Successful Implementation of Dry Gas Seal in High Pressure Recycle gas Compressor at Hydrocracker & Effect of Gas composition on DGS Performance

Why - Dry Gas Seal???

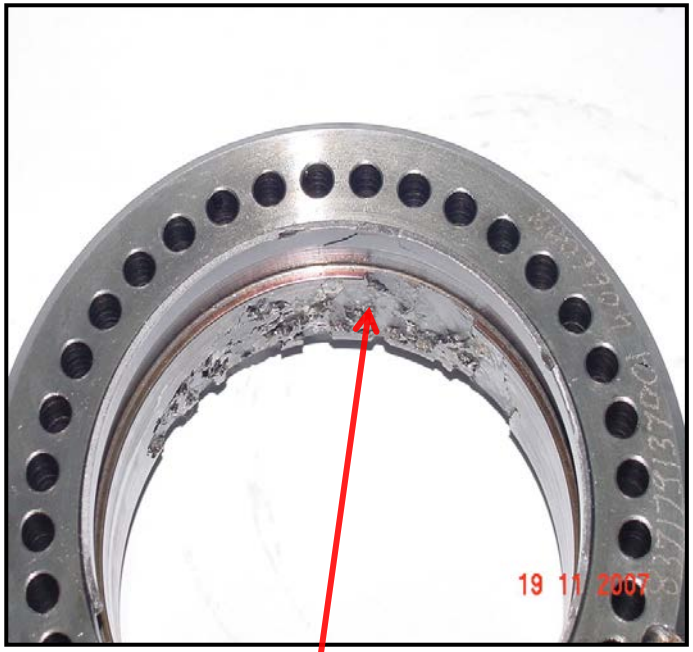
- M&I shutdown and Catalyst replacement once in 3 years.
- The life of wet seal rings system - 1.5 years to 2 Years (bottle neck)
- Unplanned shutdown resulted in loss of production and profitability.
- Enhancement of wet seal ring life is not possible; The Wet Seal system is obsolete.
- Latest Compressors are currently fitted with Dry Gas Seals.

Wet Seal failure

**FAILURE OF HP SEAL RING –
DISCHARGE SIDE - DRIVE END**

**FAILURE OF HP SEAL RING –
SUCTION SIDE - NON DRIVE END**

Wet Seal failure



SEVERE BABBIT PEEL OFF IN OUTBOARD LP SEAL RING

WORNOUT BABBIT LINING IN LP SEAL RING – DRIVE END

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Wet Seal Vs Dry Gas Seal

WET SEAL SYSTEM	DRY GAS SEAL
Comprise of oil rings, pump, degassing unit, oil reservoir, overhead tank	Comprises of Dry Gas Seal cartridges, DGS rack
Limited life span - 2 years	Life over 5 years between overhauls
Frictional loss of 1 - 2% of compressor shaft power	Negligible frictional loss
Leakage to flare: 40 to 200 scfm	Minimum leakage to flare: 0.3 to 4 scfm
Lead to unplanned shutdown	Enhanced Eqpt. Reliability and Unit Availability

DGS - Techno-Commercial Benefits

Operating Cost

- **Less Power Loss due to gas shear forces.**
- **Energy required to operate the Seal oil pumps & Auxiliaries are totally eliminated.**
- **Seal oil consumption – NIL**

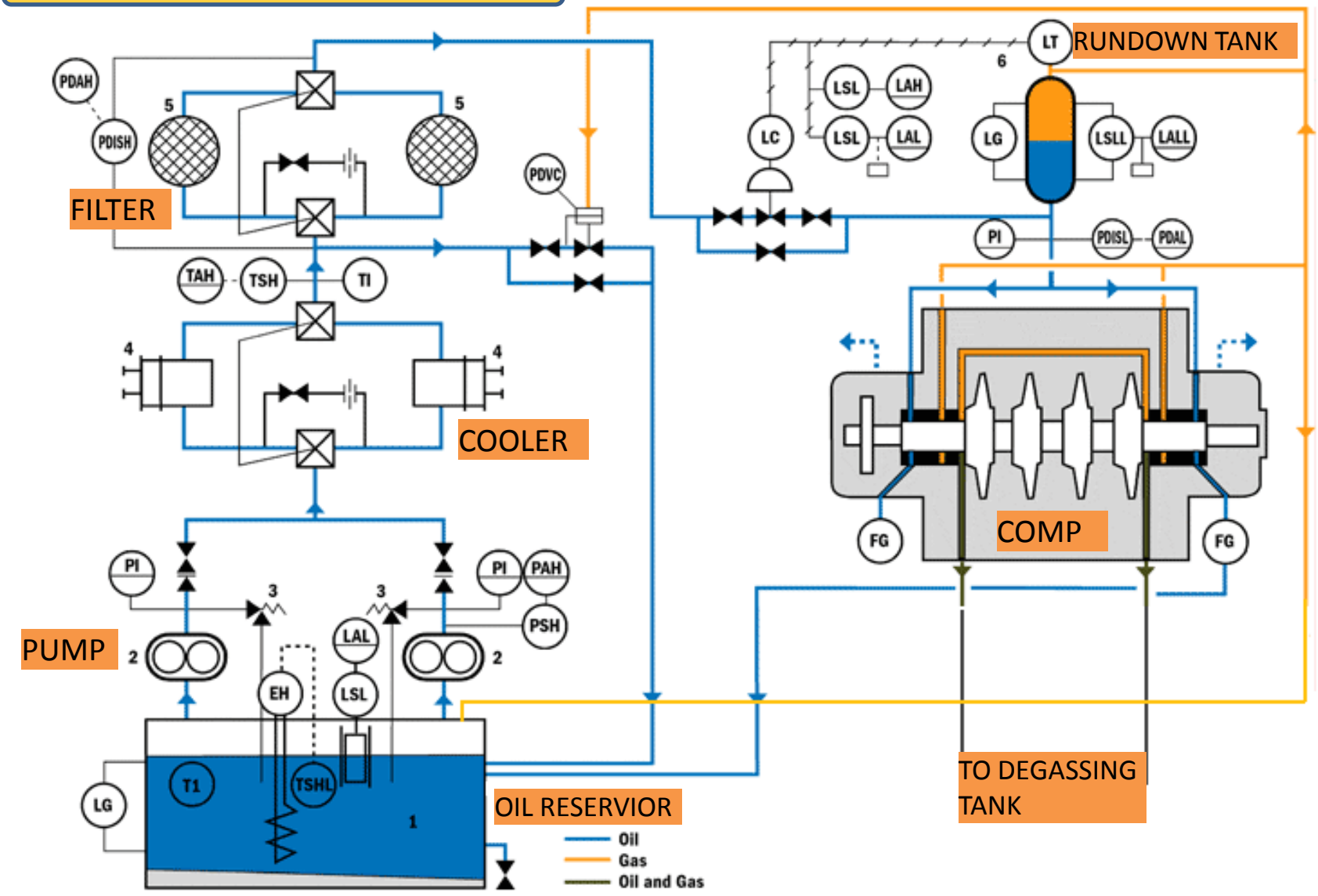
Maintenance Cost

- **No Seal oil Pumps, Valves, Coolers, Reservoirs and Overhead tanks**
- **Instrumentation.**

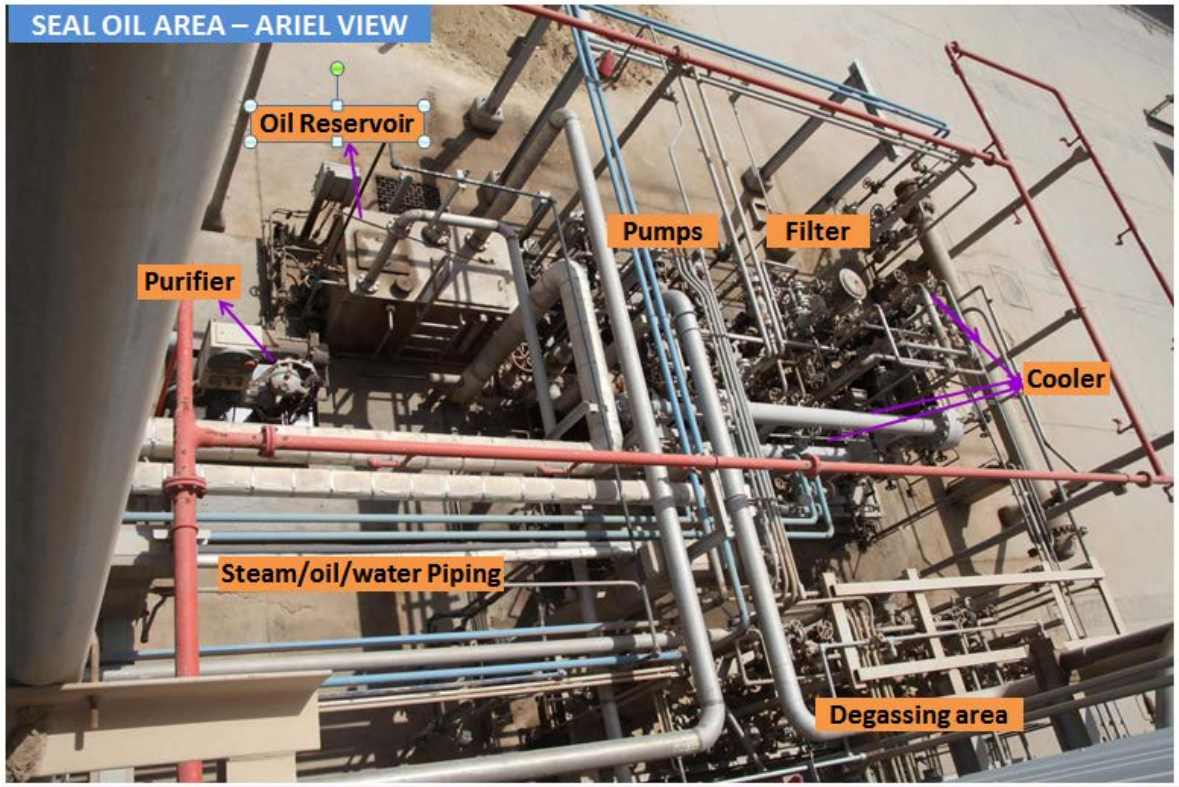
Gas Recovery Cost

- **Due to very small clearance (3μ) between the stationary and rotating faces, leakage of gas to flare could be reduced to 0.3SCFM - 4 SCFM.**

WET SEAL SCHEMATIC

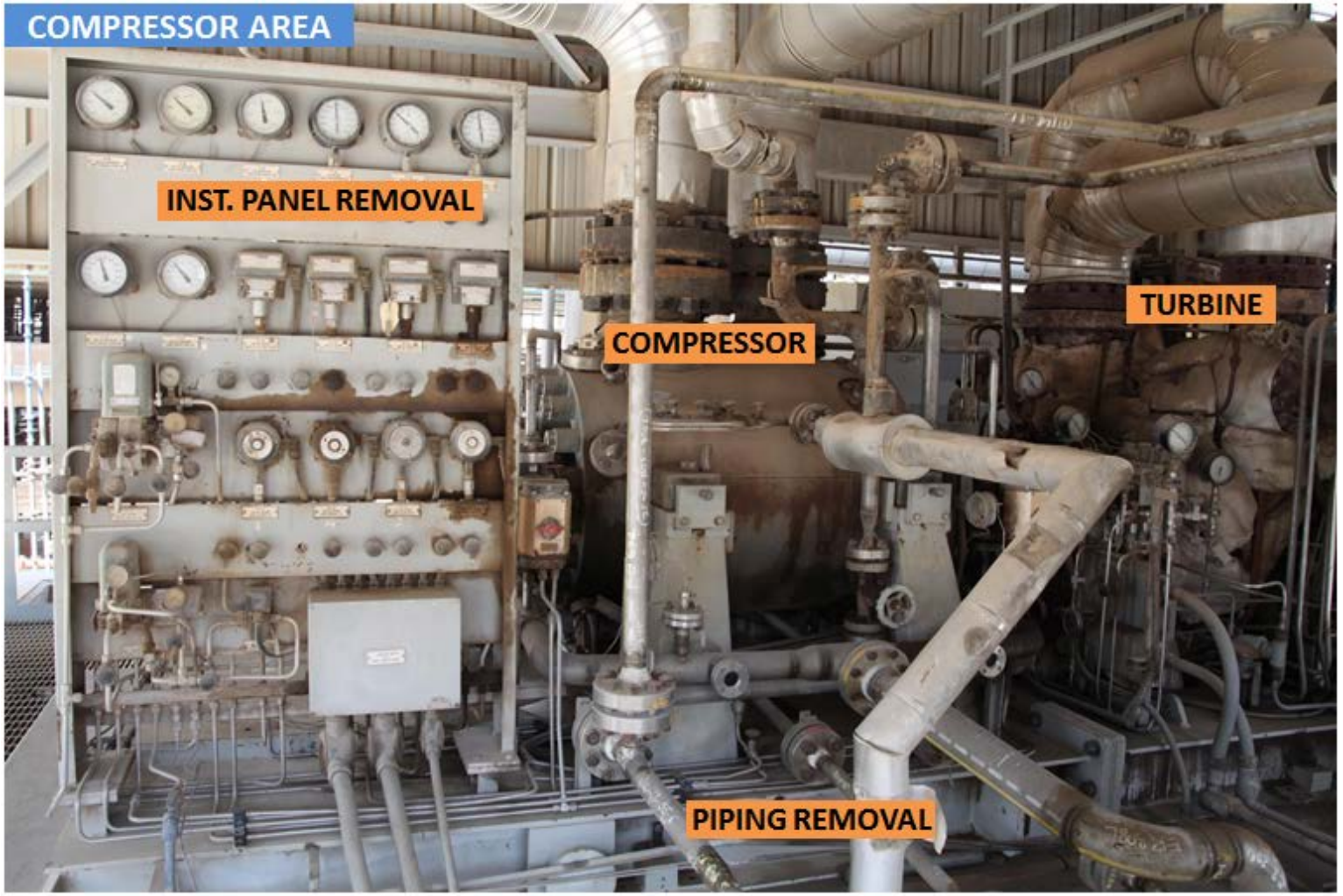


Seal Oil Area



OVERHEAD TANK

Compressor & Instrument Panel



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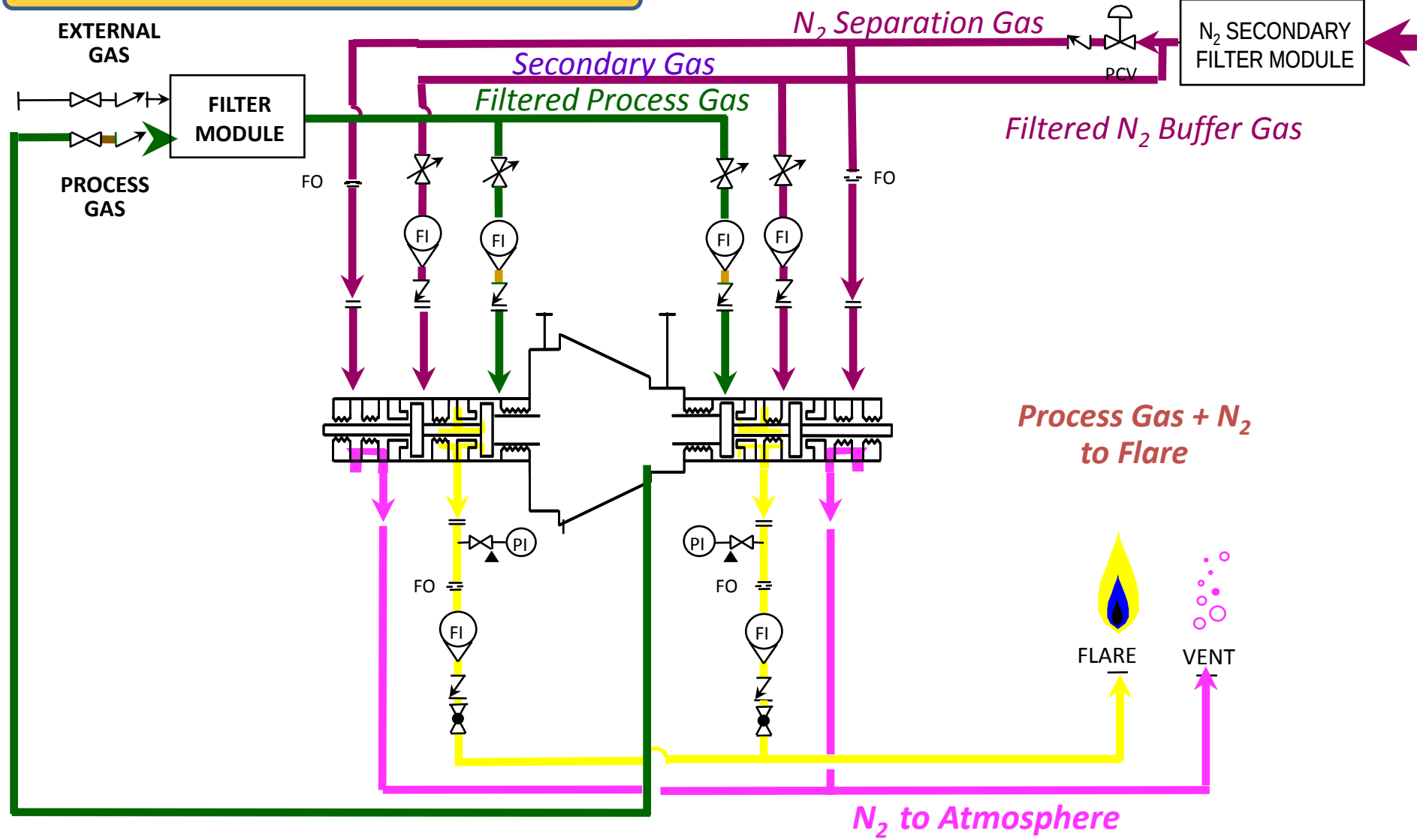
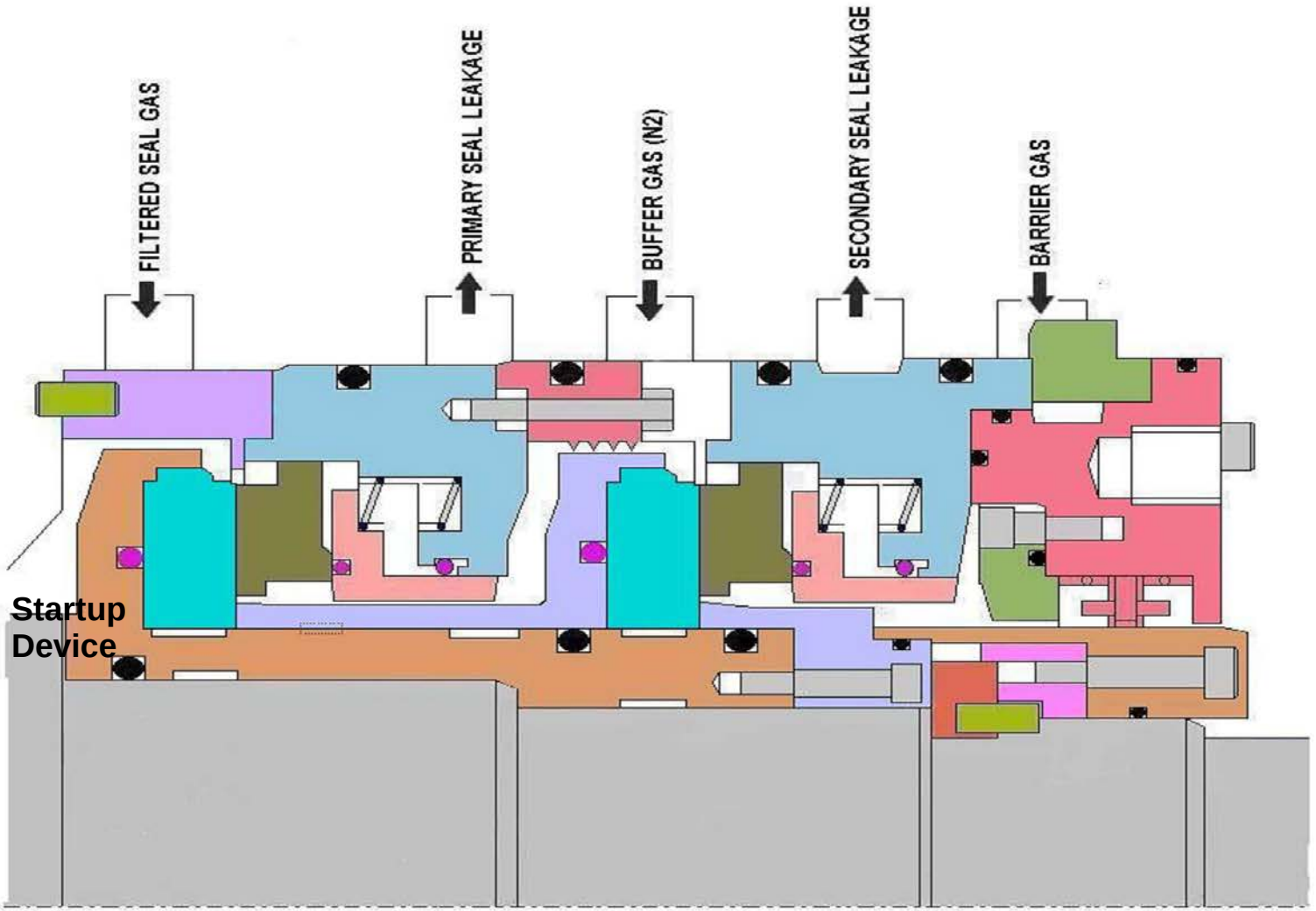
DRY GAS SEAL SCHEMATIC



Dry Gas Seal Layout



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Dry Gas Seal Installation

Seal Oil Console dismantled

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Dry Gas Seal - Installation

New Bundle shifting to position

New Bundle Assembly in progress

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Dry Gas Seal Installation

DGS Rack Erection/ Leveling Completed

Compressor loop test

- **To verify the mechanical integrity, a mechanical run test was conducted.**

TEST PROCEDURE:

- **System has to be pressurized with N_2 to 400psig**
- **Test speed - 8,000 RPM for minimum four hours**

PROJECT COMMISIONING

- DGS Retrofit activity completed on 22nd June 2012
- C-14-101: Commissioned on 22nd July 2012
- C-14-102: Commissioned on 7th August 2012

DGS Performance after Commissioning

Dry Gas Seal Performance

C-14-101 is in continuous operation since commissioning in June 2012

=> Zero failure in 30 months and counting……

- **MTBF with Wet Seal system was only 18 months**

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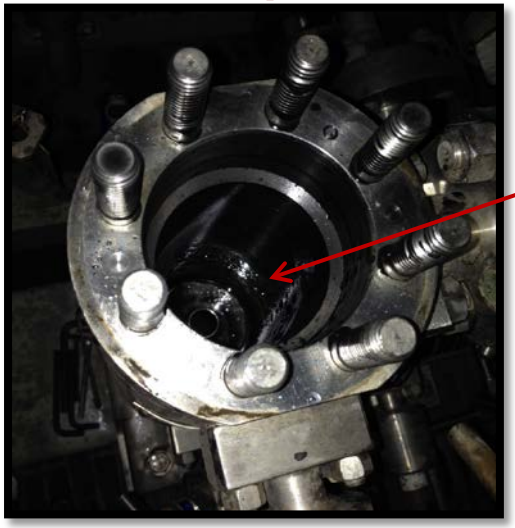
Dry Gas Seal Failure

C-14-102 experienced DGS failure 4 times between June 2012 & up till now.



Moisture inside filter housing

Primary seal gas filter – Hydrocarbon deposit

Condensate on Seal Faces

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DGS Failure - DPT & Joule Thomson Effect

- **Dew Point Temperature (DPT):**
  - DPT is the temperature at which the Gas mixture will start to condense in to Liquid.
  - Process Gas composition & Pressure affects the DPT

- **Joule Thomson Effect:**
  - Gas Pressure reduction leads to Gas Temperature reduction.

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Process Gas Composition: FEED Vs Actual

GAS	FEED Data	Revised Data
Nitrogen	0.41	0.6
Hydrogen	89.95	89
Methane	6.66	5.9
Ethane	0.21	0.3
Propane	0.98	0.9
I-Butane	0.96	1.15
n-Butane	0.39	0.55
I-Pentane	0.29	0.55
n-Pentane	0.08	0.6
n-Hexane	0.07	0.45

Root Cause Analysis of Failure…..Conclusion

- ✓ Seal gas temperature is too close to the Dew Point Temperature(DPT).
- ✓ C6+ hydrocarbon due to the pressure drop across filters, orifices and between seal faces resulted in condensation due to “Joule – Thompson” effect;
- ✓ Condensate increased the friction between the seal faces that led to “Dry Gas seal Failure”.

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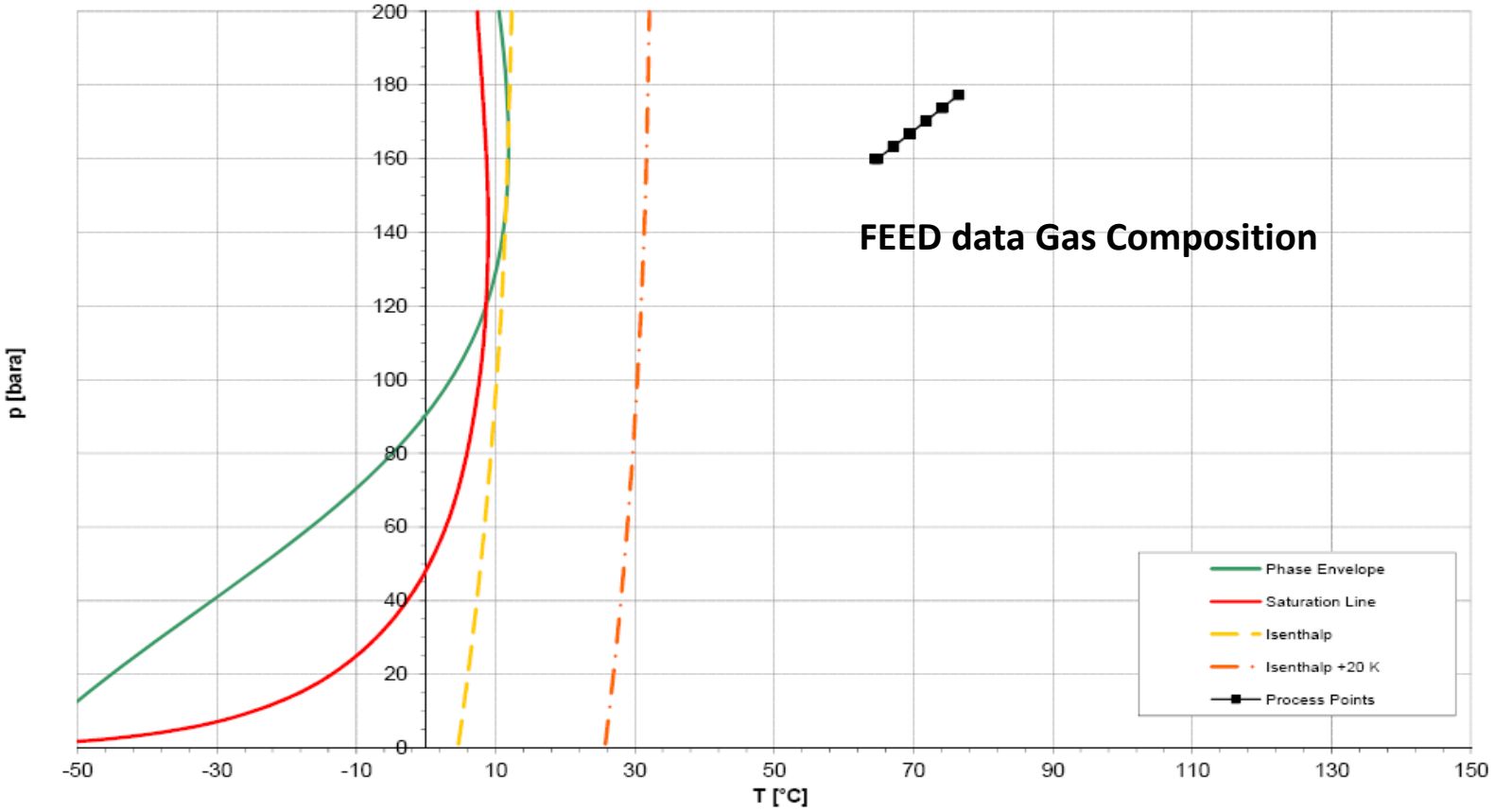
Effect of Gas Composition on DPT

Phase Envelope / Saturation Lines

FOR		PAGE	2 of 7	By	S.Schifferle
PROJECT	Mina Abdulla 84/11	DATE	17 September 2013	Case	
JOB NO.		REV.	0	MW	4.60 kg/kmol



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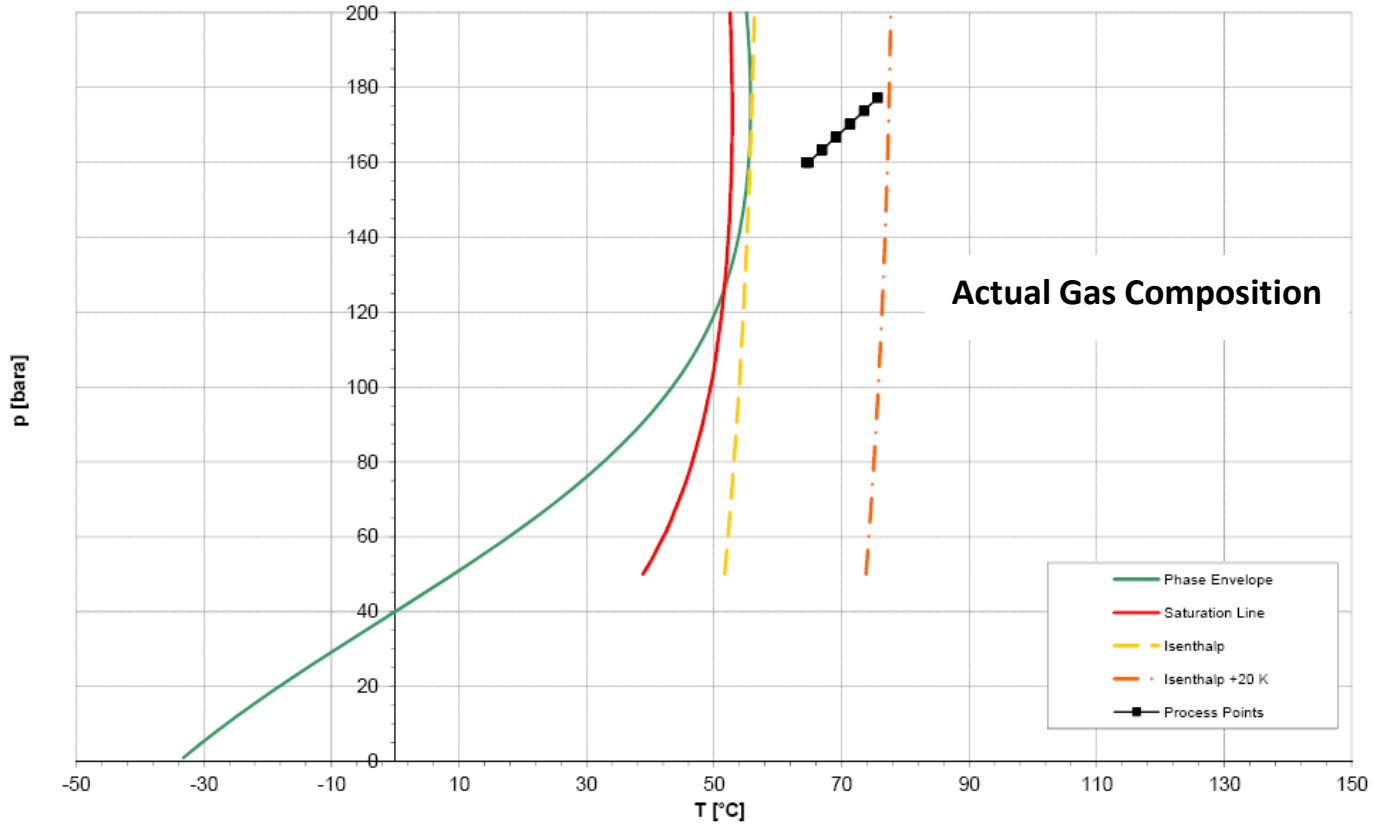
Effect of Gas Composition on DPT

Phase Envelope / Saturation Lines

FOR		PAGE	3 of 7	By	S.Schifferle
PROJECT	Mina Abdulla 84/11	DATE	17 September 2013	Case	
JOB NO.		REV.	0	MW	5.75 kg/kmol



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Solution - Improve Seal gas Temperature

Short Term

- Steam jacketing.

Long Term

- Use of electrical seal gas heater.

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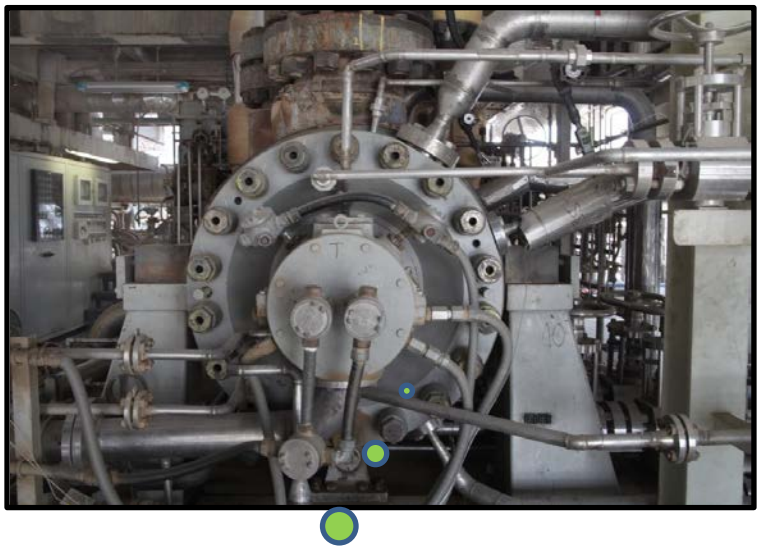
Steam Jacketing

FABRICATED STEAM JACKET TO IMPROVE EFFICIENCY OF SEAL GAS HEATING



Primary Seal gas Pre-heating by Steam jacket up to 1.6metre

Steam Jacket DE Side

Steam Jacket NDE Side

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DGS – Electrical Heater

Installation of Seal gas Electric heater

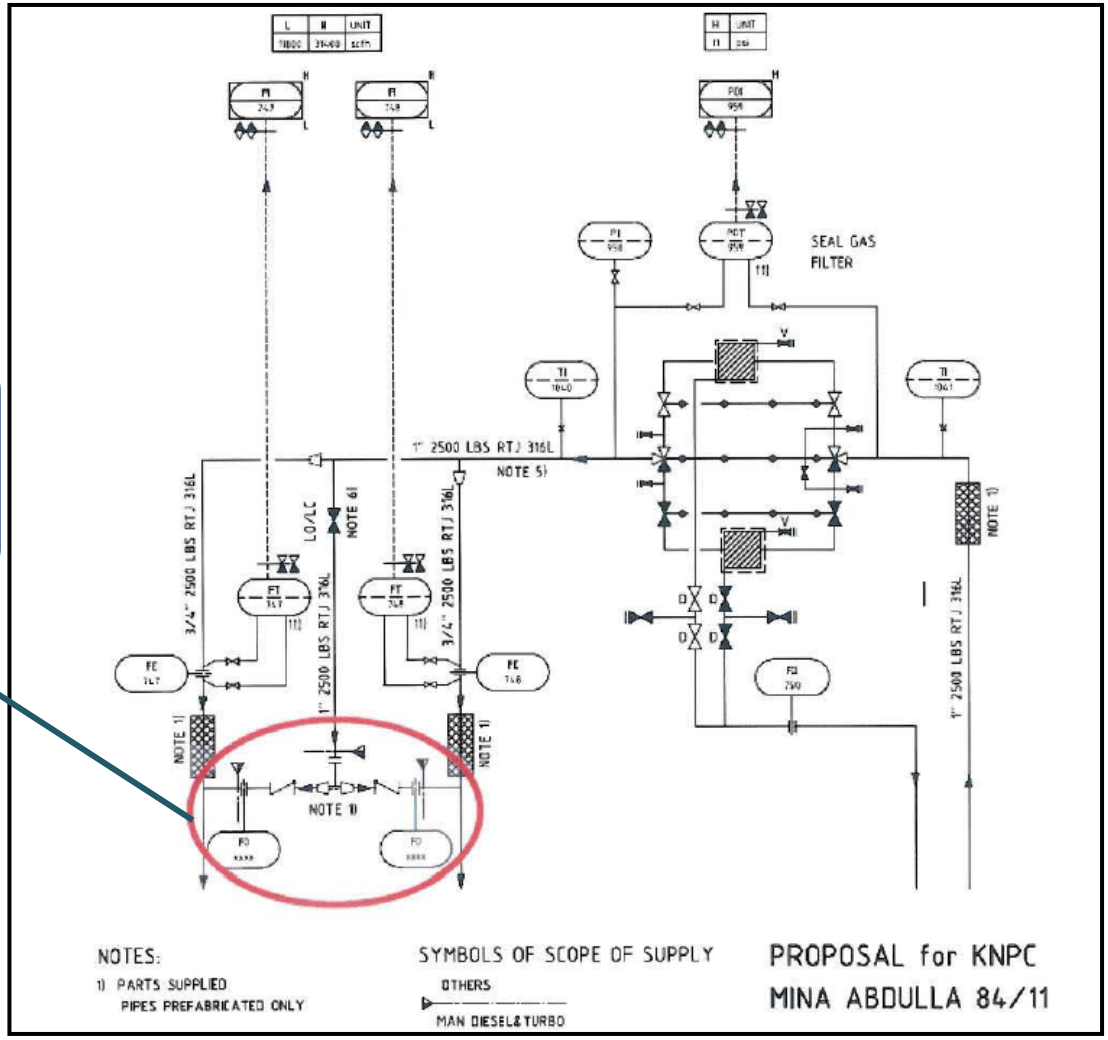
- A proven methodology to avoid Seal Gas condensation.
- The system consist of :
    - Electrical heater
    - Thyristor control unit in the control room.

System Description

- Heater outlet seal gas temperature signal given to the thyristor.
- The heater is only in service, if there is a certain gas flow, detected by the existing FI.
- A temperature sensor built into the heater monitors the block temperature and switches off the thyristor on set-point values.
- The condition of heater, thyristor, seal gas temperature, etc…is signalized in the DCS system.

Schematic

Non-return Valve in DGS rack



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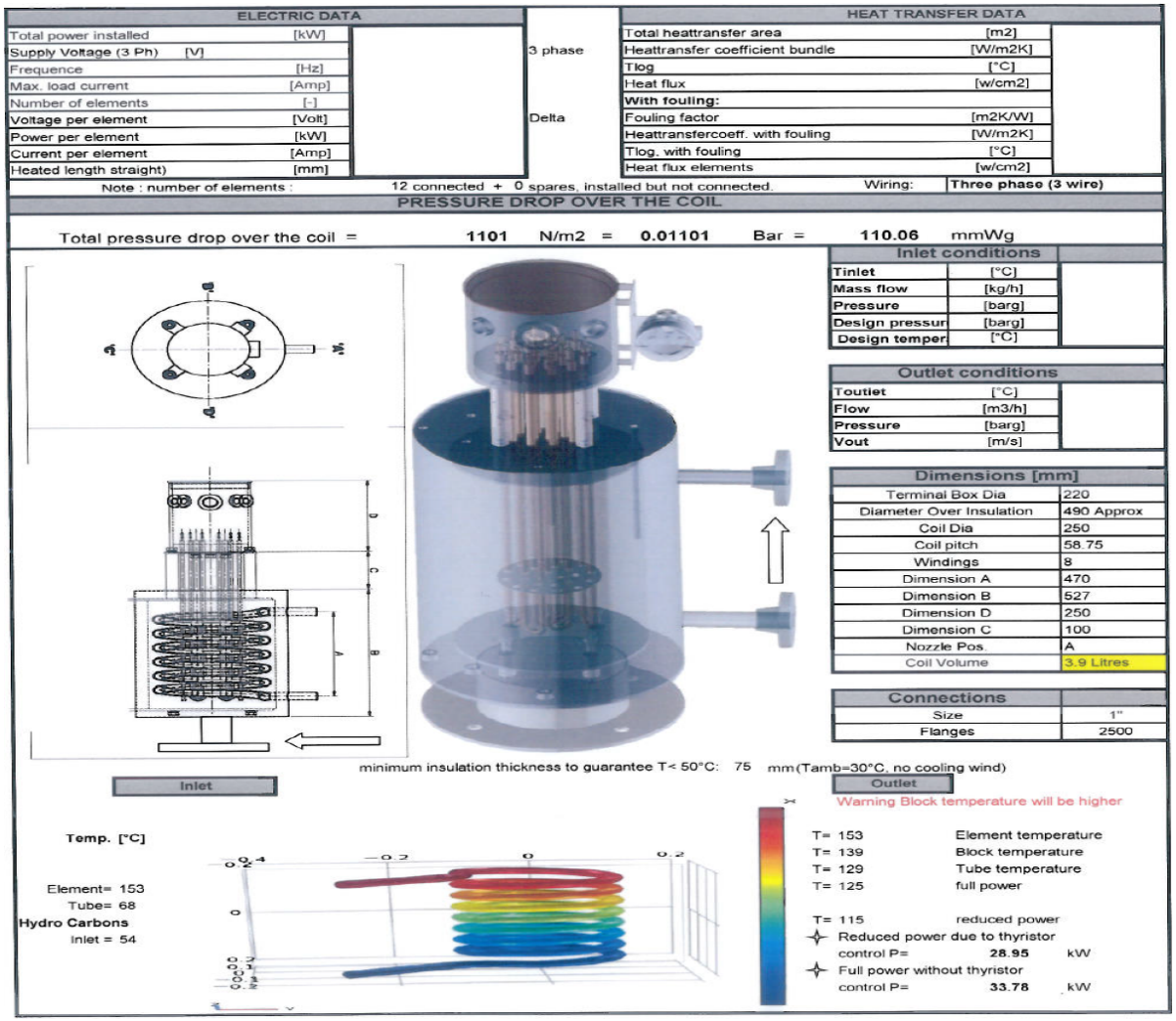
Typical Electrical Heater Assembly



ELECTRIC DATA			
Total power installed	[kW]		
Supply Voltage (3 Ph)	[V]	3 phase	
Frequence	[Hz]		
Max. load current	[Amp]		
Number of elements	[-]		
Voltage per element	[Volt]	Delta	
Power per element	[kW]		
Current per element	[Amp]		
Heated length straight)	[mm]		

HEAT TRANSFER DATA	
Total heattransfer area	[m2]
Heattransfer coefficient bundle	[W/m2K]
Tlog	[°C]
Heat flux	[w/cm2]
With fouling:	
Fouling factor	[m2K/W]
Heattransfercoeff. with fouling	[W/m2K]
Tlog, with fouling	[°C]
Heat flux elements	[w/cm2]

Note : number of elements : 12 connected + 0 spares, installed but not connected. Wiring: **Three phase (3 wire)**

PRESSURE DROP OVER THE COIL

Total pressure drop over the coil = **1101** N/m2 = **0.01101** Bar = **110.06** mmWg

Inlet conditions	
Tinlet	[°C]
Mass flow	[kg/h]
Pressure	[barg]
Design pressur	[barg]
Design temper	[°C]

Outlet conditions	
Toutlet	[°C]
Flow	[m3/h]
Pressure	[barg]
Vout	[m/s]

Dimensions [mm]	
Terminal Box Dia	220
Diameter Over Insulation	490 Approx
Coil Dia	250
Coil pitch	58.75
Windings	8
Dimension A	470
Dimension B	527
Dimension D	250
Dimension C	100
Nozzle Pos.	A
Coil Volume	3.9 Litres

Connections	
Size	1"
Flanges	2500

minimum insulation thickness to guarantee T< 50°C: 75 mm (Tamb=30°C, no cooling wind)

Inlet

Outlet

Warning Block temperature will be higher

Temp. [°C]

Element= 153
Tube= 68
Hydro Carbons
Inlet = 54

T= 153 Element temperature
T= 139 Block temperature
T= 129 Tube temperature
T= 125 full power

T= 115 reduced power
Reduced power due to thyristor control P= 28.95 kW
Full power without thyristor control P= 33.78 kW

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Conclusion

- ✓ Dry gas seal performance greatly depends on the process gas composition.
- ✓ Hence, it is imperative that all precautions are taken to ensure that gas composition in FEED data is accurate, so that unforeseen failure of seal gas condensation be avoided after commissioning.

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