

# Low Pressure CO<sub>2</sub> Air Conditioning System

John Meyer, Ph.D.

Visteon Corporation

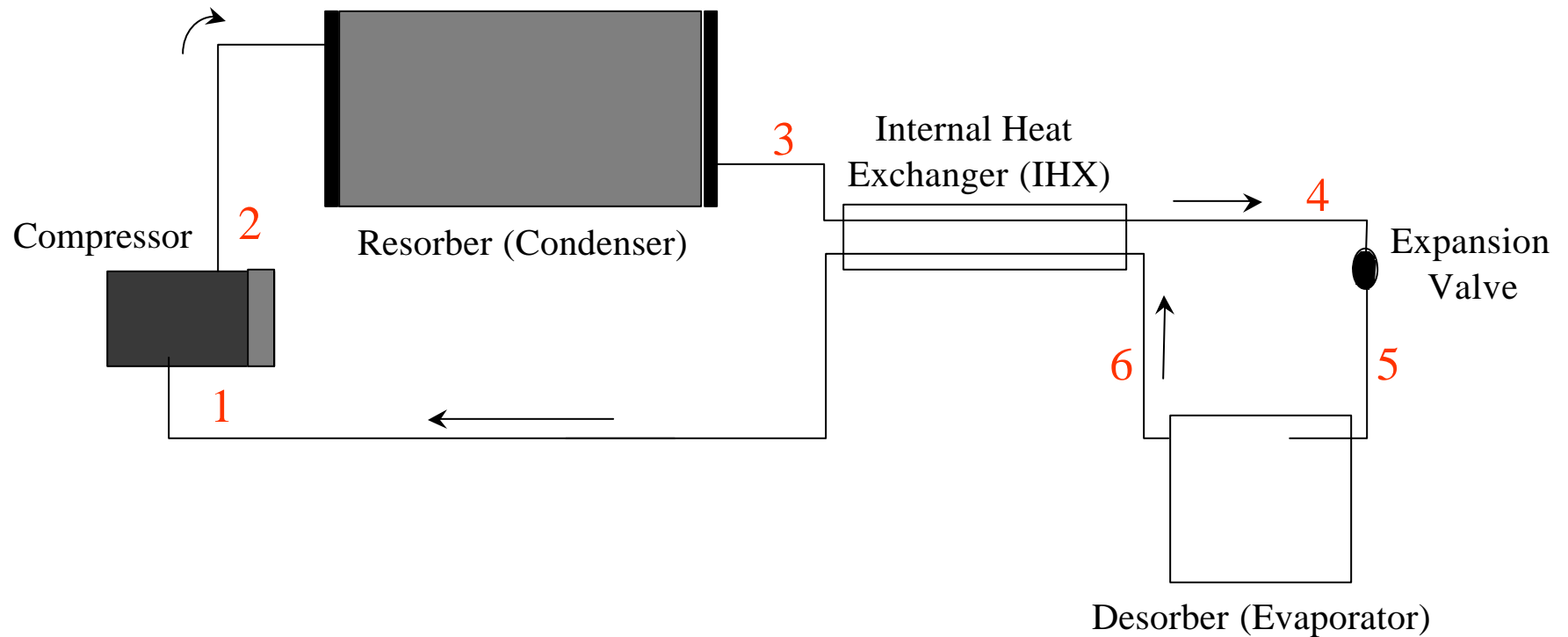
Christopher J. Seeton

Spauschus Associates, Inc

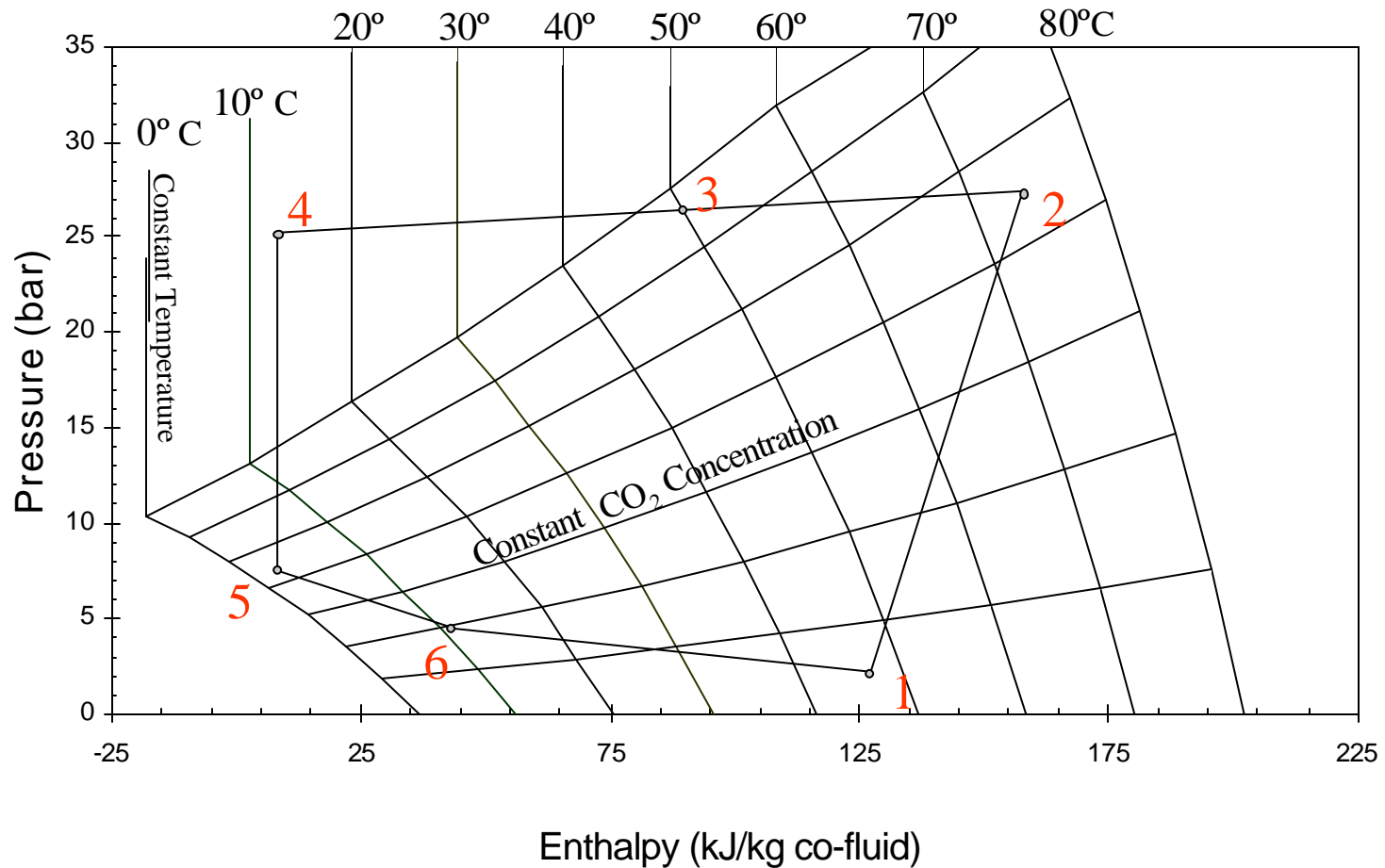
# Low Pressure CO<sub>2</sub>

- Description
  - Uses a “co-fluid”, which absorbs and desorbs CO<sub>2</sub> to maintain low pressures
  - Utilizes heat of solution rather than heat of vaporization
- Characteristics
  - Cold Cycle – discharge temps @ 10-20°C above ambient
- Operates at pressures near those of R134a
  - COP has potential to rival R134a or CO<sub>2</sub> technologies
  - Requires minimal hardware modifications

# System Schematic for LP CO<sub>2</sub>



# Property and Cycle Diagram for LP CO<sub>2</sub>



# Component Modifications for LP CO<sub>2</sub>

- Resorber (Condenser)
  - Best performance to date from Visteon “NRT” design
  - Circuitry of two-pass core is 20-19
- Desorber (Evaporator)
  - Best performance to date from Visteon single tank evaporator
  - Simple U-flow arrangement takes advantage of sensible heat transfer from the liquid co-fluid
- Compressor
  - Best performance to date from modified V-90 scroll
  - Modified to prevent over-compression
  - Discharge port enlarged to eliminate choking

# Component Modifications for LP CO<sub>2</sub>

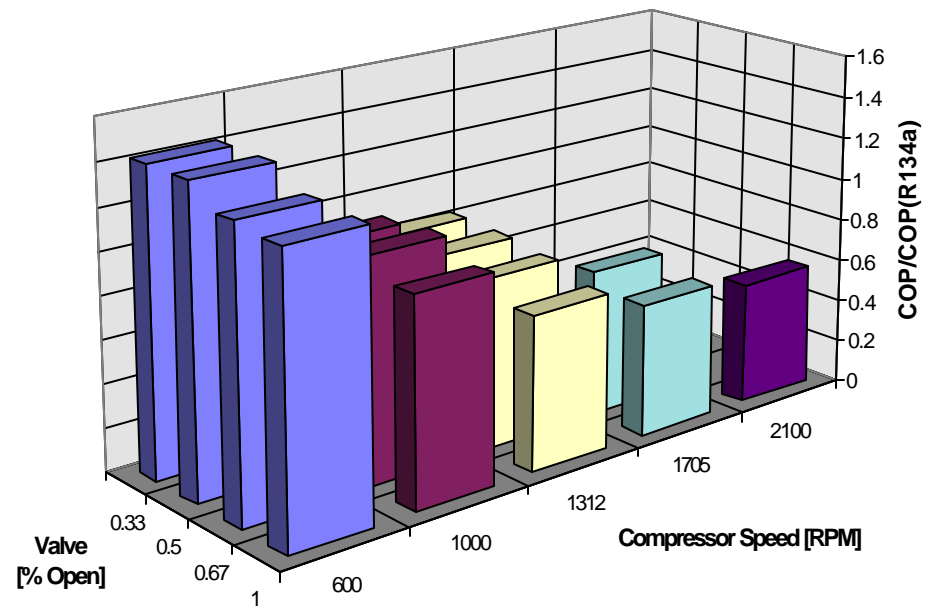
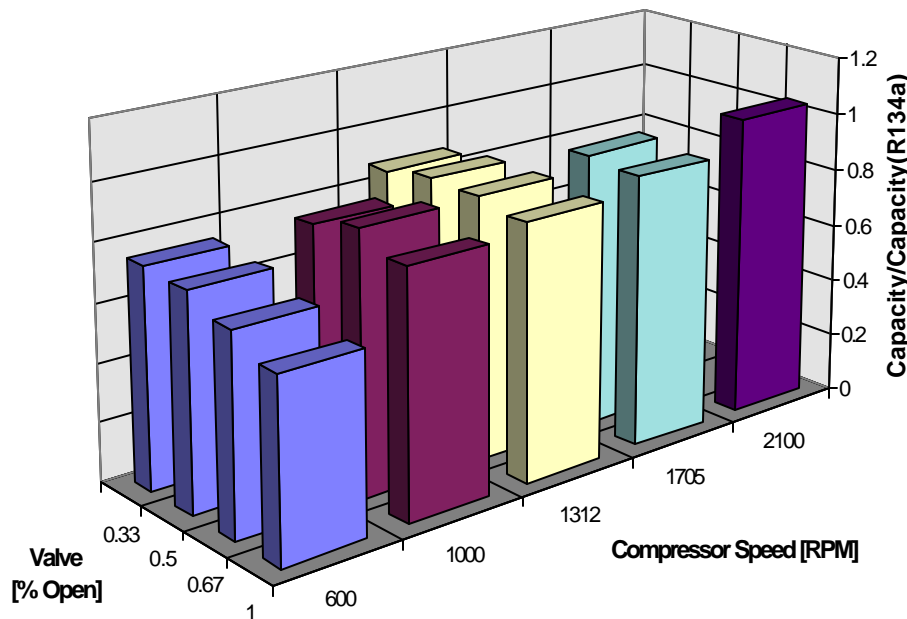
- Lines
  - Test stand has SS lines
  - Production lines will utilize current hose technology and if necessary borrow transcritical CO<sub>2</sub> barrier technology
- Expansion valve
  - Test stand has manual needle valve
  - Future expansion valve will be “smart” (TXV or microprocessor)
- Internal heat exchanger (IHX)
  - Required to cool flow before expansion
  - Resembles plate evaporator without fins
  - High capacity and effectiveness required
- Receiver/Dryer
  - May not be necessary
  - Function can be integrated into IHX

# Efficiency Improvement Update

- System tests are ongoing to determine the interactions between
  - Mass of co-fluid
  - Mass of CO<sub>2</sub>
  - Compressor speed
  - Expansion valve setting
- For comparisons, testing is performed at a single condition
- Compressor speeds for the co-fluid system are much lower than for the R134a system
  - 1/4 to 1/2 speeds

# Efficiency Update

- All data shown were tested at a single condition, which simulates the early part of a pull-down on a hot day
- Capacity is fairly flat with changes in RPM and valve setting until RPM's get very low (~600-800 RPM)
- Compressor power increases as RPM's increase
- COP increases greatly as RPM's are reduced



# LP CO<sub>2</sub> Vehicle Update

- Co-fluid is Propylene Carbonate
- Control strategy consists of fixed expansion valve
- Resorber/Desorber are slightly modified current production condenser/evaporator
- Internal heat exchanger is one-of-a kind prototype
- Lines are braided stainless steel
- Fittings are “non-production” intent
- Compressor is modified V-90 scroll

# Long Term System Goals

- Objective to have nearly “production Intent” vehicle by June 2001 (Phoenix 2001 meeting)
- Control strategy will be responsive to system conditions
- Resorber/Desorber will be further refined for co-fluid system
- Internal heat exchanger will near “production intent”
- Compatibility and safety of connection hoses will be ensured
- Compressor will be further optimized

# LP CO<sub>2</sub> Challenges

- Internal heat exchanger capacity greater than either resorber or desorber
  - Large source of irreversibilities
  - Small approach temperature needed to maintain efficiency
- Flow distribution in evaporator hurts capacity
  - Temperature glide in evaporator reduces  $\int T$  irreversibilities compared to constant temperature (R-134a, CO<sub>2</sub>)
  - Need co-fluid with higher CO<sub>2</sub> heat of solution
- Production issues
  - Charging/servicing co-fluid system
  - Control strategy and required hardware undecided
- Heating effectiveness
  - Currently unknown