PROCESS CONTROL FOR PARALLEL OPERATION OF TWO HELIUM LIQUEFIERS AT VECC, KOLKATA

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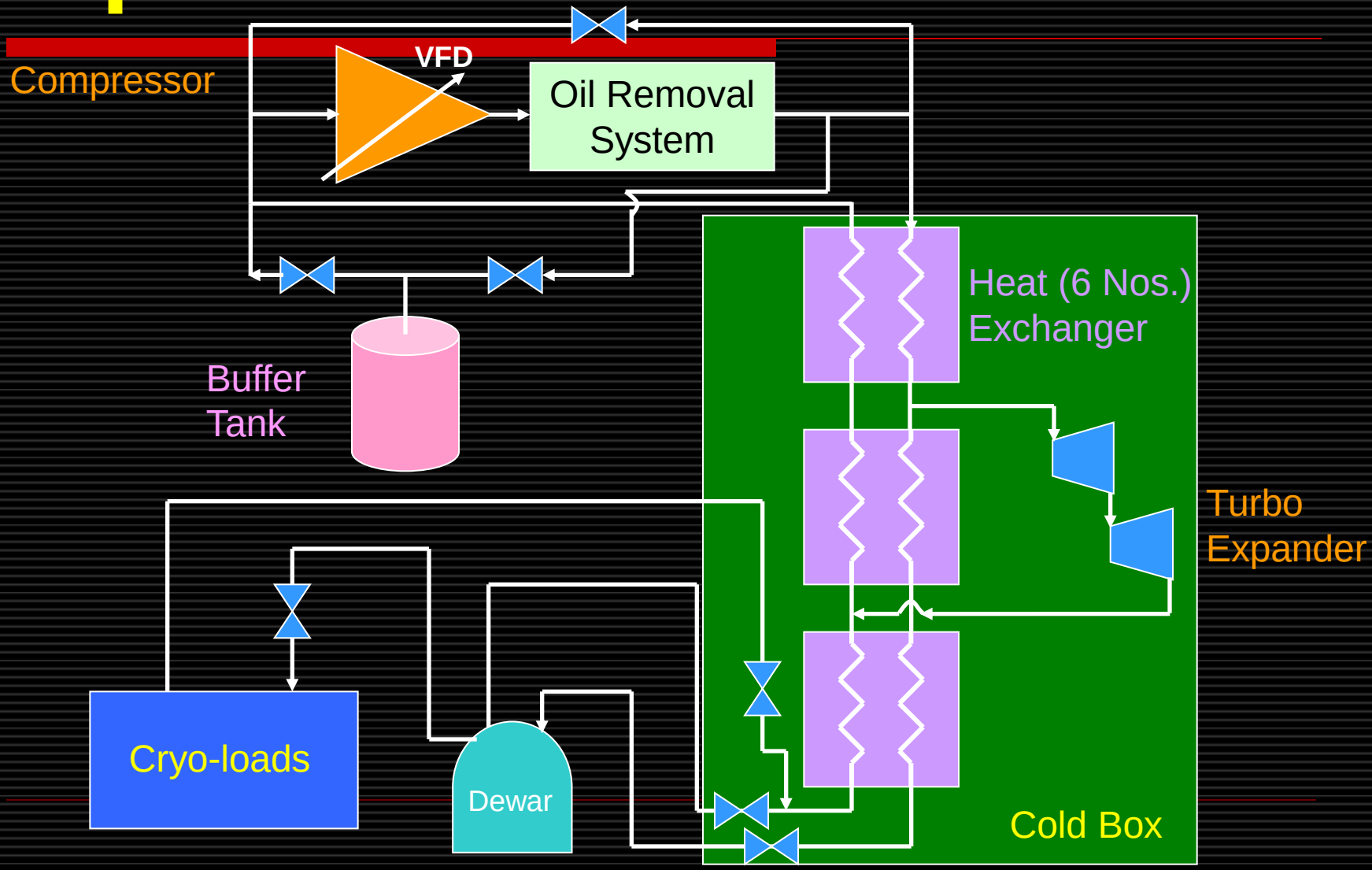
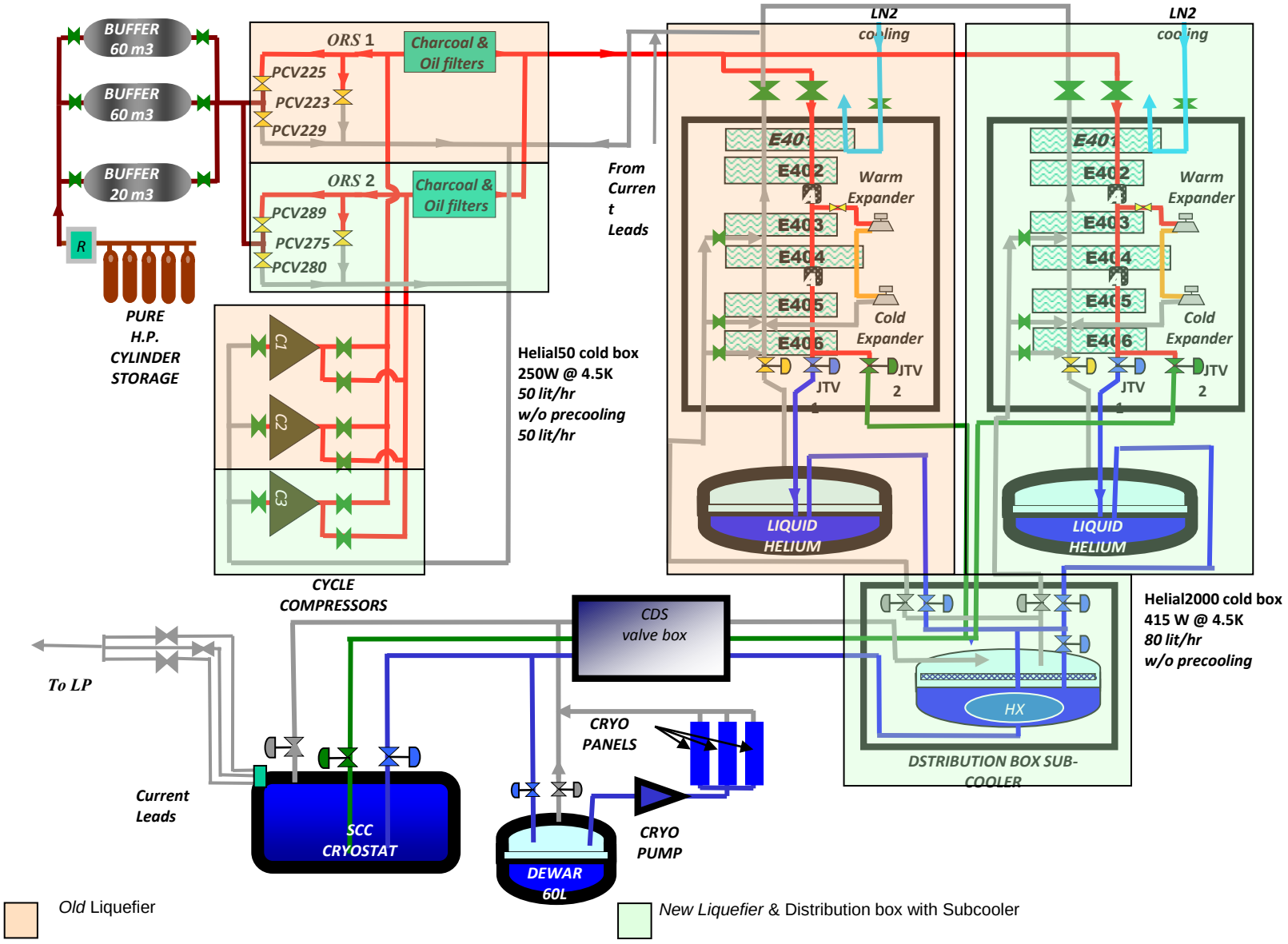
Process Diagram of helium liquefier



Gas management System

- Gas management system consists of two control valves,
  - one unloading valve which automatically sends excess helium inventory to the buffers when the helium gas generated is in excess compared to the refrigeration system capacity; and
  - one loading valve which adds helium inventory to the system from the buffer tank when the liquefaction capacity is higher than the flow recovered from the cryomodules.
- These two valves work in concert with the by-pass valve, which automatically recycles excess flow from compressor discharge to suction.
- Gas Management system of one liquefier is operational while two are running in parallel.

Cryogenic System of VECC



MOTIVATIONS

- VECC's Cryogenic Plants: two liquefiers, three compressors, gas management system etc.
- Parallel run of compressors associates with
  - flexibility to run two liquefiers at tandem
  - saving of power because of sharing of helium flow
  - pressure fluctuations in one due to transients in other
  - tripping of compressors and disconnection of cold box
- Benefits override all other concerns
- Disadvantages to be solved by control means

EPICS based control system

Channel Archiver for database

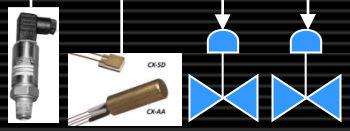
MEDM OPIs IOC

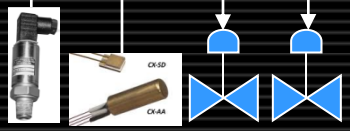
LAN

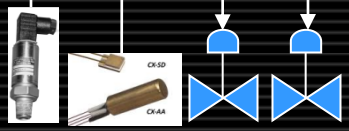
Helial 2000

Helial 50

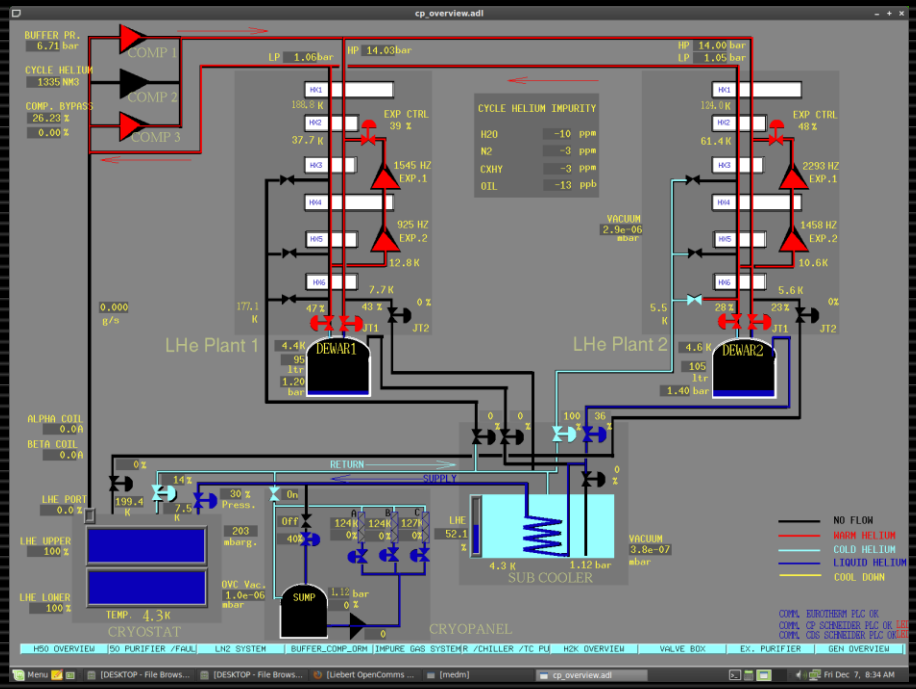
Overall Management

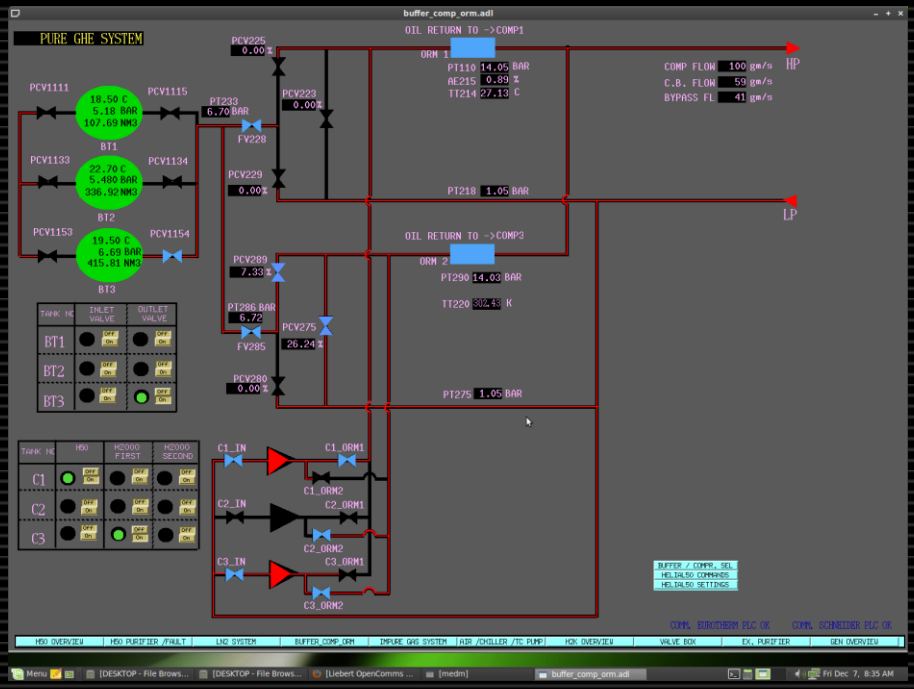




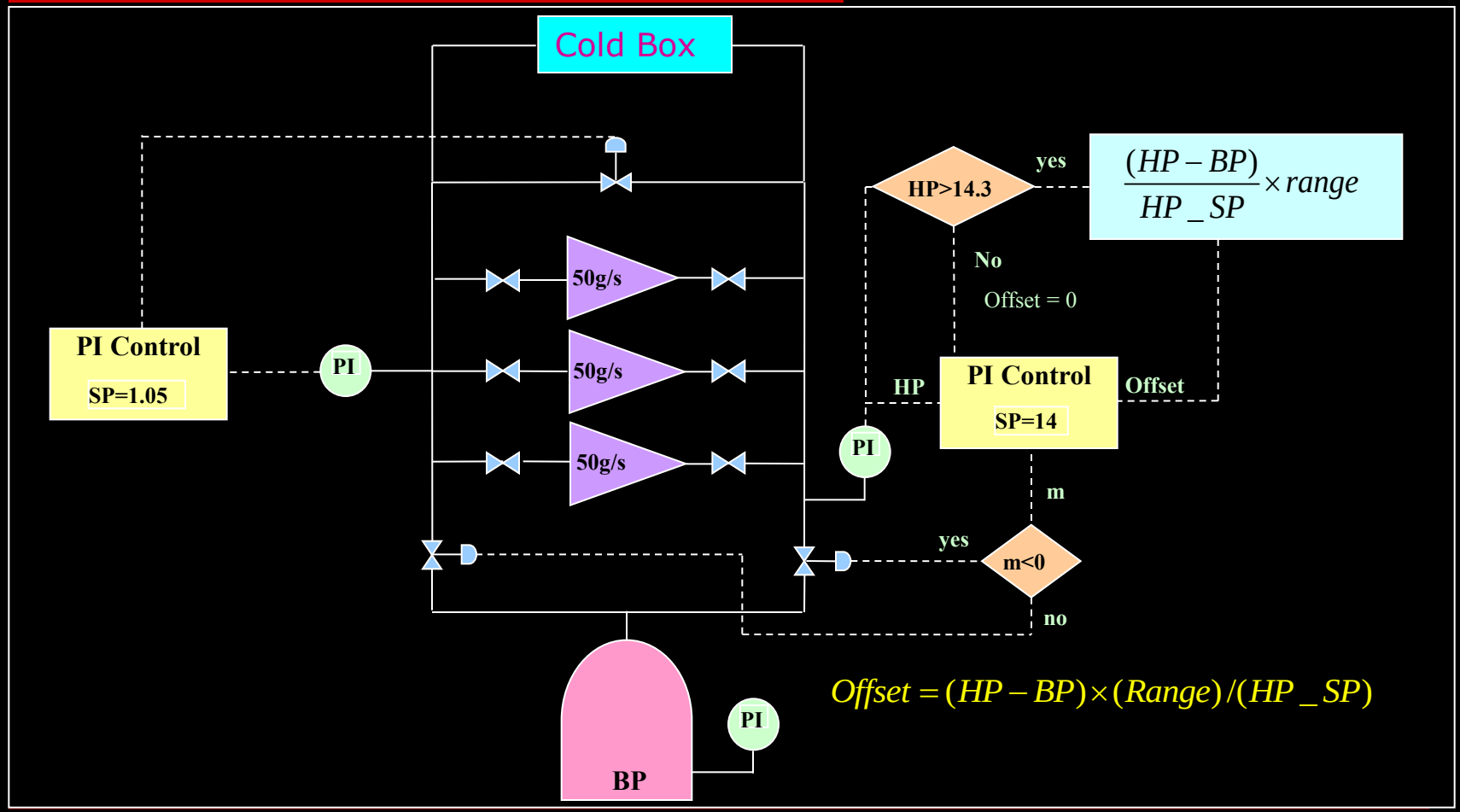


MEDM Overview Screen of the Cryogenic System

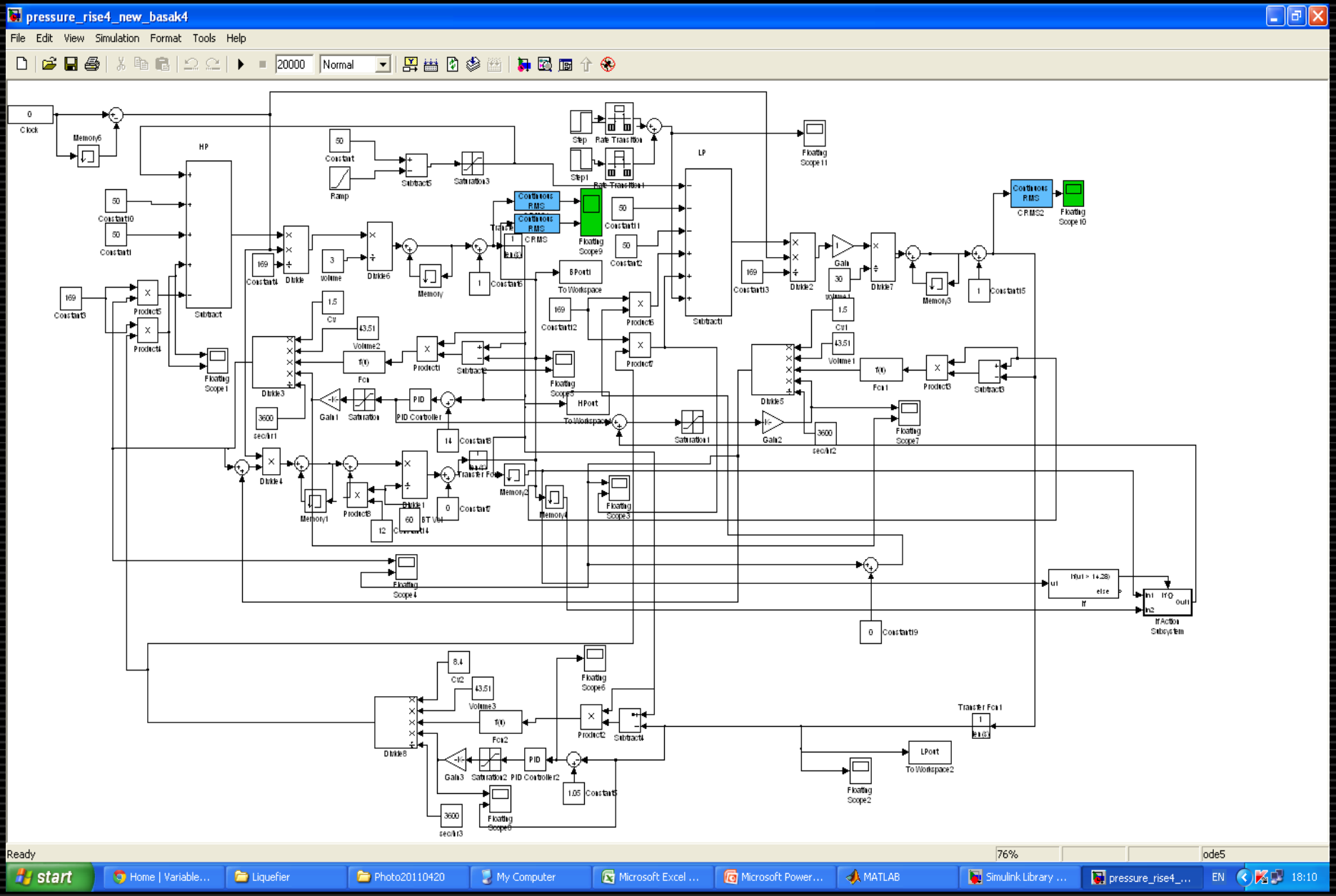




Technique followed to solve pressure fluctuation



Simulation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HP
LP
Subtract
Subtract1
Clock
Memory6
Constant
Ramp
Subtract5
Saturation3
Step
Rate Transition
Step1
Rate Transition1
Floating Scope11
Continuous RMS
CRMS
CRMS2
Floating Scope9
Floating Scope10
Constant10
Constant11
Constant4
Divide
volume
Divide6
Memory
Constant5
Transfer Fcn
To Workspace
Constant12
Product6
Product7
Constant13
Divide2
Gain
Volume1
Divide7
Memory3
Constant15
Product5
Product4
Floating Scope1
Divide3
Cv1
Volume2
Fcn
Product1
Subtract2
Floating Scope5
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Gain2
Divide5
Fcn1
Product3
Subtract3
Floating Scope7
Gain1
Saturation
PID Controller
Constant8
Constant7
Divide4
Memory1
Product8
Divide1
Memory2
Memory4
Floating Scope3
Floating Scope4
Constant19
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Volume3
Fcn2
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Product2
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PID Controller2
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Microsoft Power...
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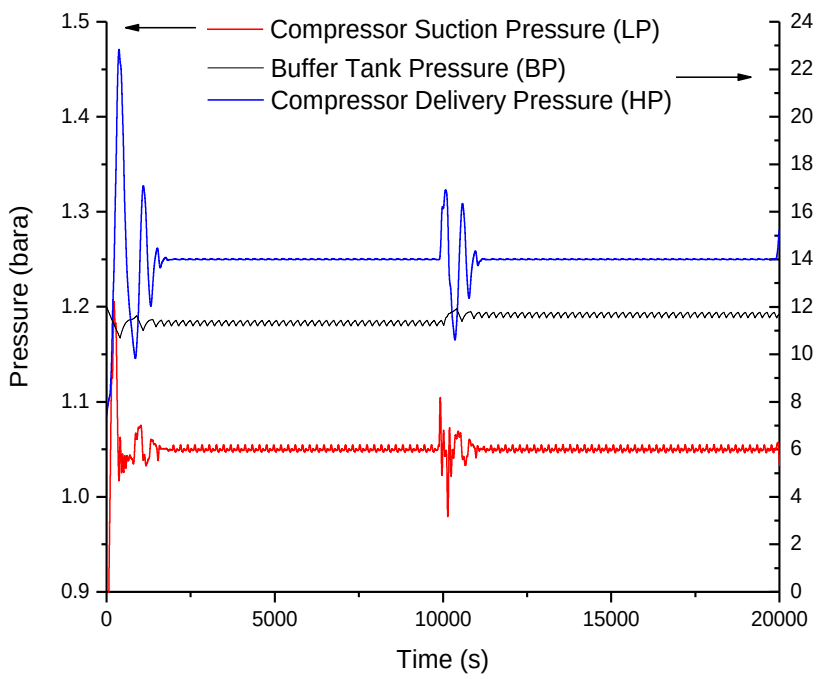
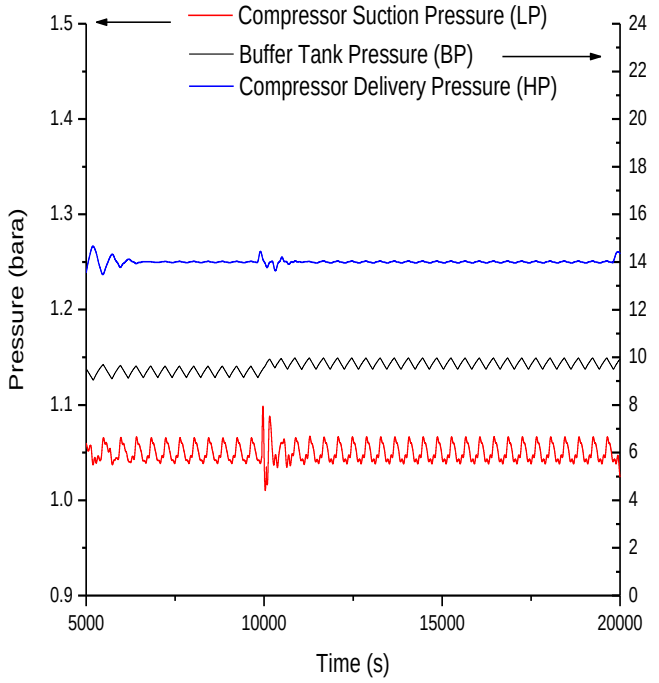
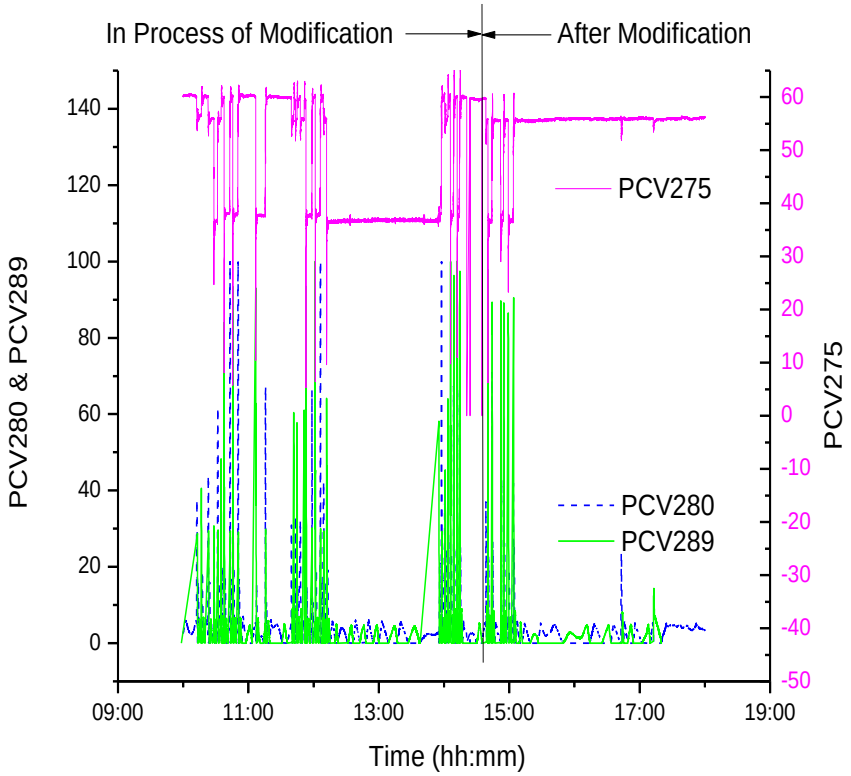
18:10

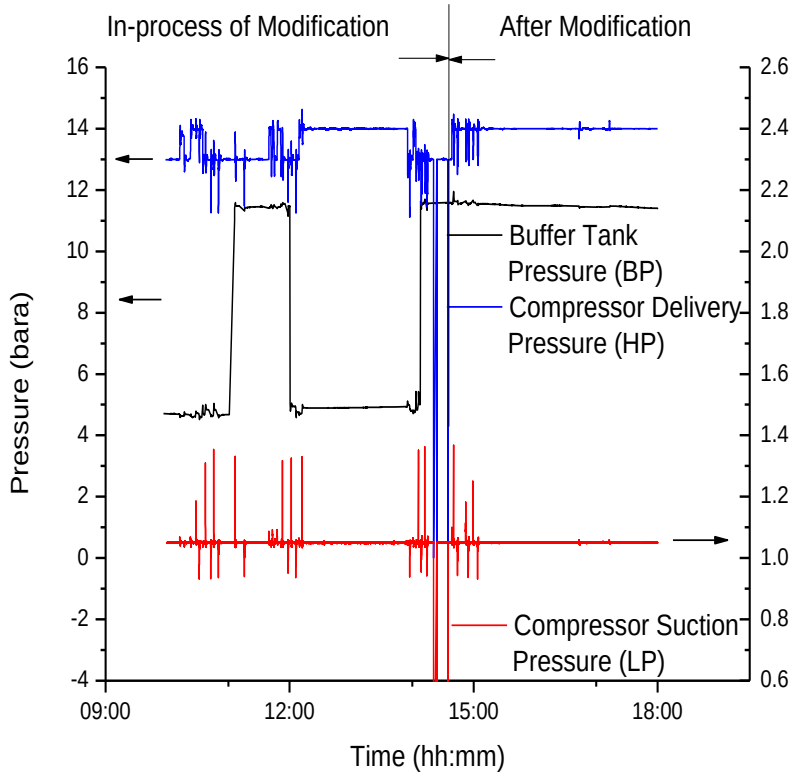
Simulation results before and after modification



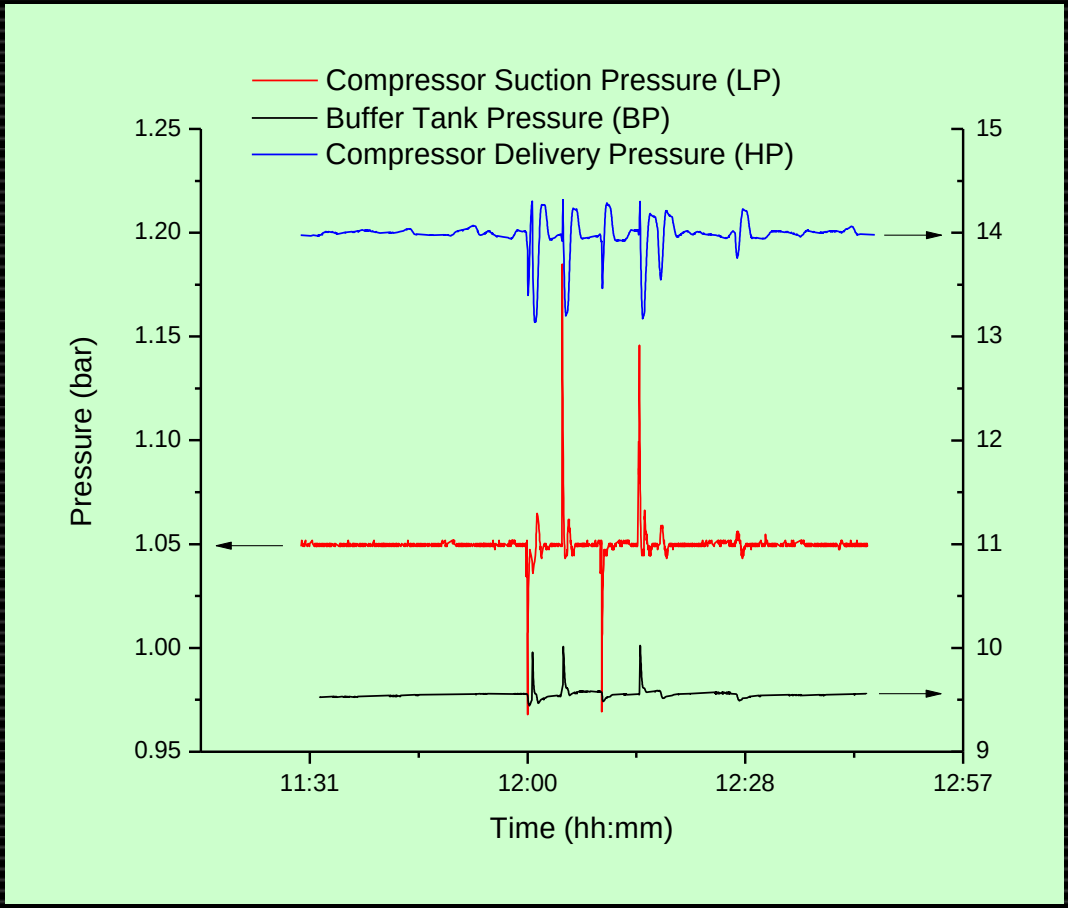


Valve opening and pressure graph before and after modification





A closer look of pressure for starting & stopping of one compr.



Conclusion

- Parallel operation of compressors is feasible without sudden trip
- Two liquefiers running with only two compressors for power saving - operating since 2010
- Implementation of the same along with VFD being studied
- Automatic compressor management using mass flow feedback