ASIA TURBOMACHINERY & PUMP SYMPOSIUM
MARCH 2018 | SUNTEC SINGAPORE

Glycol-Based Lube Oil Behavior & Its Effects In Fuel Gas Compression System

Yupiter Kristiyanto
Aditya Kris Harjanto
Douglas J. Funk

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION
TEXAS A&M UNIVERSITY

Author Biography

- Yupiter Kristiyanto, Machinery Engineer, MSc, 9 years experience in Rotating Equipment, ExxonMobil Indonesia Affiliate

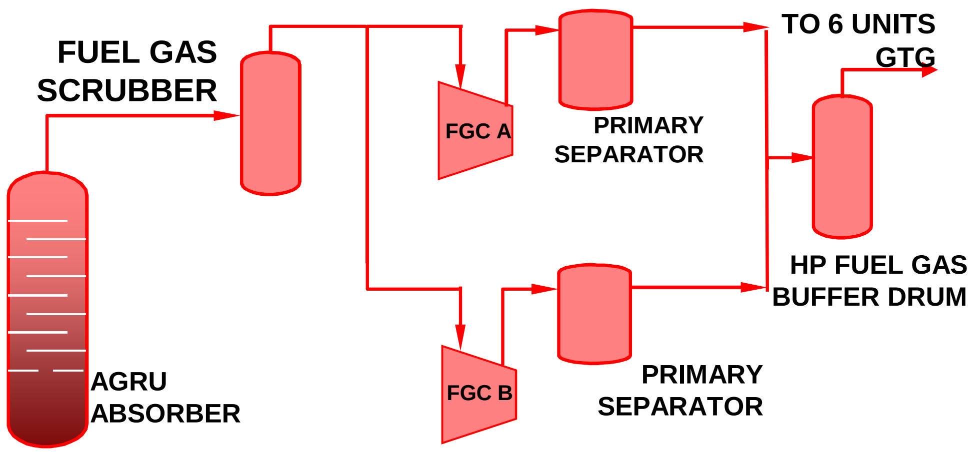
- Aditya Kris Harjanto, Facilities Engineer, BSc, 4 years experience in Process Engineering, ExxonMobil Indonesia Affiliate

- Douglas J Funk, Mechanical Maintenance Specialist, 30+ years experience in Rotating Equipment Maintenance, ExxonMobil Indonesia Affiliate

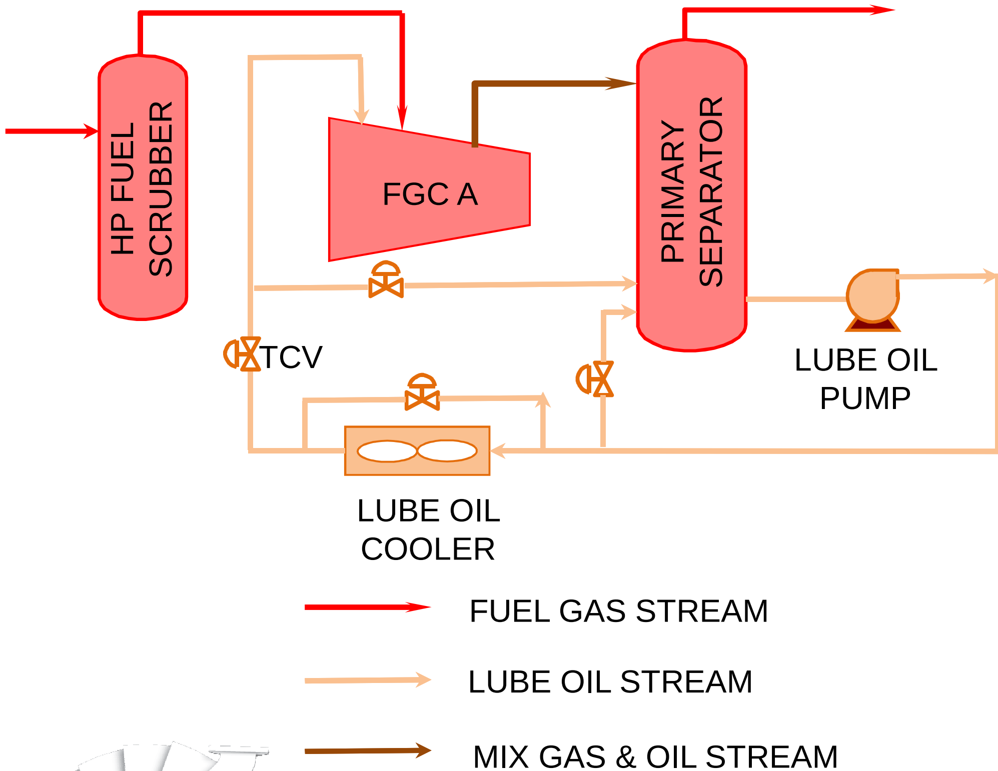
Introduction

- Oil-flooded screw compressors (2 units x 100% duty) deliver fuel gas from AGRU Absorber at saturated condition to GTG to sustain oil production facilities @ ~33 MW power demand
- Each Fuel Gas Compressor (FGC) is rated for 0.788 Msm^3/day with max 100 ppm H2S

Simplified PFD
Fuel Gas Compressor (FGC)



FGC Lube Oil Schematic Diagram

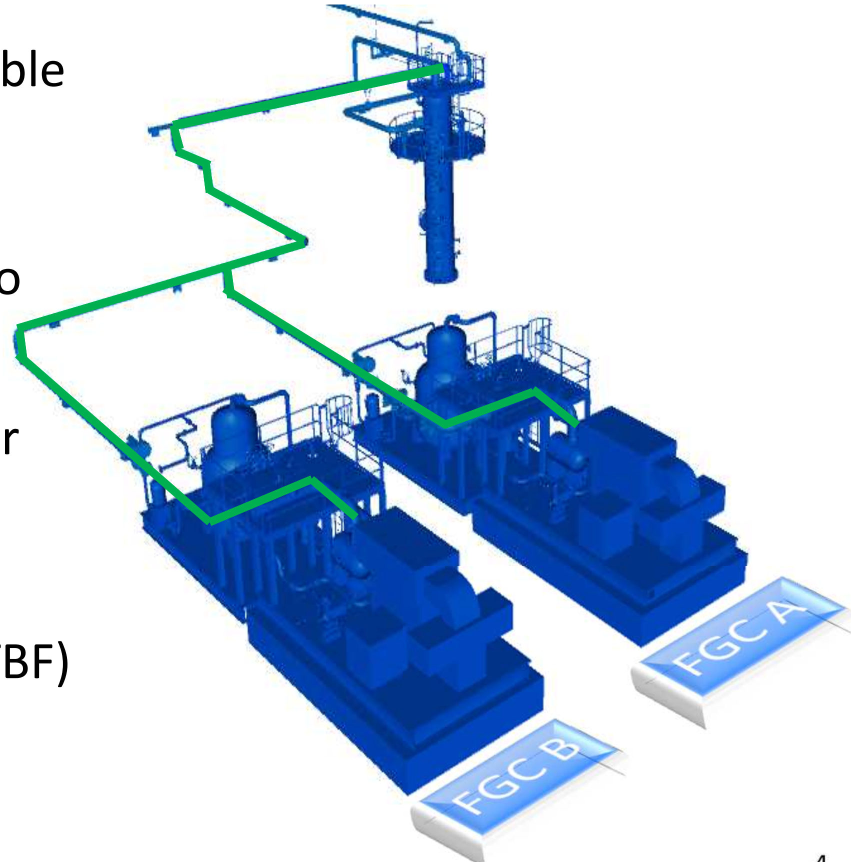


Lube Oil System consists of:

- 2 x 100% Vertical Gear Pumps
  - Capacity: 110 m^3/hr
  - Ps: 3000 kPag, Pd: 3600 kPag
  - Ts: 90degC, Td: 100degC
- Lube Oil Cooler (Air-Cooled Fan) with Temperature Control Valve
- Lube oil is Polyalkylene Glycol (ISO VG 68) with hygroscopic behavior

Background

- ❑ Fuel gas compressor experienced considerable downtime resulting in costly diesel fuel consumption & additional flaring
- ❑ The repetitive downtime events were due to
  - lube oil pump failures
  - low oil level events in primary separator
- ❑ The downtime events also relate to high maintenance costs
  - Frequent lube oil repairs (3 months MTBF)
  - Lube oil refills (<6 months interval)



Findings

- Repetitive Failures of Vertical Mounted Gear Pump

Worn Out Screw

Overheat Casing

Broken Shaft

Findings

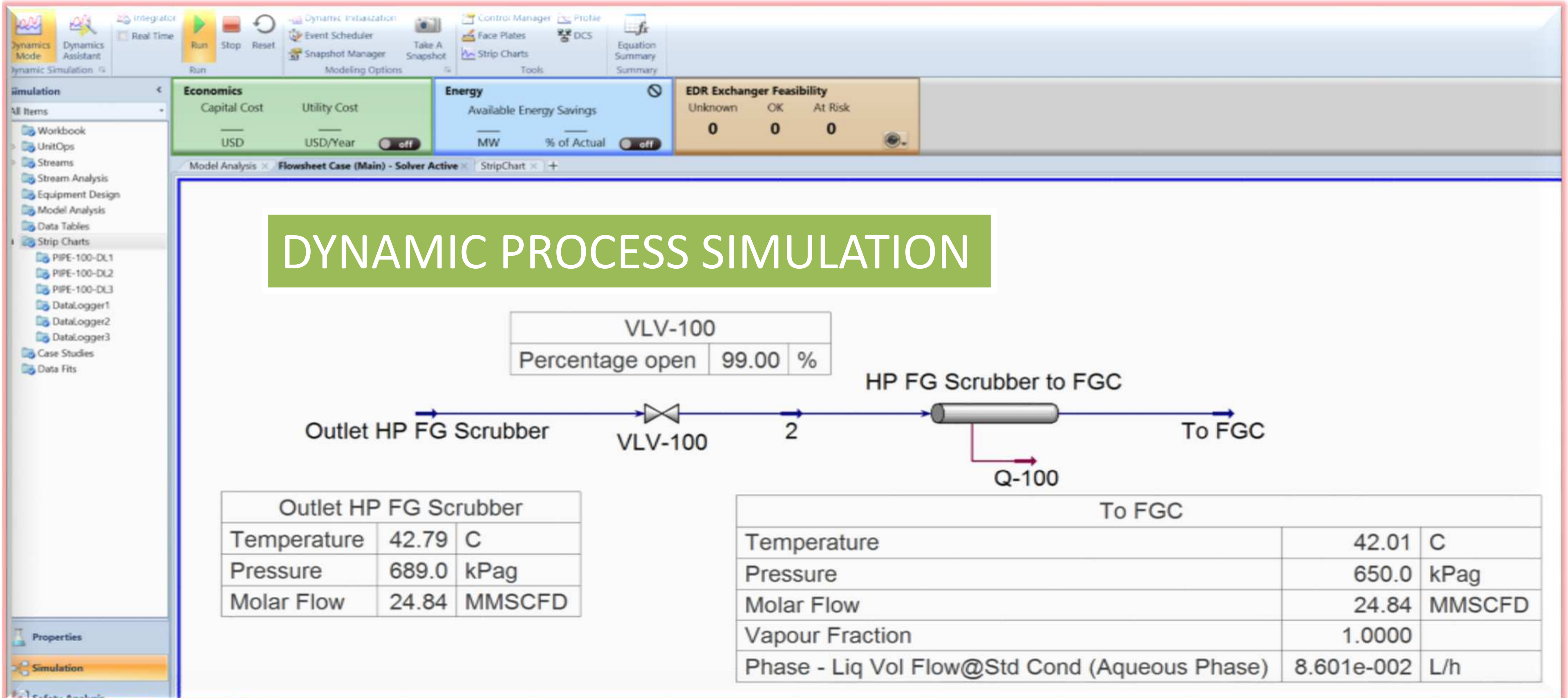
- ❑ Journal Shaft Deposit
  - "Sludge"-like deposit
  - Easy to remove
  - No scratch
  - Deposit layer location confirmed at high temperature location

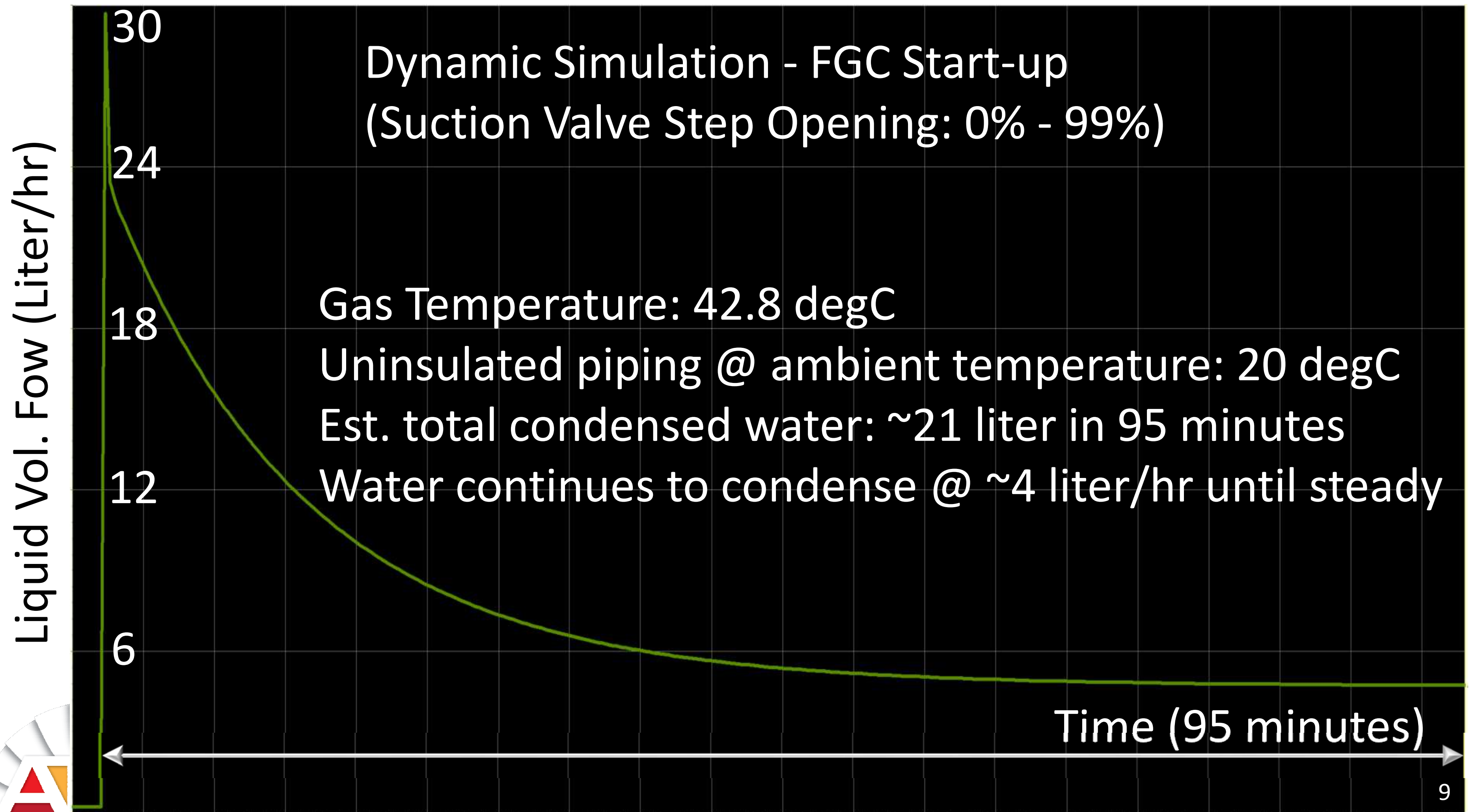
Observations

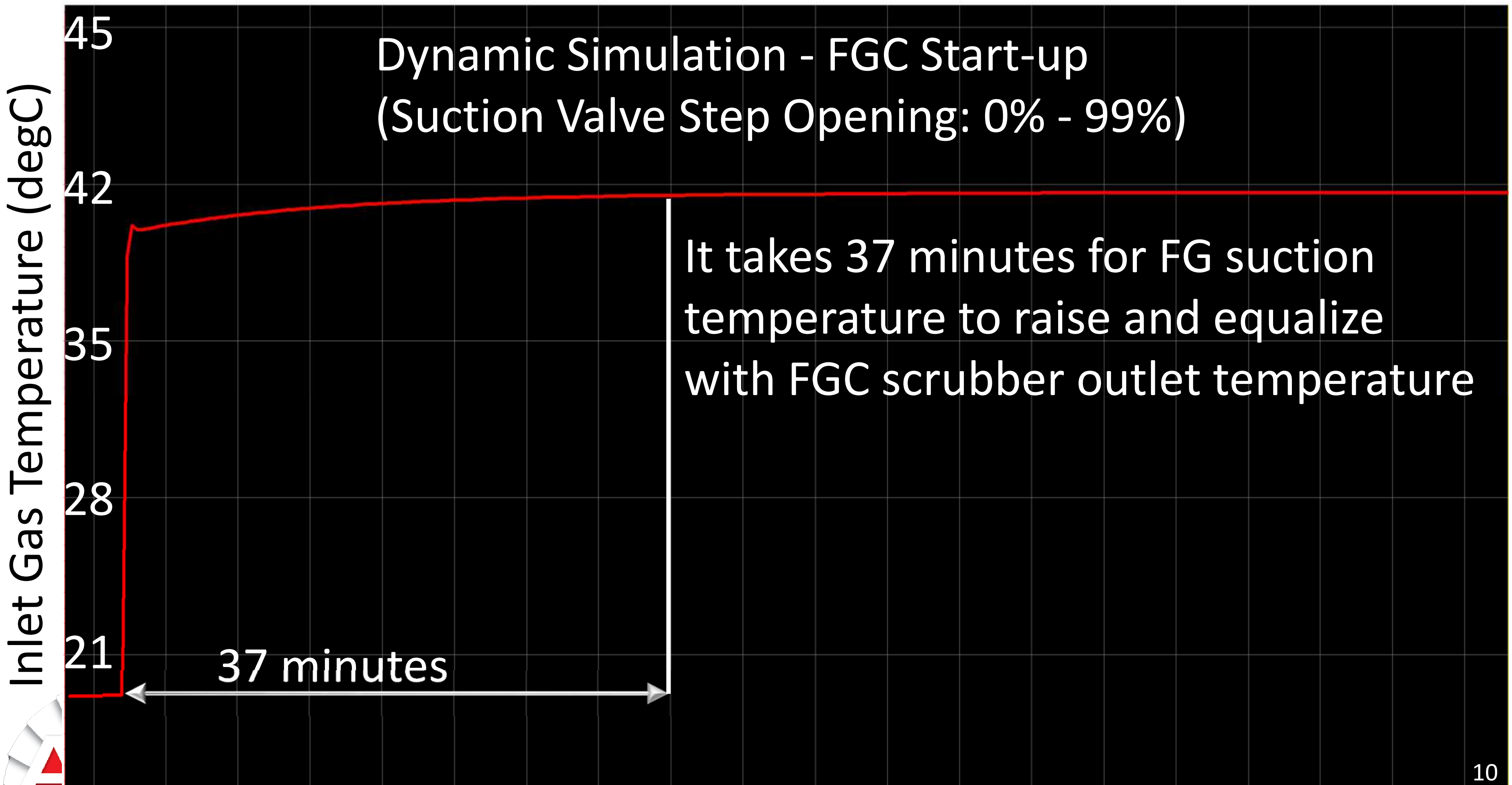
- Water Content
  - Normal Operations: 8% - 10%
  - After start-up: 1.2% to 6% in 12 hours
- Viscosity Drop from 62 cSt to 44 cSt
- Saturation limit was approximately 10% (emulsion was visually observed)
  - Saturation limit not publicly available

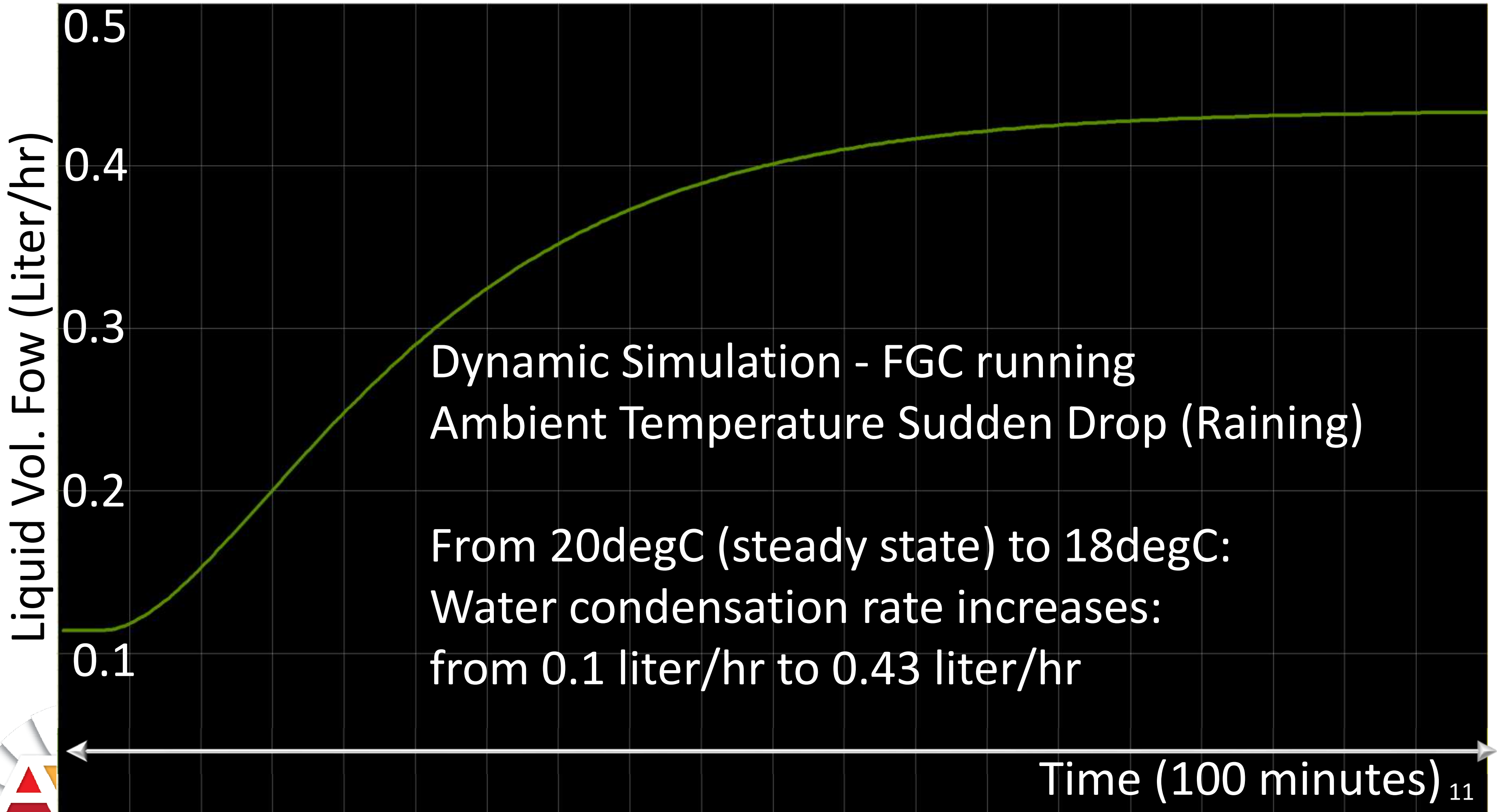
New Oil Oil 8% water

Further Analysis




Dynamic Simulation - FGC Start-up
(Suction Valve Step Opening: 0% - 99%)
Gas Temperature: 42.8 degC
Uninsulated piping @ ambient temperature: 20 degC
Est. total condensed water: ~21 liter in 95 minutes
Water continues to condense @ ~4 liter/hr until steady
Liquid Vol. Fow (Liter/hr)
30
24
18
12
6
Time (95 minutes)


Dynamic Simulation - FGC Start-up
(Suction Valve Step Opening: 0% - 99%)
Inlet Gas Temperature (degC)
45
42
35
28
21
It takes 37 minutes for FG suction temperature to raise and equalize with FGC scrubber outlet temperature
37 minutes



Liquid Vol. Fow (Liter/hr)
0.5
0.4
0.3
0.2
0.1
Dynamic Simulation - FGC running
Ambient Temperature Sudden Drop (Raining)
From 20degC (steady state) to 18degC:
Water condensation rate increases:
from 0.1 liter/hr to 0.43 liter/hr
Time (100 minutes)

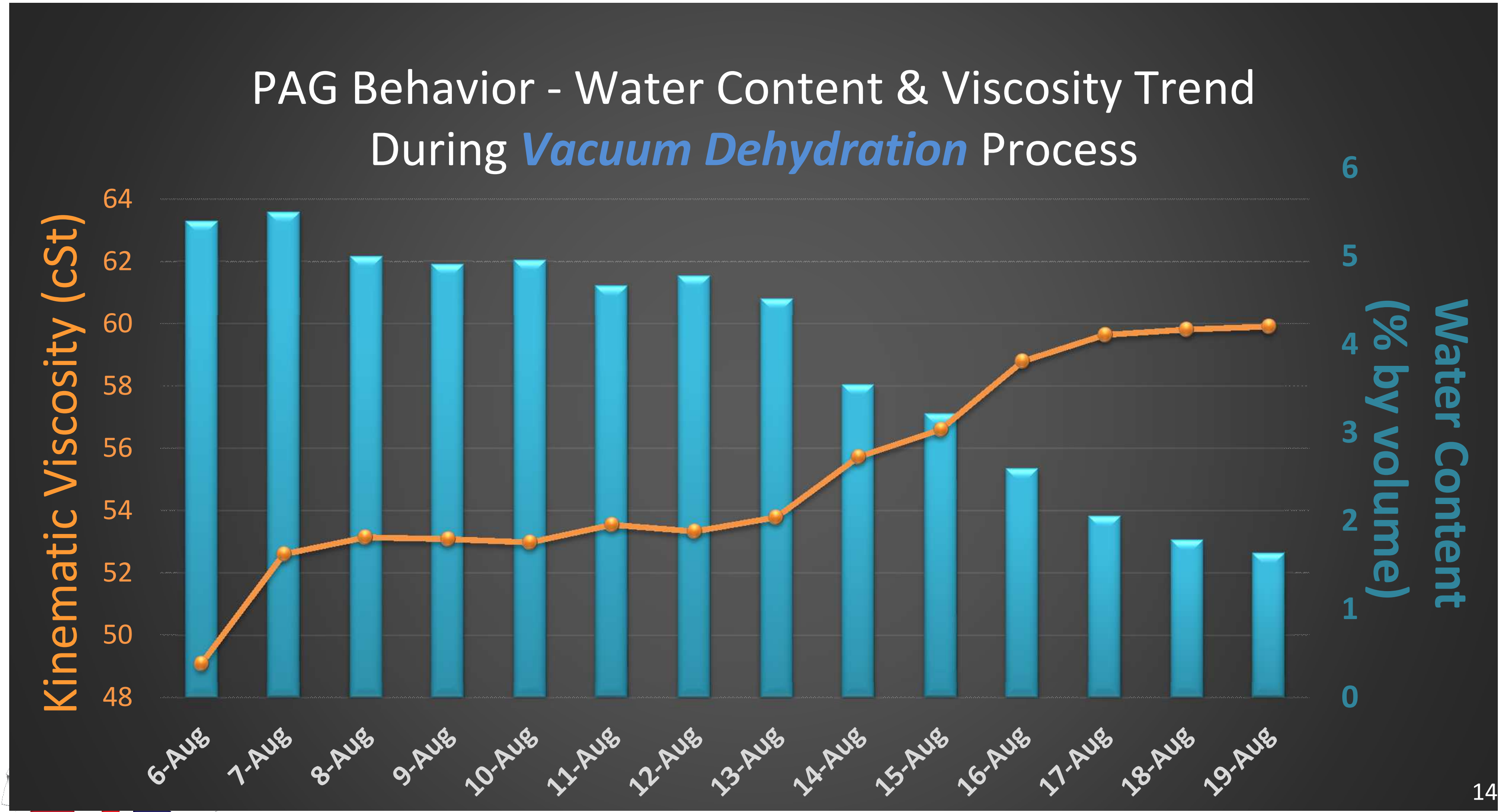
Conclusions

- Water condenses along an uninsulated 60m pipe from FG scrubber to FGC suction mostly during start-up and/or raining condition
- PAG lube absorbs the water resulting in viscosity drop leading to poor lubrication (severe friction & overheat LO Pump)
  - Less viscous lube is easily carried over to GTG fuel lines

Carried-over Lube
@ GTG Fuel Gas Filter

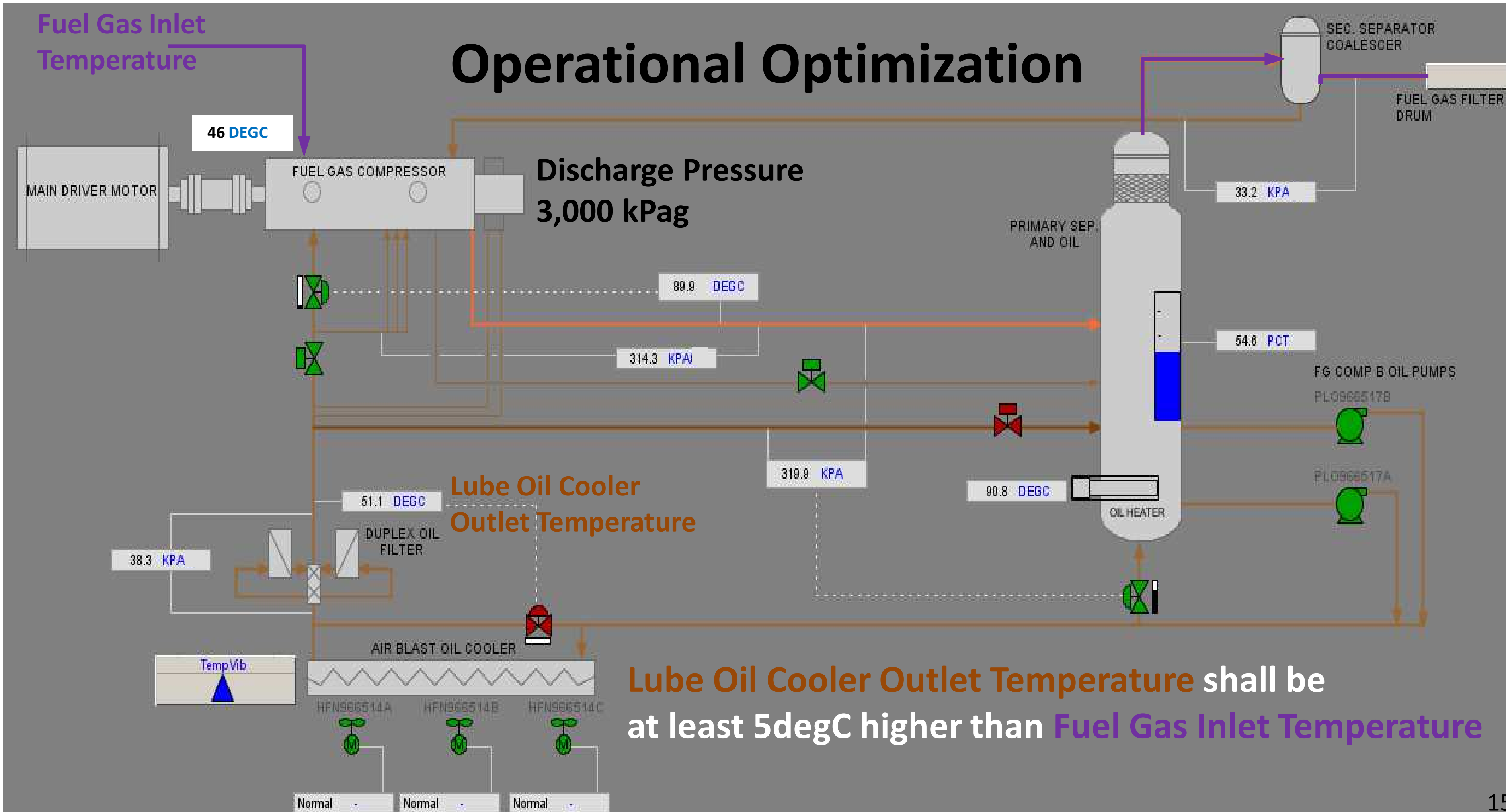
Short Term Solutions (Actions Already Taken)

1. ***Performed vacuum dehydration*** to remove water from the lube
   - Vacuum -0.7barg @65degC, water removed from 5.8% to 1.6%
   - Recovered viscosity from 48 cSt to 60 cSt
   - ✓ Avoid expensive spent on LO refill
2. ***Set Lube Oil Cooler Outlet Temperature*** at least 5degC above Fuel Gas Inlet Temperature to avoid further water condensation when comingle with the lube at compressor suction
   - ✓ Improved LO Pump MTBF



PAG Behavior - Water Content & Viscosity Trend
During *Vacuum Dehydration* Process
Kinematic Viscosity (cSt)
64
62
60
58
56
54
52
50
48
Water Content
(% by volume)
6
5
4
3
2
1
0
6-Aug
7-Aug
8-Aug
9-Aug
10-Aug
11-Aug
12-Aug
13-Aug
14-Aug
15-Aug
16-Aug
17-Aug
18-Aug
19-Aug

Operational Optimization



Lube Oil Cooler Outlet Temperature shall be at least 5degC higher than **Fuel Gas Inlet Temperature**

Long Term Solutions

- ❑ Install Electrical Heat Tracing from FG scrubber to Compressor suction to avoid water condensation
- ❑ Use VG 100 for On-line Top-up (Compatible Mix with VG68)
  - Regain Viscosity to maintain rotor hydrodynamic force
- ❑ Upgrade LO Pump to Twin Screw with Timing Gear
  - Allow wider range of viscosity variation
  - Upgrade to corrosion-resistant material due to H2S & water presence

Lessons Learned

- Design Optimization:
  - Potential water condensation during unit start-up needs to be fully recognized through dynamic process simulation.
  - Whenever practicable, gas temperature at compressor inlet shall have margin over its dew point or be fully dehydrated
  - Electrical heat tracing essential necessity evaluation
  - Lube selection to consider water condensation for compressors requiring internal lubrication (oil-flooded screw, sliding vane compressor, and lubricated reciprocating compressor)

Lessons Learned

- Operational Optimization
  - Ensure injected oil temperature always 5degC above inlet gas temperature at compressor suction
  - FGC in fully depressurized mode whenever stand-by (i.e. Blowdown with every shutdown/ trip/ stop) to avoid water condensation by the dormant gas stream