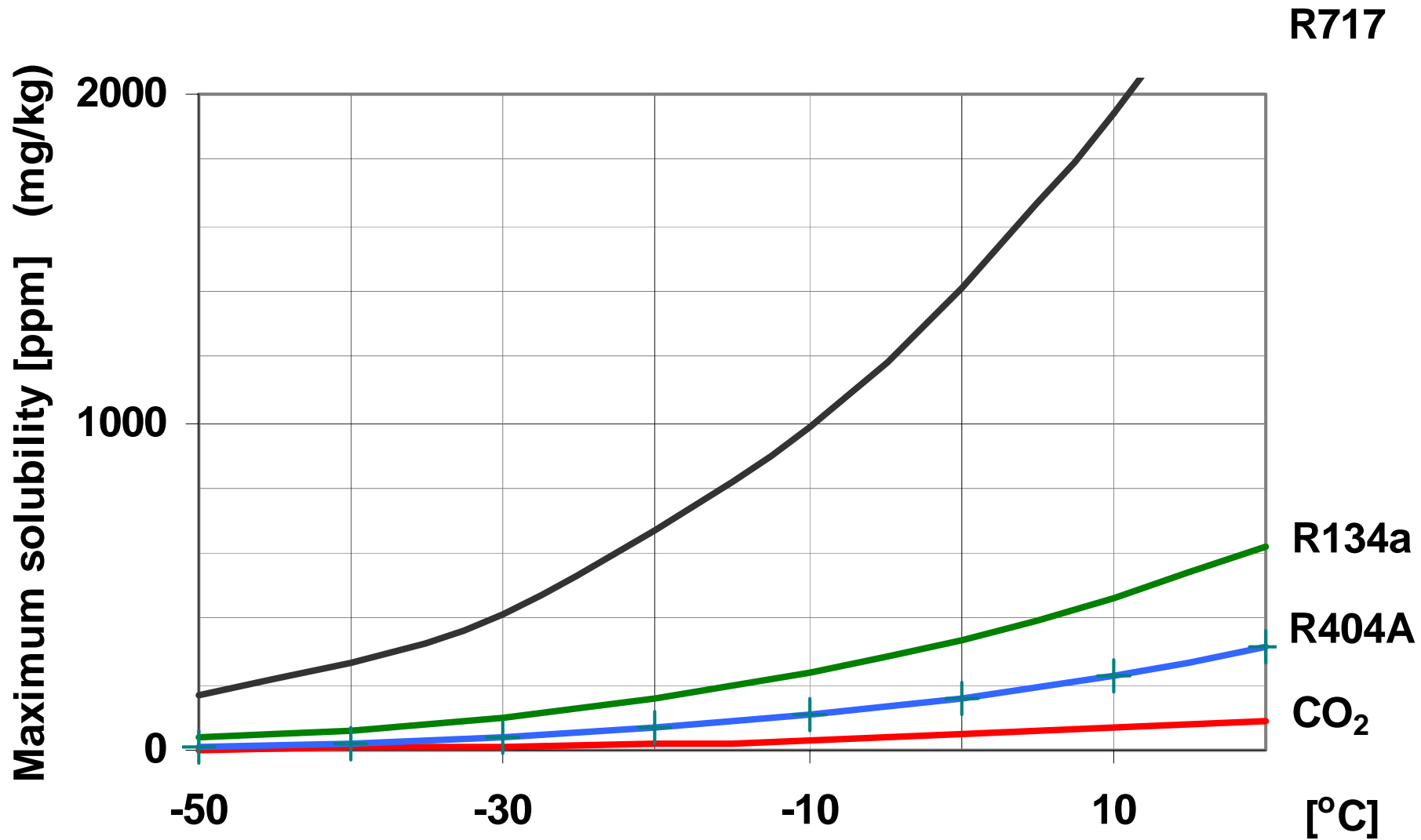


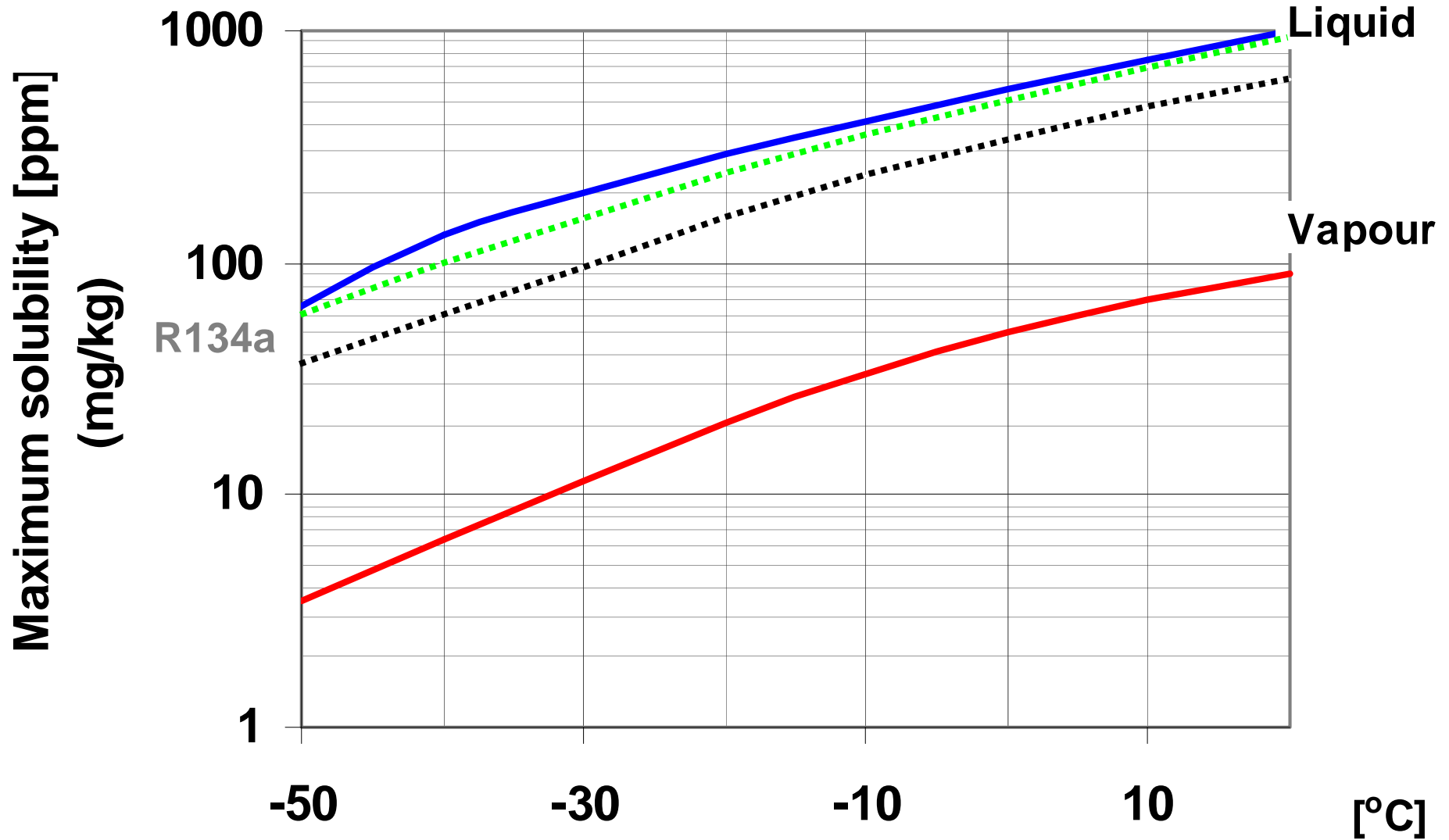
Moisture / water in CO₂ systems

Industrial Refrigeration

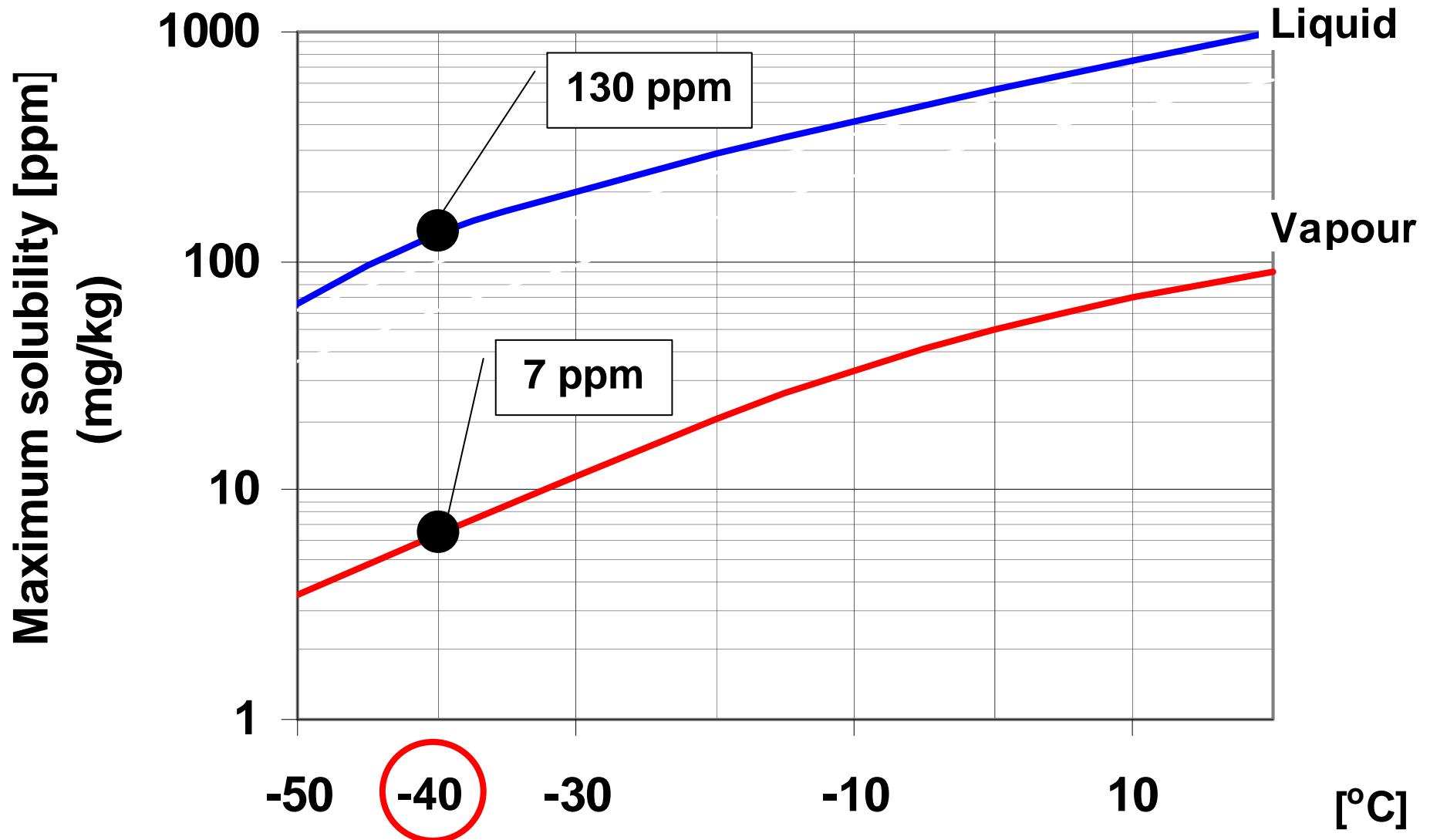
Water solubility in various refrigerants in vapour phase



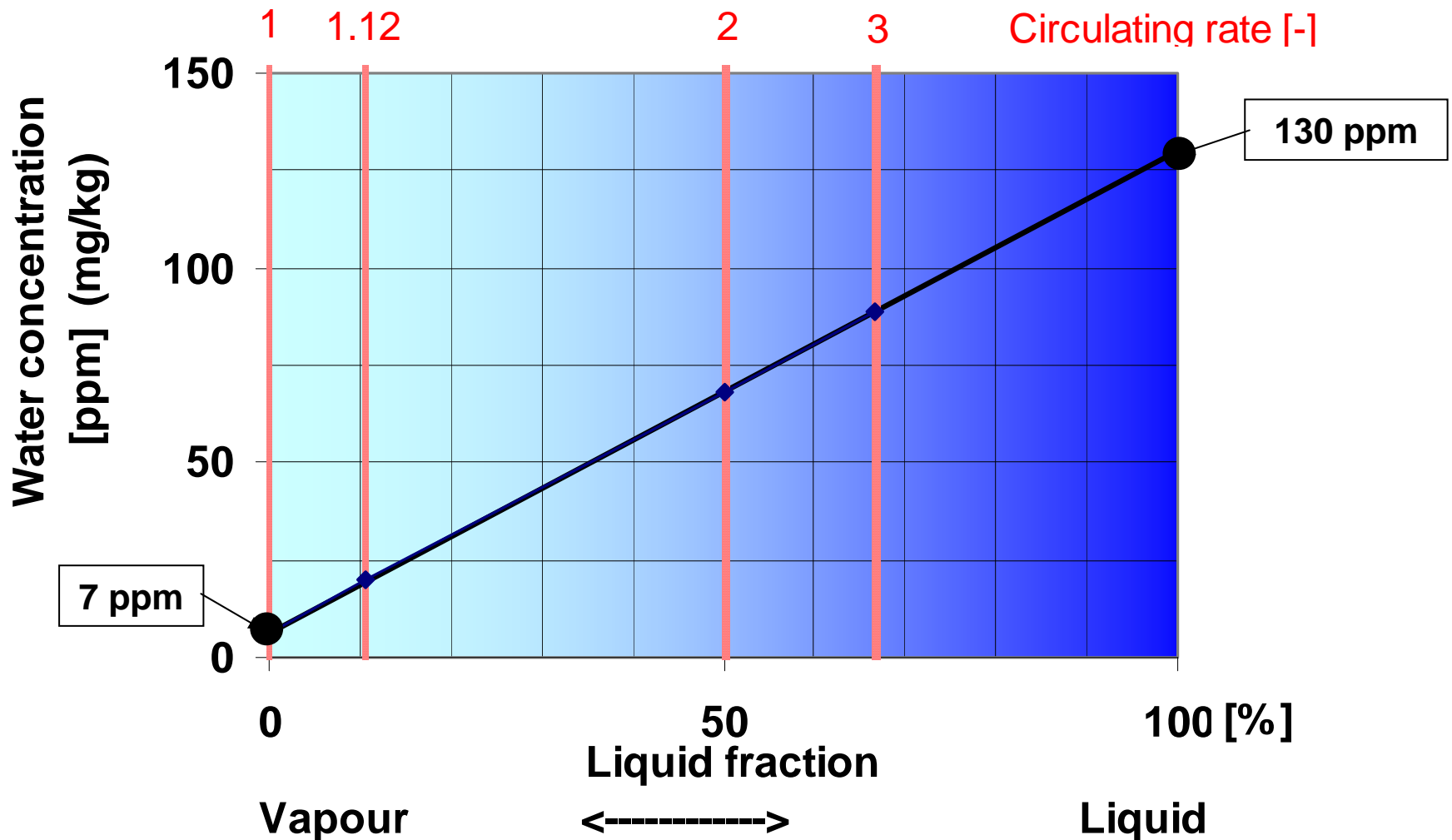
Water solubility in CO₂

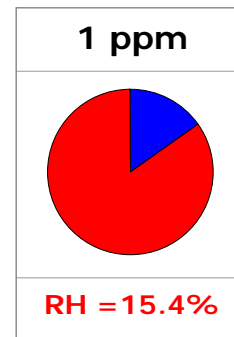
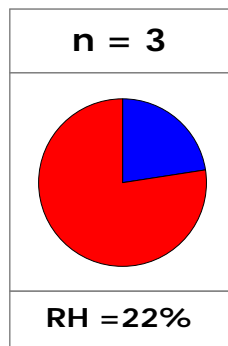


Water solubility in CO₂



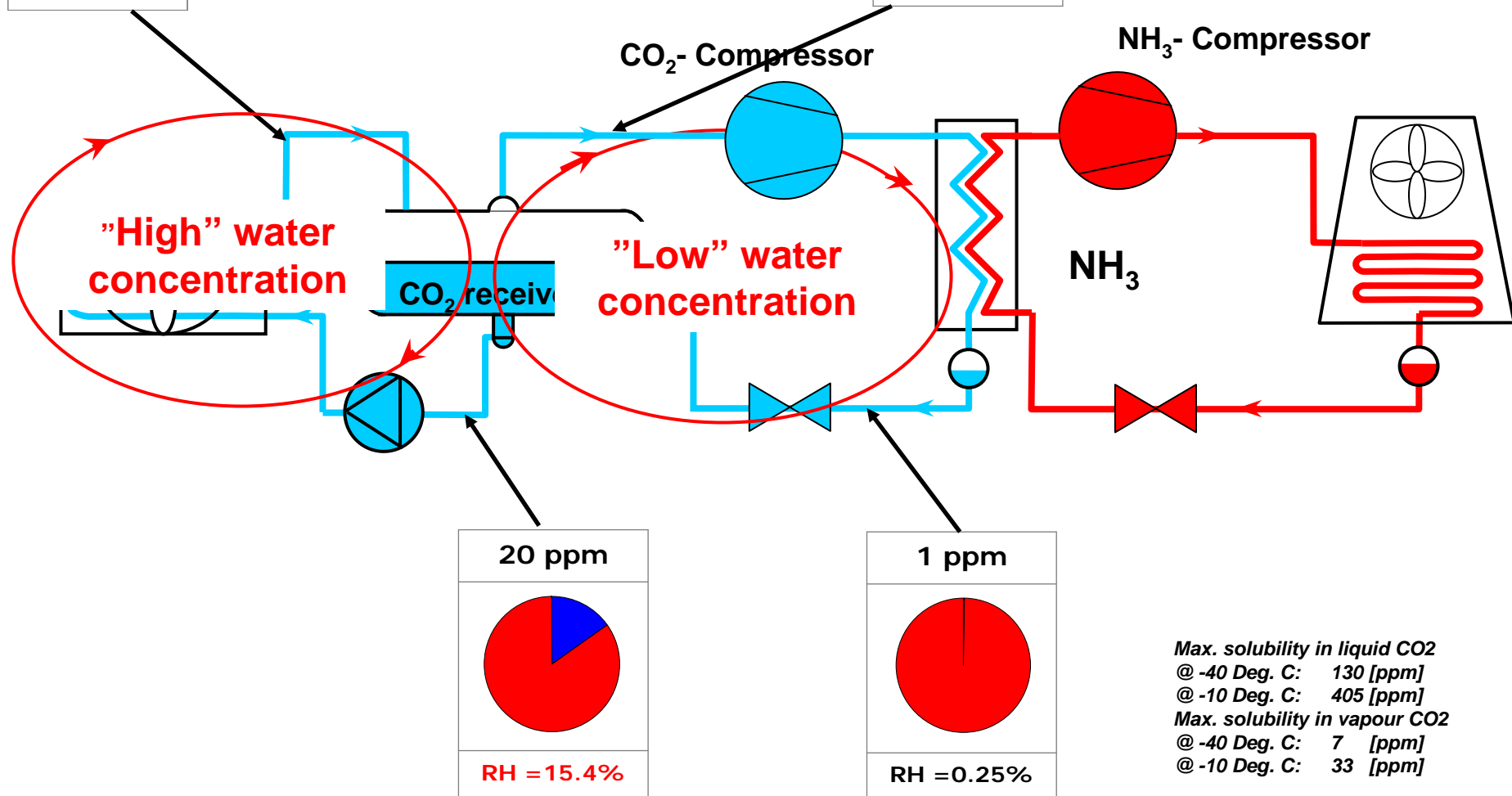
Max. water solubility in wet CO₂ return lines @ -40 °C *Danfoss*



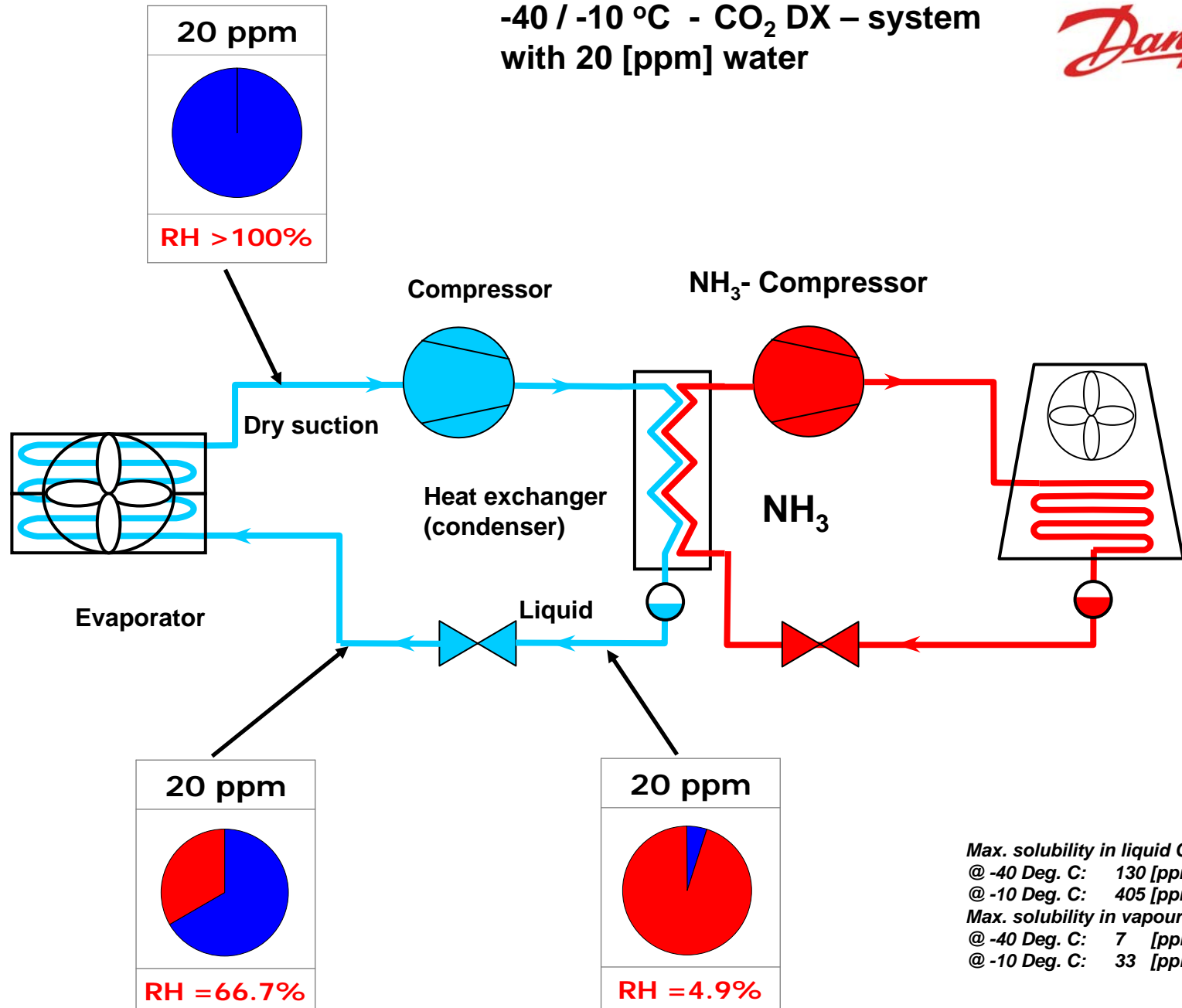


Danfoss

Example:
-40 / -10 °C - CO₂ pump
circulating – system
with 20 [ppm] water



Example:
-40 / -10 °C - CO₂ DX – system
with 20 [ppm] water

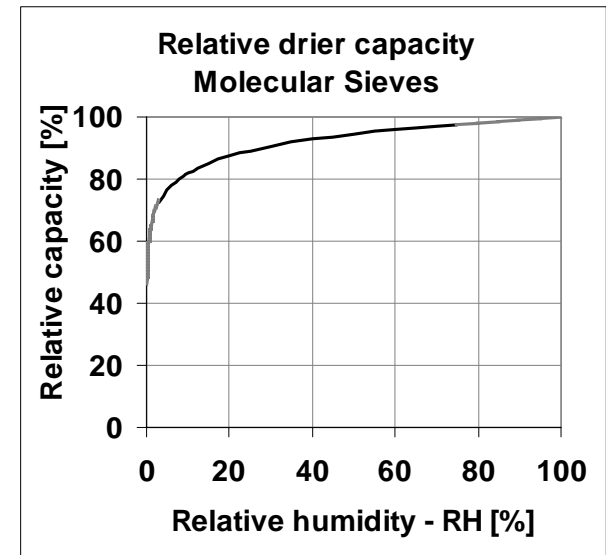
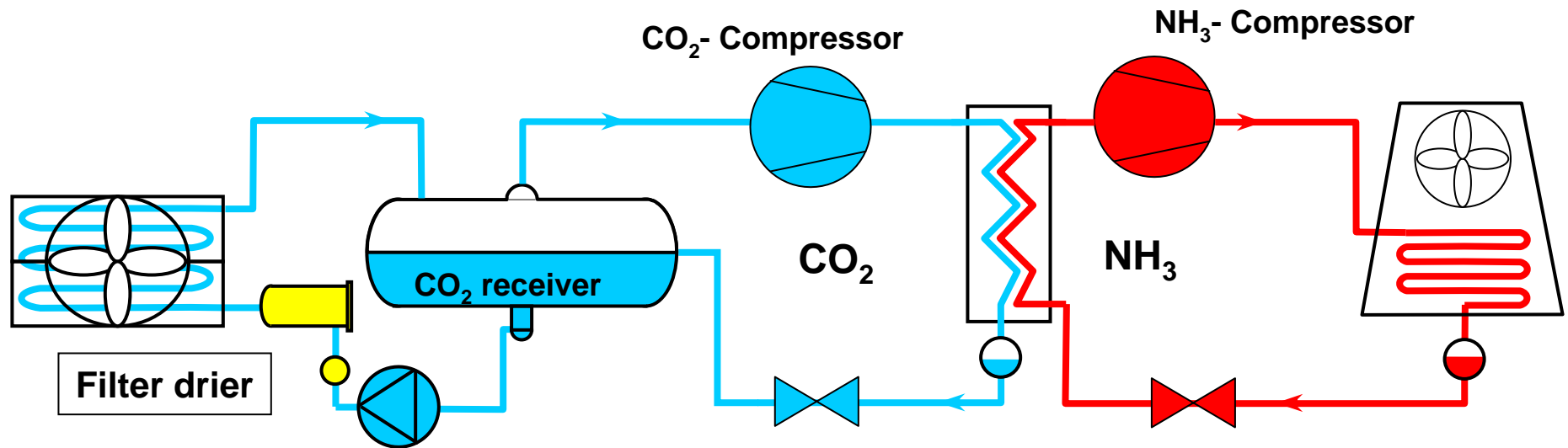


Max. solubility in liquid CO₂
 @ -40 Deg. C: 130 [ppm]
 @ -10 Deg. C: 405 [ppm]
 Max. solubility in vapour CO₂
 @ -40 Deg. C: 7 [ppm]
 @ -10 Deg. C: 33 [ppm]

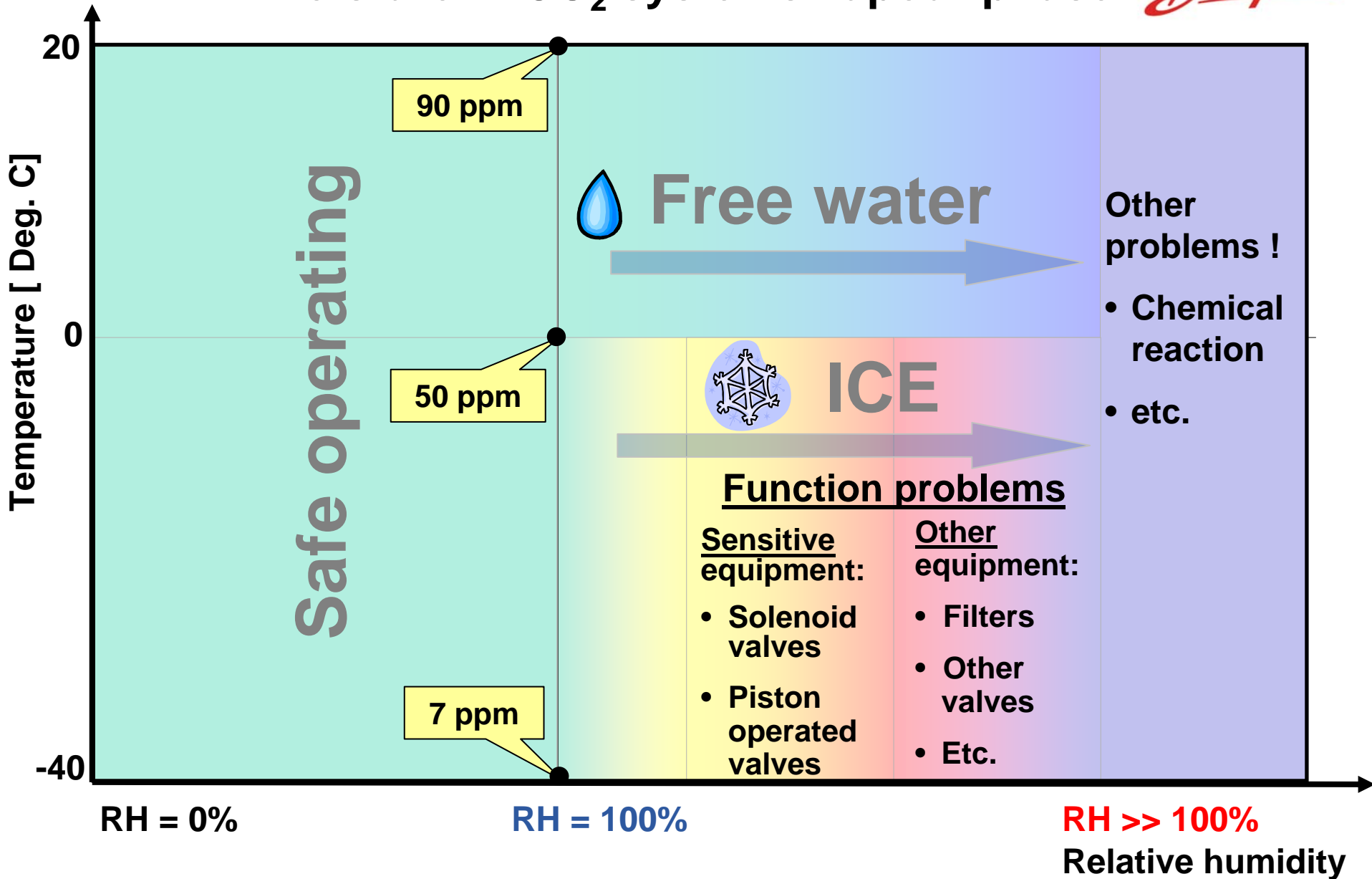
Ammonia CO₂ Cascade System



Filter Drier and Moisture Indicator

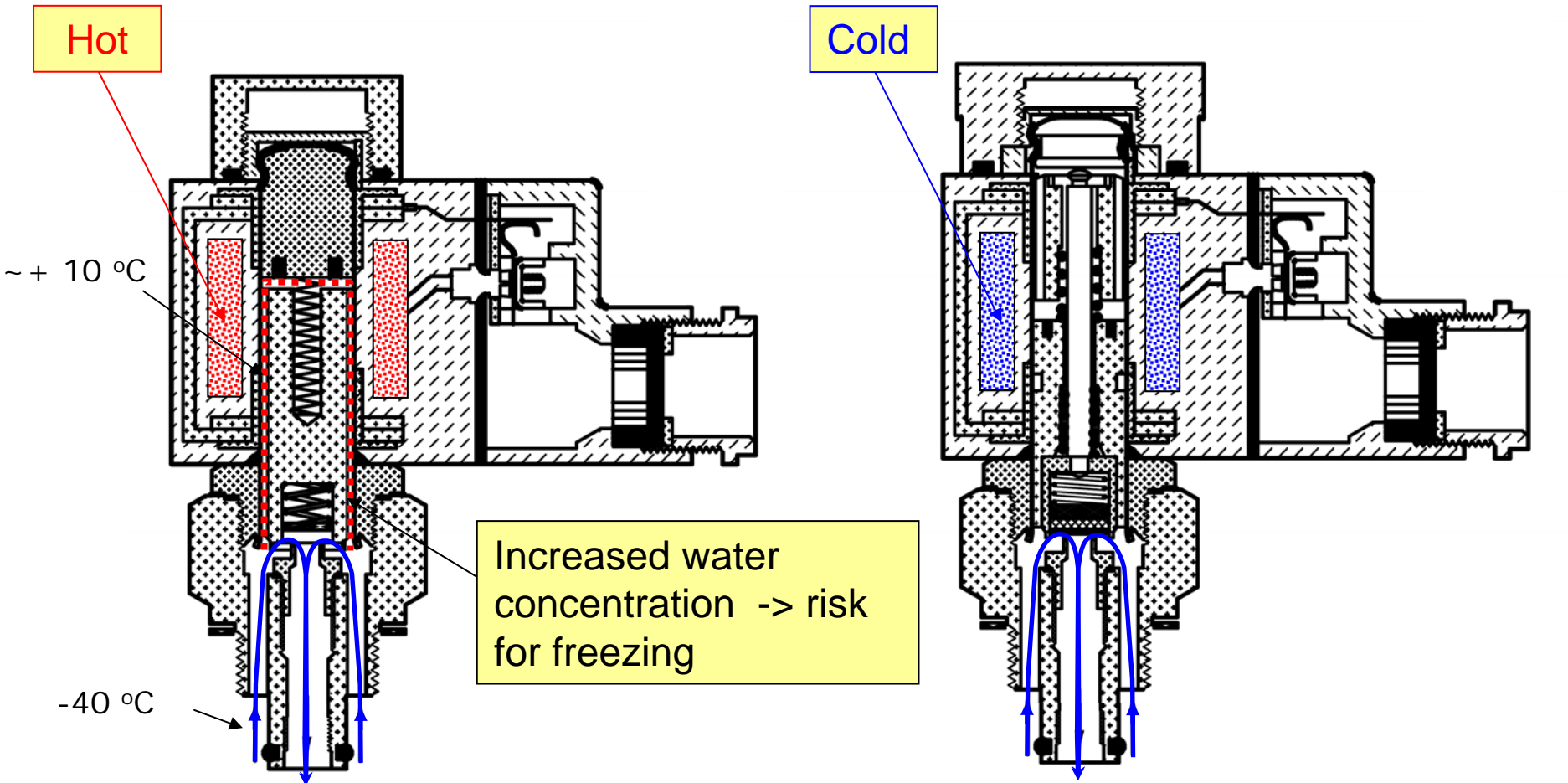


Moisture in CO₂ systems vapour phase *Danfoss*



Solenoid valves in CO2 systems

Risk of freezing water

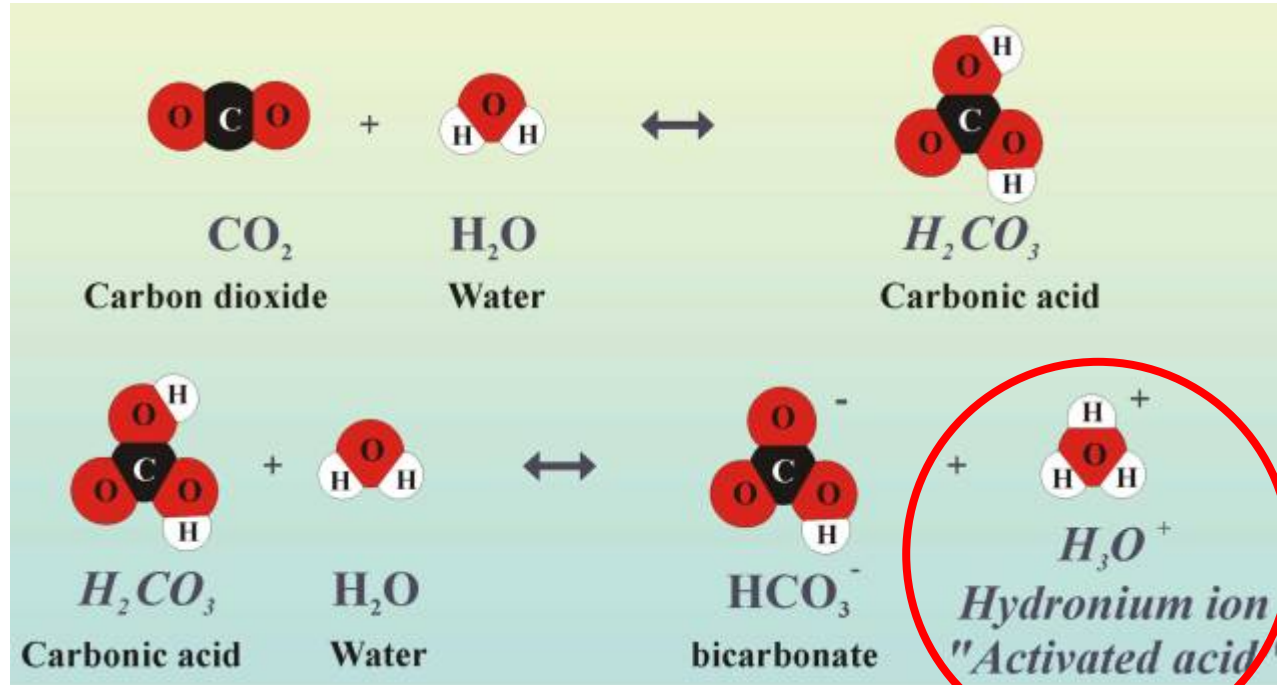


NC -> Power on during operation

NO -> No power on during operation

Water in CO₂ systems

Danfoss



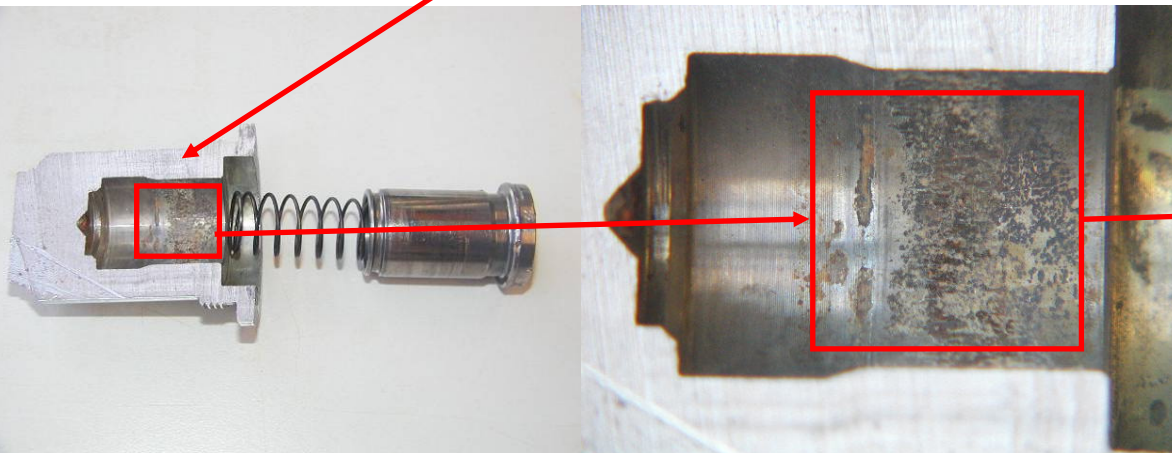
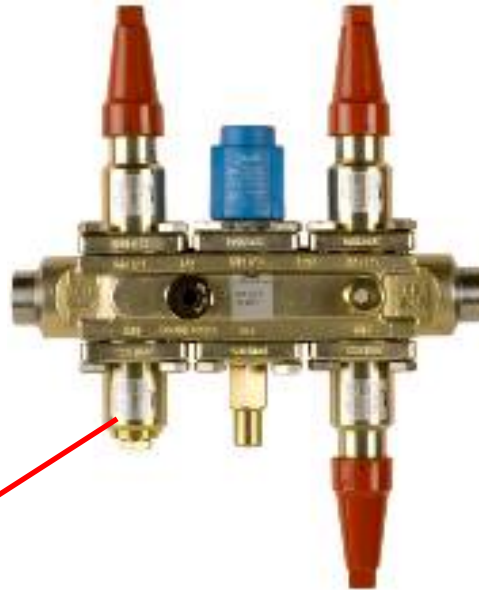
If water is present in CO₂ systems, water reacts with CO₂ and creates Carbonic acid.

The concentration is depending on the water content

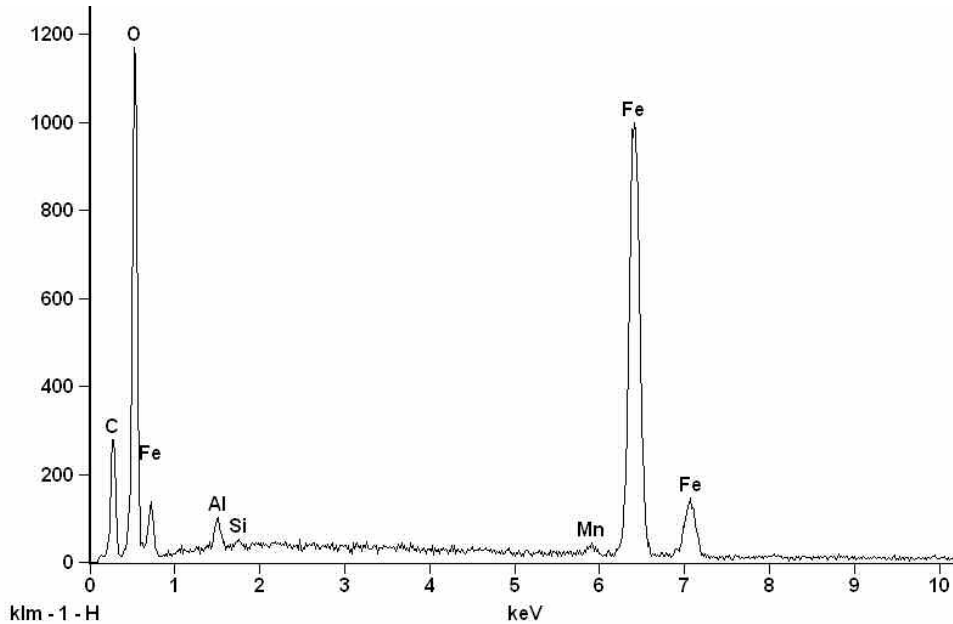
Strong acid

Analysis of a deposit on the surface of the cylinder in an ICF20-valve with sticking piston

Danfoss



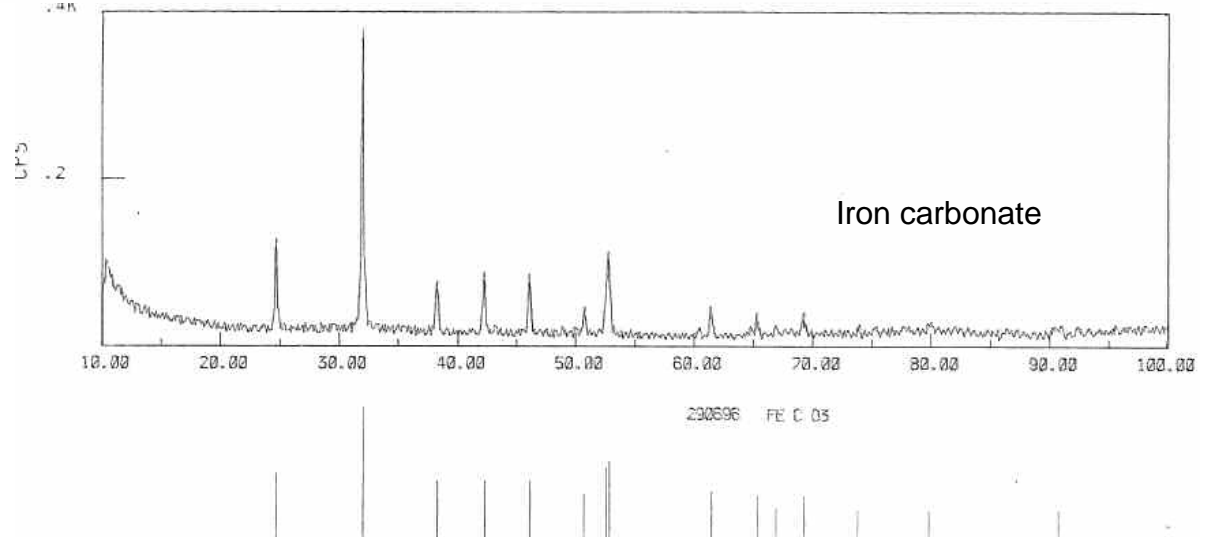
Analysis



Energy dispersive analysis (SEM/EDA)

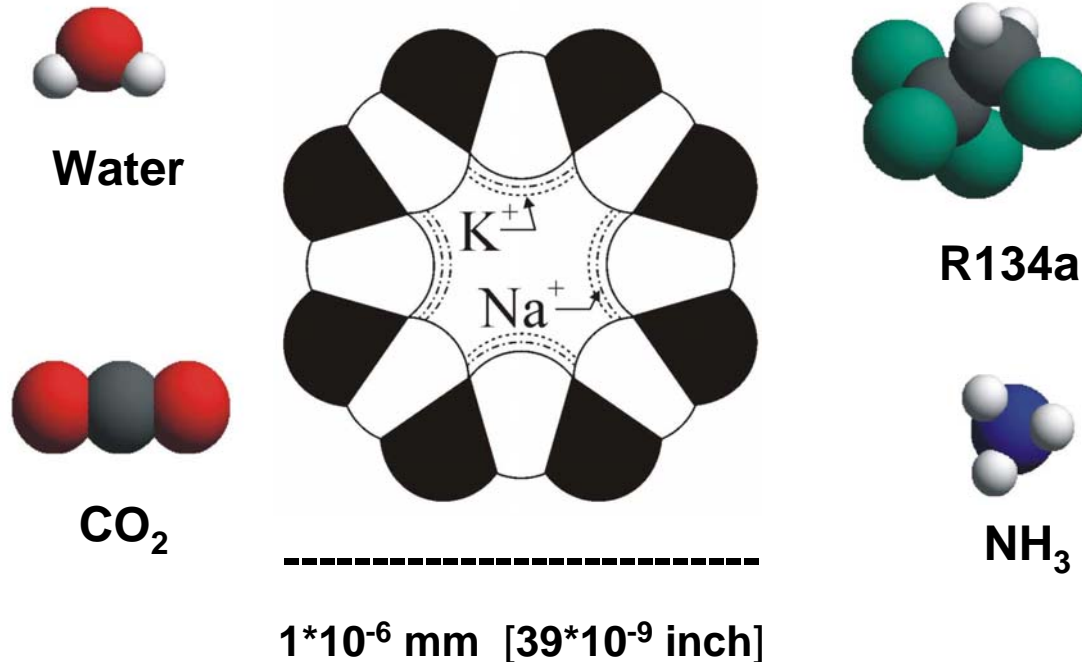
The dry powder mainly contains
iron, oxygen and carbon.

X-ray diffraction spectrum
of the dry powder identifies it
to be pure iron carbonate.



Refrigerant molecules and Molecular Sieves *Danfoss*

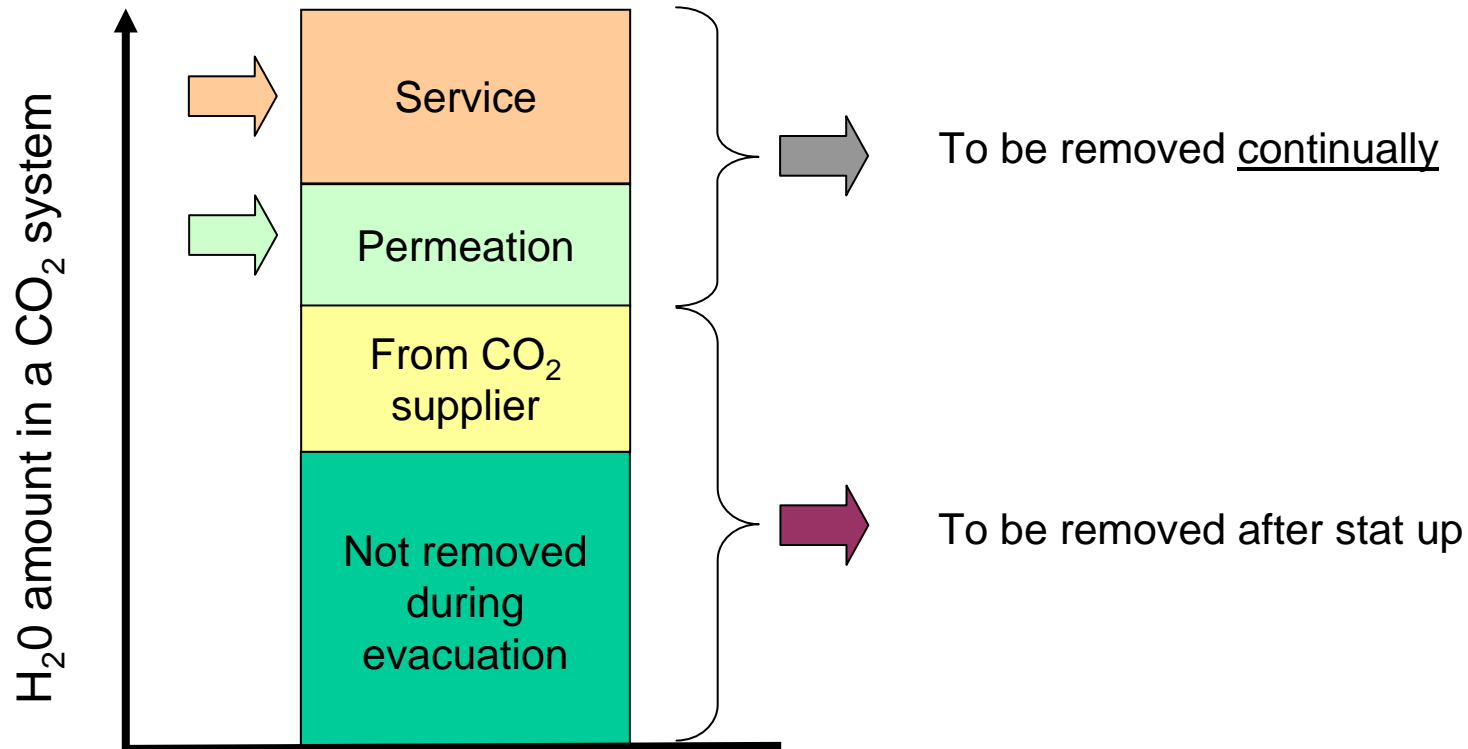
Micropore size in Zeolite LTA



CO_2 penetrates through the micropores unlike other refrigerants like R134a. If water is present, it will also penetrate through the micropores and throw CO_2 out, due to difference in polarity of water and CO_2 .

CO_2 driers with Molecular Sieves are very efficient.

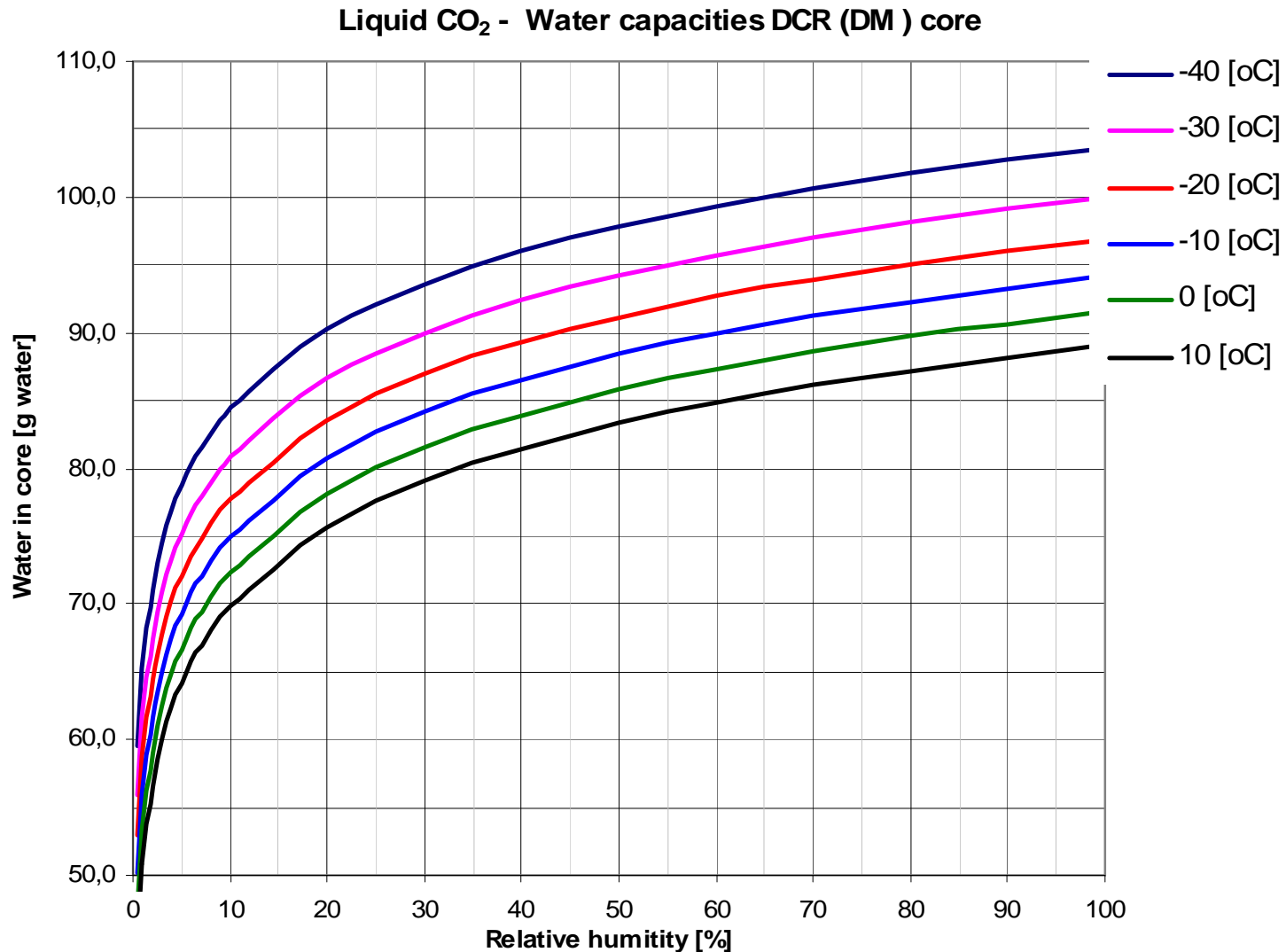
Moisture in CO₂ system



Rule of thumb:

- 1 DCR element can contain ~80 g H₂O
- 2 elements / 500 kg CO₂
- 1. inspection – 1 week:
 - < 80 g H₂O -> next inspection interval double
 - ~ 80 g H₂O -> next inspection interval unchanged

Capacity – DCR



Water in CO₂ systems



How can water penetrate into a CO₂ system?

- ▶ Diffusion
- ▶ Maintenance and repair practices
- ▶ Incomplete water removal during installation / commissioning
- ▶ Water-contaminated lubricant charged into the system
- ▶ Water-contaminated CO₂ charged into the system

Obviously, all these mechanisms should be avoided/minimized !

Note: 1 gram water in 1000 kg CO₂ → 1 ppm