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Mechanical Seal Failure in the oil flooded compressor

SK incheon petrochem

TURBOMACHINERY LABORATORY
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Contents

Introduction

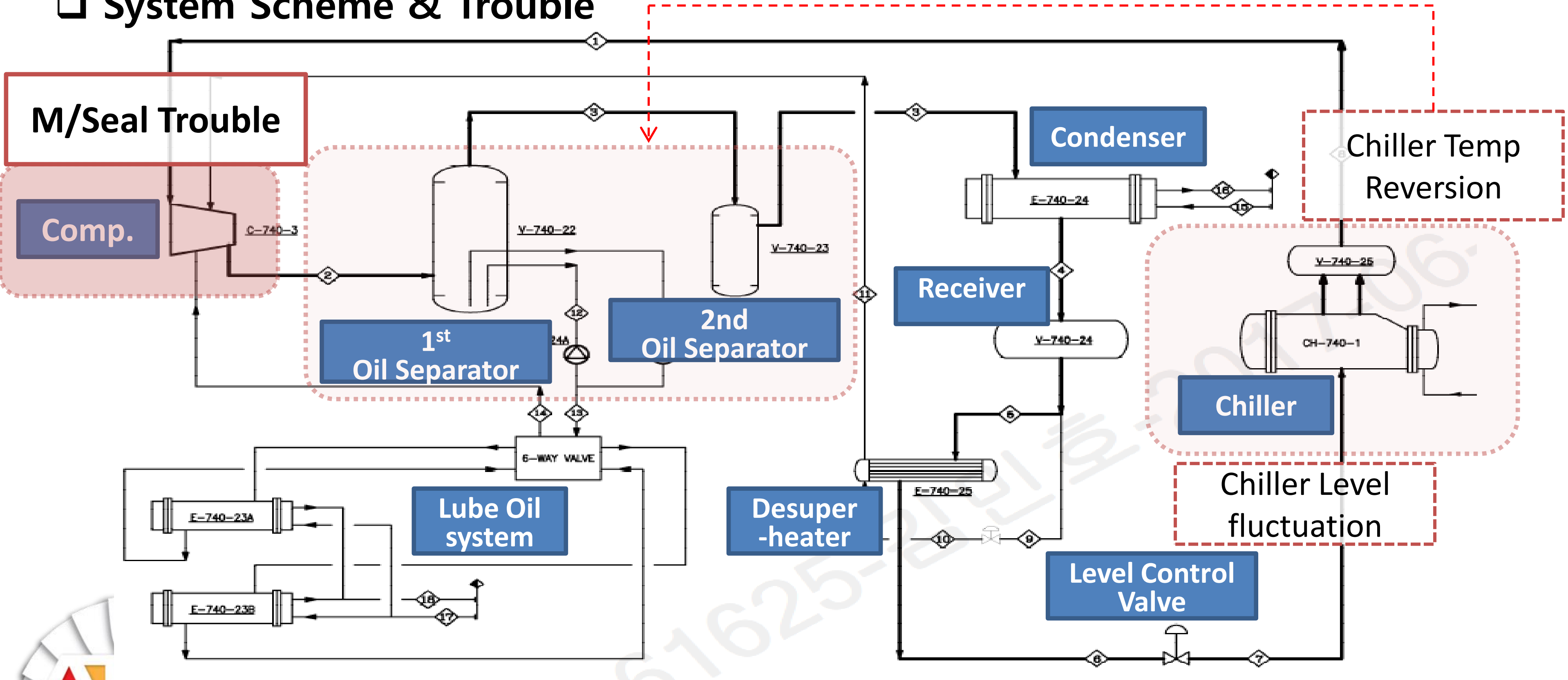
We consistently experienced mechanical seal failure of the oil–flooded screw compressor in the refrigeration system.

The first seal failure happened on July, 2015, which is a year passed since start-up. This seal failure was repeated 4 times every 3 months. All the seal failures were caused by the oil carbonization. These phenomena happened on the outboard seal only and all seal failures' phenomena were almost same. We finally solved this problem by adjusting the seal face flatness.

Introduction

Compressor Spec.	1750 kW / 3550 rpm
Refrigerant	Propane(R-290)

❑ System Scheme & Trouble



Trouble

Trouble History

1) Jul. '2014 – The refrigeration system start-up

2) Jul. '2015 – 1st Mechanical Seal Trouble : Emergency shut down

Mechanical seal replacement without any modification

3) Oct. '2015 – 2nd Mechanical Seal Trouble : Emergency shut down

Mechanical seal replacement without any modification

4) Jan. '2016 – 3rd Mechanical Seal Trouble : Planned shutdown

Mechanical Seal was modified to change the roughness from 30 um to 60 um and additional flushing line was installed → **Failed**

5) Mar. '2016 – 4th Mechanical Seal Trouble : Planned shutdown

Mechanical seal was modified to face flatness. The light band on seal face was adjusted as 7 L.B. → **Performed well**

Trouble

Oil Leakage

❑ Oil Leakage

13. Jan. ’16

53.3 cc/day

5. Feb. ’16

55.9 cc/day

11. Feb. ’16

43.2 cc/day

17. Feb. ’16

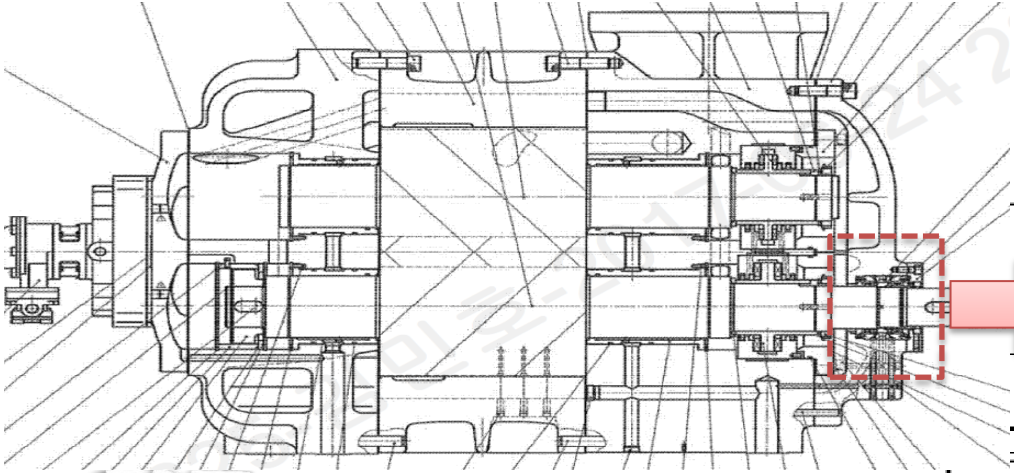
19.2 cc/day

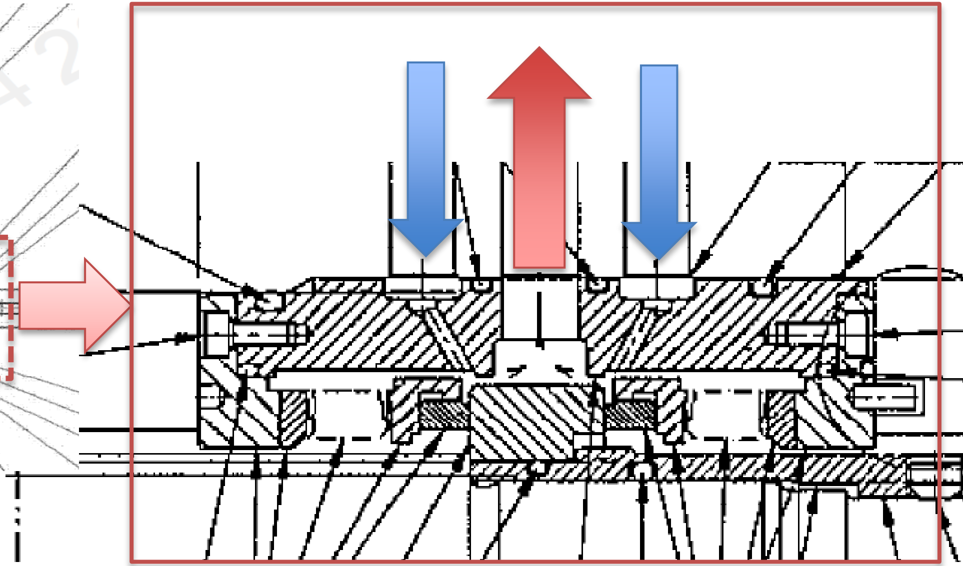
Dark !!

Trouble

Carbonization

- Type : Dual Pressurized Seal / Face to Face
- Oil Injection Rate = 21 LPM
- Seal Face Material(Stationary / Rotating) = Carbon / TC





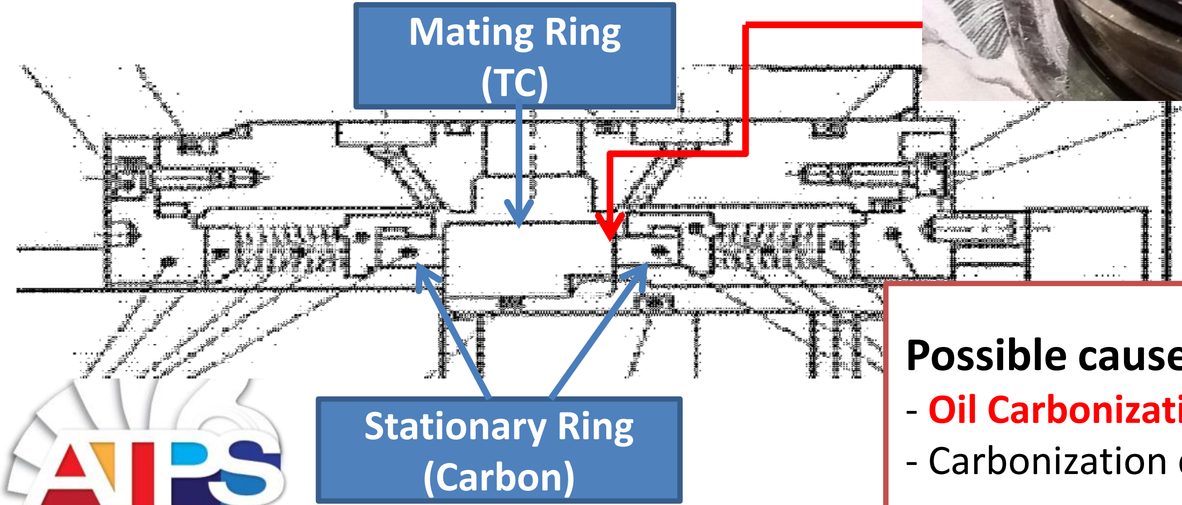
Trouble

- **The carbonization happened at the inner dia. of outboard seal**
- **Sealing Face looks good, not bad except for carbonization**
- **There is no carbonization on Inboard side and the Mating Ring was clean**

Carbonization

< Stationary Ring >

Oil Carbonization



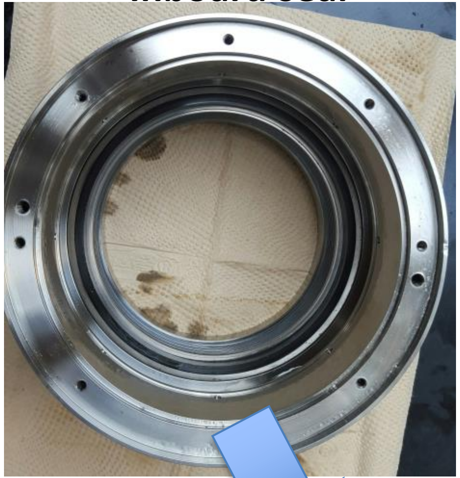
Possible cause for Seal Trouble

- **Oil Carbonization** on the Stationary Ring by the Heat
- Carbonization deposit makes the seal faces opened

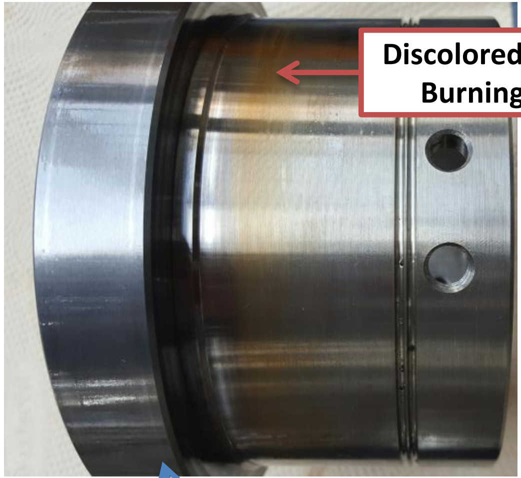
Trouble

Carbonization

< Inboard seal >



< Seal Sleeve >



Discolored by Burning

Mating Ring

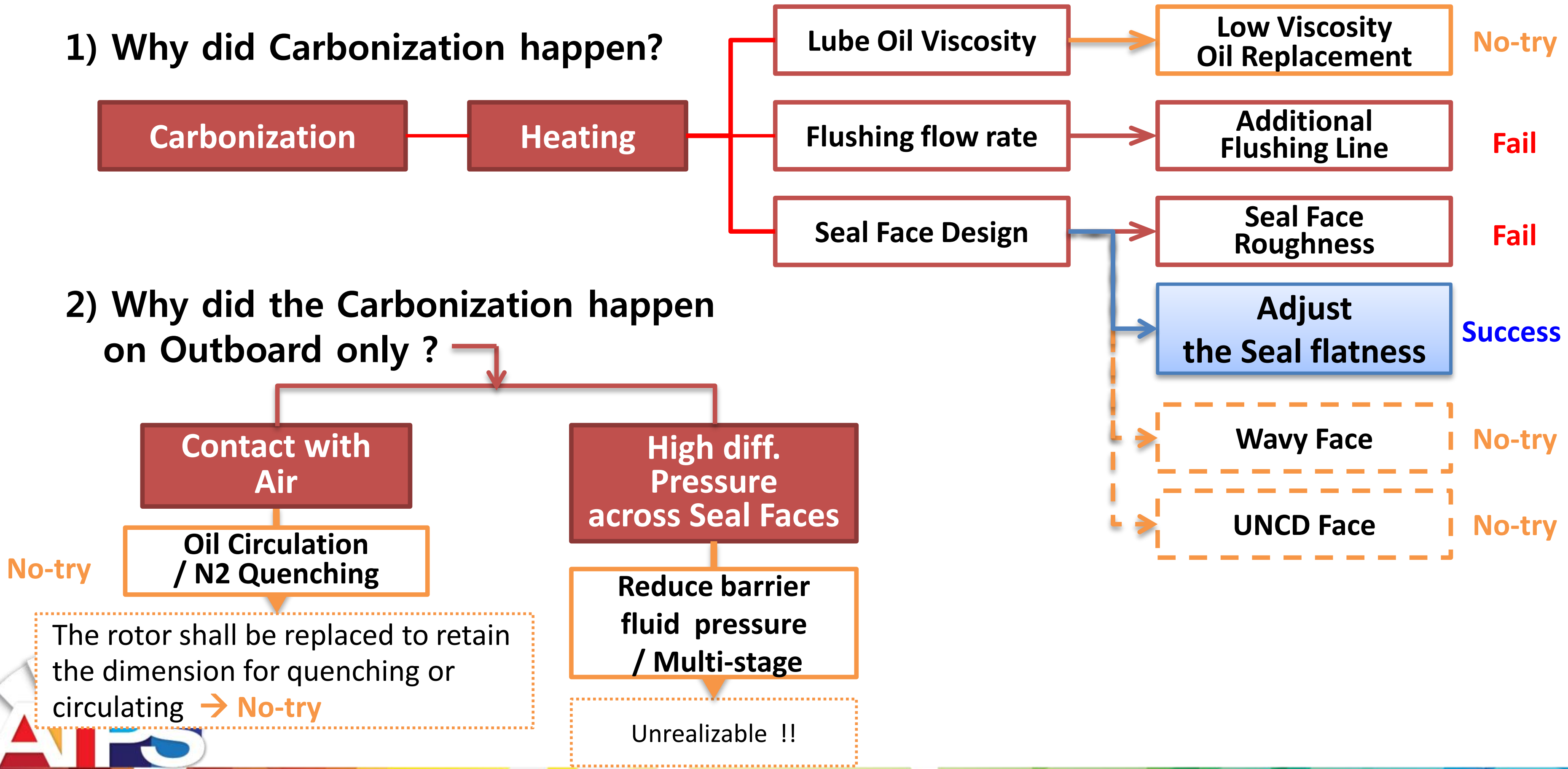
< Outboard seal >

Seal Face looks good

Oil Carbonization

Cause Analysis

Cause Analysis & Solution

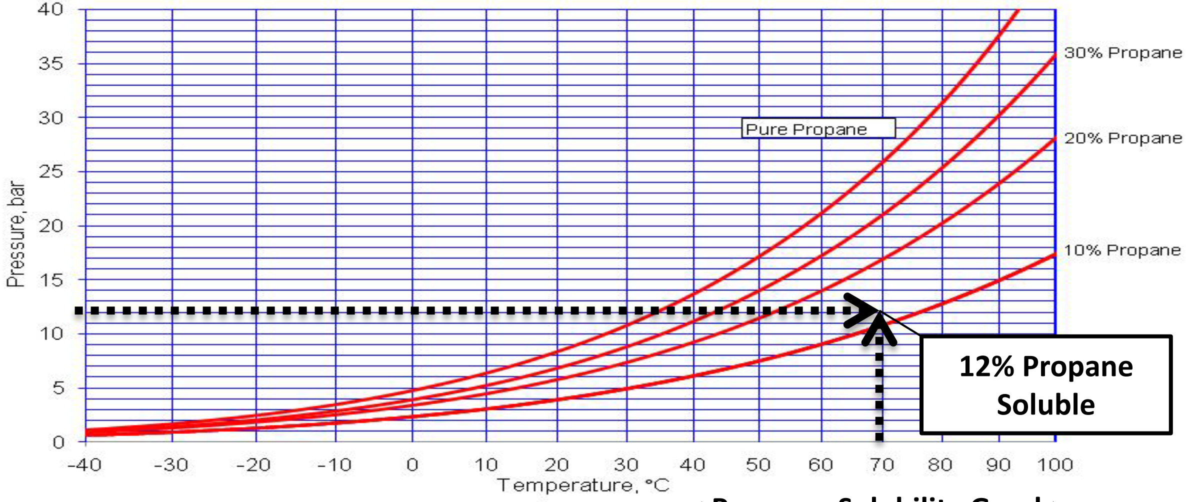


Troubleshooting

Lube Oil Viscosity

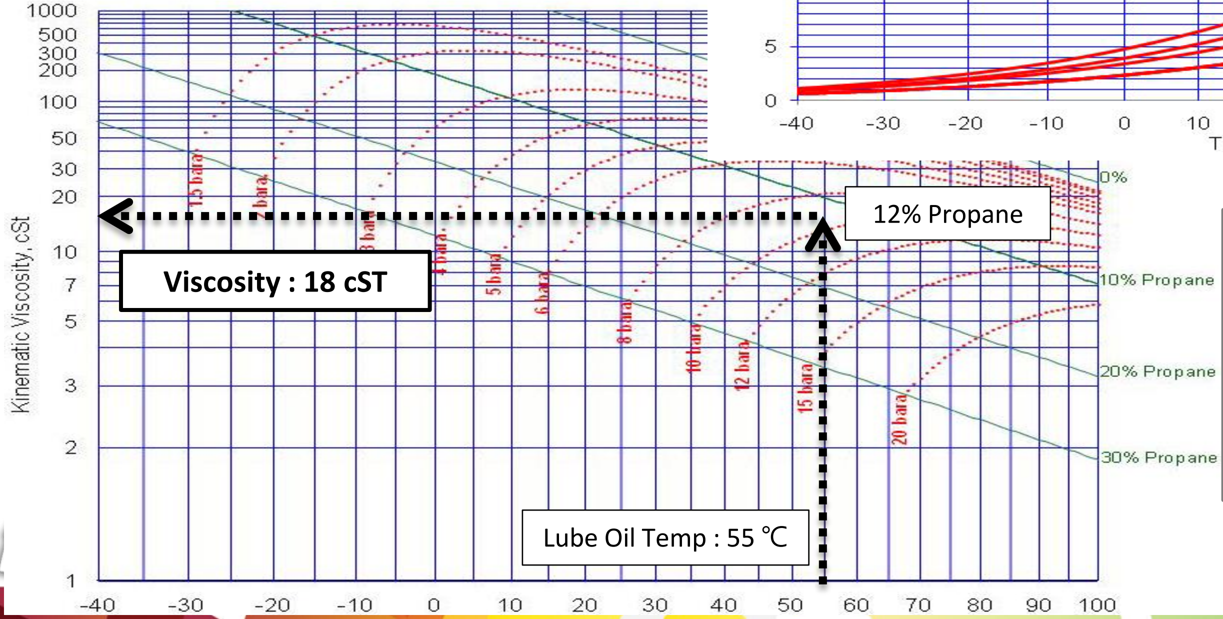
Lubricant : Gargoyle Arctic SHE 230
- Viscosity : 220 cSt @ 40 ℃

*** Proper Vis. Range : 10 ~40 cSt**



< Propane Solubility Graph>

< Propane Viscosity Graph >



Pure Lube Oil Viscosity is 220 cSt at 40 degC
But the propane is soluble in lube oil through the compressor and separator and the lube oil is injected to the bearing and seal as approx. 18 cSt

The lube oil viscosity is not a problem !!

Troubleshooting

▶ At a 3rd shutdown - planned

1) Adjustment the roughness

- Matte finish(higher roughness) on the seal faces was applied to provide full fluid's film and improve lubrication

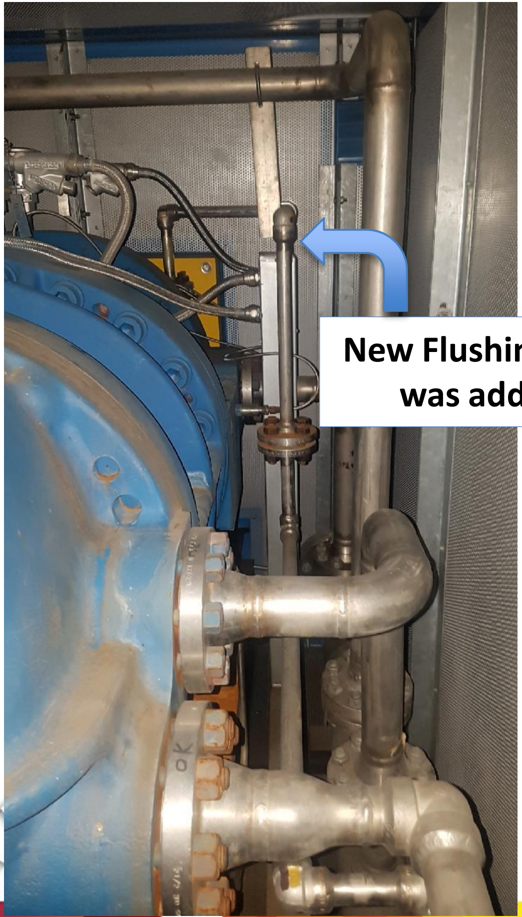
2) Installation of the additional flushing line

- In the oil-flooded screw compressor, the seal was located at the end of the main rotor's shaft.
- There is no oil injection line for mechanical seal only
- Oil was injected through the radial and thrust bearing.
- The new flushing line was added to increase the oil injection flow.

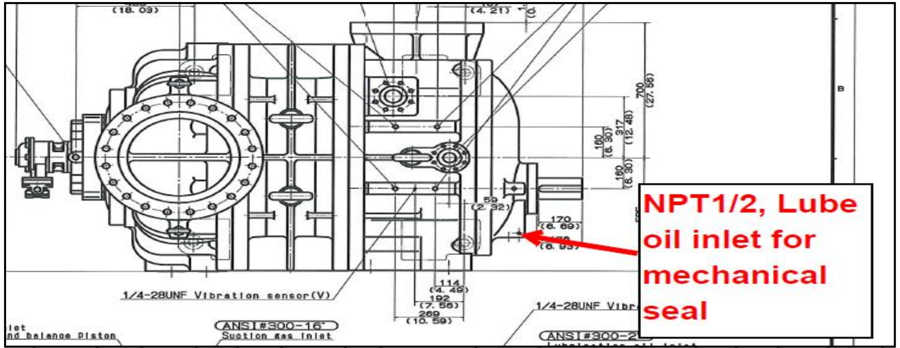
But these trials did not help and the carbonization happened again in 3 months

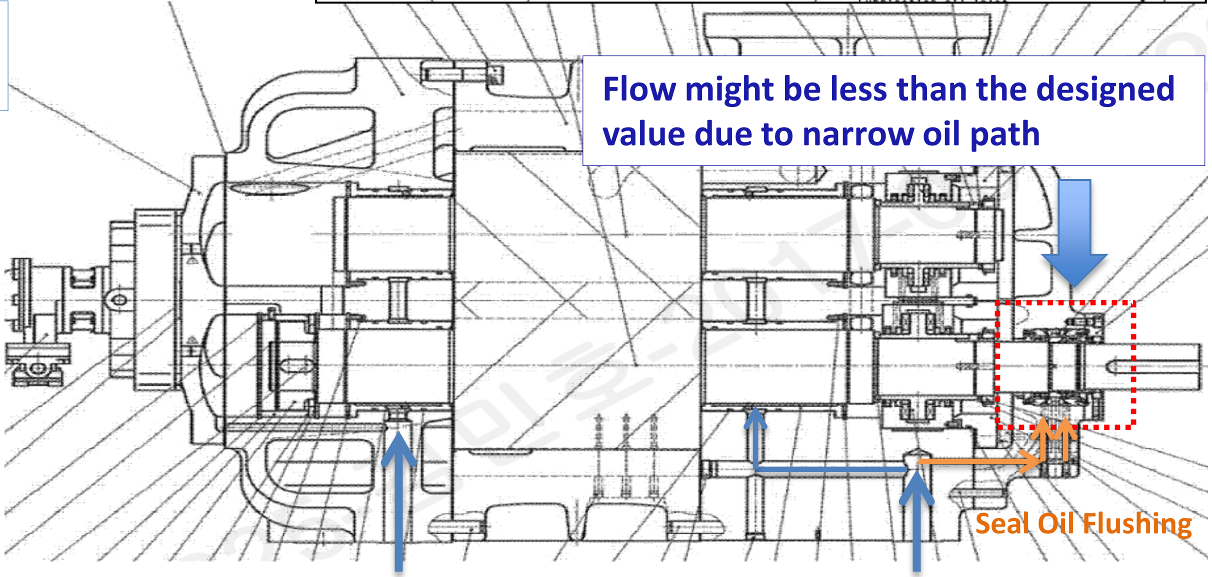
Troubleshooting

New flushing line



New Flushing Line was added





Flow might be less than the designed value due to narrow oil path

Lube Oil

Lube Oil

Troubleshooting

▶ At a 4th shutdown - planned

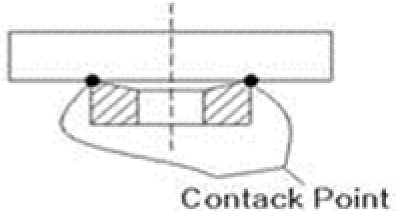
To adjust the seal flatness

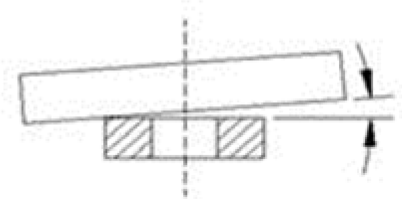
- We considered the reduction of contacting area on seal faces to decrease heat generated at seal faces
- The flatness of seal faces were adjusted as 7 convex L.B.

➔ **Finally the carbonization didn't emerge anymore**

Seal Face Flatness 2 L.B. → 7 L.B.(0.29 um x 7 L.B. ≒ 2 um)

√ 1 L.B. = Wave length of the Helium Monochromatic Light x ½ = 2900 Å = 0.29 um





*** Mechanical Seal Band**

: Test Method to verity the face flatness

- Manufacturer's general standards

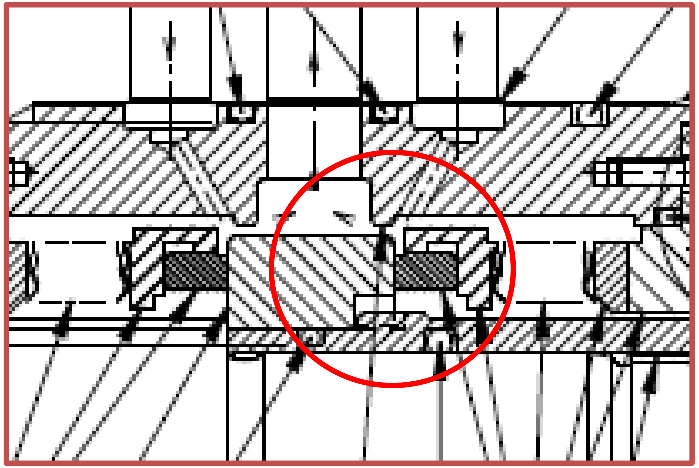
: within 3 L.B.

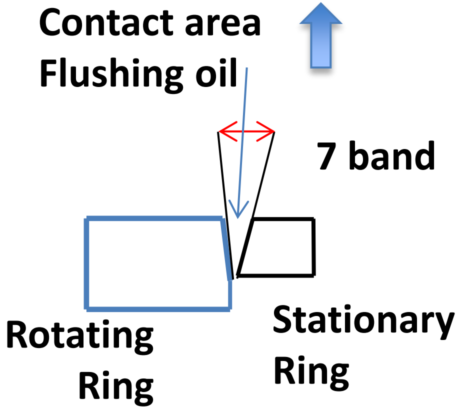
Troubleshooting

Effect - adjustment of the seal faces flatness (Assume)

1) Increase the area which is fully lubricated with the flushing oil

2) Increase the flushing flow rate





Troubleshooting

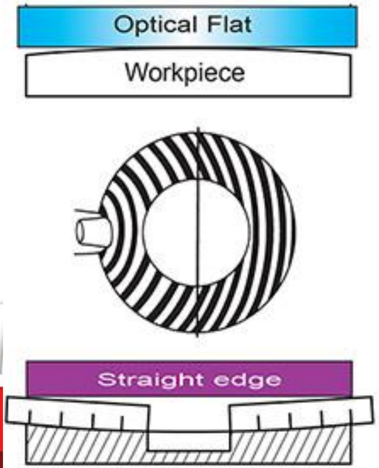
Effect - adjustment of the seal flatness (Assume)

3) Decrease the heat generation

Heat Generation $$H = P_f \times V \times A_f \times f$$

Total Pressure $$P_f = \Delta P \times (b - k) + P_{sp}$$

K-factor is changed by the seal faces flatness's adjustment as well as sealing fluid.



For convex seal faces (converging fluid film), K is greater than 0.5

- For flat faces, K is 0.5

Summary

The seal failure was caused by the oil carbonization and all seal failures' phenomena were almost same. These phenomena happened on the outboard seal only.

According to our analysis, the carbonization came from the high lube oil viscosity, low flushing flow rate, contact with air, and high differential pressure on the seal faces.

We finally solved this problem by optimizing the seal faces flatness under the current operating condition.

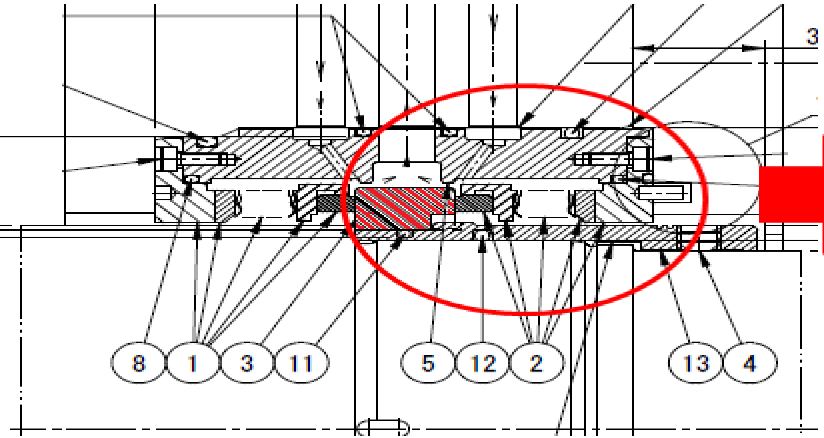
This action may not be common solutions. But it is one of easy approaches to sort out carbonization issue under an urgent situation.

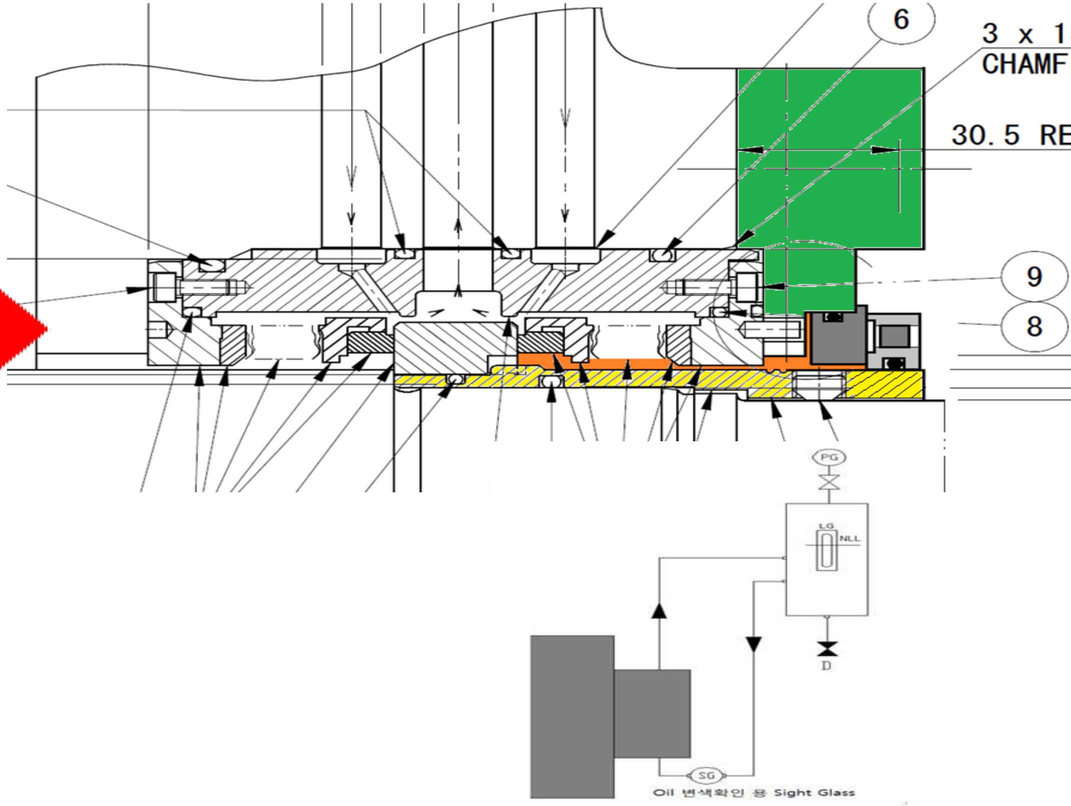
End of Document

ACKNOWLEDGEMENTS
This work has been encouraged by the Korea Rotating Machinery Engineers Association (KRMEA). The authors are grateful for the encourgement

[Back-up]Mechanical Seal Failure

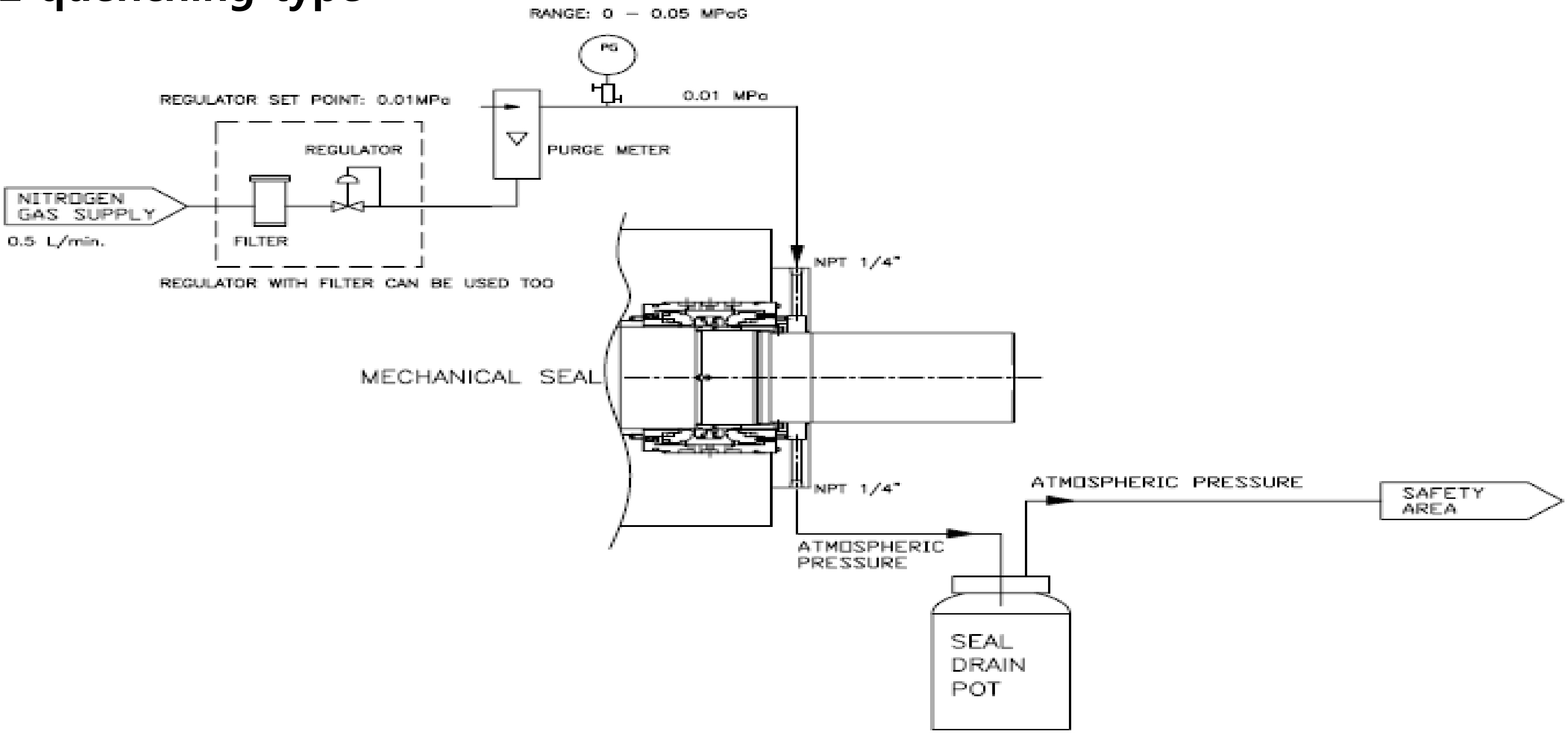
- ❑ **Oil Circulation type**





[Back-up]Mechanical Seal Failure

- N2 quenching type



[Back-up]Mechanical Seal Failure

- ❑ **Wavy Face**