Ultra Low Charge Ammonia Systems for Cold Storage Applications

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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

What’s a “typical” system?

Schematic courtesy of Doug Reindl – IRC – University of Wisconsin

ASHRAE / Ultra Low Charge Ammonia Systems for Cold Storage Applications
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 NH₃ 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 NH₃ field piping. Only field piping required is fluid pipe from condenser to fluid coolers
Ultra Low Charge NH₃ 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 NH₃ 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.
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

Outside the Box
- Fluid cooler
- Pump station
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 ft² (8,236 m²)
- Room Temperature = -10 F (-23 C)
- Unit Evaporator Temperature = -20 F (-29 C)
- Design load = 350 ft² /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 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 than evaporative
  - No water treatment required with adiabatic
Monthly Energy & Water Usage Comparison (Cooling Tower vs Adiabatic Cooler)

<table>
<thead>
<tr>
<th></th>
<th>Evaporative Fluid Coolers</th>
<th>Adiabatic Coolers</th>
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</thead>
<tbody>
<tr>
<td>Annual Energy Use (kWh)</td>
<td>16,932,190</td>
<td>17,241,928</td>
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<td>Annual Energy Cost @ 10 cents per kWh</td>
<td>$1,693,219</td>
<td>$1,724,192</td>
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<td>Annual Water Use (Gallons)</td>
<td>28,874,594</td>
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<td>Annual Water Cost @ $7 per 1000 Gal</td>
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<td>Annual Water Treatment Cost</td>
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</tbody>
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Adiabatic Cooler Simple Payback Period of 3 Years
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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