NH3 / CO_2 Cascade System for Freeze Drier Application

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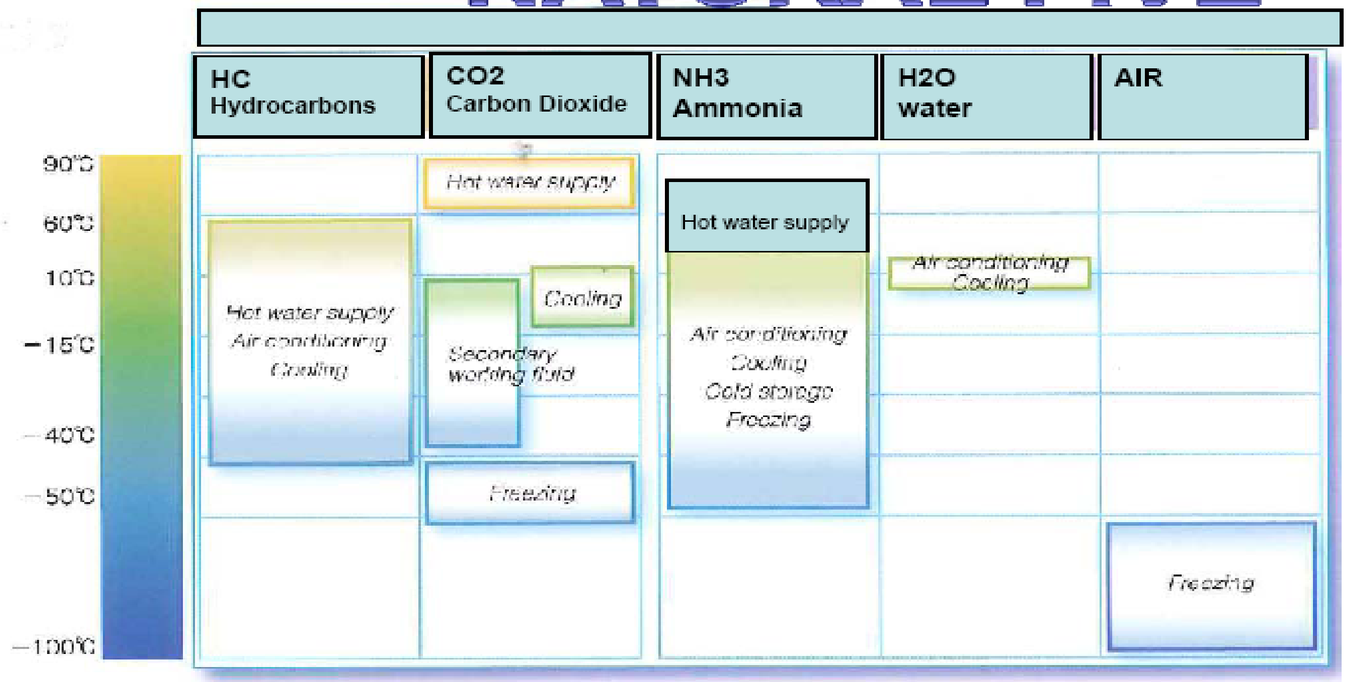
FOCUS

MYCOM

NATURAL FIVE



MAYEKAWA

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DOC.2010-141 R2

NATURAL FIVE

HC
CO_2
NH_3
H_2O
Air

5

Natural Refrigerant

•Characteristics of HFC & HCFC Refrigerants

Refrigerant ODP: Ozone Depletion Potential GWP: Global Warming Potential		ODP	GWP [100yrs]	Safety Classification
HCFC	R22	0.055	1810	A1
HFC	R134a	0	1430	A1
	R404a	0	3922	A1/A1
	R407C	0	1650	A1/A1
	R410a	0	2088	A1/A1

•Characteristics of Natural Refrigerants

Refrigerant ODP: Ozone Depletion Potential GWP: Global Warming Potential		ODP	GWP [100yrs]	Safety classification
Natural Refrigerants	CO_2 (R744)	0	1	A1
	Ammonia (R717)	0	0	B2
	Propane (R290)	0	3	A3
	Iso-Butane (R600a)	0	3	A3

- Problem - Energy Costs & Demand Increasing
- Solution - Natural Refrigerants reduce energy consumption

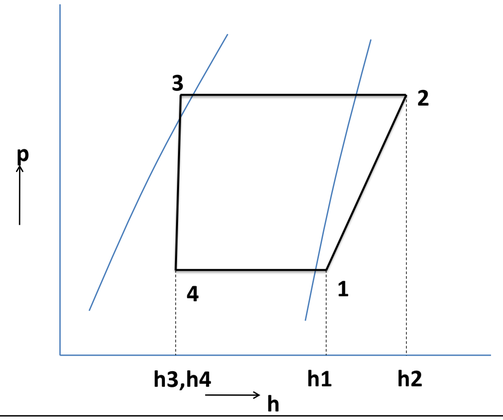
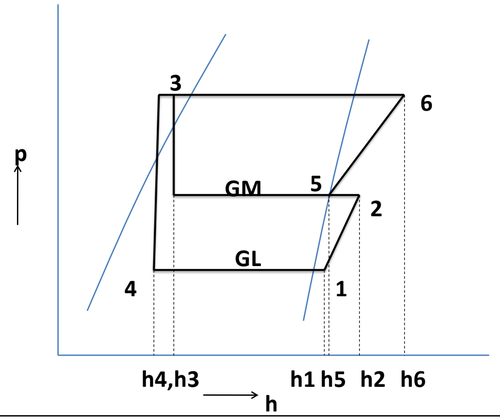
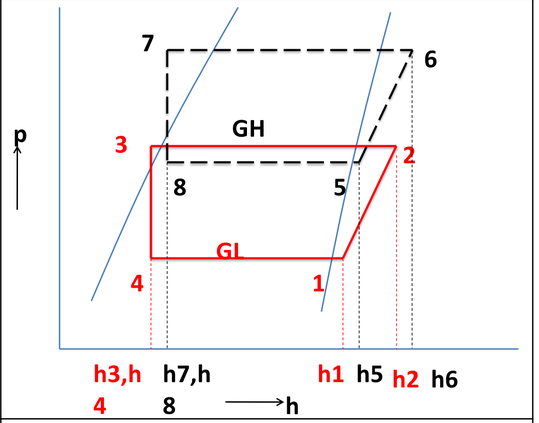
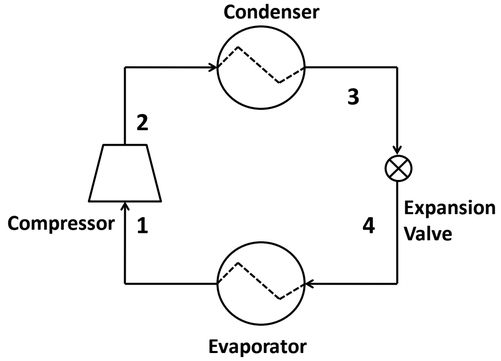
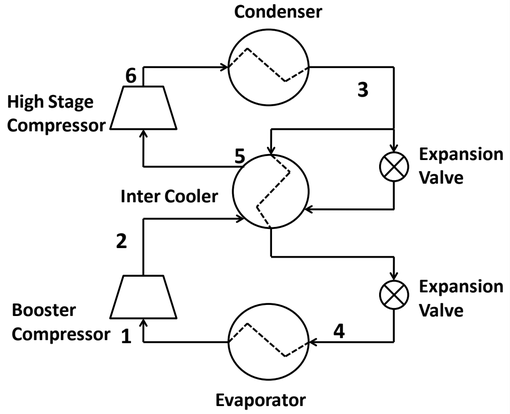
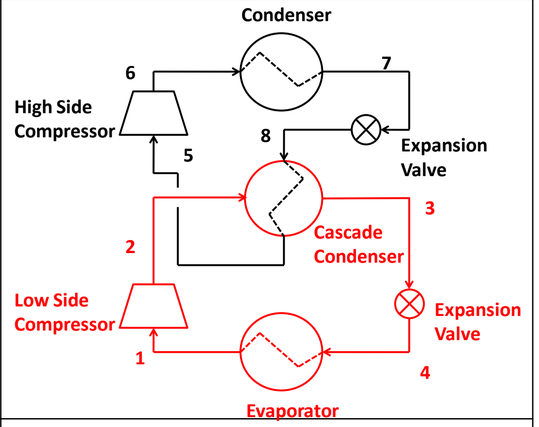
- Problem - HFC & HCFC = High ODP & GWP
- Solution - Natural Refrigerants = 0 ODP & GWP 1

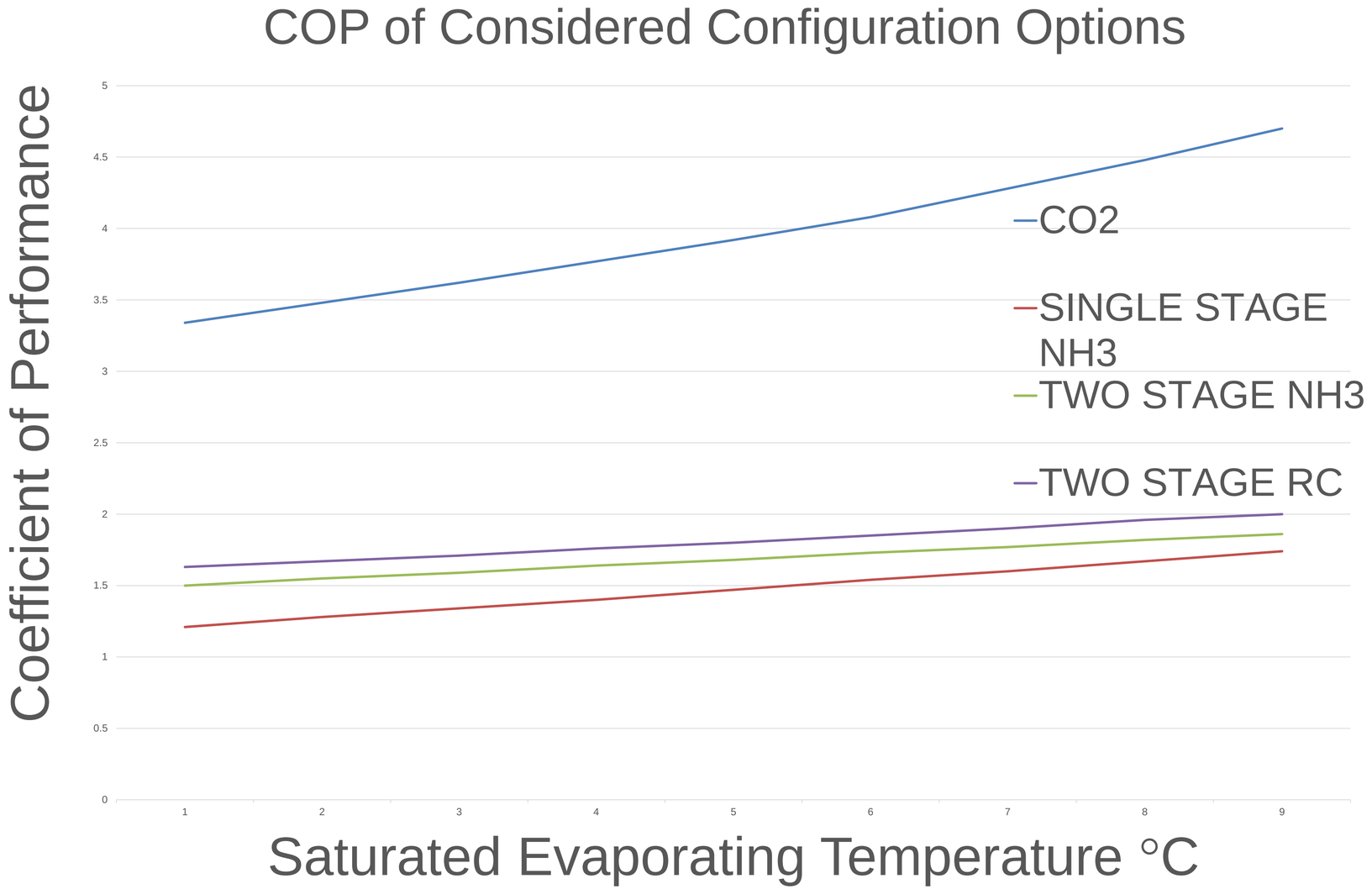
- Environmental Awareness
- Our Children's Future

•Design Conditions

- 300 kW @ Te -40 degC

		Refrigeration Capacity:	Absorbed Power:	C.O.P :
Single Stage Economised Screw	-	302.7 kWr	197.1kW	1.54
Two Stage Screw Compressor	-	298.5 kWr	168.2kW	1.77
Two Stage Reciprocating Comp	-	166.6 kWr	87.6kW	1.96
CO_2 Reciprocating Compressor	-	302.1 kWr	70.6kW	4.28

	Single Stage compression	Two Stage compression	Cascade Refrigeration
p-h chart			
Flow diagram			
COP	$COP = \frac{h1 - h4}{h2 - h1}$	$COP = \frac{GL(h1 - h4)}{GL(h2 - h1) + (GL + GM)(h6 - h5)}$ $(GL = 1.0)$	$COP = \frac{GL(h1 - h4)}{GL(h2 - h1) + GH(H6 - h5)}$ $(GL = 1.0)$


COP of Considered Configuration Options
Coefficient of Performance
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
9
CO2
SINGLE STAGE NH3
TWO STAGE NH3
TWO STAGE RC
Saturated Evaporating Temperature °C

CO_2 :

- Non flammable – 10% by volume will extinguish flame
- Non irritable to eyes and skin – odourless - colourless
- Potential for asphyxiation in high concentrations 1.5 times heavier than air
- Triple point of -56.6 °C
- Higher pressures with LT applications
- CO_2 compressor swept volumes can be 6 – 8 times smaller than booster NH3 compressors
- Smaller piping diameters
- Excellent thermodynamic properties

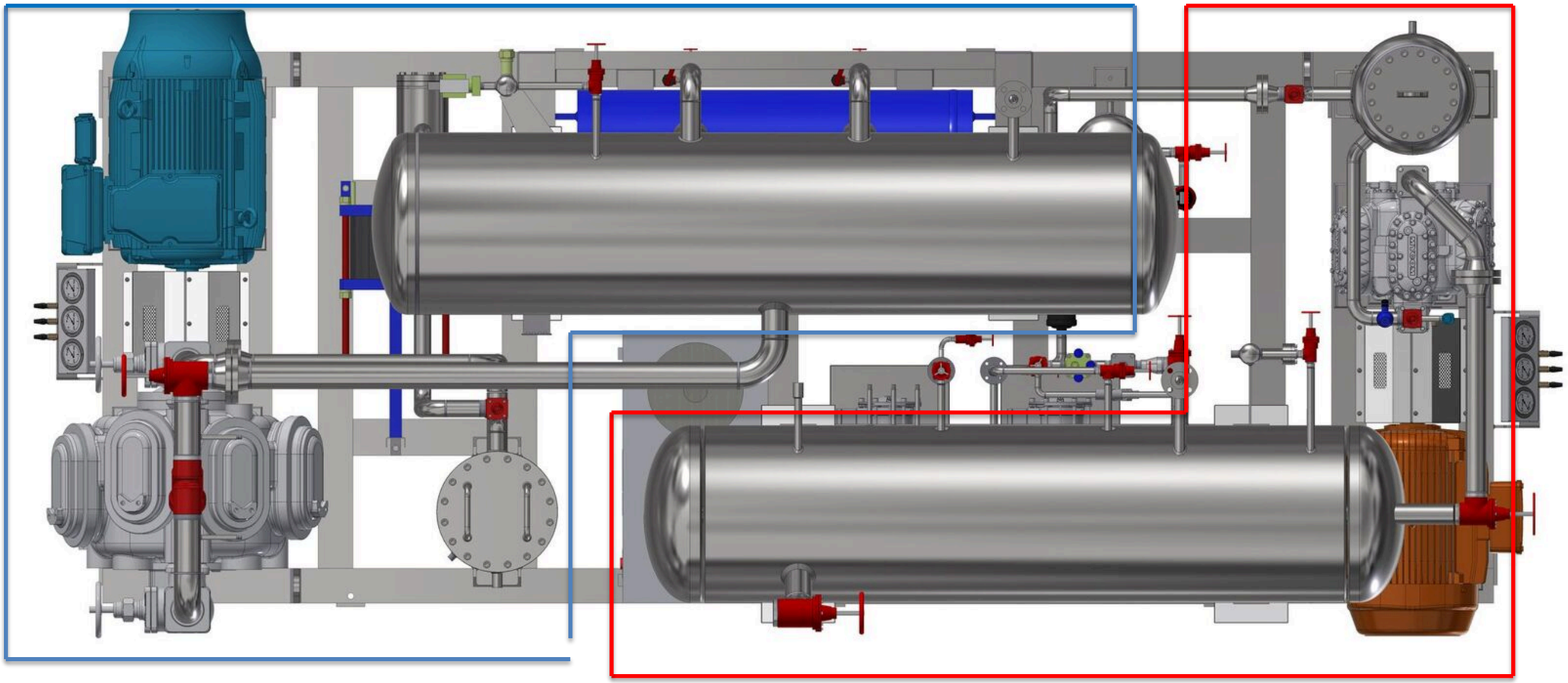
•Equipment Selection

CO_2 Compressor	-	Mayekawa Single Stage 50 bar Reciprocating
CO_2 Compressor Motor	-	WEG 90kW W22 Premium High Eff TEFC Motor
CO_2 Condenser	-	Vahterus PSHE-4HH Shell & Plate 50 bar
CO_2 Refrigerant Control	-	Danfoss ICM Valve with ICAD Actuator
CO_2 Liquid Pumps	-	Witt HRP-8050
NH3 Compressor	-	Mayekawa Single Stage 50 bar Reciprocating
NH3 Compressor Motor	-	WEG 132kW W22 Premium High Eff TEFC Motor
NH3 Condenser	-	Alfa Laval M10 Plate Heat Exchanger
NH3 Refrigerant Control	-	Danfoss HFI High Side Float

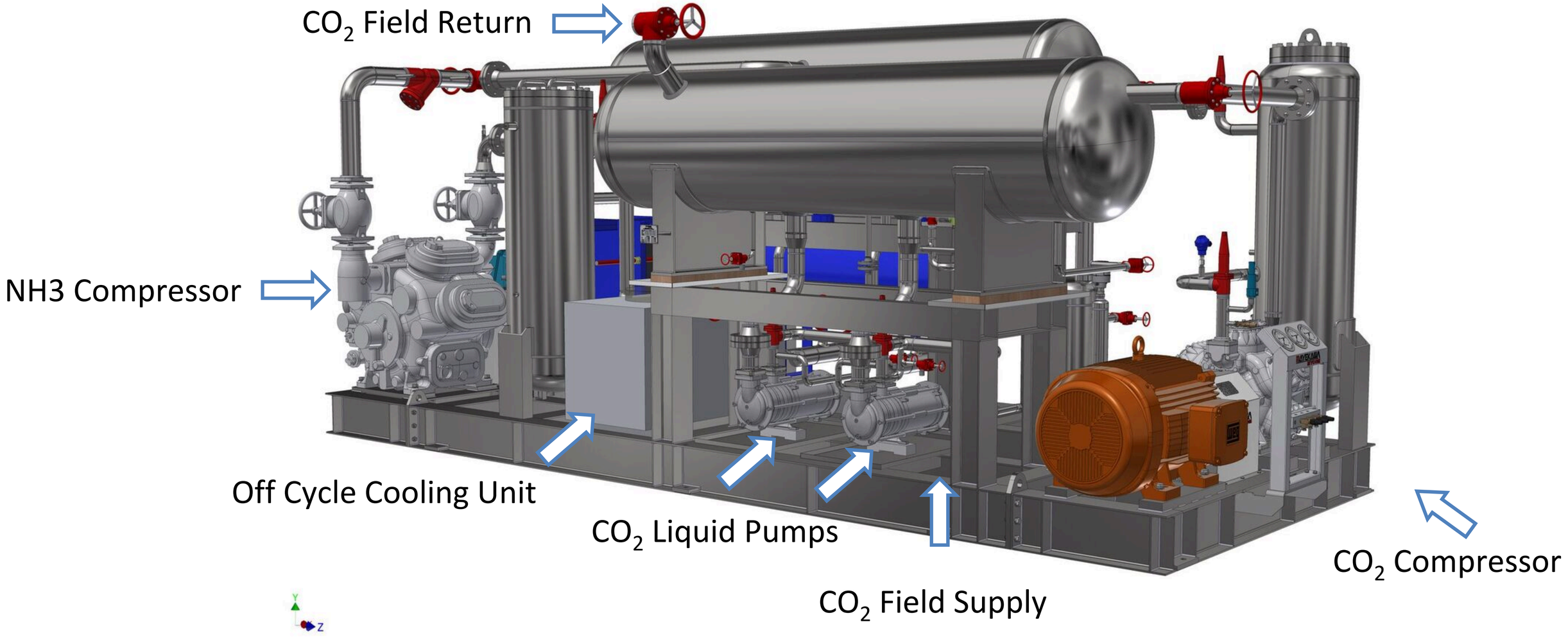
Features of the System Design :

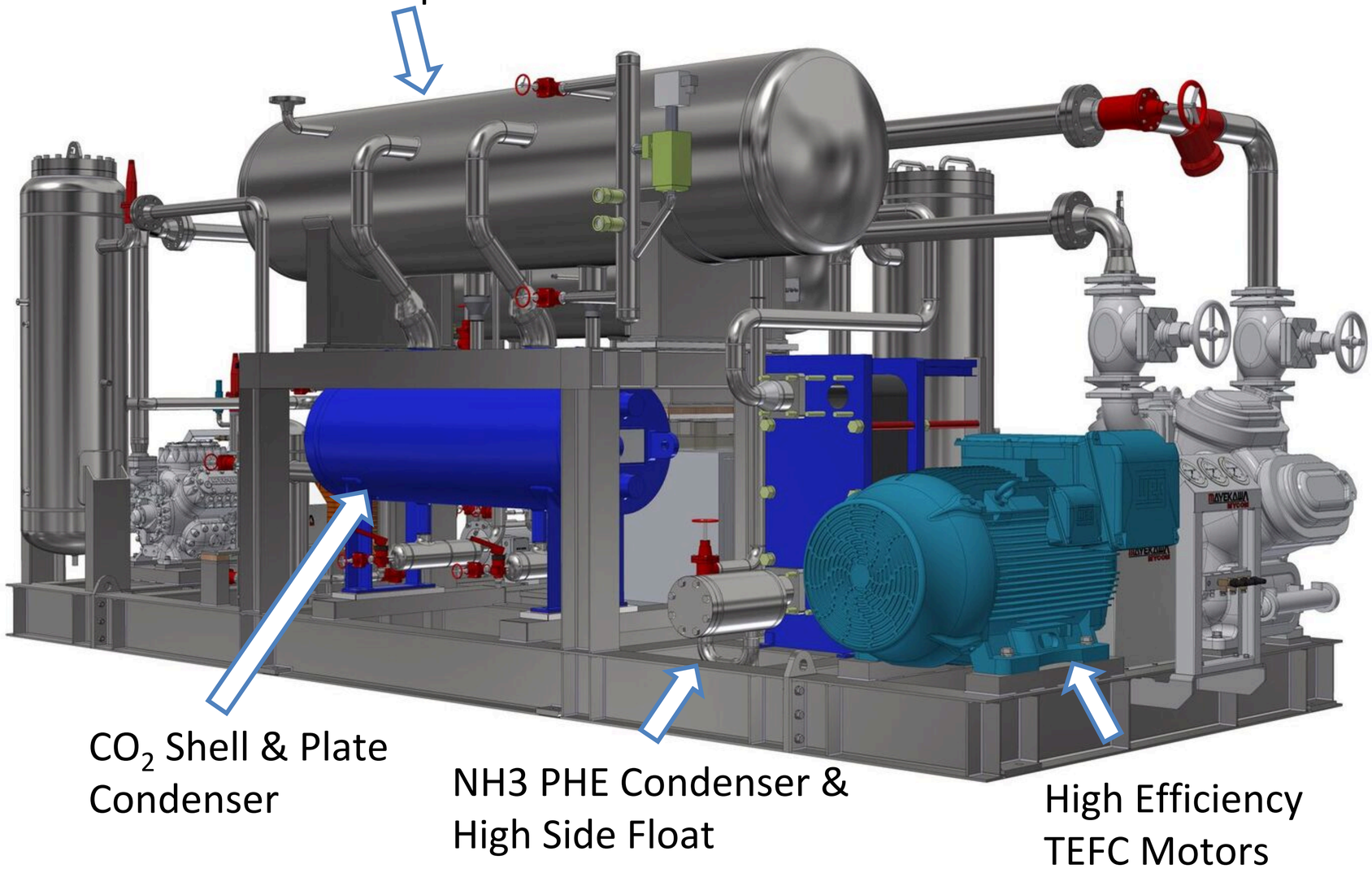
- Low Ammonia Charge – High side float
- Compact Foot Print
- Sectional Base Frame for ease of installation
- High efficiency TEFC Motors
- Compressor Motor VFD Control
- Cooling Tower Fan VFD Control
- Off cycle CO_2 cooling system

NH3 System

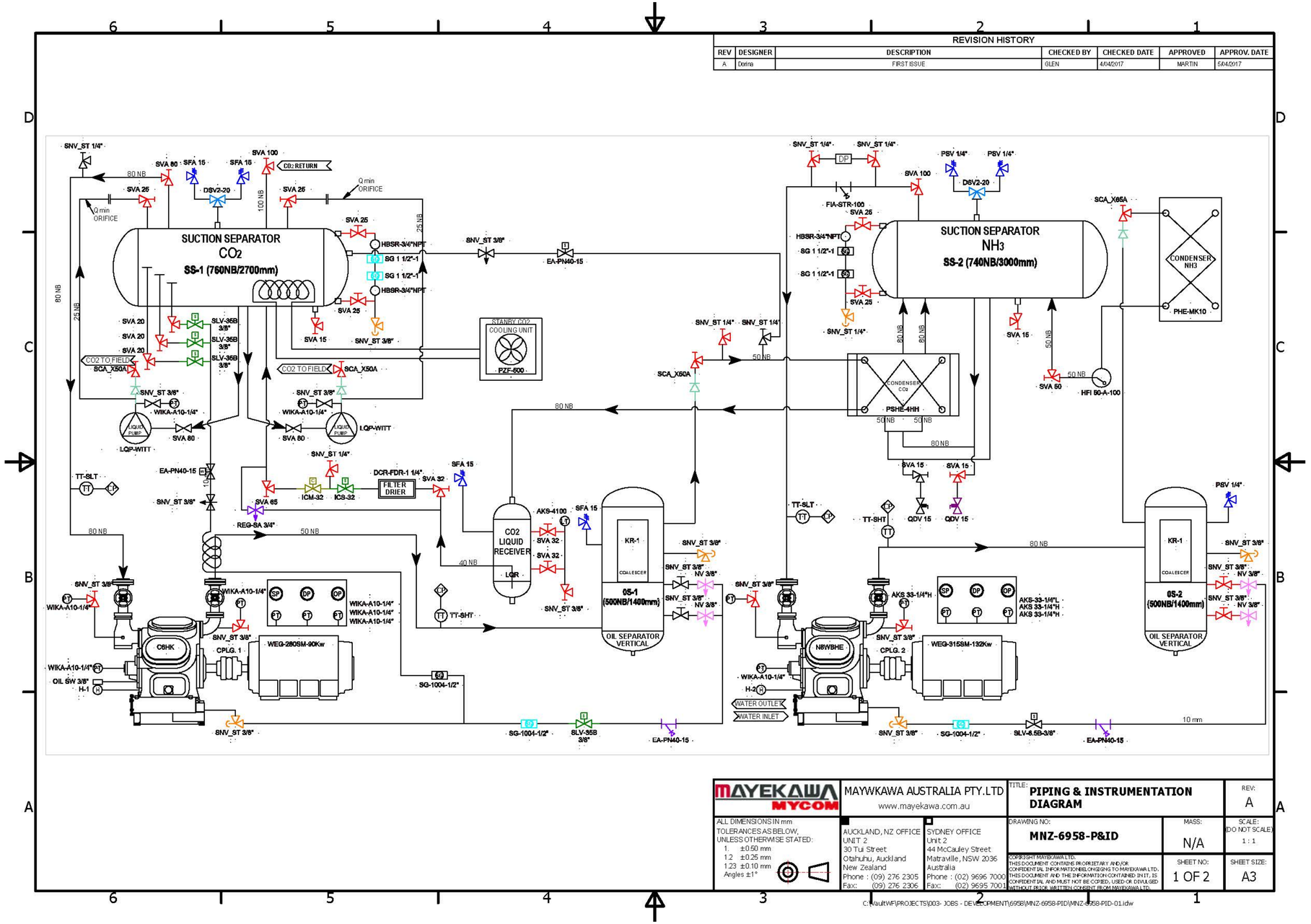


CO_2 System


CO_2 Field Return
NH3 Compressor
Off Cycle Cooling Unit
CO_2 Liquid Pumps
CO_2 Field Supply
CO_2 Compressor


NH3 Suction Separator
CO_2 Shell & Plate Condenser
NH3 PHE Condenser & High Side Float
High Efficiency TEFC Motors

Flow Diagram



- **CO_2 Refrigeration Systems :**

» Sub Critical - Cooling Systems

» Trans Critical - High Grade Heating

» CO_2 Secondary - Low NH3 Charges

» Retrofit or Greenfield - Cost & Application

- Depending on system operating conditions and applications, Ammonia CO_2 Cascade Systems can achieve COP's well in excess of alternative configurations.

- Application examples have shown that refrigeration systems utilising Natural Refrigerants are effective in reducing annual energy consumption and CO_2 emissions.

- By encouraging and promoting the use of the "Natural Five Refrigerants" we as an industry can be proud of our contribution to a sustainable and low carbon environment.

AUSTRALIA

ATMO sphere

Questions ?

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Thank you very much!

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Natural is what we design for!