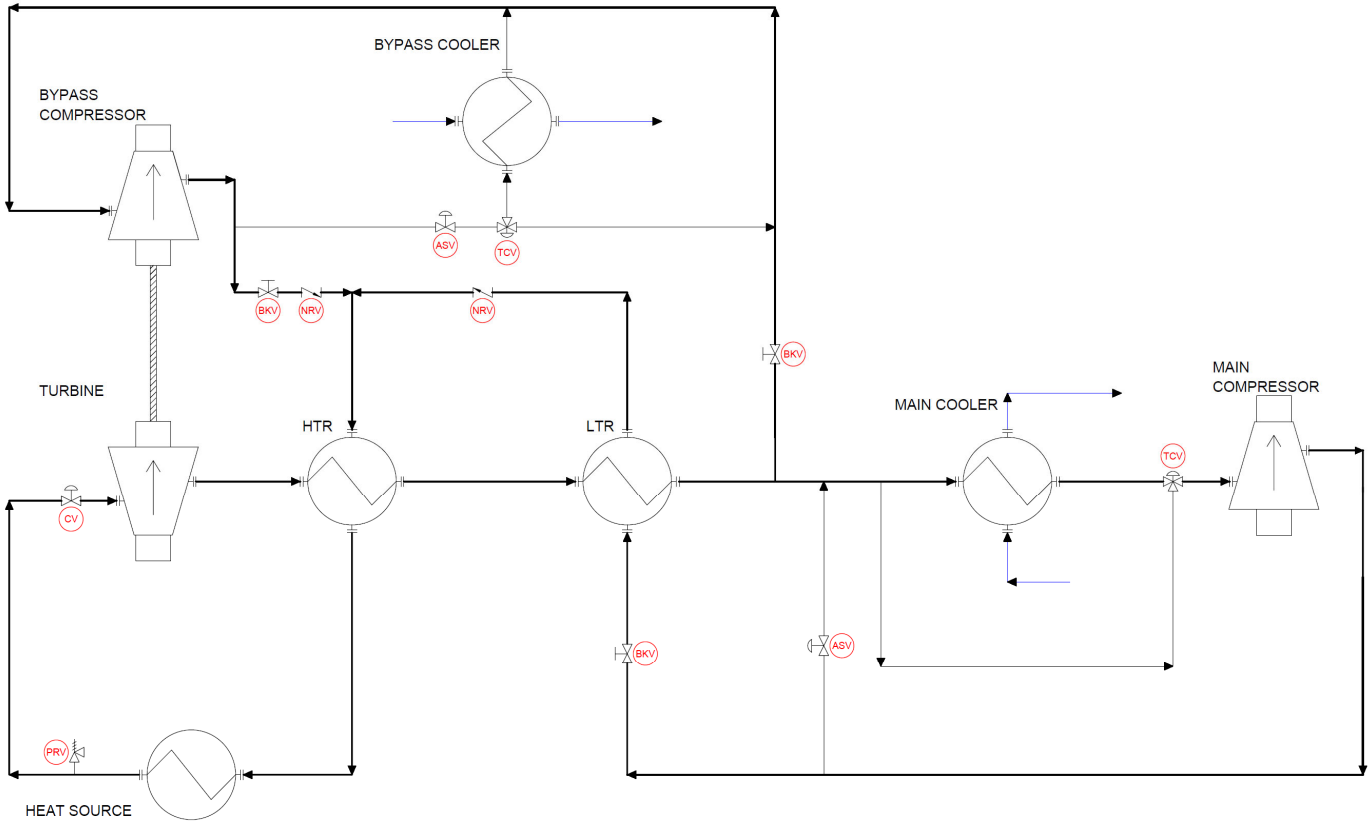
Supercritical CO_2 Power Cycles Symposium

Inventory Management Operational Strategies for a 10 MWe sCO_2 Power Block

January Smith (SwRI)

Recompression Closed Brayton Cycle



STEP Cycle Conditions

Model Names	Cycle Configuration	Description	Load %	Net Power Level (MWe)	Cooler Exit Temperature	Turbine Inlet Temperature	Cycle Efficiency
133	Simple	Simple cycle minimum load case	Min	2.5	35°C	500°C	22.6%
136	Simple	Simple cycle maximum load case	Max	6.4	35°C	500°C	28.3%
151	Recompression	Baseline case	100%	10.0	35°C	715°C	43.4%
152	Recompression	"Hot" Day Case	70%	6.6	50°C	675°C	37.4%
153	Recompression	"Cold" Day Case	100%	9.9	20°C	525°C	36.8%
154	Recompression	Partial load case using invetory control	40%	4.0	35°C	715°C	37.0%
155	Recompression	RCBC at 500°C turbine inlet temperature	70%	6.9	35°C	500°C	32.5%
157	Recompression	Partial load case using TSV throttling (transient condition)	40%	4.2	35°C	715°C	30.8%
157a	Recompression	Partial load case using TSV throttling	40%	3.9	35°C	675°C	29.6%

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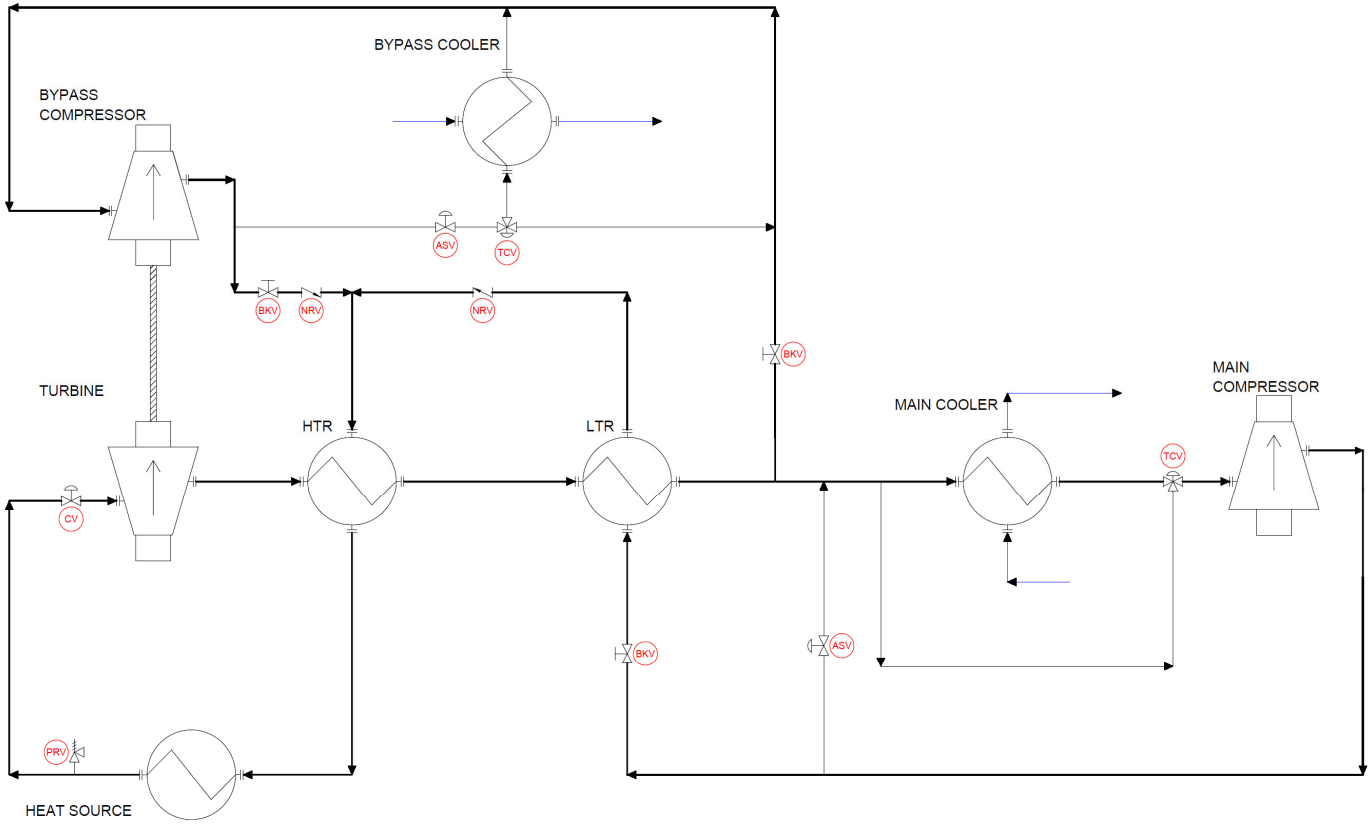
IMS Interface



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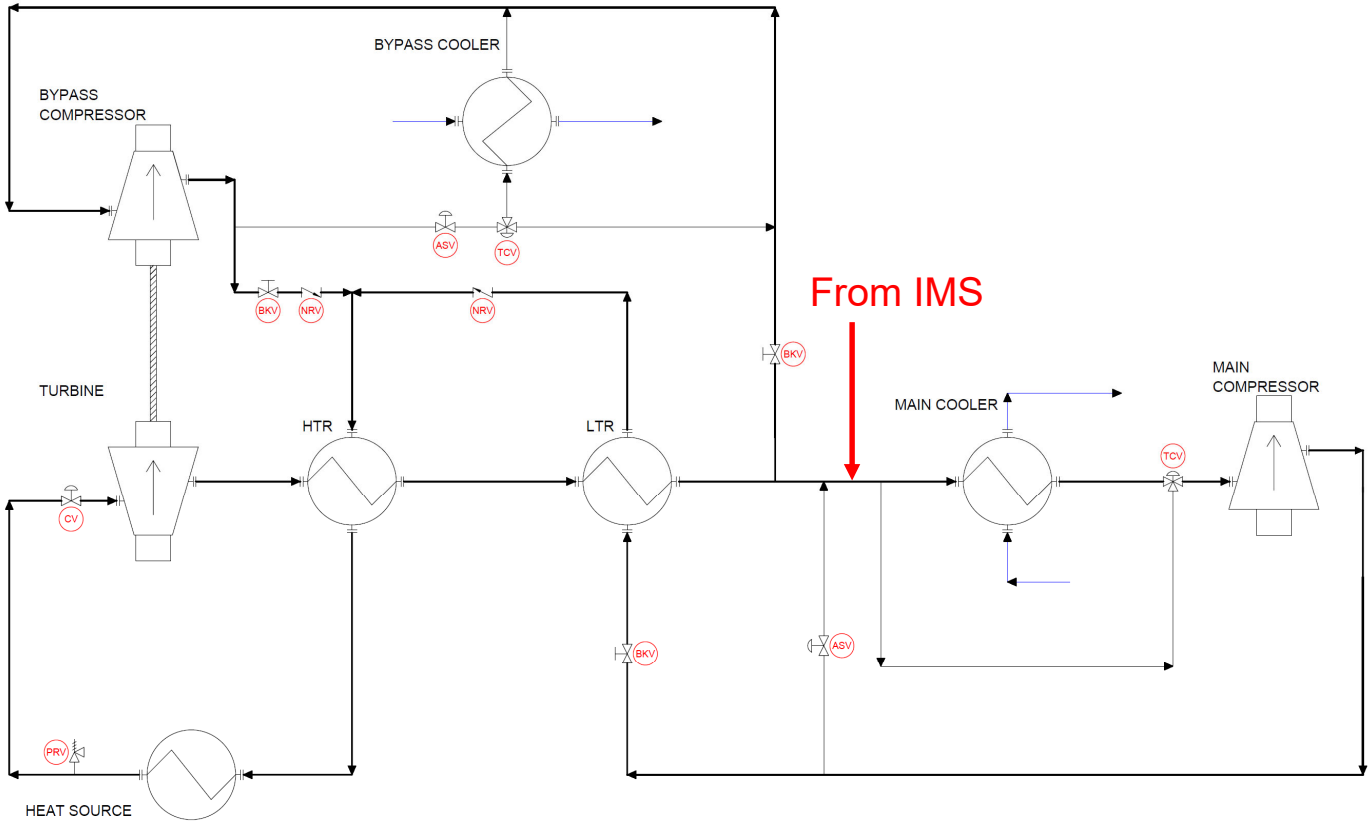

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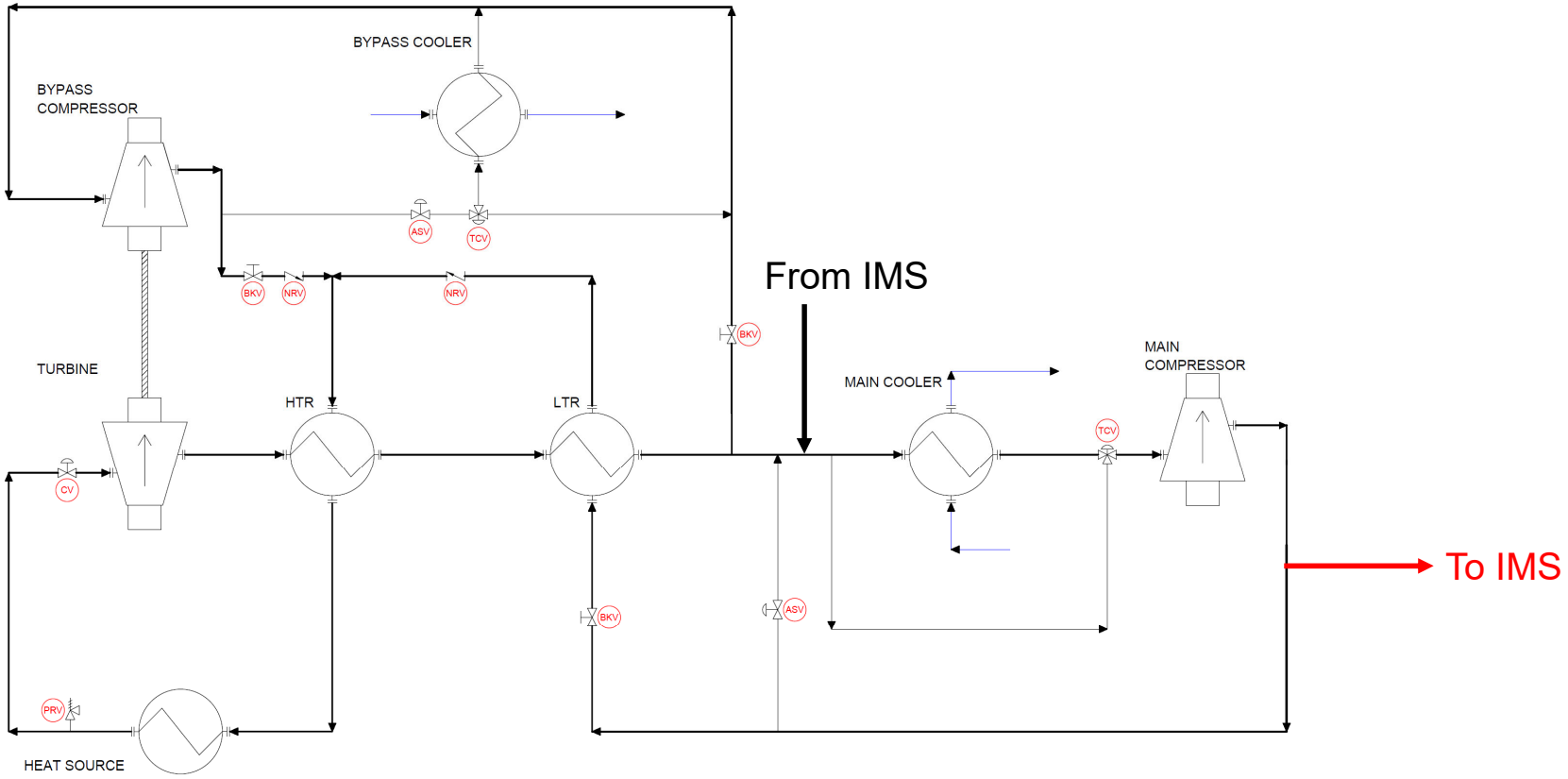

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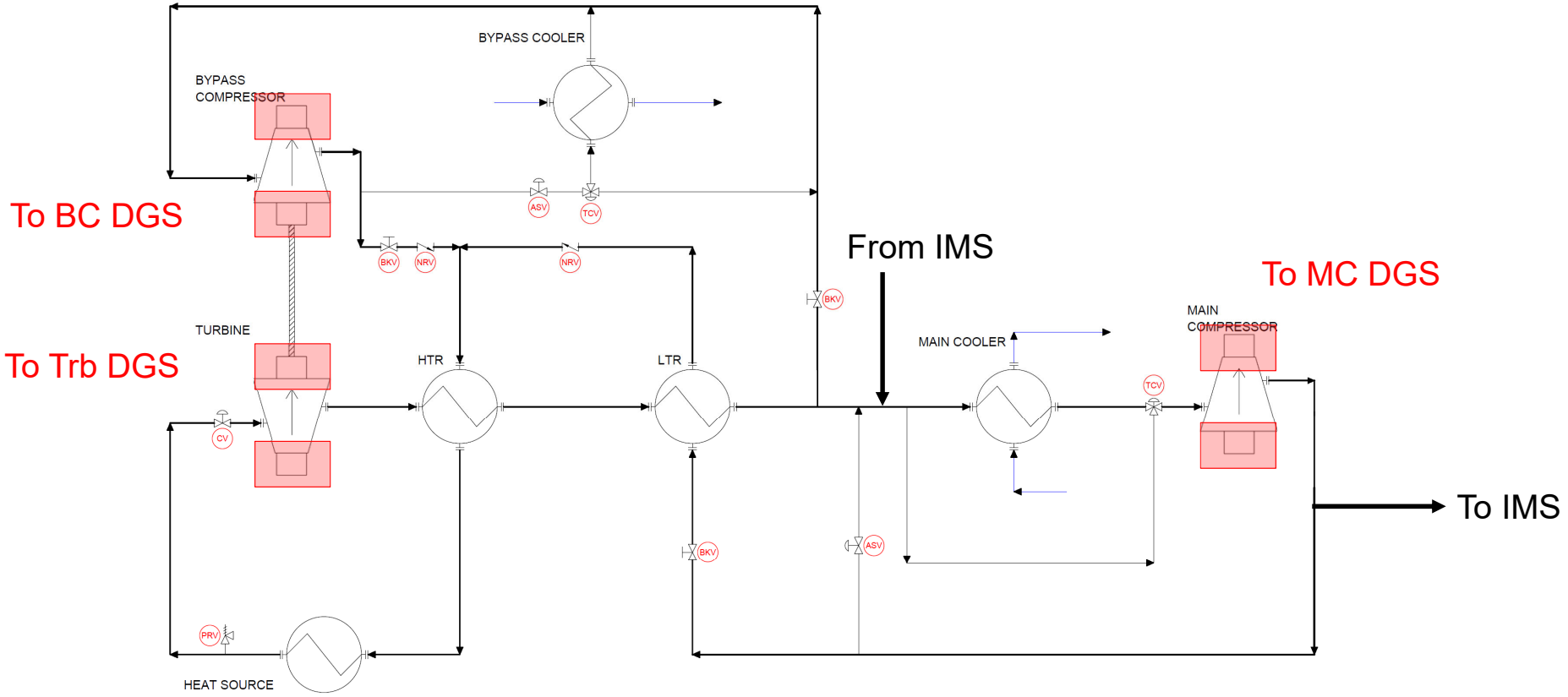
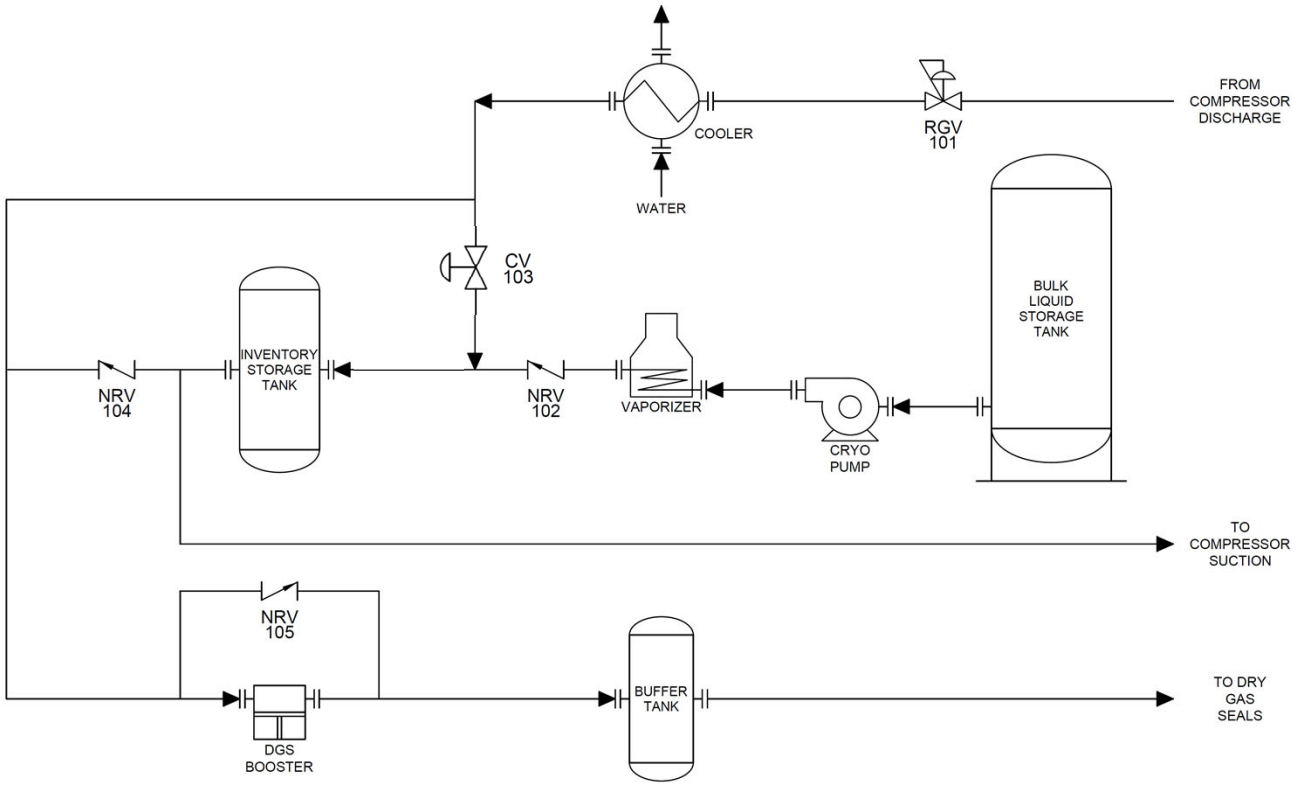


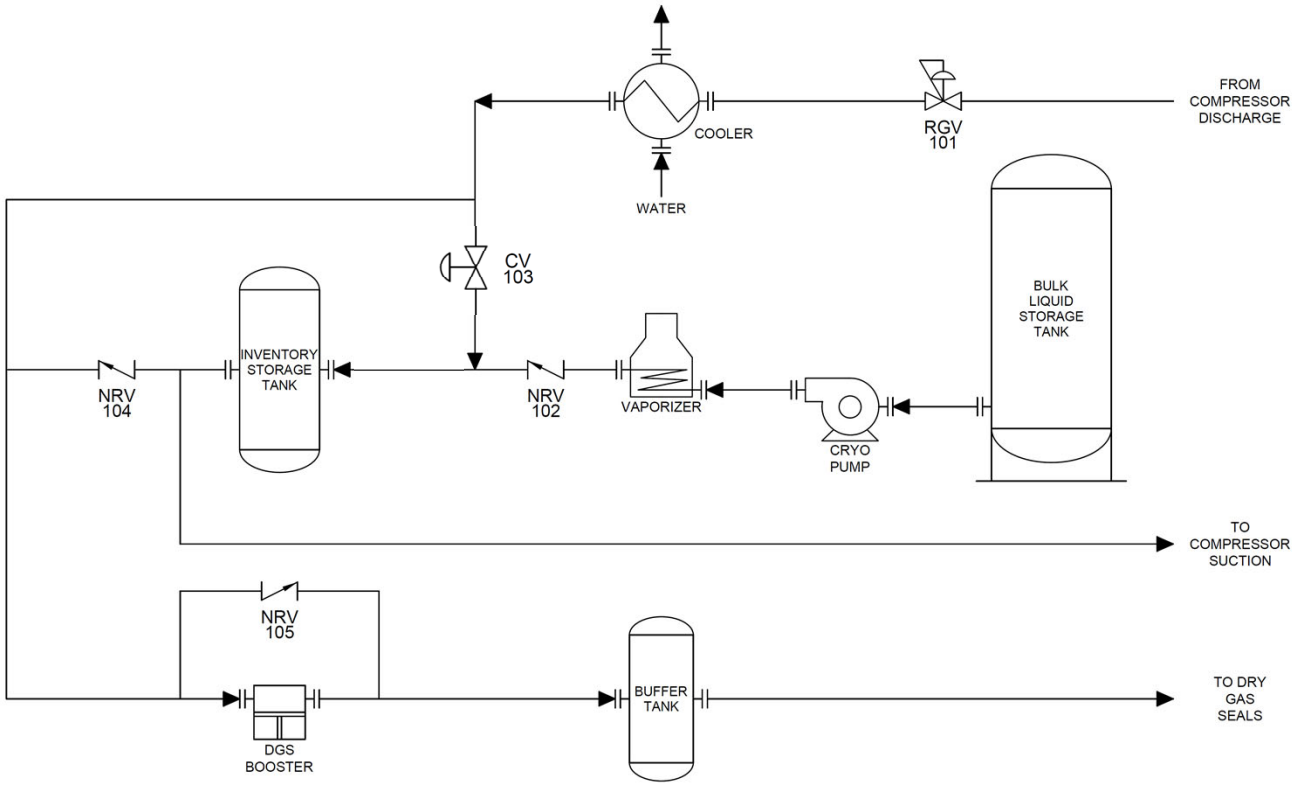
Inventory Management System



IMS Functions

FILL SYSTEM

Components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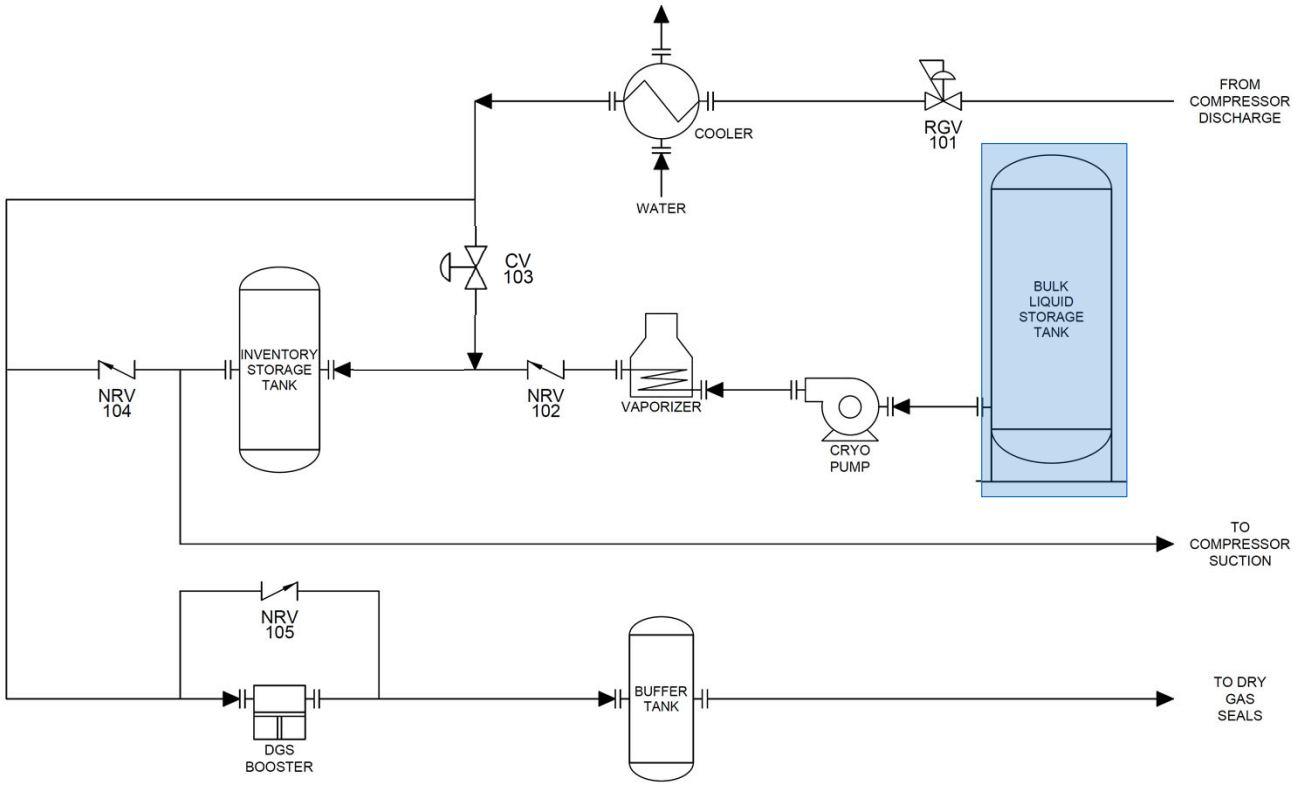
Components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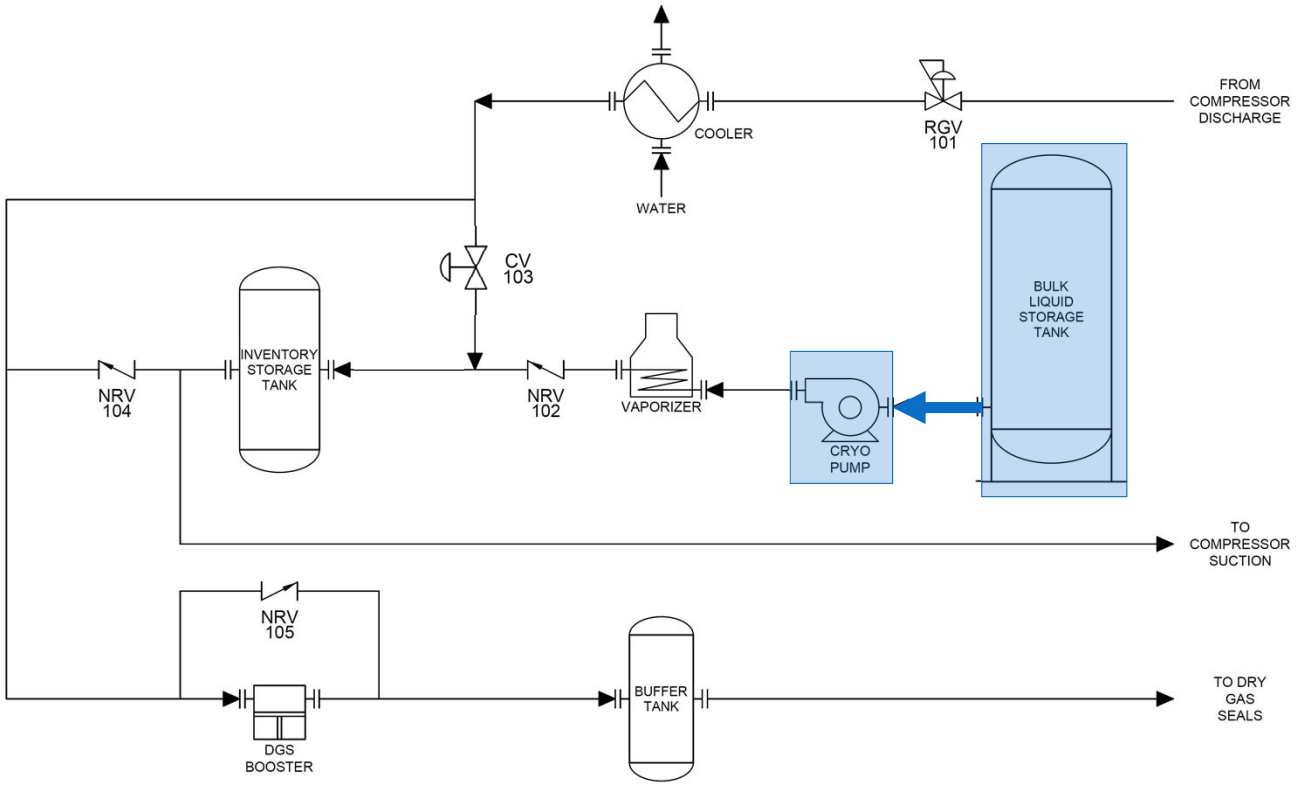
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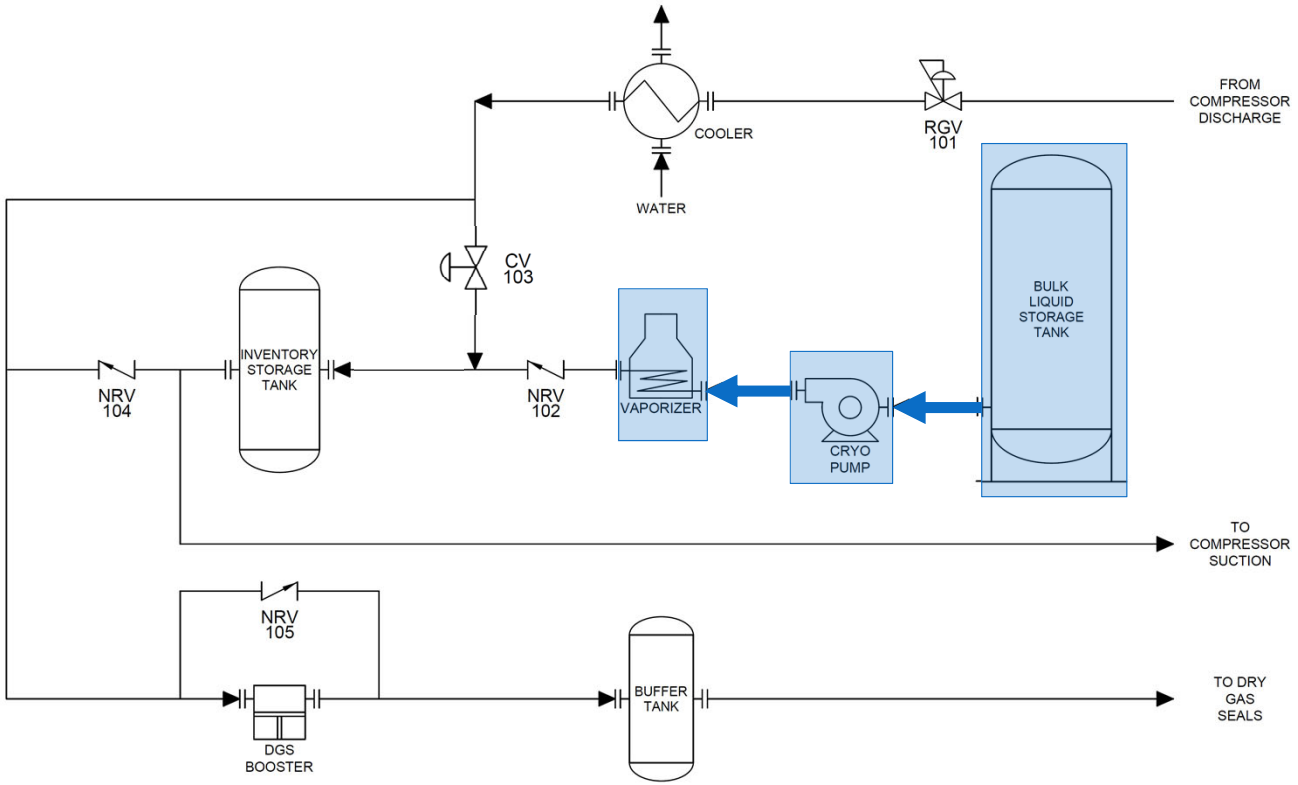
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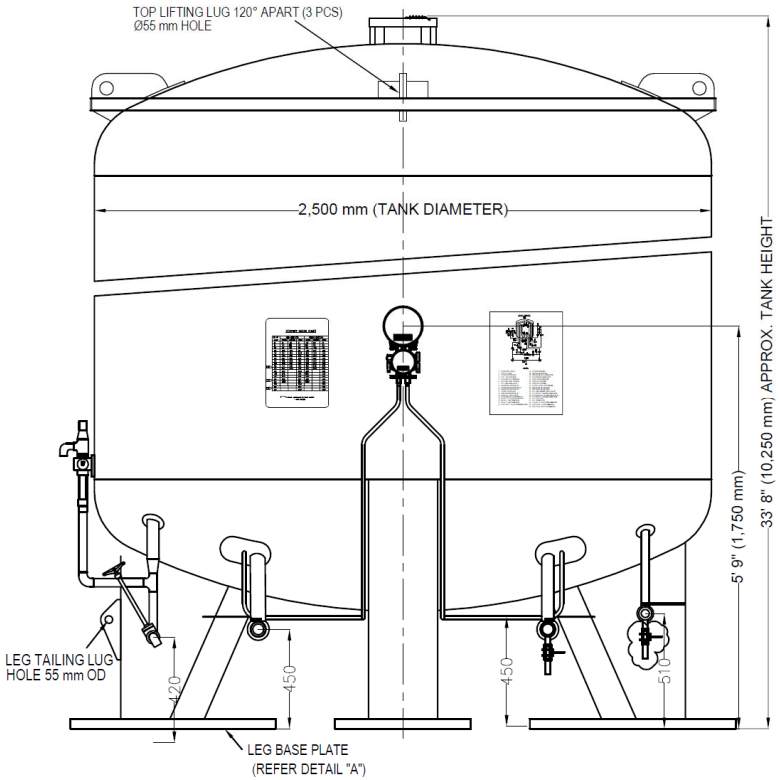
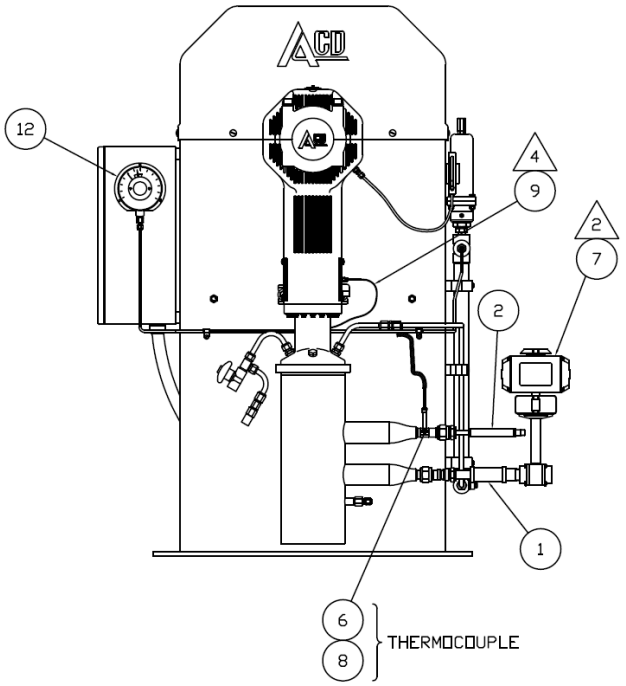
Bulk Liquid Tank

- How large of a tank?
  - Required inventory of power block
  - Estimated leakage of system
  - Frequency of tank refills
- Standard Sizes?
  - 14, 30, and 50 tons
- Can tank support withdraw rate?
  - Size of pressure building vaporizer



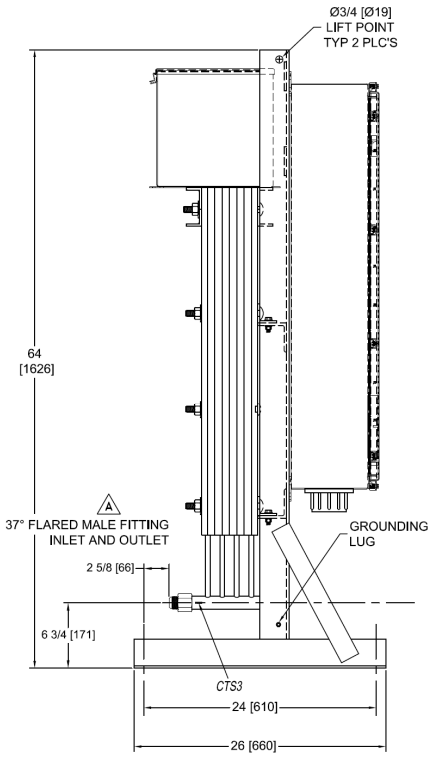
Cryogenic Pumps

- Boost pressure of the liquid CO_2 to max working pressure of 206 bar
- Parallel, fully redundant pumps
- Avoid dry ice formation with turndown

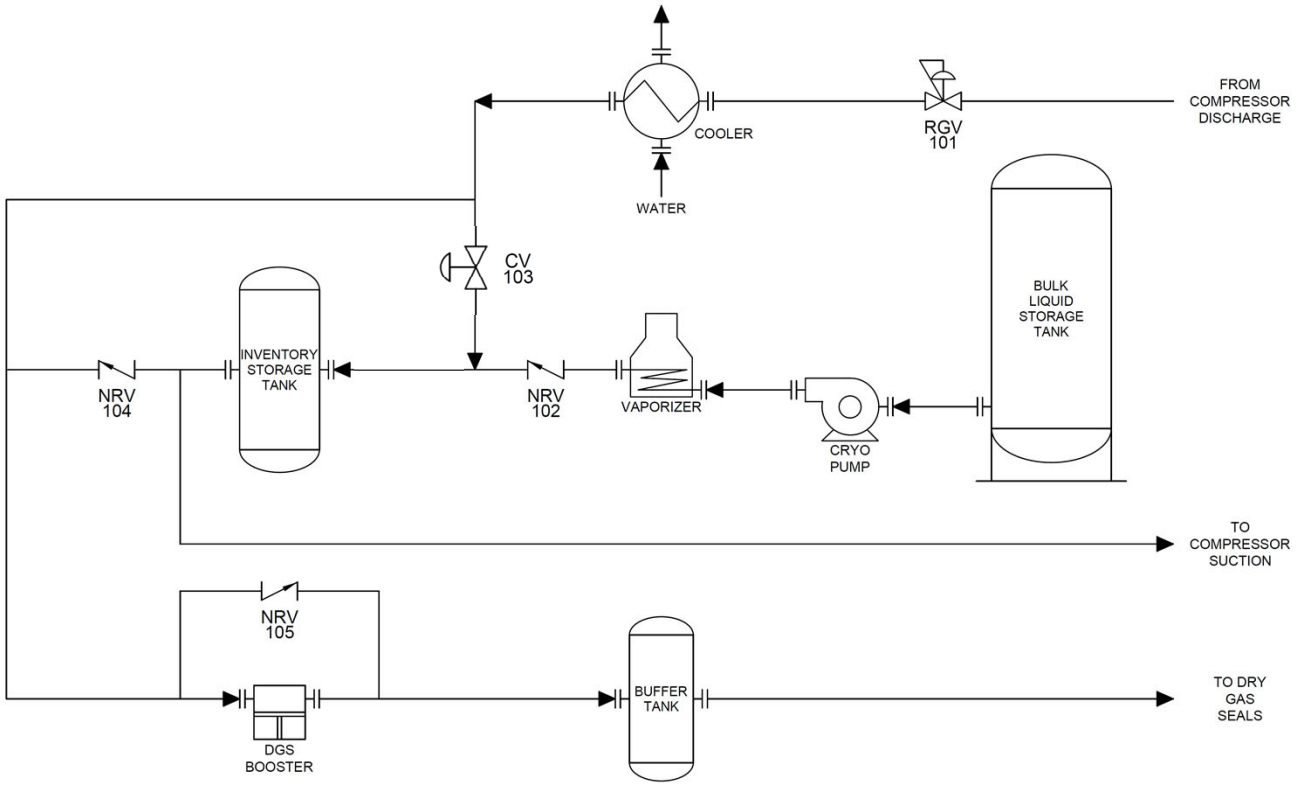


Vaporizer

- 90 kW electric vaporizer
- Selected over ambient vaporizer for dry ice concerns



Controls and Operation



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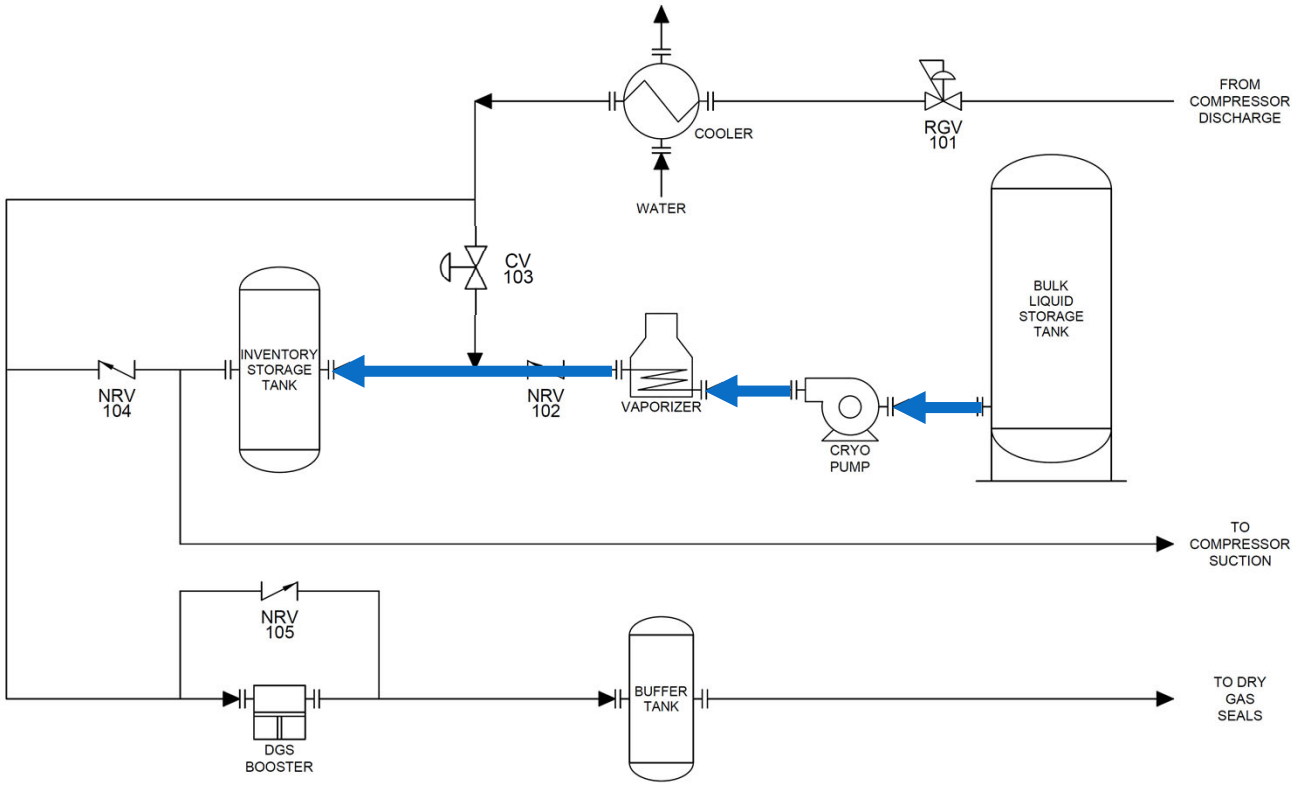
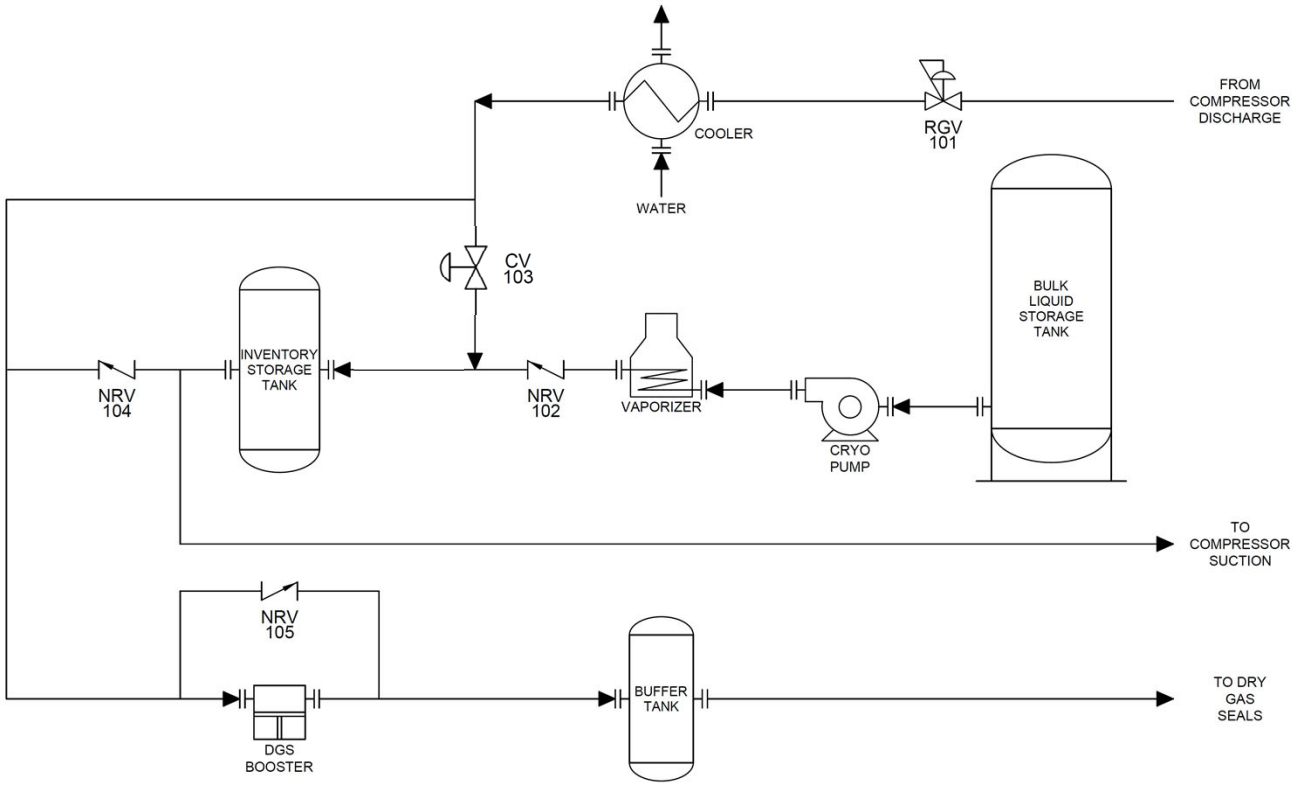


INVENTORY CONTROL

Components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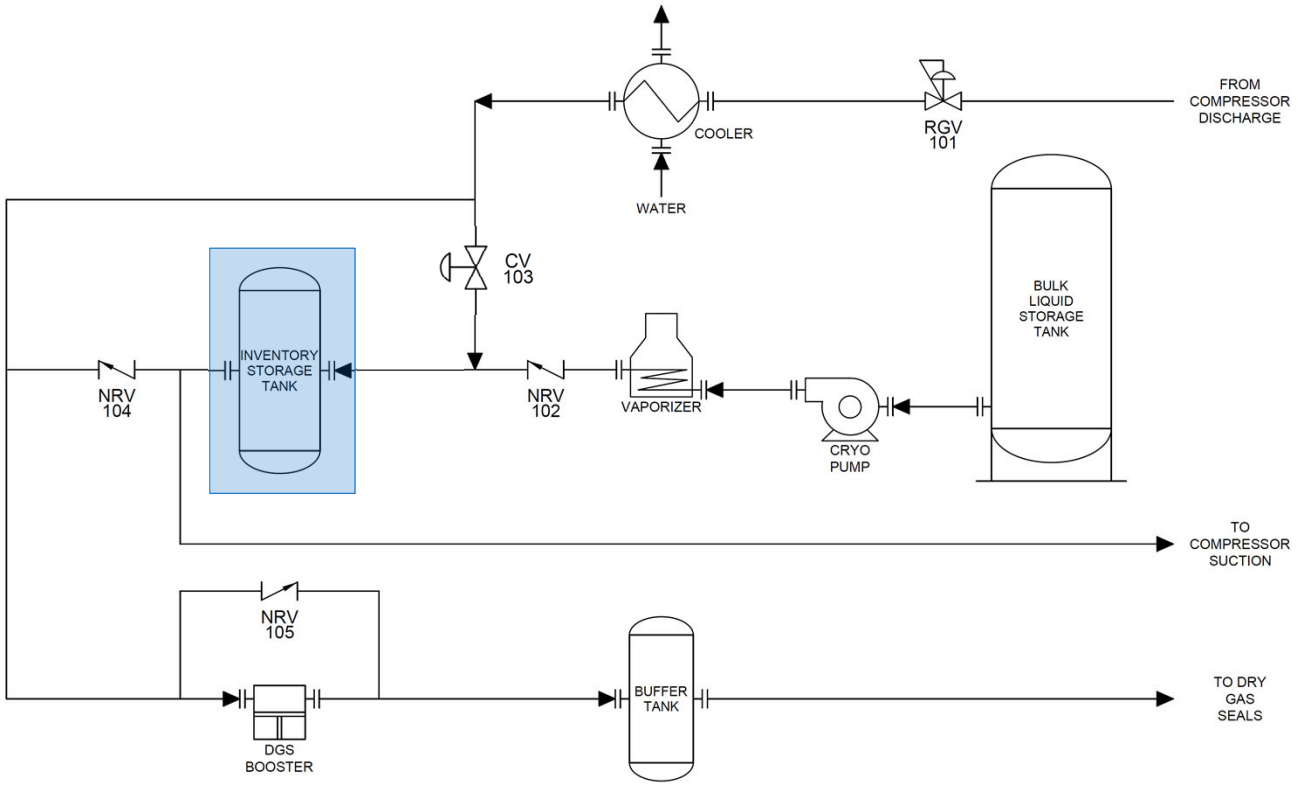
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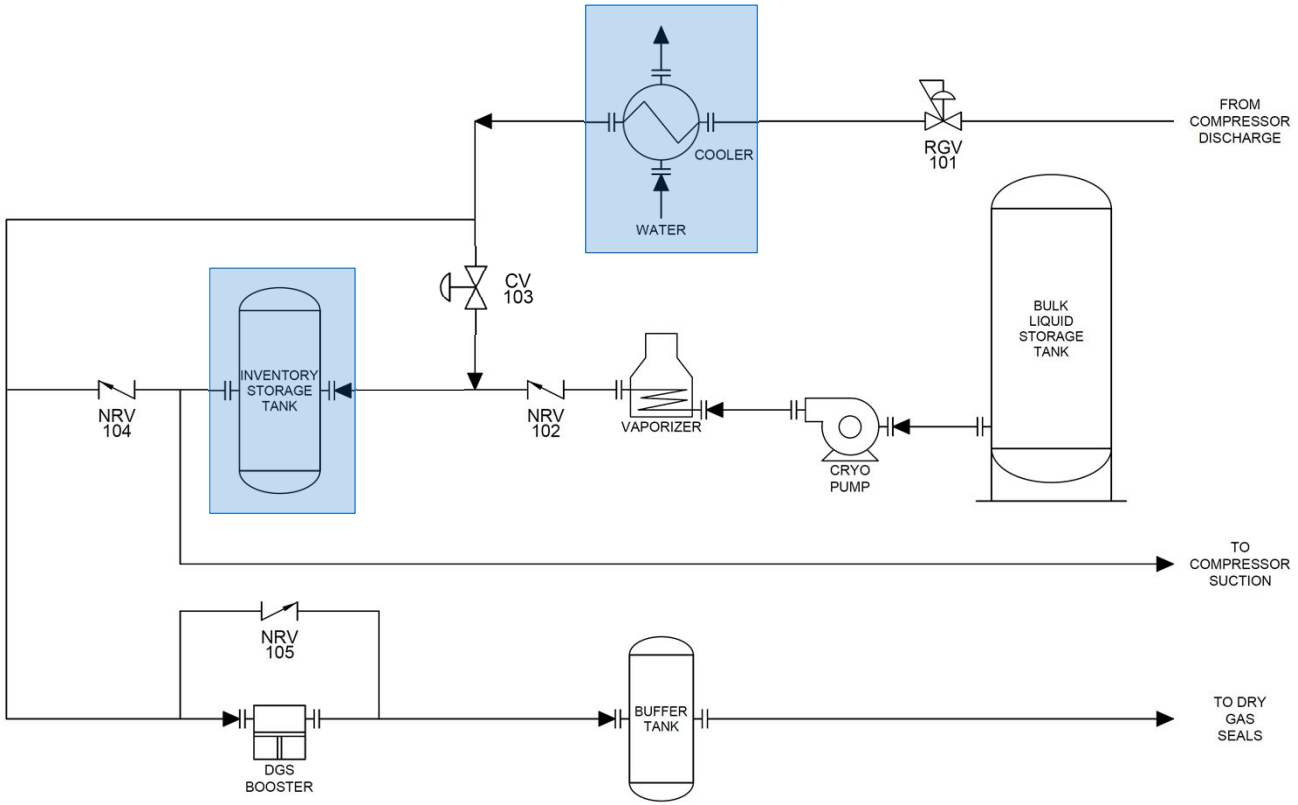
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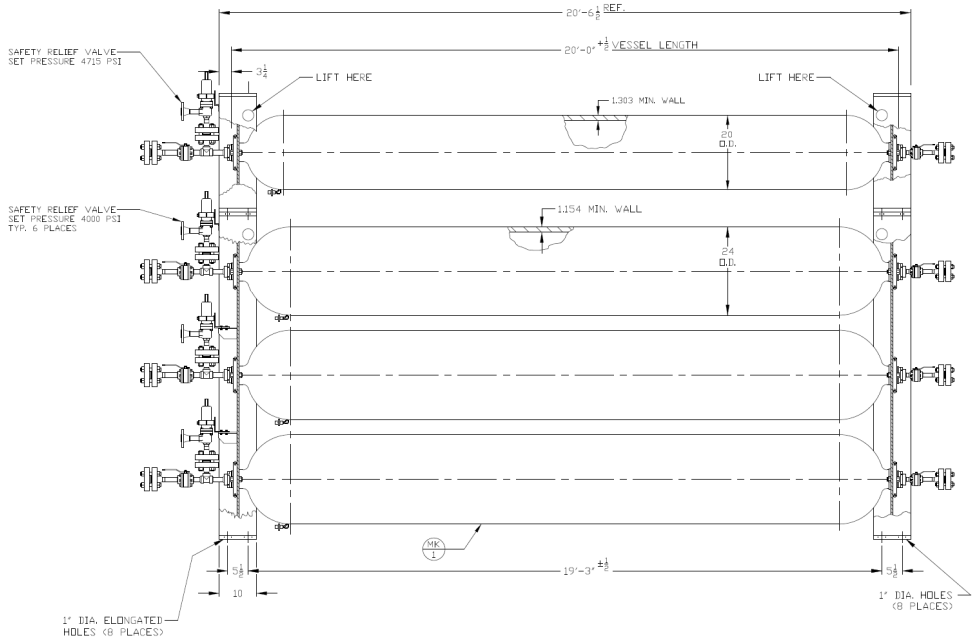
Inventory Storage Tank

- Volume to support load change mass
  - Difference between Case 151 and 154
  - 20% margin
- Pressure between process low and high setpoints
- Temperature controlled for density impact on volume required



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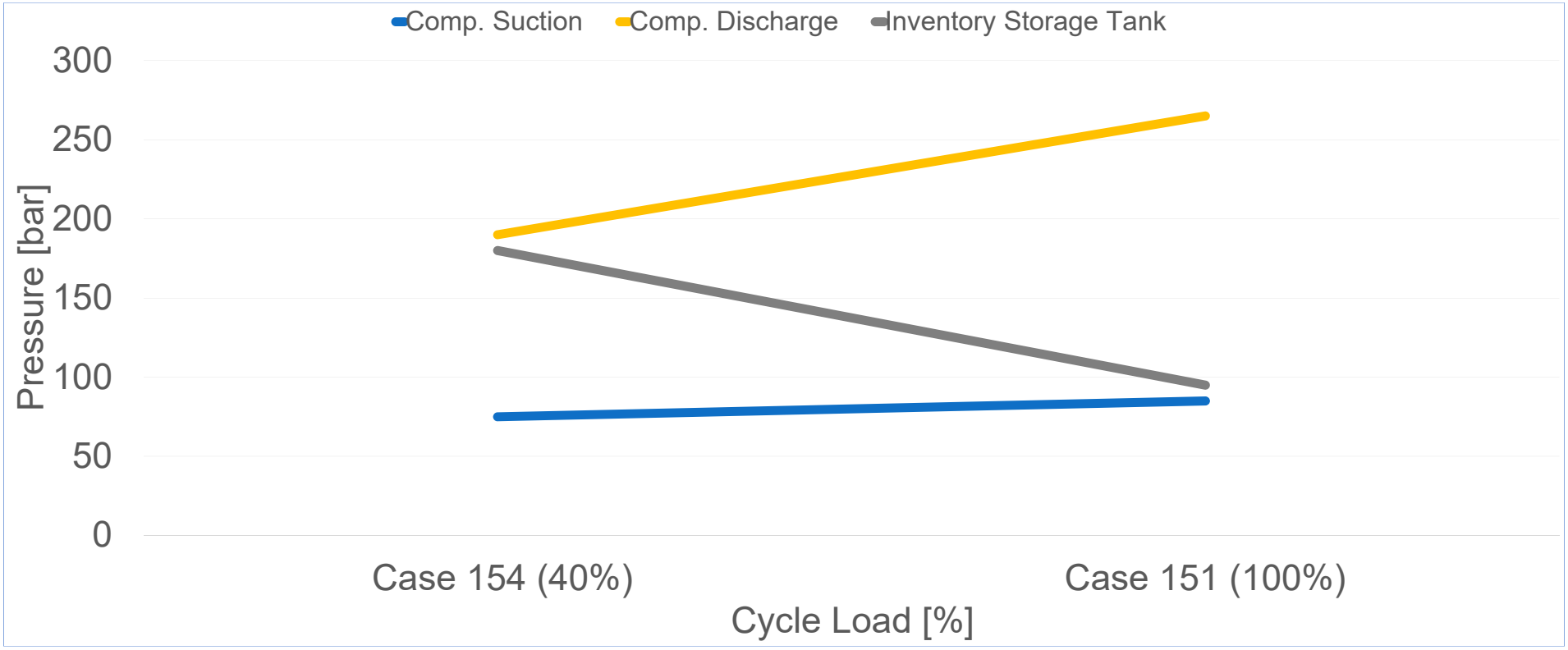
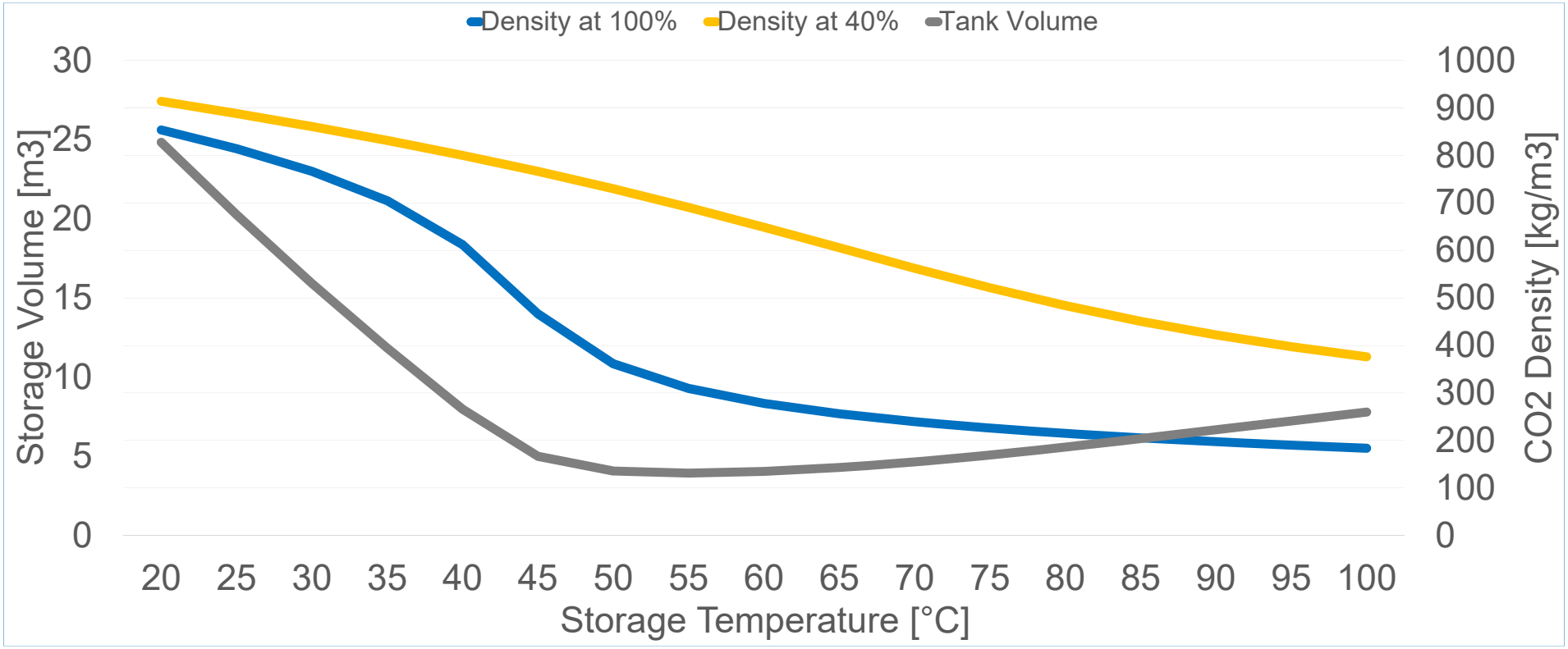


Inventory Storage Tank

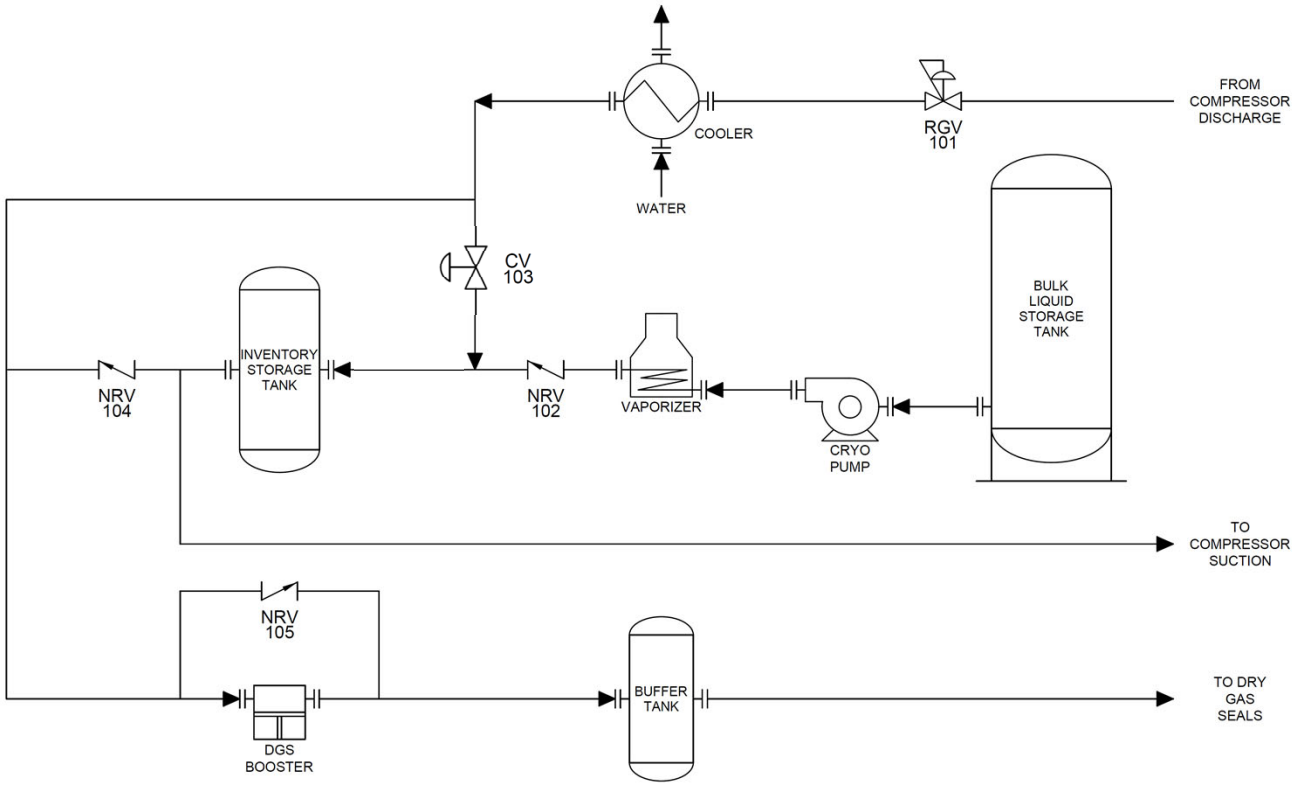
$$\text{Initial Tank Volume} = \frac{\Delta m}{\rho_{40\%} - \rho_{100\%}}$$



Inventory Cooler

- Designed to reduce heat added to inventory storage tank from compression

Controls and Operation



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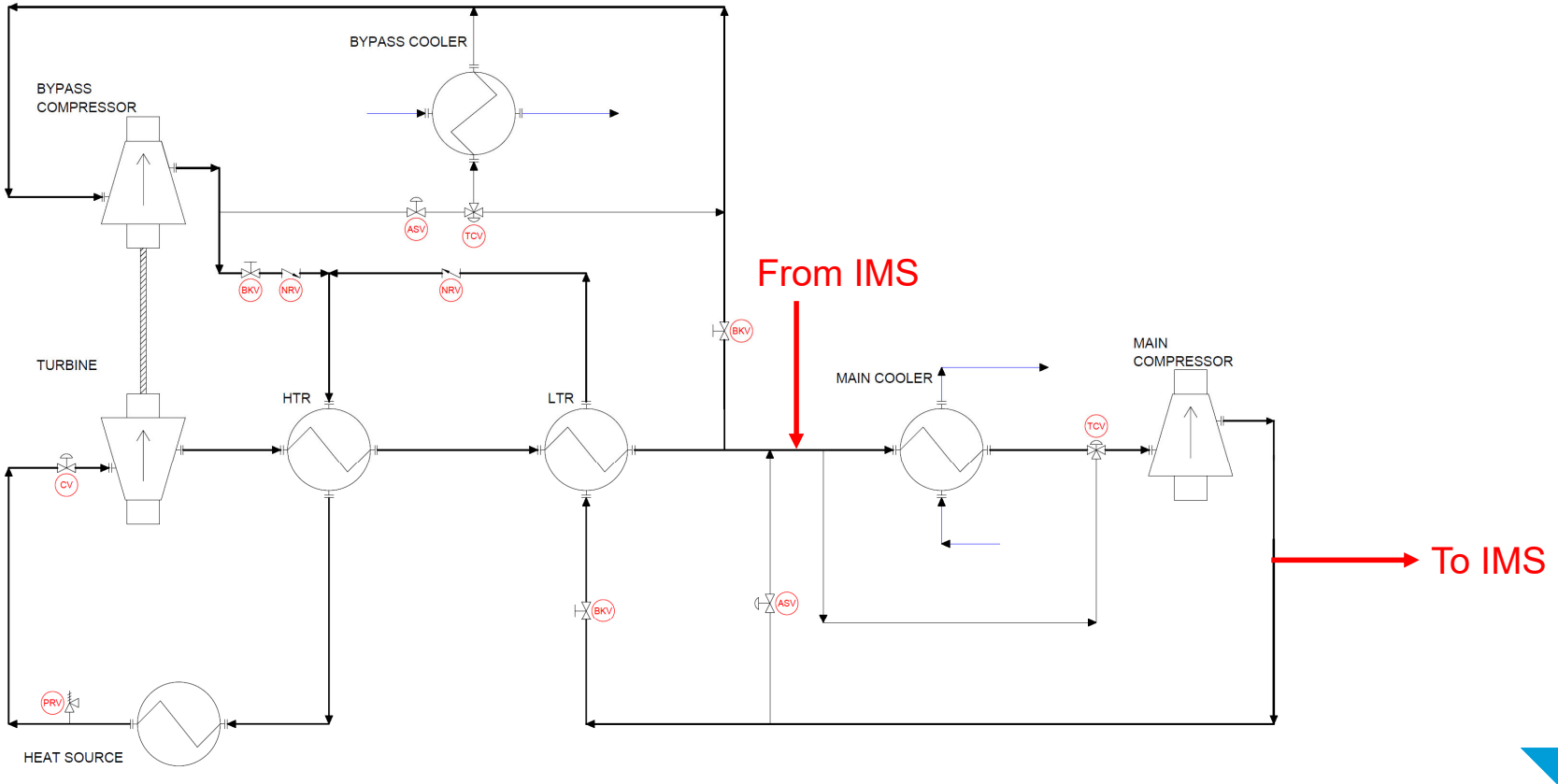

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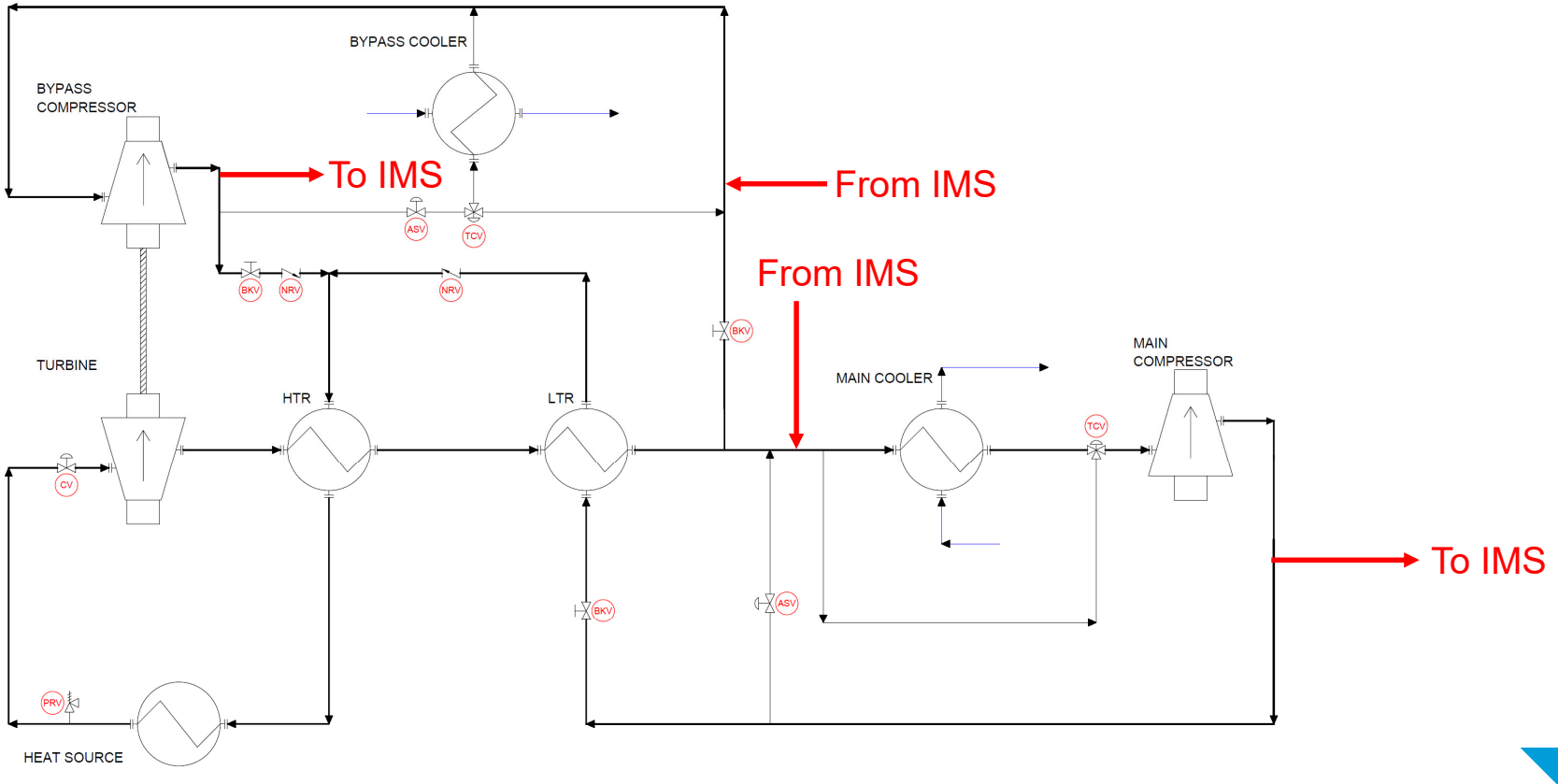

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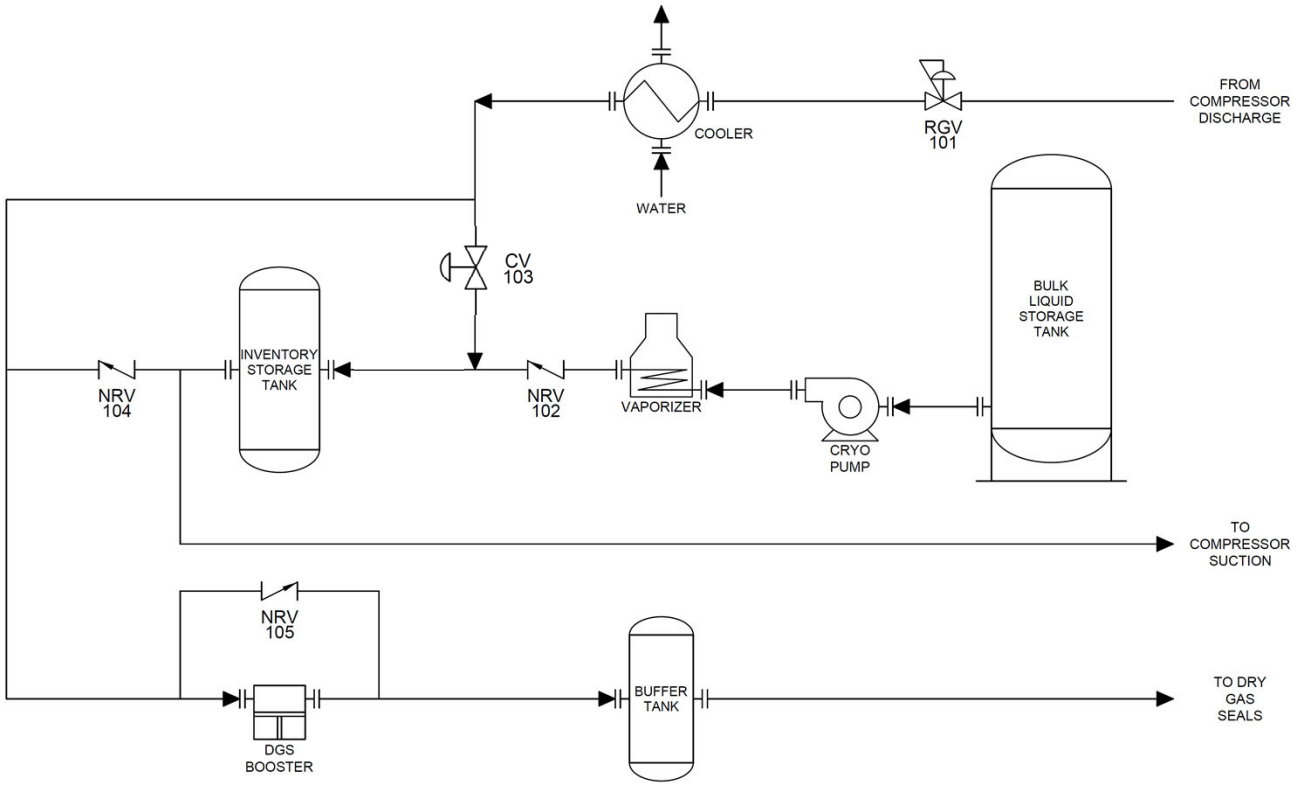

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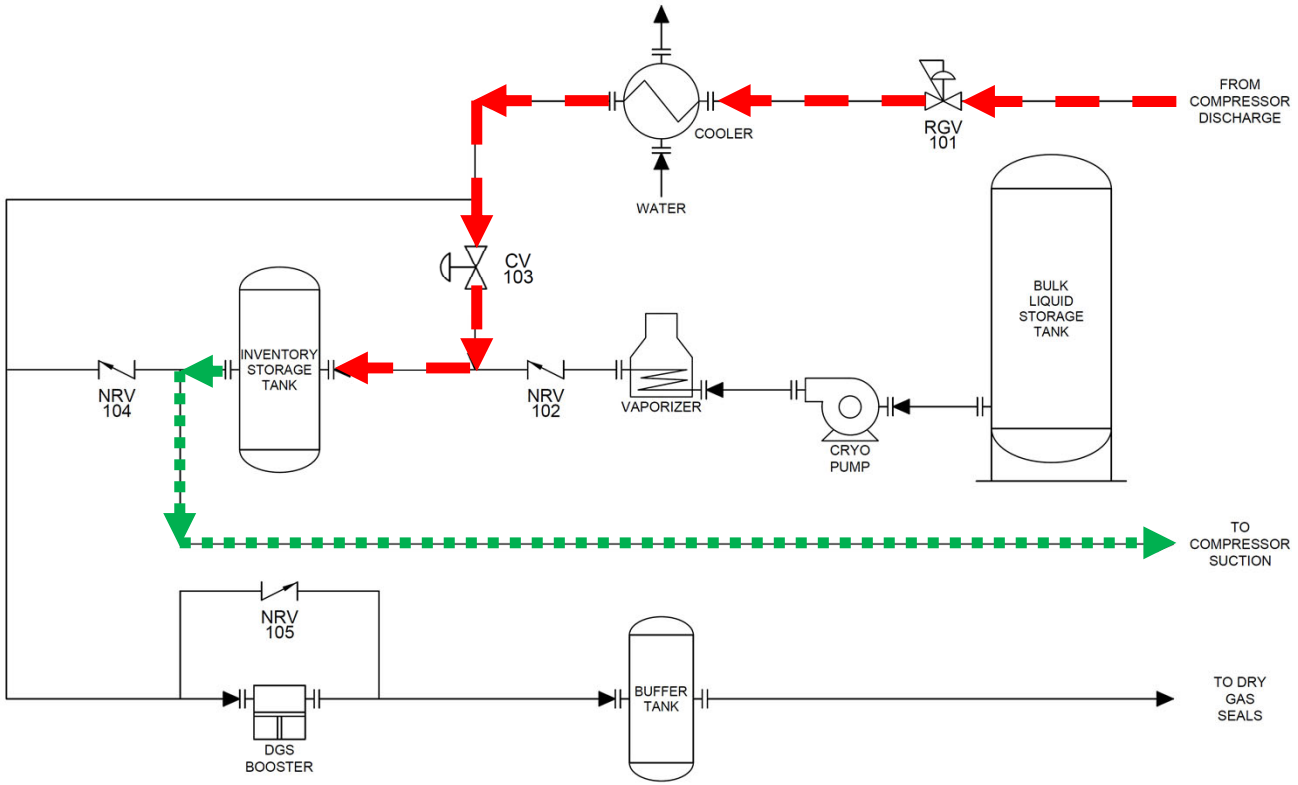
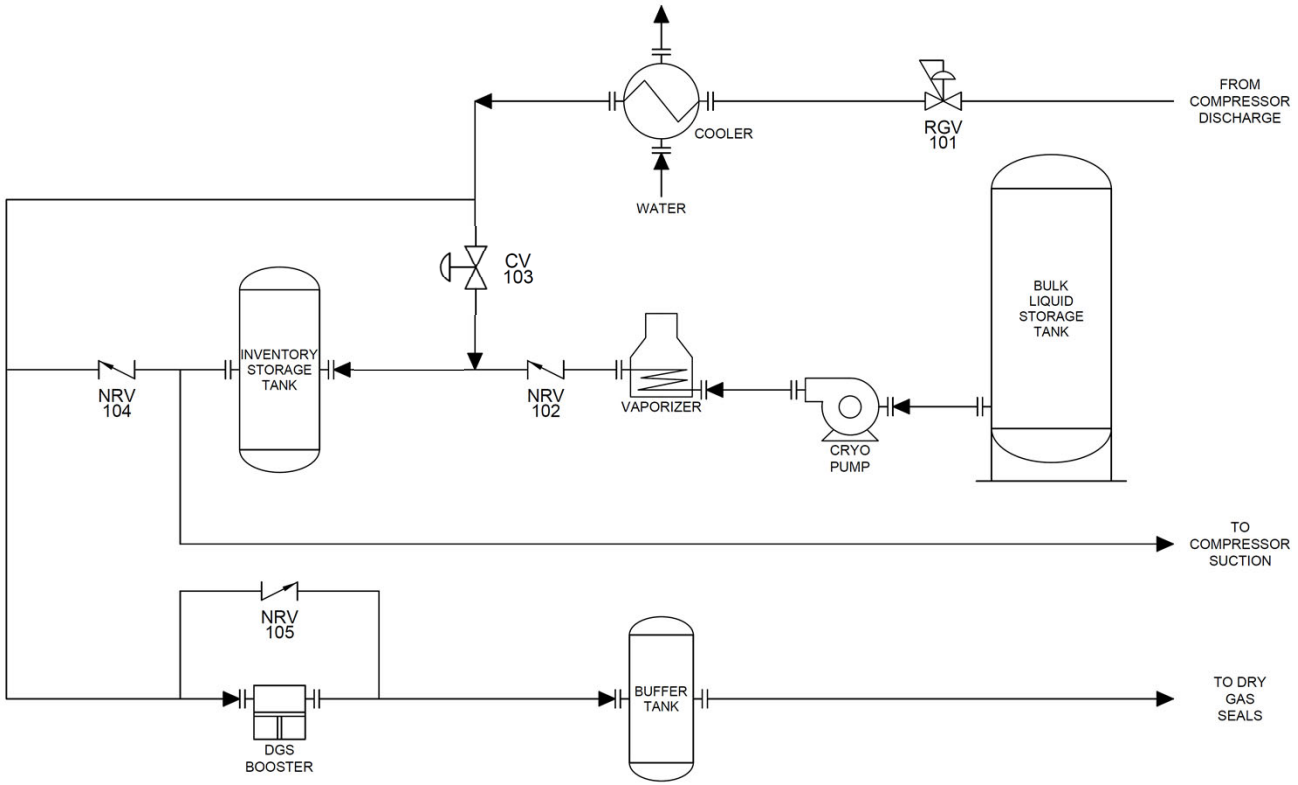


DGS SUPPLY FLOWS

Components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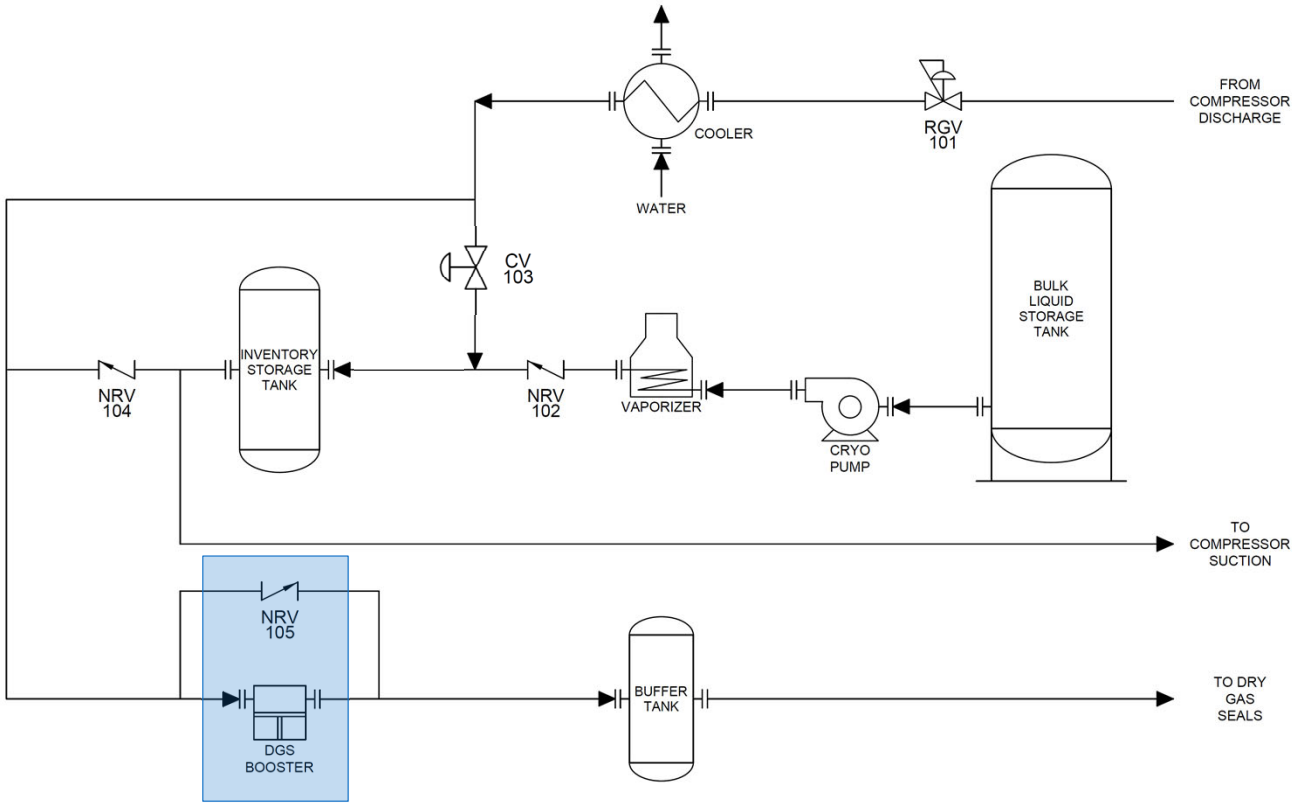
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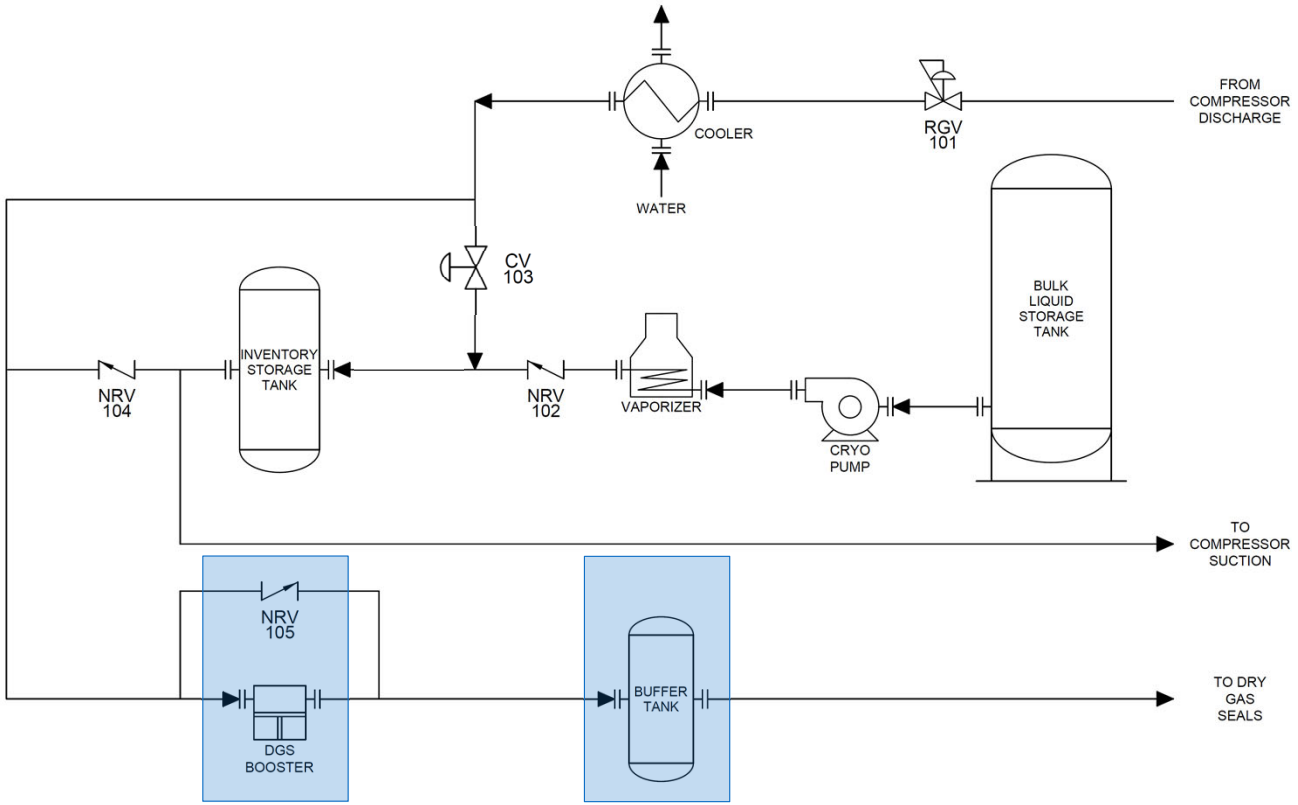
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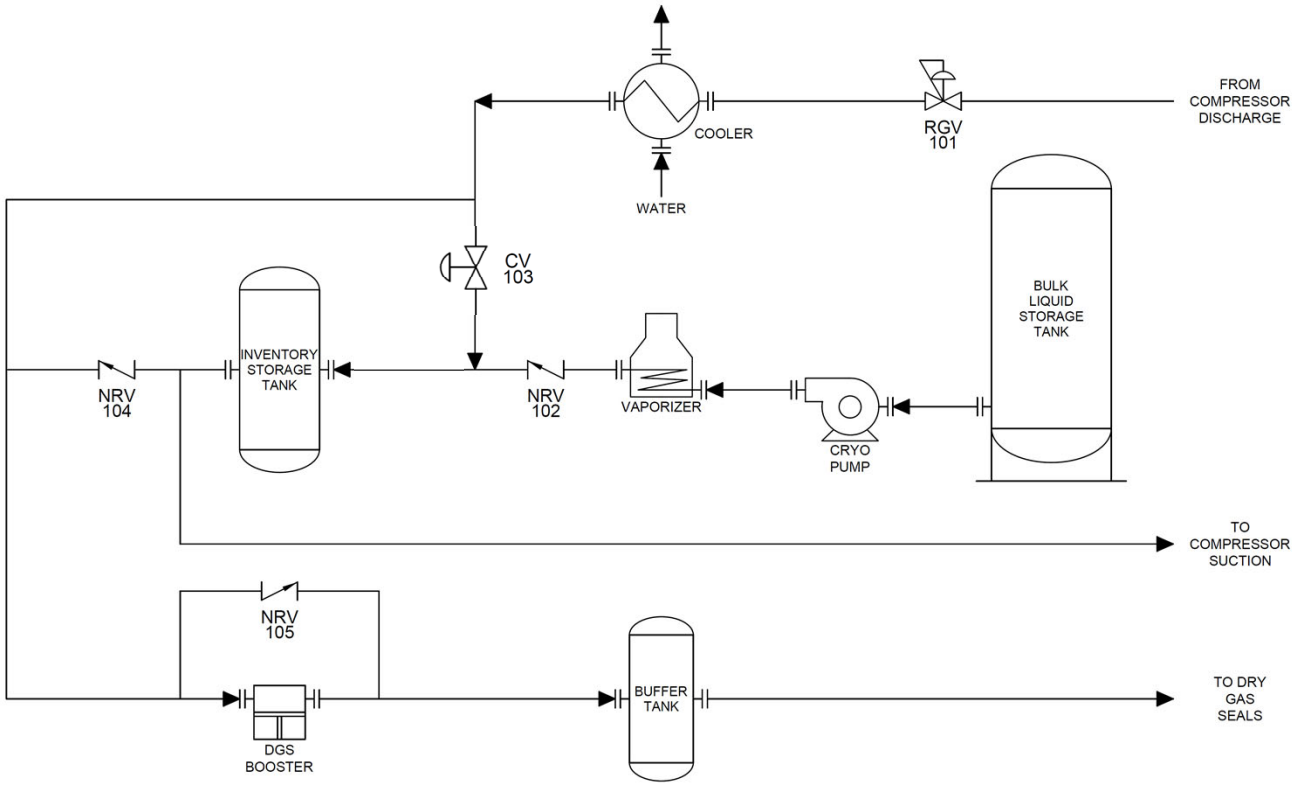
Controls and Operation



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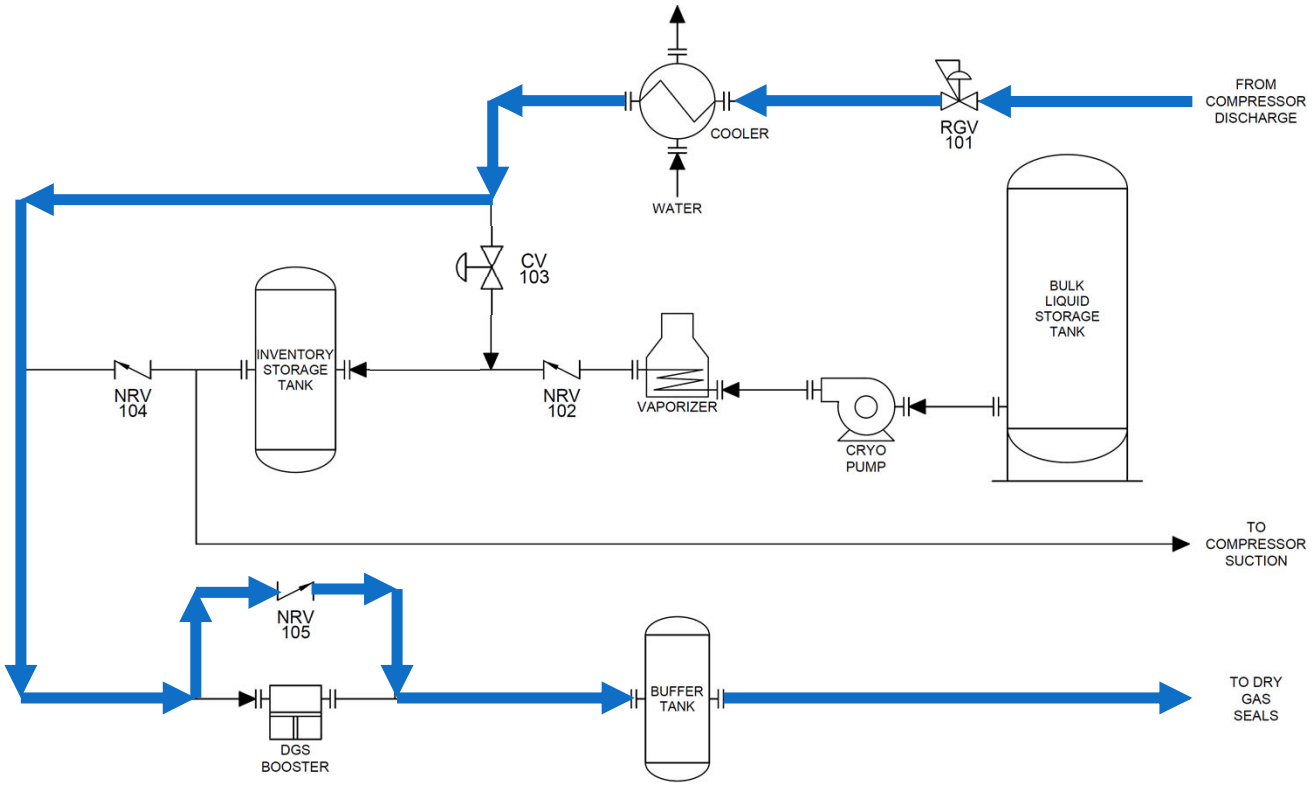

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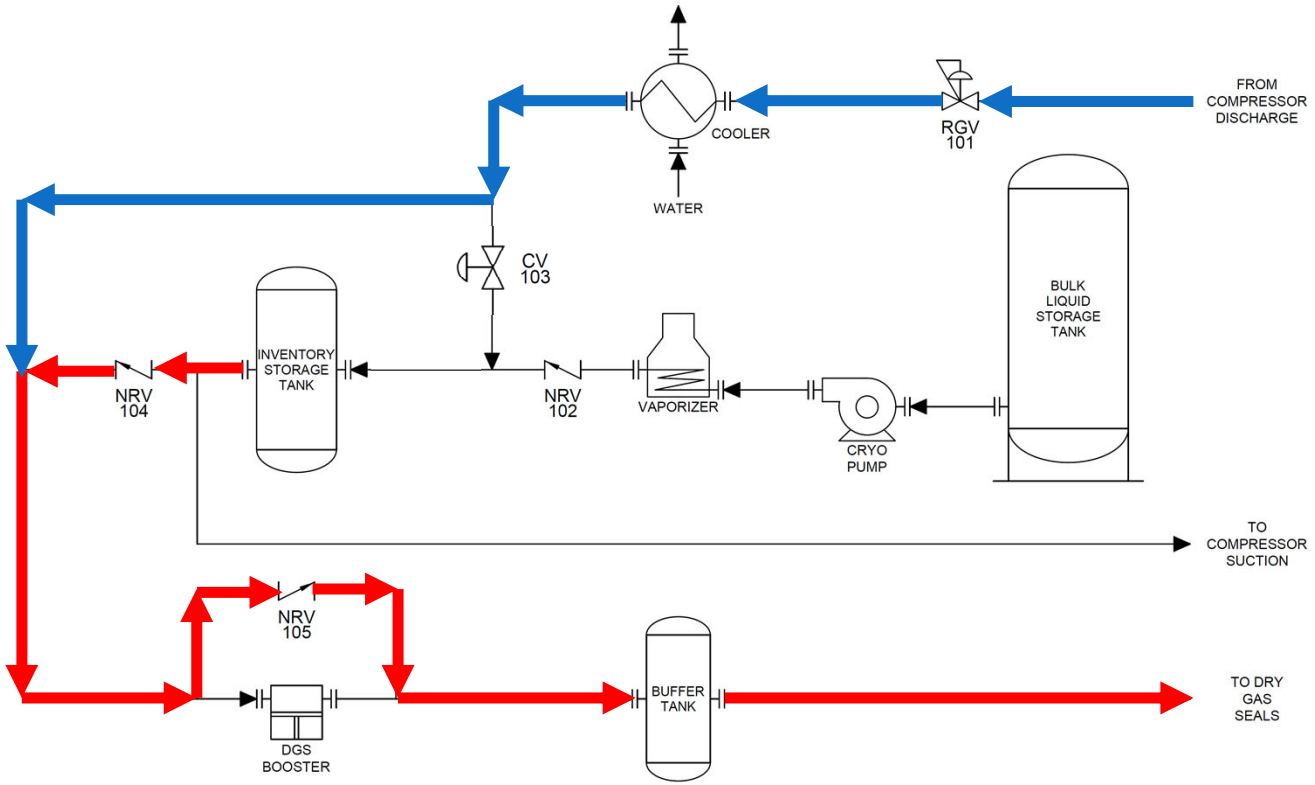

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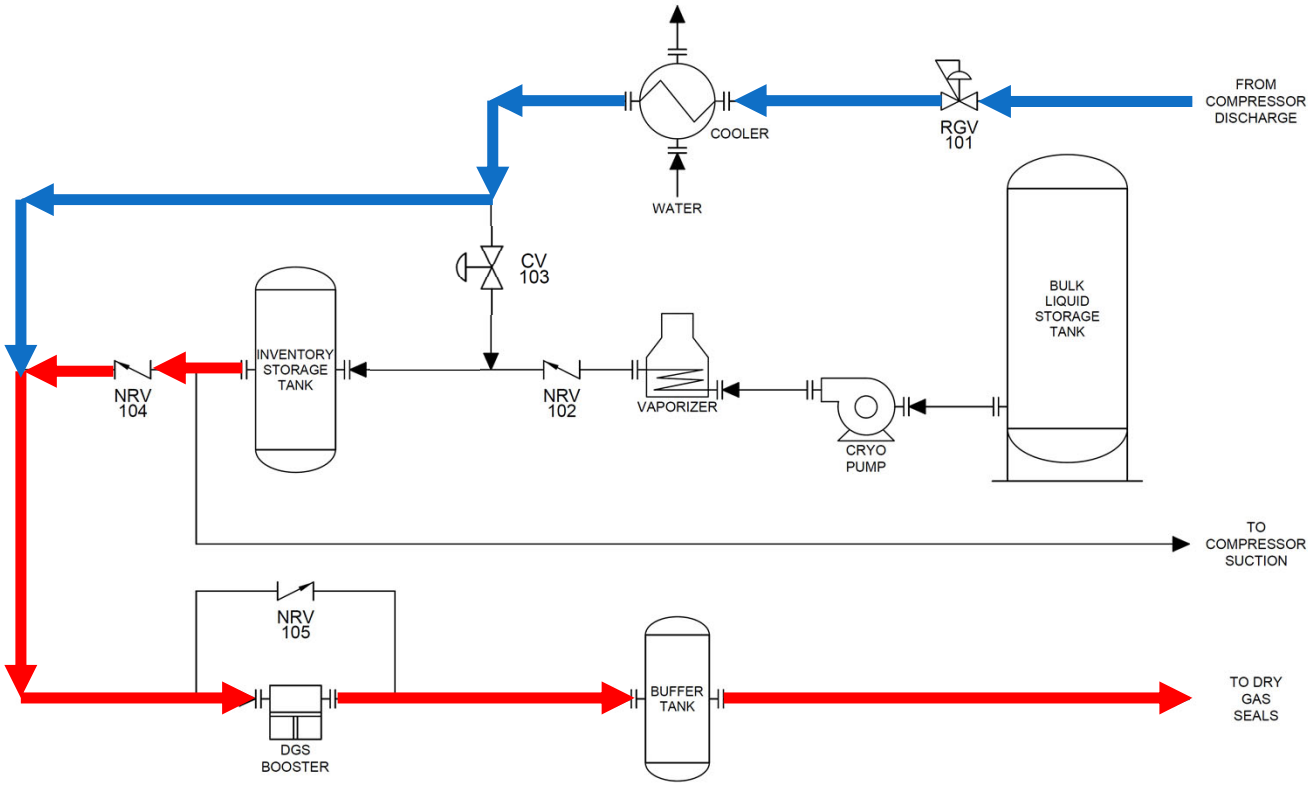

IMS Functions

QUESTIONS?

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ACKNOWLEDGEMENTS

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DISCLAIMER