

2022 TITLE 24 ENERGY CODE PROPOSAL - TRANSCRITICAL CO2 REFRIGERATION SYSTEMS

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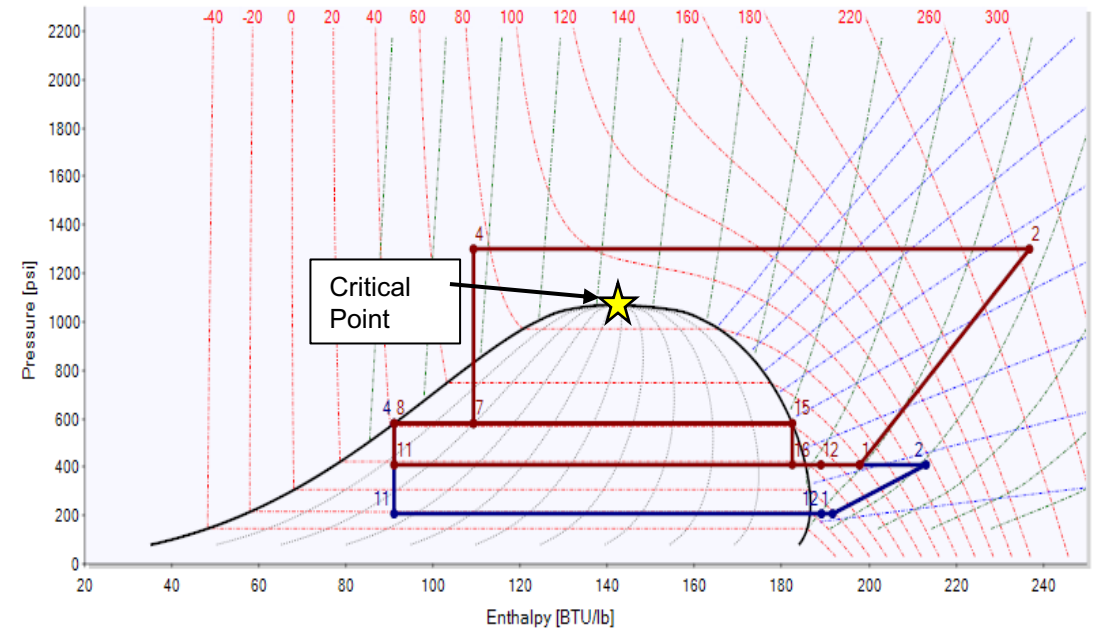


Motivation

- Phase out high GWP refrigerants
- Increasing popularity of CO2 systems
- Title 24 does not include CO2 systems
- Savings opportunities for new installations
- Clarify design practices

Transcritical CO2 System

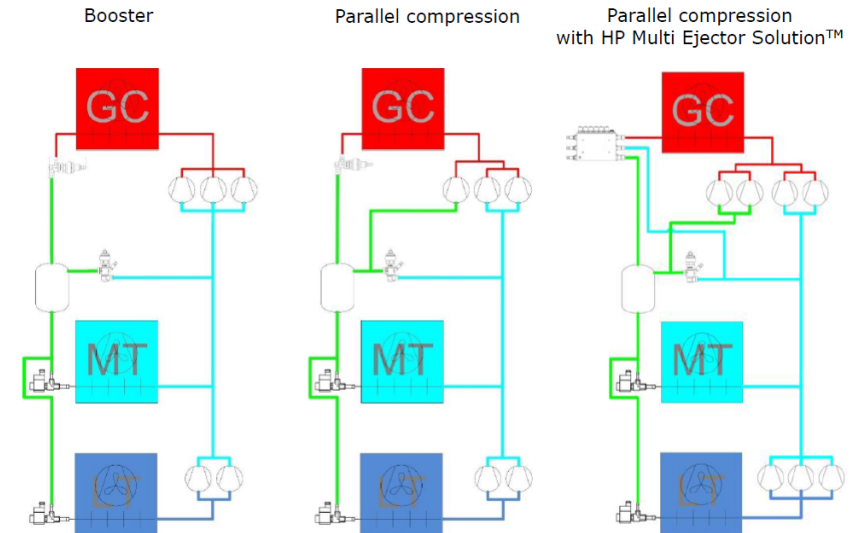
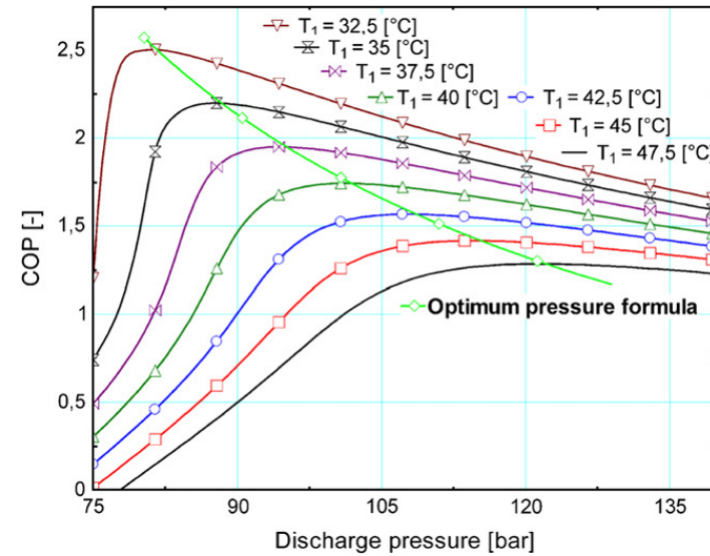
- CO2 as only working fluid
- Low critical point (~87F SCT)
- System efficiency significantly decrease during transcritical operation



BACKGROUND

Considerations

- // Gas cooler sizing
 - First cost vs. minimizing transcritical hours (i.e., annual operating costs)
- // Gas cooler pressure control
 - Optimized transcritical pressure control
 - Subcritical ambient temp. following control
- // Mandate gas cooler type in certain climate zones (adiabatic)
- // Parallel Compression
- // Gas ejectors for improved COP in transcritical mode



BACKGROUND

Code proposal change summary

Addition of design and control requirements for transcritical CO2 booster systems Title 24, Part 6 Section 120.6(a) and 120.6(b)

Building Types	System Type	Type of Change	Proposed Measures
Refrigerated Warehouses (RWH)	New construction transcritical CO2 booster systems	Mandatory	<ul style="list-style-type: none">• Minimum gas cooler sizing• Minimum gas cooler specific efficiency• Floating head pressure control• Minimum saturated condensing temperature• Parallel compression• Gas ejectors• Gas cooler pressure control during transcritical operation
Commercial Refrigeration	New construction transcritical CO2 booster systems	Mandatory	<ul style="list-style-type: none">• Minimum gas cooler sizing• Minimum gas cooler specific efficiency• Floating head pressure control• Minimum saturated condensing temperature• Parallel compression• Gas ejectors• Gas cooler pressure control during transcritical operation

MARKET OVERVIEW



- Current Market
 - // As of November 2017, 290 transcritical CO2 systems were installed in the U.S. (Shecco)
 - // Many large manufacturers producing transcritical CO2 equipment
- Market Trends
 - // Major food retailers choosing to install transcritical CO2 systems to avoid future compliance costs (“Future proof”)
 - // Cold storage facilities also adopting CO2 system technology
- Market Barriers
 - // Owner and contractor knowledge gap, limited installation base
 - // CO2 systems operate at much higher pressures (~1200 psi)
 - Unique expertise required in installation, operation compared to traditional halocarbon systems
 - // Proposed code would remove roadblocks to market adoption by allowing owners to understand baseline CO2 design and efficiency

Develop a “standard practice” transcritical CO2 booster system

Gather information

- Through interviews/ discussions with key stakeholders, and review of sample refrigeration design legends
- Info needed: Gas cooler (GC) sizing, GC controls, intermediate receiver design pressure



Simulate proposed measures

- Estimate energy savings compared to developed baseline (DOE2.2R models from prior code cycles)
- All 16 CA climate zones to be simulated as transcritical CO2 systems
- Statewide savings to be calculated by taking the kWh saved per SF for cost effective measures and multiplying by the projected SF of new construction forecast, adjusting for % of CO2 systems
- No preliminary savings to present at this time

Baseline Key Assumptions (Preliminary)

Gas Cooler Sizing

- 8F TD between gas cooler outlet and ambient air

Gas Cooler Specific Efficiency (Air Cooled)

- 45 Btuh/W

Minimum SCT

- 60F

Head Pressure Control

- Dry bulb following during subcritical operation
- Optimized head pressure control during transcritical operation, fans operate at 100% speed
- Fans controlled in unison, variable speed

Other

- No parallel compression
- No gas ejectors
- Variable capacity control on trim compressors

Proposed Measures (Preliminary)

Gas Cooler Sizing

- Analyze TDs between 2F and 10F TD between gas cooler outlet and ambient air
- Minimum sizing determined by cost/benefit analysis (first cost of larger condenser vs. energy savings from lower head pressures on average)

Minimum SCT

- 55F

Head Pressure Control

- Subcritical operation same as baseline assumption
- Optimized head pressure control during transcritical operation, fans vary speed to maintain fixed TD
- Fans controlled in unison, variable speed

Other

- Parallel compression
- Gas ejectors
- Variable capacity control on trim compressors

Draft Code Language

Transcritical CO₂ Refrigeration Systems. New transcritical CO₂ refrigeration systems utilized in refrigerated warehouses shall conform to the following:

- A. Gas coolers shall meet the specific efficiency requirements listed in TABLE 120.6-X.

CONDENSER TYPE	MINIMUM SPECIFIC EFFICIENCY	RATING CONDITIONS
Air Cooled	XX Btuh/Watt	TBD
Adiabatic	XX Btuh/Watt	TBD

- B. Design leaving gas temperature for air-cooled gas cooler shall be less than or equal to the design drybulb temperature plus XX°F
- C. Design leaving gas temperature necessary for adiabatic gas coolers to reject the design total heat of rejection of a refrigeration system assuming dry mode performance shall be less than or equal to the design drybulb temperature plus XX°F
- D. While operating below the critical point, the gas cooler pressure shall be controlled in accordance to 120.6(a)4F

- F. While operating above the critical point, the gas cooler pressure shall be controlled via a holdback valve at the outlet of the gas cooler with the pressure setpoint determined by an algorithm which optimizes for the highest compressor efficiency at existing ambient conditions. The gas cooler fans shall be variable speed and controlled in unison in order to maintain a fixed temperature difference between the gas cooler outlet temperature and ambient temperature.
- G. Systems shall be designed with one or more of the following:
- Adiabatic or evaporative condensers
 - Parallel compression
 - Gas ejectors
 - Expanders

EXEMPTION: Systems installed in climate zones TBD

QUESTIONS?



We Need Your Feedback!

Please contact

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