

WORLD-CLASS OUTSTANDING INTERNATIONAL
PROGRAM | EXHIBITION | NETWORKING

SEPARATION SEAL UPGRADE TO OVERCOME REPETITIVE FAILURES

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42nd Turbomachinery
29th Pump SYMPOSIA

GEORGE R. BROWN CONVENTION CENTER
9.30 – 10.3.2013

Objectives

- Trouble shooting of Separation seal failures.
- Reference for DGS design selection at Project stage.
- Share experience with audience for improved DGS performance (in certain applications).



Contents

- ✓ Problem
- ✓ Events' Summary
- ✓ Observations & Findings
- ✓ Root Cause Failure Factors
- ✓ Solutions
- ✓ Selection & Implementation
- ✓ Conclusion



Problem

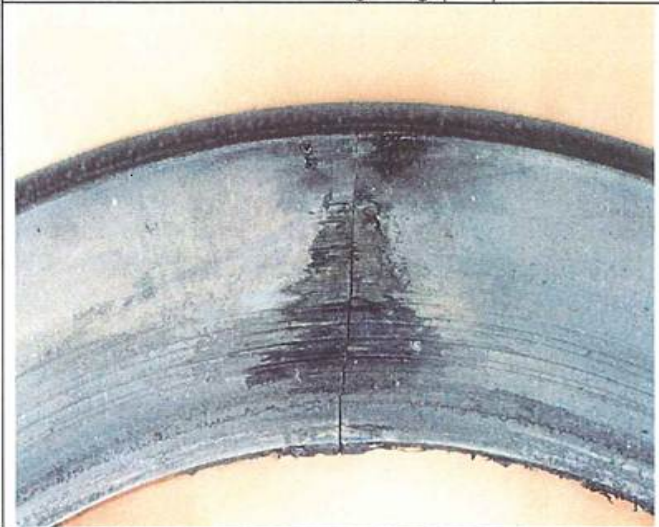
- Repetitive failures of Separation Seal (Contacting Design type).
- Flooding of main gas seal with lube oil.
- Excessive leakage of lube oil from DGS cavity drains.
- Lube oil accumulation at Primary & Secondary vent lines.
- Lube oil & vapors mixture seepage to buffer gas skid filters.



Events' Summary

- **Cracked mating ring – in to 7 pieces (Sept 2000).**
- First modification made on 18/28-K001/2 FG Compressor Gas Seal Cartridges (Year 2000) was:
 - (a) Adding O-ring at locking-sleeve / collar between items 11 & 13; to prevent oil migration.
 - (b) Increase annulus area --- around outboard retainer between O-rings 33 and 34 --- to reduce flow restriction thus preventing possible reversed pressure.

Outboard Mating Ring (#12)



Surface condition : Heavy contacting mark at the all surface
Liquid migration : Wetted overall with oil contamination

Visual Inspection: Inboard seal

Inboard Mating Ring (#1)



Surface condition : Heavy contacting mark at the all surface
Liquid migration : Wetted overall with oil contamination

Sleeve (#11) & O-ring (#9)



O-ring (#9) overheated and smashed into fragments

- **This has reduced failure frequencies due to oil migration but still at a level of unacceptable MTBF.**

Separation Seal Upgrade to overcome Repetitive Failures



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Events' Summary

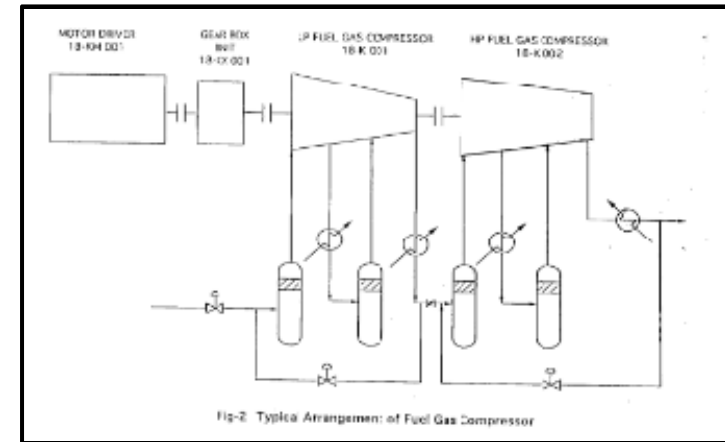
- Frequent seal failures in Fuel Gas Compressors, experienced over 12 years of operation.
- 9 sets of DGS were replaced on 4 units in last 4 years.
- Lube oil migration is monitored for quantity, color, and debris.
- Separation Seal Gas supply Nitrogen pressure was increased gradually from 0.45 (design) to 0.9 barg.
- About 50 to 150 ml/day accumulated lube oil being drained on daily basis from seal cavity.



Equipment Details

Compressor

- Service : Fuel Gas Compressors
- Type : LP (MCL) & HP (BCL)
- Model : MCL 9H-7C (LP Compressor)
BCL 5V-8B (HP Compressor)
- Max working pressure : 7 barg (LP) & 29 barg (HP)



Dry Gas Seal

- Gas seal : Tandem 28AT Model
- Separation seal : Contacting type, (T82)
- Size : 7.625" (for LP) , 6.625" (for HP)

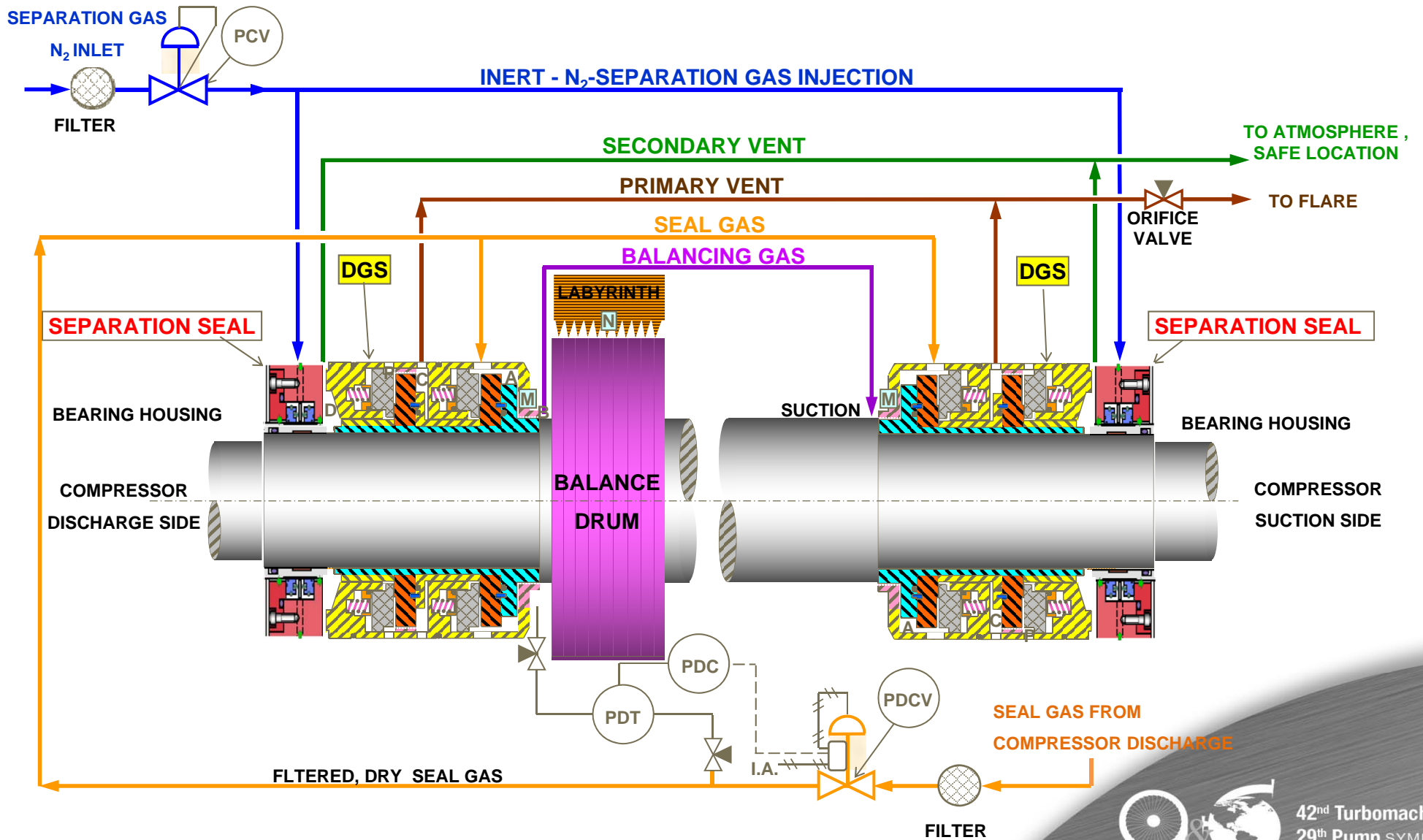
Separation Seal Upgrade to overcome Repetitive Failures



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DGS Schematic



Separation Seal Upgrade to overcome Repetitive Failures

Observations & Findings



- Lube oil accumulation inside seal bore



- High/hard spots
- Sharp edge / Irregularities



- Oil film on Secondary seal ring faces

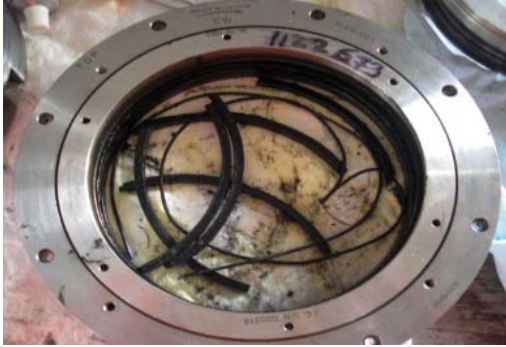
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Observations & findings



- Separation seal carbon segments in damaged and dislocated condition



- Worn out seal rings



- Carbon deposit

Separation Seal Upgrade to overcome Repetitive Failures

Observations & Findings



- Excess oil collected from both Primary & Secondary drain line



- Oil reached up to primary vent line



- Oil collected from vent line drain points

Separation Seal Upgrade to overcome Repetitive Failures



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Observations & Findings



- Lube Oil migration issue found more severe at NDE (Thrust Bearing) relative to DE (Non Thrust) DGS assembly.

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Root Cause Failure Factors

Dusty climate effect on breather element function. (Equipment Strategy)

Location of the oil - vapor extraction point from bearing housing

Lack of physical restriction like baffle / deflector / labyrinth between bearing and separation seal.



T-82 separation seal design does not work properly for compact Bearing Housing, where extraction of oil-vapor mixture is ineffective

Solution

Available Options

Option-1

Compressor / system retrofit

- ❑ Bearing housing modification:
- ❑ Maintenance Strategy upgrade
- ❑ Improving QA / QC for the new spares

Considered secondary for implementation

Option-2

Separation seal upgrades

Sequence of schemes considered:

1. Original seal (T-82) with oil deflector
2. Enhanced seal design (T-83)
3. T-83 with oil deflector.
4. Labyrinth seal design.
5. Non-contacting seal design (T-93FR).
6. T-93FR with oil slinger/deflector.

Implemented Successfully

Design Features of selected T-93FR

- Non-contacting for longer life and improved reliability.
- Bi-directional.
- Suitable for running with N2 separation gas irrespective of dew point.
- Self-centering design minimizes wear even during upset conditions.
- Robust cartridge design.
- Eliminate 'Fallback', 'Hang-on' phenomenon.
- Low heat generation, hence reduce coking.

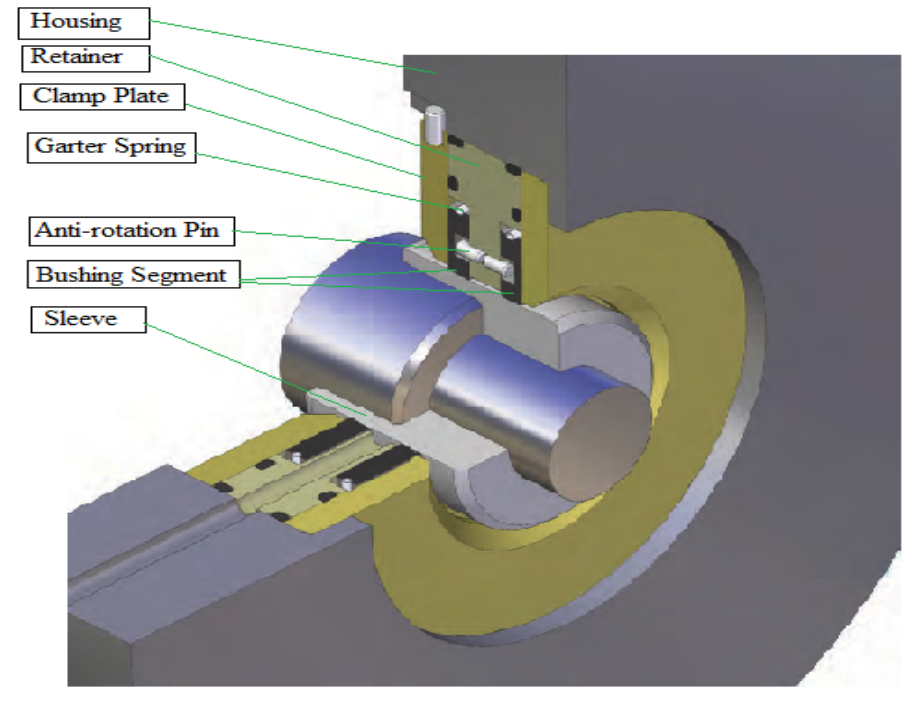


Selected Option

“Upgrade existing DGSs to available technology of Non contacting type Separation Seal (T-93FR) with Oil Slinger / Deflector provision followed by related modifications in Main Gas Sea”

✓ Options considered at RasGas to phase out the existing T82 Separation Seal with T93FR Separation Seal, but with Oil Slinger / Deflector provision to solve this oil migration issue.

✓ This enhanced design was so far running successfully at RG.



T-93FR Upgrade Requirement

1. N2 Pressure Regulator:

T-93FR is designed to operate at low N2 pressure from 0.02 – 0.25 bar, while the old T-82 was in operation with higher range from 0.25 – 0.75 bar.

2. N2 Gas Flow Meter:

With T-93FR seal system, N2 flow rate consumption will increase as per followings: -

- Original T-82 range : 2 - 5 NM3/HR
- T-93FR, cold static Range : 8- 12 NM3/HR
- T-93FR, hot dynamic : 2 – 4 NM3/HR



New Seal T-93FR – Few Snap Shots



- Oil slinger (deflector)



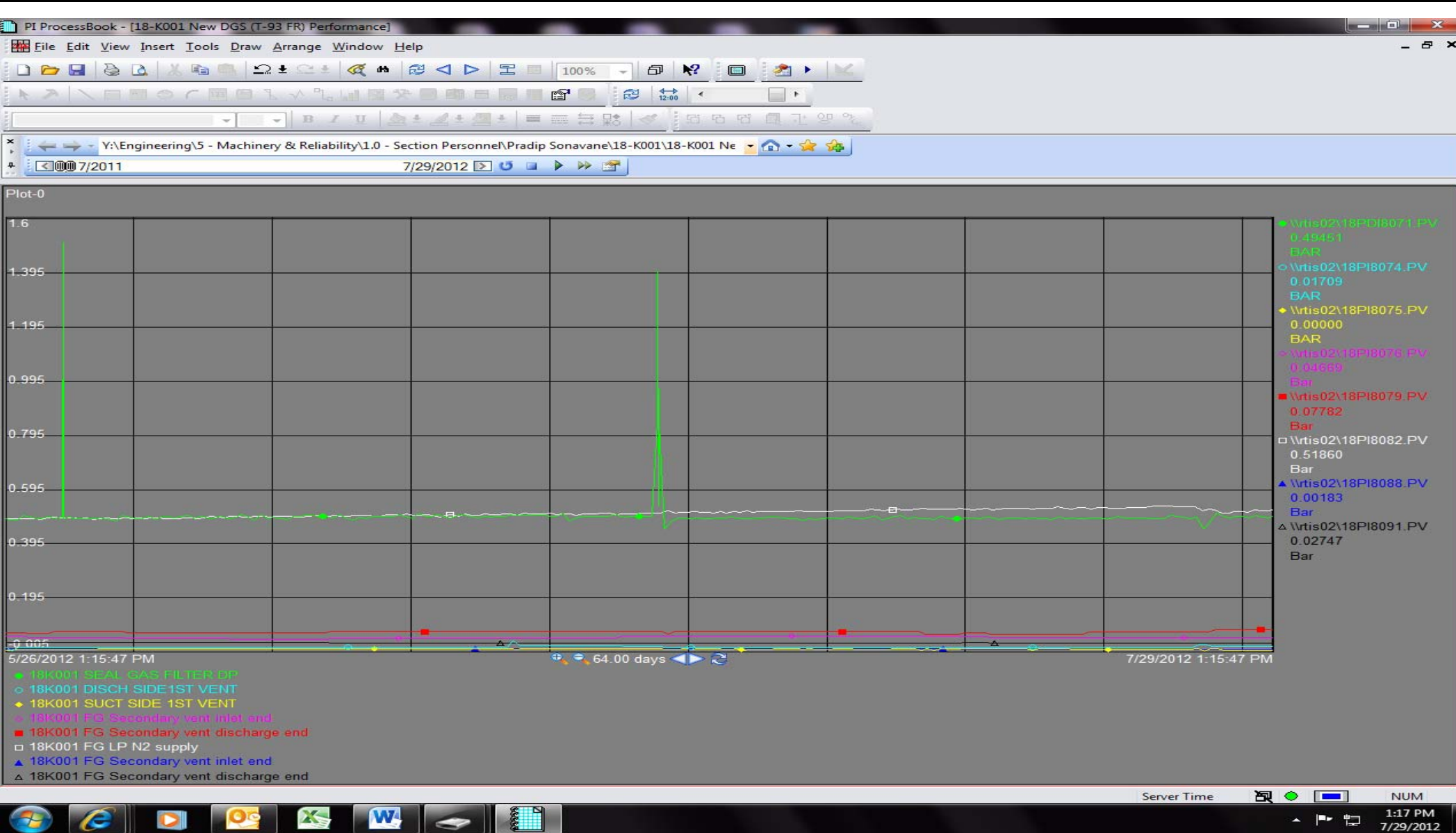
- Bearing installation



- Bearing assembly

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DGS Performance Monitoring



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Conclusion

- DGS Upgrade with Floating Ring / Non Contacting Type T-93FR Separation Seal has so far successfully solved the Lube Oil Migration / Ingress issue.
- Oil Slinger provision along with Dual Segmented Floating Carbon Ring T-93FR Cartridge Assembly has proven as effective barrier between Main Gas Seal and Bearing Housing.
- This upgrade was carried out without any modification works on Compressor side.
- T-93FR Non contacting Type Separation Seal performance observed to be significantly better in comparison with T-82 and T-83 contacting type Separation Seals.
- Successful prototype implementation based on full OEM and End User contribution



Thank you ! !

Questions ? ?

