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The Application of Evaporative Condensers for Subcritical CO₂ Condensing and Transcritical CO₂ Gas Cooling

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INTRODUCTION

- CO₂ evaporative condensers and gas coolers enable the efficient application of CO₂ refrigeration anywhere in the world
- At 28°C ambient Wet Bulb Temperature (WBT) 31°C CO₂ gas cooler exit temperature, i.e. the critical temperature, is easily achievable
- Ambient design WBTs above 28°C are experienced in very few locations in the world like The Gulf and Vietnam
- Suction Heat Exchangers are obviated in virtually all applications
- Energy recovery from expanding transcritical fluid no longer has much merit with the high COPs resulting from evaporative condensers and gas coolers.
- Suitable for conversion of existing HFC/CO₂ cascade systems and expensive CO₂ cascade condensers are no longer required.
- Large scale application of CO₂ to all refrigeration and AC duties awaits the availability of larger compressors

Performance of a Bock HGX 46/345-4SCO₂T CO₂ Compressor at 50HZ.

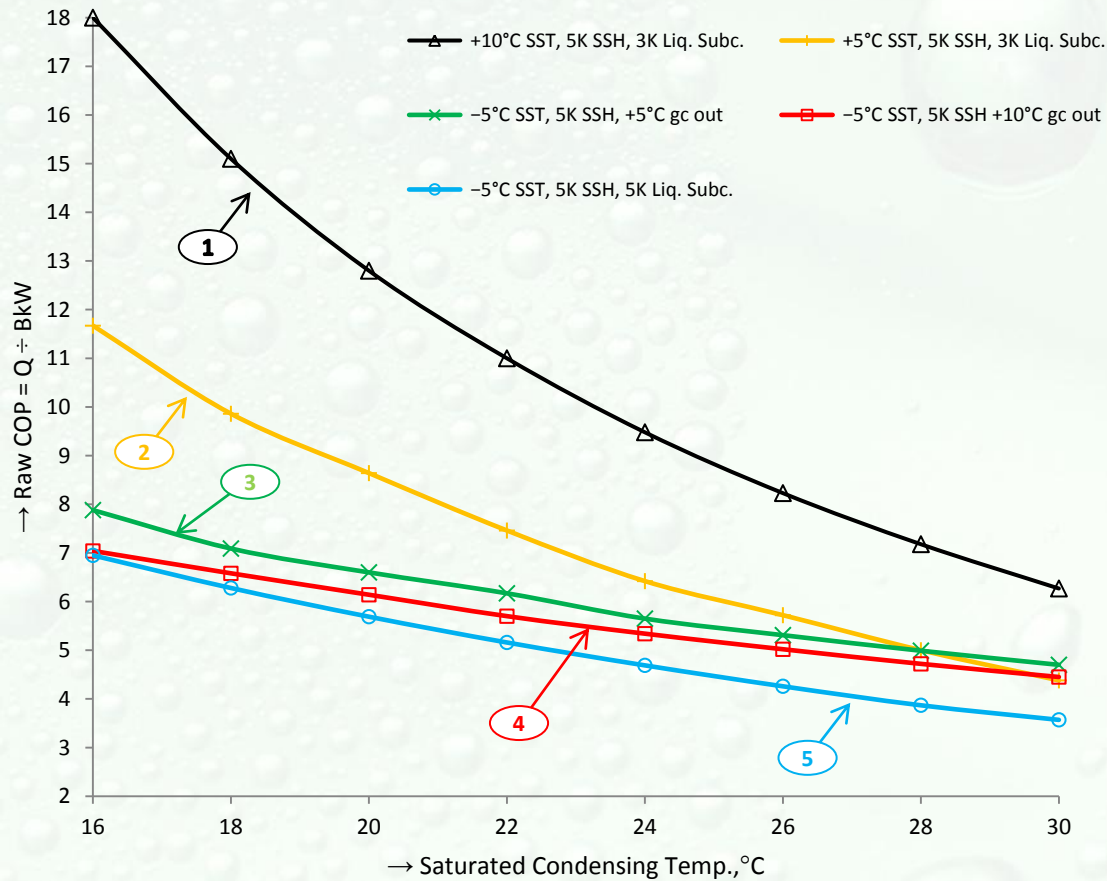


Figure 1. CO₂ Compressor COP variation with subcritical saturated condensing temperature.

Compressor Make & Model for R717, R22, R507A, R290 & R134a: Mycom 8 WB, 1,000 rpm

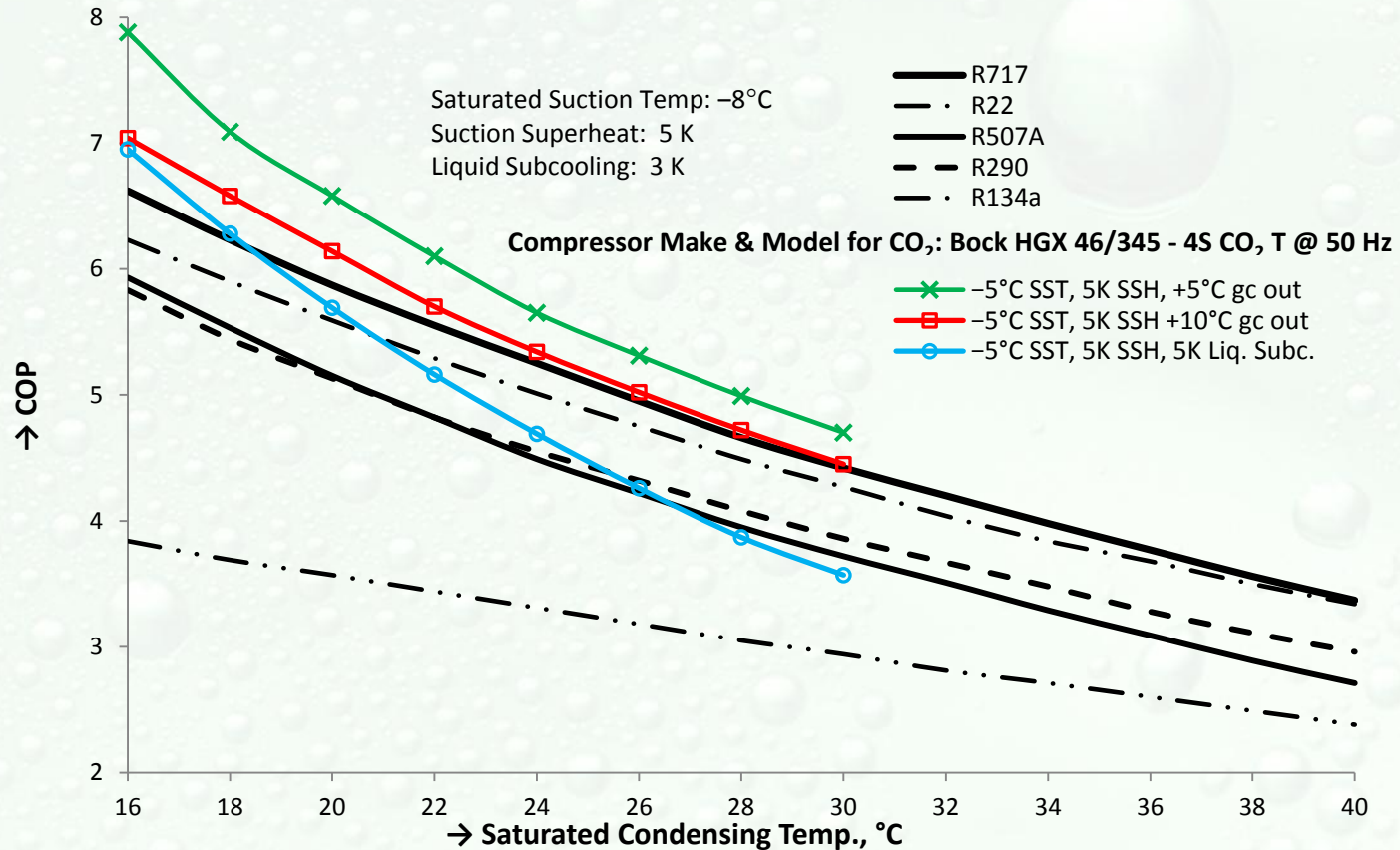


Figure 2: The variation in COPs of R717, R22, R507A, R290 and R134a with Saturated Condensing Temperature compared to subcritical CO_2 from 16 to 30 $^{\circ}\text{C}$ Saturated Condensing Temperature

Source: Bock VAP10 Software

CO₂ compressor performance for chilled water AC & retrofit.

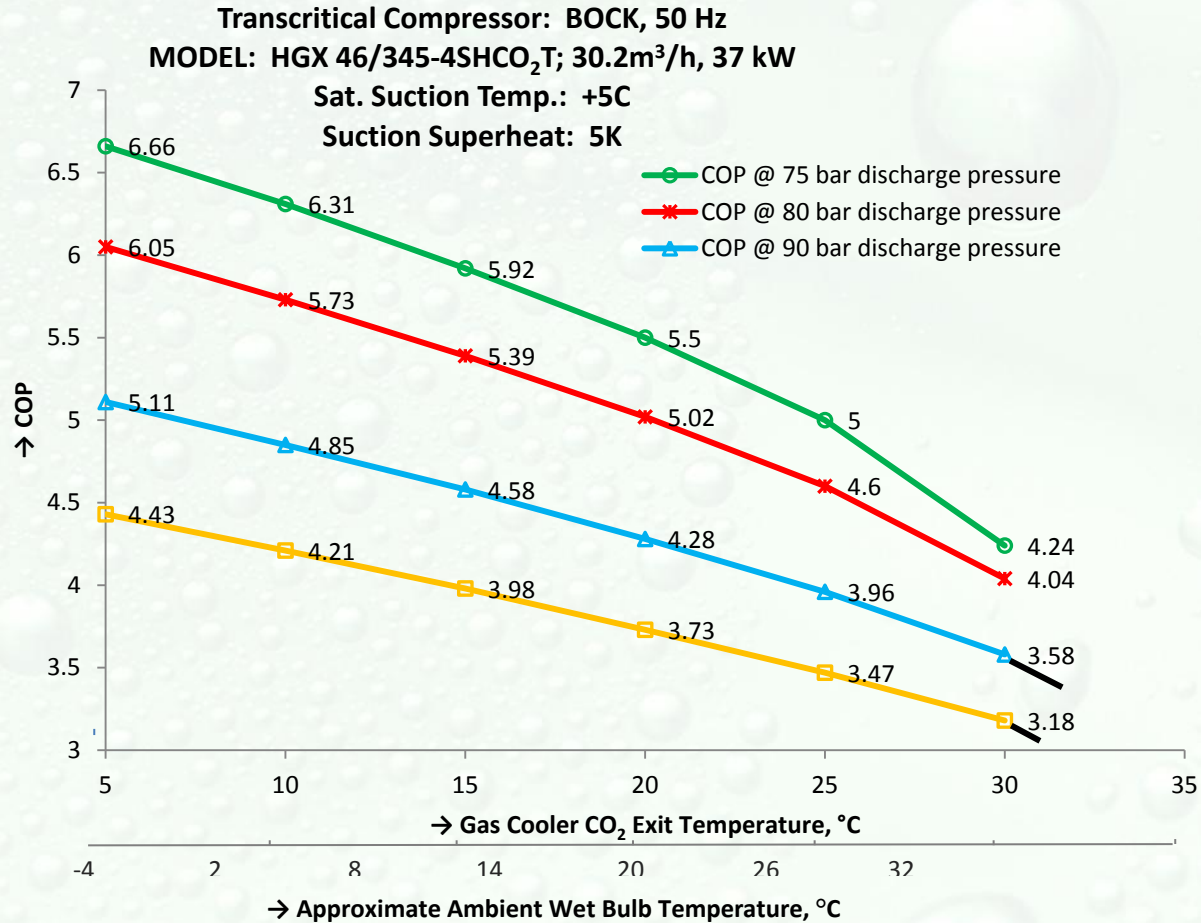


Figure 3: COP variation with gas cooler CO₂ leaving temperature at 75-100 bar discharge pressure, +5°C SST, 5K SSH

Source: Bock VAP10 Software

Figure 4. USA climate zones with approximate percentage incidence of subcritical CO₂ condensing annually

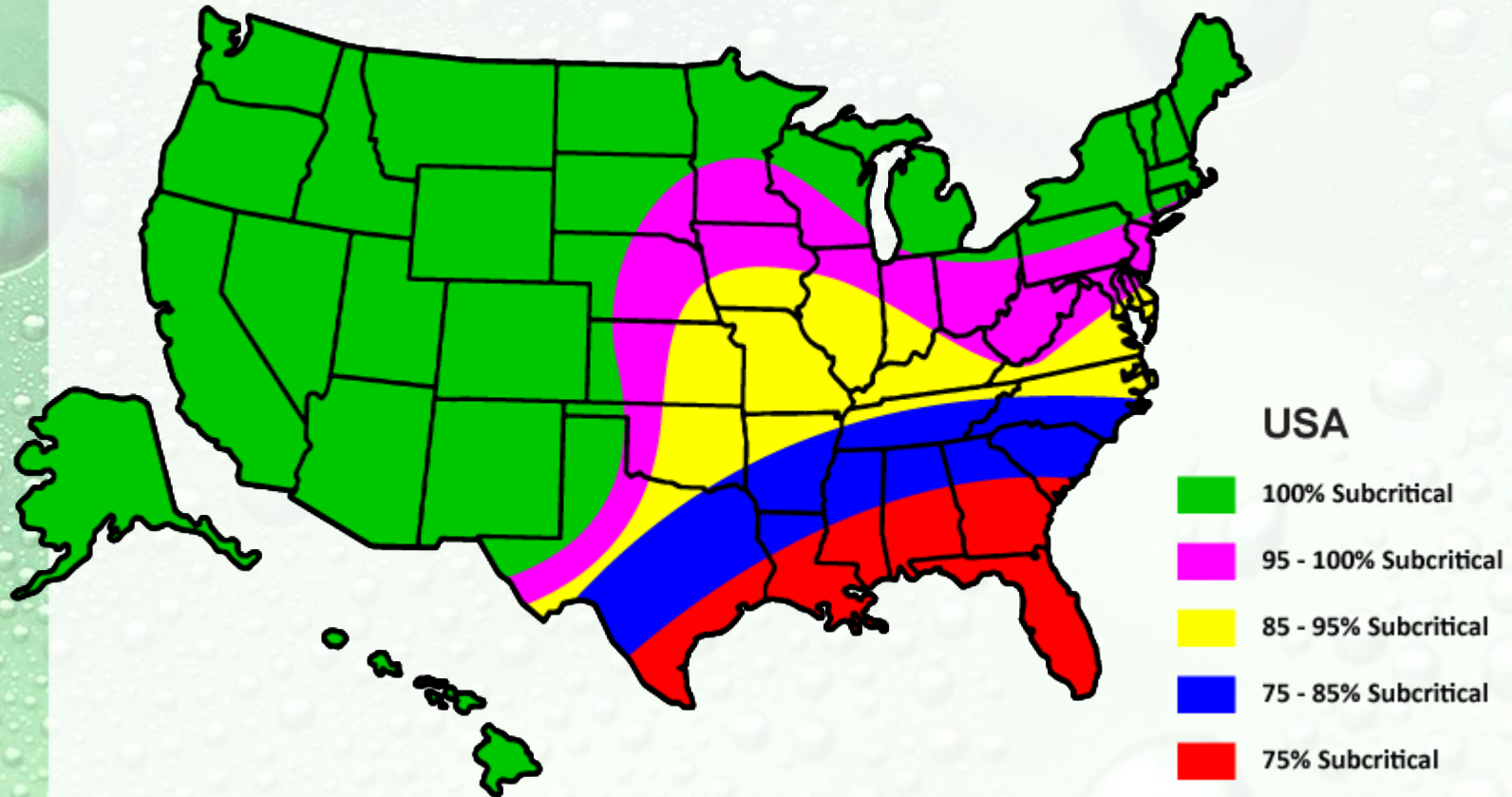


Figure 6. Virtually all of Continental Europe can enjoy subcritical CO₂ condensing 100% of the time



ADVANTAGES OF CO₂ EVAPORATIVE CONDENSERS AND GAS COOLERS

- Lower discharge pressures mostly below critical point
- Lower CO₂ exit temperature from gas cooler
- A high cost CO₂ cascade condenser is no longer required
- Above three factors increase capacity and reduce energy consumption – High COP
- Compressors have easier operating conditions both lower pressures and temperatures – reduced maintenance, higher reliability, lower oil consumption
- High pressure of CO₂ allows much lower discharge pressures down to 15°C condensing and even lower
- Evaporative CO₂ condensing outperforms all other refrigerants, including ammonia, over a whole year running with surprisingly high COPs

DISADVANTAGES

- Higher capital cost but offset by elimination of a cascade condenser
- Consumes water
- Poses a minor potential legionella threat if not maintained properly

ADVANTAGES OF HYBRID CO₂ EVAPORATIVE CONDENSERS AND GAS COOLERS

- Less air circulated
- Less water consumption
- Less energy consumption
- Air cooled section more effective with adiabatically precooled air
- Smaller footprint
- High discharge air temperatures reduce legionella threat
- No plume formation – much less if any free water in the air discharge
- Allows 100% air cooled operation in winter in cool climates

DISADVANTAGES

- More expensive than evaporative condensers



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Thank you very much for your attention!

Figure 5. Latin America climate zones with approximate percentage incidence of subcritical CO₂ condensing annually



Figure 7. Asian climate zones with approximate percentage incidence of subcritical CO₂ condensing annually

