

ET Summit 2022

Presented by



A Near-Zero GWP Heat Pump System for All-Electric Heating & Cooling in California

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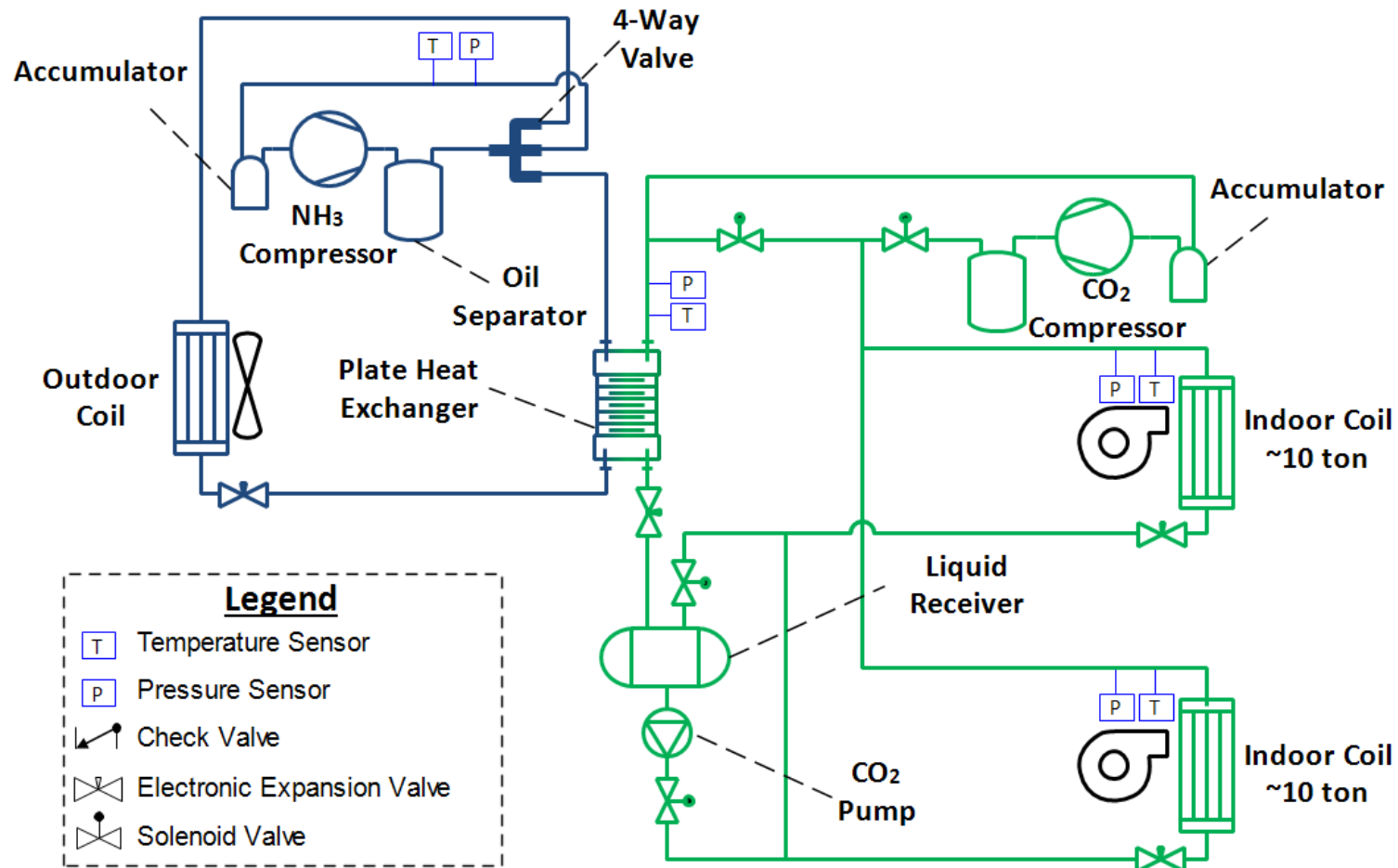
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Project Goal & Objective

- Goal
 - Demonstrate the performance and cost effectiveness of a novel NH₃ / CO₂ reversible heat pump for small commercial and multi-family applications
- Objectives
 - Design, optimize and evaluate a prototype of the heat pump in the lab
 - Deploy production units in **3** distinct California climate zones
 - Conduct measurement and verification of the field units for at least **9** months of operation

Simplified System Schematic



System Pros and Cons

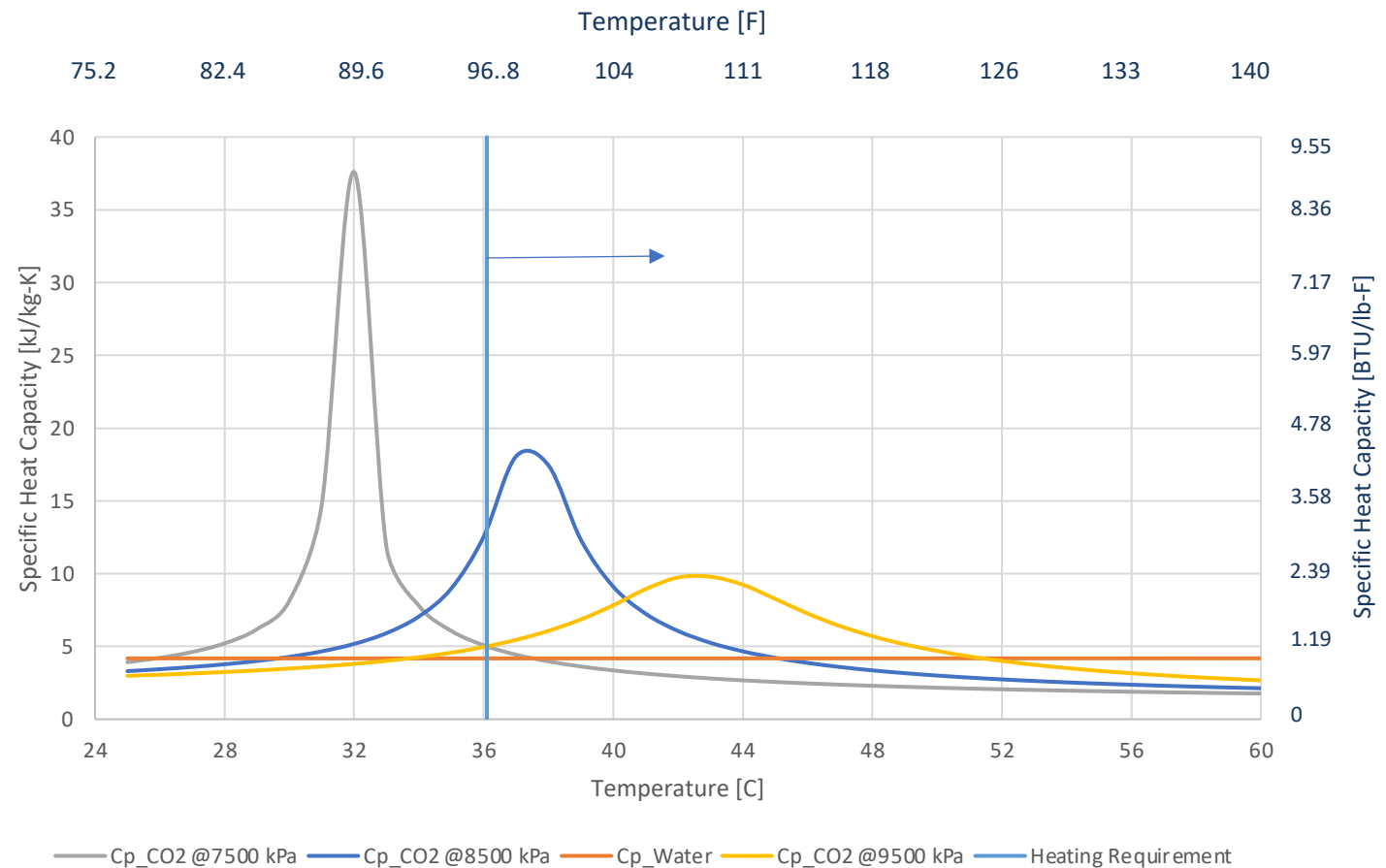
- Better configuration flexibility than RTUs, especially for multi-story buildings
- Lower installation cost than hydronic systems, due to reduced pipe sizes and easier cutting and joining
- Largely eliminated GHG emissions due to refrigerant leakage, due to the use of zero GWP refrigerant and ultra GWP distribution fluid
- Ammonia is highly reactive, cannot be used in direct contact with copper
- Toxic and mildly flammable refrigerant
- Reduced availability of off-the-shelf components
- Carbon dioxide has high operating pressures, increasingly system complexity
- Limited selection for components

Design and Safety Considerations

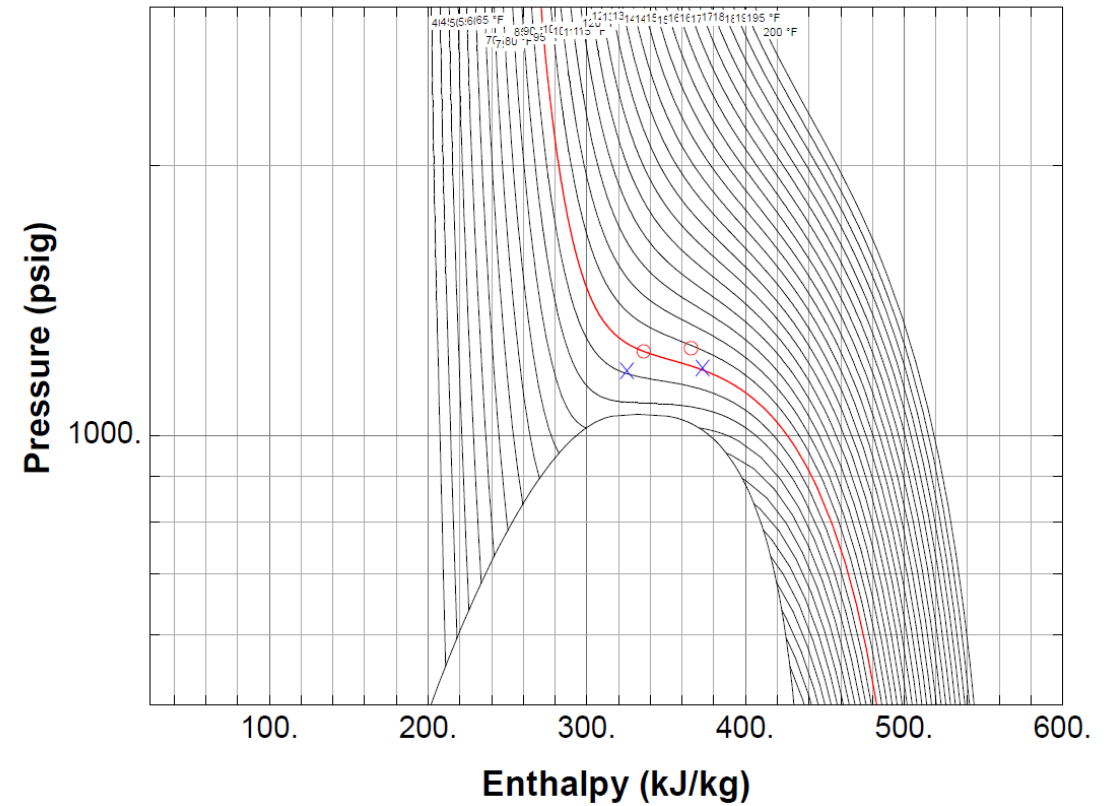
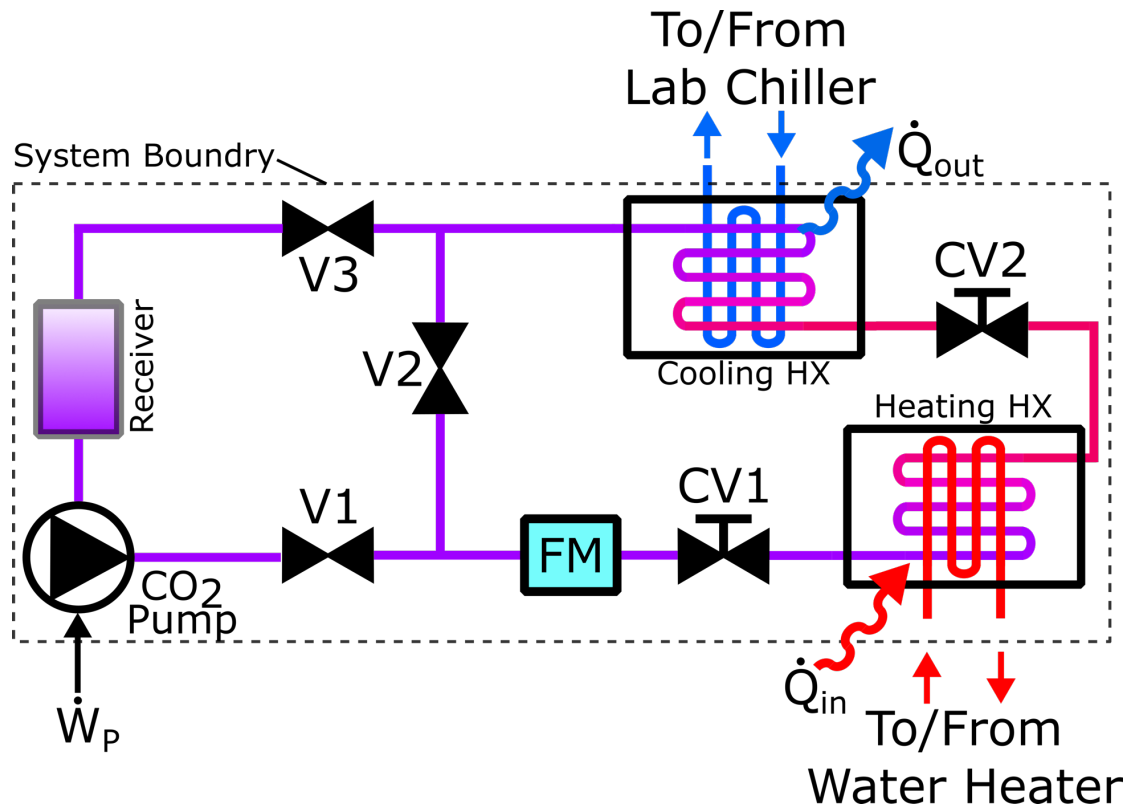
- Requirements for refrigerant leakage sensors
- If intermediate heat exchanger ruptures, NH₃ can enter CO₂ side and cause rapid corrosion failure of copper pipes
 - Welded steel for both cycles is the safest option but would increase install difficulty/cost
- Regulatory:
 - NH₃ release: CalARP: applies only for >500 lb (EPA limit >10,000)
 - Qualifications: mechanical contractor w/ ASME pipe certification

Modeling Results

- Efficiency requirements will be challenging to reach with available selections (18 SEER & 9.6 HSPF)
 - Optimization of system operation
 - Optimizing design to maximize NH₃ contribution
- What if we can avoid using a CO₂ compressor?
 - Supercritical CO₂ at these operating conditions have similar density and viscosity to liquid CO₂

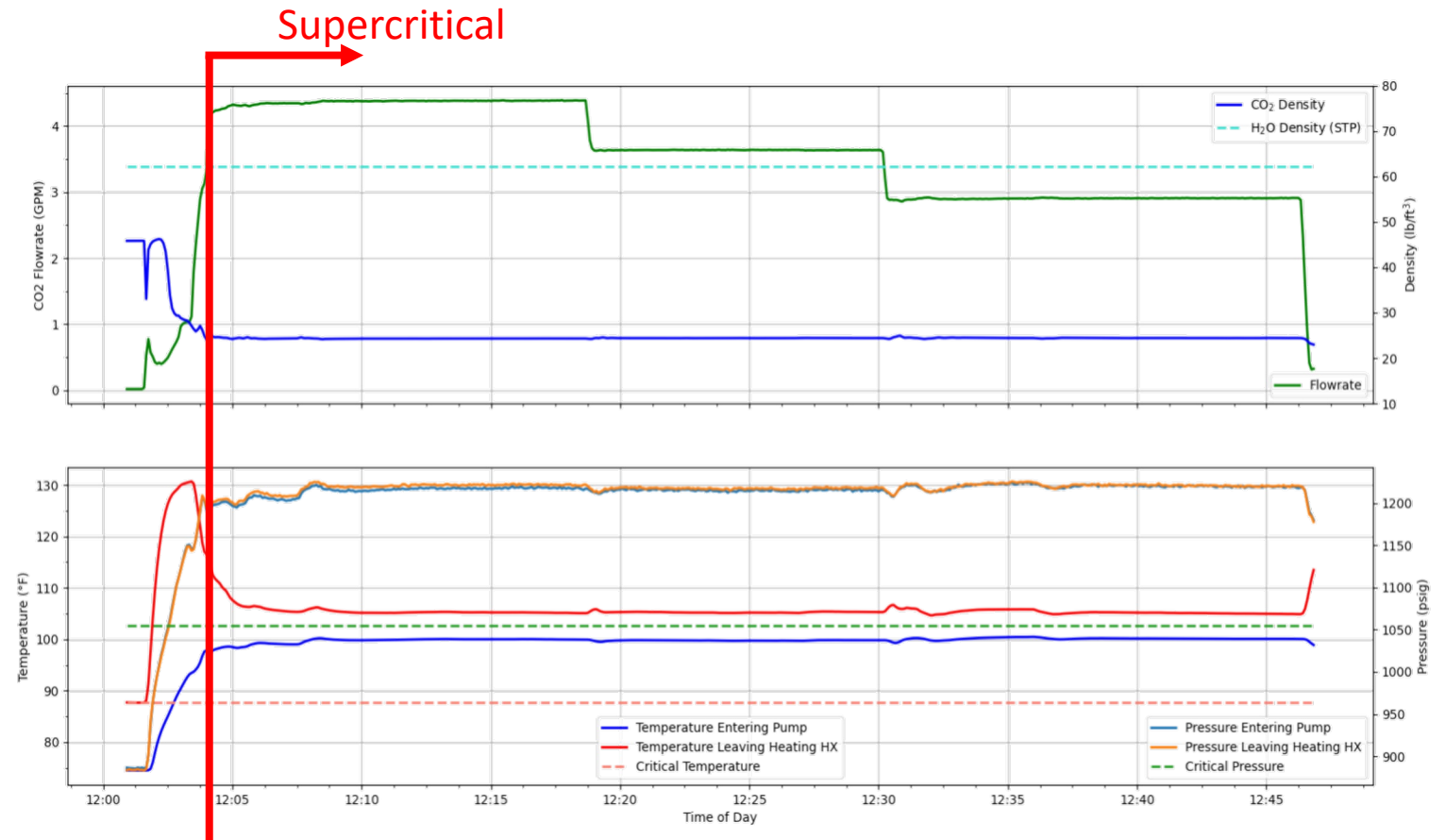


Supercritical CO₂ Test Loop



Initial Findings

- CO₂ pump is able to circulate supercritical CO₂!
- Next steps will characterize the pump performance over a range of conditions
- Lab prototype will consider both compressor and pump operation



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