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THE GREENCHILL PARTNERSHIP

Introduction to CO2 Cascade Systems

June 21th , 2012

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- Q&A session after presentation
- Submit your questions using CHAT at anytime; we'll go through them during Q&A
  - If you'd like to remain anonymous, send your question by CHAT to Keilly Witman instead of to all participants
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Today's speaker…….

Rusty Walker – Hill PHOENIX Learning Center

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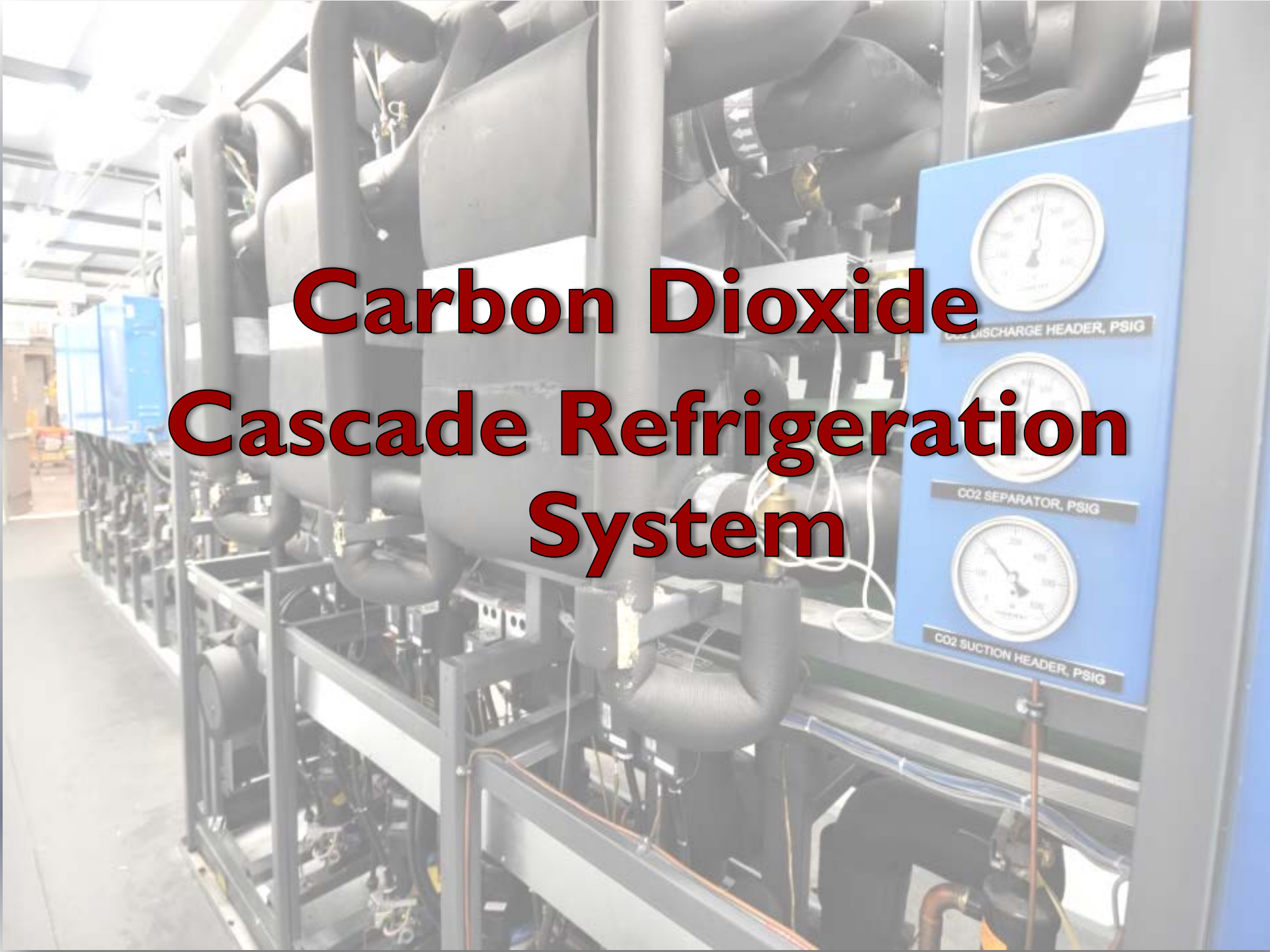
Rusty Walker is a Senior Corporate Trainer with Hill PHOENIX Learning Center. He has more than 25 years of experience in the industry. He conducts many courses and seminars throughout the country on refrigeration systems, power systems, display cases, and walk-in coolers, and is well versed in most aspects of the industry. An avid music and baseball enthusiast, Rusty often sets the tone for his courses with a lively tune.



Carbon Dioxide Cascade Refrigeration System

Useful Definitions

Direct Expansion	A refrigeration system that includes a compressor, condenser, evaporator coil, and an expansion device
Primary Refrigerant	A fluid used to lower the temperature of a secondary coolant (i.e. R-22, R-404a, R-507, R-410A, R-717, etc…)
Secondary Coolant	(a.k.a Secondary Refrigerant, Secondary Fluid) A fluid used to transfer heat from a heat source (i.e. refrigerated space) to a primary refrigerant.
Single-Phase Secondary Coolant	(a.k.a Secondary Refrigerant, Secondary Fluid) A fluid used to transfer heat from a heat source (i.e. refrigerated space) to a primary refrigerant.
Two-Phase Secondary Coolant	a secondary fluid which absorbs heat by means of latent heat transfer resulting in a change in phase (i.e. carbon dioxide, ice-slurries)

Useful Definitions

Cascade System	A system having two (or more) refrigerant circuits, each with a compressor, condenser and evaporator, where the evaporator of one circuit cools the condenser of another circuit
Upper Cascade	the refrigerant circuit in a cascade system that cools the condenser of the lower-cascade and transfers the heat to a heat sink, typically outdoor ambient
Lower Cascade	The refrigerant circuit in a cascade system that removes heat from a refrigerated load and transfers the heat to the upper-cascade

Subcritical vs. Transcritical

- **Subcritical** - CO2 systems where the pressure of the CO2 is maintained well below the critical pressure of 87^0F / ~1055 psig
- Operating pressures for subcritical systems are slightly higher than those in conventional direct-expansion systems but are similar to those seen in air-conditioning applications using **R-410A**.
- **Transcritical** - CO2 systems that are designed to operate at pressures above the critical pressure, above 1055 psig.

Triple Point vs. Critical Point

- Triple Point
- Liquid CO_2 below 60PSIG changes to Dry Ice

- Critical Point
- 87^0F = 1055 psig
- No longer able to distinguish between liquid and vapor.
- An undefined gas.
- Only found in a Transcritical system.

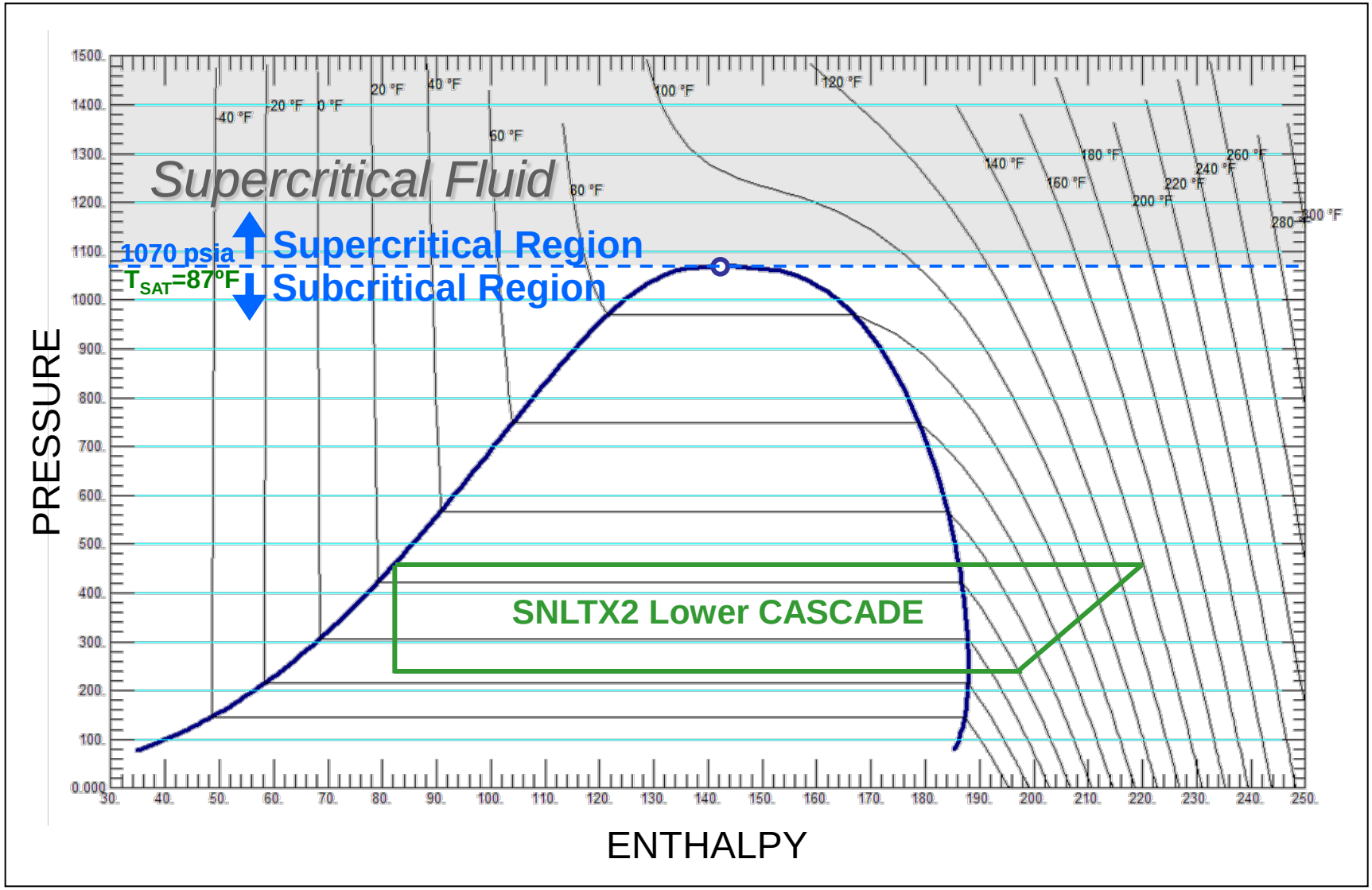
Carbon Dioxide is used as a secondary coolant or a Direct Expansion Refrigerant

Carbon Dioxide = CO_2 = R-744

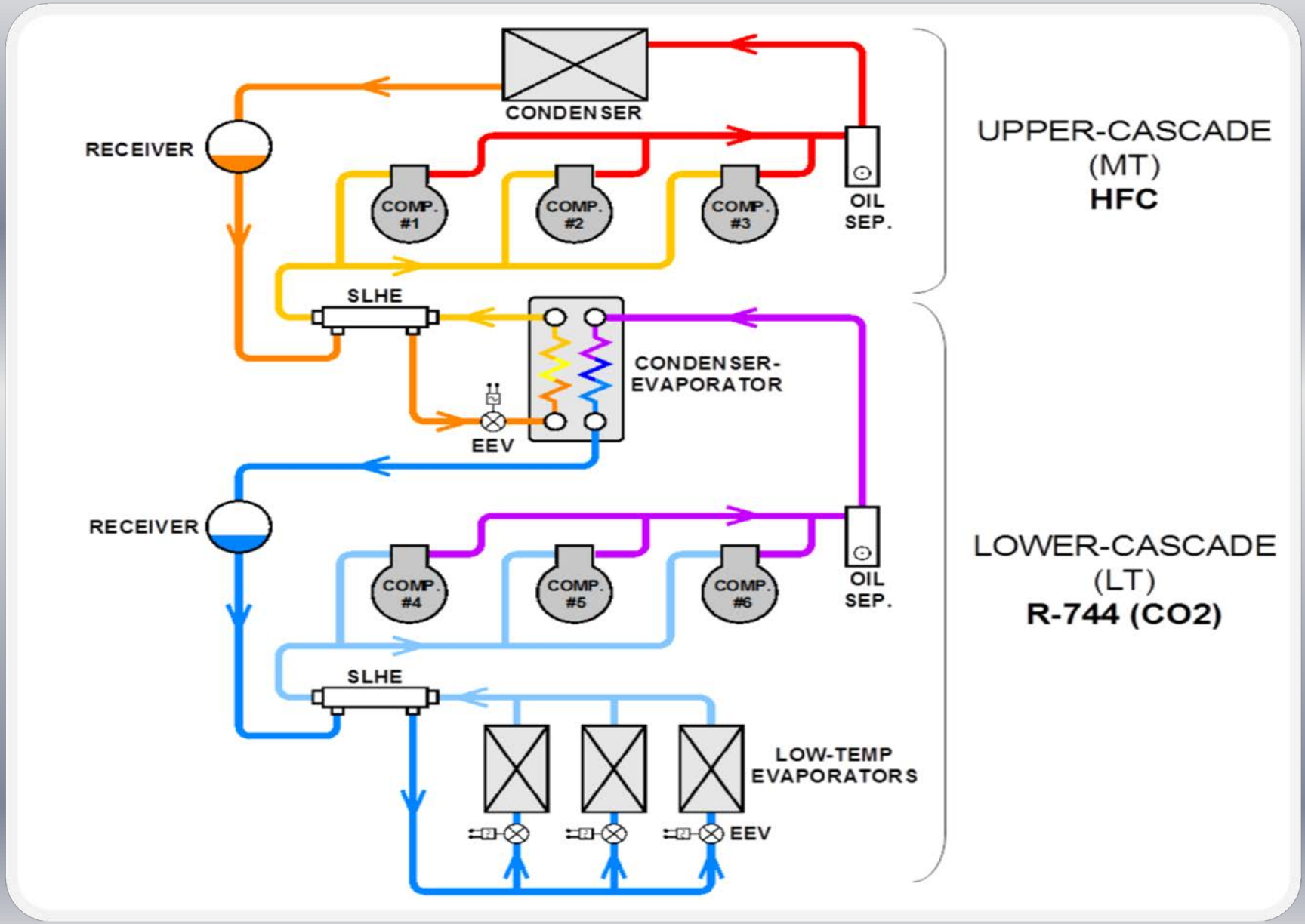
Types of CO_2 Cascade Systems

- Secondary-Low & Medium Temperature
- Cascade (Sub-critical) Low Temperature
- Transcritical Medium Temperature

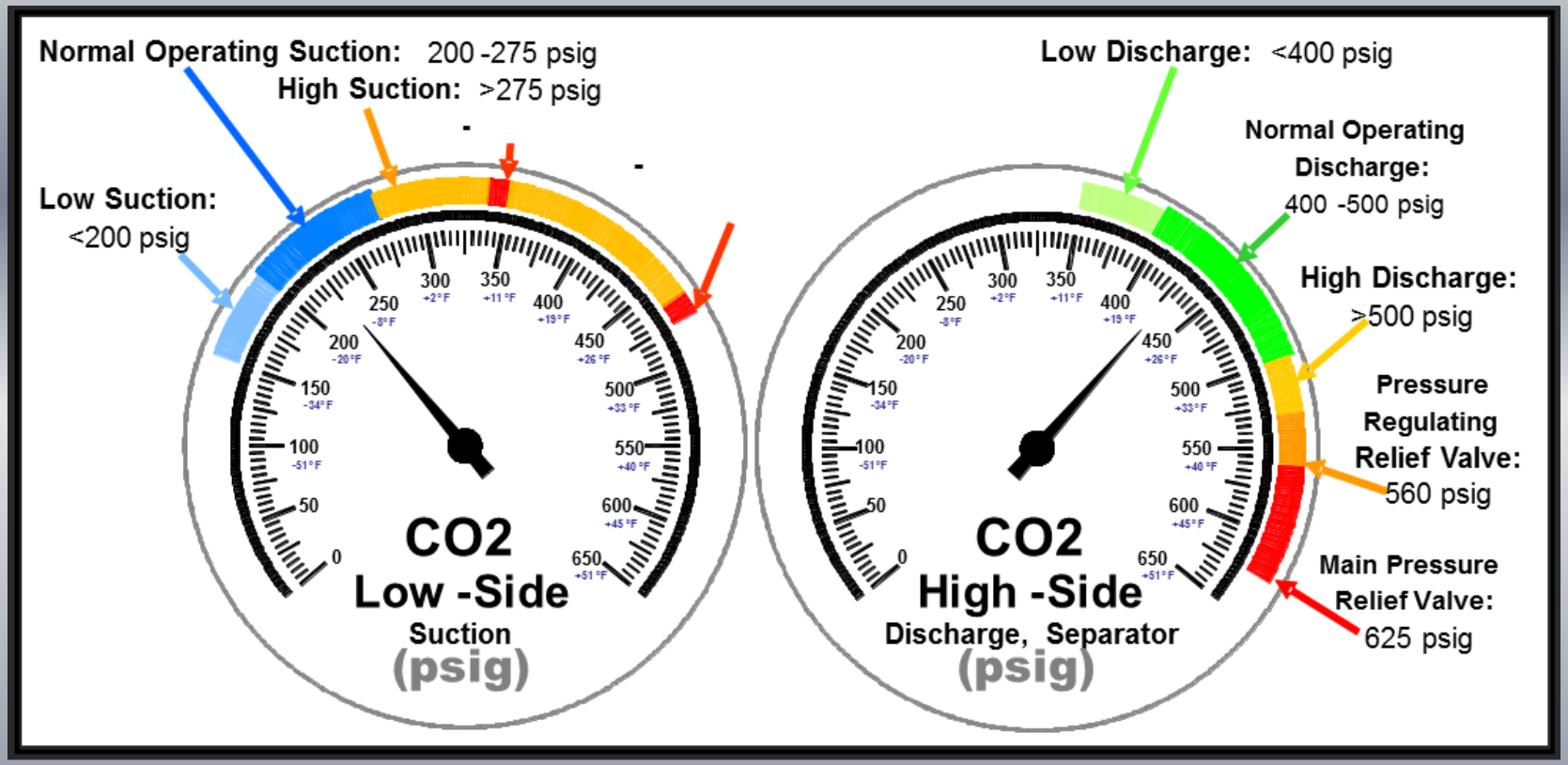
CO_2 Cascade System Types



Low Temperature – CO_2 Cascade System



System Typical Operating Pressures



Low-Side

(Suction)

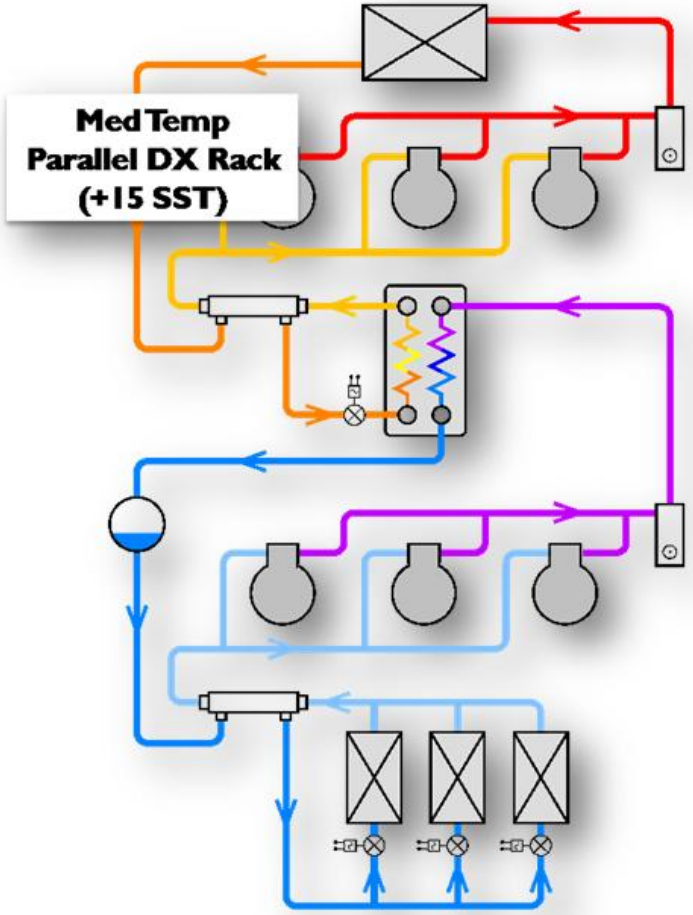
Typ. Operating Suction 200-275 psig

High-Side

(Discharge and Receiver)

Typ. Operating Discharge 400-500 psig

Low Temperature – CO_2 Cascade System



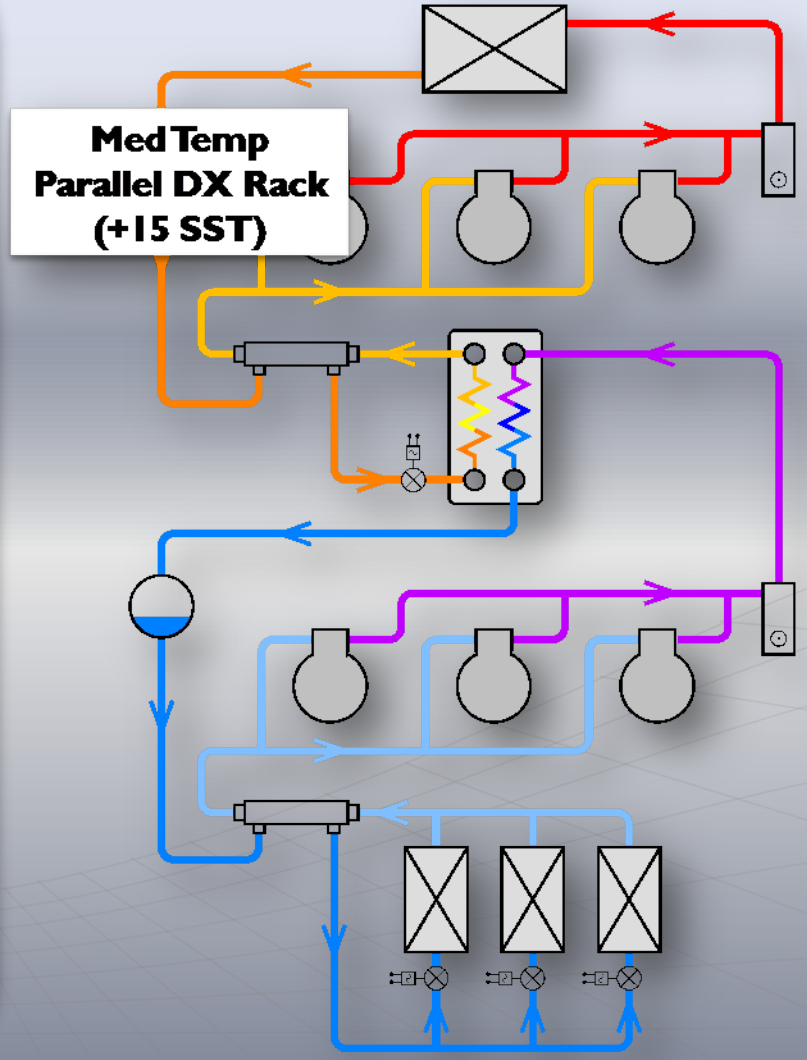
Low Temperature – CO_2 Cascade System

Advancing CO_2 technology will lead to better energy vs. traditional DX systems

- Low temperature system that compresses CO_2 to an intermediate pressure (425 psig = 25 degF).
- Even smaller copper piping than CO_2 Secondary.
- Uses components easily available in the aftermarket.
- Better heat transfer properties of CO_2 and better TD's lead to higher compressor SST and better energy efficiency.
- Widely available, low cost natural refrigerant with nearly zero global warming potential.

LTX2 Cascade Operations and Features

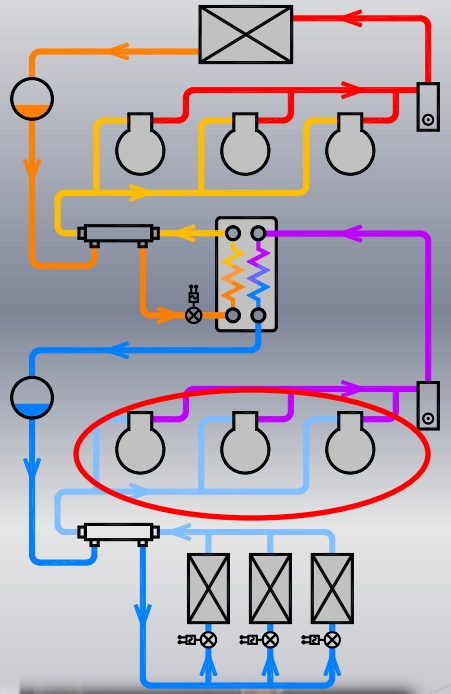
- Utilizes CO_2 as a direct expansion cascade refrigerant for the low-temperature system.
- Uses efficient and quiet CO_2 subcritical compressors.
- Evaporators designed specifically for use with CO_2 as a direct expansion refrigerant.
- Display cases and freezers are equipped With EEV's for steady, automatic control of superheat leaving the evaporators.



Low Temperature – CO_2 Cascade System

CO2 Compressors:

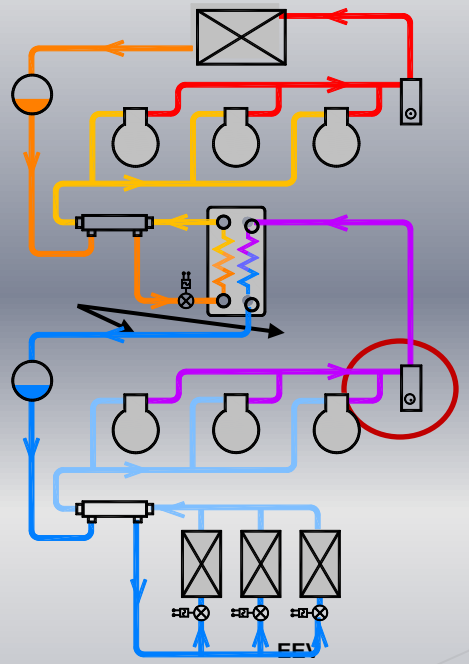
- Typical 3-5 Units in Parallel
- Types Available:
  - Reciprocating – Bitzer
  - Scroll – Emerson
- Accessories:
  - High Pressure Switch
  - Low Pressure Switch
- Capacity Control:
  - VS on Reciprocating
  - Digital Scroll
- UL for Both Models



Low Temperature – CO_2 Cascade System

Oil Separator:

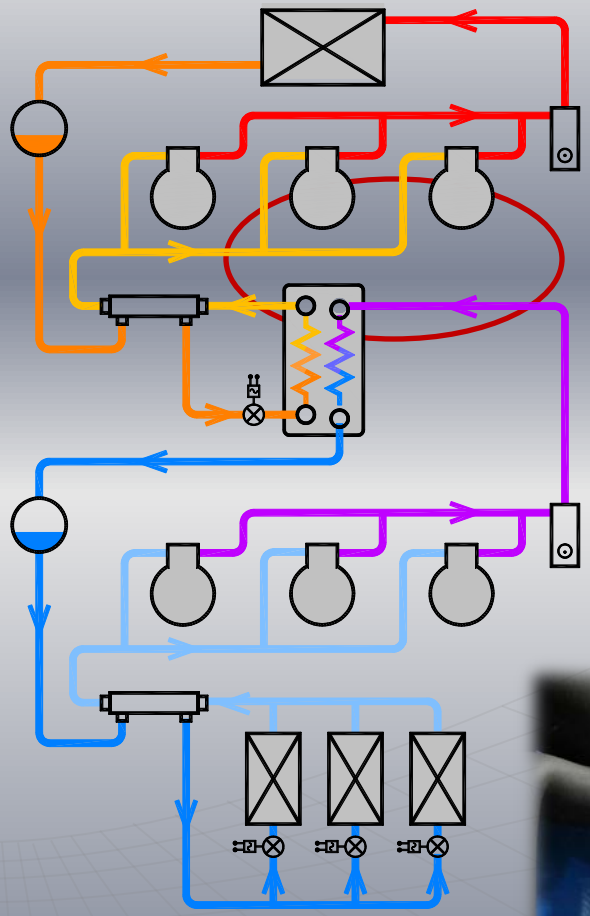
- Removes Most of the Oil Carried Over from Compression
- Accessories:
  - Oil Filter
  - Sight Glass



Low Temperature – CO_2 Cascade System

Condenser-Evaporator:

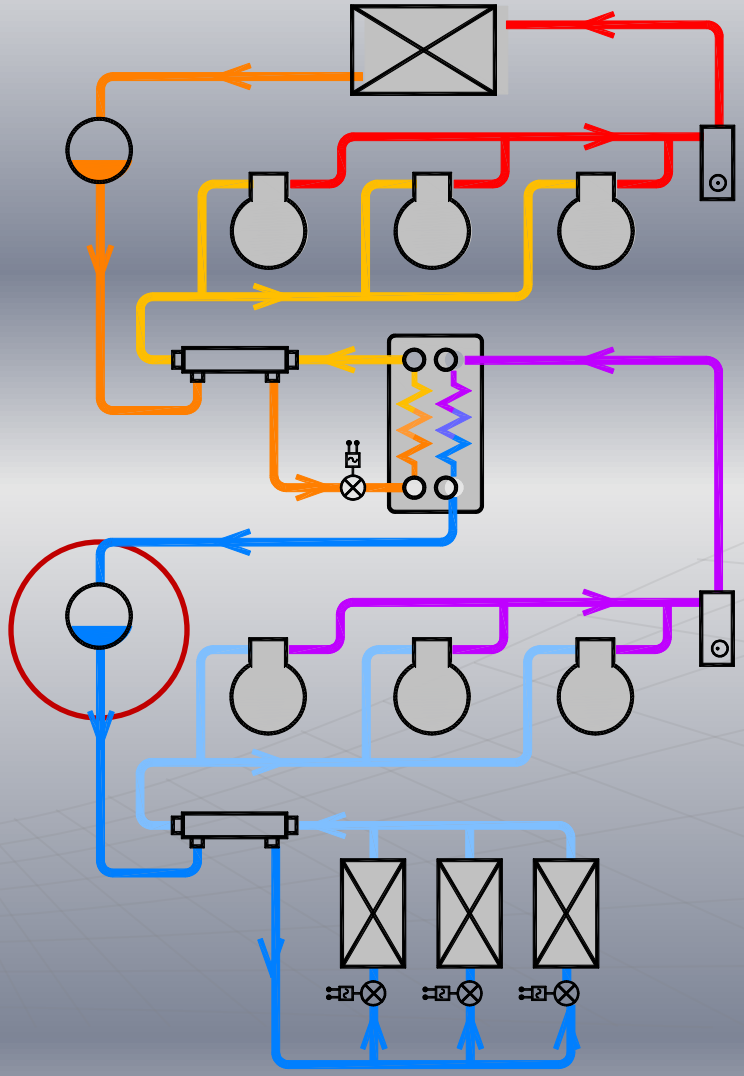
- Condenses CO2 Discharge Gas into Liquid
- Evaporates Primary HFC Refrigerant
- Typically 2-4 Units in Parallel



Low Temperature – CO_2 Cascade System

CO2 Receiver:

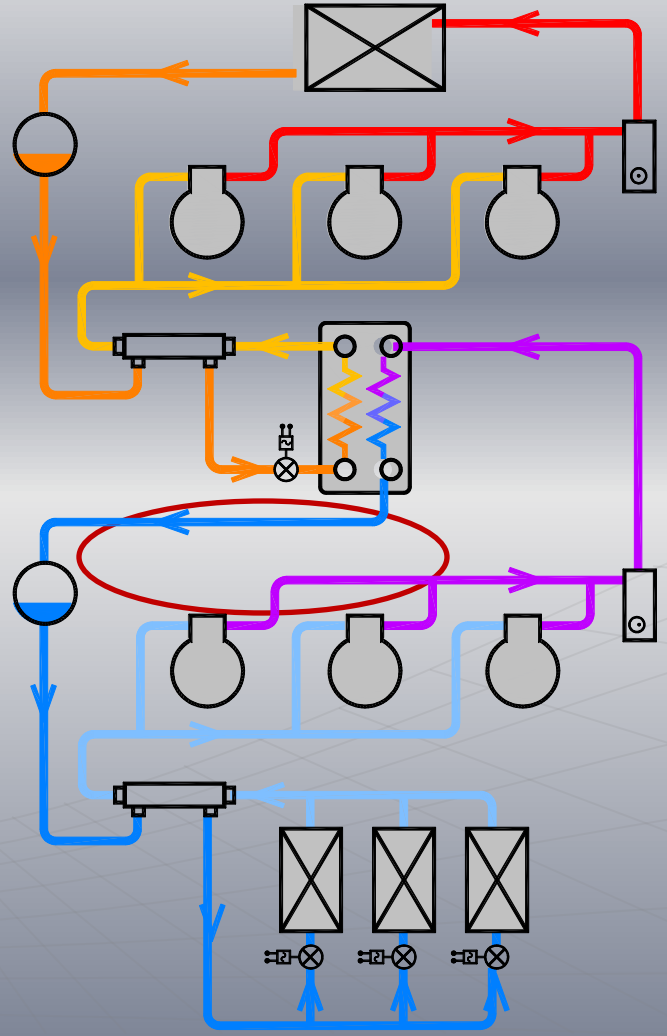
- Compensates for Level Fluctuations during Defrost
- Can be UL or ASME Vessel
- Accessories:
  - Sight Glasses
  - Dual Pressure Relief Valve
  - Liquid Level Switch
  - Liquid Filter-Drier
  - Charging Valve



Low Temperature – CO_2 Cascade System

Evaporator Electronic Expansion Valves:

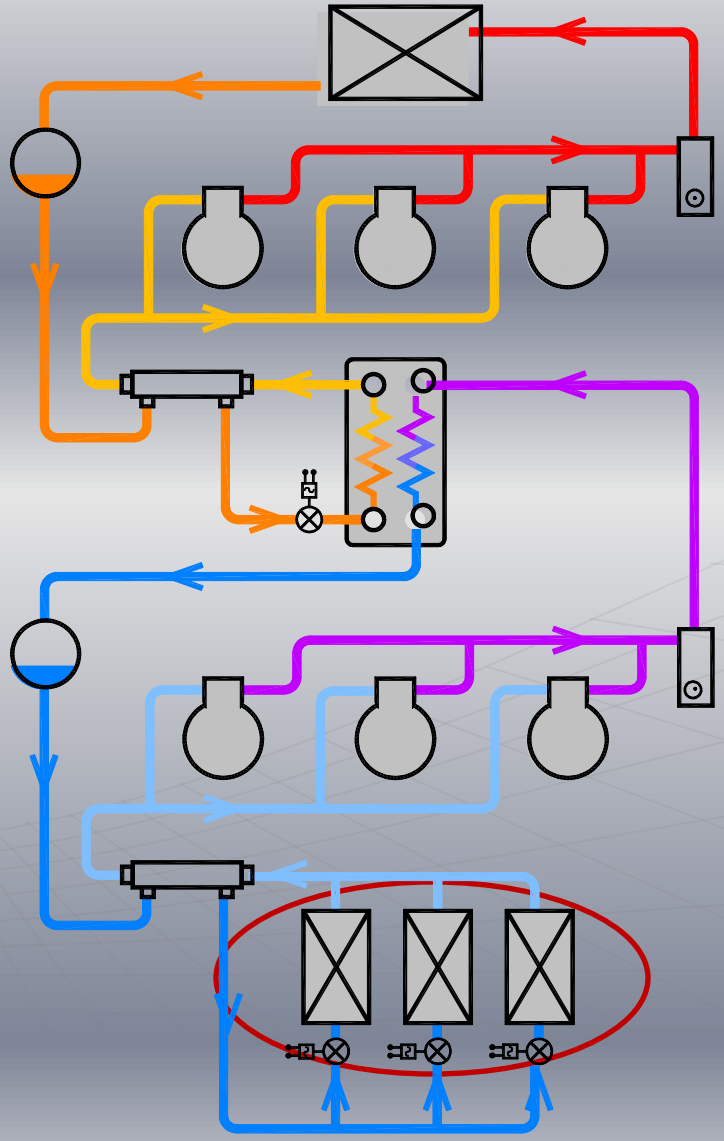
- Regulates flow of CO2 into Coil to Maintain Desired Superheat
- Stepper or PulseValve from
- Accessories:
  - Pressure Transducer
  - Temperature Probe



Low Temperature – CO_2 Cascade System

Evaporator Coils:

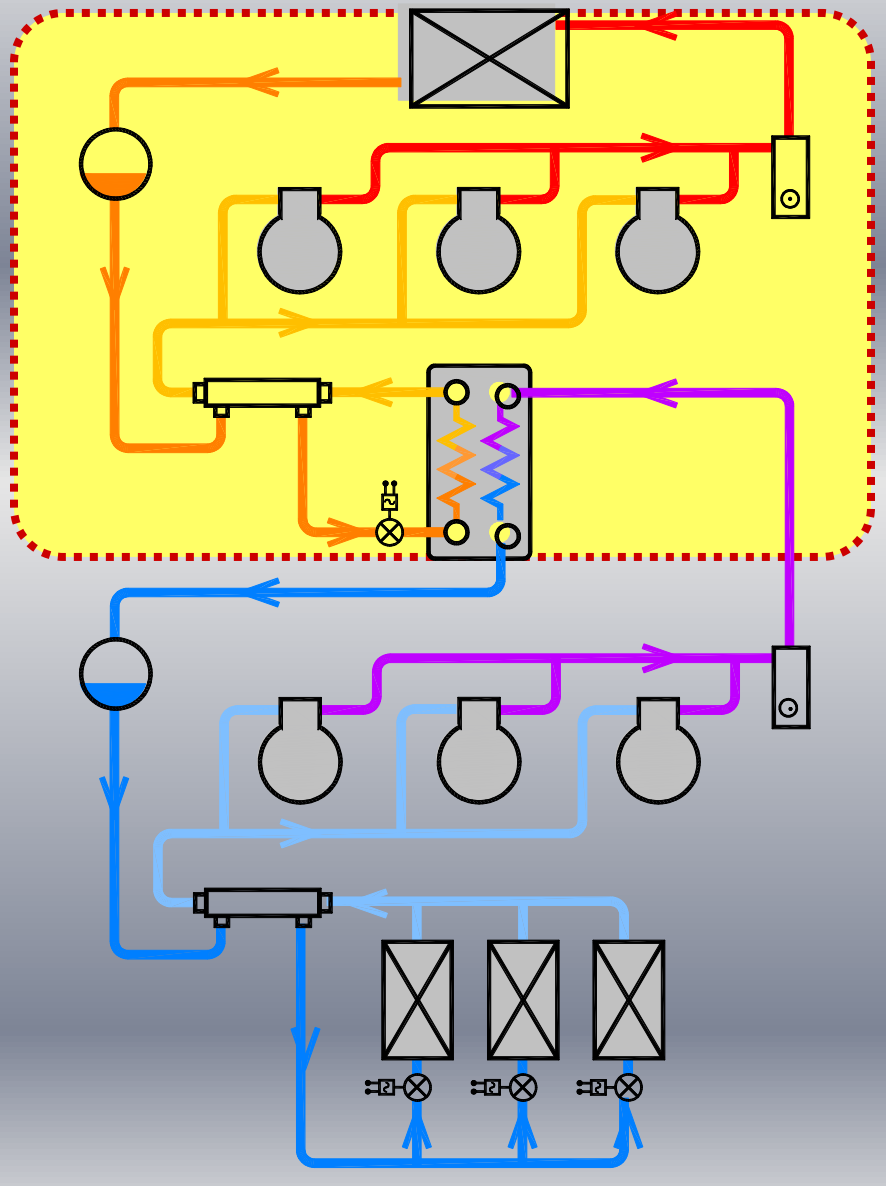
- Evaporates CO2 to Refrigerate Case or Walk-In
- Hill PHOENIX Display Cases
- Heatcraft's RPD Unit-Cooler
- Same Cross-Section as HFC DX but Re-Circuited for CO2
- Electric Defrost
- Accessories:
  - SLHE
  - Solenoid from Sporlan (possibly one per circuit, if needed)



Low Temperature – CO_2 Cascade System

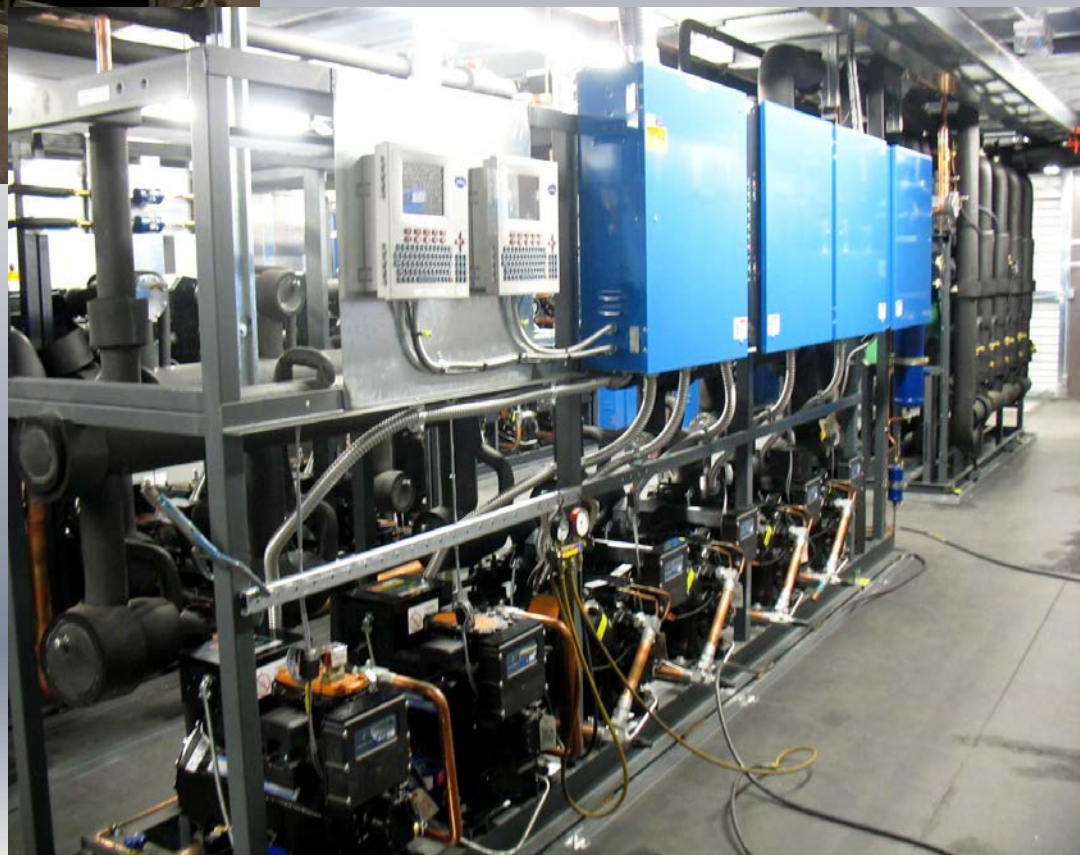
Upper-Cascade:

- Refrigerates Condenser of Lower-Cascade
- Can Refrigerate other MT Loads Also (either DX or Secondary Coolant)
- Typical HFC System



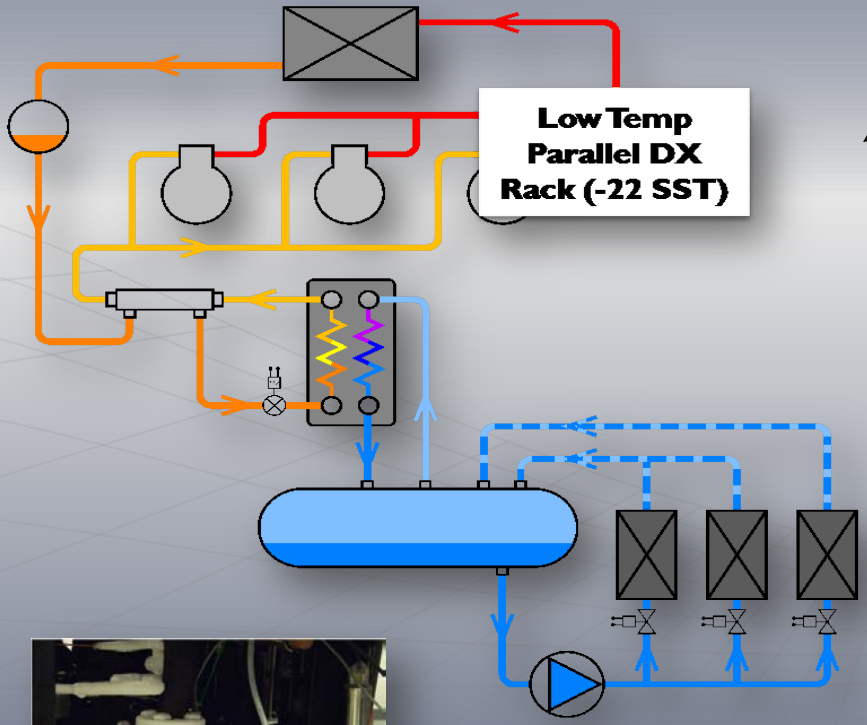
Upper-Cascade Systems

- Any refrigerant
- Any compressor
- Any condenser

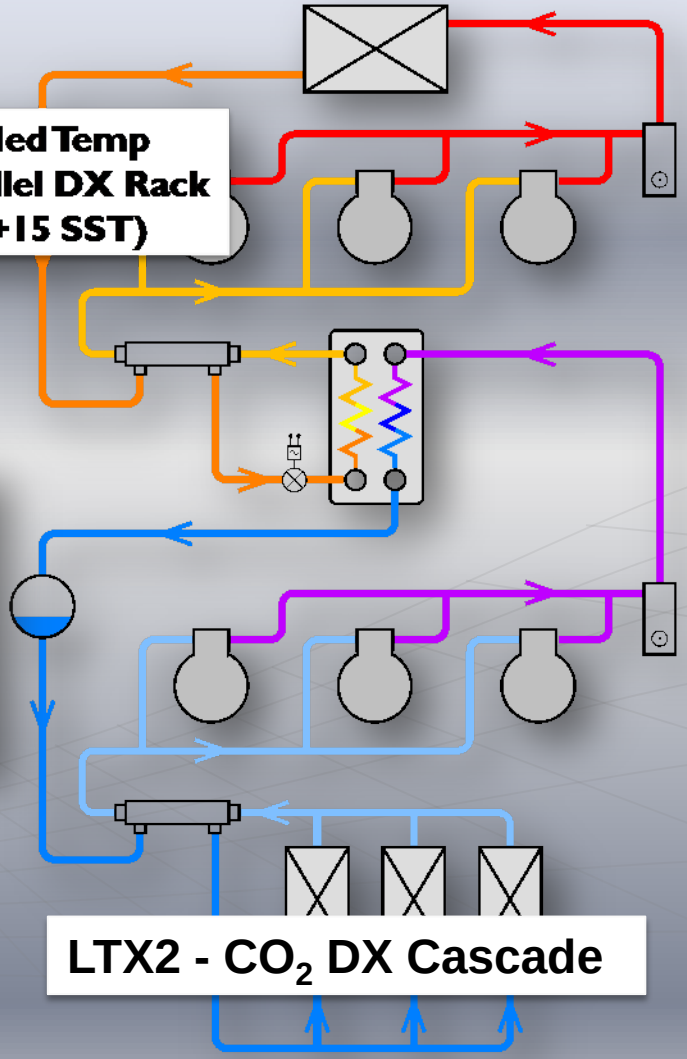


The Difference Between Secondary & Cascade

- Pumps vs. Compressors
- HFC Rack SST

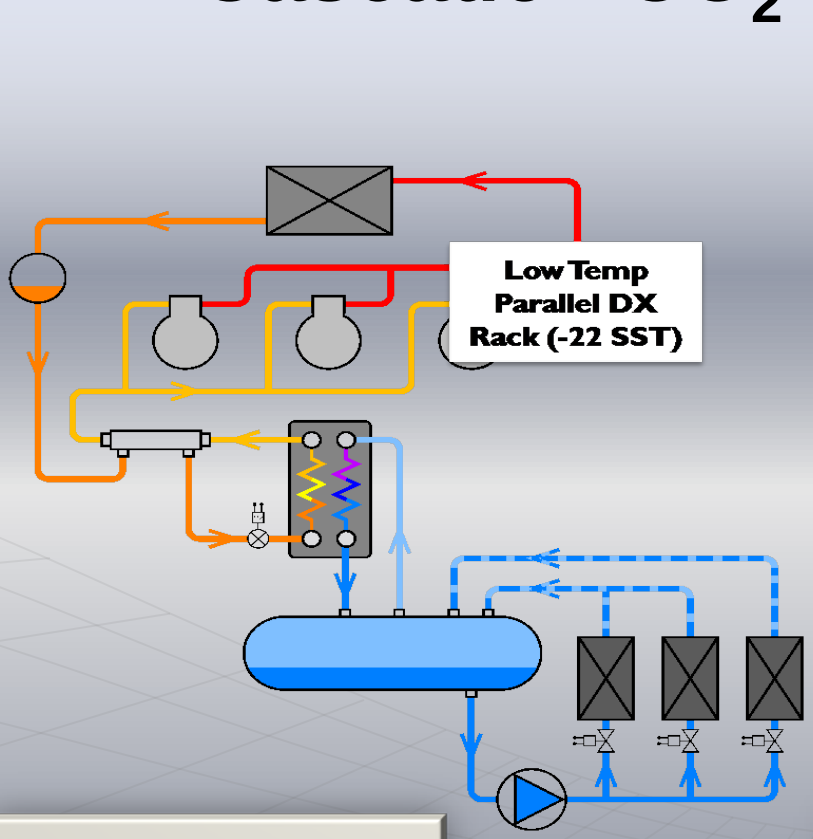


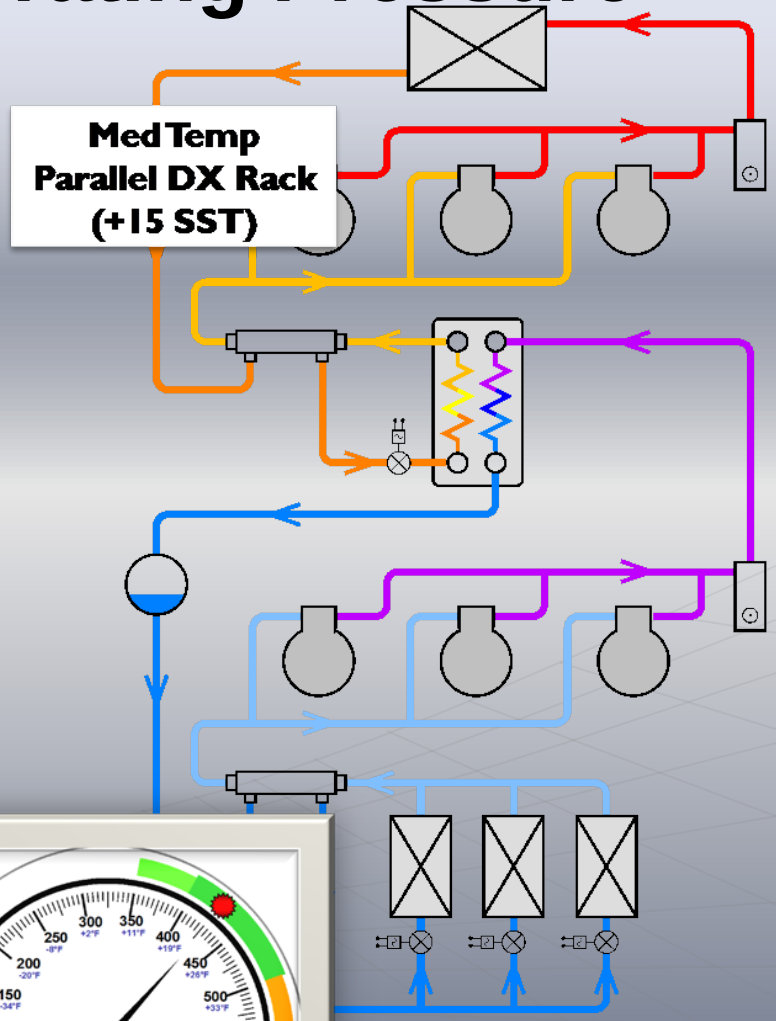
LT2 - CO_2 Secondary

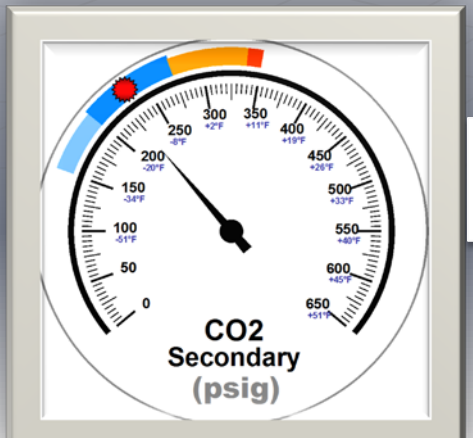


LTX2 - CO_2 DX Cascade

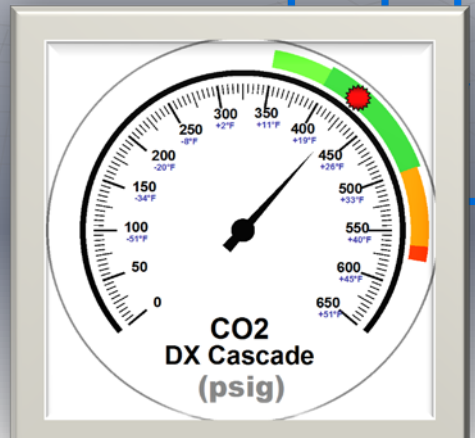
The Difference Between Secondary & Cascade - CO_2 Operating Pressure





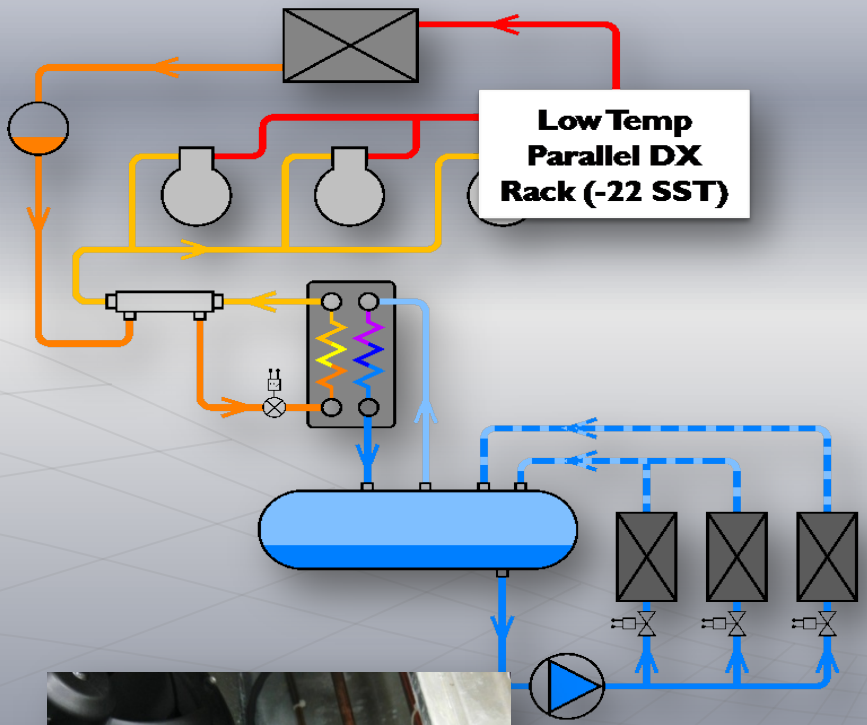


LT2 - CO_2 Secondary

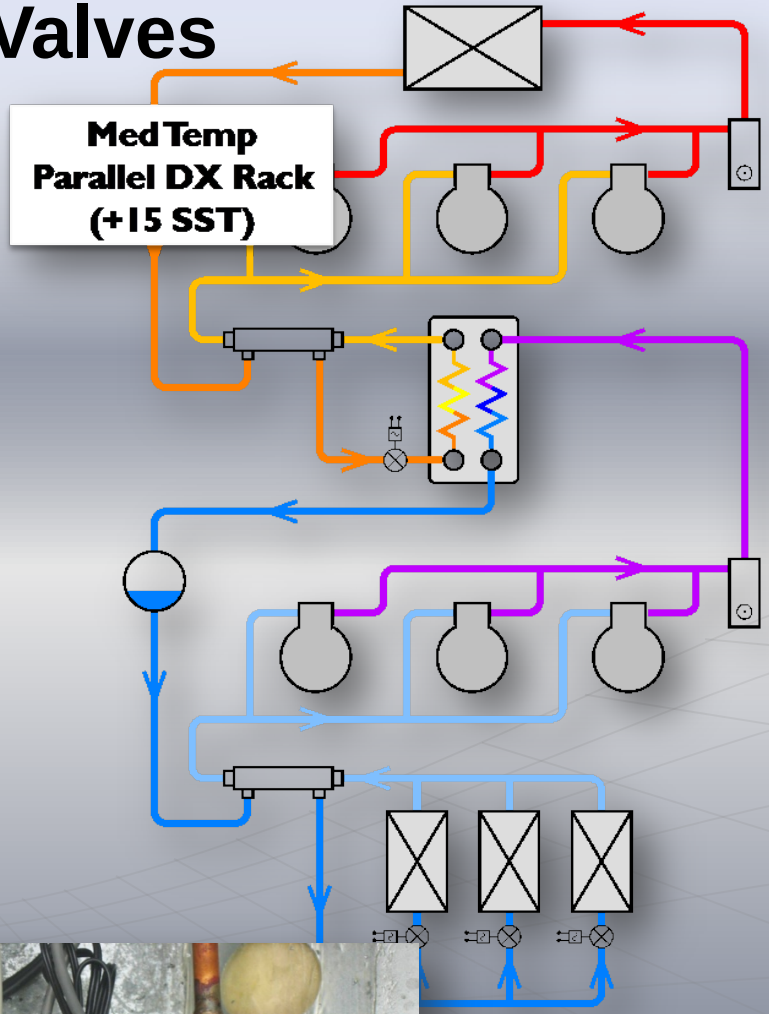


LTX2 - CO_2 DX Cascade

The Difference Between Secondary & Cascade Case Control Valves



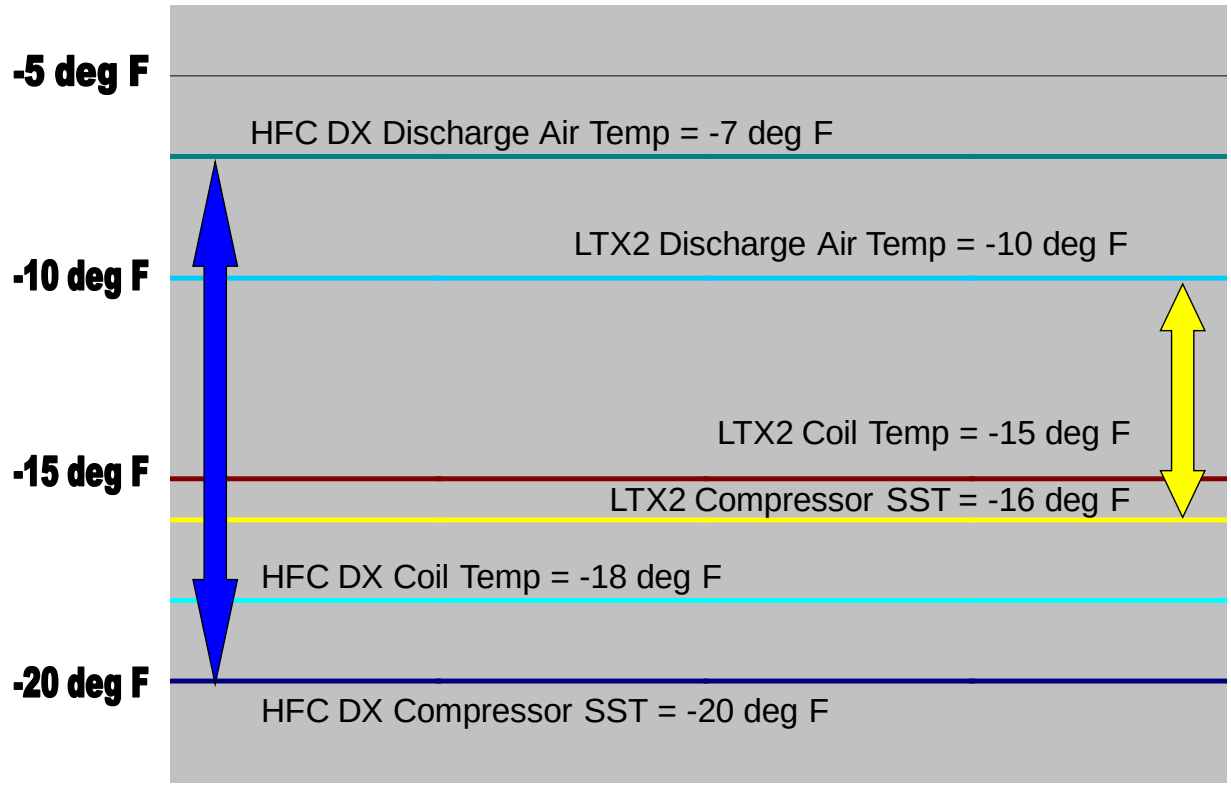
LT2 - CO_2 Secondary

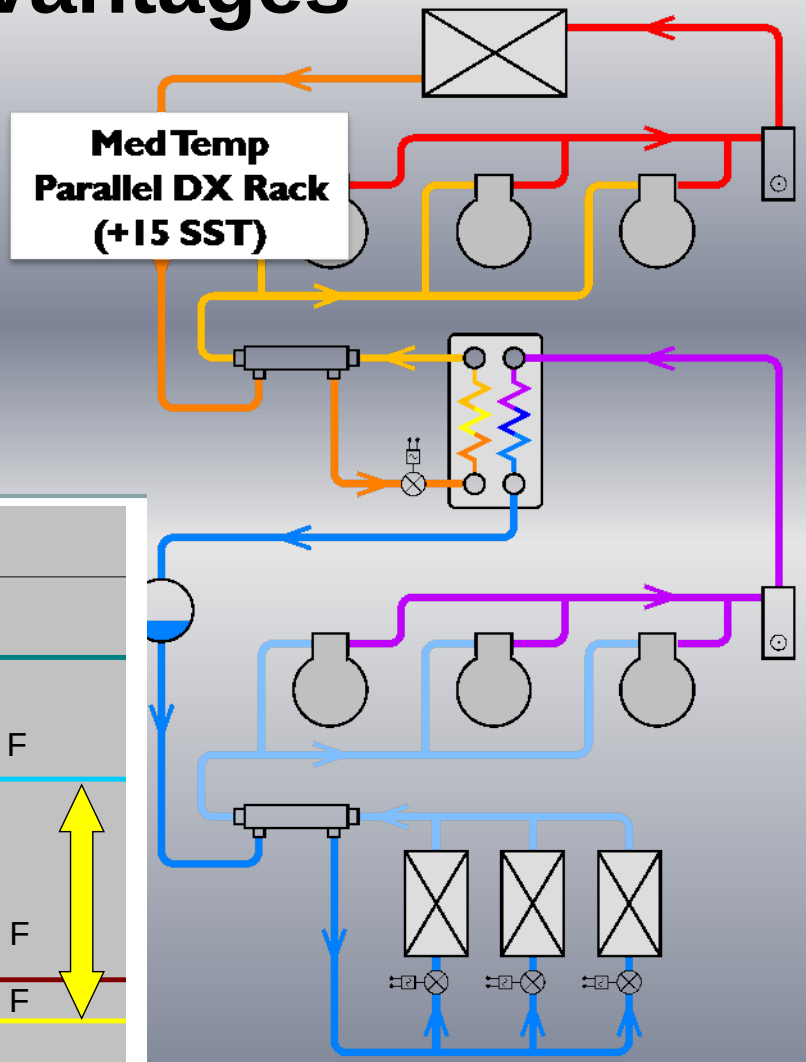


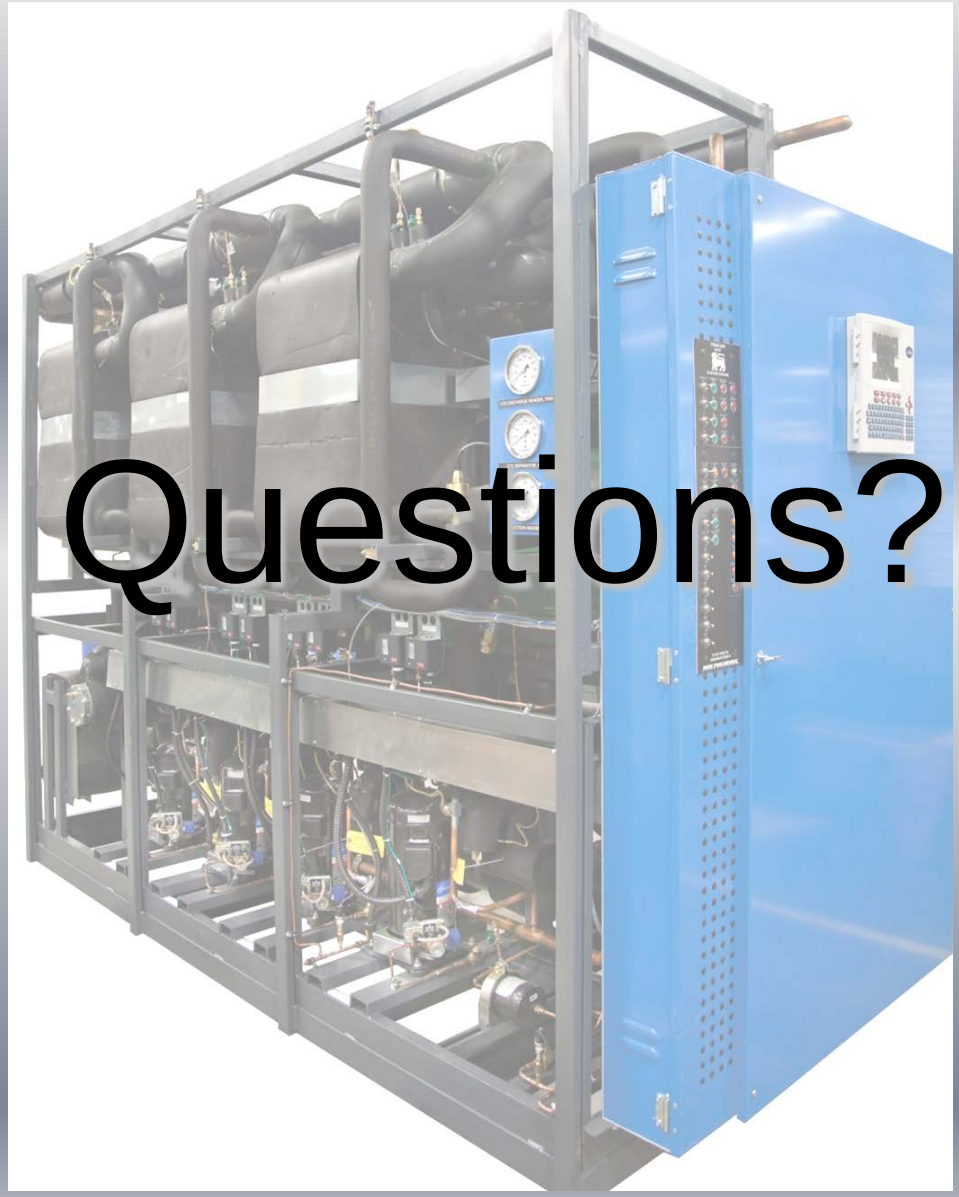
LTX2 - CO_2 DX Cascade

LT Cascade Advantages

- Smaller line sizes than HFC DX
- Lower energy consumption for CO2 Cascade systems
- Better heat transfer on CO2 side for higher compressor SST
- Coil TD's better than DX Systems






Questions?