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Cascade CO_2/Ammonia

First Refrigerated Warehouse in USA Using Cascade CO_2/NH_3—Background Drivers

Industrial Case Study session - Part 1

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M&M Refrigeration, LLC

Background Drivers

- **Refrigerant Situation:**

  The phase-out of many of the CFC and HCFC refrigerants, leading to a global phase out agreement known as the Montreal Protocol.

Background Drivers, cont.

- **Ammonia Charge Restrictions and Concerns:**

  Due to various governing authorities, jurisdictions and community resistance to accept large charge industrial Ammonia refrigeration systems within the community, I began to search other alternatives that could provide an efficient low charge industrial Ammonia refrigeration system.

Background Drivers, cont.

- **Ammonia's Damaging Effects:**

  In the unlikely event of a refrigerant leak in the food storage, processing and employee work areas, the Cascade CO_2/NH_3 refrigeration system has no contaminating refrigerants in the food storage, processing and employee work areas.

Background Drivers, cont.

- **Electricity Costs:**

  Electrical costs continue to increase. Our initial calculations seemed to indicate that the CO_2 operating costs could be 3% to 5% more than an equivalent two-stage Ammonia system. After one year of operation we realized the actual costs seemed to be about 5% less than an equivalent two stage Ammonia system.

  Independent third party studies have shown that a Cascade CO_2 Ammonia refrigeration system is approximately 5.8 percent more efficient than an equivalent two-stage Ammonia system for a typical refrigerated warehouse.

Background Drivers, cont.

- **Lower First Costs:**

  The Cascade CO_2/NH_3 system has, in some cases, proven to offer a lower first cost. Factors contributing to the lower costs are:

  - Smaller low stage compressors
  - Smaller suction and discharge piping, valves and insulation
  - Lower refrigerant costs

Background Drivers, cont.

- **Lower Temperatures at Reasonable Costs:**

  The third party independent study concluded that the Cascade CO_2/NH_3 system shows an overall 5.8% improvement in efficiency compared with the conventional two-stage ammonia system. Moreover, the improvement in efficiency of the -58°F (-50°C) and -20°F (-28.9°C) suction groups was 37.3% and 12.3% respectively when compared to the conventional two-stage ammonia system.

System Efficiency Results

Summary of 3rd Party Study

	2-Stage NH3 Reference System [kW/TR]	CO2/NH3 Cascade System [kW/TR]	% Improvement In Efficiency
-20F Suction Group	0.8	0.7	12.3
-58F Suction Group	1.6	1.0	37.3
Combined -20F and -58F Suction Groups	1.2	0.9	28.7
High Temp Suction Group	0.7	0.8	-8.5
Total SystemkW/TR (Compressors)	1.7	1.6	8.1
Total System kW/TR (Compressors and Condenser)	1.9	1.8	6.8
Total System kW/TR (Compressors, Condenser and Air Units)	2.4	2.3	5.8

Background Drivers, cont.

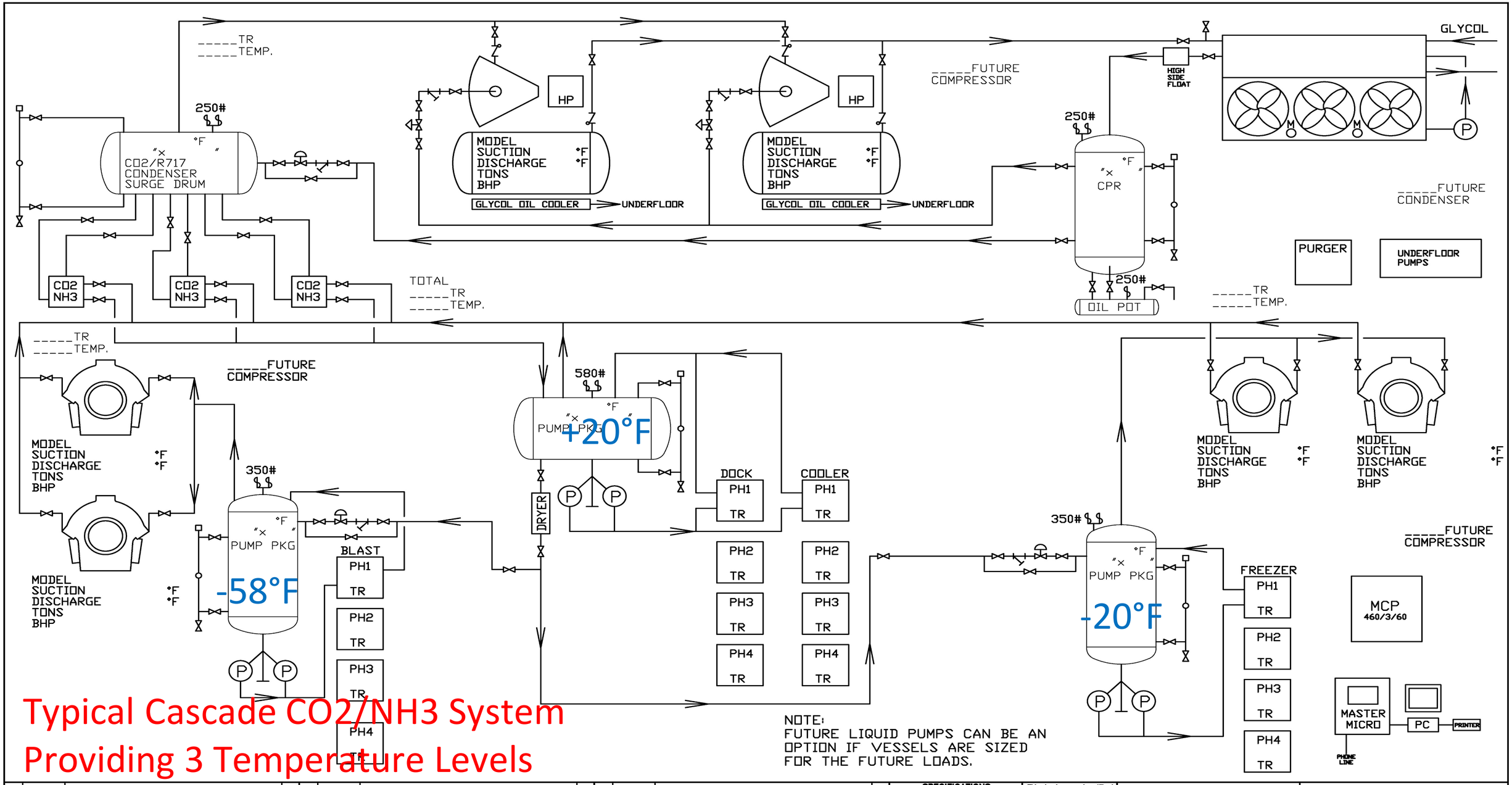
- **Less Space Requirement:**

  Since low stage compressors are much smaller, (approximately 1/8th the size) than an equivalent Ammonia compressor, areas such as the machinery rooms can be smaller thereby reducing the building size and cost.

Background Drivers, cont.

- **Reduced OSHA-PSM & EPA-RMP Requirement:**

  Since most systems are well under the 10,000 pound threshold Ammonia charge, the Occupational Safety and Health Standards—PSM 29CFR 1910.119 and the US EPA Risk Management Program (RMP) Rule are greatly reduced. Some General Duty requirements still apply.



Typical Cascade CO2/NH3 System Providing 3 Temperature Levels

REV	DATE	REVISION	BY

SPECIFICATIONS
DIMENSIONS ARE APPROXIMATE
DO NOT SCALE
DO NOT USE FOR PREFABRICATION OF PIPING

EQUIPMENT WEIGHT

This drawing may be utilized only for the purpose of constructing or installing the work shown thereon at the place of manufacture or the site of the work specified. Any other use of this drawing, including without limitation any reproduction or alteration of this drawing without the prior written approval of M&M Refrigeration is prohibited.

M&M Refrigeration Inc.
P.O. BOX 449 Federalsburg, MD 21632

CO2 CASCADE SYSTEM (5)

DATE	04-12-05
DWG. BY	JWN
P/C	
APP. BY	

DWG. NO. 050330 REV

BM SHEET NO. 1 of 1

CO_2 - Systems

Advantages – Lower first cost - Piping

Piping example – 300TR at -40F

Wet suction, 300ft pipe, two 90 bends, one stop valve				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	°F	PSI	ft / sec
Ammonia	**12"**	1.01	0.31	54
CO2	**6"**	0.96	2.85	23

Dry suction, 100ft pipe, two 90 bends, one stop valve				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	°F	PSI	ft / sec
Ammonia	**12"**	0.29	0.089	68
CO2	**6"**	0.33	1	39

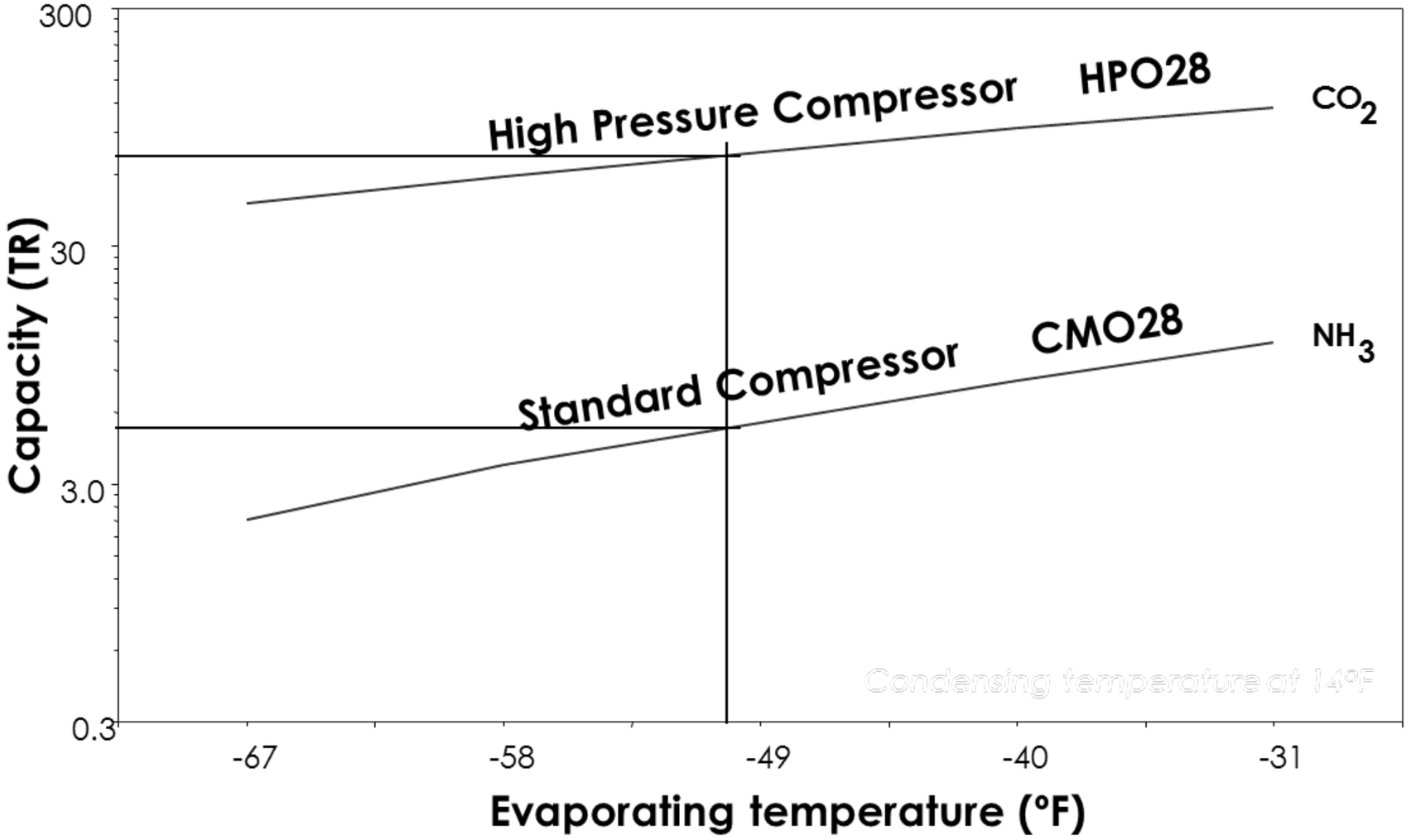
Liquid, 300ft pipe				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	°F	PSI	ft / sec
Ammonia	**2 1/2"**	1.4	1.4	3.6
CO2	**4"**	0.3	1.05	3.5

Discharge, 100ft pipe				
	Pipe size	Temperature drop	Pressure drop	Velocity
	Inch	°F	PSI	ft / sec
Ammonia	6"	0.21	0.2	79
CO2	4"	0.14	0.9	29

- In general same pipe material and wall thickness as for ammonia
- Copper pipes can be used as well

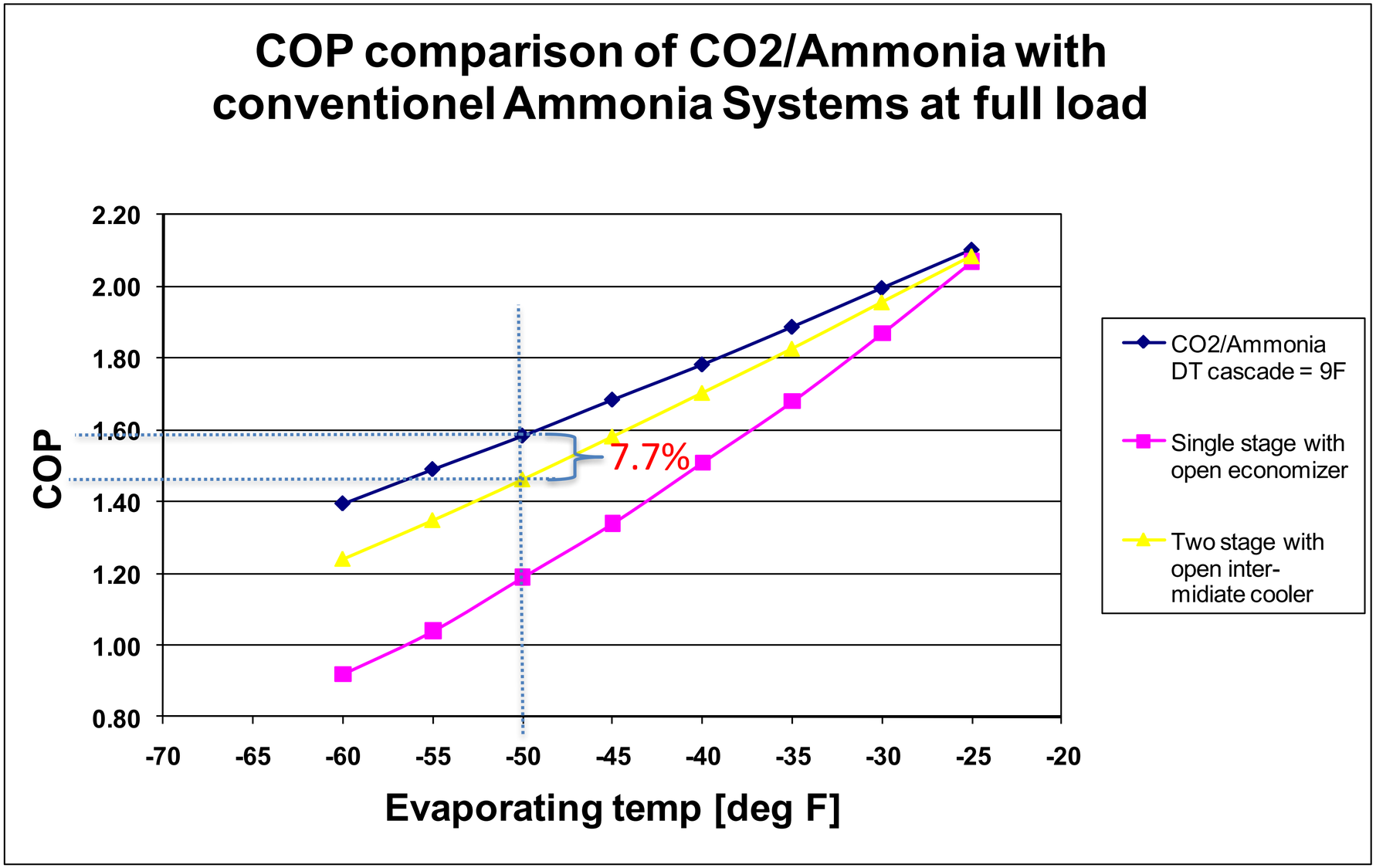
CO_2 - Systems

Advantages – Lower first cost - Compressors



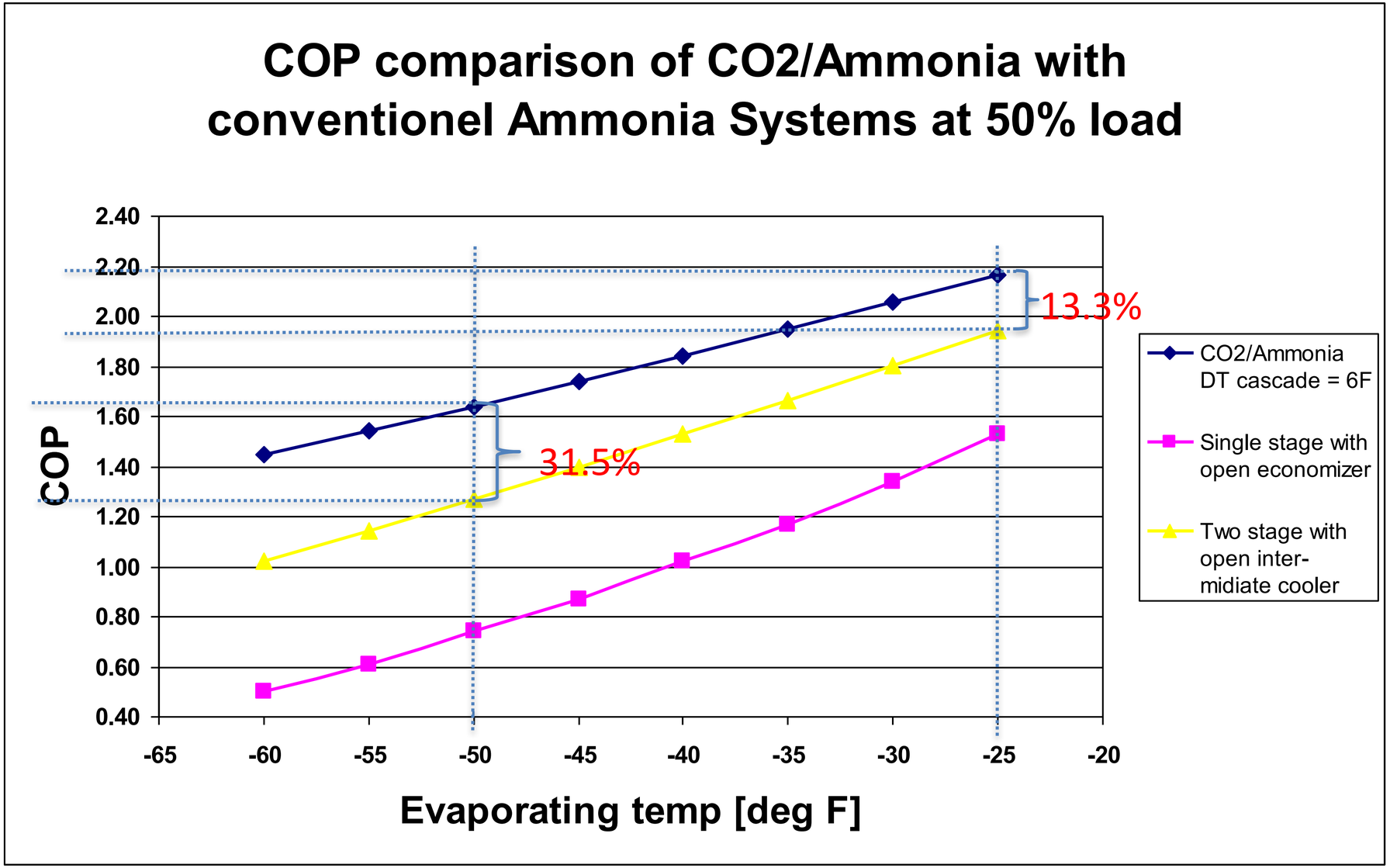
CO_2 - Systems

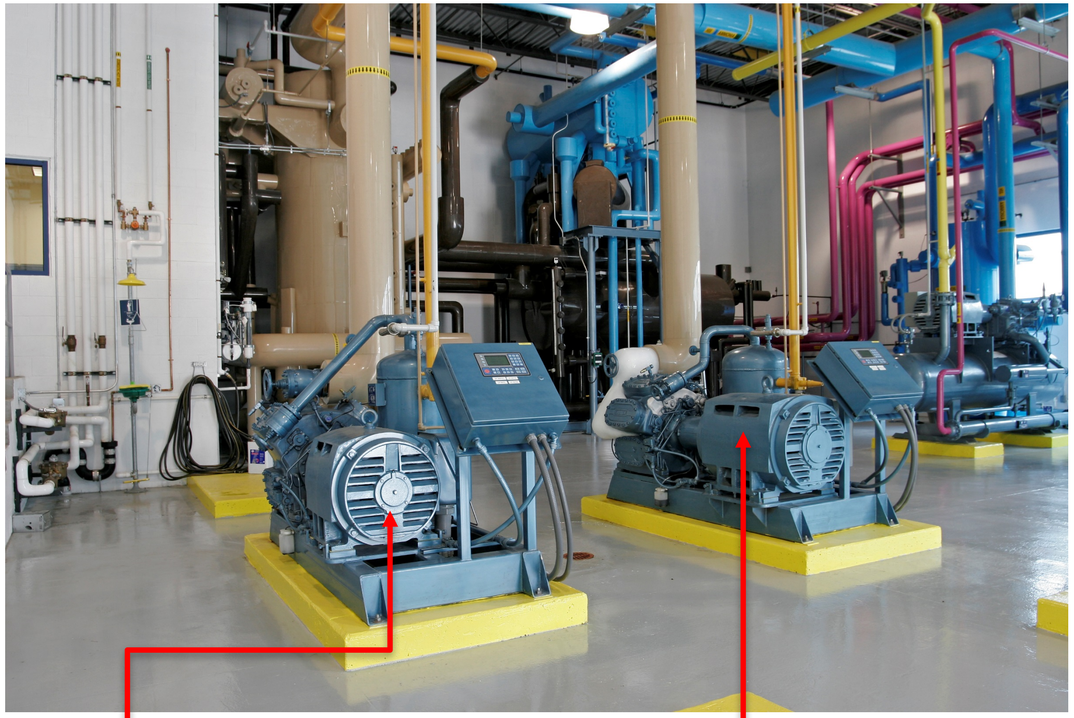
Advantages – Lower Operating Costs

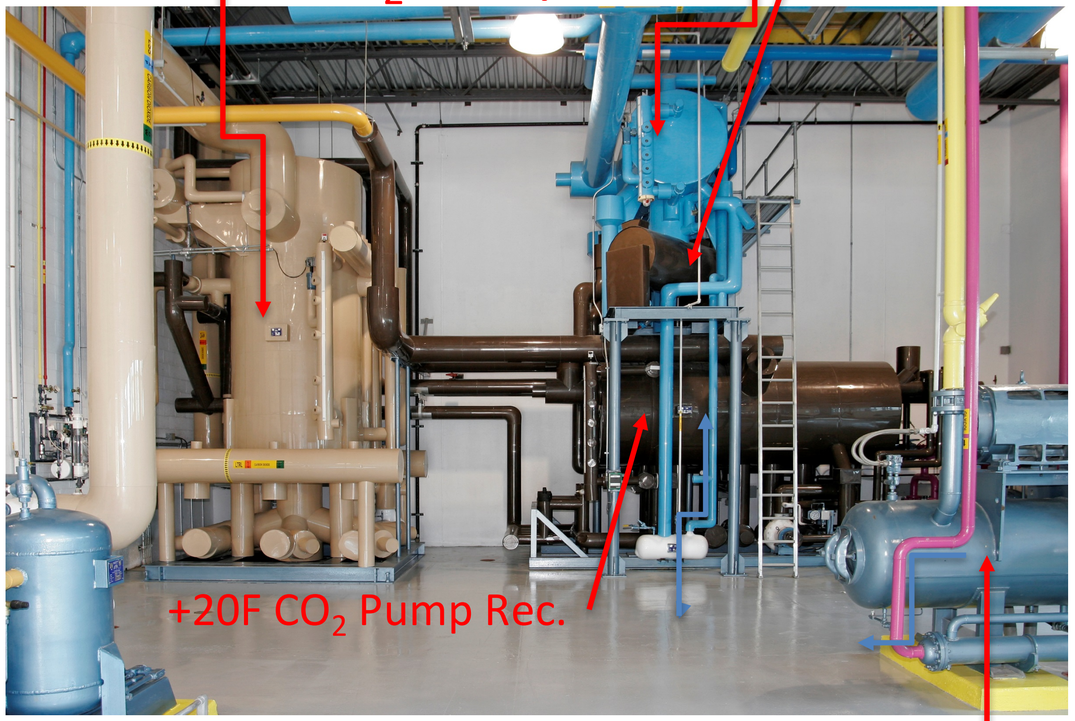


CO_2 - Systems

Advantages – Lower Operating Costs







Typical Cascade CO_2/NH_3 Refrigeration Machine Room

Typical CO_2 AHU in Penthouse

First Refrigerated Warehouse in USA to use a Cascade CO_2/NH_3 Refrigeration System.

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Thank you very much!