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The Application of Evaporative Condensers for Subcritical CO_2 Condensing and Transcritical CO_2 Gas Cooling

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INTRODUCTION

- CO_2 evaporative condensers and gas coolers enable the efficient application of CO_2 refrigeration anywhere in the world
- At 28°C ambient Wet Bulb Temperature (WBT) 31°C CO_2 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/CO_2 cascade systems and expensive CO2 cascade condensers are no longer required.
- Large scale application of CO_2 to all refrigeration and AC duties awaits the availability of larger compressors

Performance of a Bock HGX 46/345-4SCO$_2$T CO$_2$ Compressor at 50HZ.

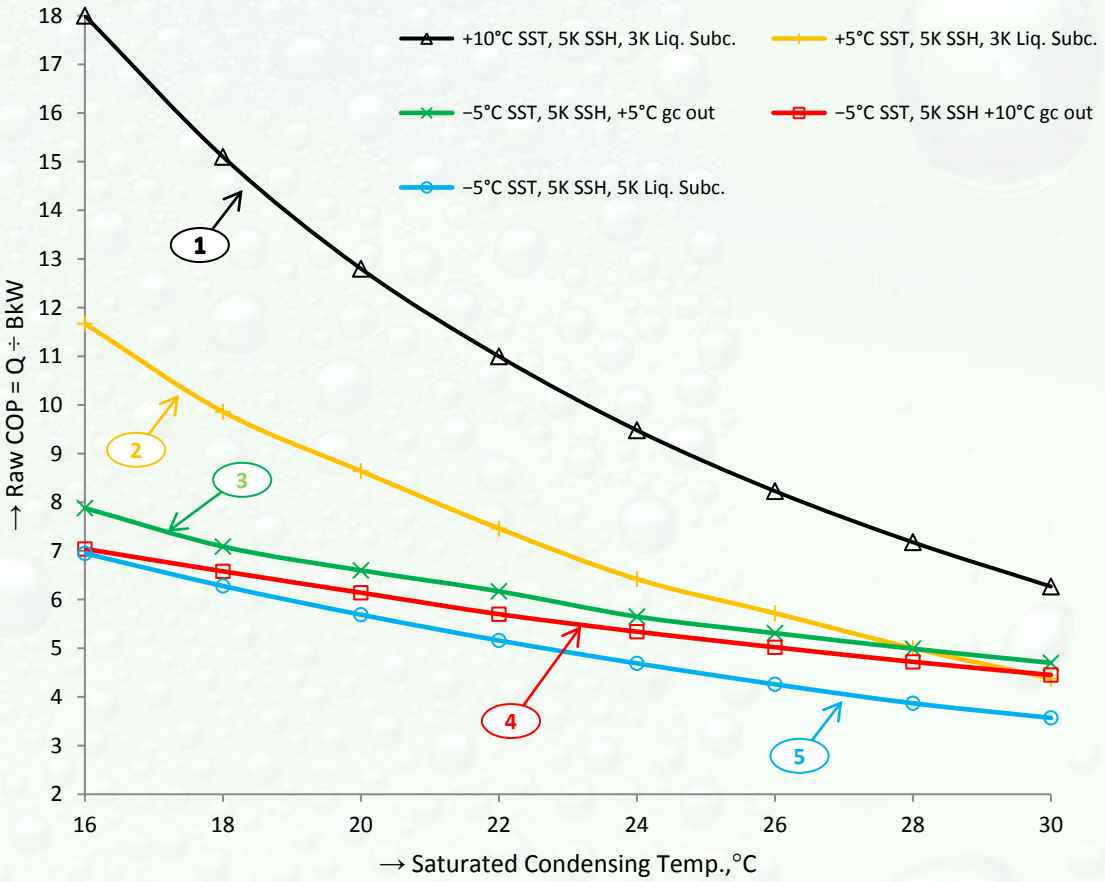


Figure 1. CO$_2$ Compressor COP variation with subcritical saturated condensing temperature.

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

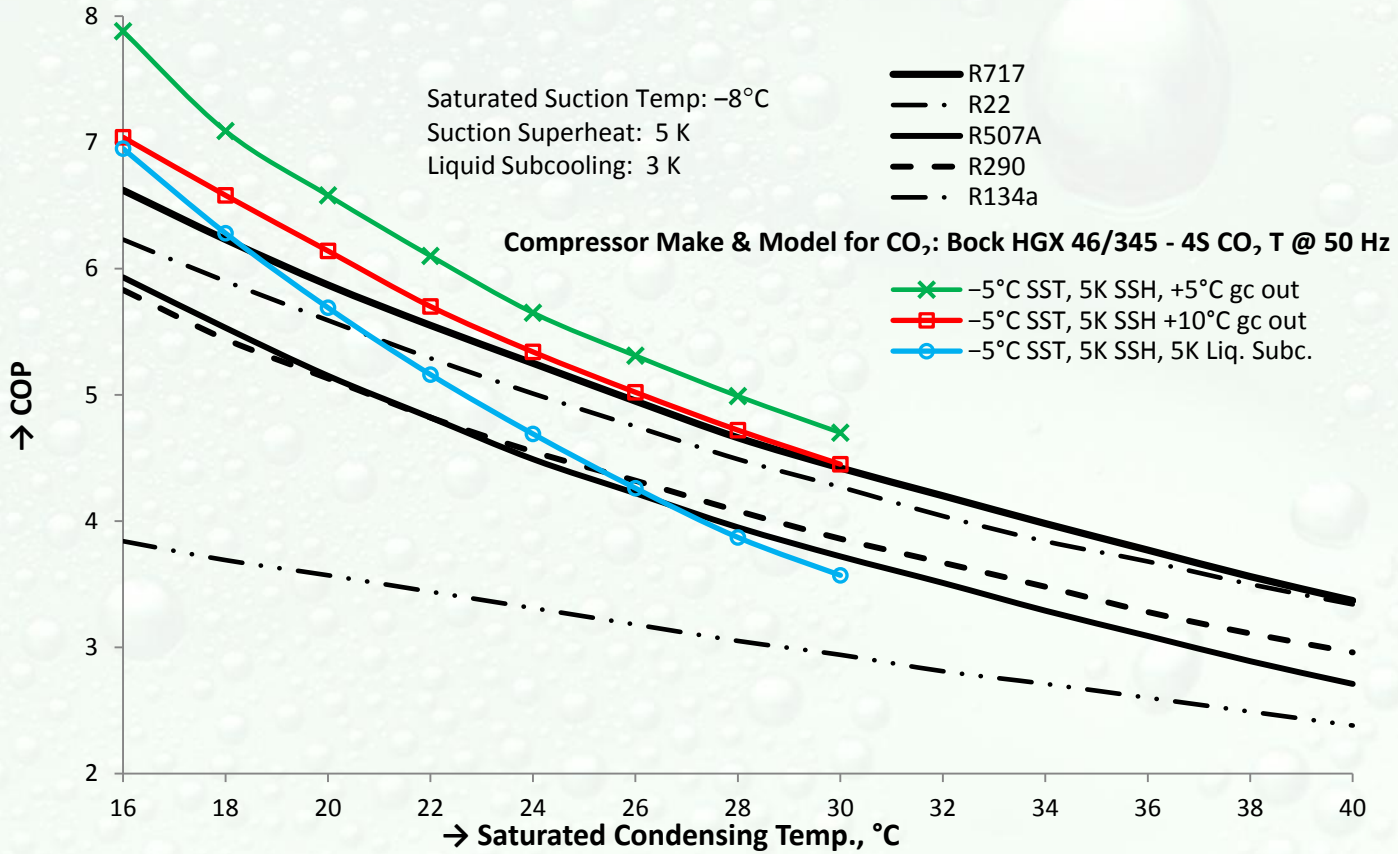


Figure 2: The variation in COPs of R717, R22, R507A, R290 and R134a with Saturated Condensing Temperature compared to subcritical CO_2 from 16 to 30°C Saturated Condensing Temperature

Source: Bock VAP10 Software

CO_2 compressor performance for chilled water AC & retrofit.

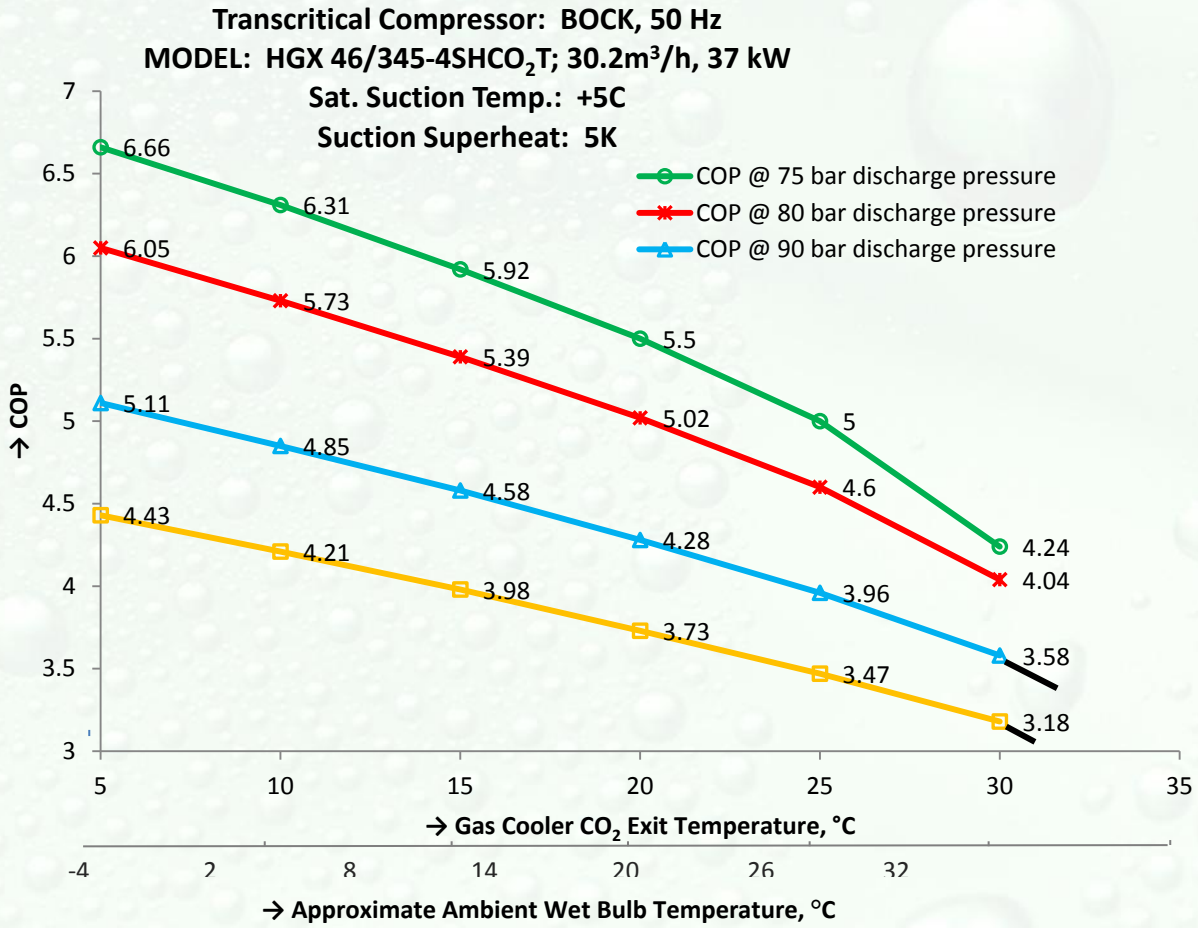


Figure 3: COP variation with gas cooler CO_2 leaving temperature at 75-100 bar discharge pressure, +5°C SST, 5K SSH

Source: Bock VAP10 Software

Figure 4. USA climate zones with approximate percentage incidence of subcritical CO_2 condensing annually

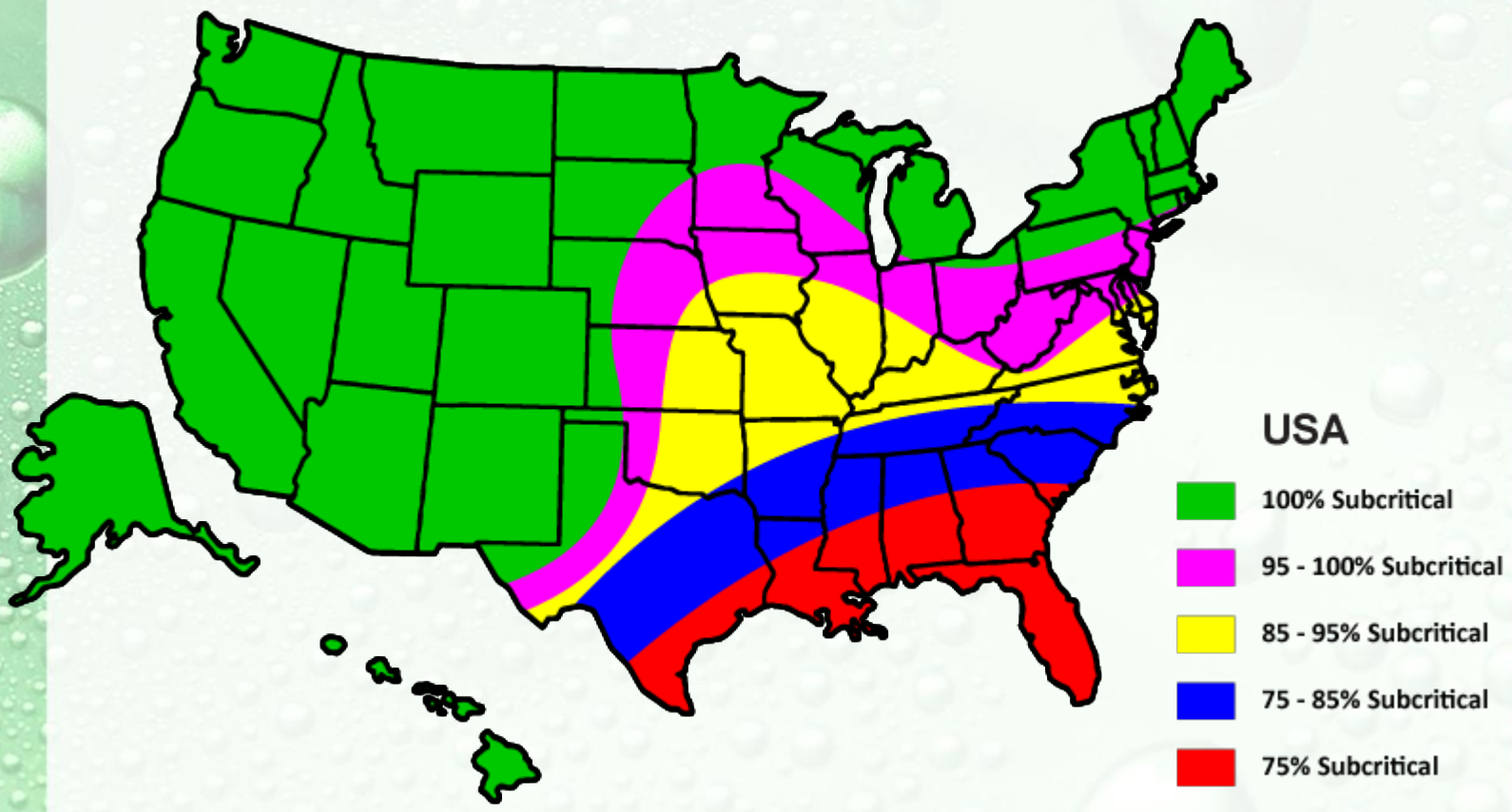
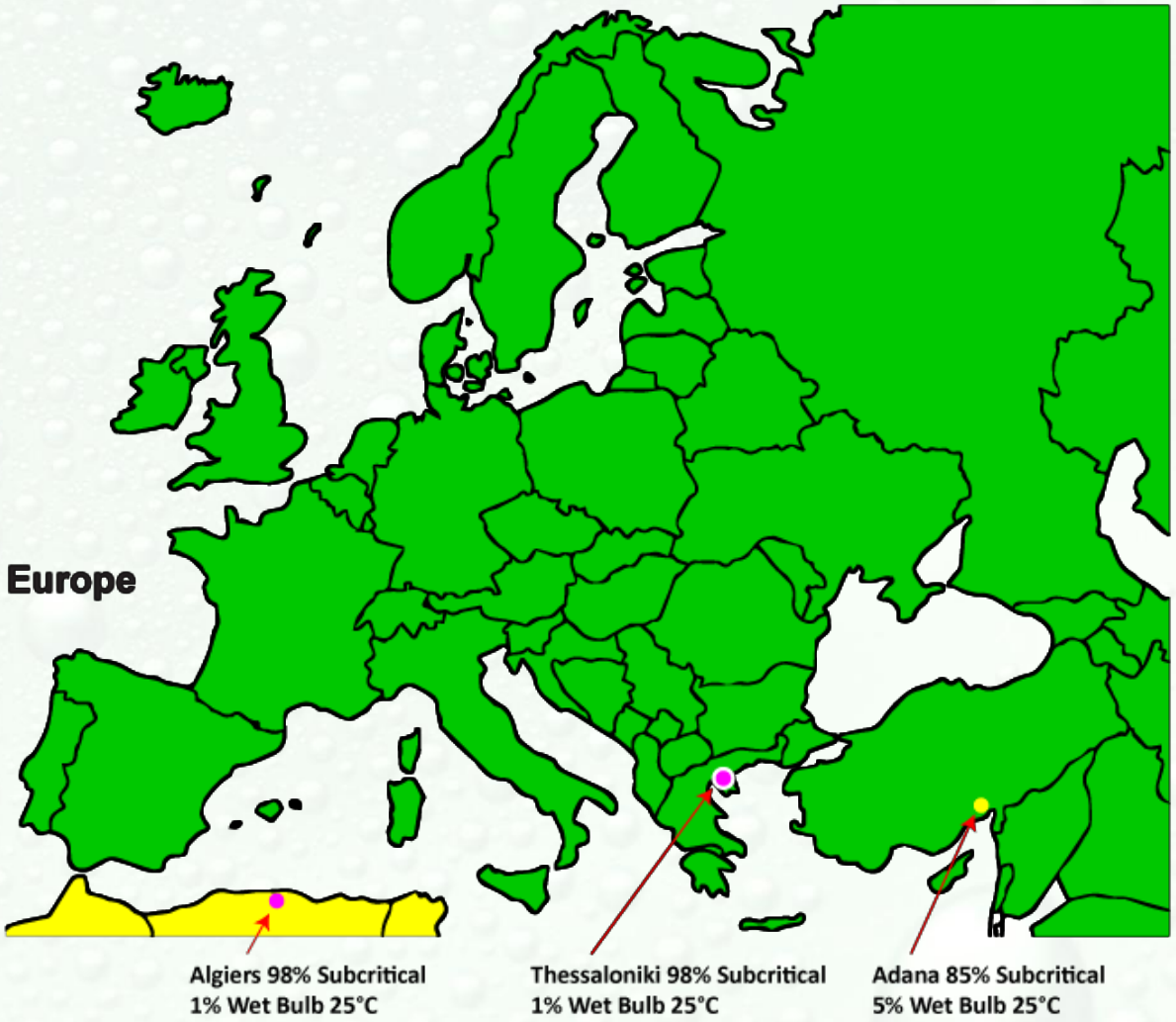


Figure 6. Virtually all of Continental Europe can enjoy subcritical CO_2 condensing 100% of the time



ADVANTAGES OF CO_2 EVAPORATIVE CONDENSERS AND GAS COOLERS

- Lower discharge pressures mostly below critical point
- Lower CO_2 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 CO_2 allows much lower discharge pressures down to 15°C condensing and even lower
- Evaporative CO_2 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 CO_2 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!

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