Natural Refrigerant Training Summit

Building a Sustainable Workforce

Introduction to CO2 Systems Design

Ignacio Varela Chaparro

Kysor Warren Epta US

NORTH AMERICAN Sustainable Refrigeration Council

Natural Refrigerant Training Summit

Thank you to our sponsors!

Premium Sponsors

Bitzer

Climate Pros

CoolSys

Copeland

Hillphoenix

Basic Sponsors

AHT a member of Daikin group

Carel

Carlyle

DeWalt

energy recovery

Hussmann

KW Kysor Warren

M&M Carnot

Parker

Sporlan

True

Who We Are

A 501c3 nonprofit working to create a sustainable future for supermarket refrigeration by removing barriers to natural refrigerant adoption.

160+
member companies

55K+
food retail locations

Goals

- Build a sustainable technician workforce
- Increase funding for natural refrigerant equipment
- Improve technology options, education, and awareness

What are Natural Refrigerants?

CO_2	C_3H_8	NH_3
R744 Carbon Dioxide	**R290** Propane	**R717** Ammonia

NORTH AMERICAN Sustainable Refrigeration Council

INTRODUCTION TO CO2 SYSTEMS DESIGN

Ignacio Varela Chaparro
R&D & New Technologies Manager

KYSOR WARREN
eptarefrigeration

TABLE OF CONTENTS

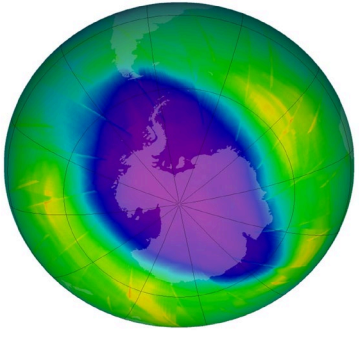
REFRIGERANTS TRANSITION

KYSOR WARREN

Early Refrigeration

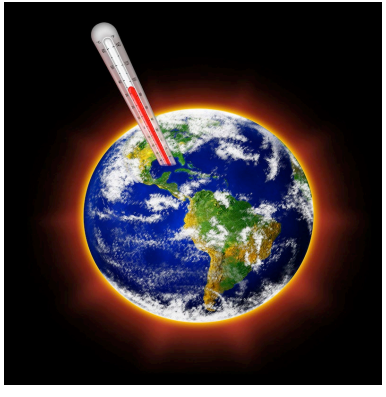
CO_2
NH_3
Naturals

ODP



CFC & HCFC
Ozone Layer Damage
R-22 / R-502

GWP



HFC
Global Warming
R- 404A / R-507A
R448A / R449A

Today's Refrigeration

CO_2
NH_3
R290
Naturals

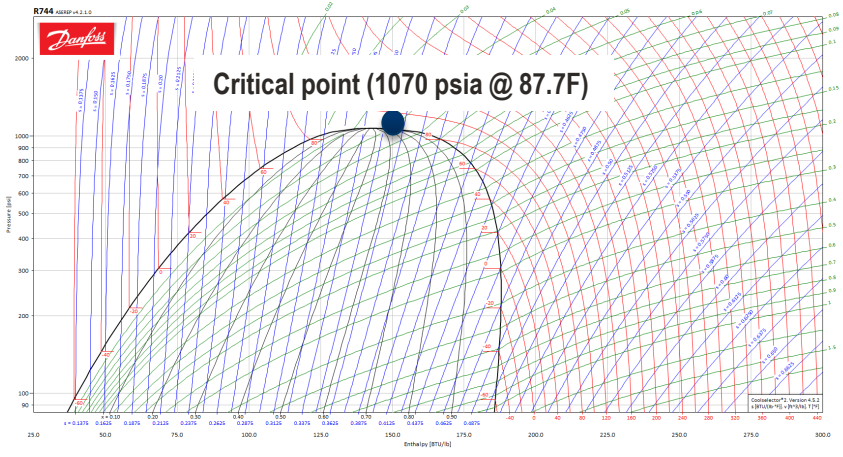
PFAS
Per- and Polyfluoroalkyl Substances

HFO
Water and Air Contamination
R471A / R454C / R455A

CO2 AS REFRIGERANT
PROPERTIES

KYSOR WARREN

- Natural component of air
- Concentration in atmosphere approximately 400 ppm (0.04%)
- Colorless
- Odorless
- Heavier than air
- High Pressure Refrigerant (above 1000 psia @ 87F)
- High volumetric capacity
  - Smaller components & less refrigerant
- Low cost refrigerant
- Not subject to phase-out
- ASHRAE Number – R744
- Hi triple point – **Initial charge with VAPOR (above 150 psi)**
  - **Do not charge CO2 liquid if pressure is below 100 psi**

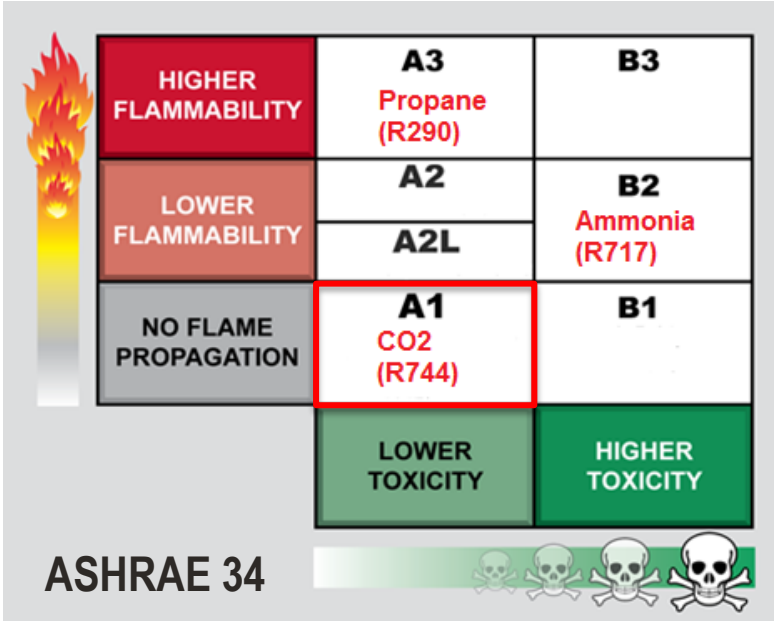


REFRIGERANTS COMPARISON

CO2 AND OTHER COMMON REFRIGERANTS

COMMERCIAL NAME	REFRIGERANT NUMBER	SAFETY GROUP	GWP (100 YEARS)	ODP
Solstice N40	R448A	A1	1273(2)	0
Opteon® XP40.	R449A	A1	1397 (1)	0
	R404A	A1	3922(1)	0
	R407A	A1	2107(1)	0
	R22	A1	1810(1)	0.055(1)
Carbon Dioxide	R744	A1	1	0
Ammonia	R717	B2	0	0
Propane	R290	A3	3	0

(1) Linde / (2) Honeywell



New refrigerants

A1 - R471A,

A2L - R454C & R455A

CO2 (R744) is the only refrigerant that operates in transcritical mode

KYSOR WARREN

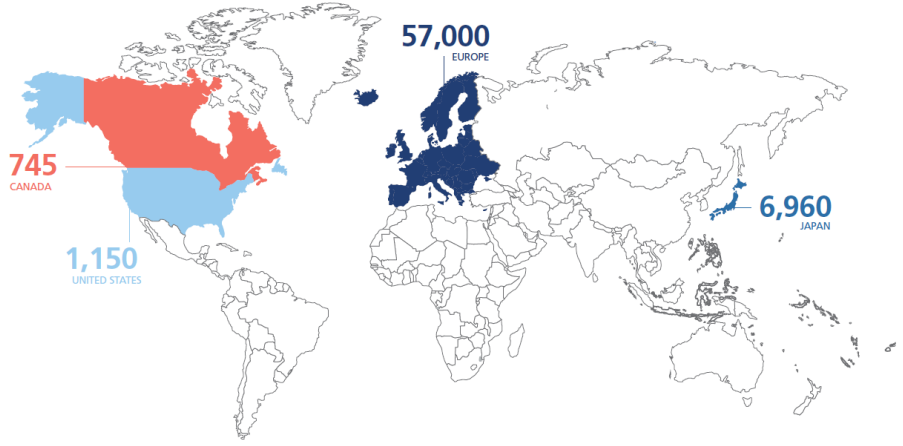
ATMO Report

2022 Edition

Natural Refrigerants: State of the Industry

Transcritical CO_2 Installations in Major Regions

(stores and industrial sites, as of December 2022)



CO2 Installations are increasing at a fast pace.

Regulations enforcement

- California - CARB
- Washington – Department of Ecology
- USA – EPA – Final Rule effective 01/2026-2027
- Europe – F- Gas

AIM ACT

OCTOBER 5TH 2023 - FINAL RULE

Refrigeration, Air Conditioning, and Heat Pump Systems*			
Sector	**Systems**	**Global Warming Potential Limit or Prohibited Substances**	**Installation Compliance Date[5]**
Cold storage warehouses	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2026
	With less than 200 lb refrigerant charge	300	January 1, 2026
	High temperature side of cascade system	300	January 1, 2026
Retail food - supermarkets	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2027
	With less than 200 lb refrigerant charge	300	January 1, 2027
	High temperature side of cascade systems	300	January 1, 2027
Retail food - remote condensing units	With 200 or more lb refrigerant charge, excluding high temperature side of cascade system	150	January 1, 2026
	With less than 200 lb refrigerant charge	300	January 1, 2026
	High temperature side of cascade system	300	January 1, 2026

SAFETY

KYSOR WARREN
eptarefrigeration

SAFETY
BASIC SAFETY PRINCIPLES

- It is recommended for all staff working on this type of installation to use personal protective equipment, at minimum:

  - ☑ Gloves
  - ☑ Glasses
  - ☑ Safety shoes



- Be aware of system pressure
  - **CO2 systems operate at much higher pressure than HFCs**
- Utilize tools and materials rated for proper pressures
  - **System operating pressures range 150 – 1500 psi**
- Avoid trapping CO2 in the system
  - **CO2 refrigerant expands quickly with temperature increase**
- Provide PRV for overpressure protection
- Avoid skin contact of refrigerant due to risk of frost or burn
- Prevent excessive vibration in piping
- Only authorized and **trained personnel** should perform maintenance or repairs on these systems

AVOID TRAPPING CO2

- Liquid CO2 has a very high coefficient of thermal expansion
- An increase in temperature will cause high increase in pressure

Example:

Starting Condition
- +5°F
- 317.6psig

Final Condition
Room temperature
- +70 °F
- 838.1psig

Effect of 1F temperature increase at different conditions

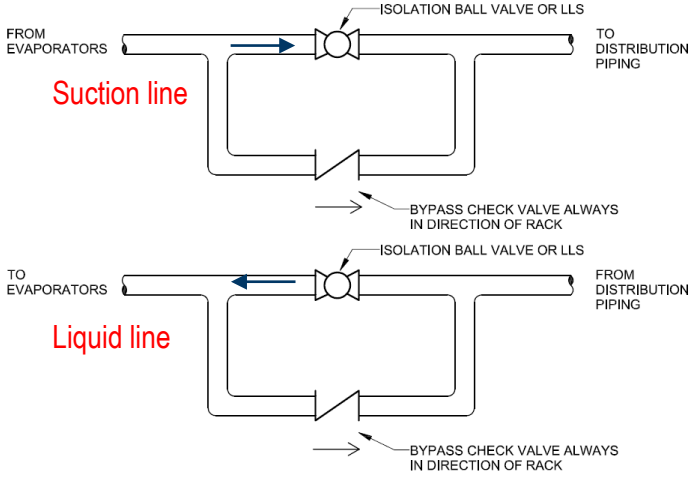
-20F (200psig) to -19F (204psig) = 4psig

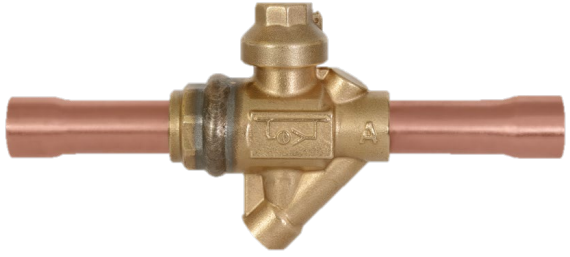
+20F (407psig) to +21F (413psig) = 6psig

+50F (638psig) to +51F (647psig) = 9psig

+69F (827psig) to +70F (838psig) = 11psig

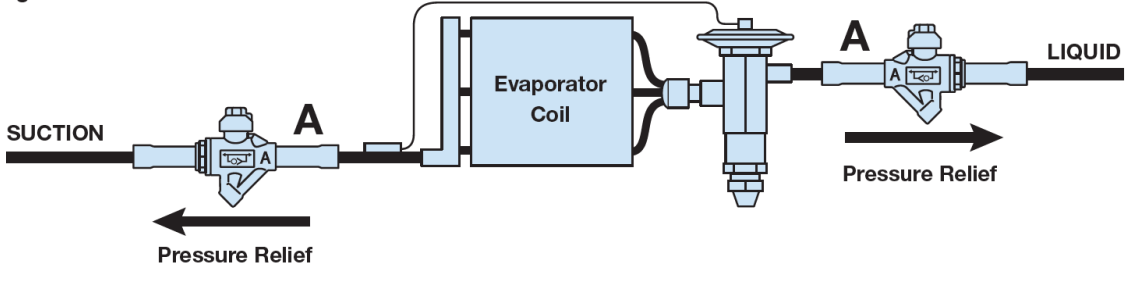
Check valves in both liquid and suction lines shall direct flow back to compressor rack





Ball valve with integrated check bypass

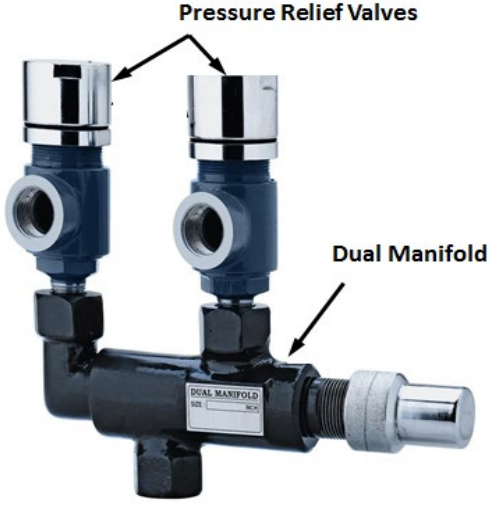
Figure 1



The “A” side of the ball valve should always be on the same side as the coil.

Relief valves are sealed by the manufacturer and should never be adjusted in the field.

Comply with local and national codes for installation of PRVs.



ANSI/ASHRAE Standard 15-2022

9.4 Pressure Relief Protection

9.4.1 *Refrigerating systems shall* be protected by a *pressure relief device* or other *approved* means to safely relieve pressure due to fire or other abnormal conditions.

9.4.2 *Pressure vessels shall* be protected in accordance with Section 9.7. *Pressure relief devices* are acceptable if they either bear a nameplate or are directly marked with a "UV" or "VR" symbol signifying compliance with *ASME Boiler and Pressure Vessel Code* 15, Section VIII.

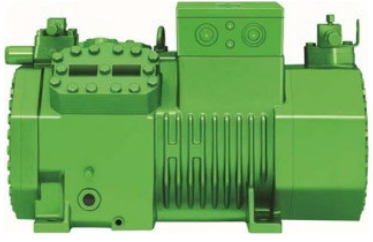
PRVs rated operation:

- Vapor
- Liquid / Vapor

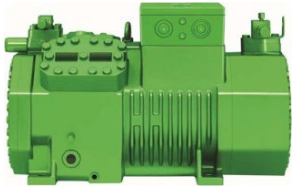
SAFETY
COMPRESSORS / PRESSURE RELIEF VALVES (PRV)

KYSOR WARREN

MT



LT

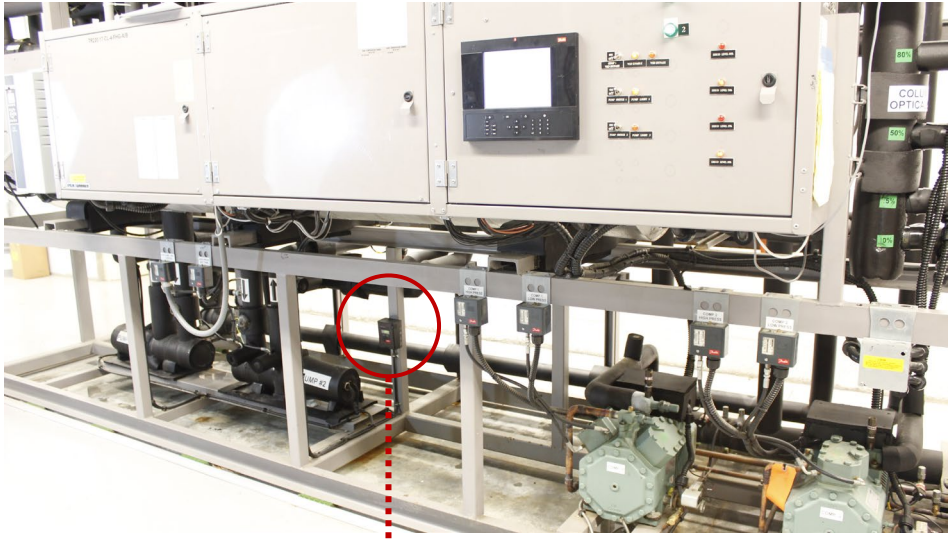


CO2 compressors come with PRV installed but those protect the compressor only, not the system
PRV setpoint on compressors are normally higher than system design pressure

SAFETY
LEAK DETECTION SYSTEM

LEAK DETECTION EQUIPMENT

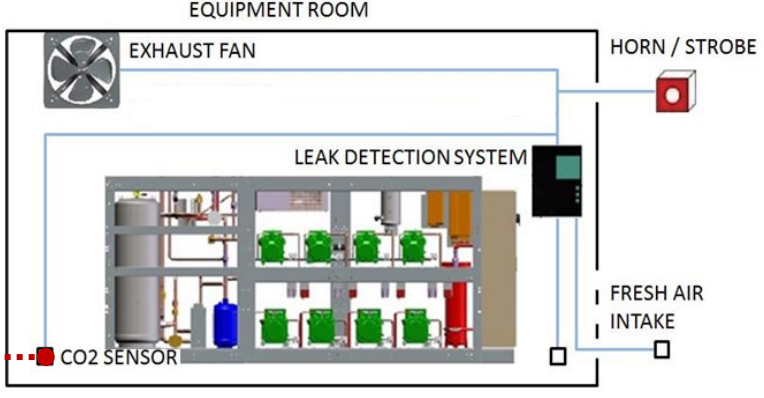
- Install leak detector sensors that trigger an alarm when the concentration level exceeds predefined CO2 concentration (ppm)
- CO2 is heavier than air, the sensors and ventilators should be located close to the floor (CO2=44 g/mol vs AIR 28 g/mol)
- Check ventilation system requirements, **code compliance**



CO2 concentration detection as low as 5 to 20 ppm

Leak detection systems

- ☑ **Emerson RLDS/MRLDS**
- ☑ **Danfoss GDC IR 10000/40000**
- ☑ **Vaisala CO2 leak detector**



SAFETY
CO2 CONCENTRATIONS

CO2 - GENERAL INSTRUCTIONS

- CO2 is unique among natural refrigerants for having good safety characteristics
  - ☑ **It is non-flammable**
  - ☑ **Non-explosive**
  - ☑ **Relatively non-toxic**

OSHA lists 5000 ppm as the TLV-TWA (Threshold Limit Value – Time Weighted Average).

- If enough concentration of carbon dioxide in an enclosed space, over a certain period of time can cause asphyxiation
- According to ASHRAE 34, a CO2 concentration of 1000 ppm is the maximum limit to ensure the comfort for the occupants

CO2 Concentration		Symptoms and effects on humans
%	ppm	
0.04%	400	Normal concentration in the atmosphere
0.1%	1000	Recommended upper limit for comfortable indoor air quality
0.5%	5000	8 hours – long term exposure limit TLV-TWA (OSHA)
1%	10,000	Drowsiness
1.5%	15,000	10 minutes – short term exposure limit TLV-TWA
2%	20,000	50% increase of breathing
3%	30,000	OSHA STEL 10 minute TWA exposure, 100% increase of breathing
5%	50,000	IDLH – Immediate Danger to Life or Health
10%	100,000	Lowest lethal concentration, few minutes exposure causes unconsciousness
30%	300,000	Brief exposure causes unconsciousness and death

DESIGN OVERVIEW

KYSOR WARREN
eptarefrigeration

CO2 REFRIGERATION

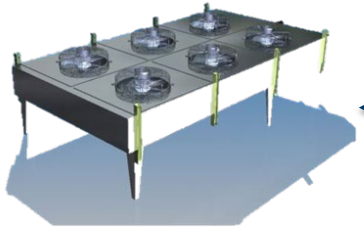
SYSTEM SOLUTION CONFIGURATIONS – HFC CHARGE REDUCTION

Concept	Medium Temp	Low Temp	HFC Charge*
Direct Expansion (Conventional)	DX HFC	DX HFC	100%
HFC / CO2 Cascade	DX HFC	DX CO2	70%
HFC / Glycol / CO2 Cascade	SC Glycol	DX CO2	15% – 30%
HFC / Glycol / CO2	SC Glycol	CO2 LOF	15% – 30%
HFC / CO2 Hybrid	LOF*** CO2	DX CO2	15% – 30%
Natural Ref** / CO2 Hybrid	LOF*** CO2	DX CO2	0%
CO2 Transcritical Booster	DX CO2	DX CO2	0%

*HFC Refrigerant use
** NH3/CO2 Mostly used for industrial applications
*** LOF: Liquid Overfeed = CO2 pumped

SYSTEM SOLUTIONS

HFC DIRECT EXPANSION MT DX, LT DX



Condenser

HFC Rack

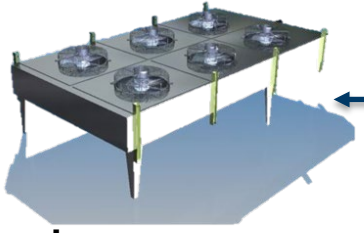
100% HFC

Low Temp HFC
Direct Expansion

Medium Temp HFC
Direct Expansion

SYSTEM SOLUTIONS

CASCADE SYSTEM HFC MT / CO2 LT DX



Condenser

Primary Rack (HFC – R134a)

70% HFC

CO2 Rack

Low Temp CO2
Direct Expansion

Medium Temp HFC
Direct Expansion

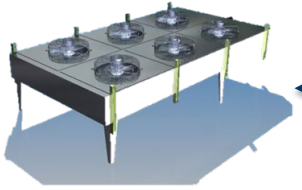
SYSTEM SOLUTIONS

CASCADE SYSTEM HFC / GLYCOL MT / CO2 LT DX

KYSOR WARREN

Primary Rack (HFC,NH3,HC)

0% - 30% HFC



Condenser

CO2 Rack

Glycol Chiller

Low Temp CO2
Direct Expansion

Medium Temp Glycol

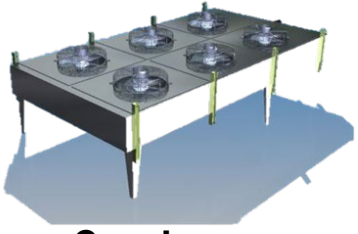
SYSTEM SOLUTIONS

CASCADE SYSTEM CO2 MT LOF / CO2 LT DX

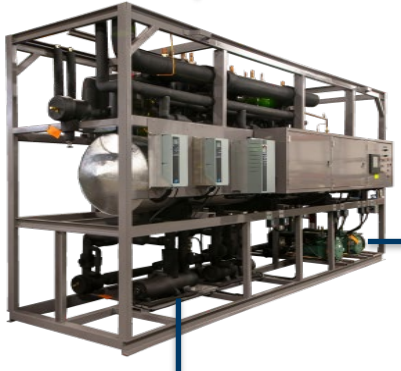
KYSOR WARREN

0% - 30% HFC

Primary Rack (HFC,NH3,HC)



Condenser



Low Temp CO2 Direct Expansion

CO2 Hybrid Rack

Medium Temp CO2 Liquid Overfeed

(CO2 Pumped)

SYSTEM SOLUTIONS

TRANSCRITICAL BOOSTER - CO2 MT DX / CO2 LT DX

KYSOR WARREN

CO2 Transcritical Booster System 0% HFC

Gas Cooler / Condenser

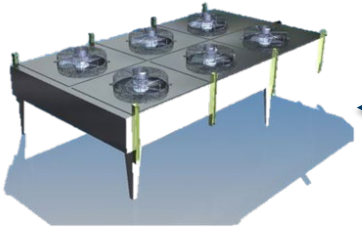
CO2 Booster Rack

Low Temp CO2 Direct Expansion

Medium Temp CO2 Direct Expansion

SYSTEM SOLUTIONS

HFC DIRECT EXPANSION MT DX, LT DX



Condenser

HFC Rack

100% HFC

Low Temp HFC
Direct Expansion

Medium Temp HFC
Direct Expansion

CO2 TRANSCRITICAL BOOSTER

- Comparable to HFC concept
- Single refrigeration system
- Single refrigerant (CO2)
- HFC free
- Higher operating pressures
  - Gas cooler 700 – 1500 psi
  - Flash gas tank 500 – 600 psi
  - MT suction group 380 – 450 psi
  - LT suction group 180 – 220 psi
- Applications
  - LT only – Not common
  - MT only – Common use
  - Booster (LT & MT) – Most common application

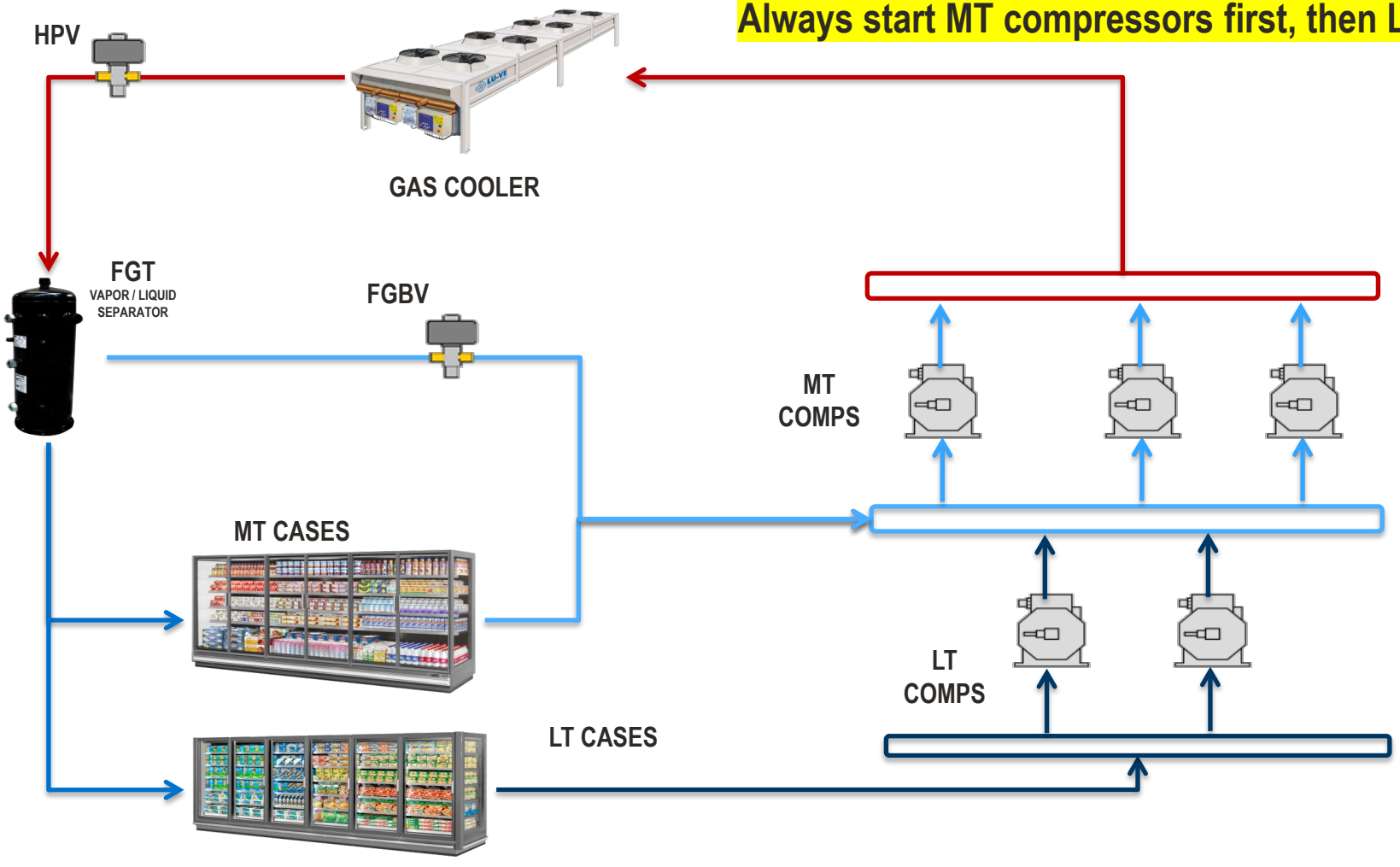
CO2 TRANSCRITICAL BOOSTER RACK

CO2 TCB REFRIGERATION SYSTEM

SIMPLE PIPING REPRESENTATION – **MAIN COMPONENTS**

KYSOR WARREN

Always start MT compressors first, then LT



HFC REFRIGERATION SYSTEM

SIMPLE PIPING REPRESENTATION – **MAIN COMPONENTS**

CONDENSER

RECEIVER
VERTICAL / HORIZONTAL

MT COMPS

LT COMPS

MT CASES

LT CASES

HFC VS CO2 TRANSCRITICAL SYSTEM
SUMMARY

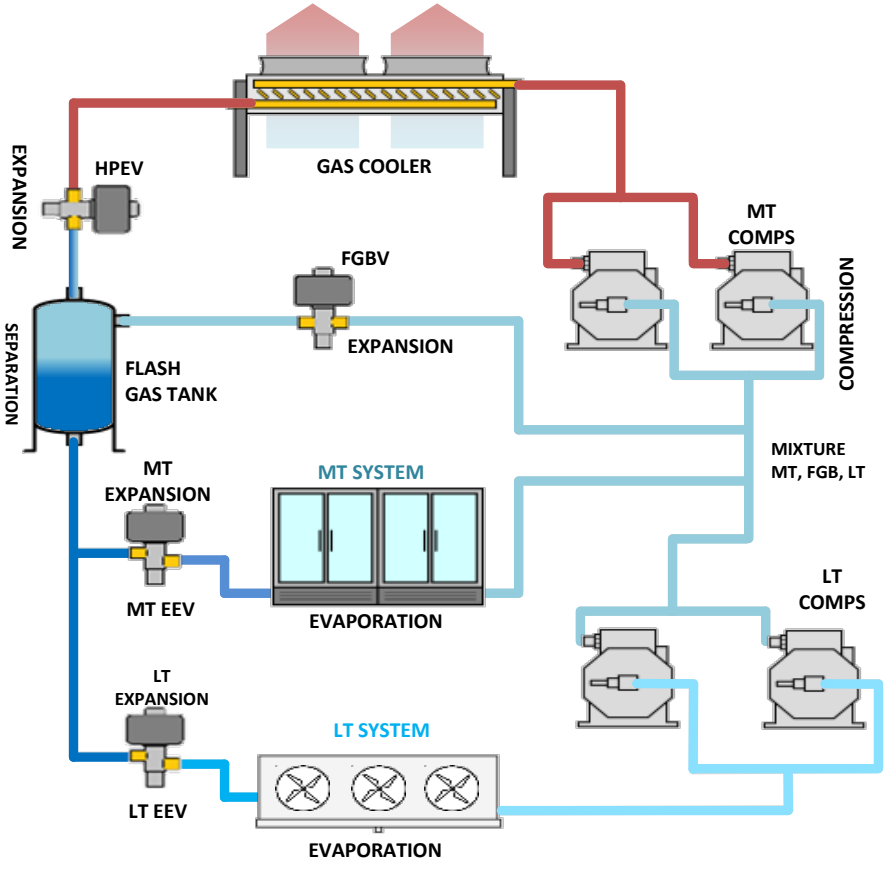
KYSOR WARREN

ITEM	HFC	Standard CO2 TCB
MT Compressor discharge	Oil separator / Condenser	Oil separator / Gas cooler (Condenser)
LT Compressors discharge	Oil separator / Condenser	Suction of MT Compressors (Important for startup)
Receiver / Flash Tank	Storage liquid refrigerant	Separates liquid and vapor
Receiver / Flash Tank pressure	Similar as condenser pressure	Few hundred psi lower than gas cooler
System main pressure levels	3 (LT suction, MT Suction, Condenser)	4 (LT suction, MT Suction, Flash tank, Gas cooler)
High Pressure Valve	N/A	Manages gas cooler pressure Reduces pressure from GC to FGT,
Flash gas bypass valve	N/A	Manages flash tank pressure Removes vapor from FGT to MT compressor suction
Piping material	K and L type copper	K, L & High-pressure copper (K65 / XHP) or SS pipe
Operating pressures	5 - 450 psig	150 – 1450 psig (approximately)
Power outage	No problem **Passive system**	Could loose charge depending on ambient temperature **Active system**

HFC VS CO2 TRANCRITICAL SYSTEM
SUMMARY

ITEM	HFC – R448A [psi]	Standard CO2 TCB [psi]
MT Compressor discharge pressure	< 400	700 - 1500
Condenser / Gas cooler pressure	< 400	700 - 1500
Receiver / Flash Tank pressure	< 400	500 - 600
LT Compressors discharge pressure	< 400	380 - 450
MT Compressor suction pressure	35- 50	380 - 450
LT Compressor suction pressure	5 – 10	180 - 220

DESIGN OVERVIEW
TC BOOSTER – FLASH GAS BYPASS



HPEV – High Pressure Expansion Valve
FGBV – Flash Gas Bypass Valve

FLASH GAS

- Is recirculated in the system (MT comps use lots of energy to recirculate)
- Does not produce cooling effect
- Flash gas formation increases with higher ambient temperatures or gas cooler outlet temperature
- Reduces pressure from FGT (520 psi) to MT suction pressure (420 psi) causing energy losses
- Can cause low superheat on MT compressors

CO2 TRANSCRITICAL SYSTEMS
EFFICIENCY IMPROVEMENT TECHNOLOGIES

KYSOR WARREN

STANDARD CO2 TRANSCRITICAL BOOSTER SYSTEM

- Air cooled gas cooler – Basic design for cold weather locations

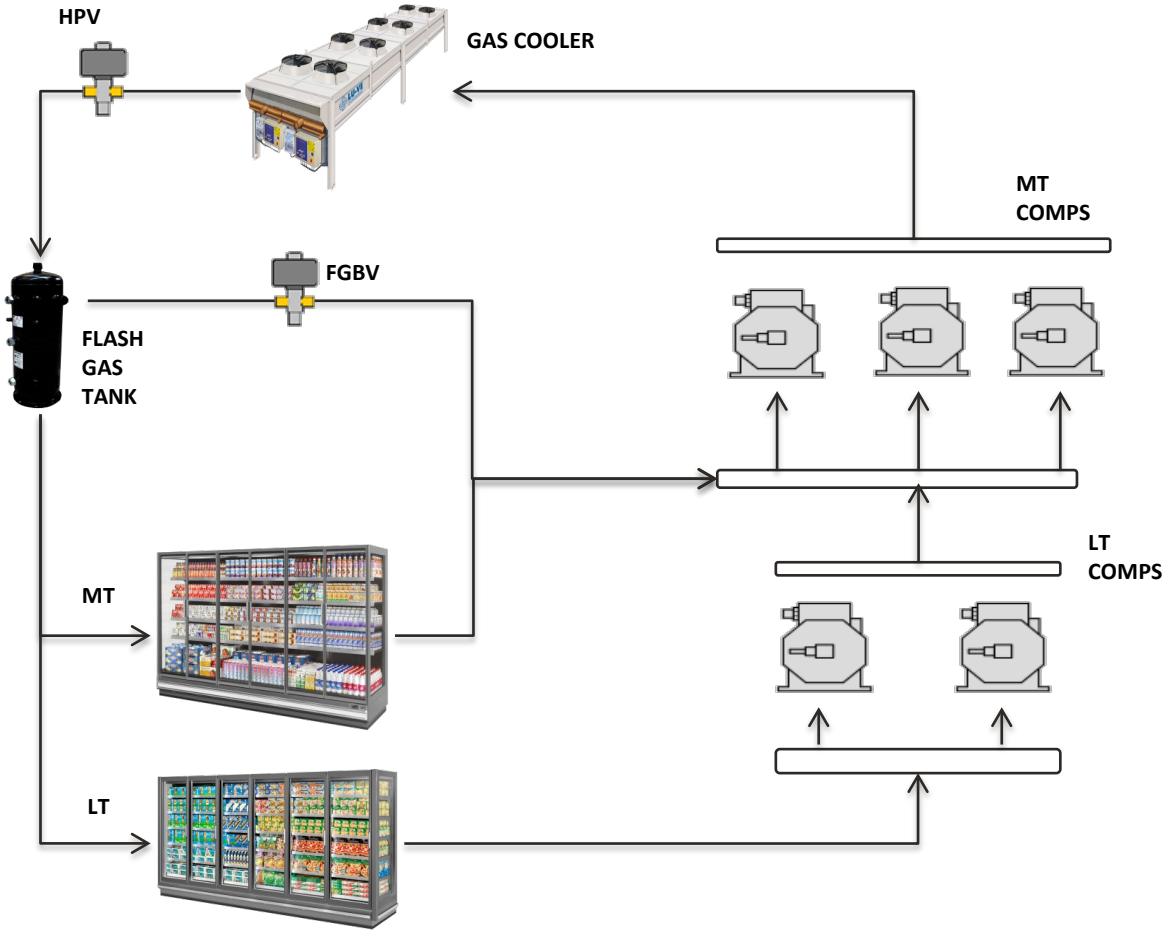
HIGH AMBIENT CONDITION SOLUTIONS – HIGH PRESSURE SIDE

- Adiabatic cooling – Most commonly used (BAC and Guntner gas coolers)
- Mechanical Cooling – Not commonly used
- Parallel Compression – Few installations
- Ejectors + Parallel Compression – Not commonly used
    - High pressure ejectors
    - Low pressure ejectors
- ETE – Extreme Temperature Efficiency – Kysor Warren Epta

ANY AMBIENT CONDITION SOLUTIONS – LOW PRESSURE SIDE

- FTE – Full Transcritical Efficiency – Kysor Warren Epta
- Liquid ejectors – Not commonly used

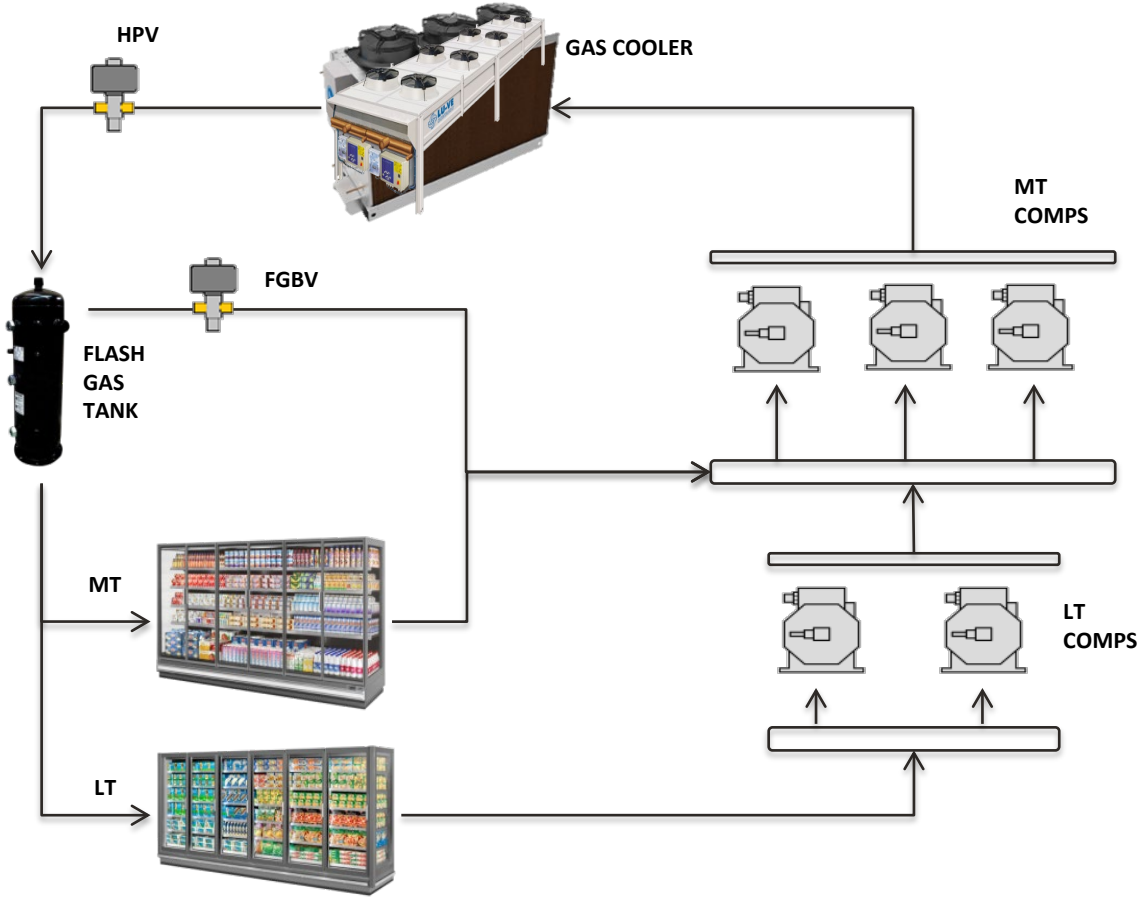
DESIGN OVERVIEW
STANDARD TRANSCRITICAL BOOSTER (TCB)



Description
Basic design

Simple design
Loses efficiency on high ambient conditions

DESIGN OVERVIEW
ADIABATIC GAS COOLING



Description

Water assisted gas cooler, increased efficiency during high ambient conditions.

Simple design, easy to implement

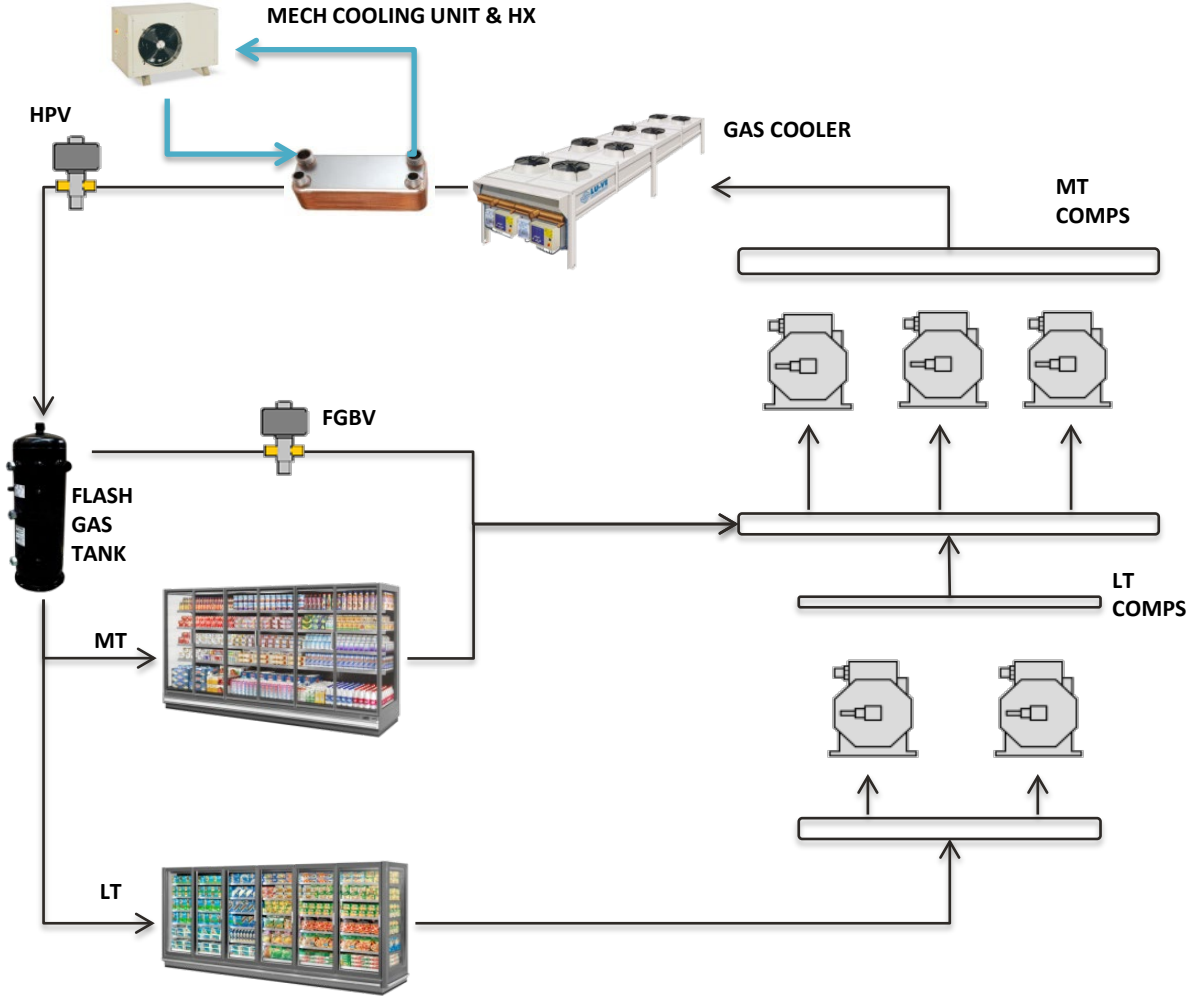
Improves efficiency in high ambient temperature conditions & low humidity

Higher up-front cost

Service factor needs to be considered

- Water usage
- Water cost
- Maintenance

DESIGN OVERVIEW
EXTERNAL MECHANICAL COOLING

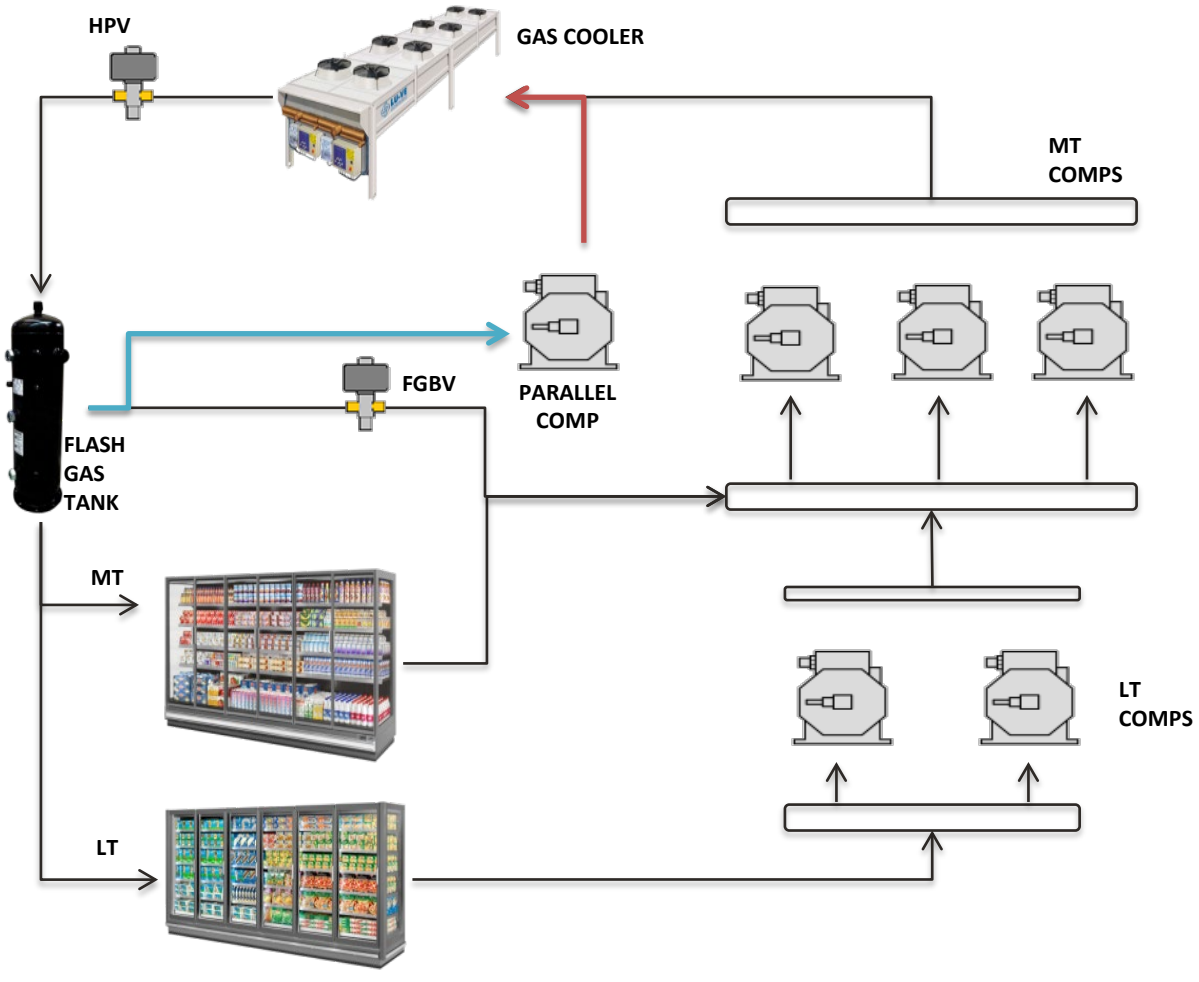


Description

Additional external condensing unit
Cooling effect on CO_2 leaving the gas cooler
Reduces flash gas formation
Less work to remove flash gas from tank
Improves efficiency

Requires additional unit
HFC / Natural refrigerants
Maintenance

DESIGN OVERVIEW
TCB + PARALLEL COMPRESSION



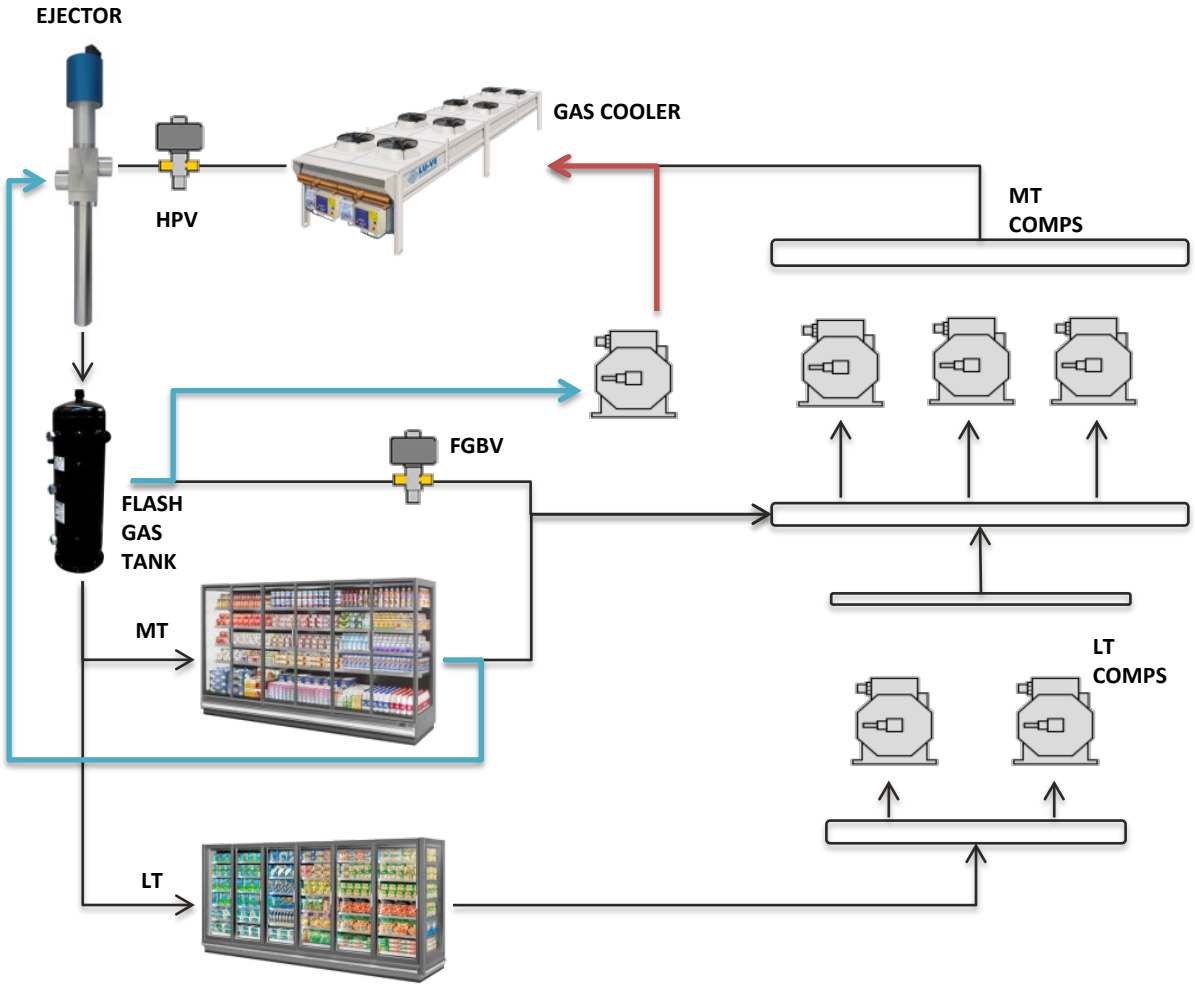
Description

Removes the flash gas from the liquid receiver.
Parallel compressor runs at flash tank pressure
Requires less compression work than MT comps
Higher efficiency than MT compressor

Additional control algorithms
Additional VFD

DESIGN OVERVIEW

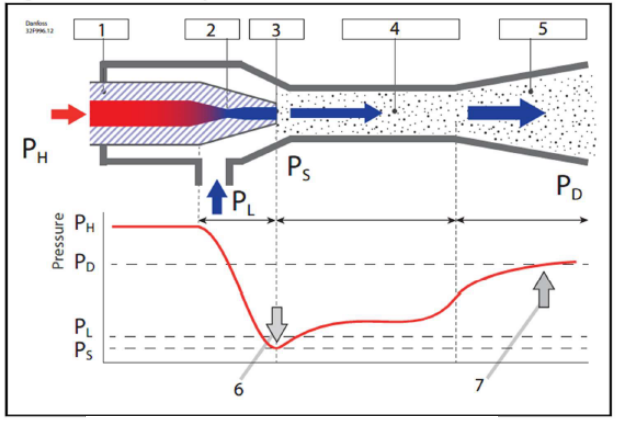
TCB + PARALLEL COMPRESSION + HIGH PRESSURE EJECTOR



Description

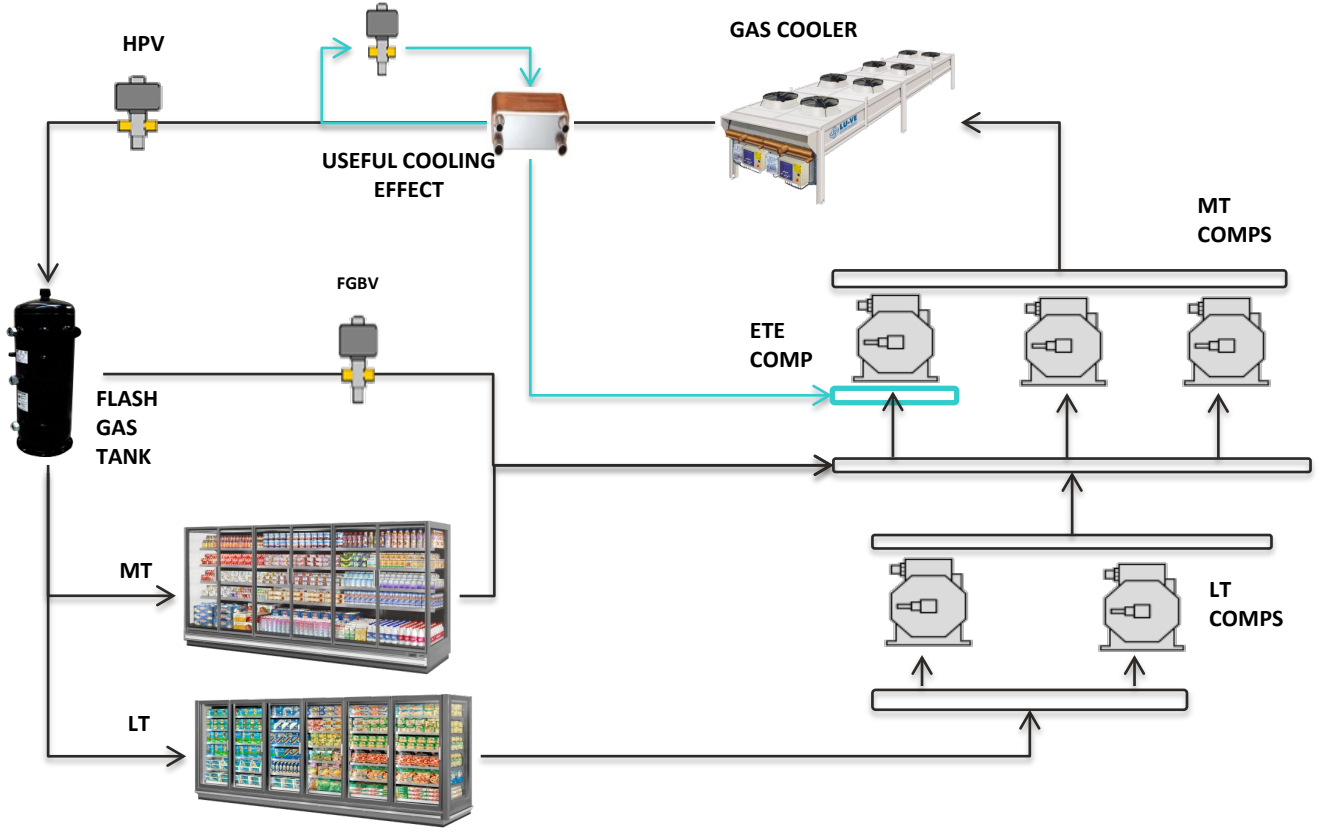
Mechanical device to use the energy from the high pressure gas to lift the pressure of MT suction return and transfer flow from MT suction to flash gas tank.

Requires the use of parallel compression on the same system
Parallel compressor works more
MT compressors work less



1	Nozzle
2	Throat
3	Exit
4	Mixing chamber
5	Diffuser
6	Intake due to pressure differential
7	Pressure increase due to reducing flow velocity

DESIGN OVERVIEW
EXTREME TEMPERATURE EFFICIENCY (ETE)



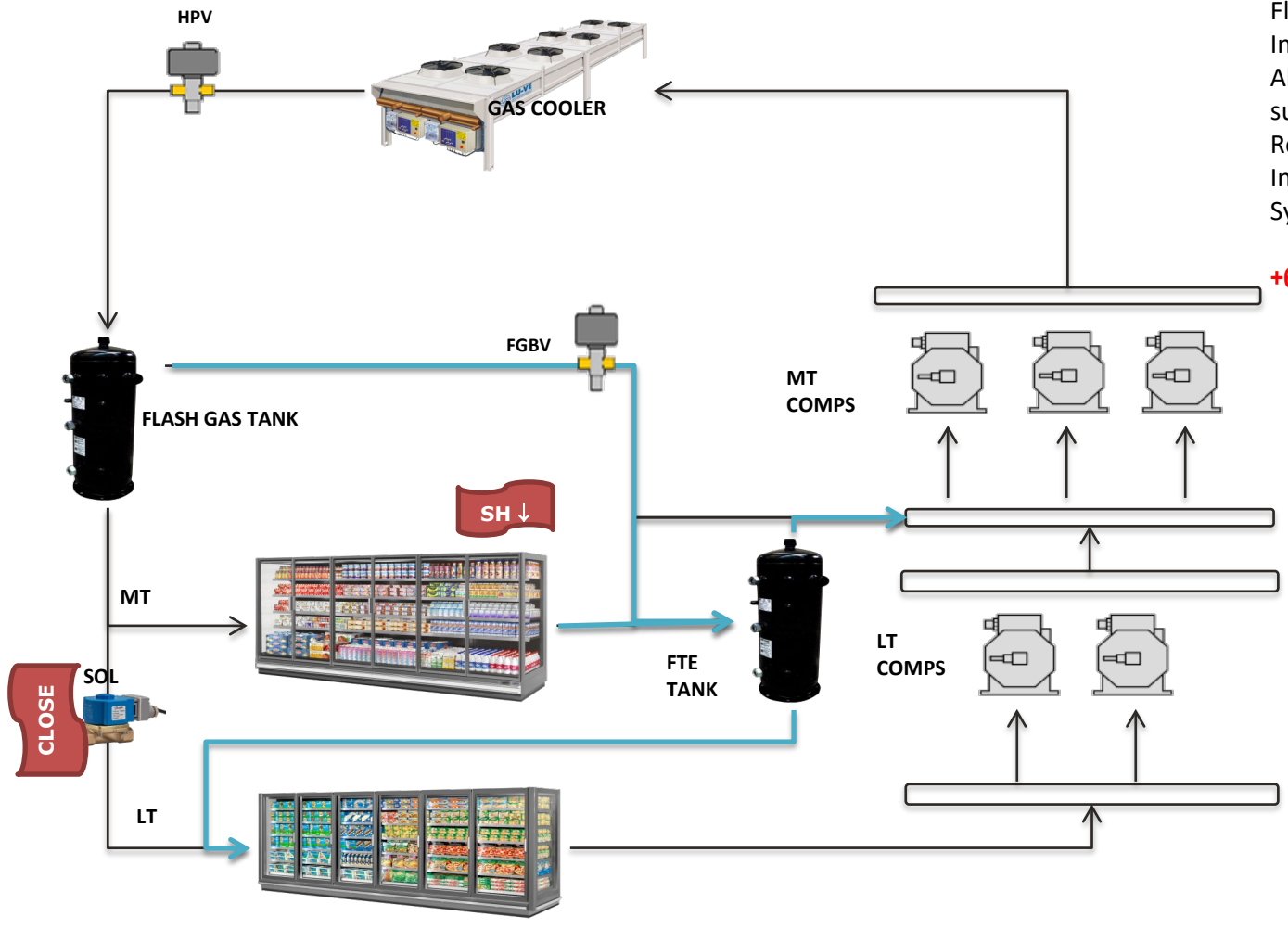
Description

Built in cooling system
Cooling effect on CO_2 after leaving the gas cooler
ETE compressor runs at higher suction pressure compared to parallel compressor
Reduces flash gas formation
Less work to remove flash gas from tank
Improves efficiency
Uses CO_2 from same system
No need for adiabatic gas cooler

Additional suction group
Additional VFD

+200 Installations globally

DESIGN OVERVIEW
FULL TRANSCRITICAL EFFICIENCY (FTE)

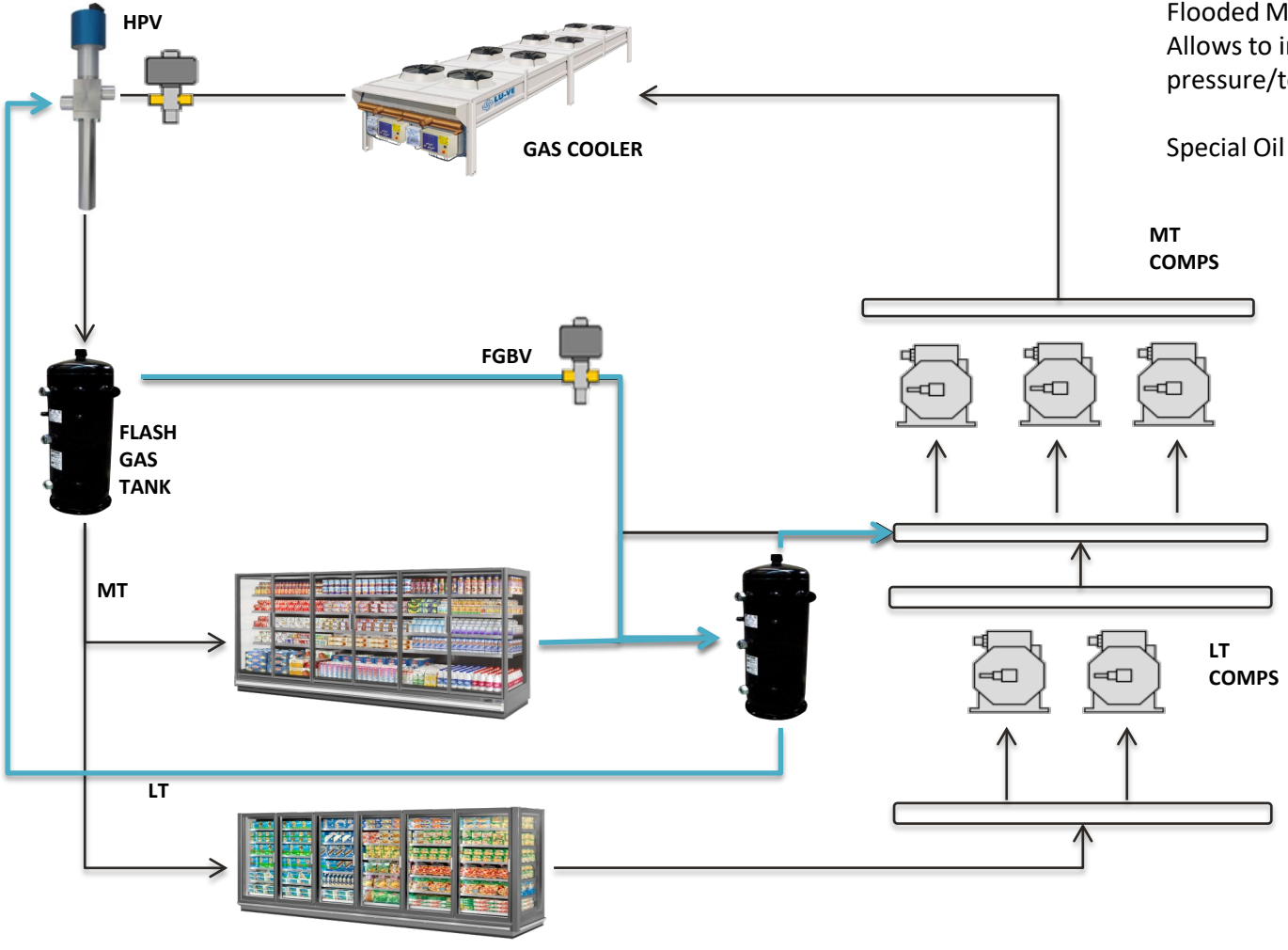


Description

System operates in the low pressure side
Flooded MT cases with lower SH
Increase MT cases capacity/efficiency
Allows to increase MT compressors suction pressure/temperature
Reduce energy consumption
Independent of ambient temperature
System requires MT and LT loads

+600 Installations globally

DESIGN OVERVIEW
LIQUID EJECTORS



Description

System operates in the low pressure side

Flooded MT cases

Allows to increase MT compressor suction pressure/temperature

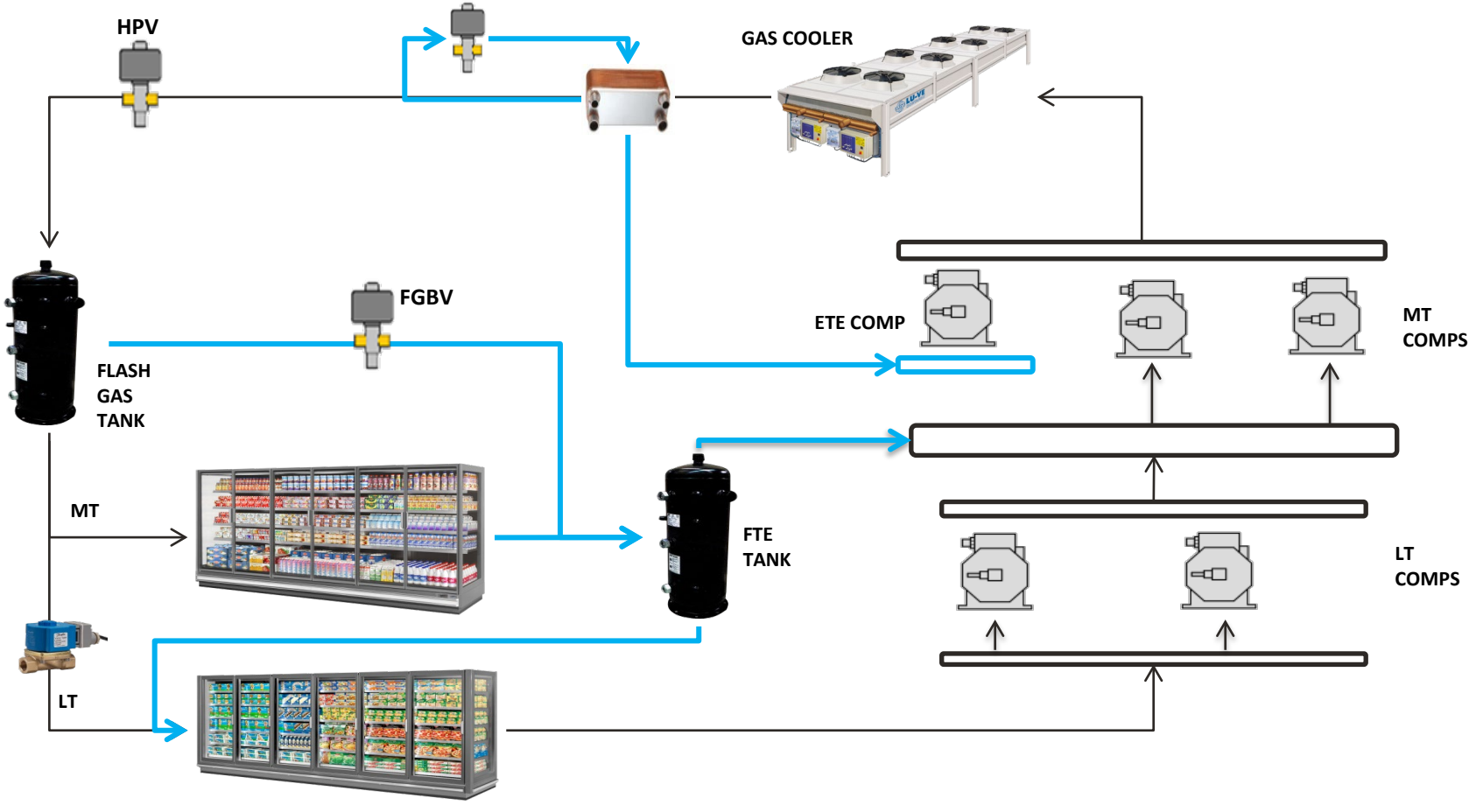
Special Oil control logic

CO2 TRANSCRITICAL SYSTEM

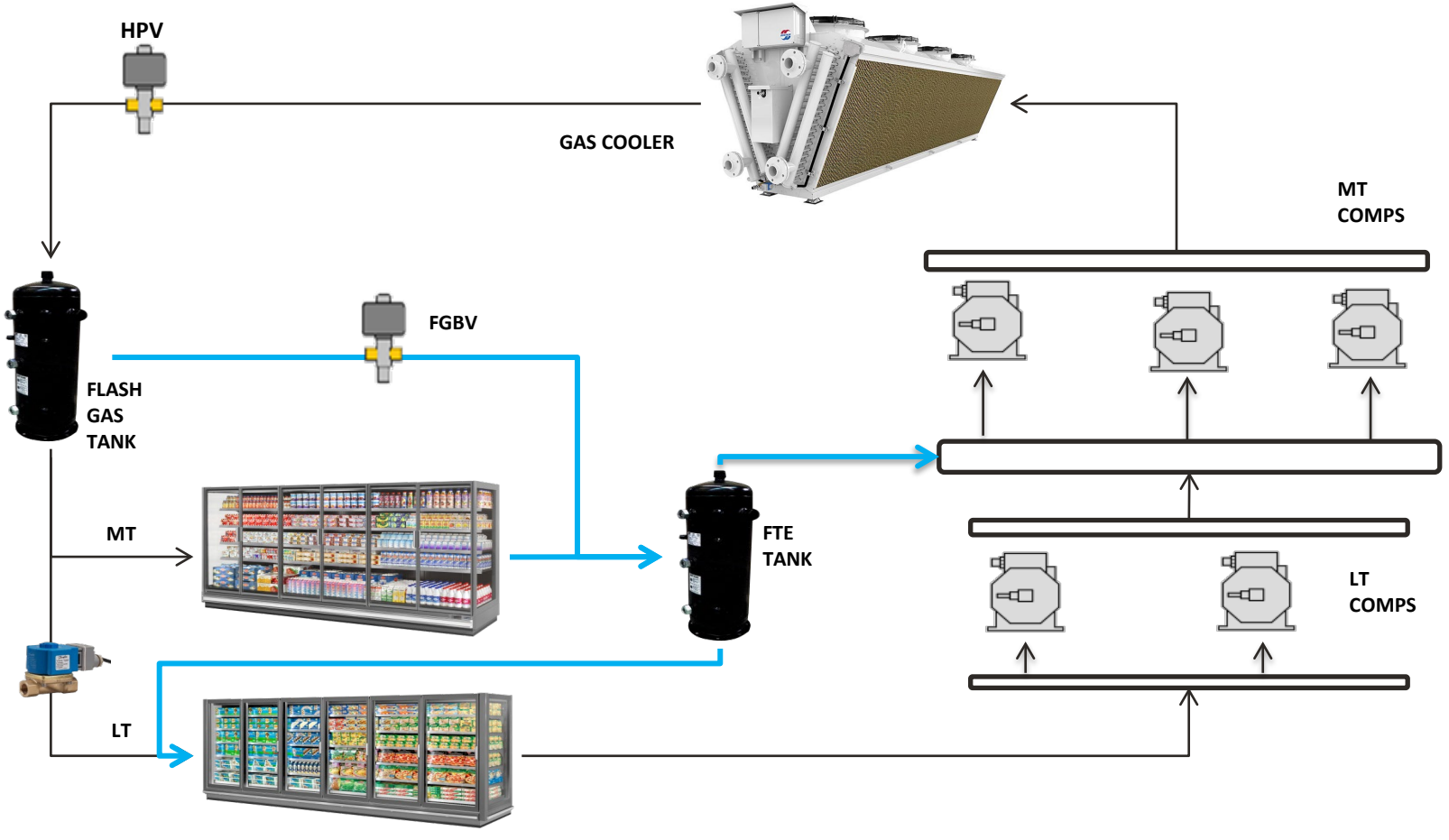
COMBINING TECHNOLOGIES FOR HIGHER EFFICIENCY

KYSOR WARREN

EXTREME TEMPERATURE EFFICIENCY + FULL TRANSCRITICAL EFFICIENCY



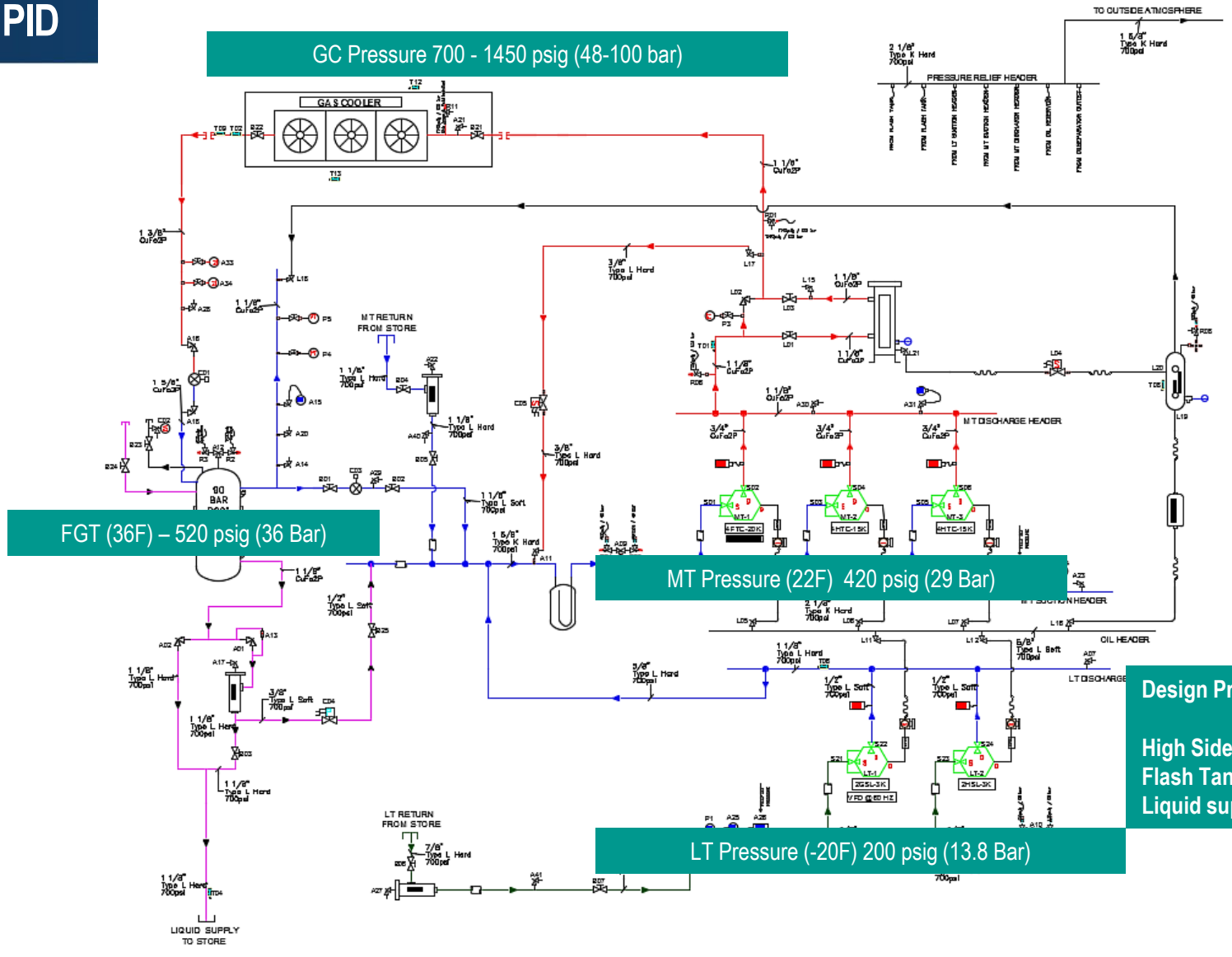
ADIABATIC GAS COOLING + FULL TRANSCRITICAL EFFICIENCY



SUBSYSTEM & COMPONENTS

KYSOR WARREN
eptarefrigeration

PID

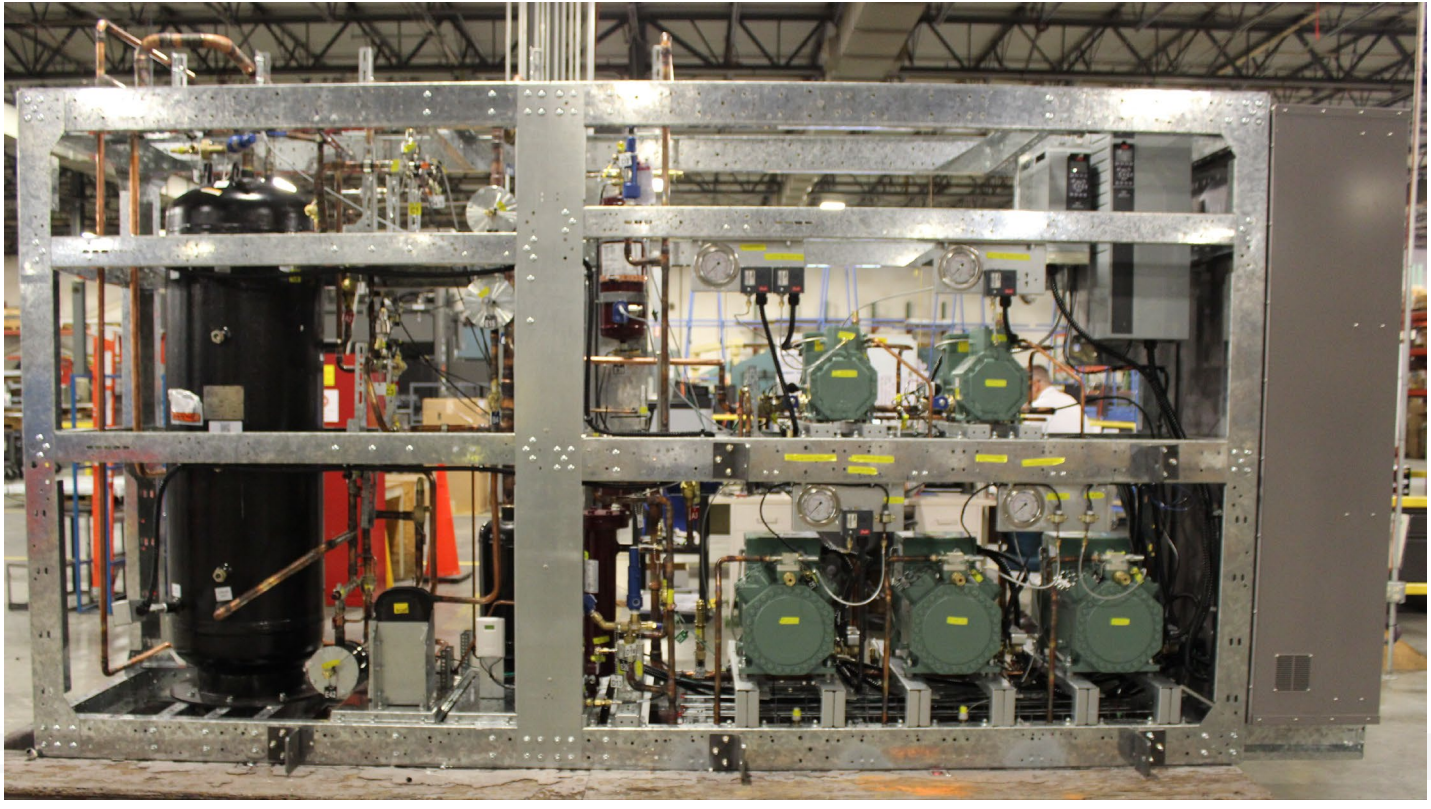


Design Pressure

High Side 1740 psi
Flash Tank – 870 or 1305 psi
Liquid supply lines 655 psi

RACK OVERVIEW
SUBSYSTEM AND COMPONENTS

RACK DESIGN OVERVIEW



- System management
  - Gas cooler
    - Pressure
    - Fan operation
  - Flash gas tank pressure
  - Oil
    - Low pressure
    - High pressure
  - Superheat
  - Refrigerant

GAS COOLER MANAGEMENT

High Pressure Valve

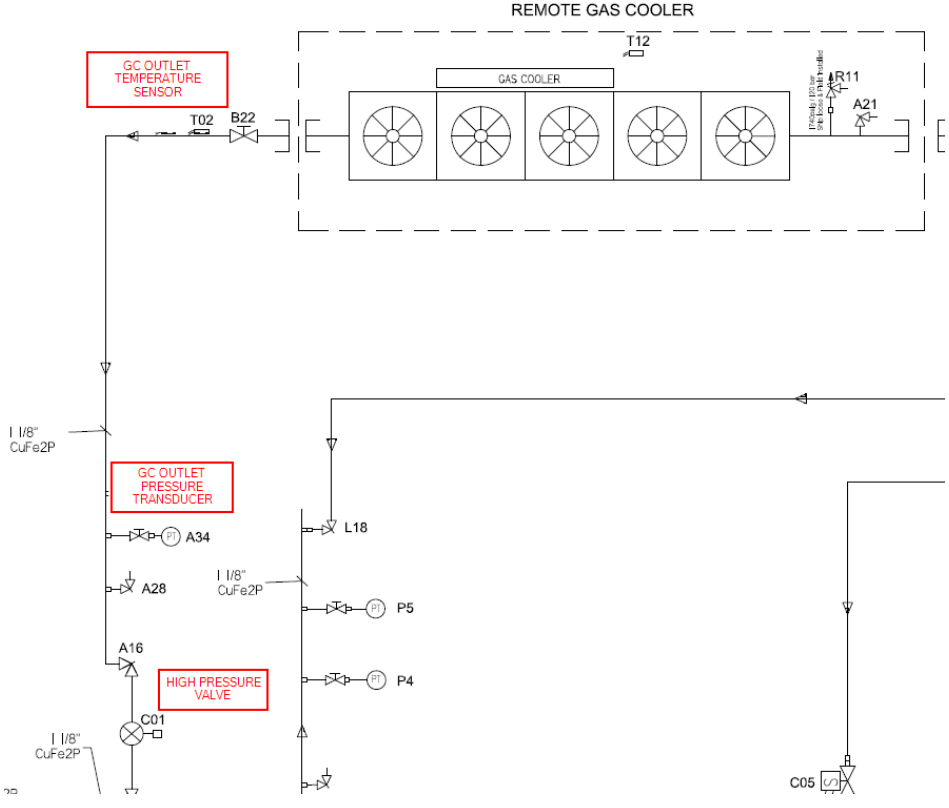
- Manages gas cooler pressure in transcritical operation mode for optimum energy efficiency
- Reduces CO2 pressure coming out of the gas cooler to the flash tank pressure levels
- Operating pressures 700-1450 psi

Gas Cooler Outlet Temperature Sensor:

- Control of Gas Cooler Fan Speed
- Controller calculates optimum pressure
- Should be mounted as close as possible as gas cooler outlet header

Gas Cooler Outlet Pressure Transducer

- Control opening of the High Pressure Valve to operate at highest efficiency
- Installed close to the High Pressure Valve



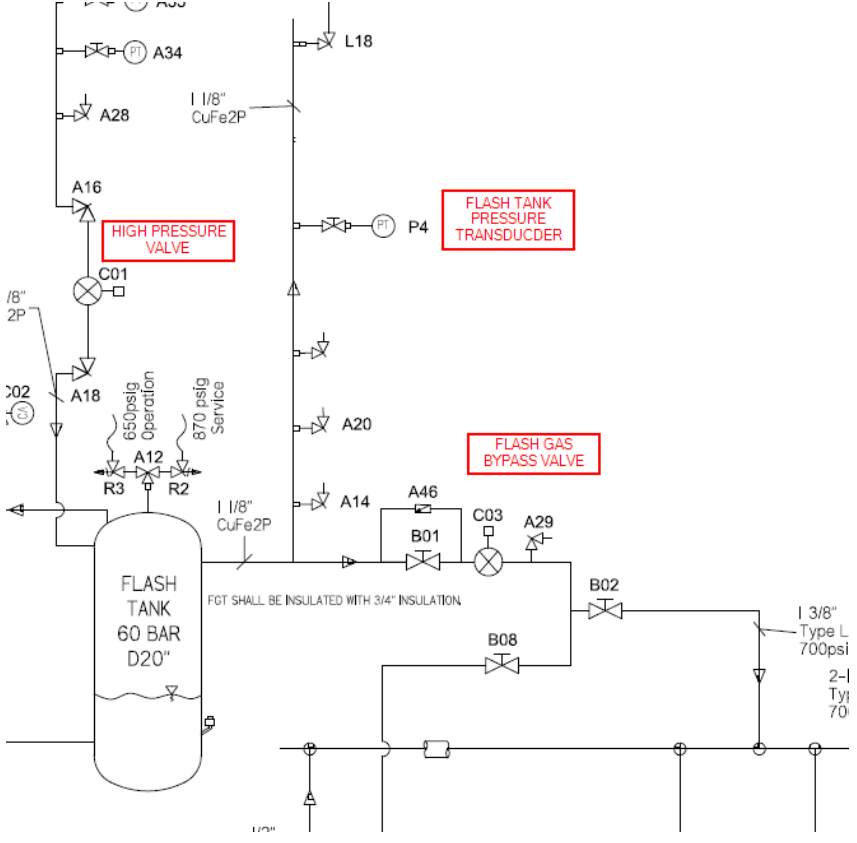
FLASH GAS TANK MANAGEMENT

Flash Gas Bypass Valve

- Maintains flash tank pressure to a specified set point.
- Allows vapor flow from flash tank to medium temperature compressor suction line.
- Operating pressure below 652 psig

Flash Tank Pressure Transducer

- Control opening of the Flash Gas Bypass Valve.



KYSOR WARREN

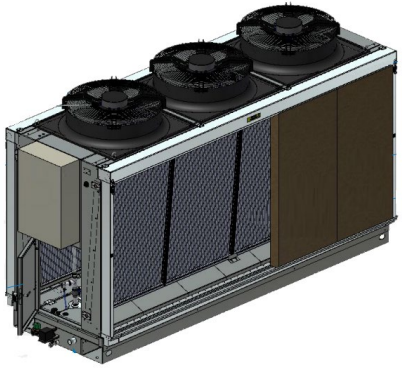
MANUAL MANIPULATION

SMA-12 SPORLAN STEP MOTOR ACTUATOR

https://www.parker.com/content/dam/Parker-com/Literature/Sporlan/Sporlan-pdf-files/Sporlan-pdf-100/SD-213-SMA-12.pdf

GAS COOLER

Adiabatic (Hybrid) Gas Cooler



Air Cooled Gas Cooler

Main Features

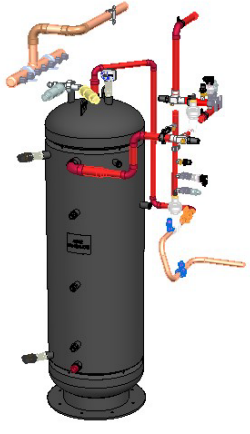
Design pressure: 1885 – 2030 psi
Fan motors: Variable speed (ECM)
Tube material: SS or High pressure copper

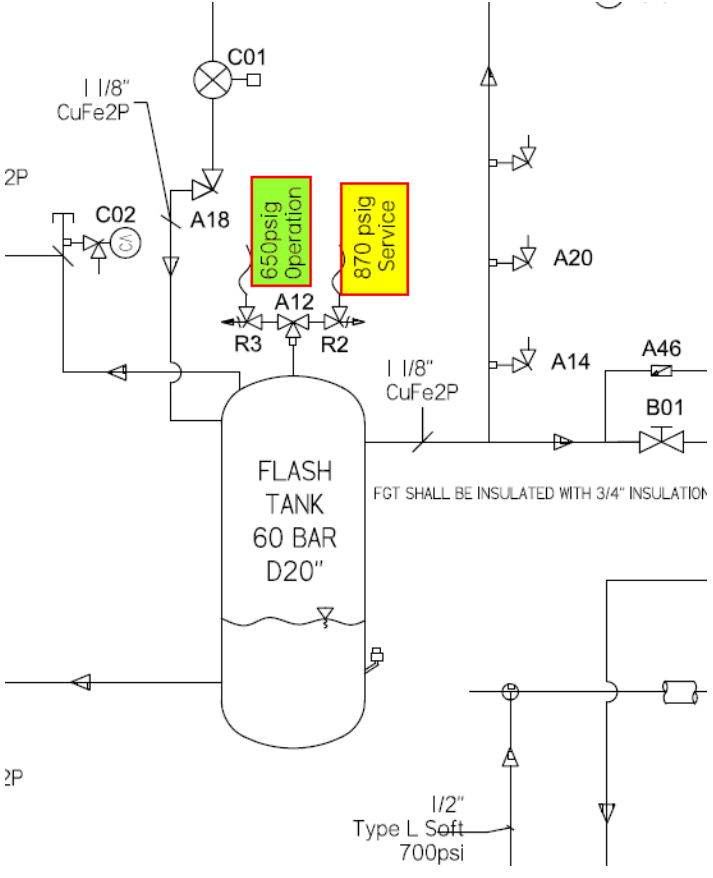
FLASH TANK

- Separates liquid and vapor refrigerant phases so that only the liquid is sent to the evaporators and the vapor can be redirected to the MT compressor suction
- Holds the refrigerant charge for proper system operation
- Design pressure: 655, 870 or 1305 psi
- Dual pressure relief valves
  - Service valve only active during service or pump down
  - Service valve is manually activated through 3 way change over valve

Recommended level to be between first and second sight glasses during operation.

During pump-down the level should never exceed the tank's top sight glass.

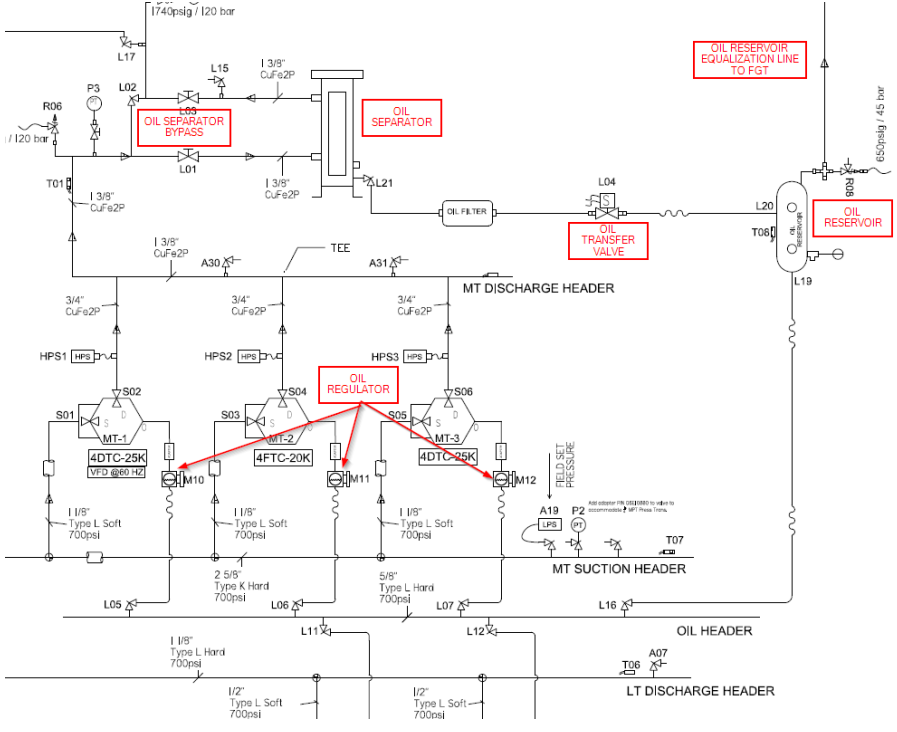




OIL SYSTEM

- Ensures positive pressure in oil system to inject oil in LT & MT compressors
- Main components
  - Oil separator
  - Transfer valve (solenoid valve)
  - Oil reservoir
  - Oil regulator
  - Equalization line
  - Oil level sensor – if applicable
  - Oil separator bypass – if applicable

LOW PRESSURE OIL SYSTEM

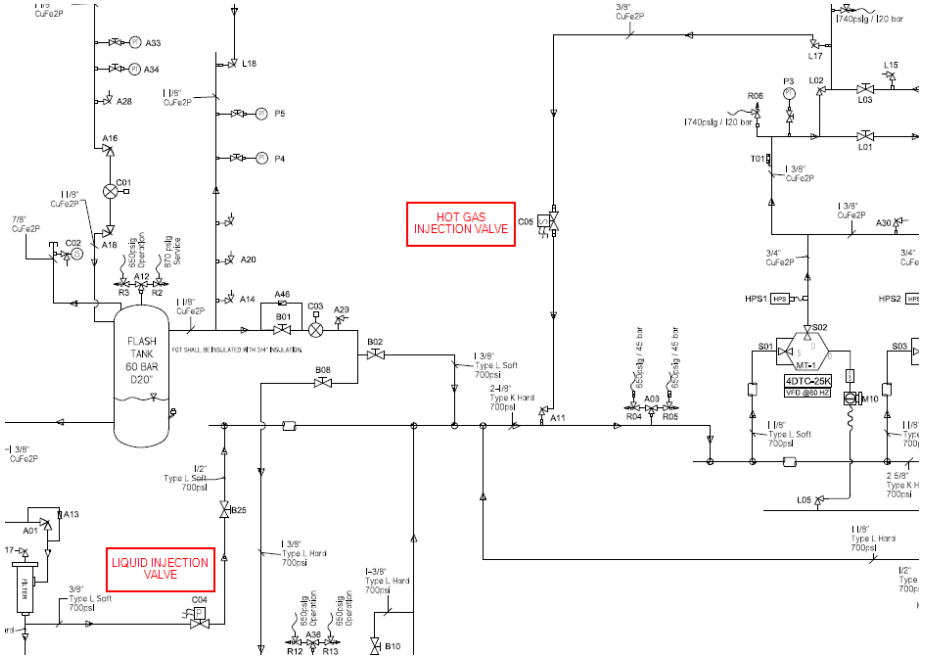


SUPERHEAT CONTROL SYSTEM

- Ensures proper superheat value for MT compressors

- Main components
  - <u>Option 1</u>
    - Hot gas injection valve (solenoid)
    - Liquid injection valve (EEV)

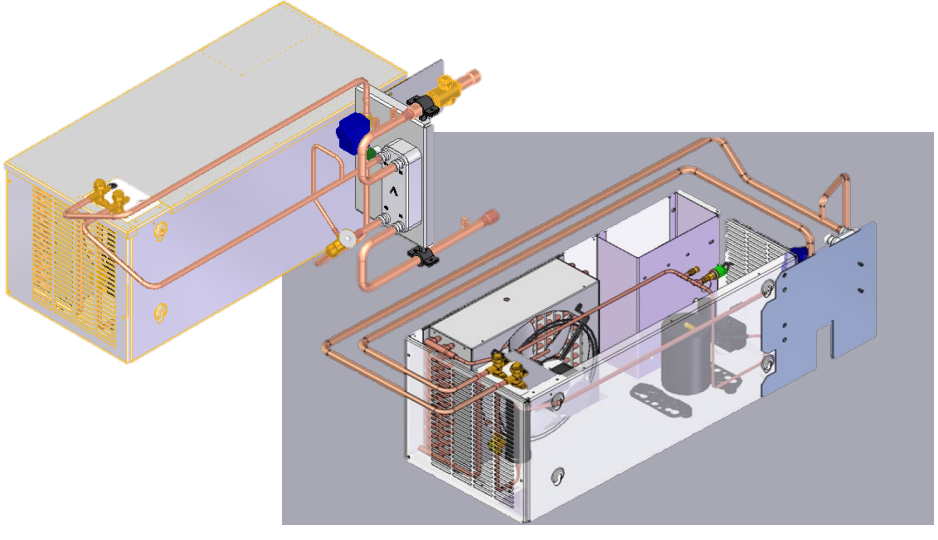
  - <u>Option 2</u>
    - Heat exchangers

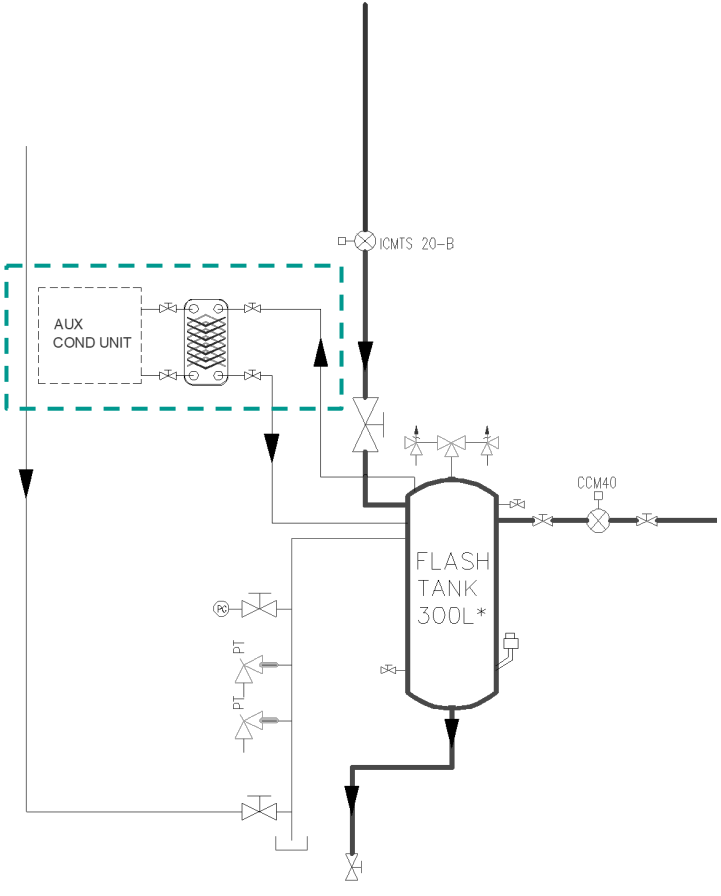


AUXILIARY CONDENSING UNIT (OPTIONAL)

SUBSYSTEM AND COMPONENTS

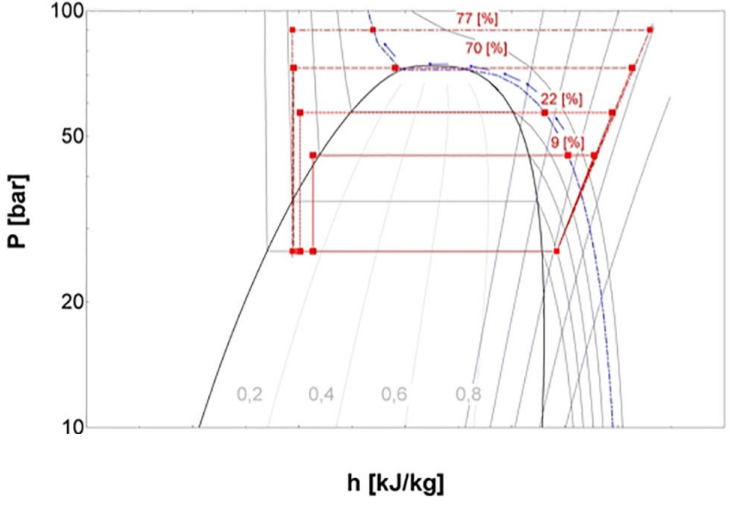
- Keep the pressure at the flash tank under relief valve setting to avoid loss of charge in power failures or servicing situations
- Condense CO2 gas from flash tank
- Needs alternate power source to function under power failure situations

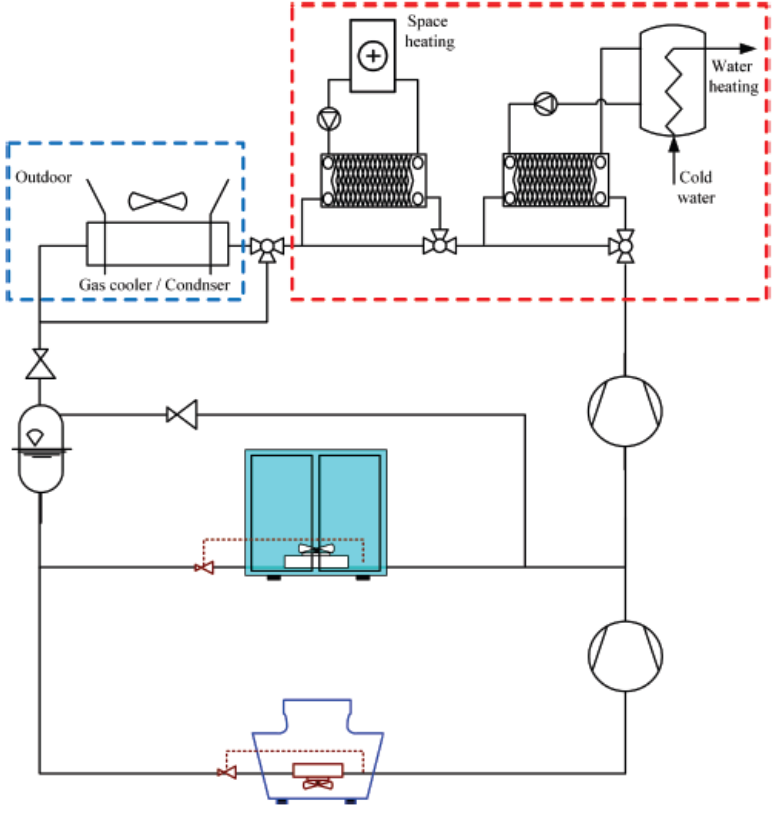




HEAT RECLAIM (OPTIONAL)
REFRIGERANT MANAGEMENT MODULE

- Recover energy heat that is normally rejected or wasted to the ambient
- Reduce the energy consumption needed for hot water, store heating or dehumidification purposes
- Heat reclaim capacity varies with system operating conditions, subcritical or transcritical modes.
- Direct or Indirect methods





https://www.danfoss.com/en-gb/service-and-support/case-stories/dcs/transcritical-co2-refrigeration-with-heat-reclaim/

CONTROLLERS

KYSOR WARREN
epta refrigeration

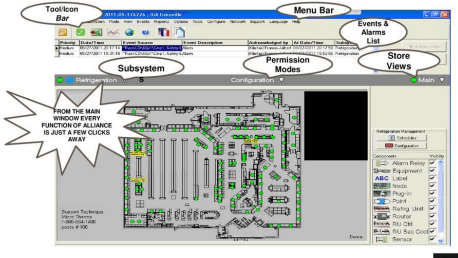
CO2 TRANSCRITICAL SYSTEMS
ELECTRONIC CONTROLS

- Site manager
- Compressors control system
- HPV & FGBV control
- Case controller
  - Display cases
  - Evaporator coils
- Electronic Expansion Valves

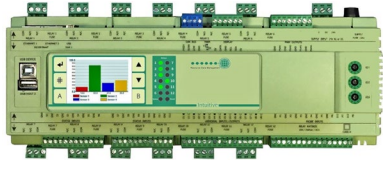
- Manage communication between rack system and case controllers, defrost schedule, lights, HVAC in some cases

Software – MT Alliance

Familiar Windows user interface:



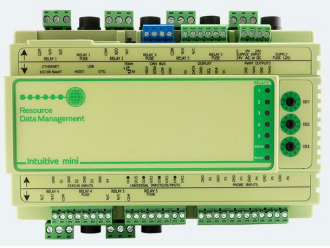
- Manage compressor operation and all features in the rack
  - One or Two suction groups (LT & MT)
  - Variable capacity for lead compressors
  - Parallel compression (check with your controls provider)
  - Ejectors (check with your controls provider)



- Manage operation of high pressure valve and flash gas bypass valve in both transcritical and subcritical conditions
- Every controls manufacturer has it own control algorithm
- Some rack controllers have HPV and FGBV controls built in
- Check proper wiring for HPV and FGBV, per controller manufacturer

CO2 TRANSCRITICAL SYSTEMS
CASE CONTROLLERS

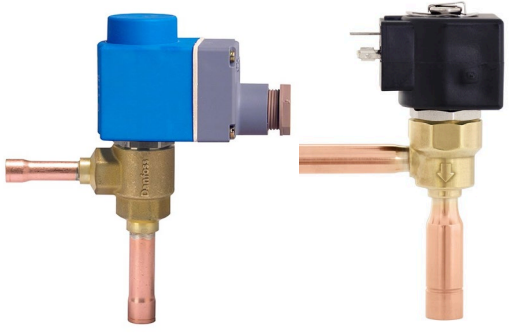
- Case controller are used in display cases as well cold rooms (coolers & freezers)
- Evaporator fan control
- Defrost control
- Lighting control
- Dual temperature
- Anti-sweat control
- EEV control
  - EEV's are required for CO2 control
  - Stepper or pulse valves available



EXPANSION VALVE CONTROL
FUNCTIONS

- Meters the refrigerant flow going to the evaporator
- Modulates
  - To maintain air temperature set point (discharge for cases / return for walk-ins)
  - Superheat

PWM



STEPPER

TXV

* In case of power failure:
Stepper valve will remain in its current position. Additional solenoid valve may be needed to close liquid refrigerant supply to avoid flooding compressors.
Pulse valve will fail closed – no additional solenoid valve is required

REFRIGERATION SYSTEM SAFETY FEATURES

- Components used rated for proper operating pressures depending the use in the system
- Install PRV where needed (liquid or vapor rated valves)
- Reverse acting operation on gas cooler fans
  - 10V = OFF , 0V = ON (100%)
- Backup power for controls
- Refrigeration load management protocols
- High pressure switches at compressor discharge

THANK YOU!!

WWW. KYSORWARREN.COM

KYSOR WARREN

epta refrigeration