CO₂ Cascade Industrial Refrigeration Systems

This short discussion is not about commercial units for grocery stores or transcritical units

Greg Robison, Vice President
M&M Refrigeration
NH₃ Single Stage System

Evaporator → NH₃ circuit → Condenser

-45°F → +95°F
NH₃ Two Stage System

Evaporator

-45°F

NH₃ circuit

+20°F

Intercooler

NH₃ circuit

+20°F

+95°F

Condenser
WHY CHOOSE CO2 CASCADE SYSTEMS FOR INDUSTRIAL APPLICATIONS?

• CO₂ is a green, natural refrigerant and is about 10 times more dense than NH₃ and Freon

• Improved power and efficiency with room temperatures below -4°F or -20°C compared to two stage NH₃ systems
  - Typical Cold Storage freezer with a truck dock, 6%-10% energy saved
  - Typical -40°F/-40°C, 30% energy saved
  - Typical -58°F/-50°C, 40% energy saved
  - When compared to single stage, the percentages are even better
  - CO₂ can be used as low as -63°F suction temperature
Independent 3rd Party Study
Field Monitoring and Evaluation
System Efficiency Results
Cascade CO₂ vs. Two Stage NH₃
BHP/TR comparison of CO2/Ammonia with conventional Ammonia Systems at full load

**BHP/TR comparison of CO2/Ammonia with conventional Ammonia Systems at 50% part load**

**BHP/TR comparison of CO2/Ammonia with conventional Ammonia Systems at full load**
WHY CHOOSE CO$_2$ CASCADE SYSTEMS FOR INDUSTRIAL APPLICATIONS?

- Lower installed first cost for a CO$_2$ cascade system compared to two stage ammonia systems (4% to 15% depending on the size of the system).
- Smaller engine rooms, smaller wet and dry suction lines and discharge lines

**CO$_2$ as a Refrigerant**  
**Piping example-300TR at -40F**

<table>
<thead>
<tr>
<th>Wet suction, 300ft pipe, two 90 bends, one stop valve</th>
<th>Dry suction, 100ft pipe, two 90 bends, one stop valve</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pipe size</strong></td>
<td><strong>Temperature drop</strong></td>
</tr>
<tr>
<td>Inch</td>
<td>F</td>
</tr>
<tr>
<td>Ammonia</td>
<td>12&quot;</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>6&quot;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liquid, 300ft pipe</th>
<th>Discharge, 100ft pipe</th>
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</thead>
<tbody>
<tr>
<td><strong>Pipe size</strong></td>
<td><strong>Temperature drop</strong></td>
</tr>
<tr>
<td>Inch</td>
<td>F</td>
</tr>
<tr>
<td>Ammonia</td>
<td>2½&quot;</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>4&quot;</td>
</tr>
</tbody>
</table>

- In general same pipe material and wall thickness as for ammonia
- Copper pipes can be used as well
WHY CHOOSE CO₂ CASCADE SYSTEMS FOR INDUSTRIAL APPLICATIONS?

• Reduced ammonia charge
  - Most systems are below 10,000# and require minimal PSM or RMP in most states.
  - Example: 720,000 square foot/15.8 million cubic foot cold storage has 7,000# NH₃ and 70,000# of CO₂. The ratio is usually 10-1.

• Lower maintenance costs
  - No cooling required on the low side compressors, air unit valve stations with electric defrost have five hand valves, one solenoid and one strainer.

• Lower refrigerant cost
  - CO₂ is about $0.25 per lb.

• CO₂ Systems are always operating at a positive pressure

• No ammonia is present in the food area

• CO₂ is non-hazardous and non-flammable

• Use CO₂ as a brine instead of glycol brine

• We have 60+ systems ranging from 50 TR up to 1800 TR
CO2 CHILLERS INSTEAD OF GLYCOL CHILLERS AT 35°F

- CO₂ ~ $1 per gallon, Glycol ~ $8 per gallon
- Brine Pump HP is 50% less
- Brine pipe size is 400% less
  - 100TR Glycol: (2) 5” pipes
  - 100TR CO₂: (1) 2” & (1) 3” pipe
- Brine piping insulation costs less
- Air units are 30% smaller
Ammonia / CO₂ South of the Border

Mexican cold-storage operator Frialsa is leading its country’s adoption of NH₃/CO₂ systems that are safer and 15%-20% more energy efficient than conventional ammonia equipment.

By Michael Berry