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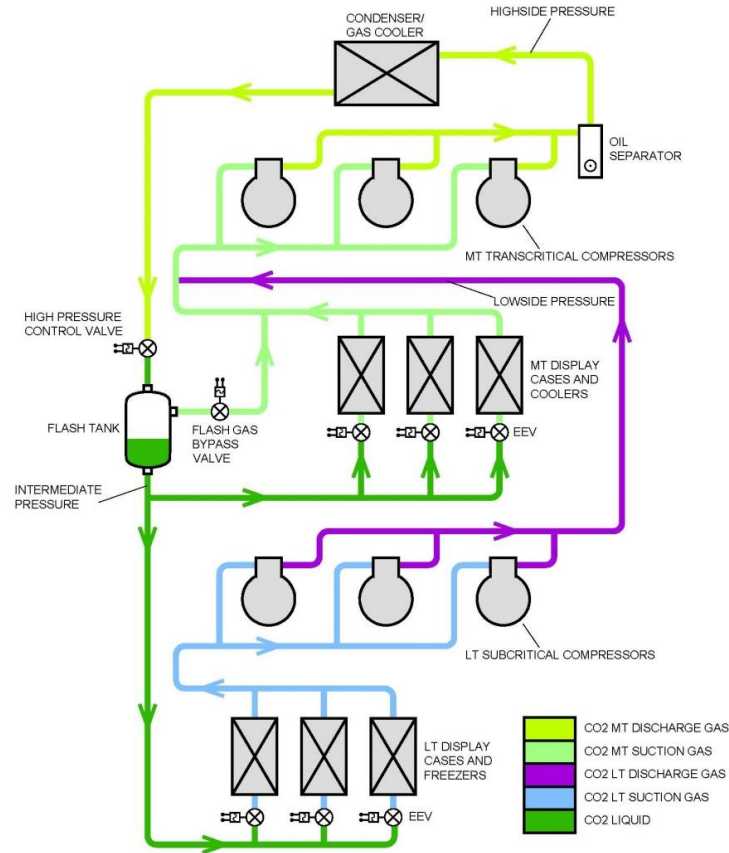
Lab study of an Advansor Transcritical CO₂ System with Parallel Compression and a Gas Ejector System

**Jeff Newel
Hillphoenix**

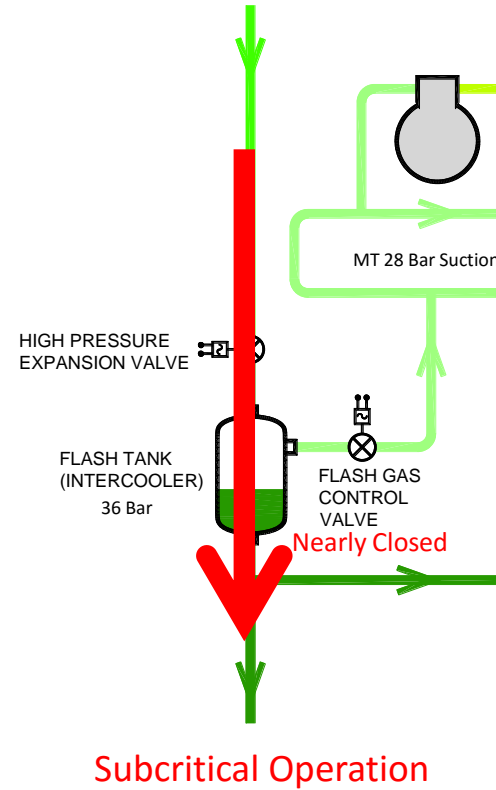
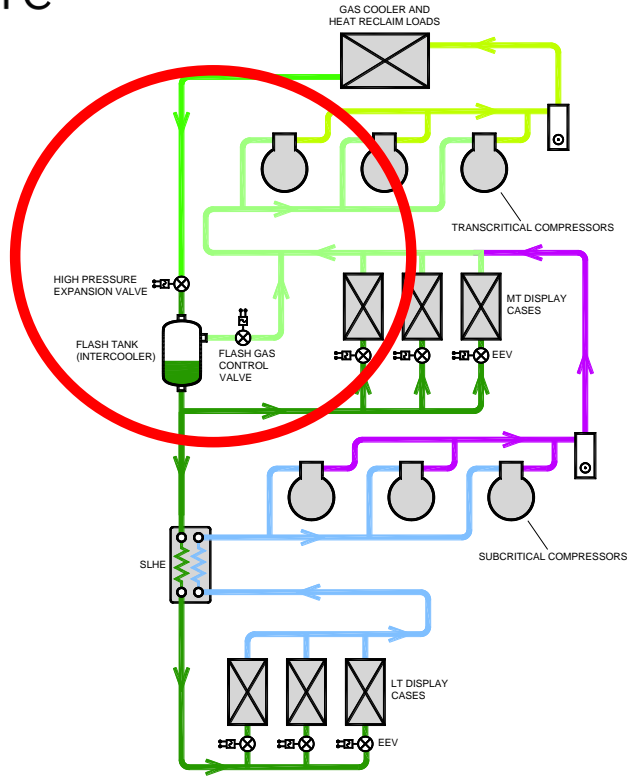
Overview

- Standard Advansor Booster System
- Addition of Parallel Compression and a Gas Ejector System
- How the Ejector works
- Lab System Overview
- Testing Expectations
- Compare the results: Standard ICMTS control .vs. Parallel .vs. Parallel with Gas Ejector

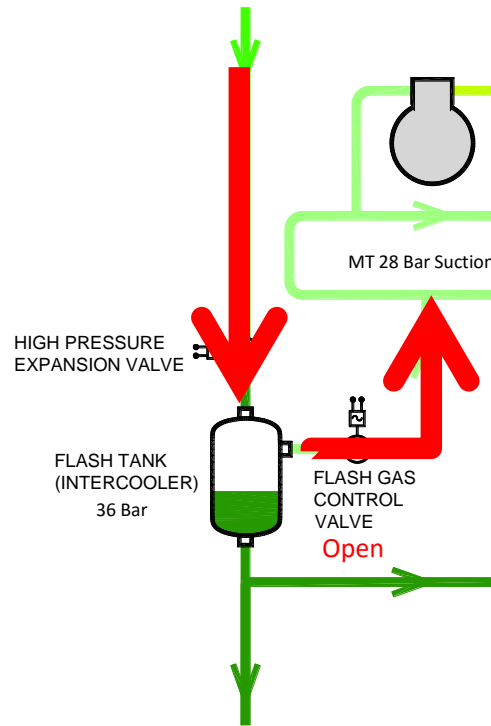
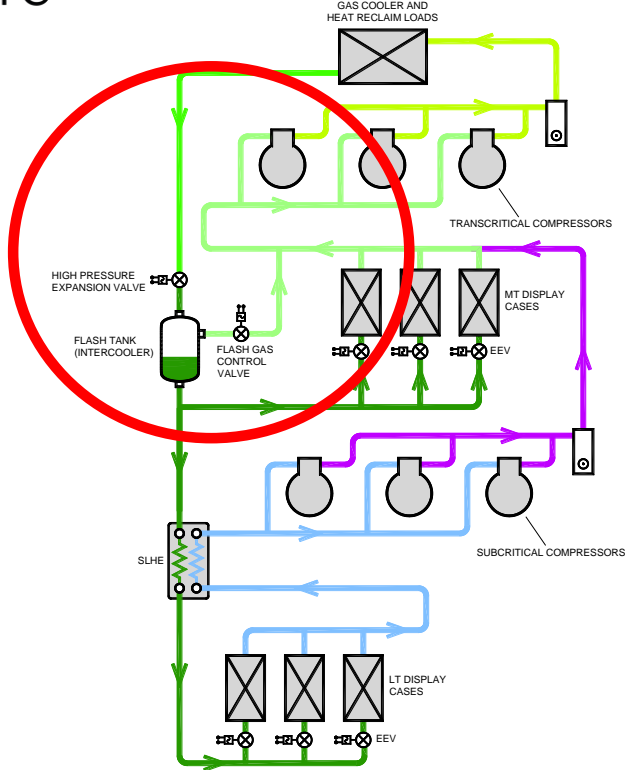
Standard Advansor CO2 Booster System



Standard Advansor Booster System

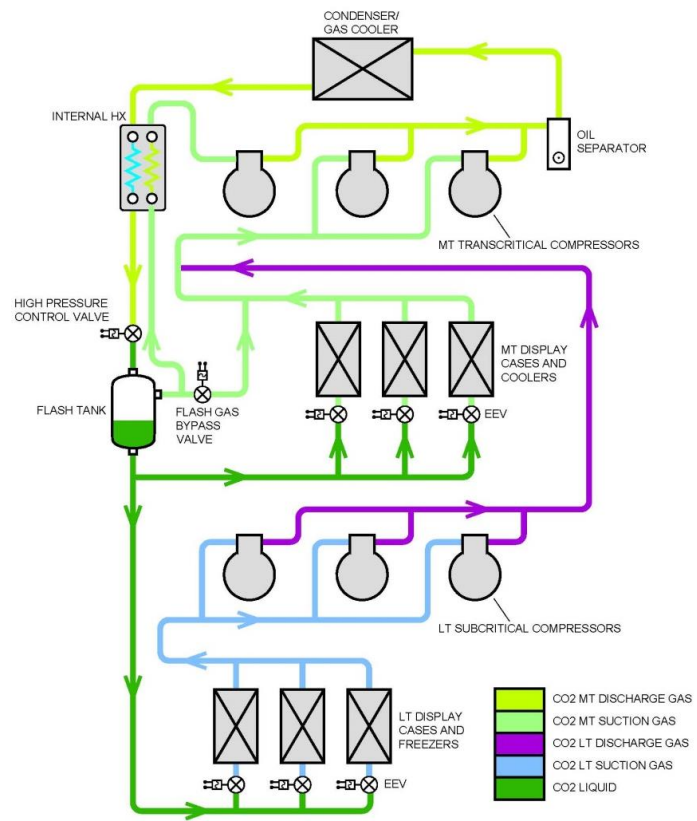
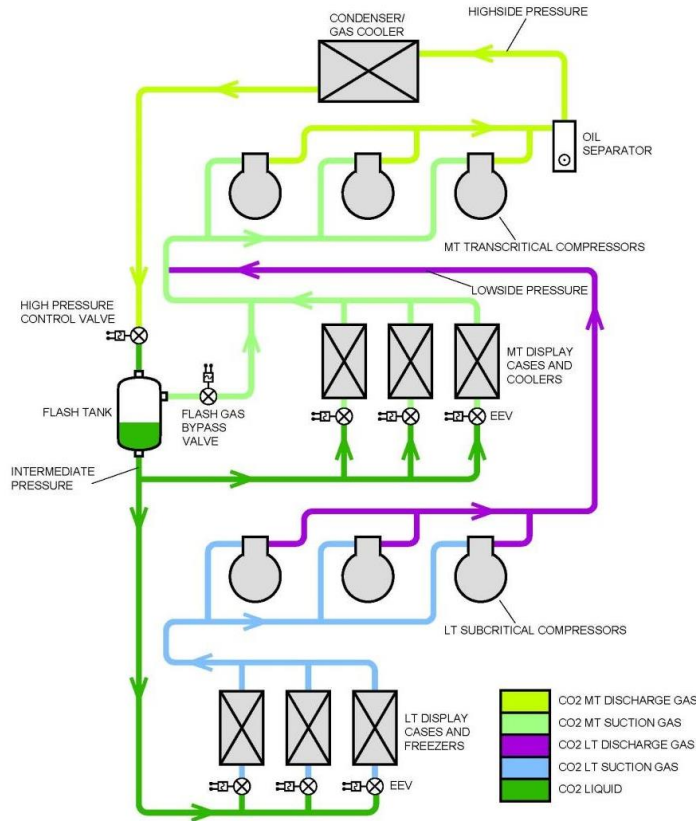


Standard Advansor Booster System

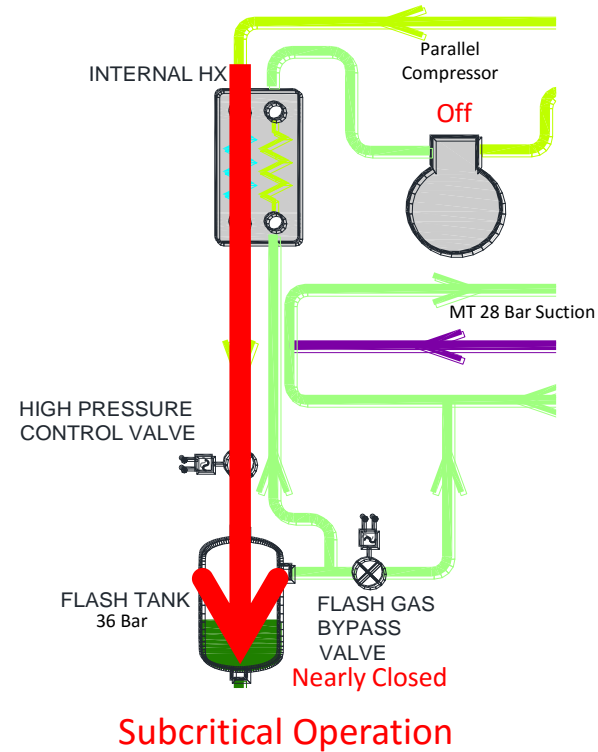
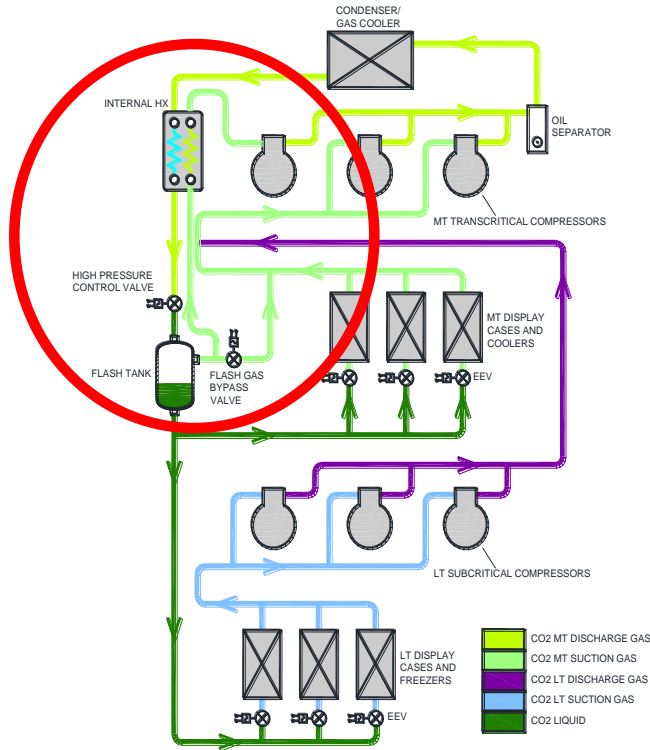


Supercritical Operation

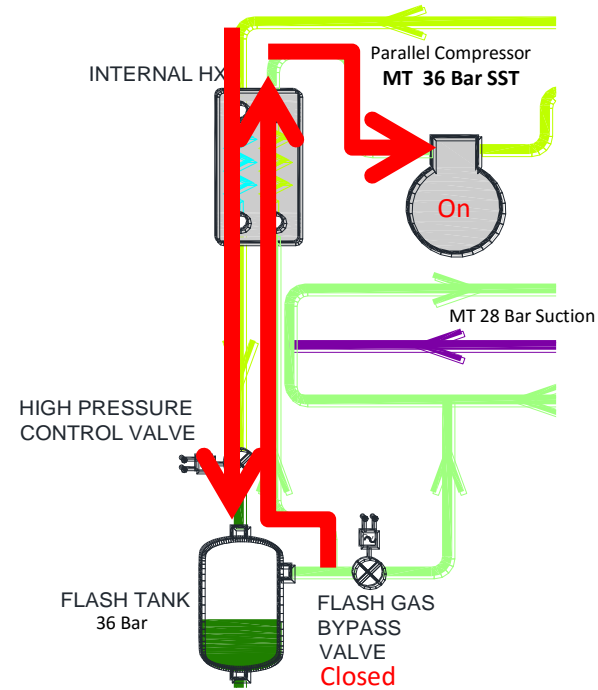
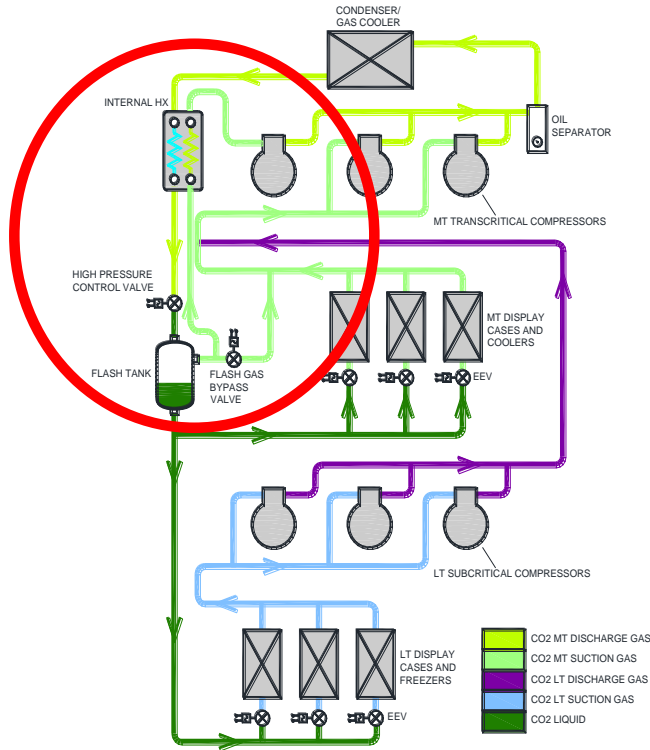
Advansor C02 Booster System with Parallel Compression



Parallel Compression

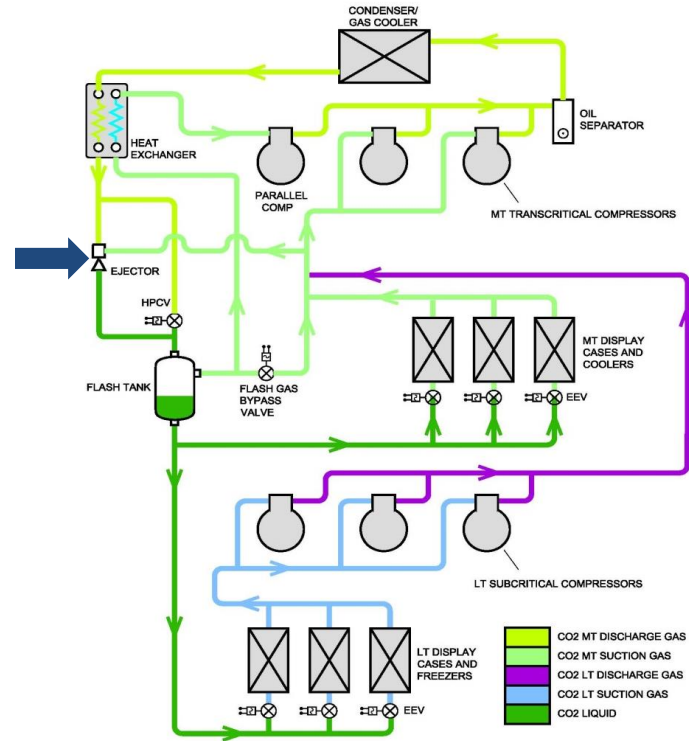
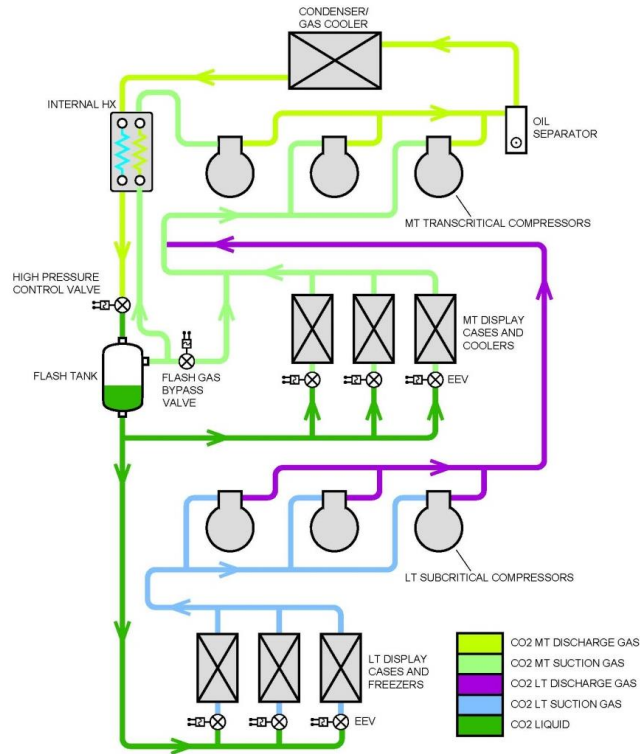


Parallel Compression

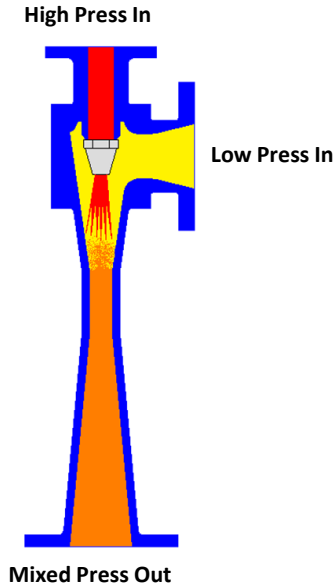


Supercritical Operation

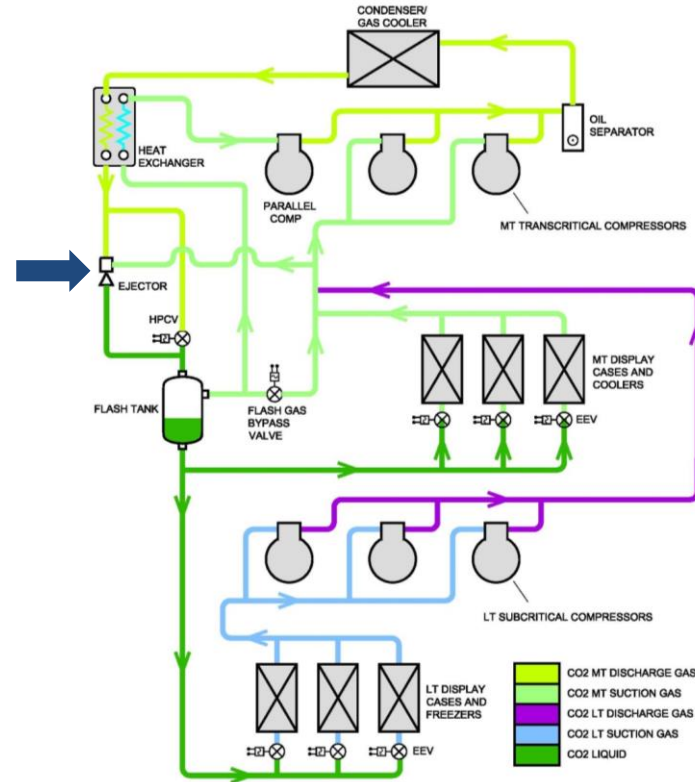
Advansor CO2 Booster System with Parallel Compression And Gas Ejector



Advansor CO2 Booster System with Parallel Compression And Gas Ejector



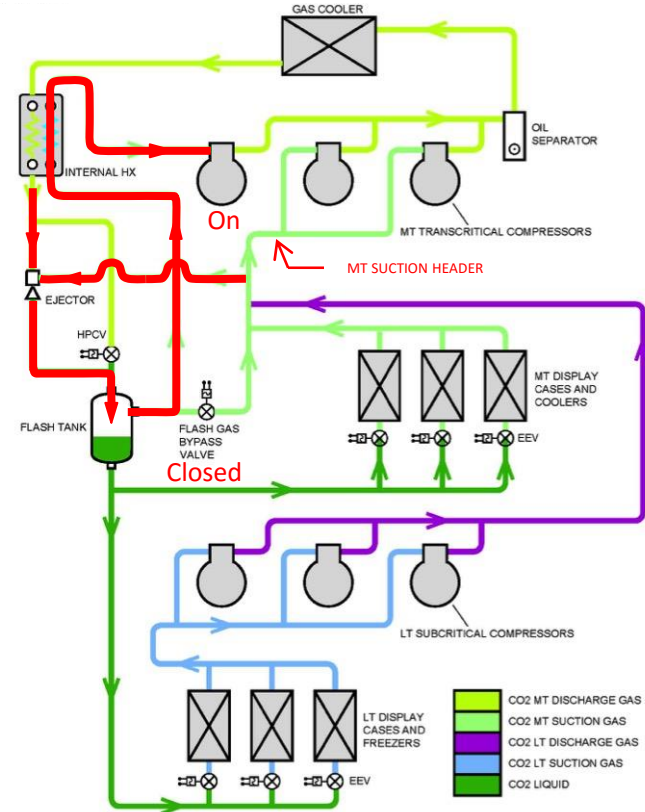
The Sugar Engineers, Google Images



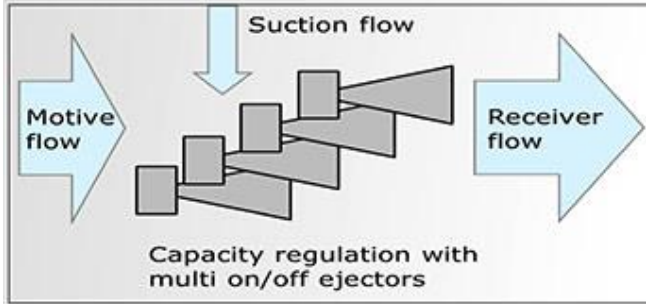
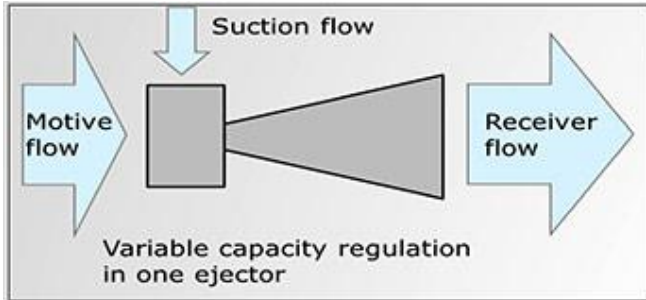
Advansor C02 Booster System with Parallel Compression And Gas Ejector

Operation

- Flash Gas Bypass Valve is Closed
- Parallel Compressor is On
- MT C02 Gas From LT Compressor Discharge and MT Loads is Lifted by Ejector to Flash Tank Pressure
- Like Parallel Compression C02 Gas is Compressed at a Higher Suction Pressure Than MT Suction
- Can Save Energy Year-round



Ejector Types

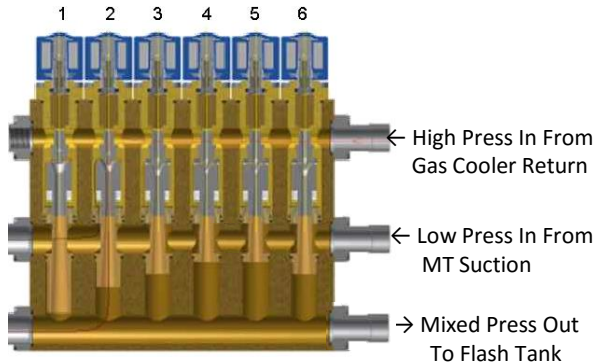
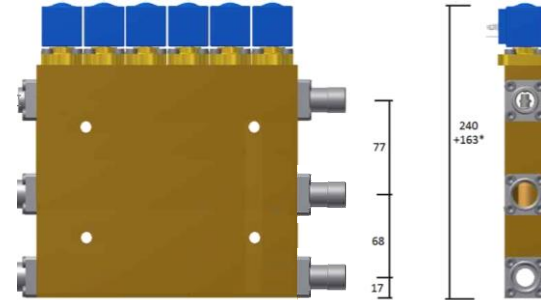
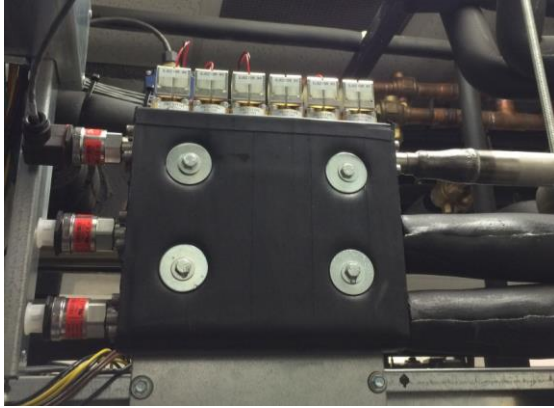


Carel Modulating Ejector



Danfoss Multi Ejector

Danfoss Ejector Assembly



Ejector Cartridges with internal check valves

Test System Loading

Low Temp (LT) Load: ≈ 50 MBTUH @ -20°F SST

Medium Temp (MT) Load: ≈ 75 MBTUH @ $+20^{\circ}\text{F}$ SST

Interstage Temp (IT) [parallel compression]
Capacity Range: 30-70 MBTUH @ $+39^{\circ}\text{F}$ SST

- Test loads are a mixture of display cases and false load



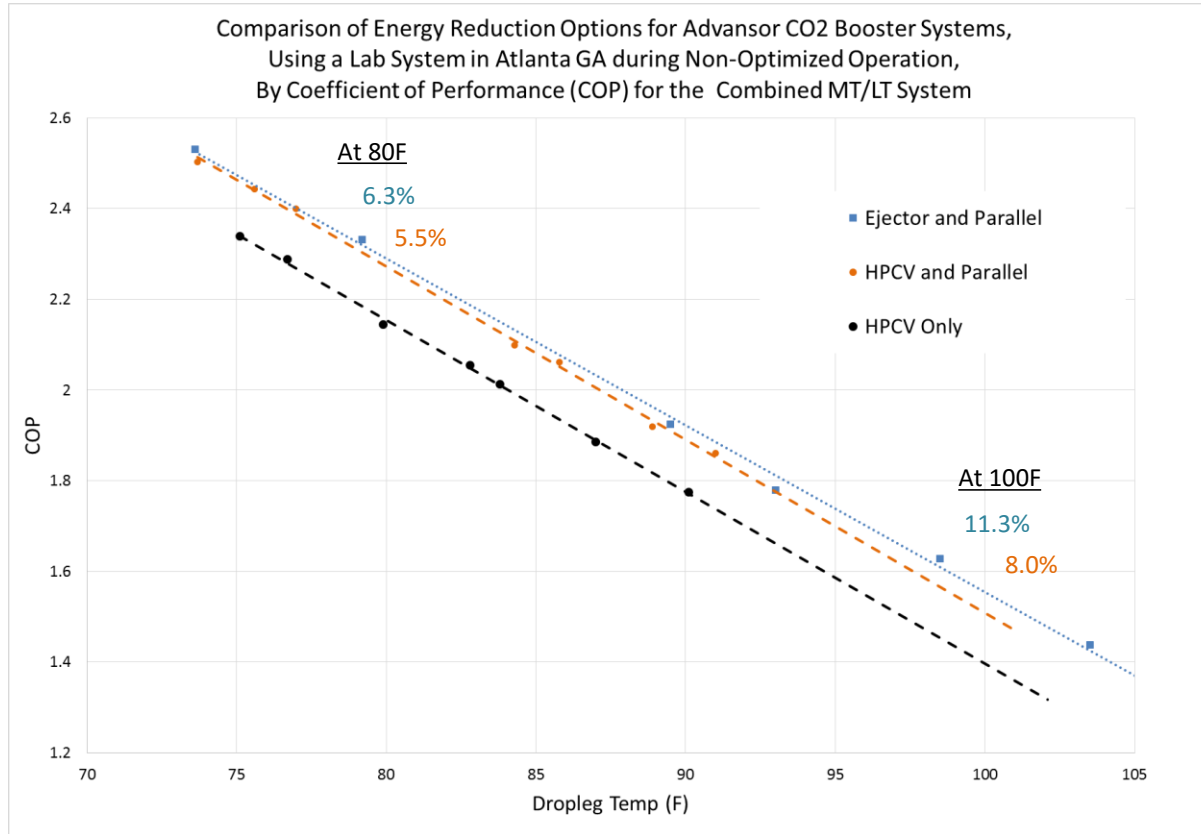
Theoretical expectations

- Energy Reductions vs. a Standard High Pressure Control Valve (HPCV) System
 - Parallel Compression
 - Peak savings of 12% - 17%
 - Annual Savings 6% - 8%
 - Ejector with Parallel Compression
 - Peak savings of 15% - 20%
 - Annual Savings 8% - 10%

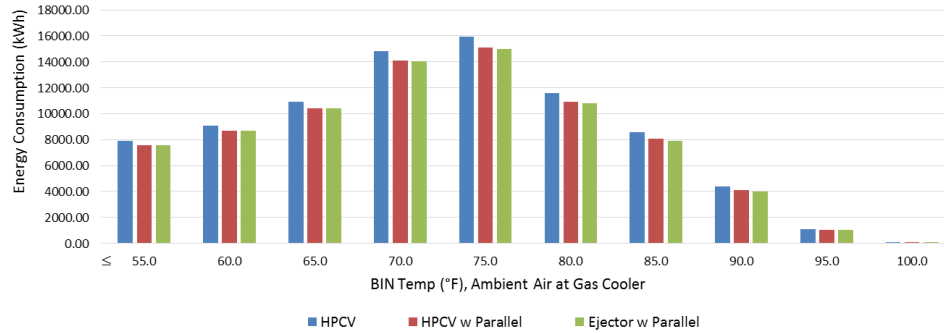
Testing at Less Than Optimum Conditions

- Flash Tank Pressure: Testing at 38 bar(g), Optimum 33 bar(g)
- Load is more LT than typical, most applications have the LT load \approx 30% of the total load, this test was \approx 40%. These options improve MT COP so a higher % LT load makes their overall system COP benefit appear smaller.
- Small test system loads combined with a larger than ideal IT compressor cause parallel compression to operate less efficiently and turn off sooner so savings is decreased.

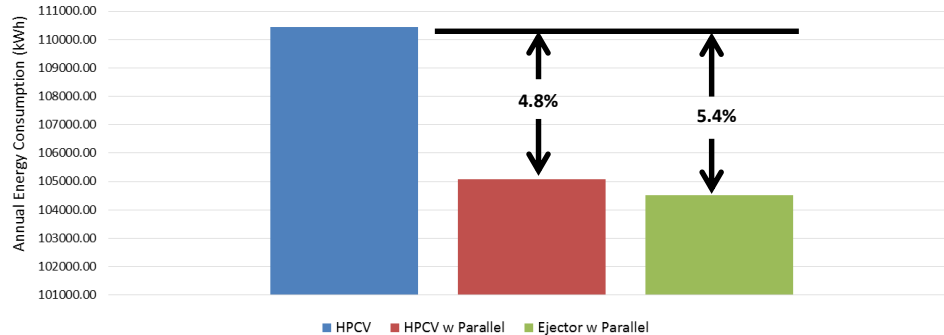
COP Data



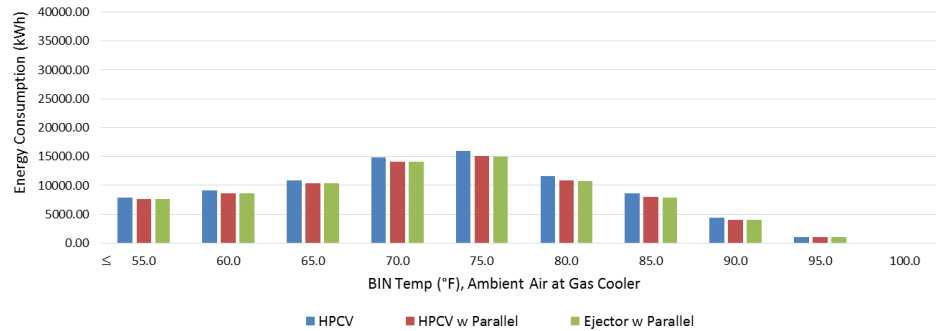
Theoretical Comparison of Energy Reduction Options for Advansor CO2 Booster Systems by Temperature Bin
 Based on: Non-Optimized Operation in Atlanta GA, with Normalized Reqr'd Load, Using Total System EER



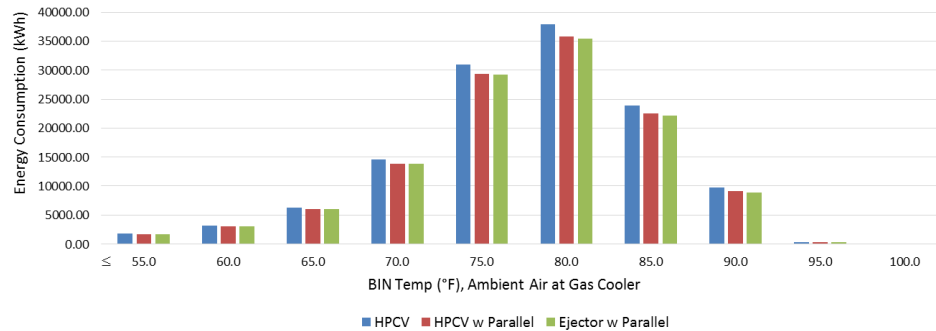
Theoretical Comparison of Energy Reduction Options for Advansor CO2 Booster Systems by Total Annual Energy Consumption
 Based on: Non-Optimized Operation in Atlanta GA, with Normalized Reqr'd Load, Using Total System EER

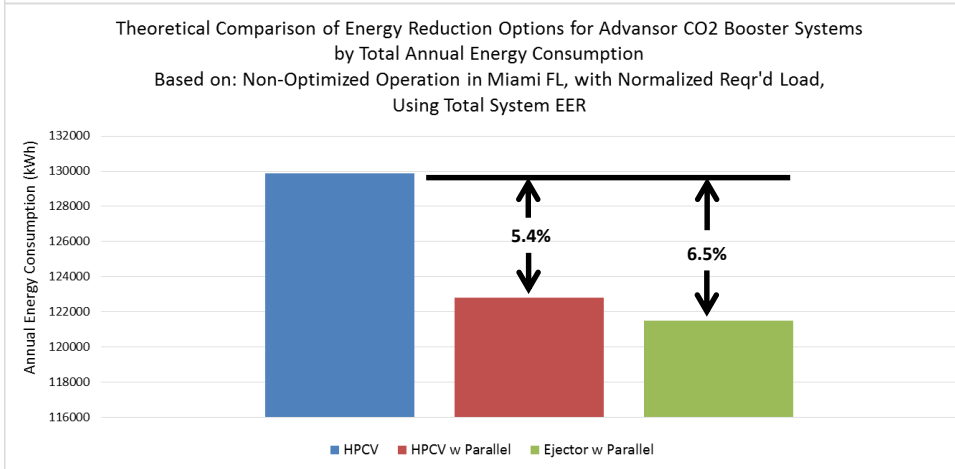
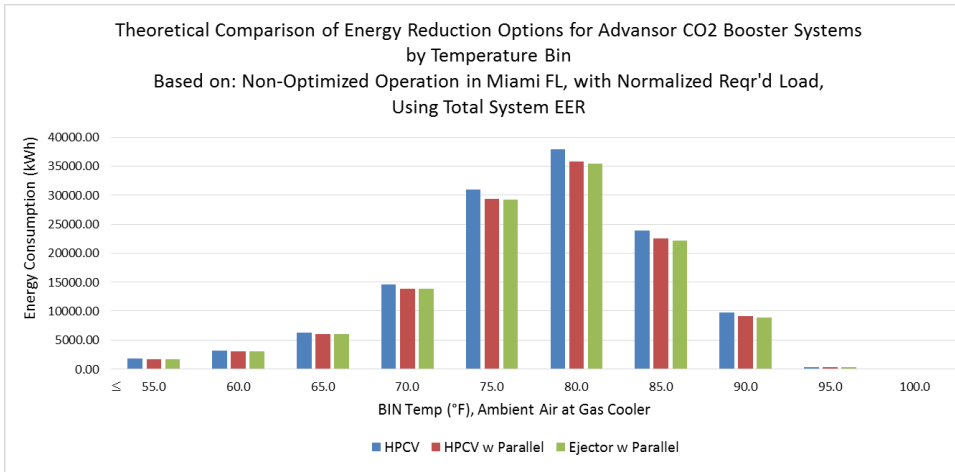


Theoretical Comparison of Energy Reduction Options for Advansor CO2 Booster Systems by Temperature Bin
 Based on: Non-Optimized Operation in Atlanta GA, with Normalized Reqr'd Load, Using Total System EER



Theoretical Comparison of Energy Reduction Options for Advansor CO2 Booster Systems by Temperature Bin
 Based on: Non-Optimized Operation in Miami FL, with Normalized Reqr'd Load, Using Total System EER





Summary

Energy Reductions .vs. a Standard High Pressure Control Valve (HPCV) System in a Warm Climate

		Theoretical Expected	Conyers, GA Non-Optimized	Advansor, DK Optimized
HPCV w Parallel Compression	Peak	12%-17%	8.0%	15%
	Annual	6%-8%	5.4%	7%
Ejector w Parallel Compression	Peak	15%-20%	11.3%	23%
	Annual	8%-10%	6.5%	11%

Hillphoenix Systems in the Field

Parallel Compression

- Mar 2016 – System Operating at Newport Naval Station Commissary
- 500 Advansor Systems w Parallel in Europe

Ejector with Parallel Compression

- May 2017 – **Sprouts** Woodstock GA, First Supermarket with an Ejector System Operating in North America
- 20+ Advansor Systems w Ejector in Europe





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Thank you very much!

