



3 Things you should know about the changing refrigeration climate

 **ATMO**
sphere
business case
natural refrigerants
25 & 26 June - Atlanta, Georgia





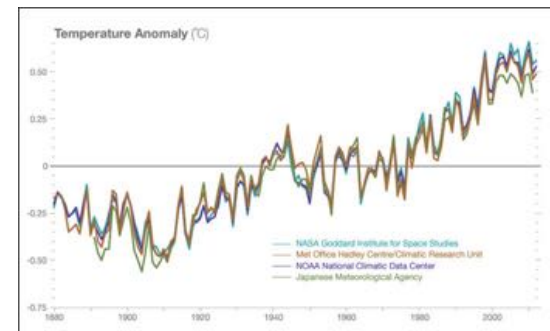
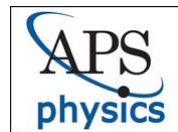
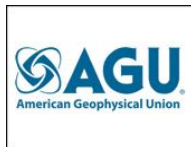
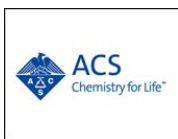
AGENDA

- What you need to know about the revised compliance schedules & impacts of non-compliance
- Innovative technologies to address changing landscape including:
 - Distributed Refrigeration – Low Charge Rooftop Packaged Systems
 - CO₂/NH₃ Cascade Systems
 - Low Charge Packaged Chillers
- Pros/Cons in evaluating options & choosing best solutions



GLOBAL WARMING IS REAL

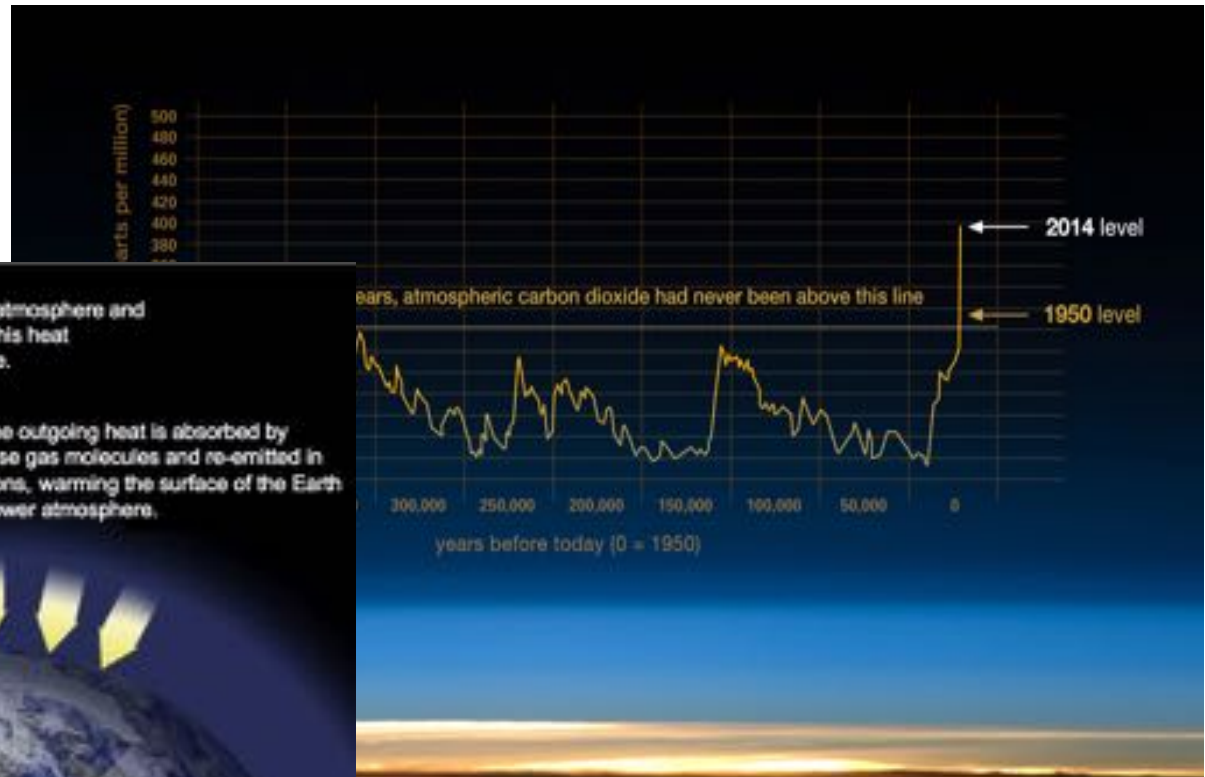
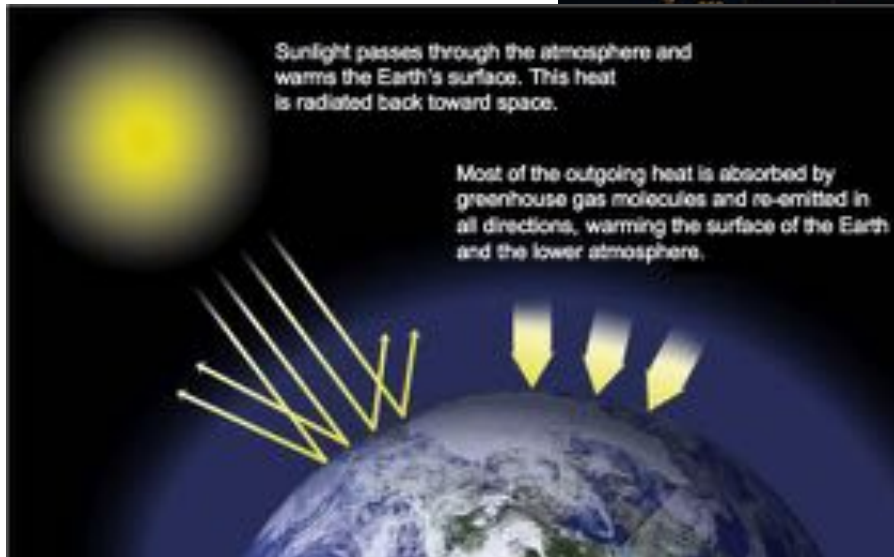
- 97% of climate scientist agree Earth is warming
- Global sea levels rose 6.7” in last century
- 10 warmest average temperature years occurring in last 12 years
- Ice caps and glaciers have decrease in huge quantities





THE PRIMARY CAUSE

Ozone depletion and greenhouse gases





REGULATORY AGENCIES



1987 Montreal Protocol: First globally supported legislation to reduce ozone depleting substances – Bans CFCs



1992 Kyoto Protocol: Expanded the agreements to reduce greenhouse gas emissions – Ban HCFCs



2013 President Obama outlined the Climate Action Plan



2014 EPA proposed new regulations under the SNAP (Significant New Alternative Policy) program to significantly move up the phase out date for many of the industries workhorse refrigerants.

Regulations are pushing the industry toward natural refrigerants.



REGULATION UPDATE

2013 President Obama issues executive order 13650
Actions to improve Chemical Facility Safety



- Issued proposed revisions for Process Safety Management
 - Adding new management systems
 - Expanding mechanical integrity
 - Expanding management of change requirements
 - Updated RAGAGEP



- Issued proposed revisions for Risk Management Program
 - Similar modifications as PSM but more detailed and broader
 - Requiring “Inherently Safer Technology”



- 2014 CFATS - Chemical Facility Anti-Terrorism Standards

Presently 3415 regulations in pipeline with focus to get as much done in this administration as possible.



REVISED COMPLIANCE SCHEDULES & IMPACTS OF NON-COMPLIANCE



REGULATION UPDATE

OSHA National Emphasis Program (NEP)

Who: Facilities with over 10,000 lbs. of NH₃ covered under Process Safety Management Program

- Inspections are unannounced
- Focus on PSM
- Based on dynamic list of questions
- Facilities must be able to demonstrate implementation



REGULATION UPDATE

OSHA National Emphasis Program (NEP)

- 641 inspections since inception
- 3060 total citations in 71 OSHA standards
- PSM represents 66 percent of violations overall
- PSM represents 60 percent of violations in ammonia (NH₃)refrigeration



CITATIONS

OSHA National Emphasis Program (NEP)

Ammonia Facilities Oct, 2012 – Sept, 2013

- 734 Violations (26% of total violations)
 - Initial violations per inspection: 9.5
 - Initial penalty per violation: \$ 4,600
- Total initial Penalties: \$ 3,376,075
 - Initial penalty per inspection: **\$ 43,845**



REGULATION UPDATE



February 2015 EPA Issued “*Enforcement Alert*” on Ammonia Alerting refrigeration industry that EPA indicated that some refrigeration facilities may be failing to properly manage hazardous chemicals like Ammonia.

United States Environmental Protection Agency Office of Enforcement and Compliance Assurance (2201A) EPA 325-R-014-0001



Enforcement Alert

Volume 14, Number 2

Office of Civil Enforcement

February 2015

Anhydrous Ammonia at Refrigeration Facilities Under Scrutiny by U.S. EPA

EPA Enforcement Efforts Focus on Prevention of Chemical Accidents

Purpose

Evidence gathered by the U.S. Environmental Protection Agency (EPA) indicates that some refrigeration facilities may be failing to properly manage hazardous chemicals, including anhydrous ammonia, as required by the Clean Air Act (CAA) Section 112(r). This Alert is intended to inform the industry that companies must take responsibility to prevent accidental releases of dangerous chemicals like anhydrous ammonia through compliance with CAA's Chemical Accident Prevention Program.



WHAT'S THE SOLUTION?

- Refrigeration industry is being pushed toward natural refrigerants
- Regulations on large charge ammonia systems are increasing



How to get the advantages of natural refrigerant and minimize the risk?

ENGINEERING SERVICES & CONSULTING | CIVIL | STRUCTURAL | ELECTRICAL | REFRIGERATION & CONTROL | WASTE WATER TREATMENT | FIRE PROTECTION | CONSTRUCTION ADMINISTRATION | SITE INSPECTIONS | SUSTAINABLE DESIGN | LEED | BIM MODELING | SUSTAINABLE PLANNING | CONSTRUCTIONABILITY REVIEW | LIFE CYCLE PLANNING | VALUE MANAGEMENT | SITE SELECTION | SUPPLY CHAIN & LOGISTICS | MODELING/OPTIMIZATION | BUDGET DEVELOPMENT & VALIDATION | PERMIT PLANNING | PROJECT SCHEDULING | DESIGN BUILD | DESIGN-BID-BUILD | GENERAL CONTRACTING | CONSTRUCTION MANAGEMENT | OWNER REPRESENTATIVE | ENGINEERING PROCUREMENT CONSTRUCTION MAINTENANCE (EPCM) | INSULATED METAL WALL & CEILING | PANELS | INSULATED METAL WALL & PANEL DUCT WORK | ROOFING SYSTEM | LOW-TEMPERATURE DOORS | INSULATED FLOORS | FREEZER FLOOR REPAIRS | MECHANICAL | HVAC | DUCT WORK FABRICATION | INSTALLATION | TURNKEY BUILDING UTILITY | HYBRIDIC PIPING | STEAM SYSTEMS | CHILL WATER SYSTEMS | GYCOL SYSTEMS | PROCESS WATER SYSTEMS | COMPRESSED AIR | FEED WATER | DOMESTIC WATER | PRE-FABRICATION/MODULAR UTILITY | REFRIGERATION ENGINEERING & CONTRACTING | AUTOMATION SERVICES | REMOTE SUPPORT & MONITORING | FABRICATION & INSTALLATION SERVICES | PARTS & SERVICE SUPPORT 24/7 | PROCESS SAFETY MANAGEMENT (PSM) | COMPLIANCE SOFTWARE | COMPRESSOR RE-BUILD AND REPAIR | TOTAL MAINTENANCE LIFE CYCLE SUPPORT | PRE-FABRICATION/MODULAR UTILITY | MASTER PLANNING | FACILITY SURVEY & CONDITIONS REPORTS | PERMIT APPLICATION & SUPPORT | SPECIFICATIONS MASTERSPEC 3-SPEC | INDUSTRIAL/MATERIAL HANDLING | ENERGY OPTIMIZATION PLANNING | TRADITIONAL DESIGN SERVICES ARCHITECTURE | INTERIOR DESIGN | LANDSCAPE DESIGN | ENGINEERING PROCESS & PACKAGING | CIVIL | STRUCTURAL | MECHANICAL | ELECTRICAL | REFRIGERATION | AUTOMATION & CONTROL | WASTE-WATER TREATMENT | FIRE PROTECTION | CONSTRUCTION ADMINISTRATION | SITE INSPECTIONS | SUSTAINABLE DESIGN | LEED | BIM MODELING | SUSTAINABLE PLANNING | CONSTRUCTIONABILITY REVIEW | LIFE CYCLE PLANNING | VALUE MANAGEMENT | SITE SELECTION | SUPPLY CHAIN & LOGISTICS | MODELING/OPTIMIZATION | BUDGET DEVELOPMENT & VALIDATION | PERMIT PLANNING | PROJECT SCHEDULING | DESIGN BUILD | DESIGN-BID-BUILD | GENERAL CONTRACTING | CONSTRUCTION MANAGEMENT | OWNER REPRESENTATIVE | ENGINEERING PROCUREMENT CONSTRUCTION MAINTENANCE (EPCM) | INSULATED METAL WALL & CEILING | PANELS | INSULATED METAL WALL & PANEL DUCT WORK | ROOFING SYSTEM | LOW-TEMPERATURE DOORS | INSULATED FLOORS | FREEZER FLOOR REPAIRS | MECHANICAL | HVAC | DUCT WORK FABRICATION | INSTALLATION | TURNKEY BUILDING UTILITY | HYBRIDIC PIPING | STEAM SYSTEMS | CHILL WATER SYSTEMS | GYCOL SYSTEMS | PROCESS WATER SYSTEMS | COMPRESSED AIR | FEED WATER | DOMESTIC WATER | PRE-FABRICATION/MODULAR UTILITY | REFRIGERATION ENGINEERING & CONTRACTING | AUTOMATION SERVICES | REMOTE SUPPORT & MONITORING | FABRICATION & INSTALLATION SERVICES | PARTS & SERVICE SUPPORT 24/7 | PROCESS SAFETY MANAGEMENT (PSM) | COMPLIANCE SOFTWARE | COMPRESSOR RE-BUILD AND REPAIR | TOTAL MAINTENANCE LIFE CYCLE SUPPORT | PRE-FABRICATION/MODULAR UTILITY | MASTER PLANNING | FACILITY SURVEY & CONDITIONS REPORTS | PERMIT APPLICATION & SUPPORT | SPECIFICATIONS MASTERSPEC 3-SPEC | INDUSTRIAL/MATERIAL HANDLING | ENERGY OPTIMIZATION PLANNING | TRADITIONAL DESIGN SERVICES ARCHITECTURE | INTERIOR DESIGN | LANDSCAPE DESIGN | ENGINEERING PROCESS & PACKAGING | CIVIL | STRUCTURAL | MECHANICAL | ELECTRICAL | REFRIGERATION | AUTOMATION & CONTROL | WASTE-WATER TREATMENT

INNOVATIVE TECHNOLOGIES TO ADDRESS CHANGING LANDSCAPE



WHAT ARE NATURAL REFRIGERANTS?

Refrigerant Designation	Refrigerant Designation	Refrigerant Number	COMMENTS
Ammonia	NH ₃	R-717	Workhorse of F&B industry
Carbon Dioxide	CO ₂	R-744	Pressures High
Propane	C ₃ H ₈	R-290	Flammable
Butane	C ₄ H ₁₂	R-600	Flammable
Propylene	C ₃ H ₆	R-1270	Flammable



WHY NATURAL REFRIGERANTS? ENVIRONMENTALLY FRIENDLY

OSHA LIMITS	Ozone Depletion Potential	Global Warming Potential
NH3	0	0
CO2	0	1
R-134	0	1300
R-404A	.04	3300
R-507	0	3300
R-22	.05	1700



WHY NATURAL REFRIGERANTS? MOST ENERGY EFFICIENT

REFRIGERANT	HEAT OF VAPORIZATION (BTU/#)	COMPRESSOR DISPLACEMENT (CFM)	COEFFICIENT OF PERFORMANCE (COP)	EFFICIENCY COMPARISON TO AMMONIA
R-507	47.28	3.43	4.15	-13%
R-404A	48.98	3.5	4.21	-12%
R-22	70.46	3.57	4.65	-3%
R-134A	64.51	6.08	4.6	-4%
R-717	474.2	3.45	4.77	0%

5°F SST, 86°F SDT, 0°F SUBCOOLING, 0°F SUPERHEAT, 2001 ASHRAE
FUNDAMENTALS HANDBOOK, SECTION 19.8 TABLE 7



WHY NOT NATURAL REFRIGERANTS? AMMONIA IS TOXIC

AMMONIA IS TOXIC

- OSHA Permissible Exposure Limit: 50 ppm
- Safety Group B2: Lower Flammability / Higher Toxicity
- Above 10,000 lbs. must comply with OSHA rule 29CFR Process Safety Management
- Any ammonia must comply with EPA (40CFR 68) General Duty Clause

HYDROCARBONS

- Highly Flammable

CARBON DIOXIDE

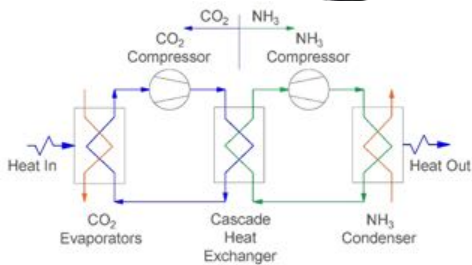
- High pressures made the use expensive until now



EMERGING TECHNOLOGIES



1. Distributed Refrigeration – Low Charge Package Solutions



2. CO₂/NH₃ Cascade Refrigeration Systems



3. Low Charge Ammonia Chillers



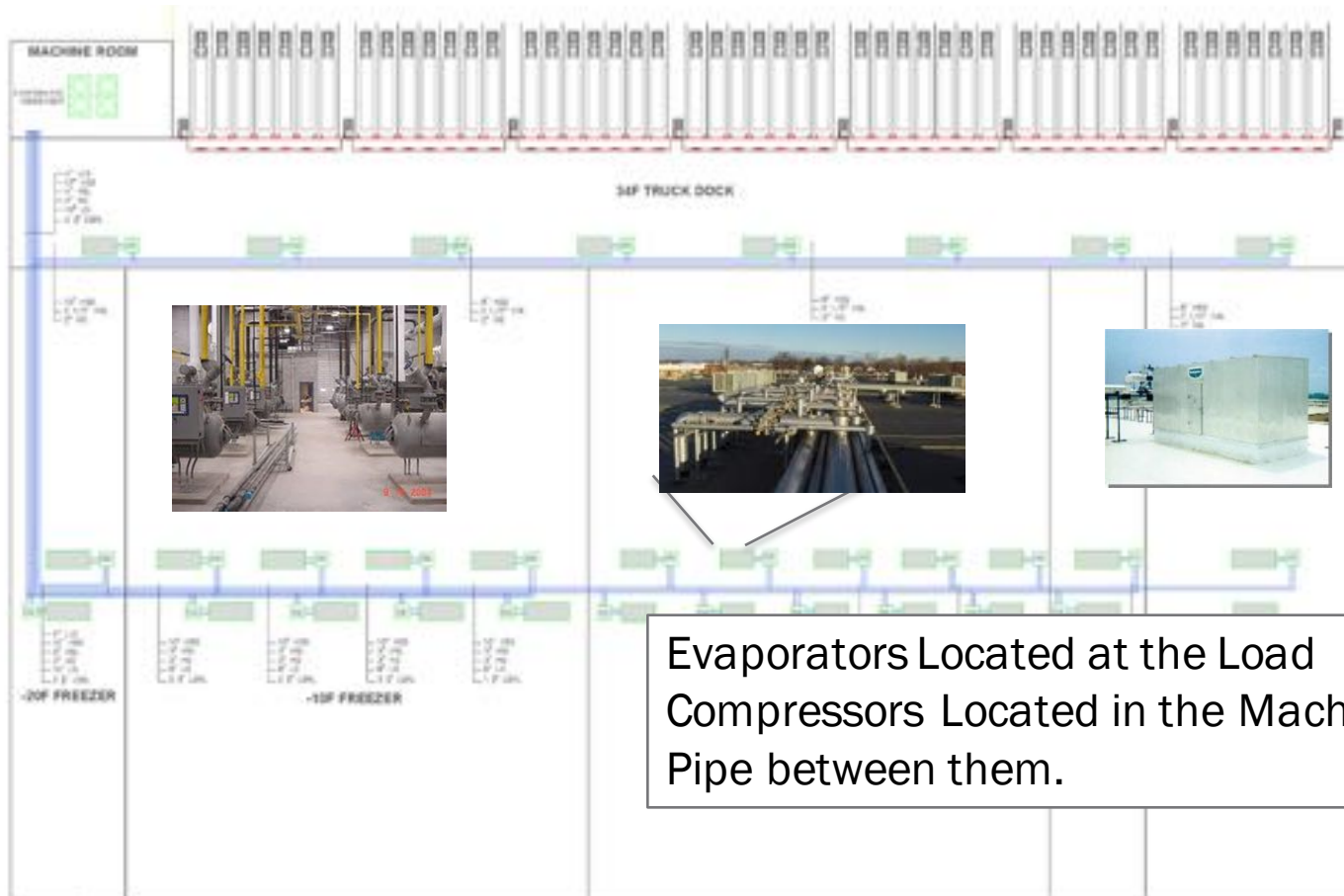
TRADITIONAL CENTRAL SYSTEM

Large Scale Central Ammonia Systems have been the backbone of industrial refrigeration systems for the Food and Beverage industry for 100 years.

- Environmentally Friendly
- Best energy efficiency of all refrigerants
- Due to industrial construction techniques, almost 0 leakage
- Very cost effective



TRADITIONAL CENTRAL SYSTEM



Evaporators Located at the Load
Compressors Located in the Machine Room
Pipe between them.



1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS

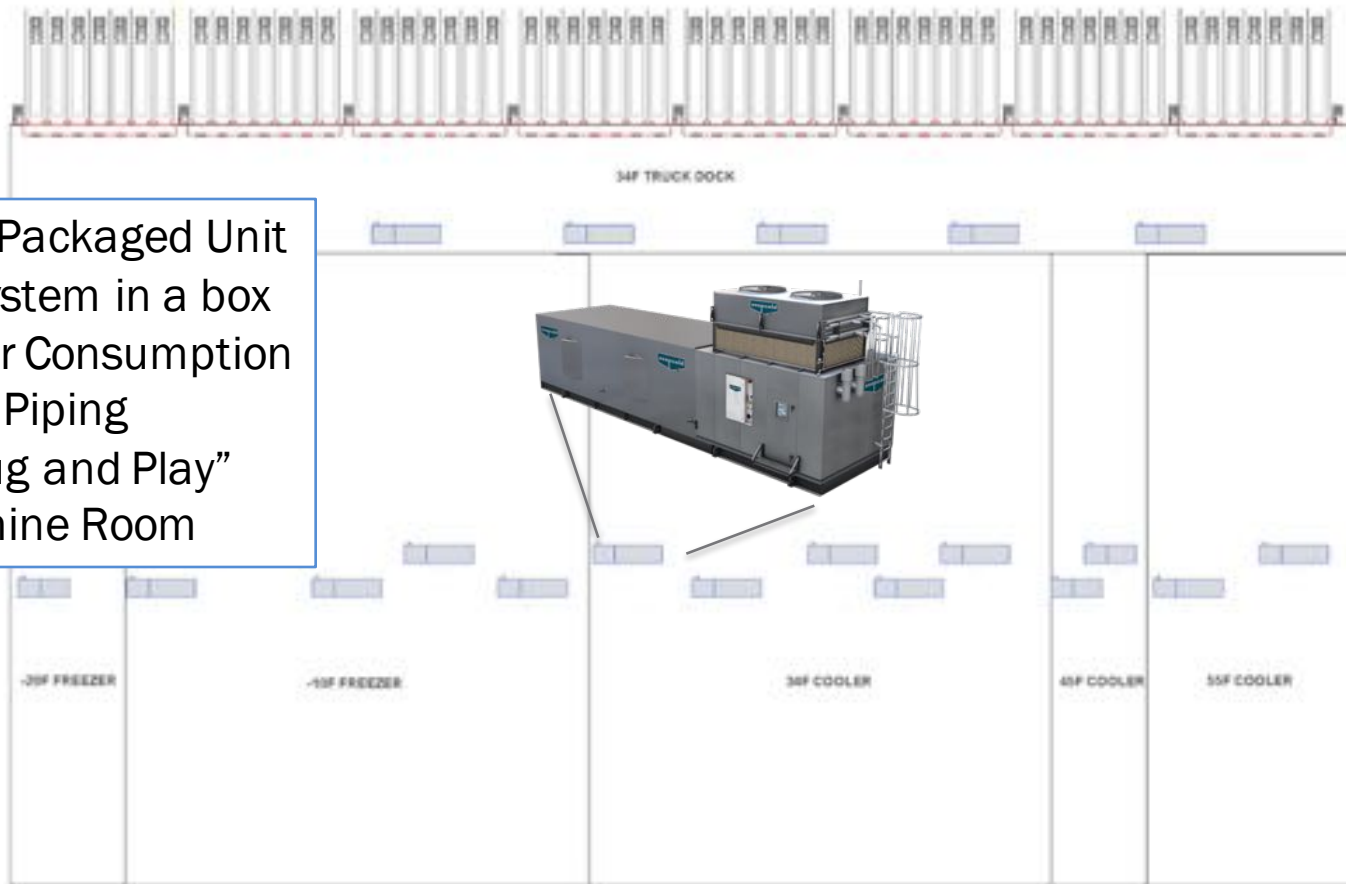
Low Charge Ammonia Packages –
Distributed Refrigeration





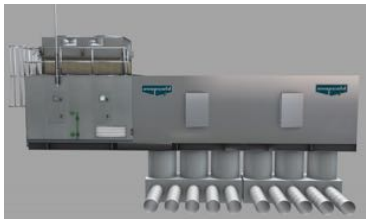
1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS

Rooftop Packaged Unit
Entire System in a box
No Water Consumption
No Field Piping
True “Plug and Play”
No Machine Room

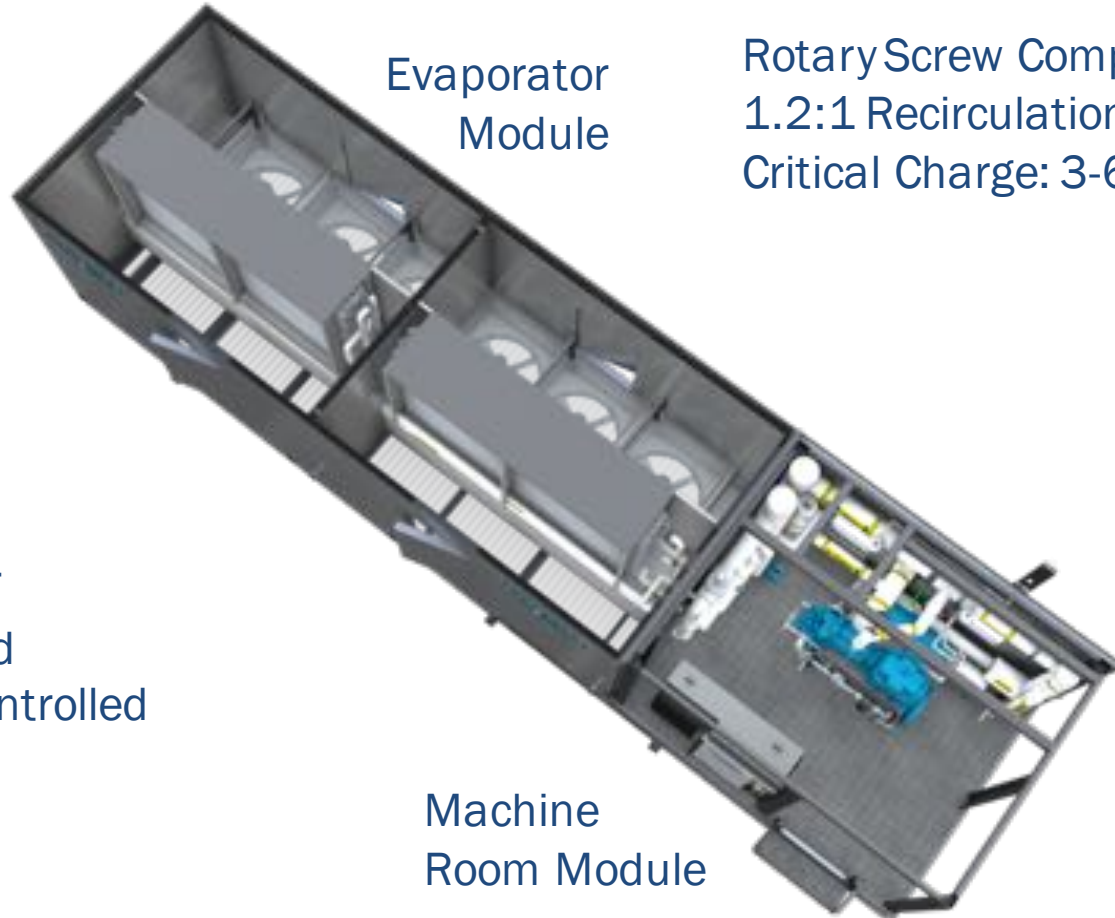




1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS



10 to 120 TR
-30°F to 50°F SST
Single Electric Feed
Microprocessor Controlled



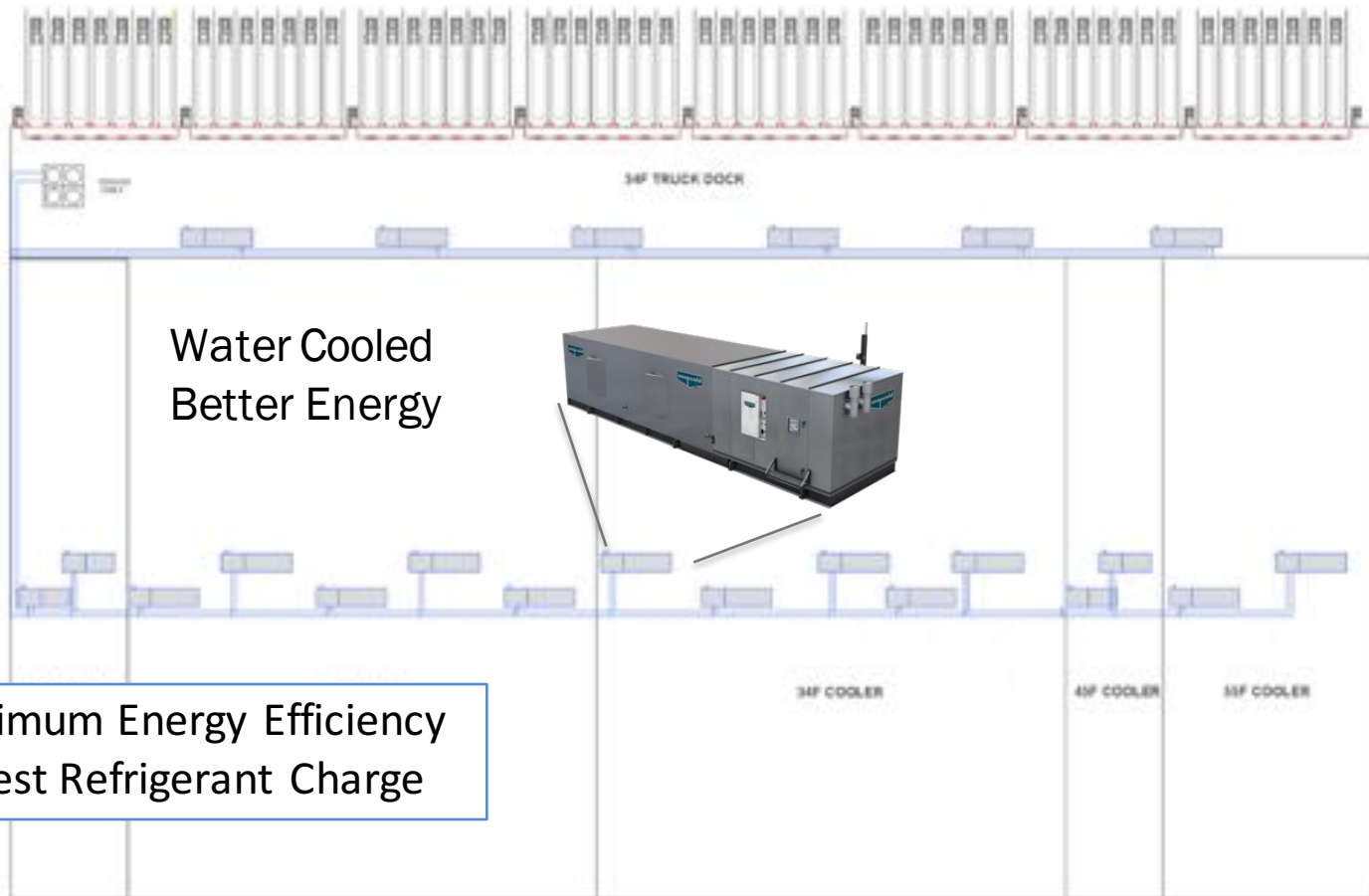
Evaporator
Module

Rotary Screw Compressor
1.2:1 Recirculation Rate
Critical Charge: 3-6 lbs. per TR

Machine
Room Module



1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS



Maximum Energy Efficiency
Lowest Refrigerant Charge



1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS

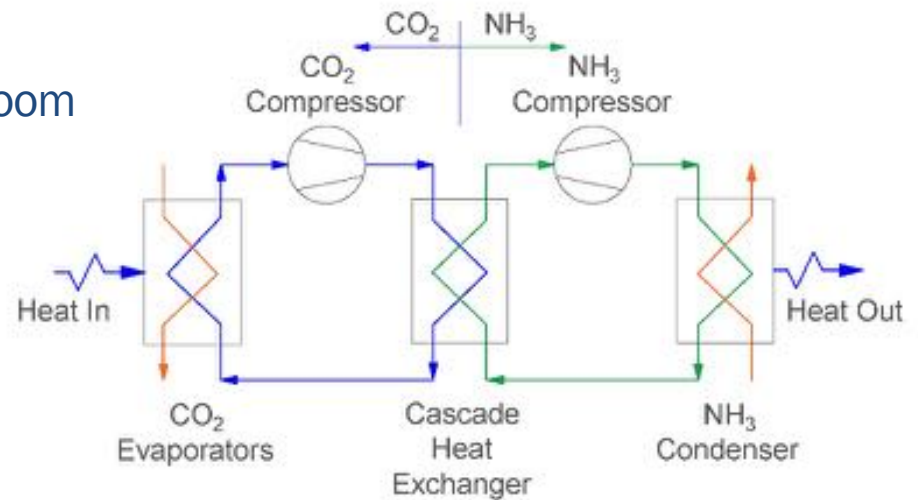
DESCRIPTION	CONVENTIONAL SYSTEM	DISTRIBUTED REFRIGERATION
REFRIGERANT CHARGE	40,350 lbs.	5,950 lbs.
GENERAL DUTY CLAUSE	YES	YES
PSM	YES	NO



2. CO₂/NH₃ CASCADE SYSTEM

In large scale industrial food processing plants, central station refrigeration system is the only choice.

- CO₂/NH₃ cascade system offers the solution
- Two refrigerants – one system
- Ammonia contained in machine room
- CO₂ distributed to the plant





2. CO₂/NH₃ CASCADE SYSTEM

Risk Comparison

OSHA LIMITS	NH ₃	CO ₂
Permissible Exposure Limit (PPM)	50	10,000
Short Term Exposure Limit (ppm)	35	30,000

Energy Comparison*

DESCRIPTION	2- STAGE NH ₃ SYSTEM (kW/TR)	CO ₂ /NH ₃ Cascade System (kW/TR)	% IMPROVEMENT IN EFFICIENCY
-20 ° F Suction System	0.8	0.7	12.3
-58 ° F Suction System	1.6	1.0	37.3
High Temp Suction System	.7	.8	-8.5
Total System kW/TR	.04	3300	5.8

* PG&E efficiency study report #0707, 2009



2. CO₂/NH₃ CASCADE SYSTEM

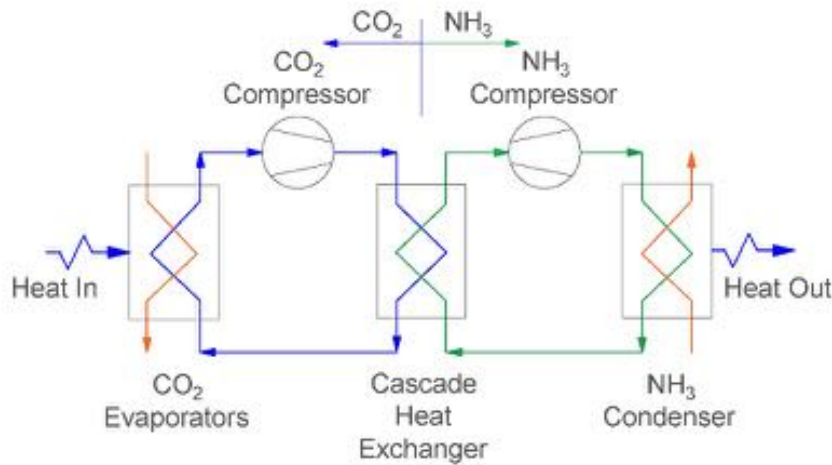
Charge Comparison

- Conventional central ammonia system: 40,000 lbs.
- CO₂/NH₃ cascade system: 7,000 lbs.

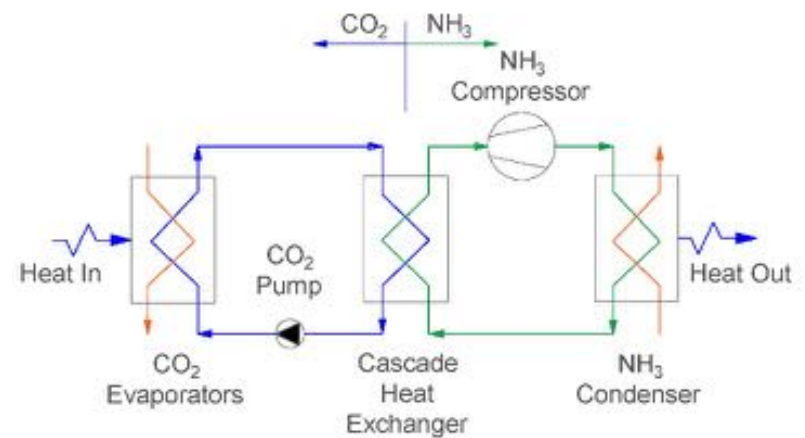


2. CO₂/NH₃ CASCADE SYSTEM

Cascade systems have two configurations



CO₂ Compression Systems

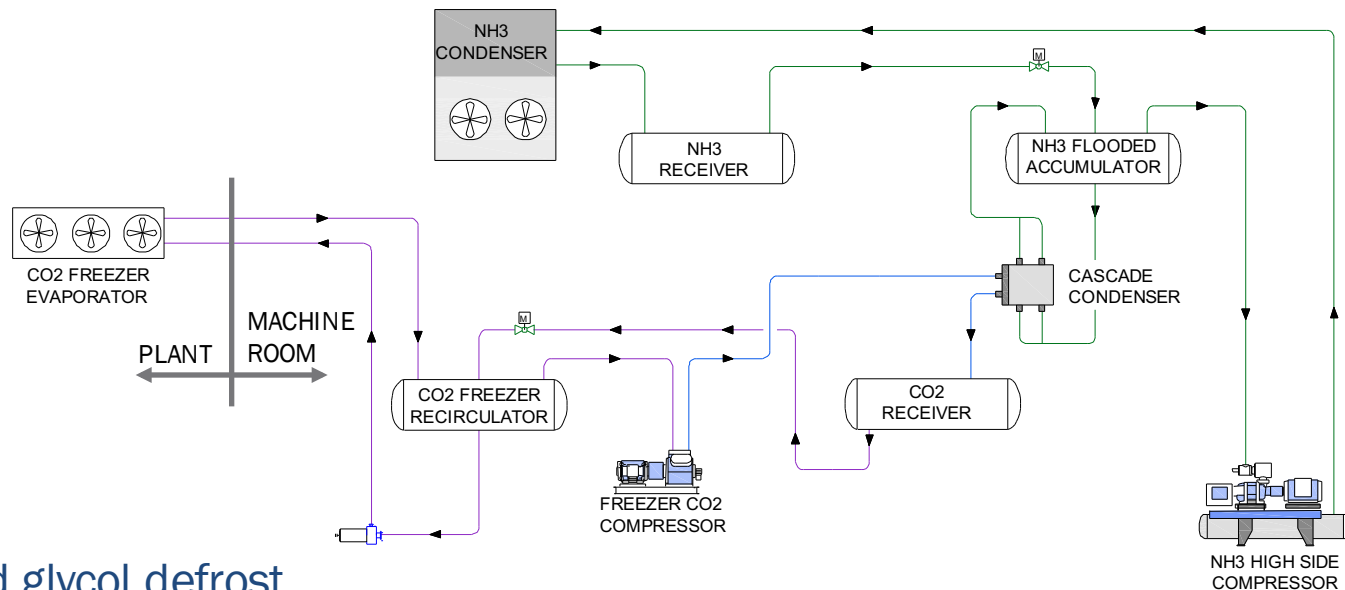


CO₂ Volatile Brine System



2. CO₂/NH₃ CASCADE SYSTEM

CASCADE COMPRESSION SYSTEM

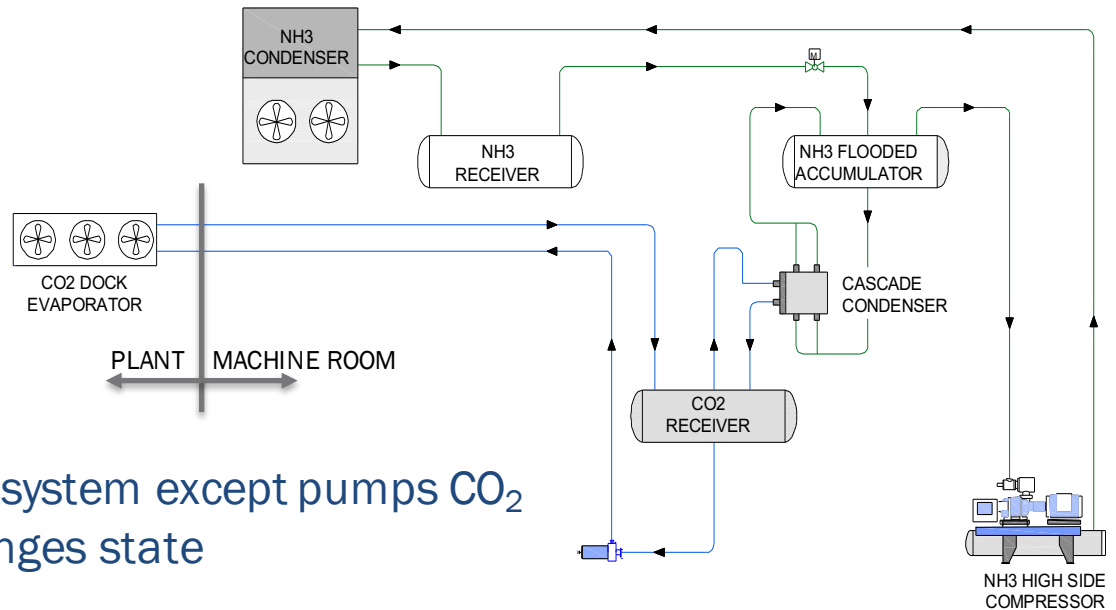


- Embedded glycol defrost
- Reciprocating Compressors
- Standard Equipment readily available



2. CO₂/NH₃ CASCADE SYSTEM

Cascade Volatile Brine System



- Similar to chilled water system except pumps CO₂
- CO₂ absorbs heat, changes state
- 20% energy savings



3. LOW CHARGE AMMONIA CHILLERS

In accordance with the Montreal Protocol, the phase out of CFC and HCFC refrigerant continues.

- R-22 will be completely banned by 2020

Numerous synthetic refrigerants are options but each has challenges:

- High Global Warming potential (potential to be replaced in future)
- Reduction in efficiency
- Increase in leakage rate
- Temperature glide



3. LOW CHARGE AMMONIA CHILLERS

The Real Opportunity For Natural Refrigerants Is HVAC

- How to overcome risk perception.
- Ammonia can not be used directly to cool occupied spaces.
- Ammonia chillers have been used in Food and Beverage for many years.
- Screw Compressor
- Computer controlled
- 150 TR to 970 TR
- Critical Charge – 1 lbs. per TR
- Requires a machine room
- Requires a cooling tower





3. LOW CHARGE AMMONIA CHILLERS



Packaged Ammonia Chillers –
Air Cooled

- Screw Compressor
- 60 TR to 200 TR
- No water consumption
- No machine room
- Less than 2 lbs. of ammonia per TR
- Complete Integrated package - True “Plug and Play” configuration
- More expensive than commercial “Freon” chillers.



PROS/CONS IN EVALUATING OPTIONS & CHOOSING BEST SOLUTIONS



1. DISTRIBUTED REFRIGERATION LOW CHARGE PACKAGED SOLUTIONS

Pro's

- Similar Energy
- Similar Cost
- No machine room
- No pipe across roof
- No valves on roof to maintain
- Similar Maintenance
- Significantly Less Charge
- Under threshold level OSHA
- Under threshold level DHLS
- Under threshold level for CalArp

Con's

- All equipment on roof
- More expensive for smaller systems





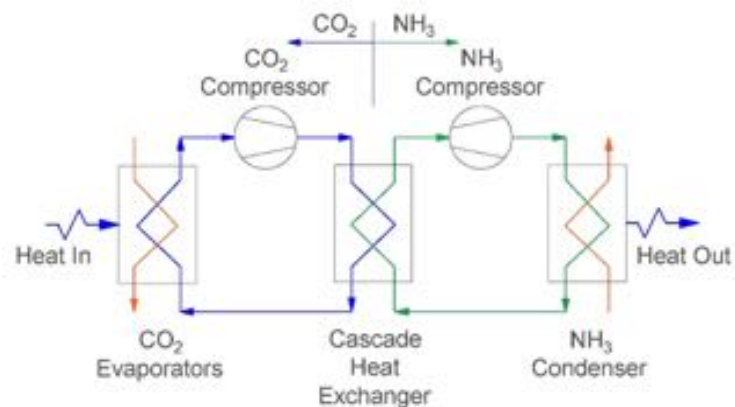
2. CO₂/NH₃ CASCADE SYSTEM

Pro's

- Natural Refrigerants
- Similar Energy - better for low temperature.
- Similar Maintenance
- Significantly Less Charge
- All ammonia contained in machine room
- Significantly less Risk

Con's

- High working pressure
- Not a lot of contractors / engineers familiar with technology





3. LOW CHARGE AMMONIA CHILLERS

Pro's

- Environmentally Friendly
- Is not going to get “phased out” later.
- Better energy performance than Freon.
- Much lower leak rate than Freons.
- Less maintenance, more industrial
- Critical charge.

Con's

- More expensive than conventional mass produced Freon chillers.





5 KEY TAKEAWAYS

1. Synthetic Refrigerants are being phased out and as environmentally friendly alternatives become commercially viable, the synthetic refrigerants that are presently being used may be phased out in the future
2. The government is increasing oversight and regulations for large charge ammonia systems
3. Distributed refrigeration with Packaged Rooftop units is a viable solution to take advantage of natural refrigerants while minimizing the risk
4. For plants that require a central system, CO₂/NH₃ cascade systems provide an alternative that minimizes large ammonia charges
5. Low Charge ammonia chillers are a viable option to replace Freon chillers using natural refrigerants while minimizing the risk



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