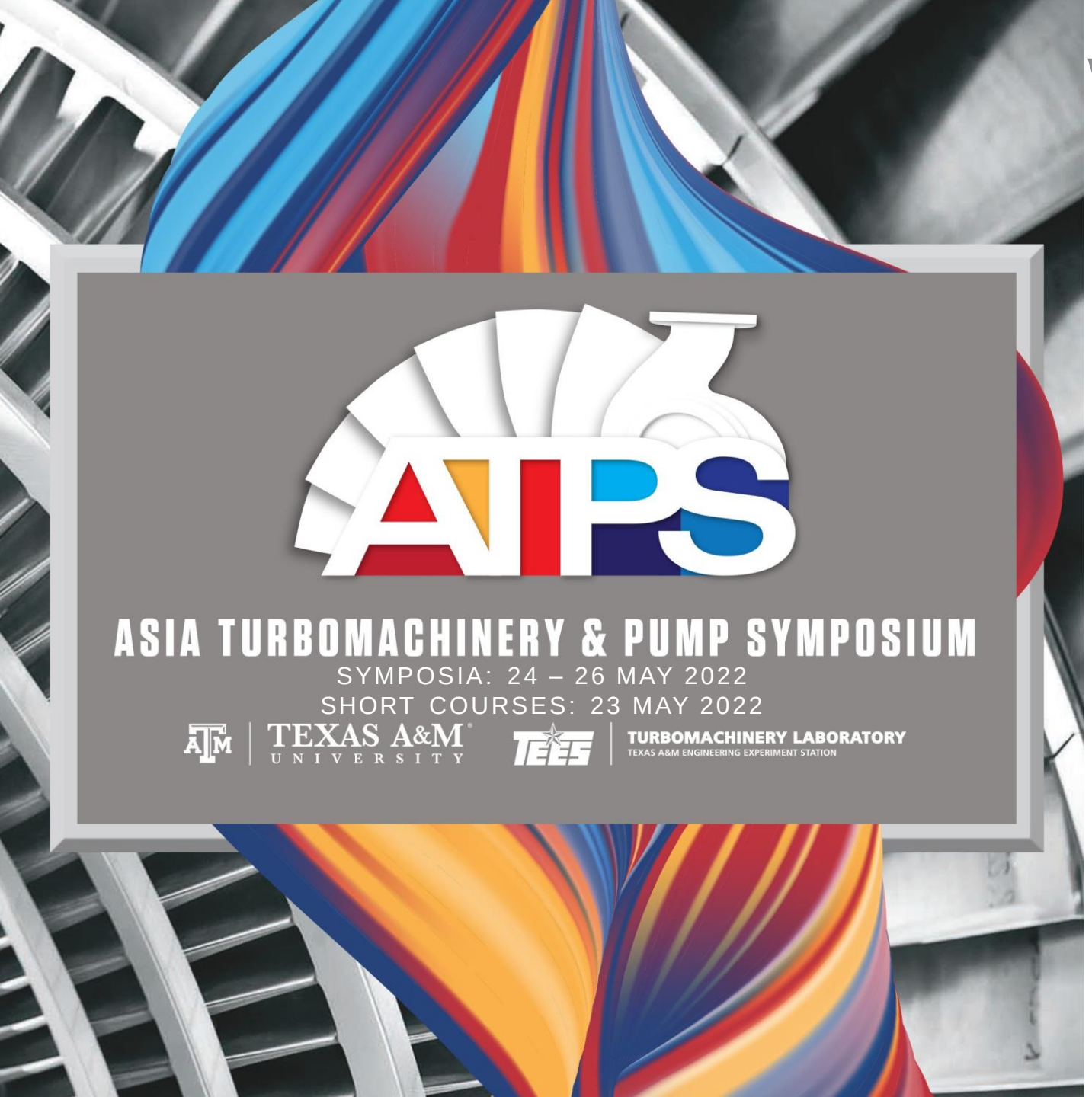

Wet Refrigeration Screw Compressor Failure due to Liquid Slugging

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AUTHORS

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Abstract

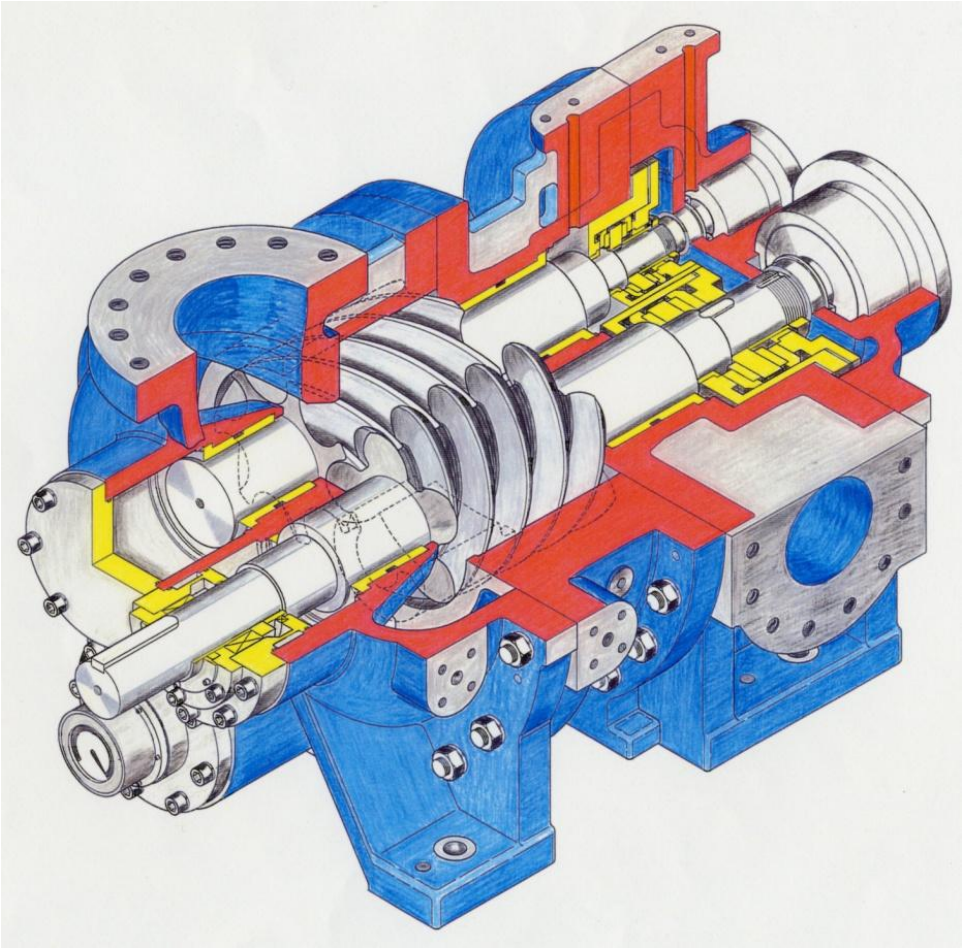
A wet screw refrigeration compressor had three failures and all failures were related to male rotor High-High axial displacement.
The failure was concluded to be due to liquid propane formation at compressor suction, resulting in abrupt excessive thrust load. The liquid formation was due to suction temperature dropped below propane condensing point.

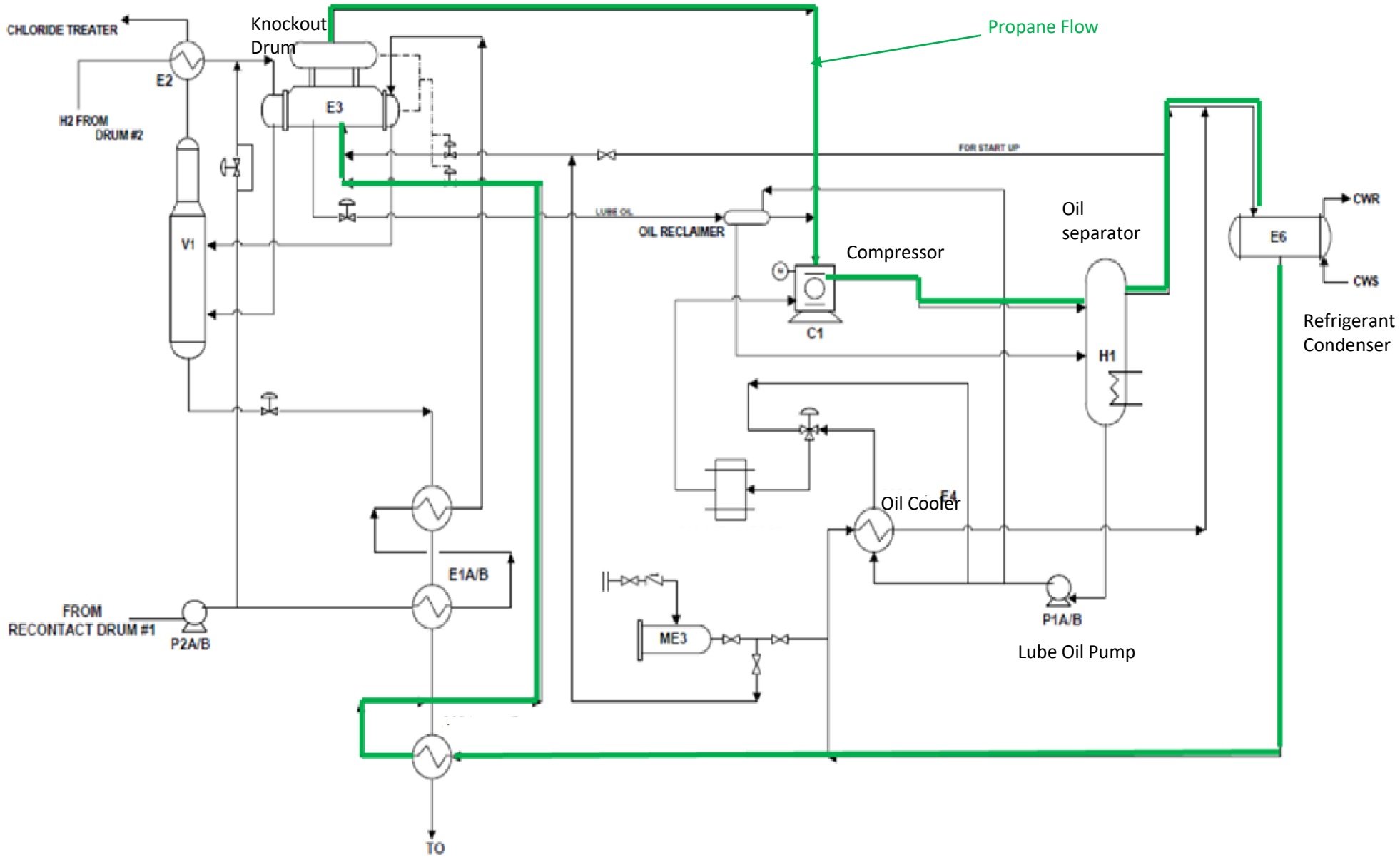
Agenda

1. Machine Detail
2. Problem Statement / Observations
3. Trend
4. Analysis
5. Solution
6. Broader learnings

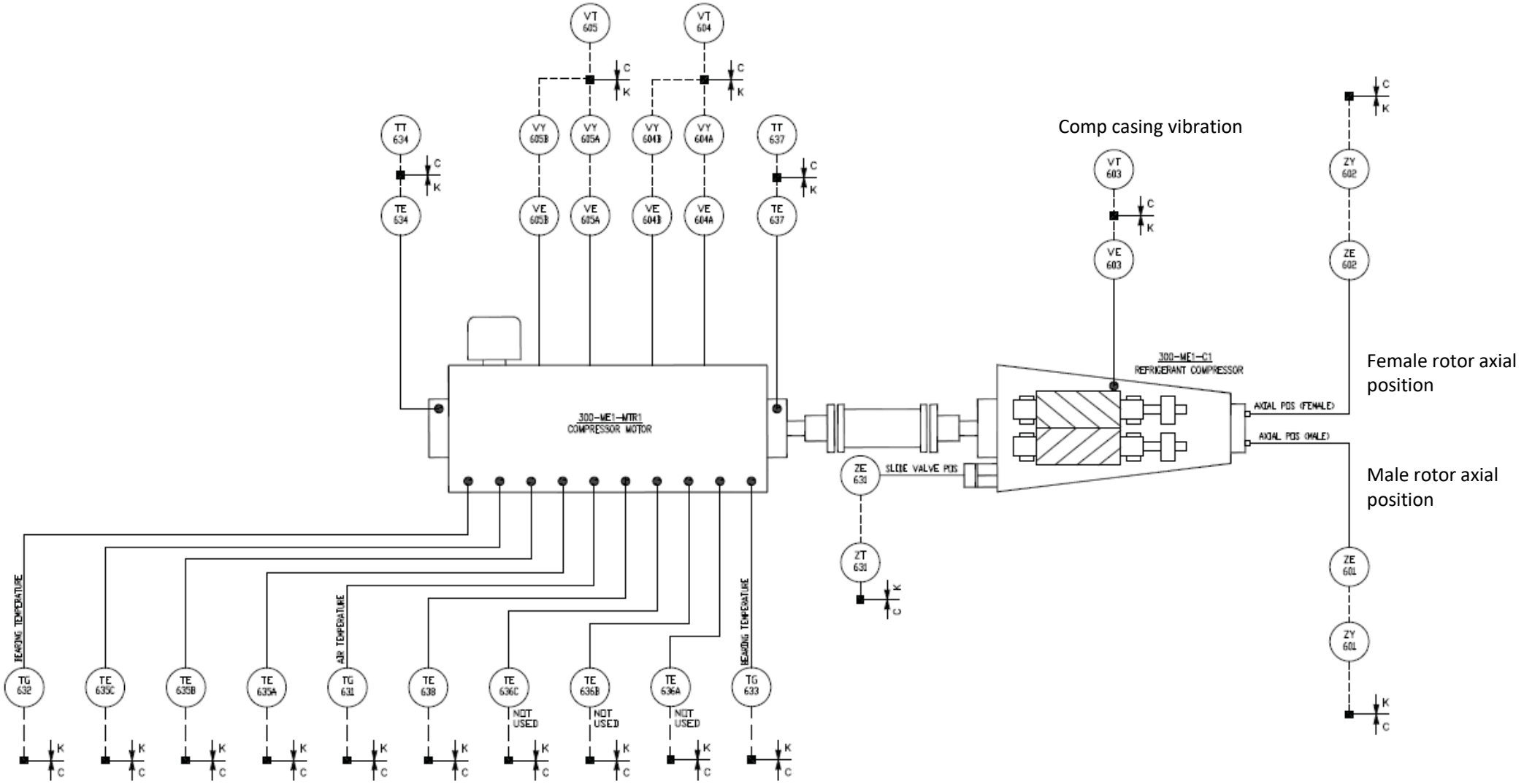
Machine Details

- Propane refrigeration wet screw compressor, ~2.1 MW.
- Single stage, variable capacity by slide valve.
- Commissioned in 2013.
- 1 axial probe for male and female rotors respectively, NDE mounted.
- Vibration protection system available.
- No bearing temperature monitoring installed.
- Works in a closed-loop system where propane is recirculated.





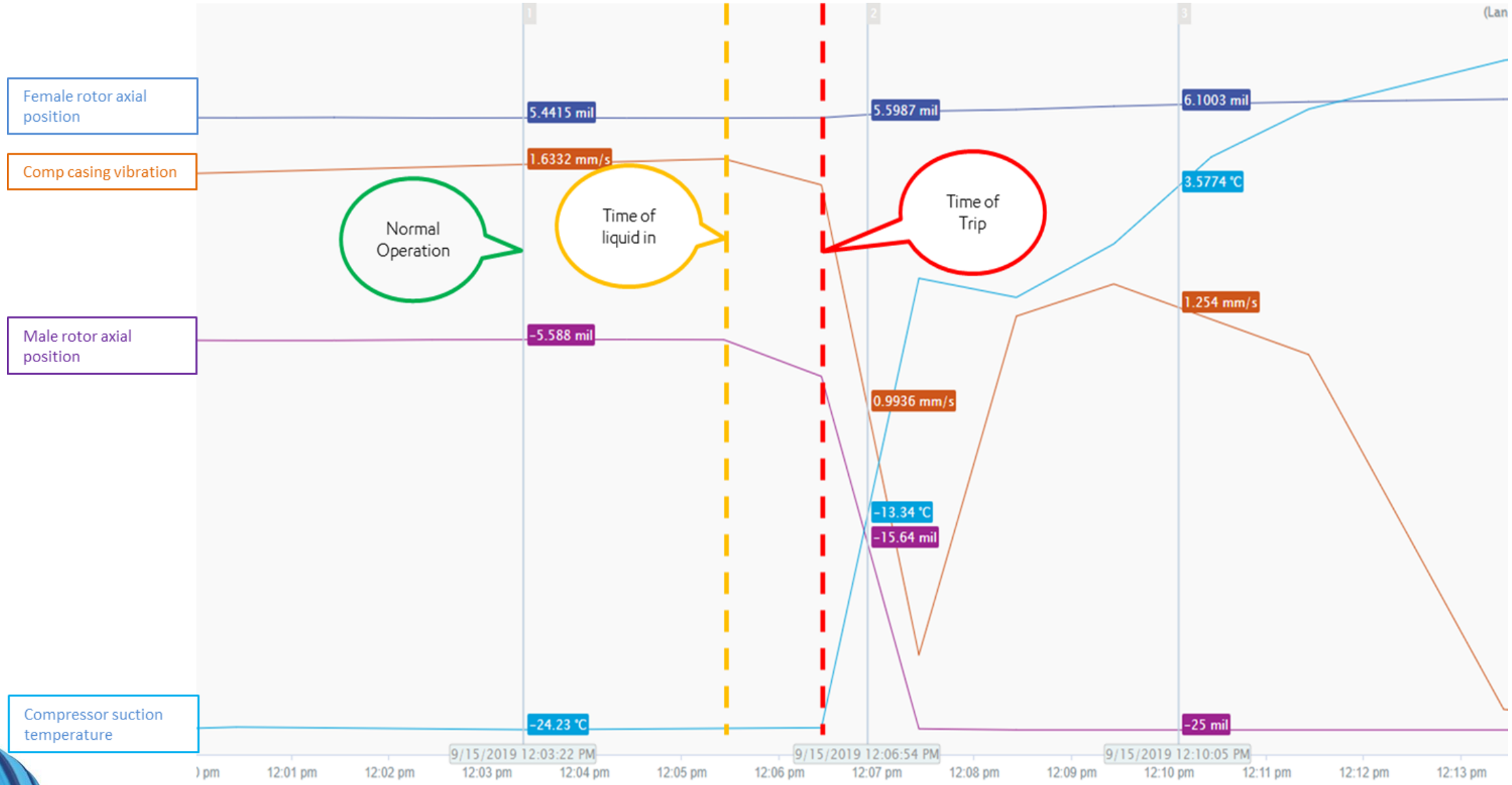
Machine Monitoring System



Problem Statement

- Compressor tripped on male rotor high-high axial displacement, an alarm was triggered less than 1 second before the trip.
- Male rotor active thrust bearing pads were worn out.
- No indication of gradual degradation of the bearing.
- Suction temperature had narrow margin to propane condensing temperature. Suction temperature is impacted by the combined chiller design, showing dips on a daily basis.
- Sudden failure of thrust bearing indicated an abrupt excessive axial force upon the rotor.

Trend

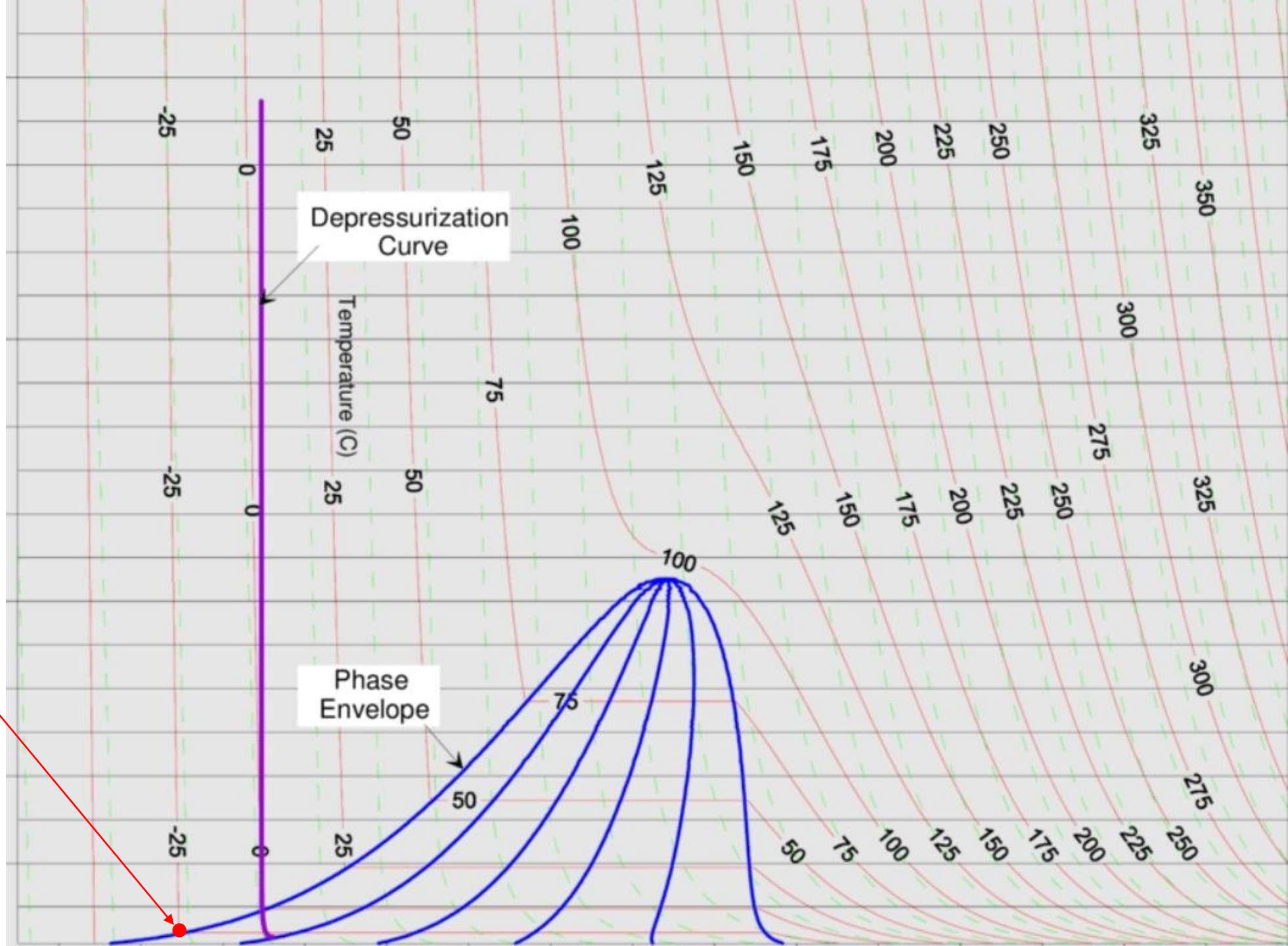


Analysis

- Before compressor tripped, rotor position indicators were stable.
- Compressor suction temperature was showing ~-24 degC, while a faster-sampling trend shows frequent drop below -25 degC.
- Propane vapor pressure chart shows condensation point was approximately -25 degC at 1 barG suction pressure.
- The entire propane refrigeration system had operated in saturation and encountered excessively sub-cooled condition at the time of failure.
- The combined chiller upstream of the compressor was configured as shown in the following slide.
- Liquid propane is preheated in the knockout drum so the gaseous propane will be sent to compressor suction.

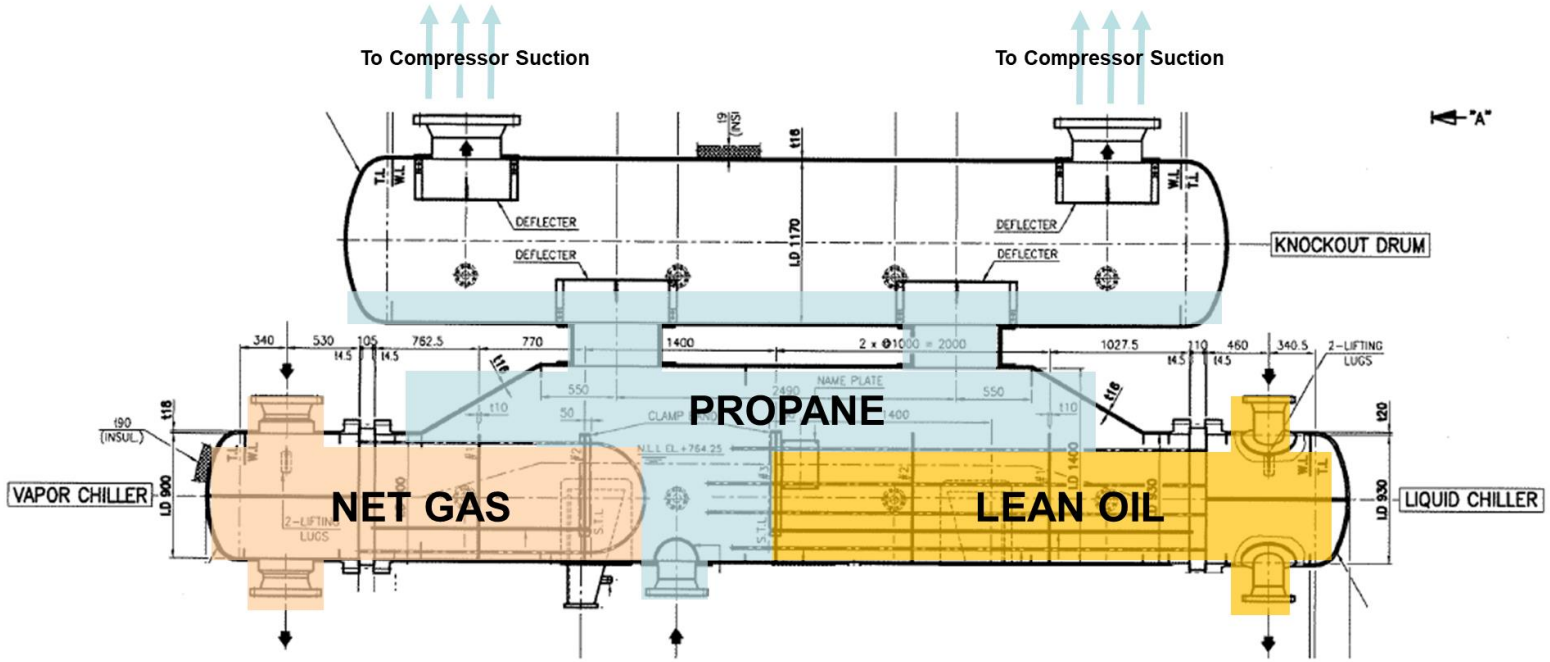
Two-phase (Liquid - Gas) Diagram for Propane

Operating Point close the phase change.



Analysis

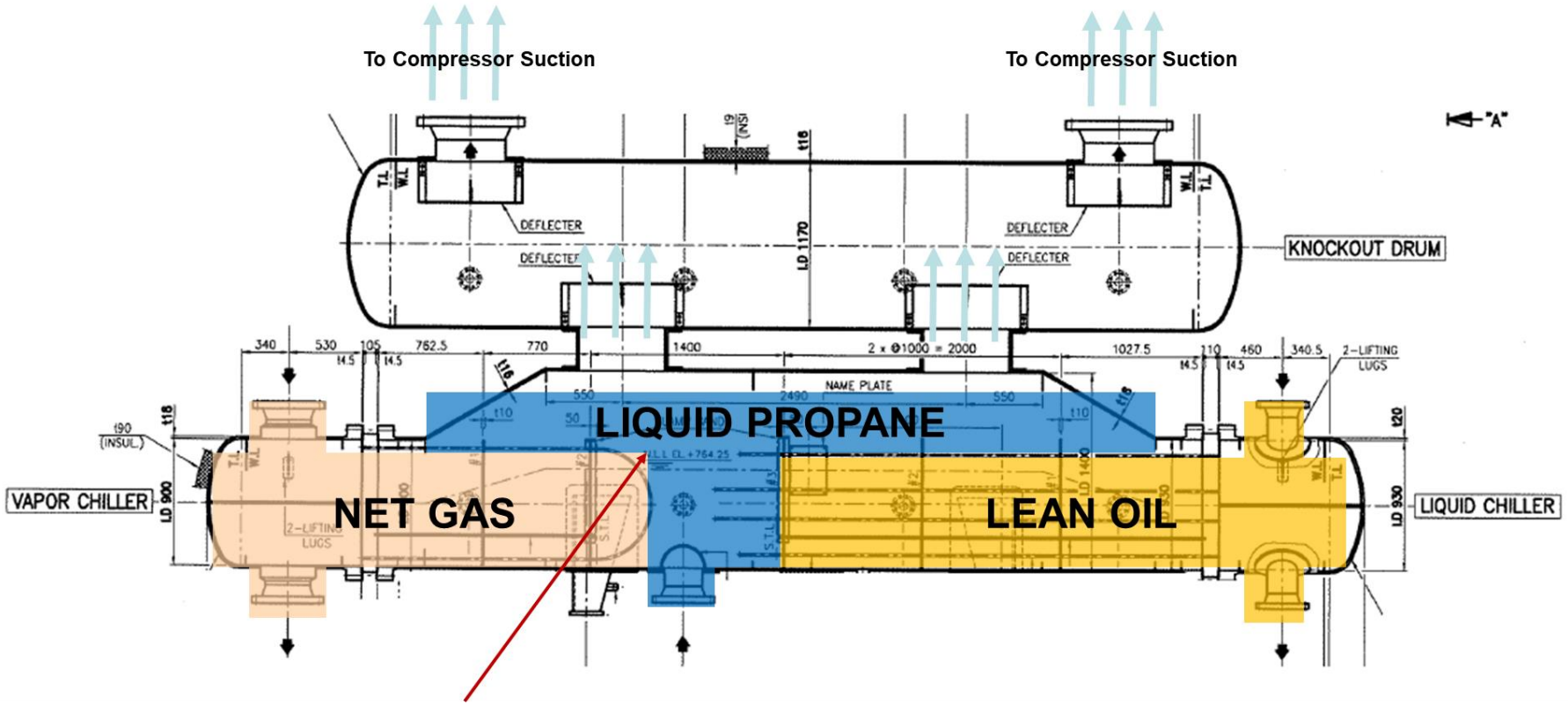
- Temperature and liquid level control of the Knockout Drum are critical to ensure no liquid propane carryover to the compressor suction. However, the operating suction temperature at ~-24 degC and its fluctuation resulted in liquid propane formation at compressor suction.



Solutions

1. Lowering Combined Chiller Liquid Level.

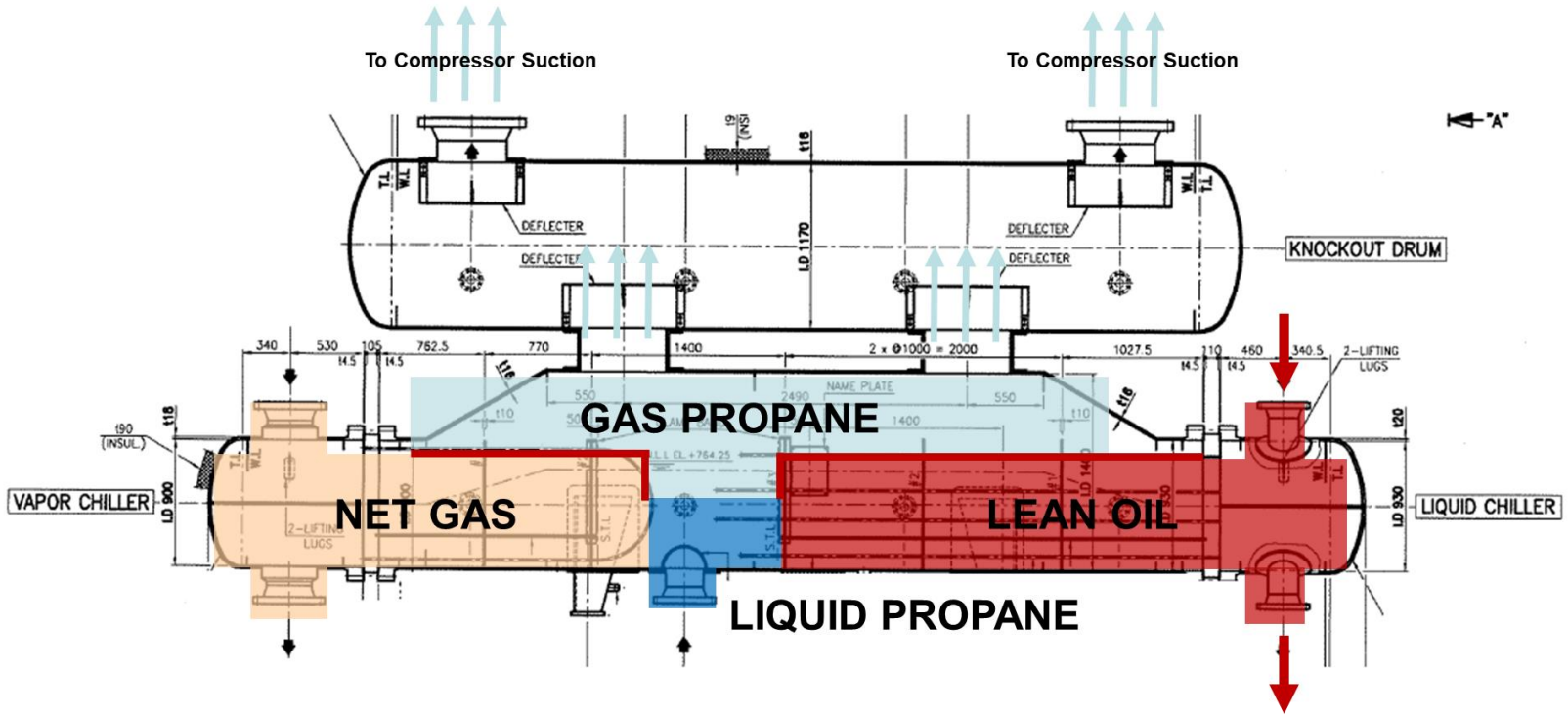
This will increase the superheat of the gaseous propane to the compressor suction, thus reduce the risk of liquid carryover.



Solutions

2. Increase Lean Oil Flow Rate

Increased lean oil flow will increase the heat duty transfer for propane superheating, also it will increase the propane vaporization.



Solutions

3. Control and Monitor Suction Temperature

By implementing Solution 1 & 2, propane temperature at compressor suction will be increased, maintaining a higher superheat margin from condensation point. Currently a 5 to 10 degC superheat is maintained.

Result

Compressor was overhauled after the damage, and restarted with all the solutions implemented.

Since then, a 5 to 10 degC superheat have been maintained at compressor suction. No recurring trips after compressor restart and all parameters are within acceptable range.

Conclusion and Broader Learning

- Rotor axial position trip helped to prevent the compressor from catastrophic failure.
- Operating below the condensation temperature can easily cause liquid propane carryover to the compressor and result in abrupt change in thrust load, damaging the thrust bearing.
- Suction process conditions of refrigeration screw compressors should be carefully controlled to prevent potential liquid formation at compressor suction, taking into consideration of the refrigerant properties.
- Maintaining proper liquid refrigerant level in the chiller is important as well to prevent two-phase operation.

Thank you
Any questions please?

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