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Hybrid and Secondary Loop CO\textsubscript{2} Refrigeration Systems

August 16, 2012
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Today’s speakers...
Rusty Walker is a Senior Corporate Trainer with Hill PHOENIX Learning Center. He has more than 25 years of experience in the industry. He conducts many courses and seminars throughout the country on refrigeration systems, power systems, display cases, and walk-in coolers, and is well versed in most aspects of the industry. An avid music and baseball enthusiast, Rusty often sets the tone for his courses with a lively tune.
Hybrid and Secondary Loop CO₂ Refrigeration Systems
## Useful Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Direct Expansion</td>
<td>A refrigeration system that includes a compressor, condenser, evaporator coil, and an expansion device</td>
</tr>
<tr>
<td>Primary Refrigerant</td>
<td>A fluid used to lower the temperature of a secondary coolant (i.e. R-22, R-404a, R-507, R-410A, R-717, etc…)</td>
</tr>
<tr>
<td>Secondary Coolant</td>
<td>(a.k.a Secondary Refrigerant, Secondary Fluid) A fluid used to transfer heat from a heat source (i.e. refrigerated space) to a primary refrigerant.</td>
</tr>
<tr>
<td>Single-Phase Secondary Coolant</td>
<td>(a.k.a Secondary Refrigerant, Secondary Fluid) A fluid used to transfer heat from a heat source (i.e. refrigerated space) to a primary refrigerant.</td>
</tr>
<tr>
<td>Two-Phase Secondary Coolant</td>
<td>A secondary fluid which absorbs heat by means of latent heat transfer resulting in a change in phase (i.e. carbon dioxide, ice-slurries)</td>
</tr>
</tbody>
</table>
Useful Definitions

**Cascade System**
A system having two (or more) refrigerant circuits, each with a compressor, condenser and evaporator, where the evaporator of one circuit cools the condenser of another circuit.

**Upper Cascade**
The refrigerant circuit in a cascade system that cools the condenser of the lower-cascade and transfers the heat to a heat sink, typically outdoor ambient.

**Lower Cascade**
The refrigerant circuit in a cascade system that removes heat from a refrigerated load and transfers the heat to the upper-cascade.
Subcritical vs. Transcritical

- **Subcritical** - CO2 systems where the pressure of the CO2 is maintained well below the critical pressure of $87^\circ F / \sim 1055$ psig.
- Operating pressures for subcritical systems are slightly higher than those in conventional direct-expansion systems but are similar to those seen in air-conditioning applications using R-410A.
- **Transcritical** - CO2 systems that are designed to operate at pressures above the critical pressure, above 1055 psig.
Triple Point vs. Critical Point

- **Triple Point**
  - Liquid CO2 below 60PSIG changes to Dry Ice

- **Critical Point**
  - 87°F = 1055 psig
  - No longer able to distinguish between liquid and vapor.
  - An undefined gas.
  - Only found in a Transcritical system.
Refrigerant Choices for Commercial Systems

One 100 pound cylinder of R-404A leaked to atmosphere equates to the tailpipe emissions of 28 - 4x4 Chevy Suburban's travelling 12,000 miles each!

Refrigerant Leaks are higher than transportation

A “Carbon Footprint” is the amount of carbon emitted from burning of fuels + the carbon equivalent (calculation) of refrigerant leaks
Carbon Dioxide is used as a secondary coolant or a Direct Expansion Refrigerant

Carbon Dioxide = CO$_2$ = R-744
Types of CO₂ Systems

- Cascade Low Temp CO2 & Medium Temp Glycol
- Secondary Low Temp CO2 & Modular Medium Temp Glycol
- Cascade Low Temp CO2 & Secondary Medium Temp CO2
MEDIUM-TEMPERATURE LOADS

LOWER-CASCADE (LT) WITH CO2 COMPRESSORS

LOW-TEMPERATURE LOADS

UPPER-CASCADE (MT) WITH R-404A COMPRESSORS

MT Secondary Load: 145 kBtu/Hr
LT CO2 Cascade Load: 242 kBtu/Hr

LEGEND
- R-404A Discharge
- R-404A Liquid
- R-404A Suction
- Glycol Return
- Glycol Supply
- CO2 Discharge
- CO2 Liquid
- CO2 Suction
Combined Medium Temperature Modular Glycol Secondary Low Temperature CO2

MT Glycol Secondary Load: 860 kBTU/Hr
LT CO2 Secondary Load: 335 kBTU/Hr
Secondary Medium Temperature CO2
Cascade Low Temperature CO2
Cascade Low Temperature CO2
Secondary Medium Temperature CO2

- Condenser and Heat Reclaim Loads
- Liquid-Vapor Separator
- Medium-Temperature Loads
- HFC Upper-Cascade Compressors
- Condenser-Evaporators
- CO2 Pump
- Solenoid Valves
- Receiver
- CO2 Lower-Cascade Compressors
- EEV's
- Medium-Temperature Loads
- Low-Temperature Loads
Combined System Low and Medium Temp CO2

- Condenser and Heat Reclaim Loads
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Combined System Low and Medium Temp CO2
Major Components and Functions

**CO2 Compressors:**
- Typical 3-5 Units in Parallel
- Types Available:
  - Reciprocating
  - Scroll
- Contain High-to-Low Internal Relief and External Low Relief
- Work with POE Oil
- Accessories:
  - Electronic Oil Float
  - High Pressure Switch
  - Low Pressure Switch
- Capacity Control:
  - VS on Reciprocating (no unloading available)
  - Digital Scroll in future
Oil Separator:
• Removes Most of the Oil Carried Over from Compression
• Accessories:
  • Oil Filter
  • Sight Glass
Major Components and Functions

Condenser-Evaporators:
- Condense Vapor from Separator and CO2 Discharge Gas from Compressors into Liquid
- Evaporates Primary HFC Refrigerant (R-404A, R-407A)
- Brazed Plate Heat Exchanger
Major Components and Functions

Liquid-Vapor Separator:
- Holds CO2 Charge
- Compensates for Level Fluctuations during Defrost
- ASME approved Vessel
Major Components and Functions

**CO2 Pumps:**
- Pressurize Liquid CO2 for delivery to MT and LT evaporators
- Primary and Backup
- Hermetic, multi-stage centrifugal pump with liquid-cooled motor
Major Components and Functions

Medium-Temperature Evaporators:
- Specially designed for CO2
- Liquid enters coils and is partially evaporated
- Two-phase mixture leaves coils
- Solenoid valve control
- Individual control of each case
- Off-Time Defrost
- Isolation/Balance Valve if needed during commissioning
Low-Temperature Evaporators:
- Specially designed for CO2
- Liquid enters Electronic Expansion Valve at coil inlet
- CO2 is fully evaporated with superheated vapor leaving coils
- Dual-Temp Control on some cases
- Electric Defrost with Coil Temperature Probe for Termination
Major Components and Functions

Upper-Cascade:
- Refrigerates Condenser-Evaporator Heat Exchangers
- Transfers heat to Ambient
- Typical HFC System
Questions