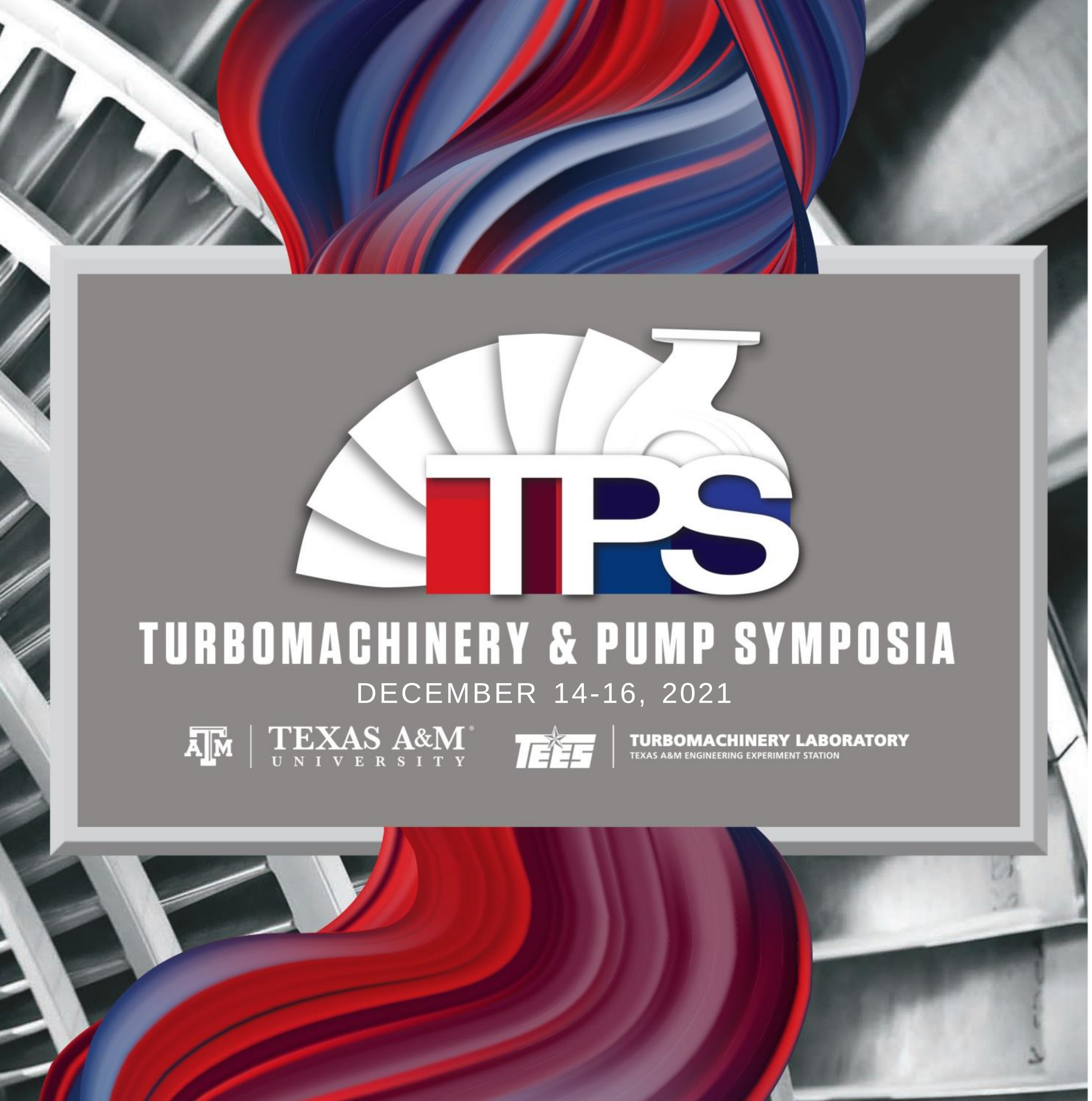

Operating Strategy of Oil-Flooded Screw Compressor Experiencing Oil Dilution in Fuel Gas System

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Authors

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Arthur Edwin Klink is the machinery advisor for ExxonMobil Cepu Limited and has 36 years experience in many facets of machinery engineering from detailed compressor and turbine design to machinery applications, project and facilities engineering. He has a BSME from Rutgers University and an MSME from Lehigh University in the US.

Abstract

Two 2,900 kW (3,900 hp) oil – flooded twin screw compressors deliver fuel gas from sour gas processing system to Gas Turbine Generators (GTG) at Banyu Urip oil production facility in Indonesia. The compressors operate with Polyalkylene Glycol (PAG) lubricant, which is hydroscopic. Water content in process gas that has direct contact in the compressor may contaminate the PAG lubricant and thus make it necessary to control lubricant water content to prevent reduction of viscosity.

While over contamination of the PAG lubricant by water may cause costly damages, the solution will also require significant downtime and high capital expense. This case study optimizes compressors operating strategy to avoid significant downtime and cost of improving the sour gas processing system. Controlling thermodynamic parameters around the compressors maintain acceptable lubricant water content and viscosity until upgrades could be made in the gas processing system.

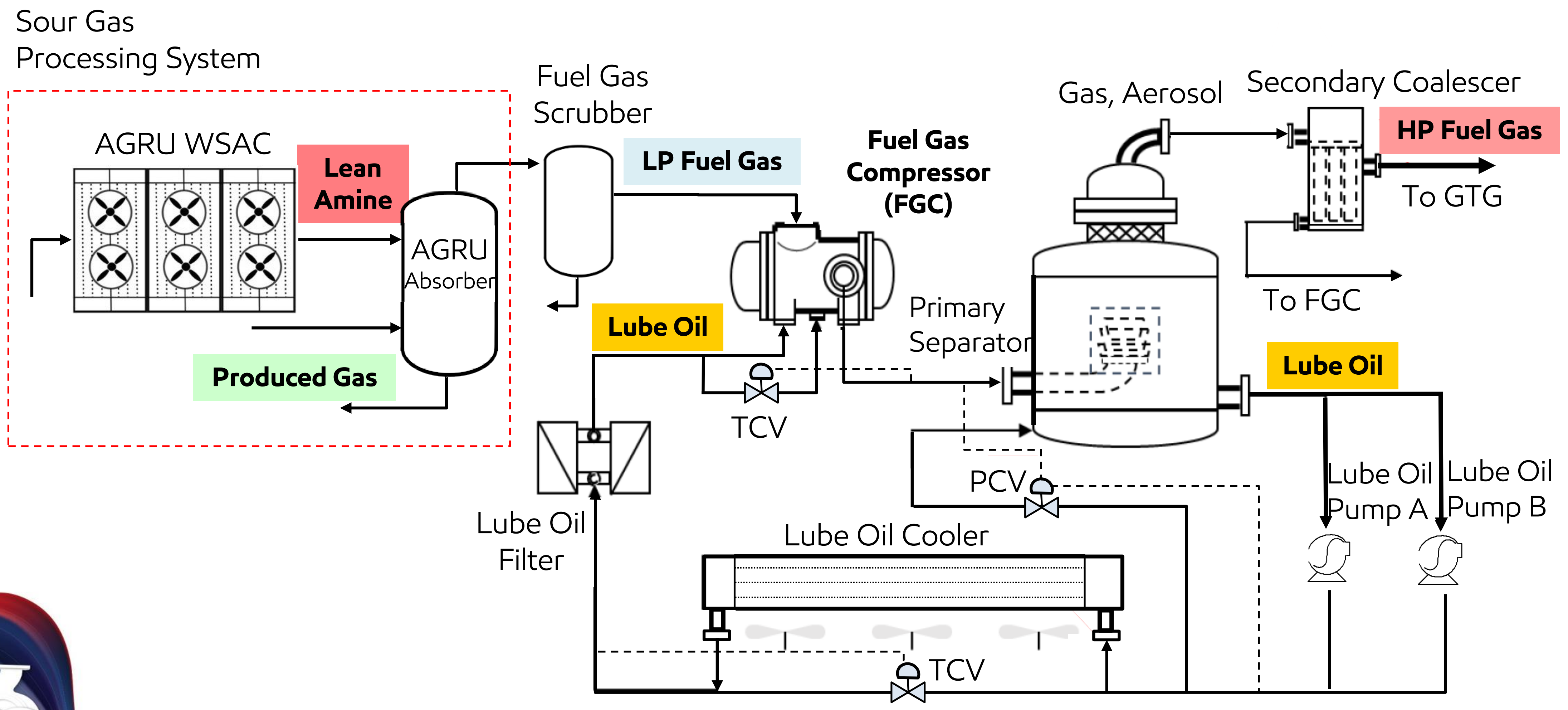
Introduction

- Oil-flooded twin screw compressors (2 x 100% duty) deliver sweetened fuel gas to Gas Turbine Generators (GTG) in Banyu Urip oil production facility.
- The compressors operate with Polyalkylene Glycol (PAG) - type lubricant, which absorb moisture and thus make it necessary to control water content in the lubricants.

Banyu Urip Central Processing Facility

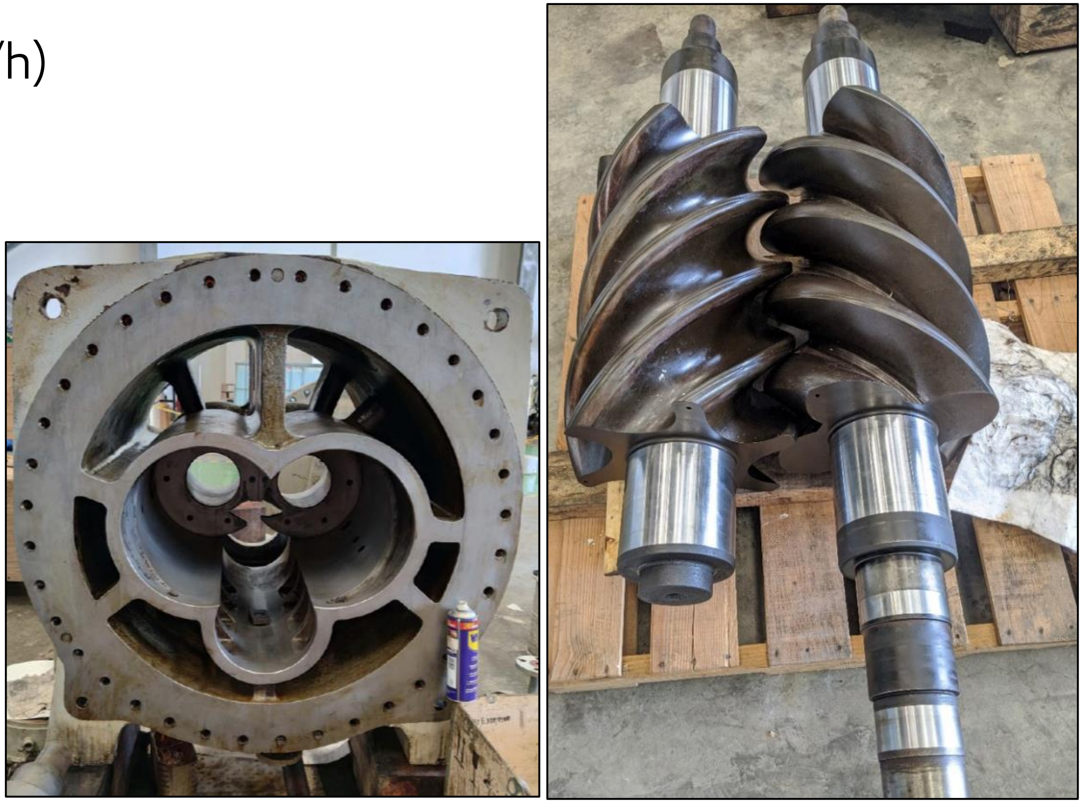
TURBOMACHINERY & PUMP SYMPOSIA

Simplified PFD



Design Operating Condition

- Mass Flow : 33,200 kg/h (73,200 lbs/h)
- Inlet Pressure : 680 kPag (99 psig)
- Inlet Temp. : 45 ^{O}C (113 ^{O}F)
- Discharge Pressure : 3,040 kPag (441 psig)
- Discharge Temp. : 90 ^{O}C (194 ^{O}F)
- Saturated phase feed gas with max. 100 ppm H_2S and 1% H_2O. Water in vapor phase at discharge.

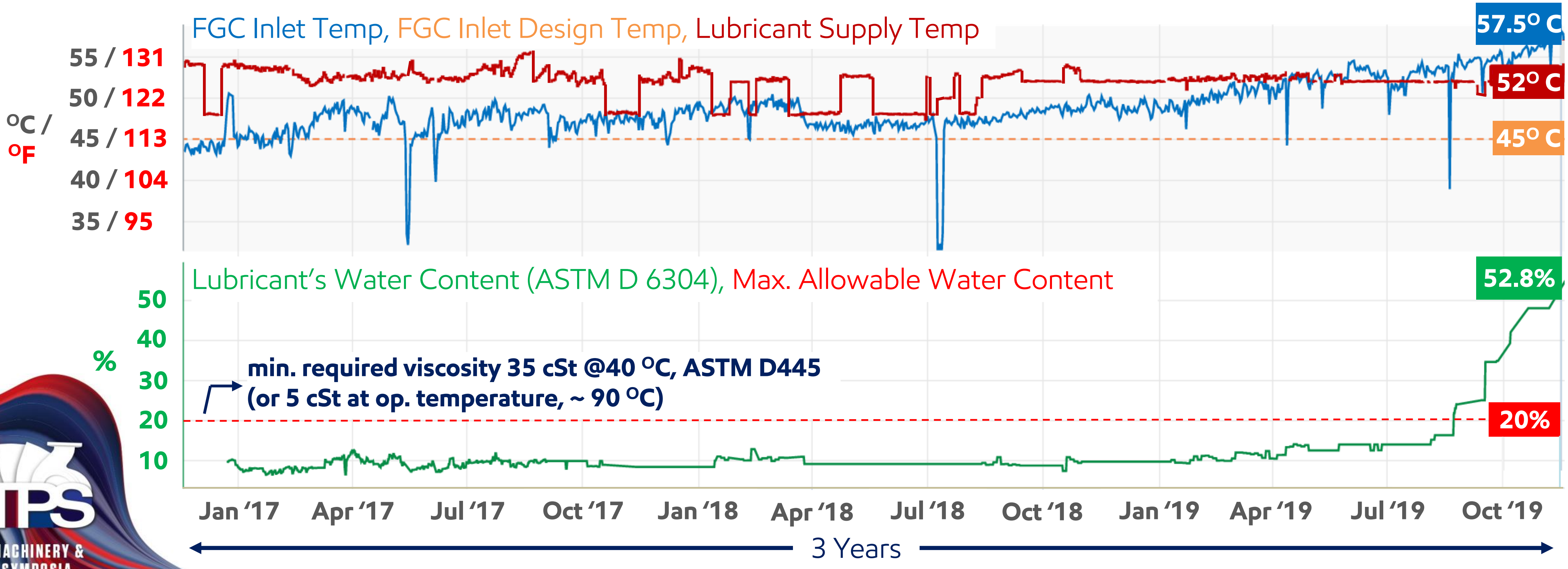


Compressor Casing and Rotors

- PAG lubricant was deemed best choice for the design fuel gas composition and conditions.

Background

- ❑ Starting in early 2017, lower cooling performance at sour gas processing system increased feed gas temperature and subsequently gas moisture content.
- ❑ When the gas inlet temperature exceeded lubricant supply temperature in the compressor, feed gas water was condensed and increased lubricant water content, causing to drop below minimum required viscosity.



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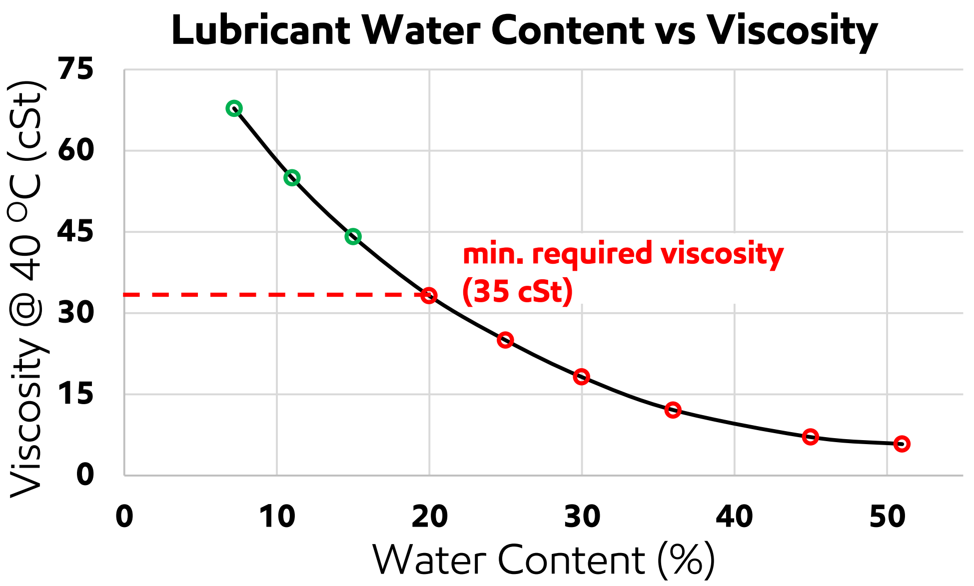
Problem Statement

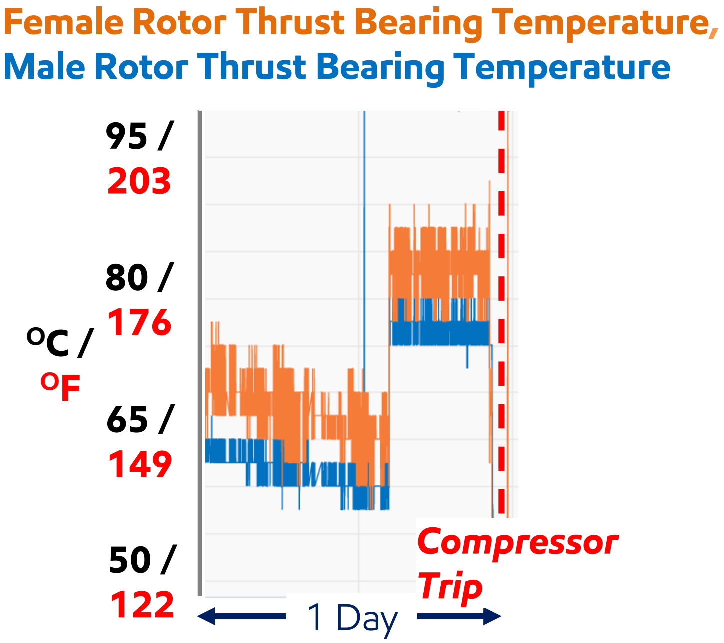


Issues

- ❑ Compressors operate below required lubricant viscosity, leading to thrust bearing failure (Nov '19).
- ❑ To maintain continuous operation, waiting for sour gas system upgrade is not possible.

Mitigation

Adjust compressor operating parameters to optimize operation with higher feed gas moisture content without risking compressor reliability.



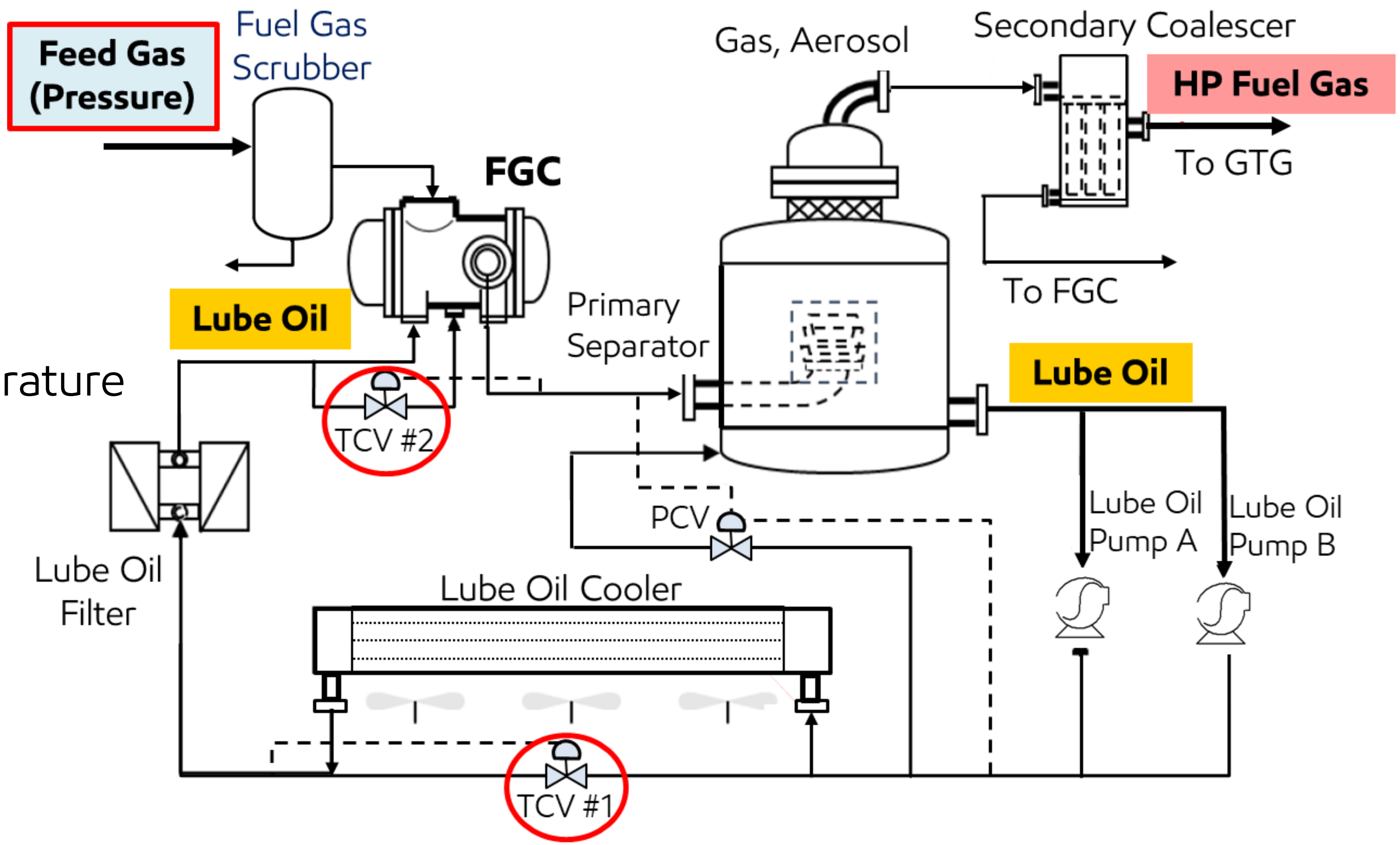
Damaged Thrust Bearing and Trending before the Failure

Controlled Parameters to Adjust

- ❑Feed gas operating pressure
- ❑Lubricant supply temperature

  (TCV #1)
- ❑Compressor discharge temperature

  (TCV #2)



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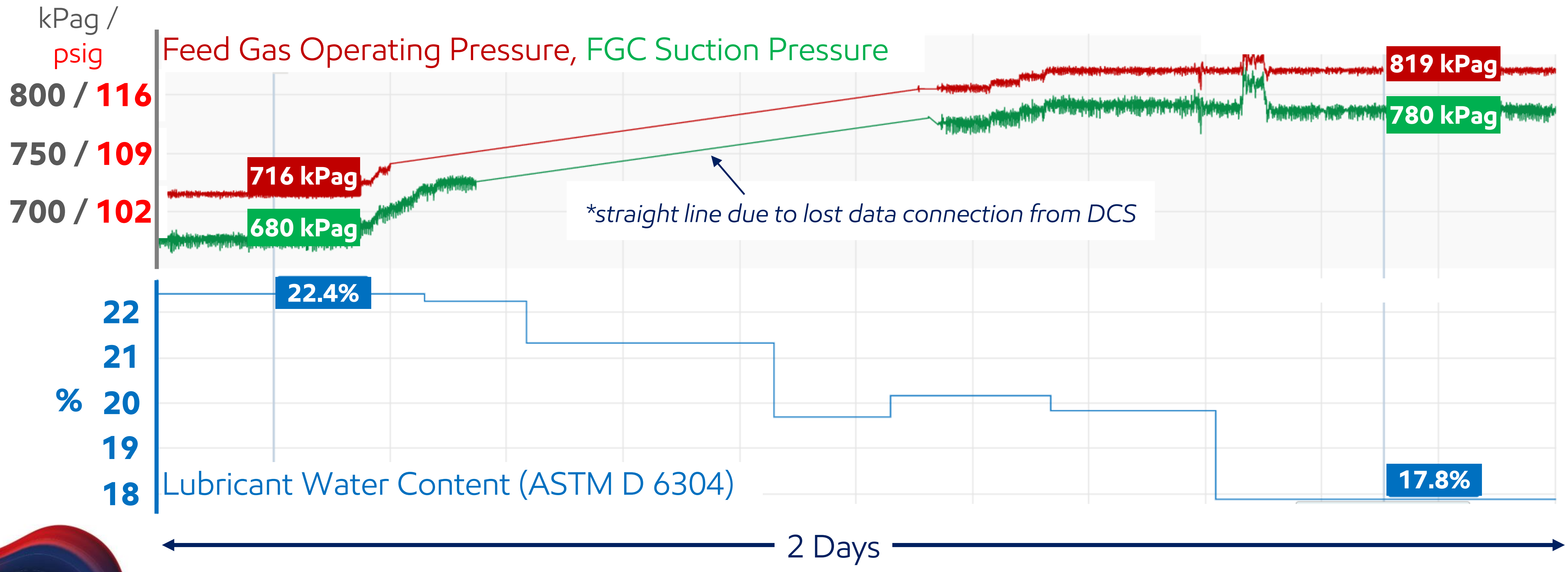
Operating Parameter Adjustment Plan

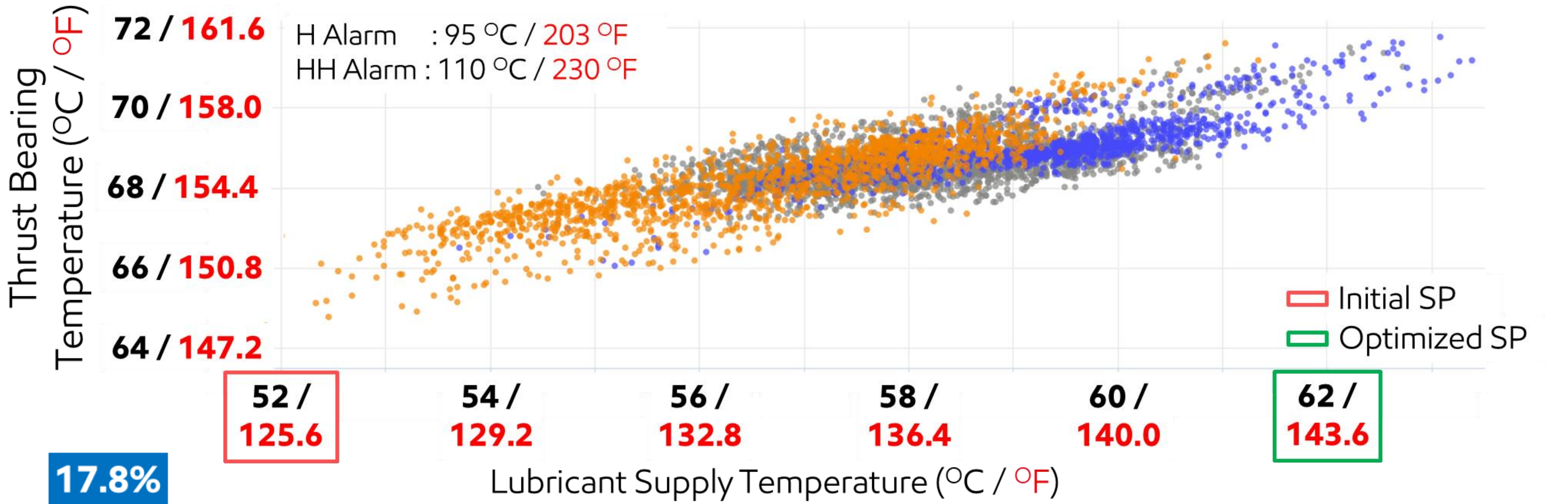
Parameter	**Initial Set Point** (with FGC Inlet Temp. at 45 °C / 113 °F)	**Evaluation**	**Set Point Target** (with FGC Inlet Temp. at 57 °C / 135 °F)
Feed Gas Operating Pressure	720 kPag / 104 psig	To condense more water in FGC suction scrubber, the feed gas pressure should be increased. Check compressor rotor thrust level and motor Amps due to higher inlet pressure.	810 to 820 kPag - H Alarm: 830 kPag / 117 to 119 psig - H Alarm: 120 psig
Lubricant Supply Temperature	52 °C / 126 °F	To prevent gas condensation, lubricant supply temperature should be at least ~5 °C / ~ 9 °F higher than the saturated inlet gas temperature.	62 to 63 °C - H Alarm: 65 °C / 143 to 145 °F - H Alarm: 149 °F
Compressor Discharge Temperature	90 °C / 194 °F	To allow more water vapor carryover to downstream system, then the discharge temperature should be increased.	93 to 94 °C - H Alarm: 95 °C / 199 to 201°F - H Alarm: 203 °F

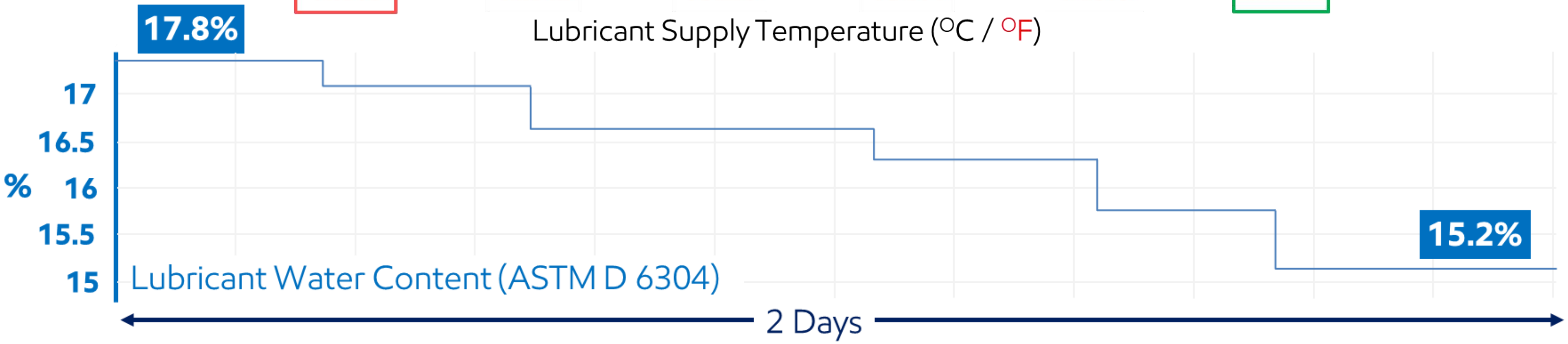
Analysis: Effect of Feed Gas Operating Pressure on Lubricant Water Content



∴ Increased feed gas operating pressure reduces moisture carryover to the FGC and subsequently lubricant water content drop by ~5%.

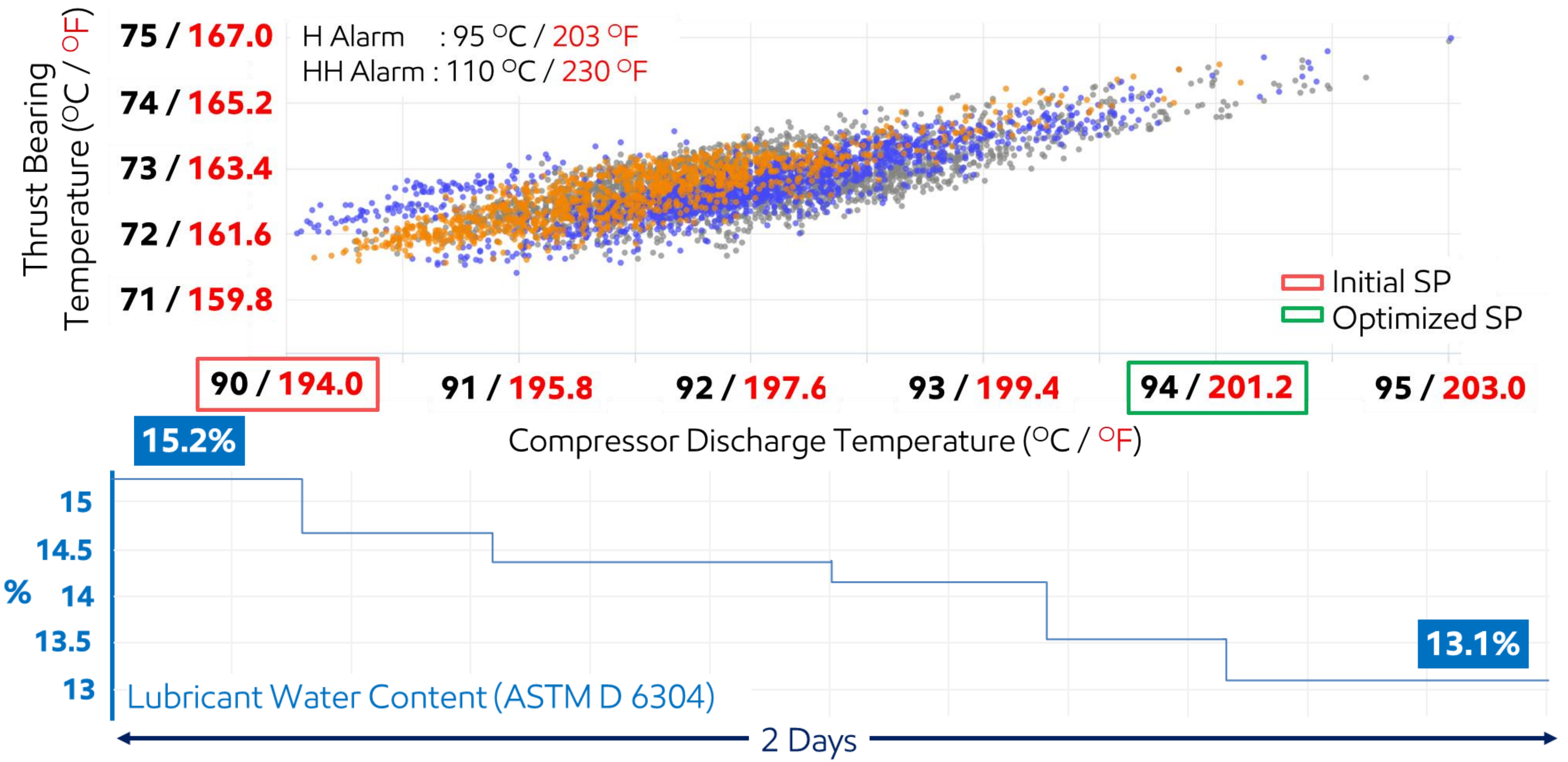
Analysis: Effect of Lubricant Supply Temperature on Lubricant Water Content





∴ Lubricant supply temp. with ~ 5 °C (~ 9 °F) higher than the saturated feed gas temp. prevents gas condensation and thus reduces water content.

Analysis: Effect of Compressor Discharge Temperature on Lubricant Water Content



∴ Increasing discharge temp. to 94 °C (201.2 °F) increases water vapor at the discharge and reduces water dilution to the lubricant.

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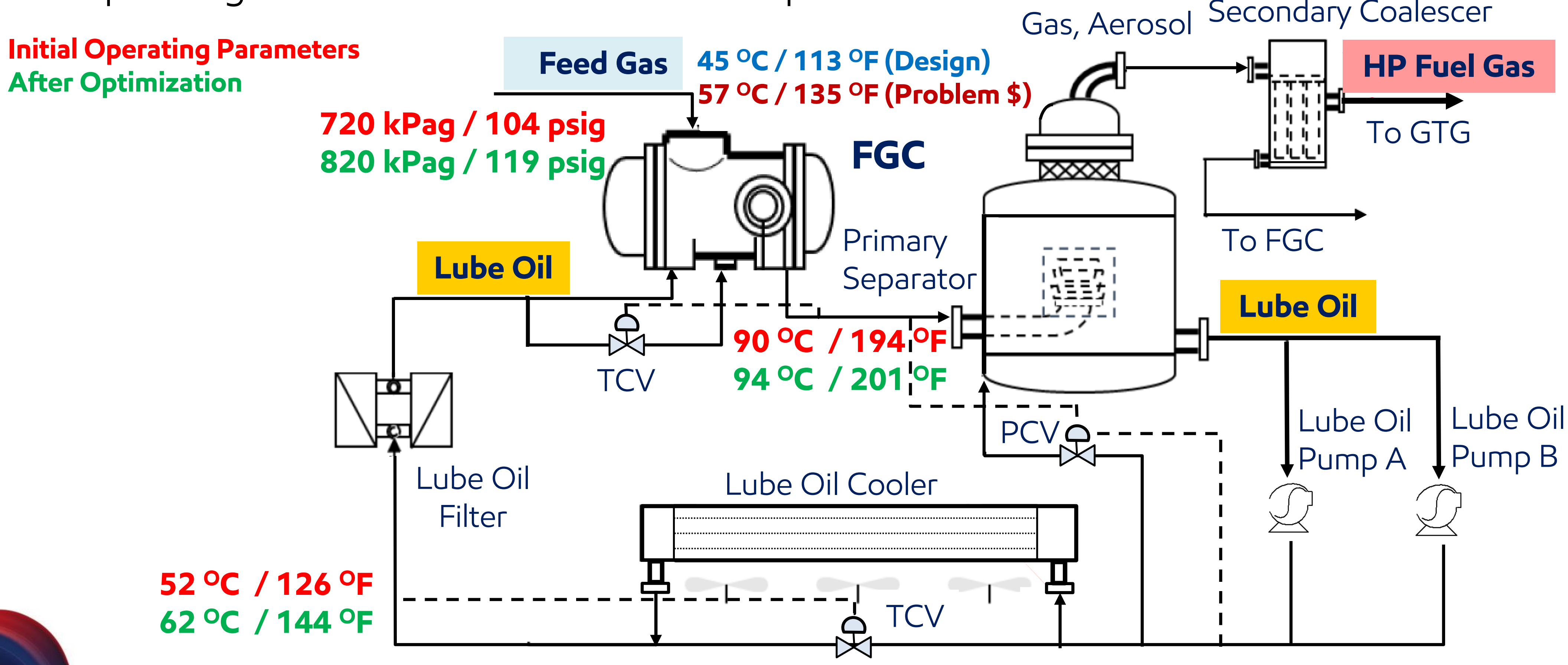
Results

FGC Operating Parameters Before and After Optimization



- ❑ Lubricant water content, which reached 52% in Nov 2019, was successfully reduced in Dec 2019 to achieve equilibrium <15 % (viscosity >5 cSt @op. condition, 94 °C).
- ❑ Since then the compressors have been operating reliably.

Conclusions

- Controlling lubricant water content in oil – flooded screw compressors is critical particularly when gas moisture content deviate from design point due to sour gas processing system performance problem.

- Increasing feed gas operating pressure and lubricant temperature adequately reduce water content while maintaining satisfactory thrust bearing temperature.

- This case study demonstrates that knowledgeable change in operating conditions has avoided costly facility modification (~ USD 750K).