Ultra Low Charge Ammonia Systems for Cold Storage Applications

ASHRAE Montreal Chapter Meeting
January 15, 2018

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Ammonia as a Refrigerant

The benefits make NH_3 an overwhelming choice:

- In most applications, Ammonia is more energy efficient for high and low temp applications by up to 10% over other refrigerant types
- It's environmentally friendly with a GWP (Global Warming Potential) and ODP (Ozone Depletion Potential) of Zero
- NH_3 has great heat transfer properties and is also a lower cost refrigerant.

YET…

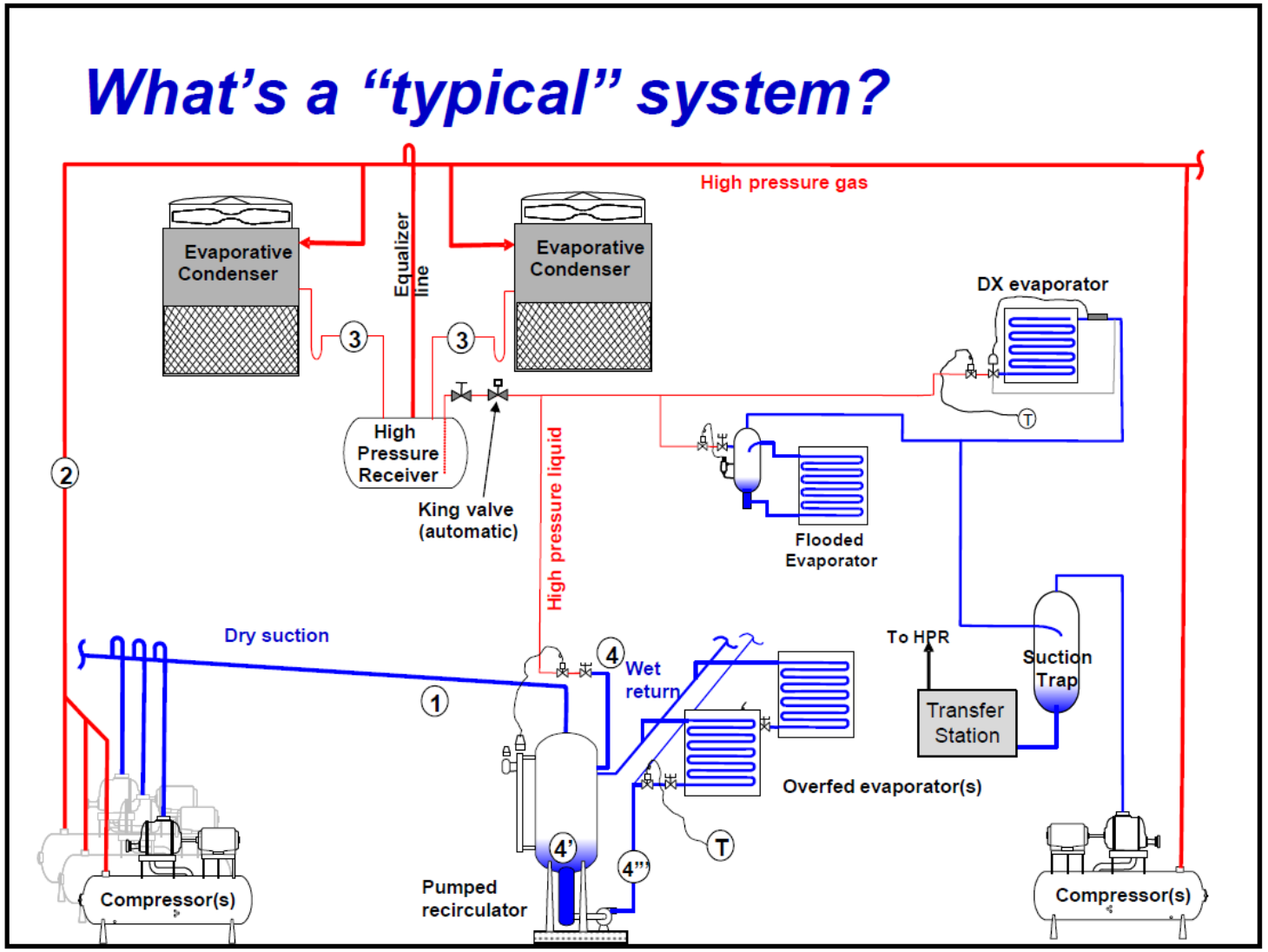
Ammonia in the concentrations and amounts required by a traditional high charge system,

- is extremely dangerous and potentially lethal to workers and the public at large.
- System leaks, thankfully, are easily detected by the chemical's pungent and noxious odor.
- Still, all facilities need a dedicated staff of employees to monitor system integrity.

Ammonia Systems for Cold Storage

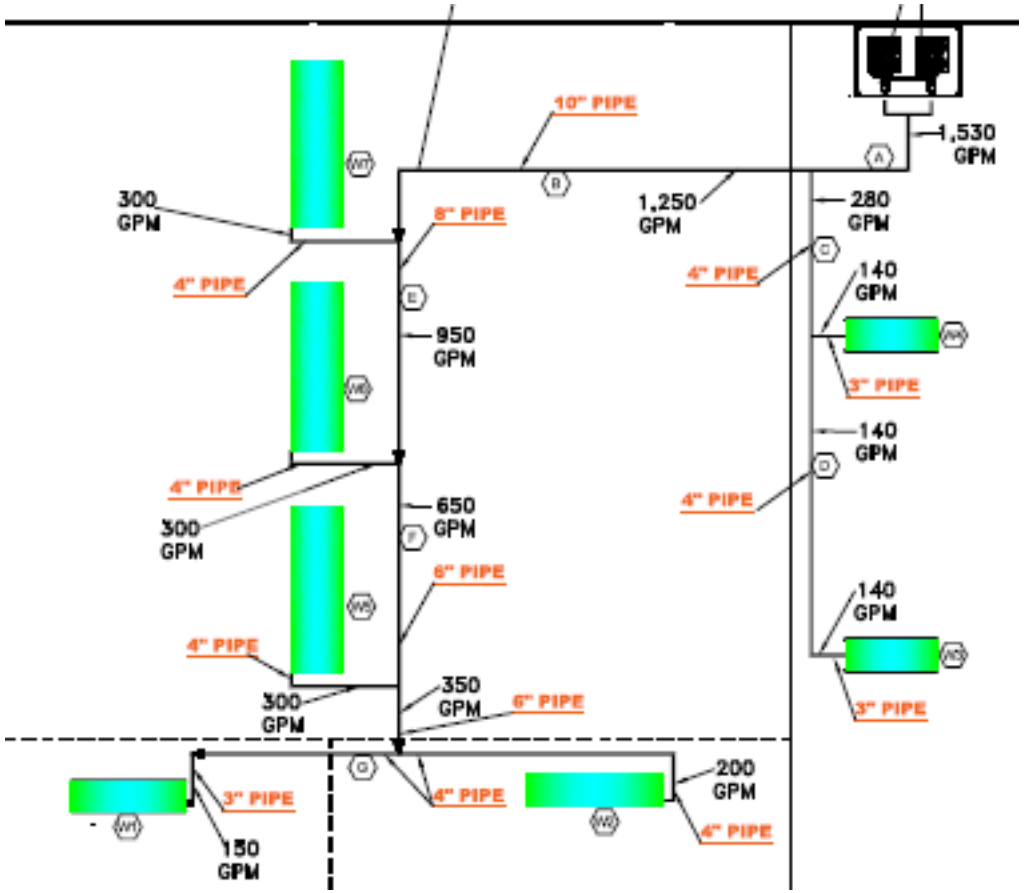
- Central Systems
- Hybrid Systems
  - Advanced DX systems
  - CO2/NH3 systems
- Packaged Systems
  - Low charge packaged systems
  - Ultra low charge packaged systems

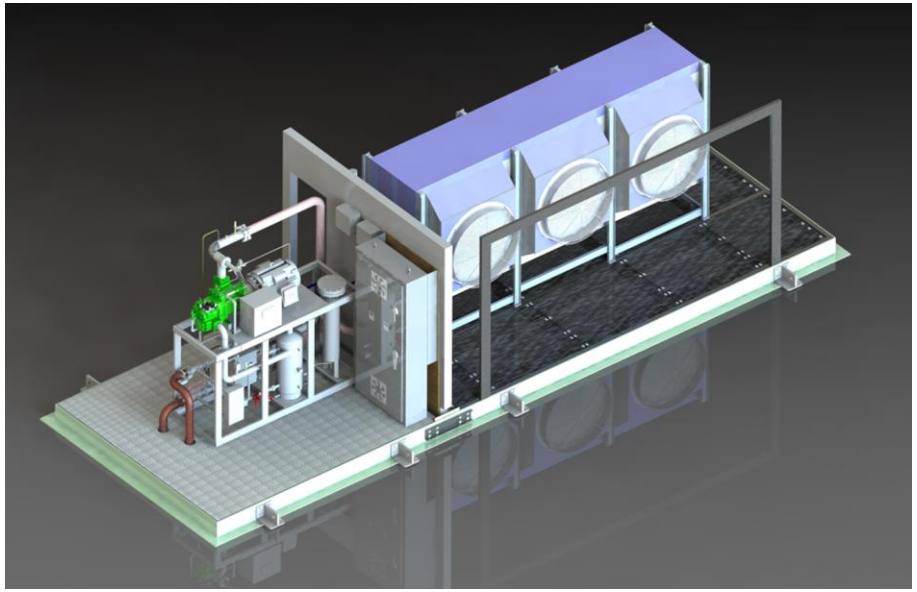
Central Ammonia Systems



Schematic courtesy of Doug Reindl – IRC – University of Wisconsin

Ultra Low Charge Ammonia Systems





Ammonia Systems for Cold Storage

- Ammonia Charge for Systems used in cold storage (example 550 TR)
  - Central Systems = 20 pounds per ton of refrigeration (11,000 lbs.)
  - Hybrid Systems = 4 to 8 pounds per ton of refrigeration (2,200 to 4,400 lbs.)
    - Advanced DX systems
    - CO2/NH3 systems
  - Packaged Systems
    - Low charge packaged systems = 4 pounds per ton of refrigeration (2,200 lbs)
    - Ultra low charge packaged systems = 0.5 pounds per ton of refrigeration (275 lbs)
- Energy for Ammonia Systems
  - All systems listed above can be expected to consume 2.5 kW/TR or less

Source: Low Ammonia Charge Refrigeration Systems for Cold Storage White Paper

Author-Terry Chapp for IARW and IACSC

Ultra Low Charge NH_3 Systems

- A distributed, complete self contained refrigeration system
- Water-cooled condensers mounted inside unit achieves ultra low charge
- **Flexible Fluid Cooler Selection & Matching**
- Reduced water consumption with adiabatic fluid coolers
- Units can be mounted on rooftop or ground level
- No longer will a dedicated machine room be needed allowing that space to be utilized for revenue producing activity
- Eliminates NH_3 field piping. Only field piping required is fluid pipe from condenser to fluid coolers

Ultra Low Charge NH_3 Systems

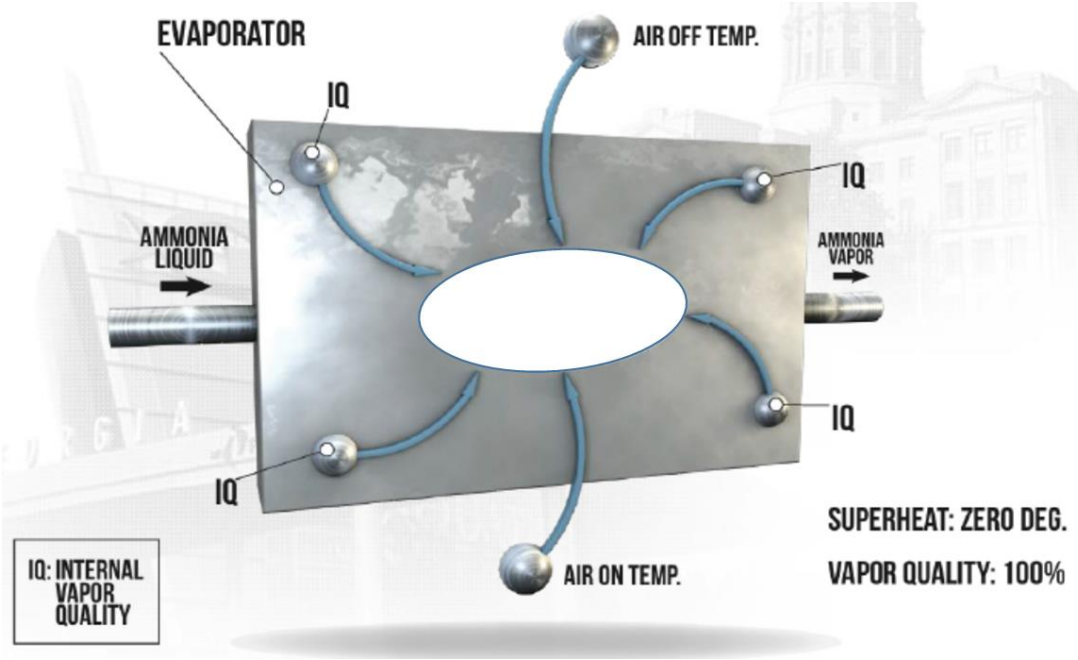
- Factory assembled and shipped to job site ready for installation
- Offers simple “plug and play” installation
- Individual unit installation and start-up can be achieved hours
- Allows single point access for maintenance and service of each unit

Ultra Low Charge NH_3 Systems

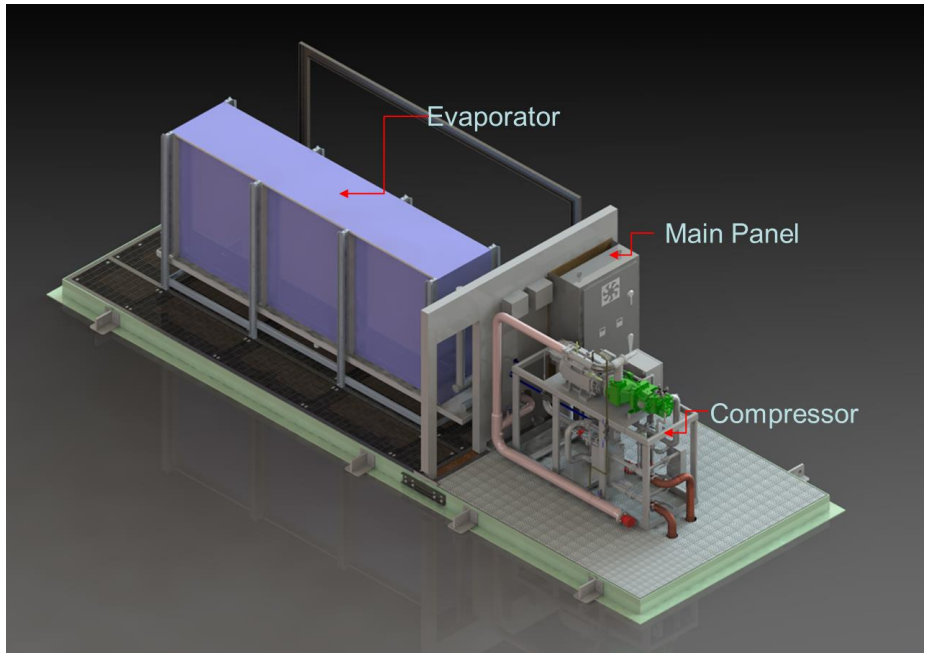
- System flexibility offers cooler, freezer, blast freezer, and convertible solutions with capacities from 10 to over 100 TR
- Offers flexibility in temperature and redundancy
- Eliminates loss of large refrigerant charges and associated liability
- Concerns over worker safety are minimized due to ultra low charge
- Provides the ability to locate your facility in places you may not be able to otherwise due to liability issues

Evaporator Control

- Refrigerant charge measured in ounces per ton capacity
- Eliminates external sensible heat-based control challenges encountered with DX (Dry Expansion) systems.
- Fully automated liquid feed modulation enables use of all evaporator coil surface.
- Electrical efficiency typically surpasses that of the central ammonia engine room.



Ultra Low Charge NH_3 Systems

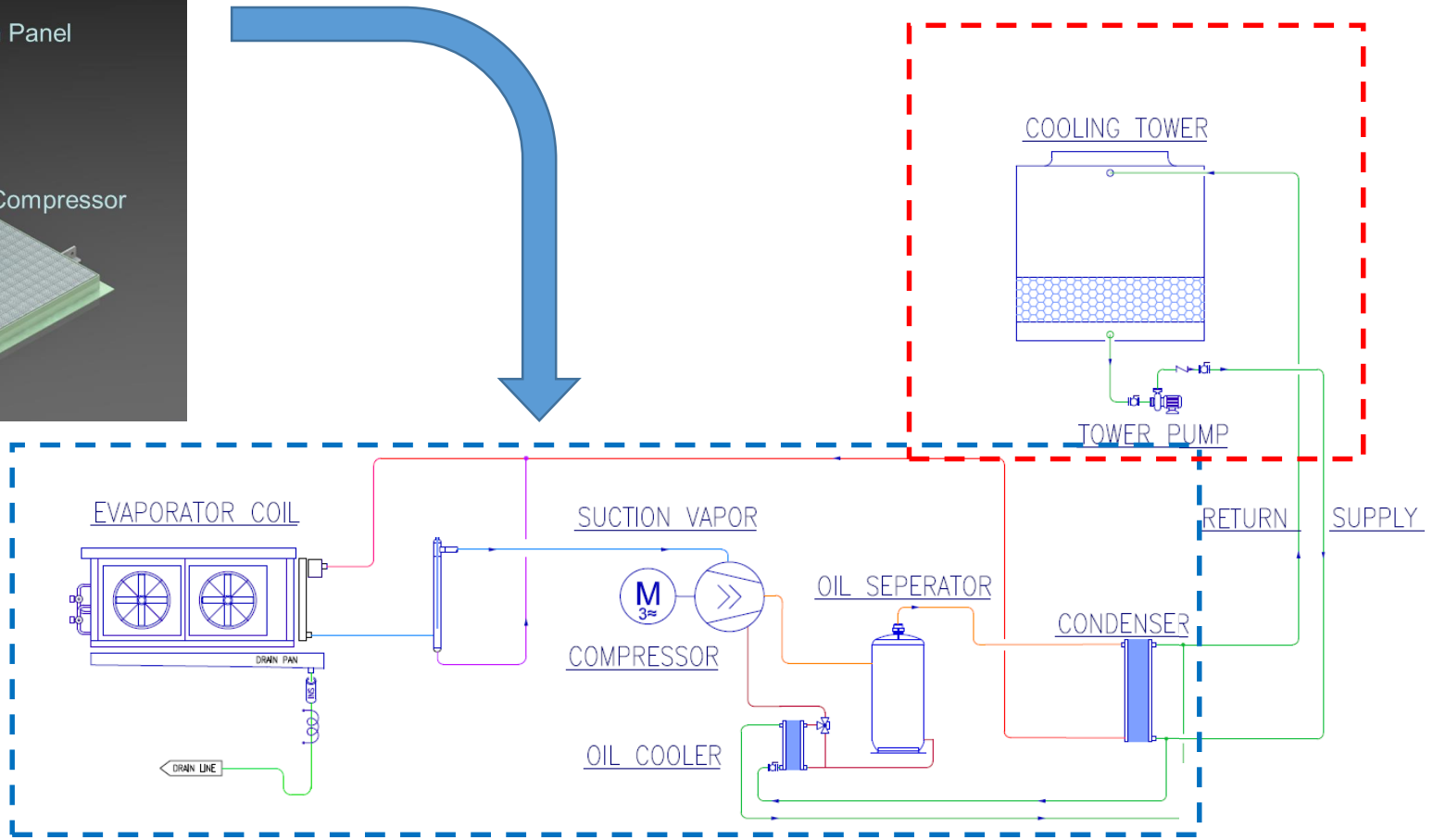


Outside the Box

- ✓ Fluid cooler
- ✓ Pump station

Inside the Box

- ✓ Open drive screw compressor
- ✓ Economizer *(Low Temperature Only)*
- ✓ Water/fluid –cooled condenser
- ✓ Industrial evaporator
- ✓ Integrated power control center
- ✓ Industrial computer controller
- ✓ Structural steel base
- ✓ Insulated enclosure

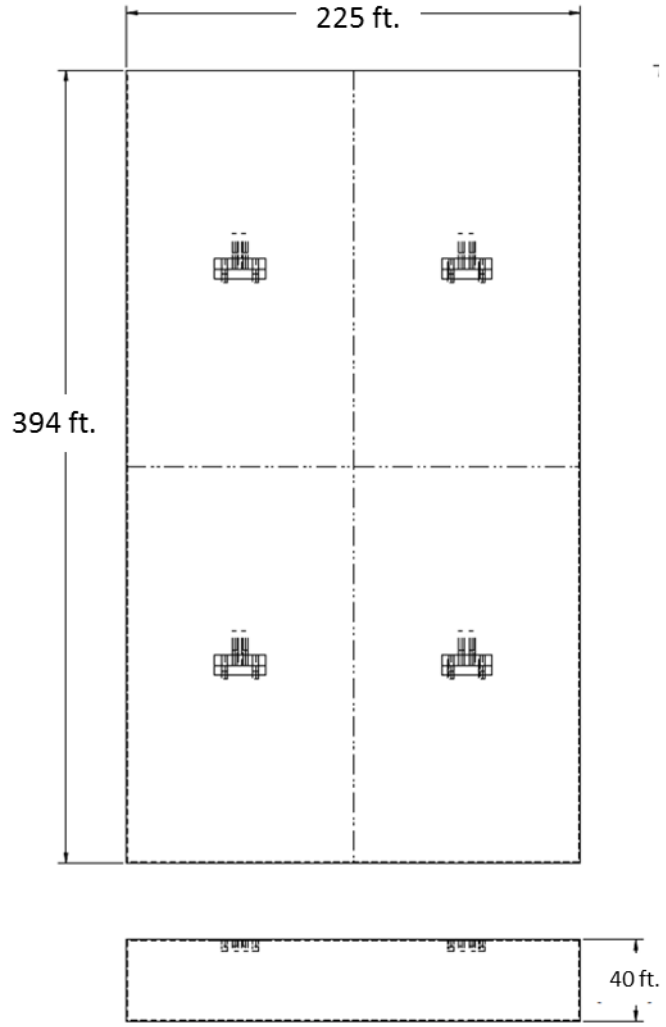


Ultra Low Charge Case Study

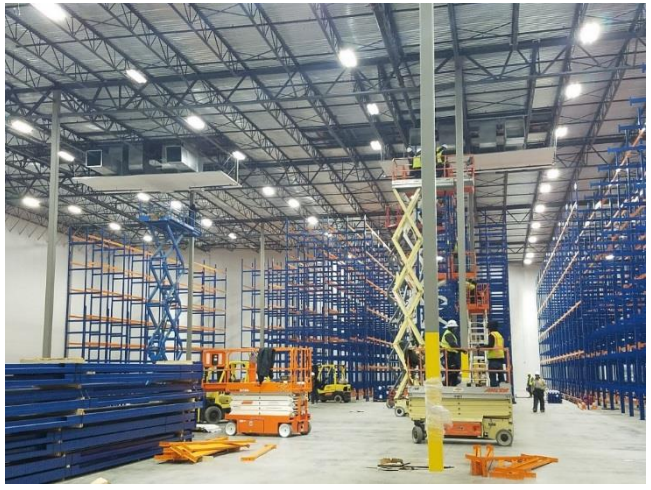
- Installation
- Ammonia Charge and Energy Analysis
- Air Distribution

Storage Freezer Application Case Study

- 225 ft x 394 ft x 40 ft high (69 m x 120 m x 12 m H)
- Room area = 88,650 ft^2 (8,236 m^2)
- Room Temperature = -10 F (-23 C)
- Unit Evaporator Temperature = -20 F (-29 C)
- Design load = 350 ft^2 /TR = 252 TR Capacity required
- Four nominal 60 TR units (63 TR operating capacity)



Installation

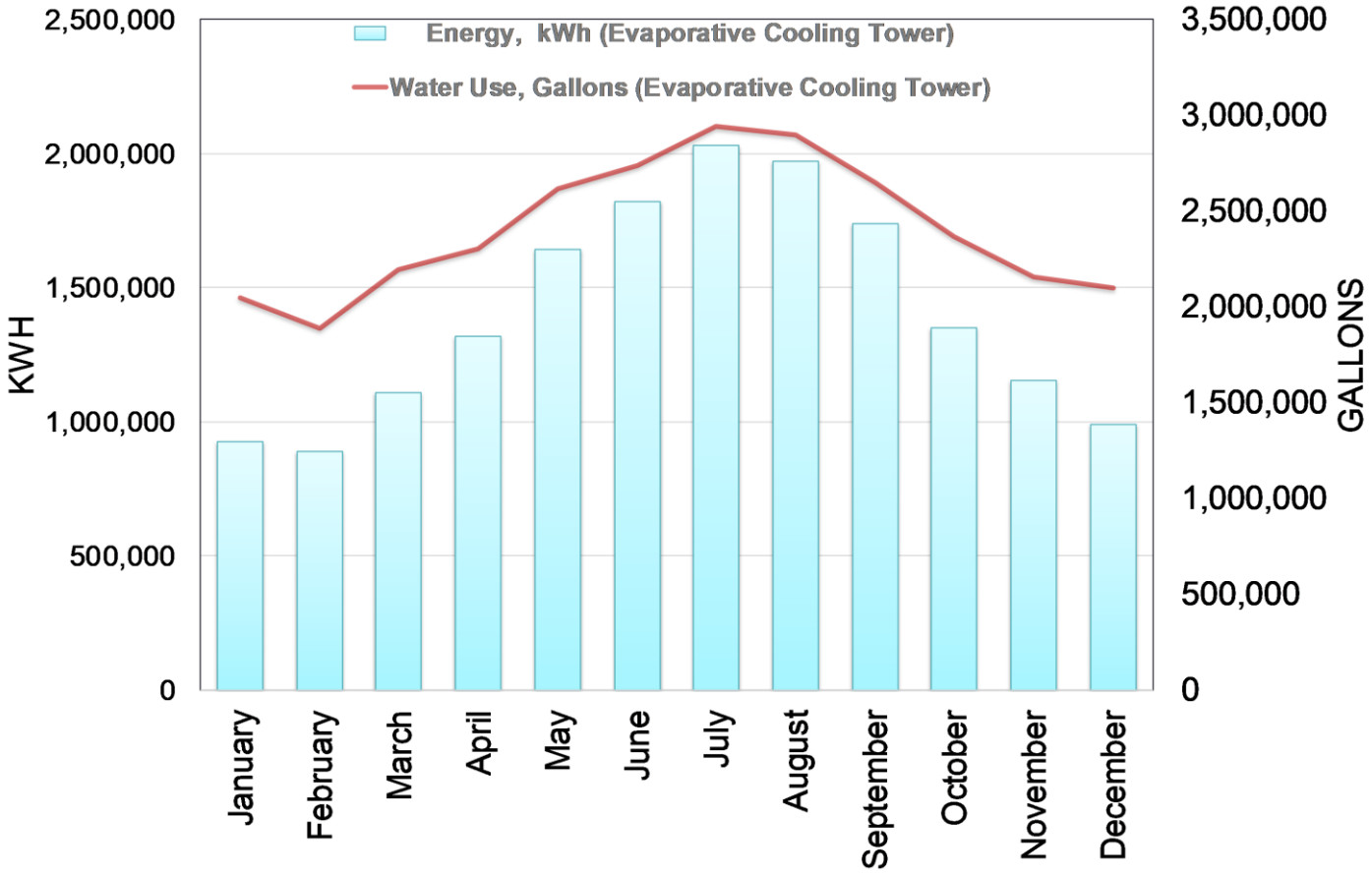


With proper preparation at the job site a two and one half hour installation per unit is achievable

Ammonia Charge

- For the ultra low charge application ½ lb. of ammonia per ton of refrigeration is achievable
- 60 TR unit will require 30 lb. of ammonia
  - Note: 60 TR freezer unit requires shaft power of 156 HP and utilizes a 170 HP electric motor
- Freezer requires a total of 120 lb. of ammonia
- In comparison a central system would require 4,800 lbs.
- The facility that includes this freezer would require over 20,000 lbs. of ammonia using central systems
- Using ultra low charge systems, the facility would require less than 600 lbs. of ammonia

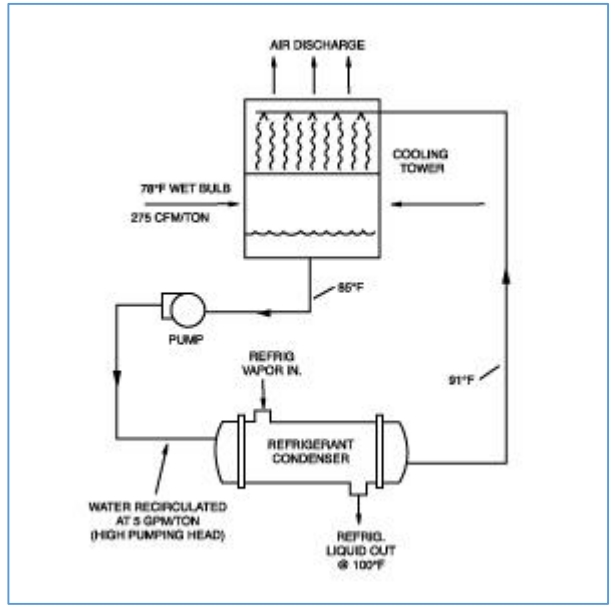
Monthly Energy & Water Summary

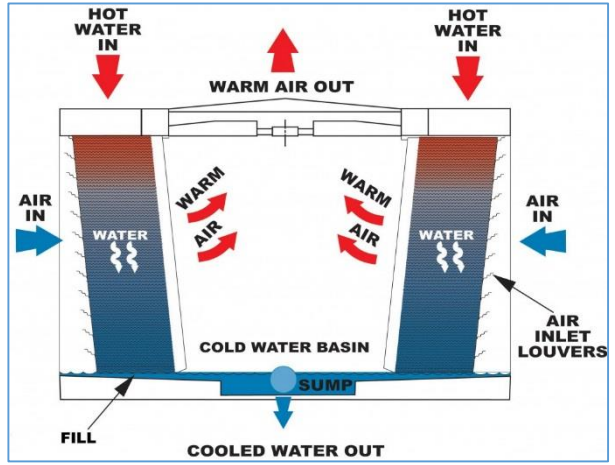


- Monthly energy and water usage show the expected trend of peaking during summer months
- Includes estimated lighting, people, infiltration, transmission, 10F product pulldown, forklifts, etc.
- Overall facility annual refrigeration energy calculated using ALL sources (compressors, evaporators, defrost, pumps, cooling tower fans, spray pumps, etc).
- Overall annual energy 17 million KWh that translates to **1.1 KW per nominal ton installed capacity**
- Compressors account for 70% of facility refrigeration system energy, equivalent to **0.8 KW per nominal ton installed capacity**
- Cooling Tower annual make-up water usage 29 million gallons, equivalent to **0.03 gpm per installed ton capacity**

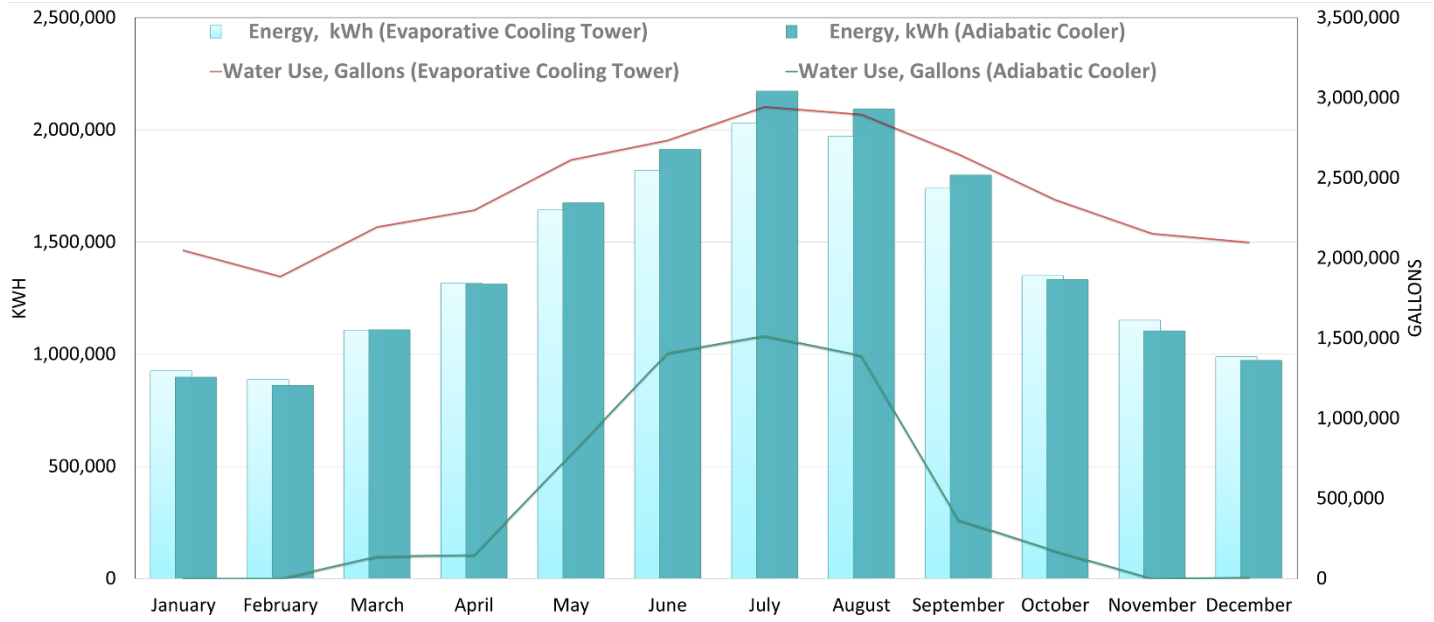
Evaporative vs. Adiabatic Fluid Cooler

- Fluid Temperature
  - Lowest fluid temperature with evaporative resulting in lower energy usage
- Water usage
  - Adiabatic water use is much lower then evaporative
  - No water treatment required with adiabatic



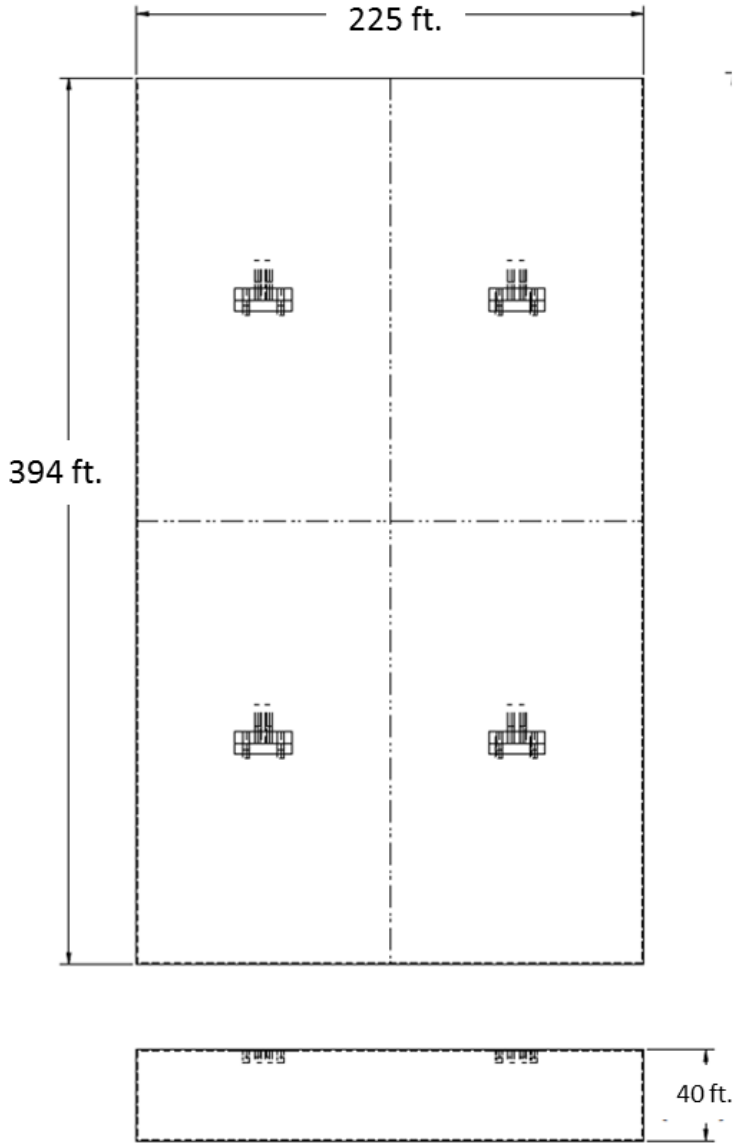


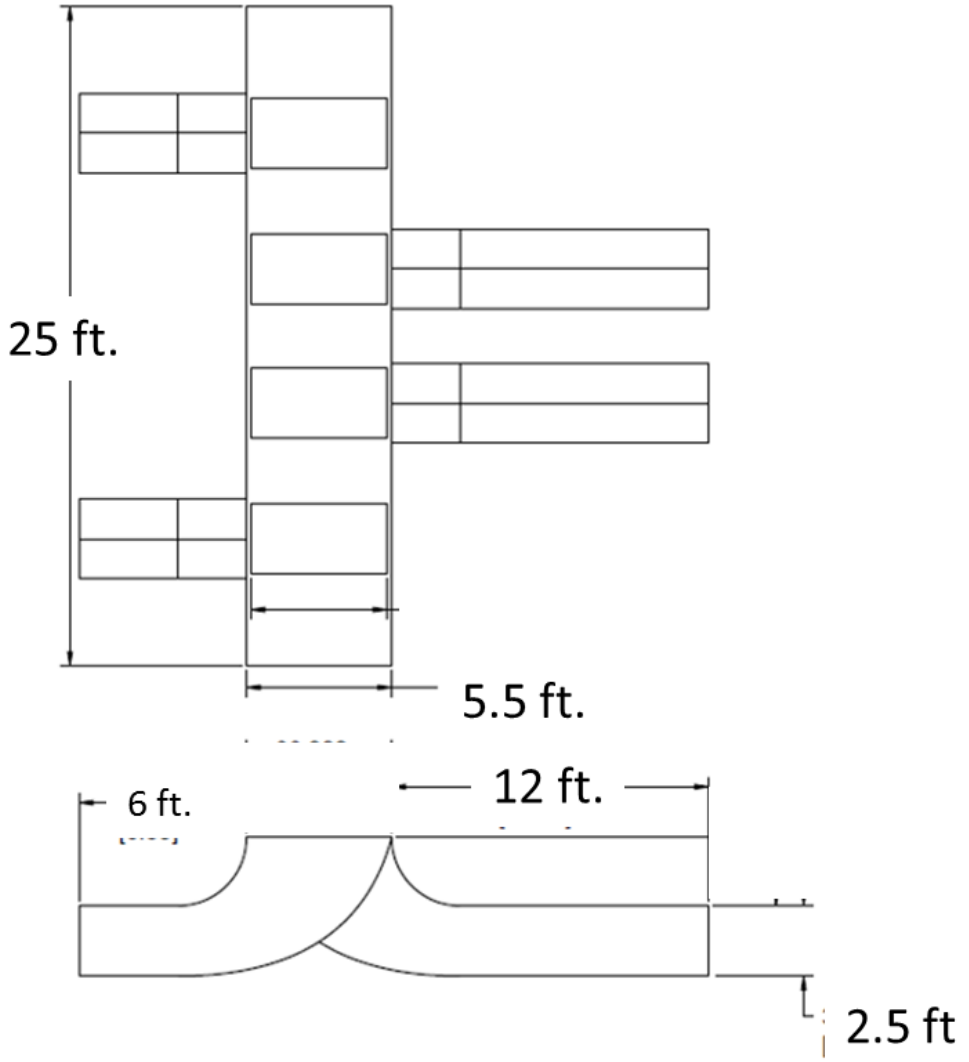
Monthly Energy & Water Usage Comparison (Cooling Tower vs Adiabatic Cooler)



	Evaporative Fluid Coolers	Adiabatic Coolers
Annual Energy Use (kWh)	16,932,190	17,241,928
Annual Energy Cost @ 10 cents per kWh	$1,693,219	$1,724,192
Annual Water Use (Gallons)	28,874,594	5,919,570
Annual Water Cost @ $7 per 1000 Gal	$202,122	$41,437
Annual Water Treatment Cost	$25,000	
Adiabatic Cooler Simple Payback Period of 3 Years		

Unit Layout and Duct Design

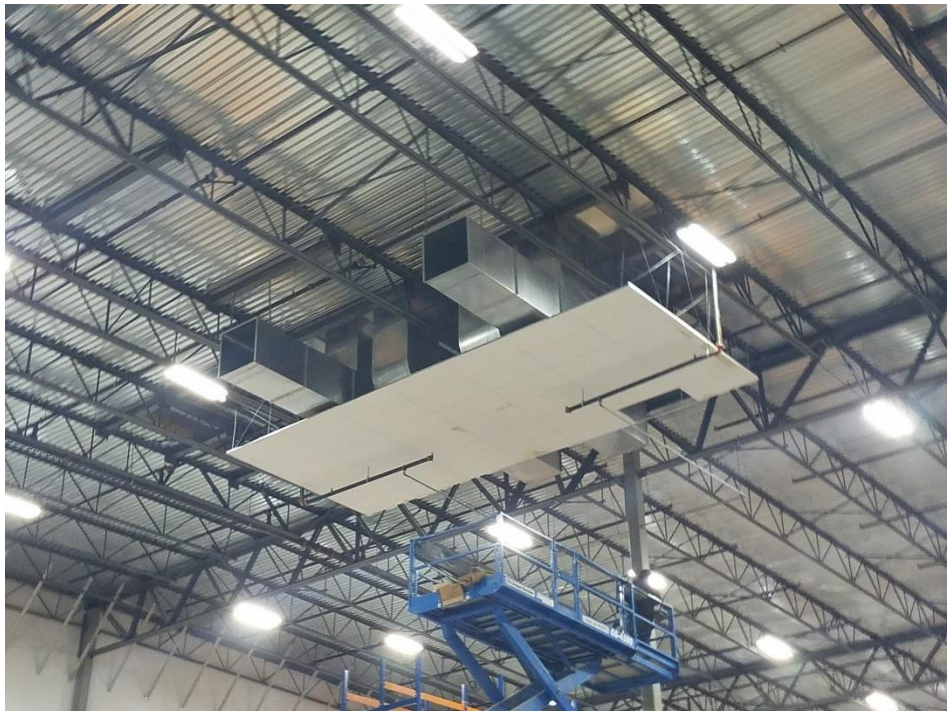


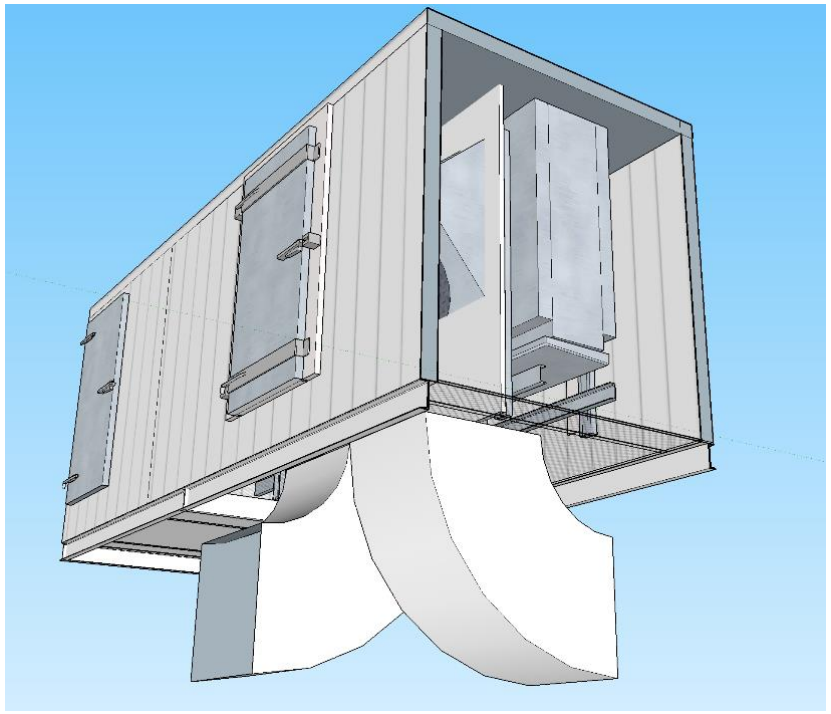


Air Distribution

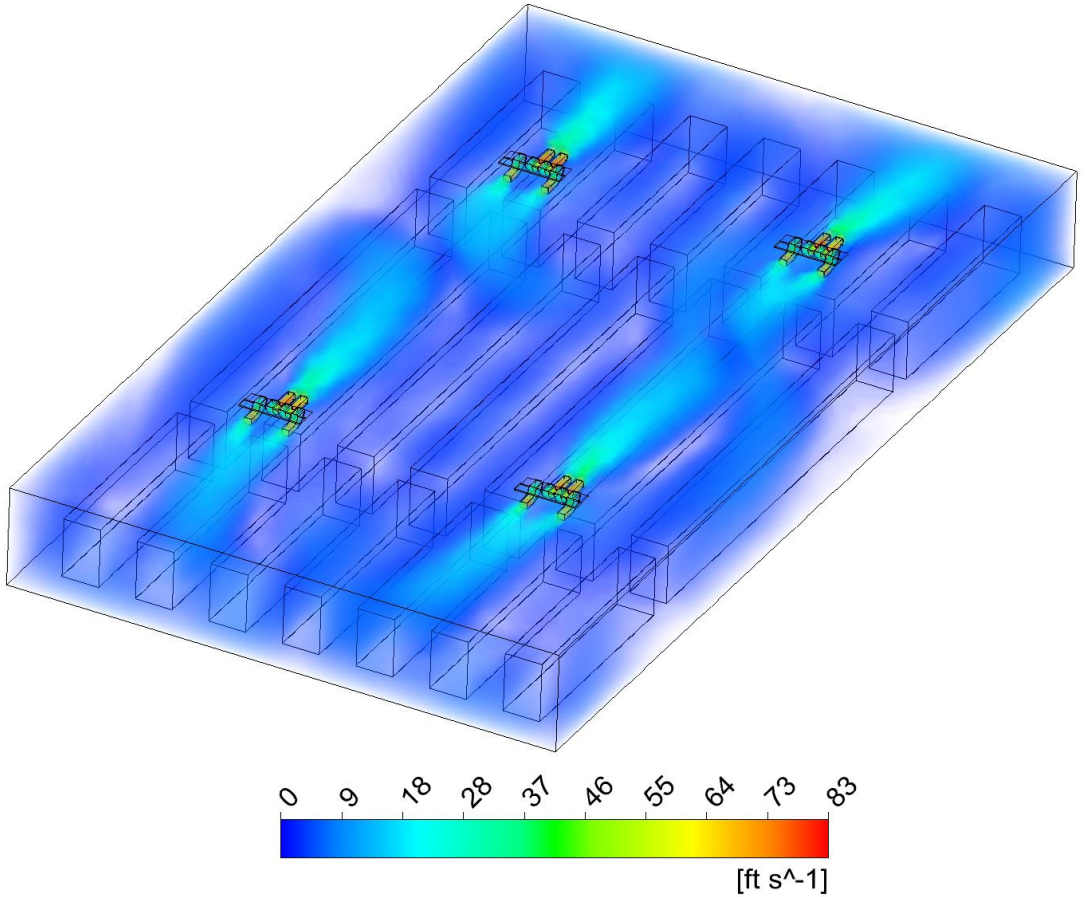
Air Distribution

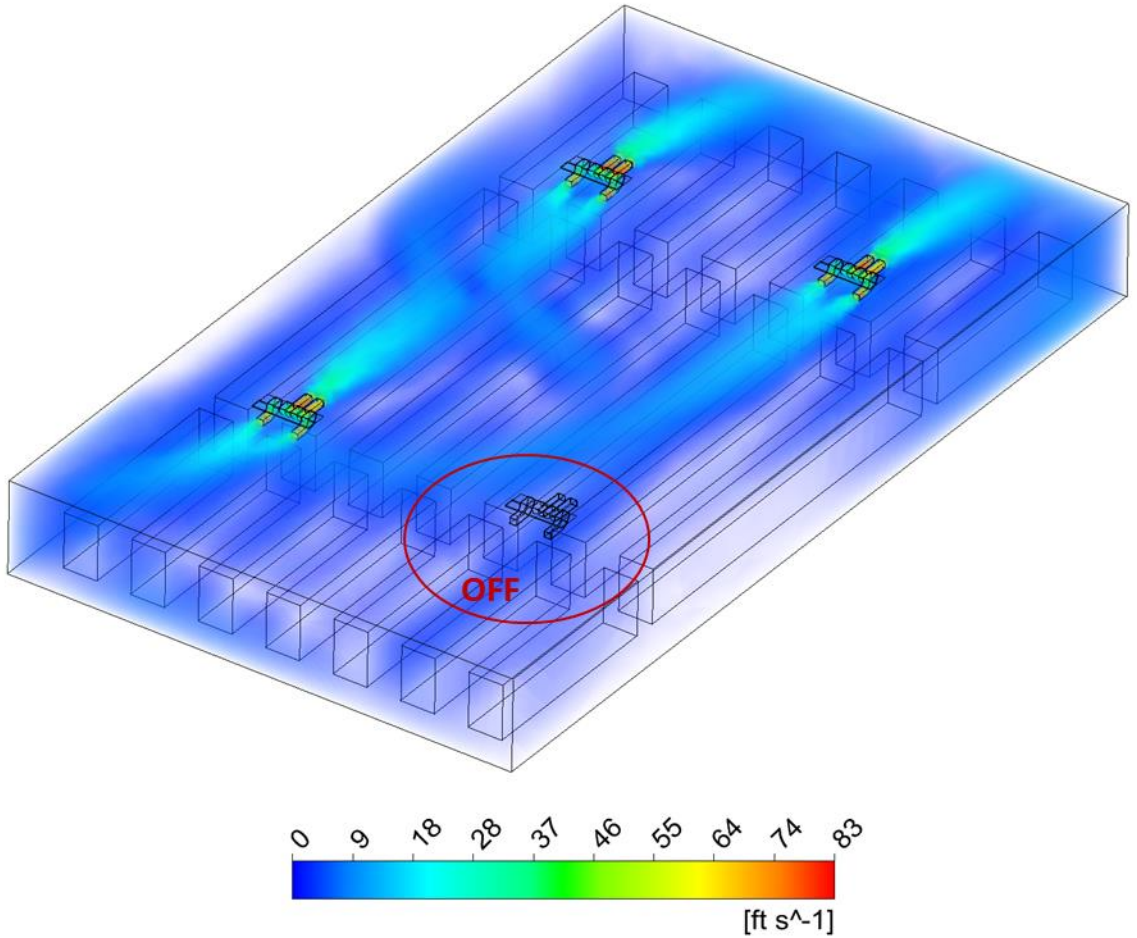
- ✓ Supply & Return partitioned
- ✓ Fans designed for ½” ESP Ducting similar to traditional penthouse design
- ✓ Long Air Throw Capability
- ✓ Design for Vertical or Horizontal Air Discharge



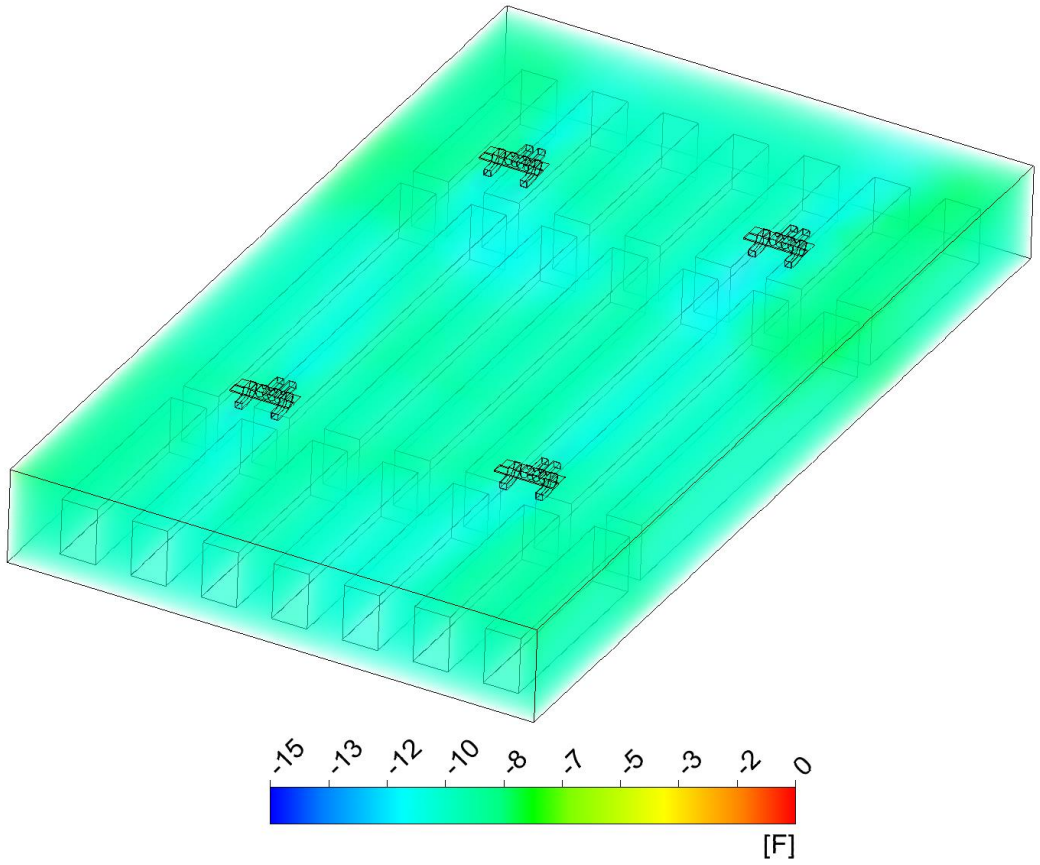


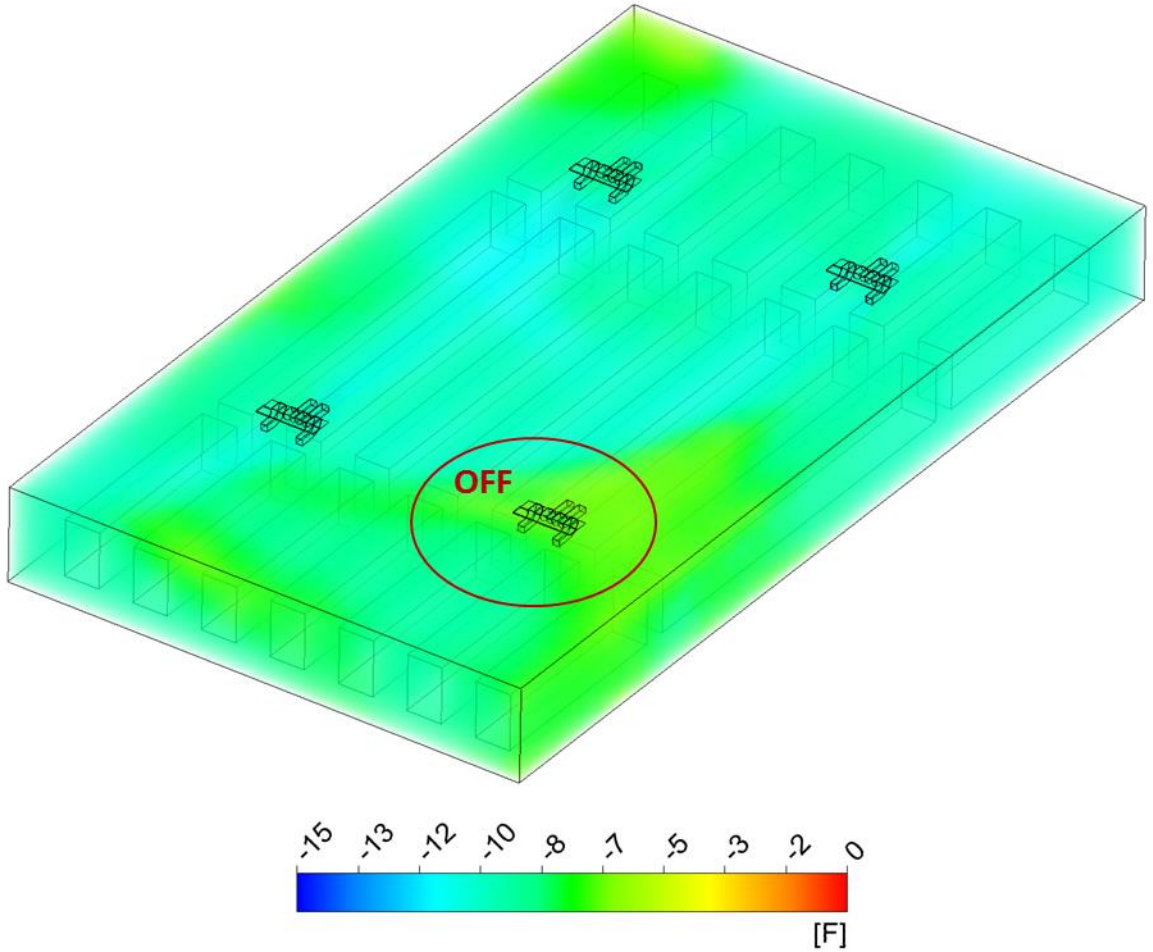
Airflow Analysis: Freezer





Thermal Analysis: Freezer





Low Charge Package NH_3 Systems Conclusions

- Low Charge Package units have the lowest charge per TR
- It is possible to have superior electrical performance with LC NH_3 Systems
- Construction costs (equipment, installation, and building modifications) can be equal for LC NH_3 Systems compared to central plants
- LC NH_3 systems can lower employee and public safety risks and still take advantage of the energy efficiency of NH_3
- New facilities as well as retrofit for existing facilities are both candidates for application of LC NH_3 Systems

Thanks for Your Time!!

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