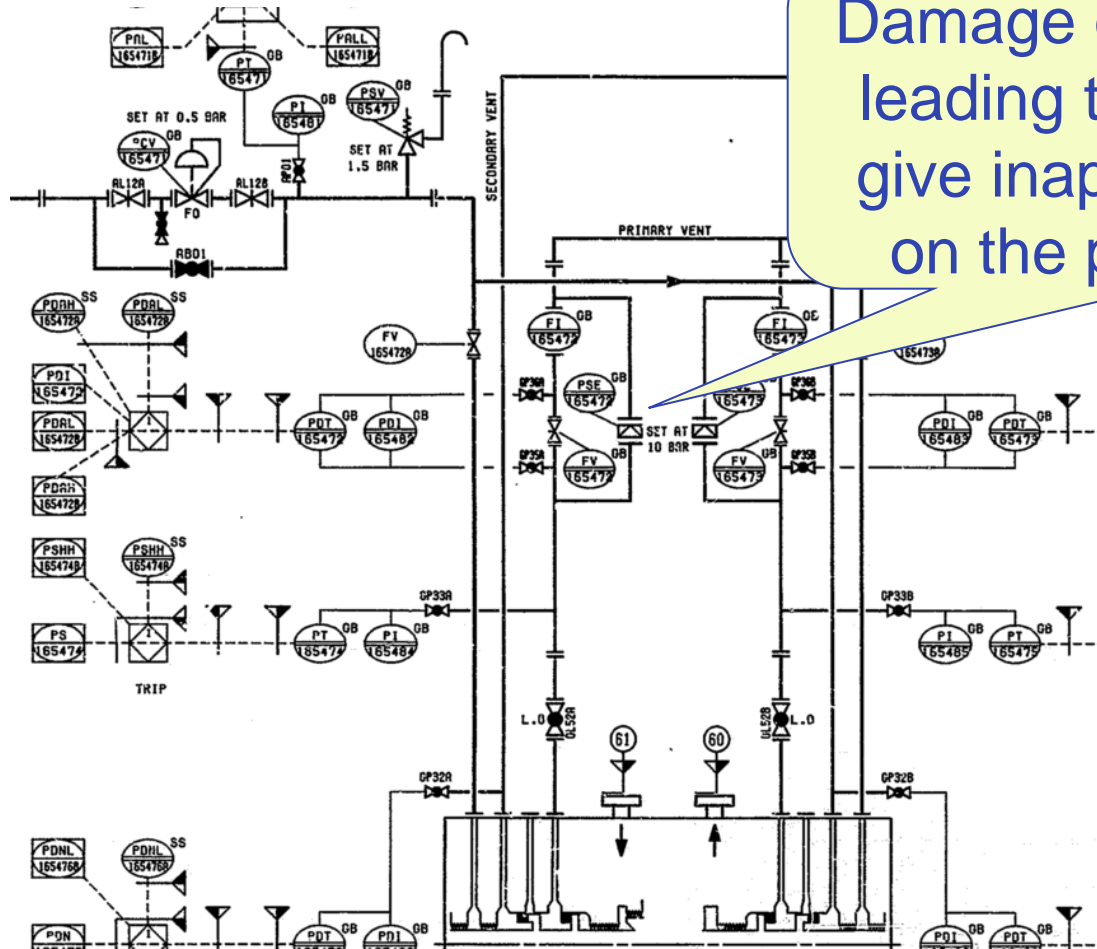
4b. Presence of heavy hydrocarbons in the seal gas beyond design specs

- Seal gas superheating is required to avoid formation of the mixed phase (liquid/gas)
- Mixed phase of the gas in the seal face and the seat area will reduce its effectiveness and can potentially damage the seals
- Presence of the heavy hydrocarbons (not envisaged during design), can reduce super heating effectiveness.

Recommendations

1. Check the composition of the gas being handled by the compressor and compare with the design gas composition. Look for heavier hydrocarbon (C6+) and analyse if the design of the seal gas superheating has been considered for all the gases. If not, change the superheating temperature.

5a. Open rupture disc on the bypass of the primary vent PDT



Damage of this rupture disc leading to the leakage will give inappropriate reading on the primary vent PDI

DGS system diagram with the rupture disc in a Propylene compressor

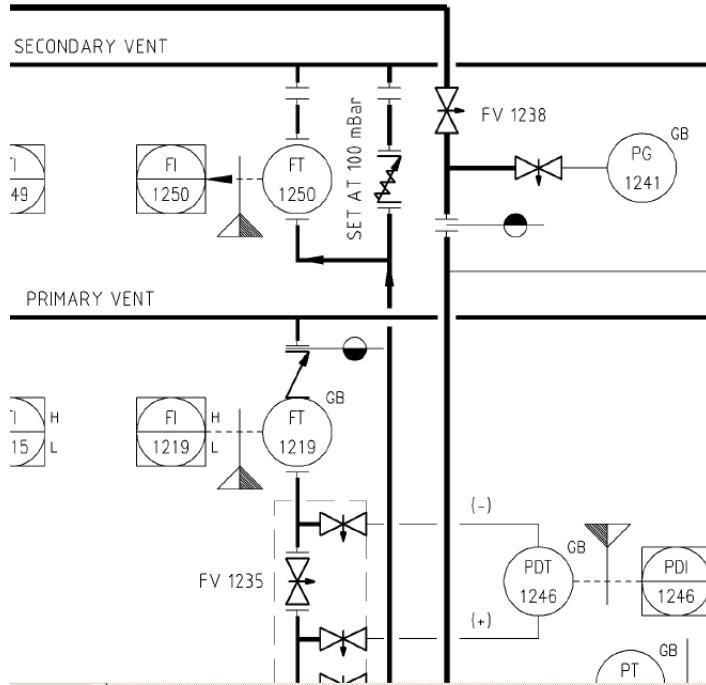
5b. Open rupture disc on the bypass of the primary vent PDT

- Opening of the rupture disc will indicate lower reading of the PDI on the primary vent
- lower PDI readings may indicate a possible seal failure.
- The misleading information may lead operators to unnecessary replace the seals

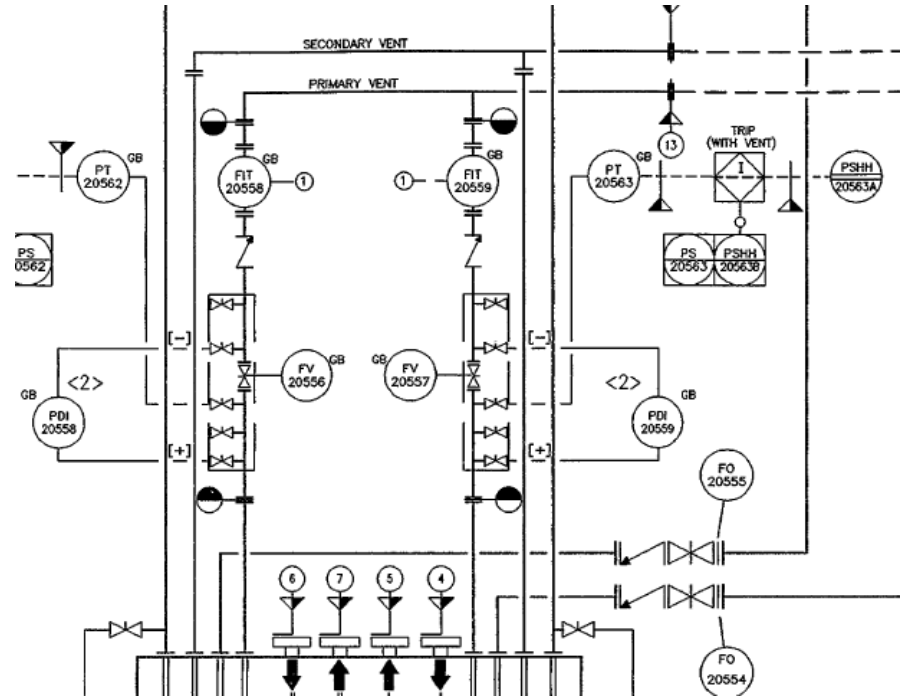
Recommendations

1. Check the trends of the PDI on the valve on the primary vent.
2. Check the flow meter reading on the primary vent
3. Investigate when the problem arose (if after any seal replacement or any trip event)
4. Measure the temperature just downstream of the rupture disc
5. Analyse the results of the above to reach the conclusion

6a. Outboard seals instrumentation in the Tandem seals arrangement



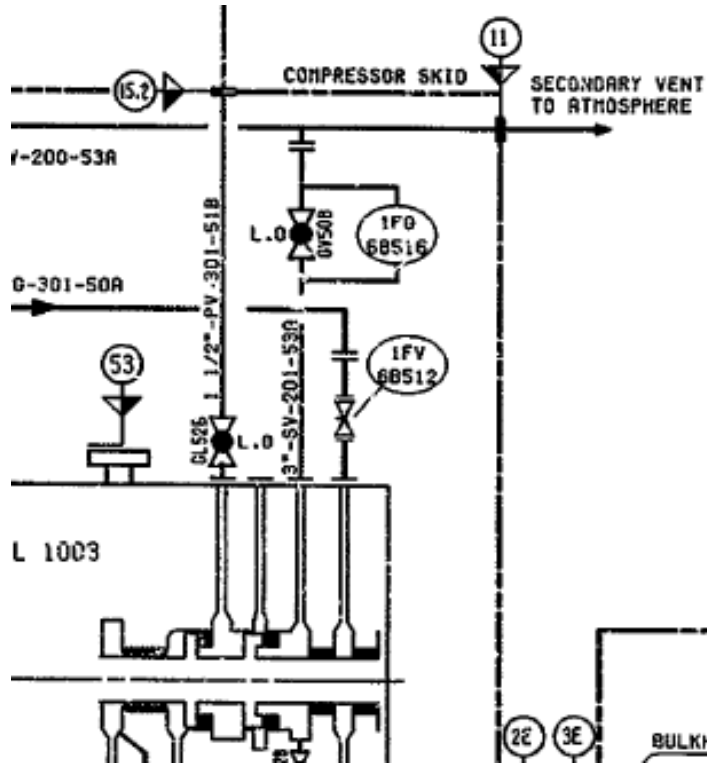
Secondary vent with flow indication and rupture disc



Secondary vent without any instrumentation

Various types of Secondary vent

6b. Outboard seals instrumentation in the Tandem seals arrangement



Secondary vent
with flow indication

Various types of Secondary vent

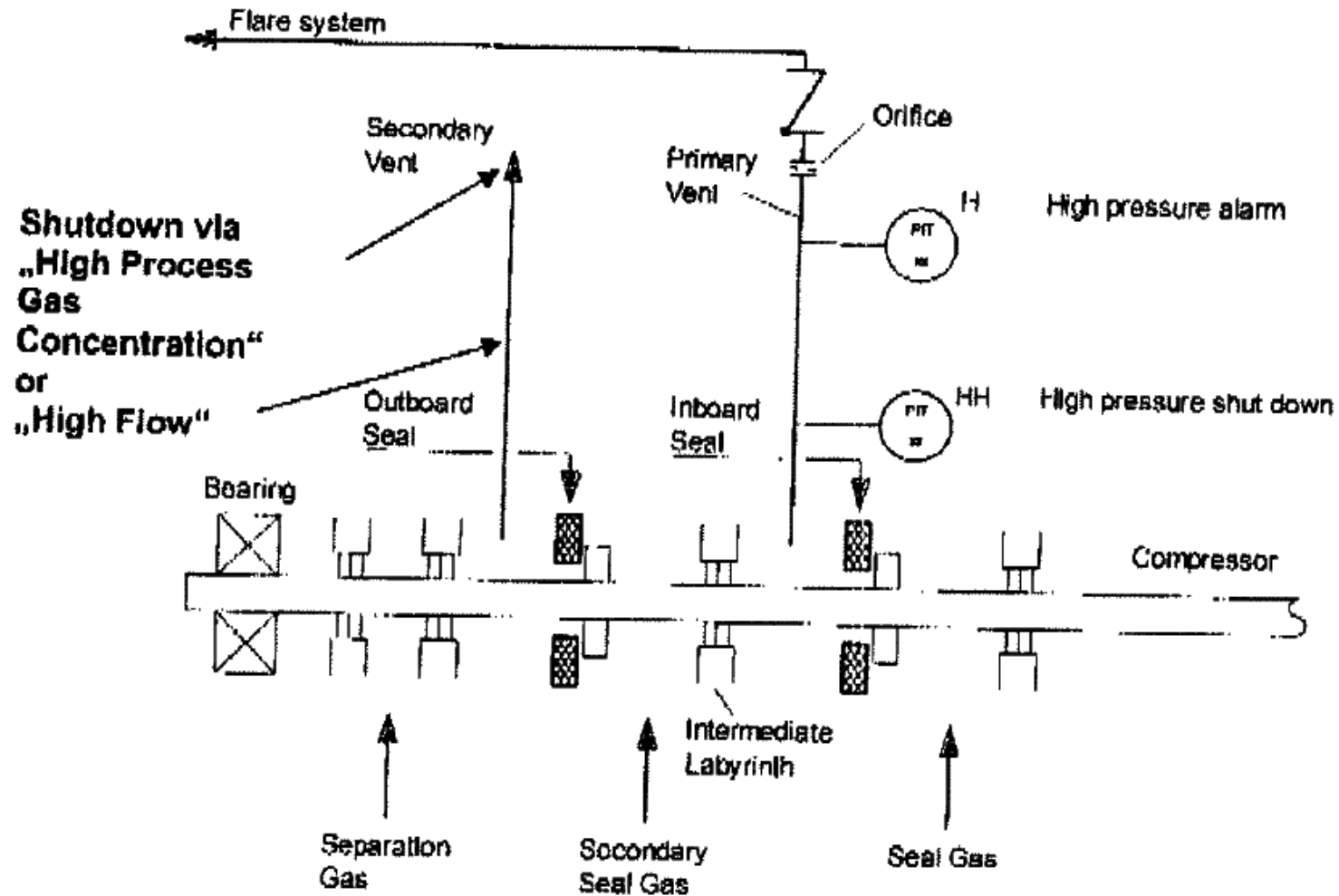
6c. outboard seals instrumentation in the Tandem seals arrangement

- Traditionally most of the outboard seals are not provided with any alarm/trip functions or indication of pressure/flow even in critical compressor applications
- In this case, if low pressure on the primary vent is observed, operators may incorrectly conclude that the secondary seals have failed

Recommendations

1. Monitor pressure and flow on the primary vent
2. If the unit has a history of secondary seal failures, install a flow meter on the secondary vent

7a. High process gas concentration systems on secondary vent



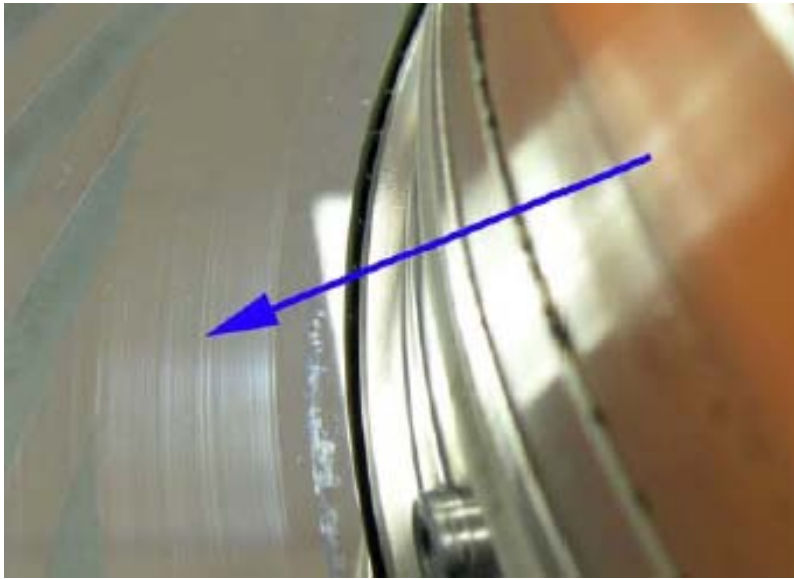
7b. High process gas concentration systems on secondary vent

- In the compressors where the secondary vent is provided with trip on high gas concentrations, there is possibility of spurious trips as the range of the gas concentration is not predictable
- The system relies on a catalyst
- This protection function is normally not recommended. However it can be used for monitoring purposes

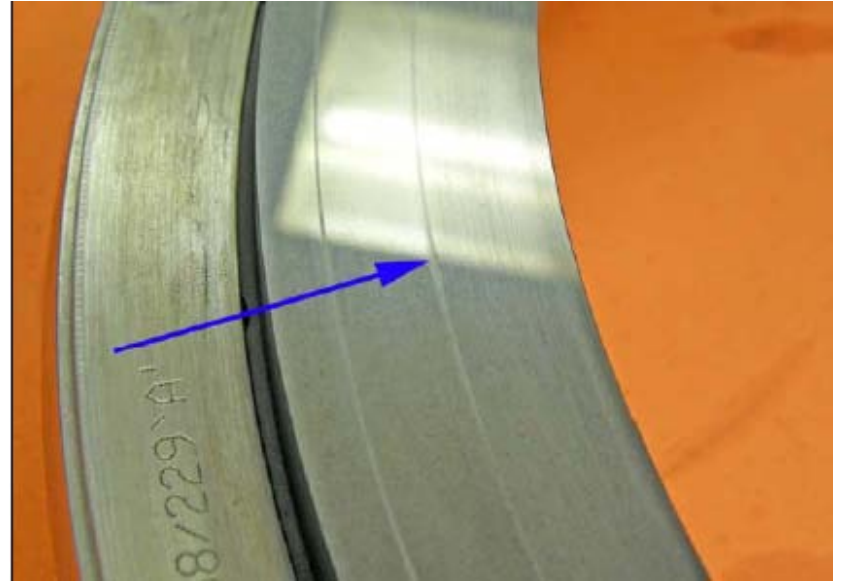
Recommendations

- Frequently check the system calibration and compare system readings with lab analysis results
- If the results are not matching, consider installing a flow meter instead

8a. Inappropriate slow roll speed



Typical running marks on the seat due to contact with face
(Courtesy: JC seal)



Typical running marks on the face due to contact with seat
(Courtesy: JC seal)

8b. Inappropriate slow roll speed

- Slow rolls are normally required to minimise the risk of rotor bowing during cool down sequence and avoid rotor locking issues at the next start up
- A very low relative speed between the face and the seat may not produce the lift causing the contact of the face and seat
- The face lift condition takes place around 2 m/s peripheral speed of the face

Recommendations

1. In order to avoid damages to the journal bearing, the speed range from 0.08 to 0.8 m/s at JB OD shall be avoided
2. For DGS with carbon face and dry N₂ as intermediate buffer gas, the speed range between 0.08 to 0.8 m/s at face shall be avoided