Hall 4A

CHILLVENTA

Chillventa Specialist Forums 2022
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CONNECTING
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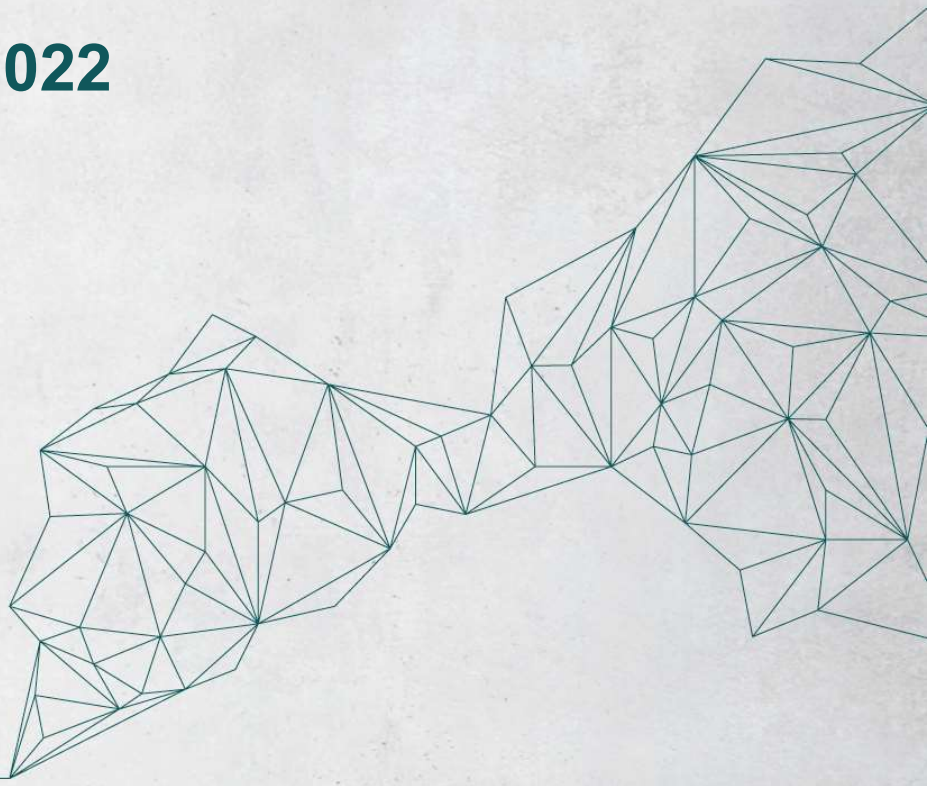


DIRECT EXPANSION (DX) OR FLOODED OPERATION OF R-717 AIR COOLER AND THEIR ENERGY EFFICIENCY ADVANTAGES

Franz Sperl
Product Management

Chillventa Specialist Forum 2022
12.10.2022

AGENDA

- Introduction - Motivation
- Test chamber
- Measurement campaigns (K1 – K4)
- Results
- Conclusion

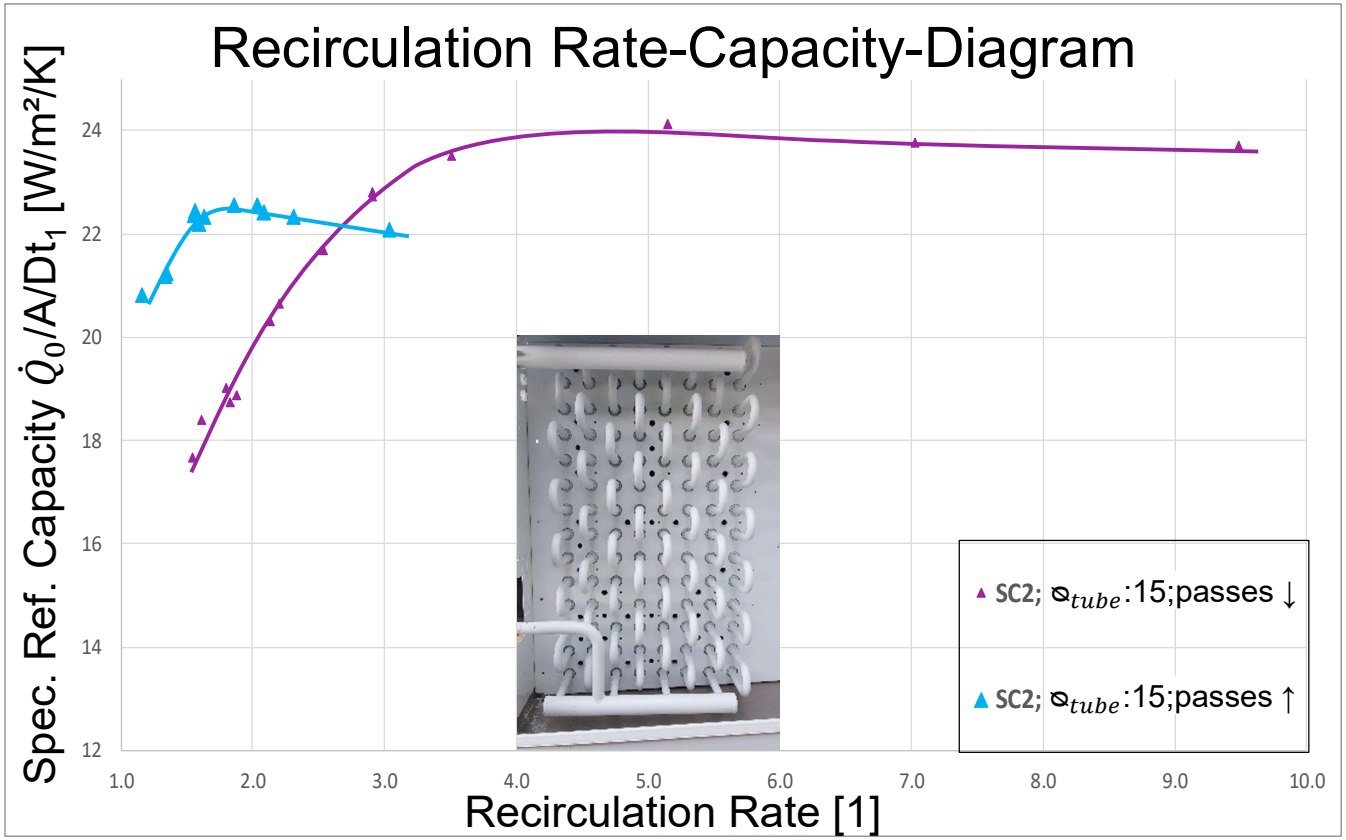
NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Motivation - Actual Industry Standard

- Established products
- Horizontal/vertical header; big core tubes
- Robust and great for high load fluctuations
- Low rr (< 2.0)
  - mostly lack in capacity
  - # of passes ↑: positive

Not every evaporator is applicable for low rr

(pay attention with optimization by e.g. gas-quality-control at existing systems)



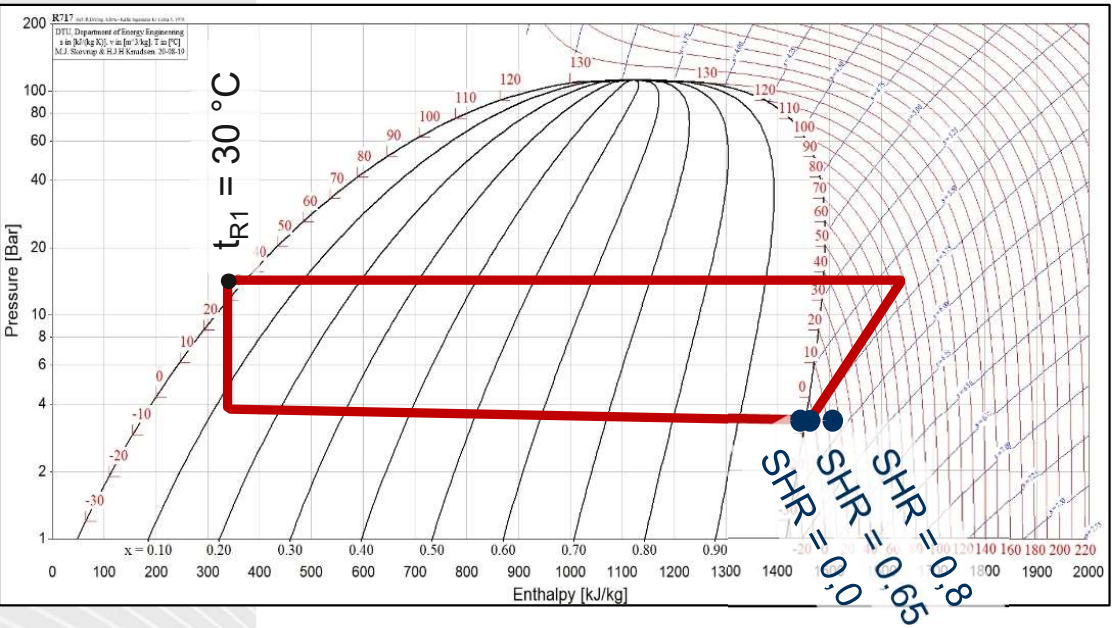
NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

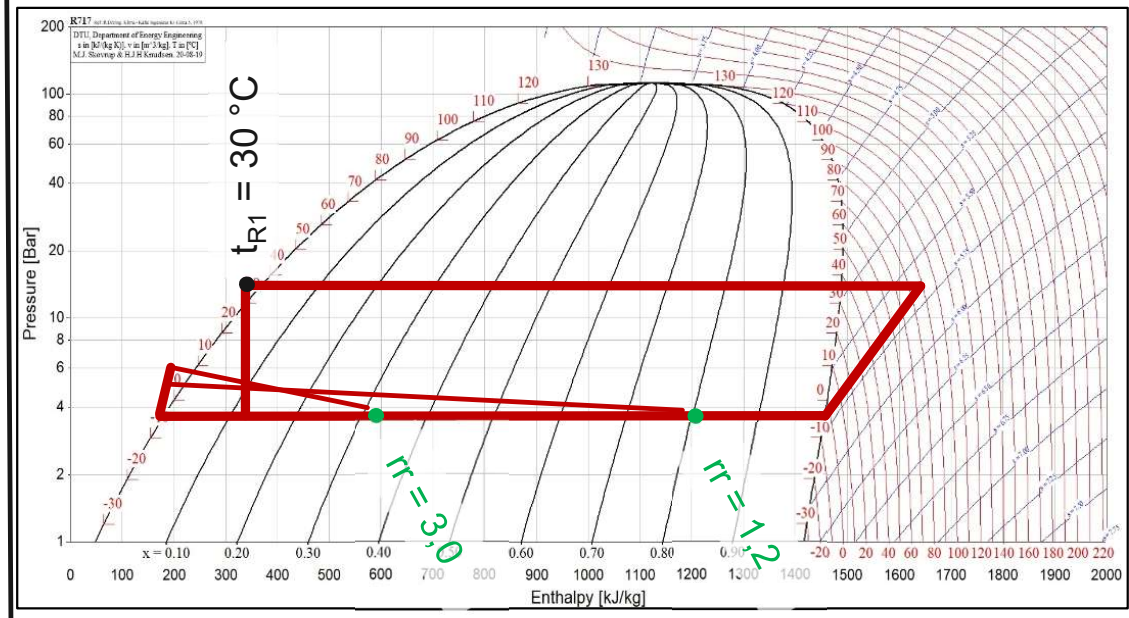
Introduction – Difference DX and Overfeed

Operation modes (OM) of the ref. system

Direct Expansion (DX)

Overfeed (rr)

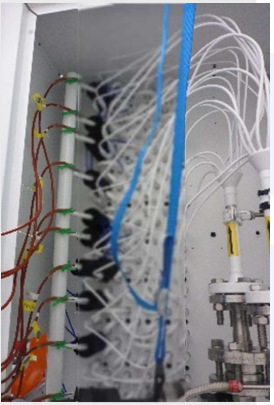




The aim is: comparison of OM and the transition

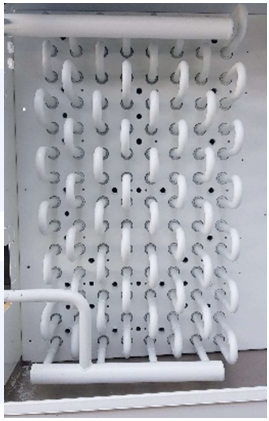
NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Introduction –Optimum rr



Best result?

Operation mode	DX		low charge Low recirculation rate	Pump
Recirculation rate (rr)	„0,8“ „0,9“	**1,0**	1,2 – 1,8	3,0

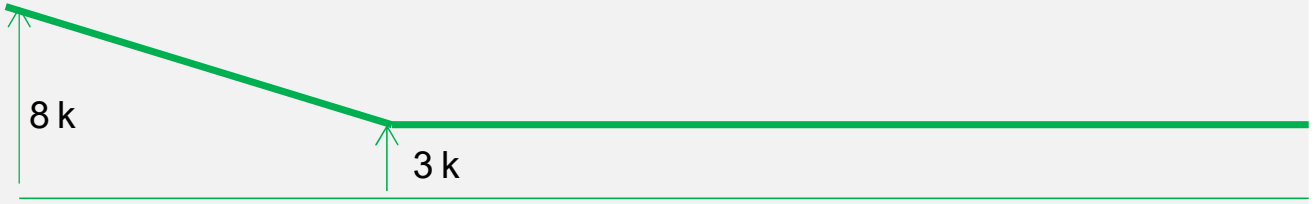


superheat overfeed

$$rr = \frac{\Delta h_0}{\Delta h_e}$$

Capacity

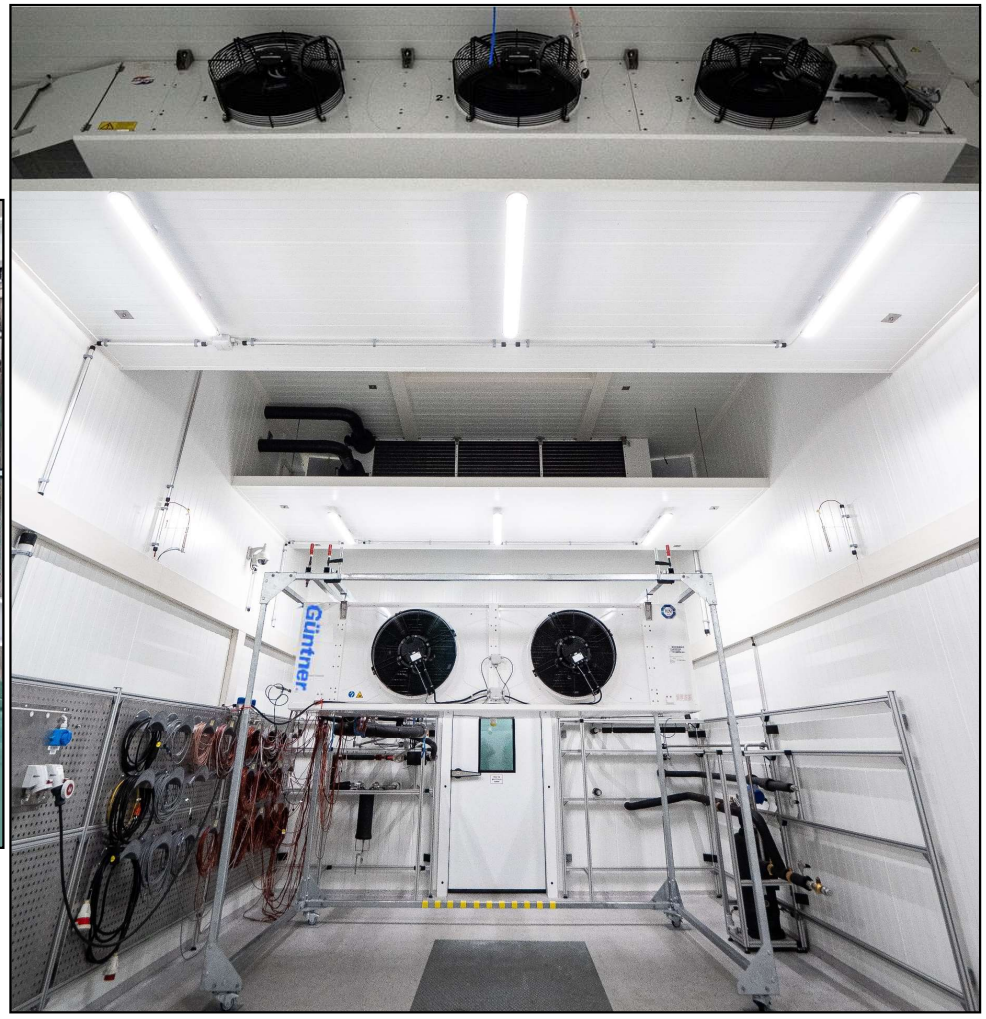
Δ t min.



NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Test Chamber

Machinery room: NH_3-rack



Test chamber

NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Measurement Campaigns

4 measurement campaigns: (based on SC2; DIN EN 328)

Standard	t_{A1} [°C]	t_{DP} [°C]	t_e [°C]	SHR [-]	t_{R1} [°C]
SC2	0	<-10	-8	0,65	30

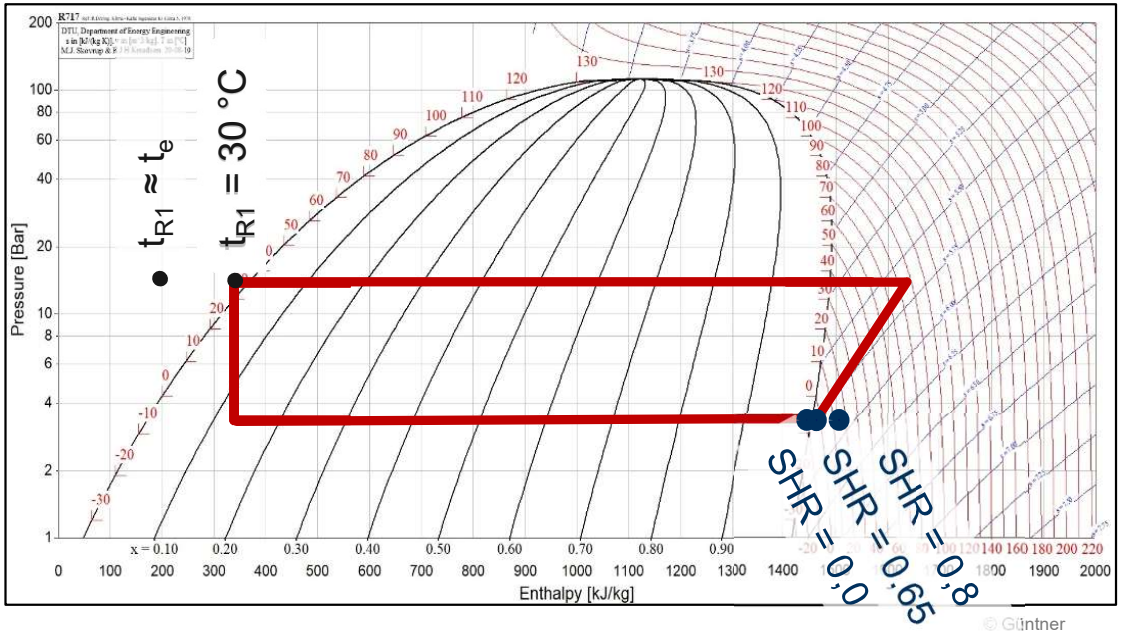
SHR = Superheat ratio

$$SHR = \frac{\Delta t_{sup}}{Dt_1} = \frac{t_{sup} - t_e}{t_{A1} - t_e}$$

5,2 K

1. K1 (DX) Variation of SHR
2. K2 (DX) Variation of t_{R1}
3. K3 (DX) Variation of SHR at tR1 ≈ te

t_{A1} = air inlet temperature (dry bulb)
t_{DP} = air dew point temperature within the room
t_e = evaporating temperature
t_{R1} = refrigerant temp. at the inlet of the exp. valve
Dt_1 = inlet temperature difference
t_{sup} = superheating temperature
Δt_{sup} = superheating



NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Measurement Campaigns

4 measurement campaigns: (based on SC2; DIN EN 328)

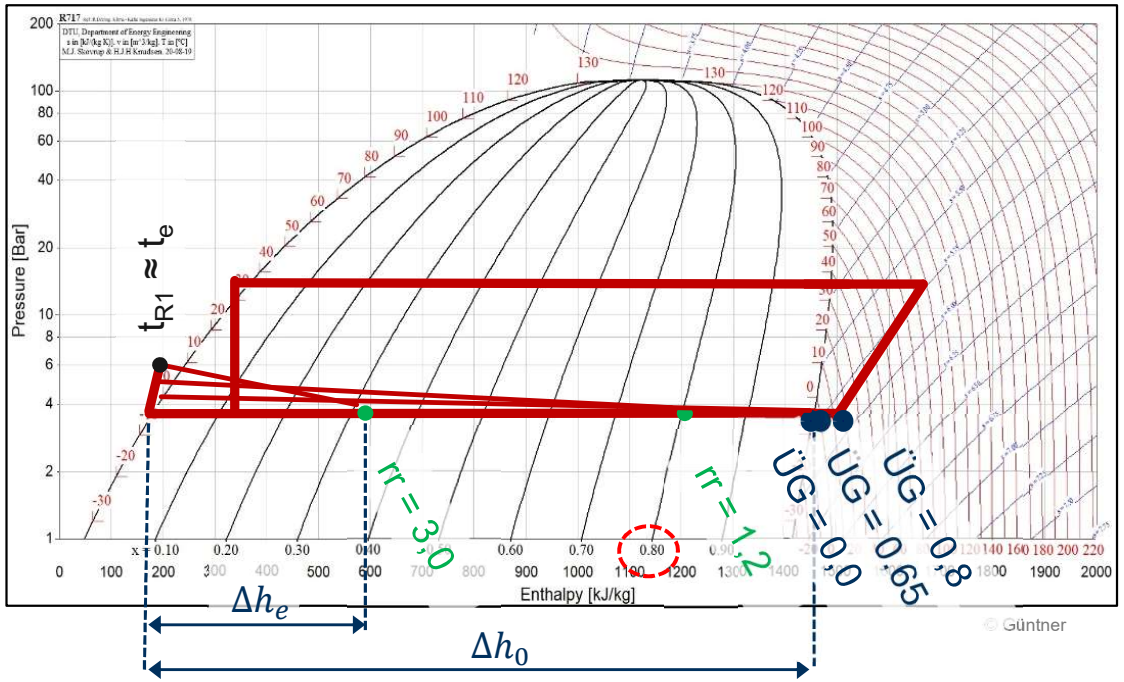
Standard	t_{A1} [°C]	t_{DP} [°C]	t_e [°C]	rr [-]	t_{R1} [°C]
SC2	0	<-10	-8	2	30

rr = recirculation rate

$$rr = \frac{\Delta h_0}{\Delta h_e} = \frac{1}{x}$$

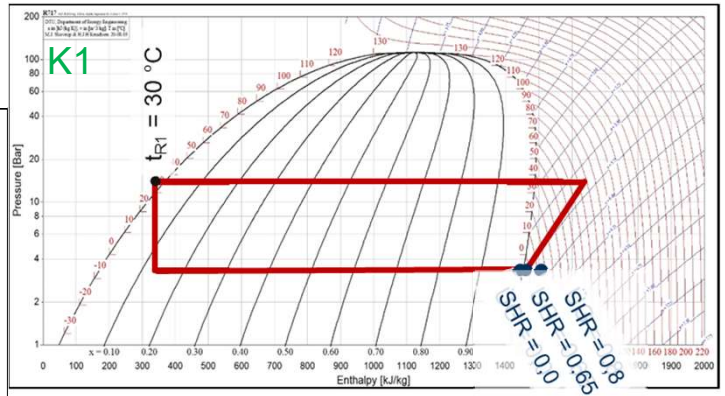
1. K1 (DX) Variation of SHR
2. K2 (DX) Variation of t_{R1}
3. K3 (DX) Variation of SHR at $t_{R1} \approx t_e$
4. K4 (Pump)
   - rr ≈ 1 und SHR
   - rr > 1

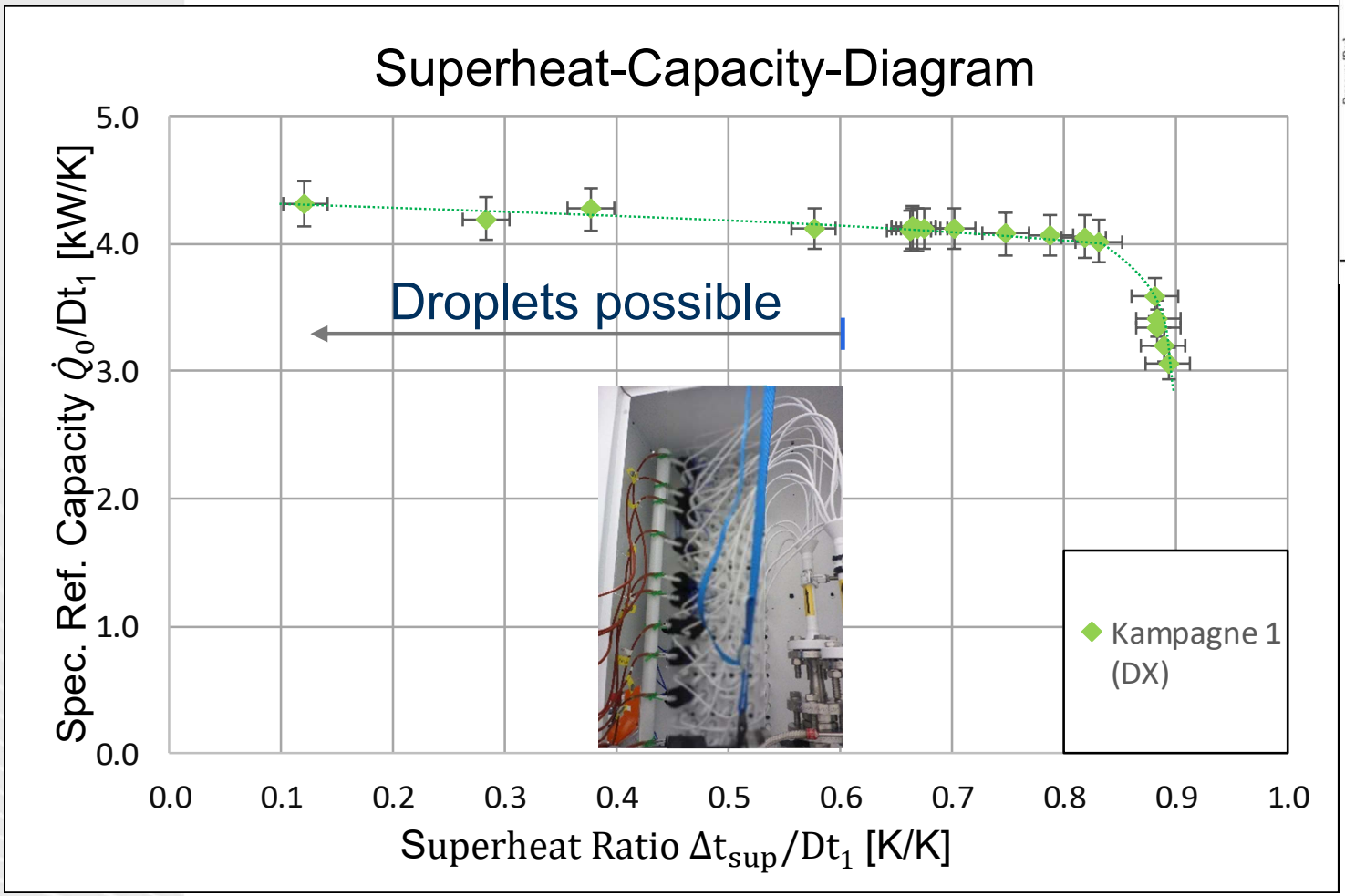
Δh_e = ref. spec. enthalpy change in the unit at p_e
Δh_0 = specific vaporization enthalpy p_e
x = vapor quality in kg_{vapor}/ kg_{total}



NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

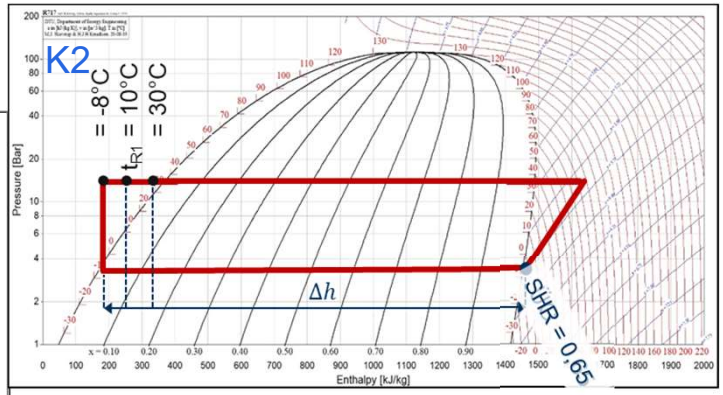
Results K1 (Variation of SHR)

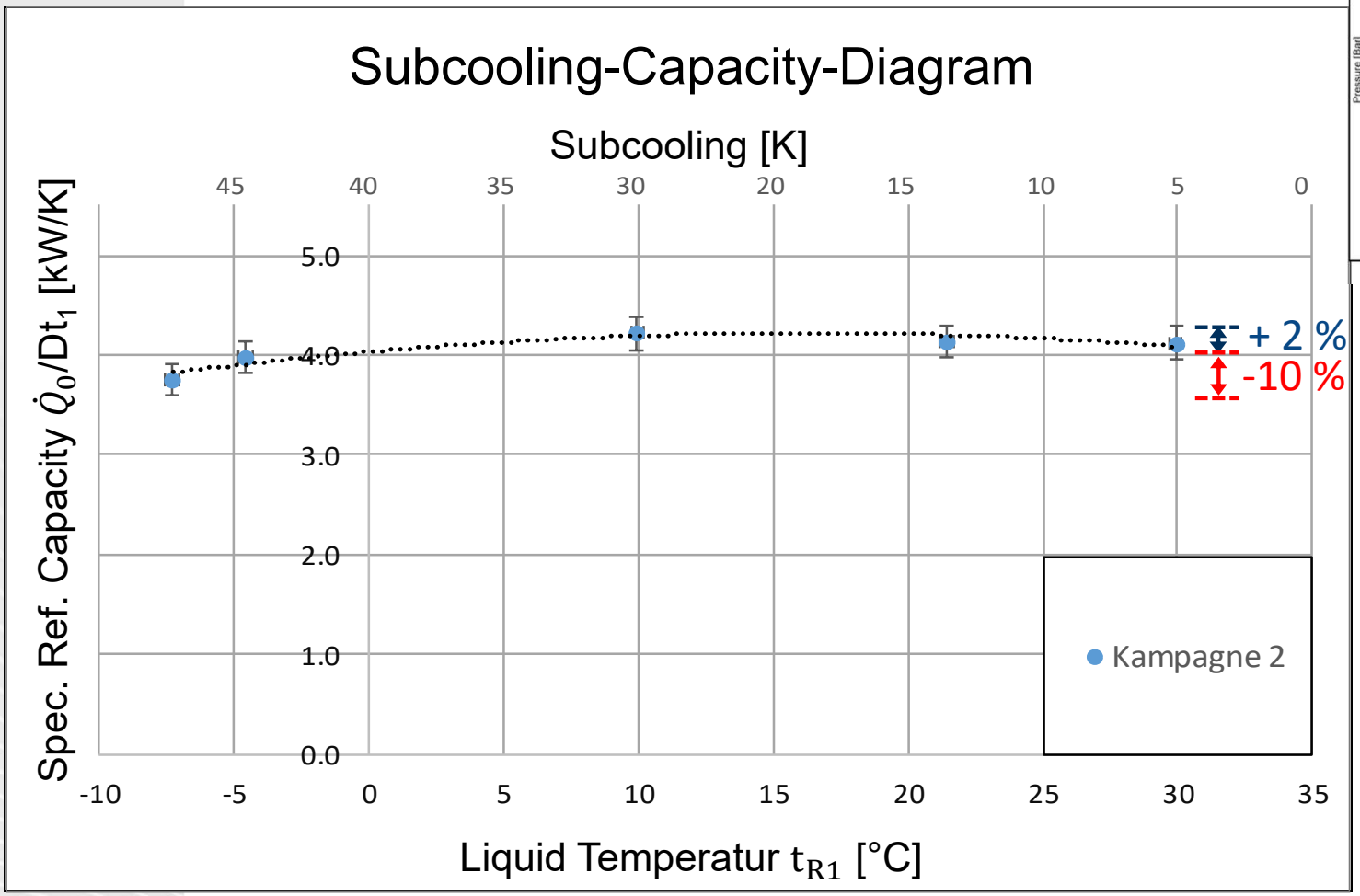




NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Results K2 (Variation of t_{R1})





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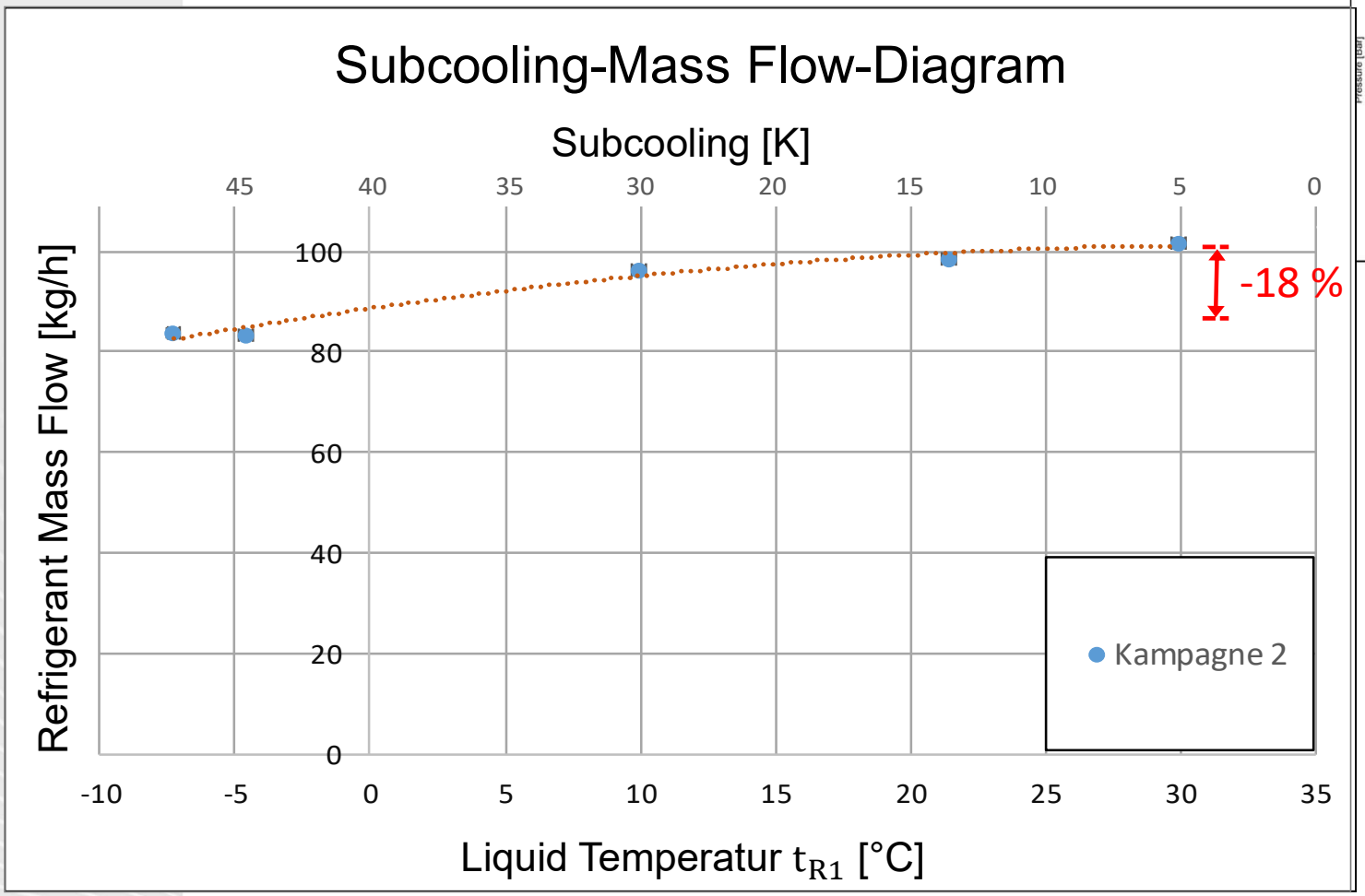
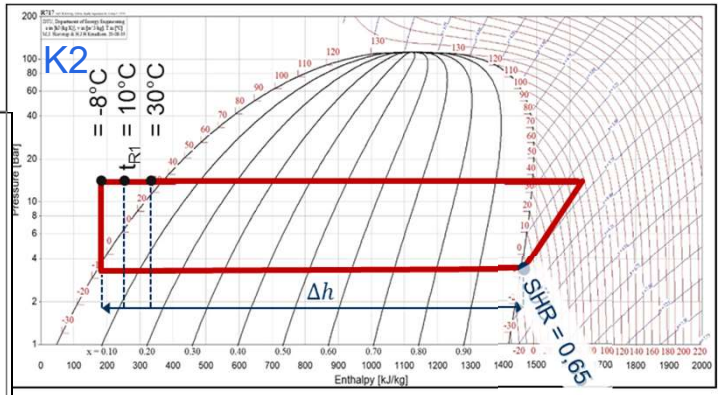
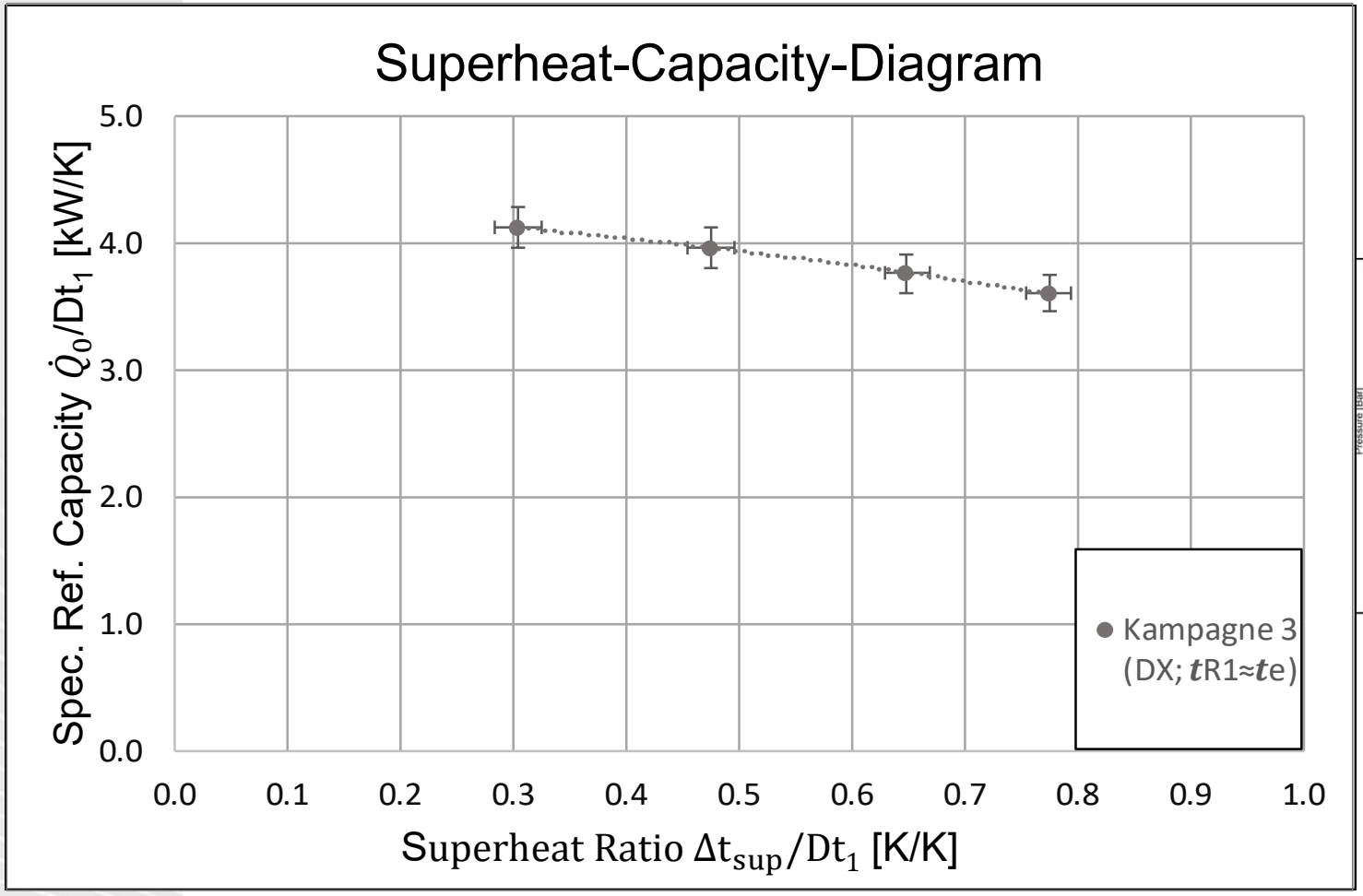
Results K2 (Variation of t_{R1})

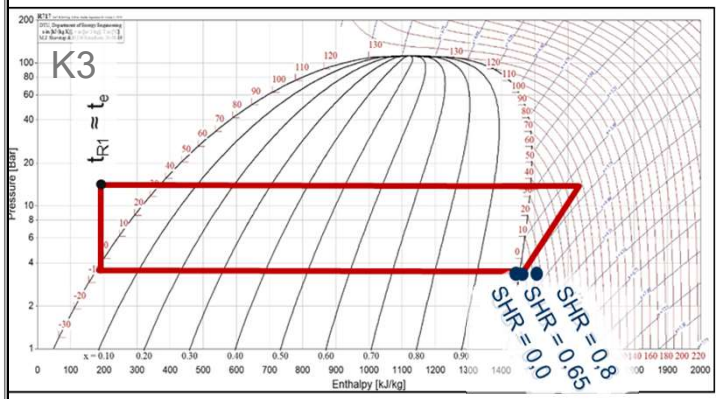




NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

K3 (Variation of SHR at tR1 ≈ te)

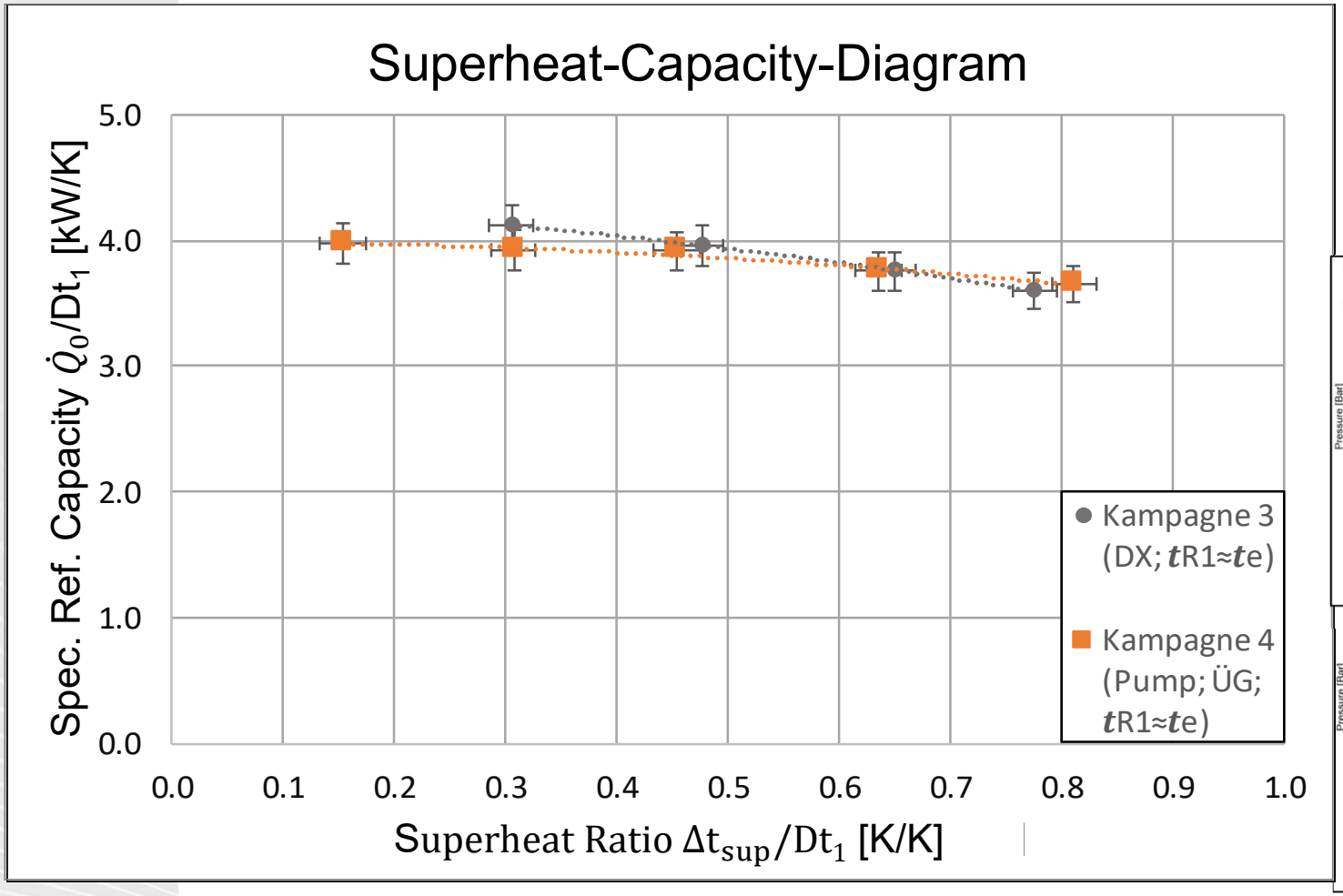


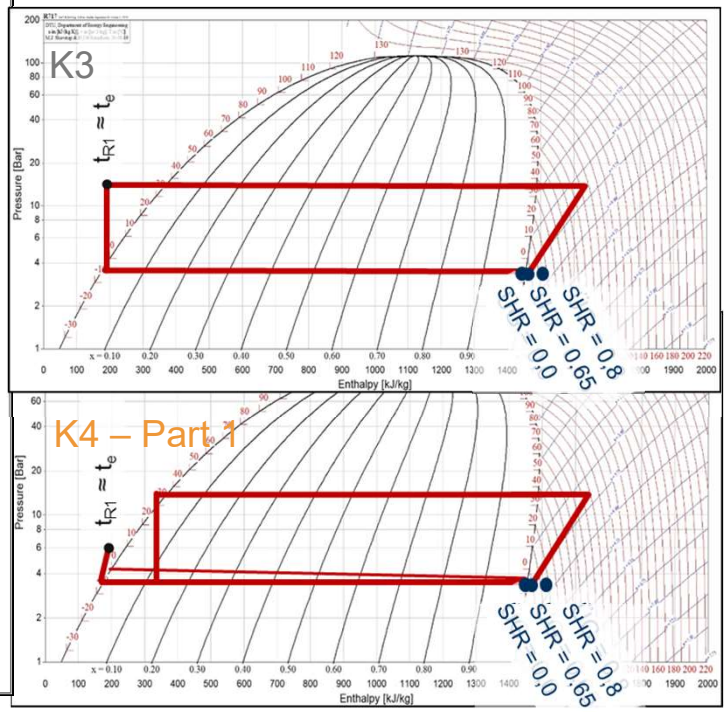


NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

K3 (DX; $t_{R1} \approx t_e$) VS. K4 (Pump; SHR)

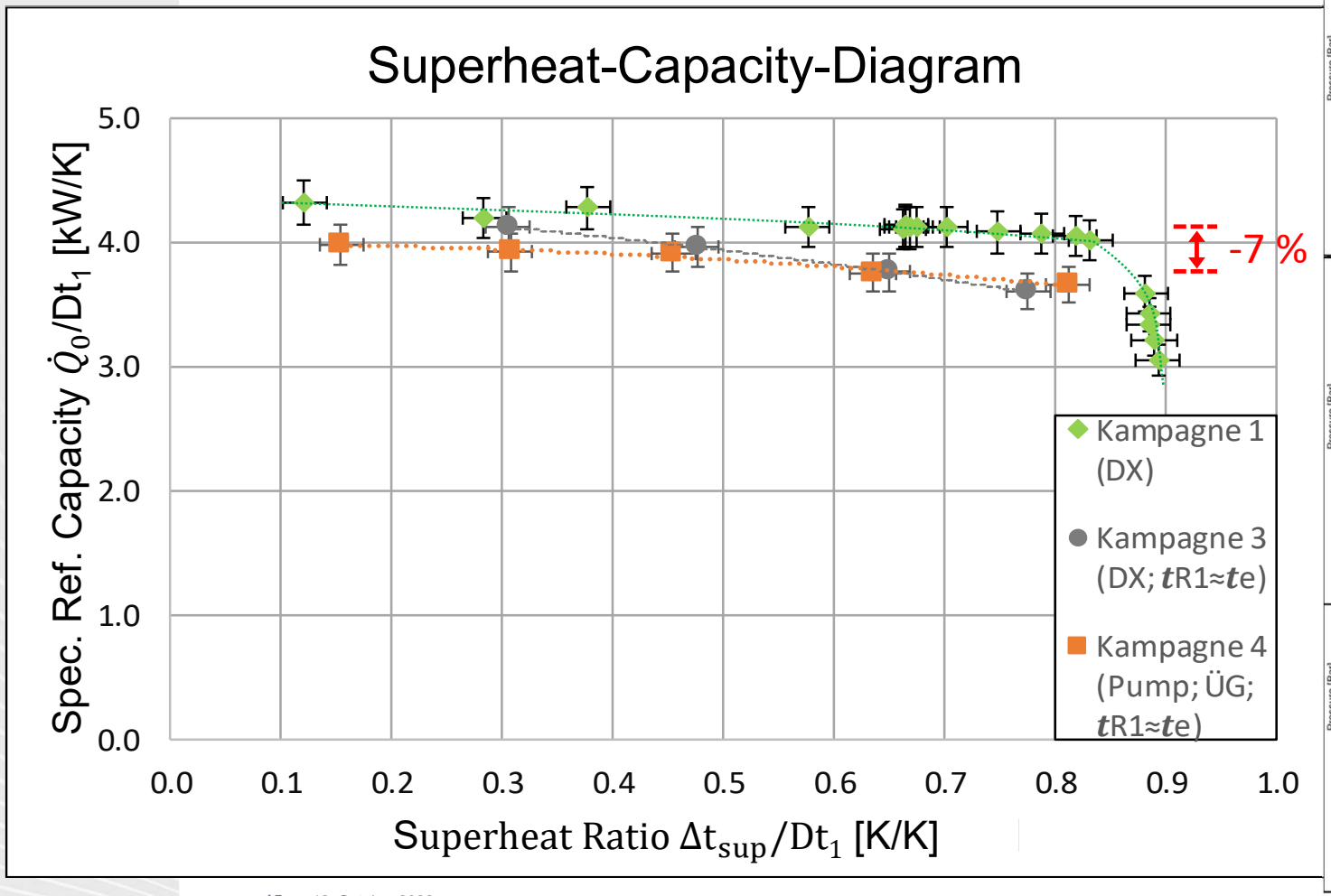
PROOF OF CONCEPT

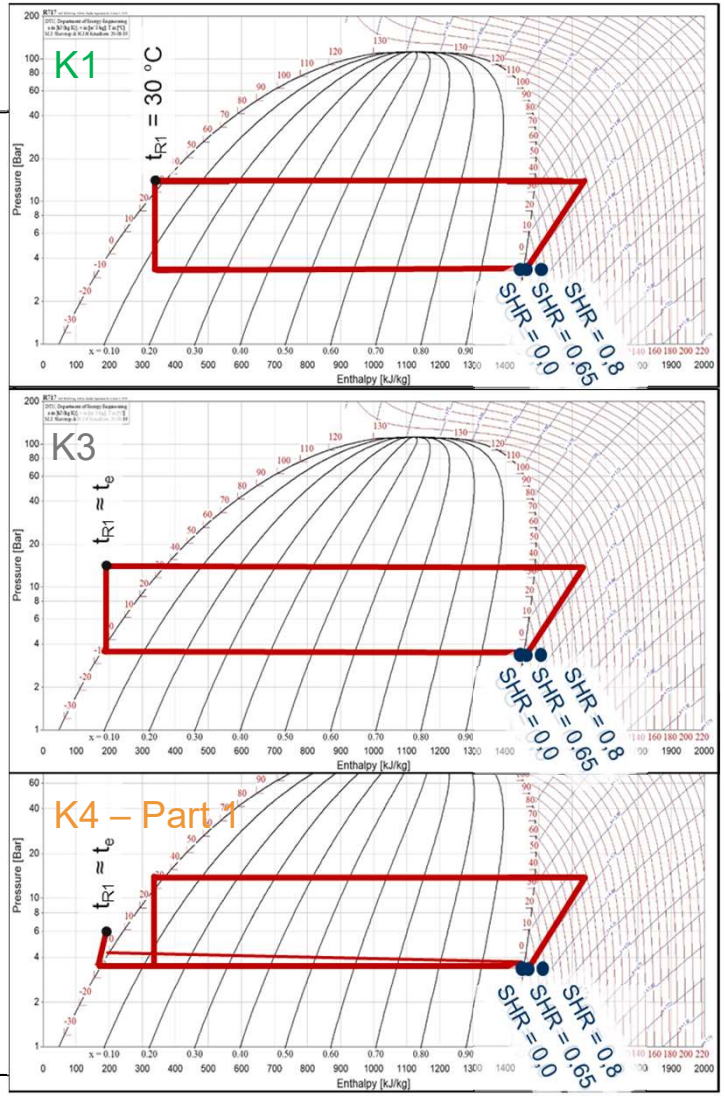




NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

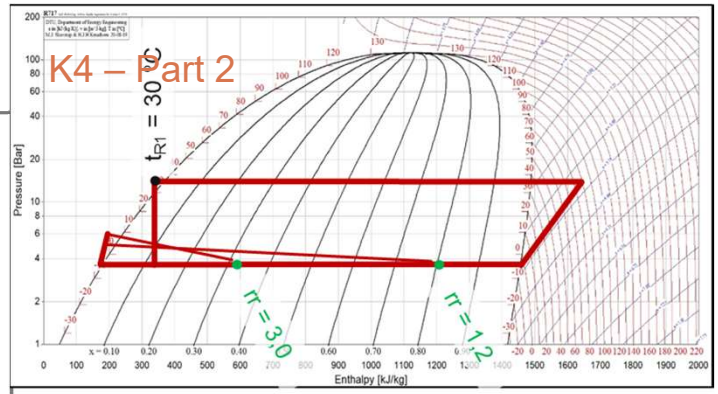
K1 (DX) VS. K3 (DX; $t_{R1} \approx t_e$) VS. K4 (Pump; SHR)

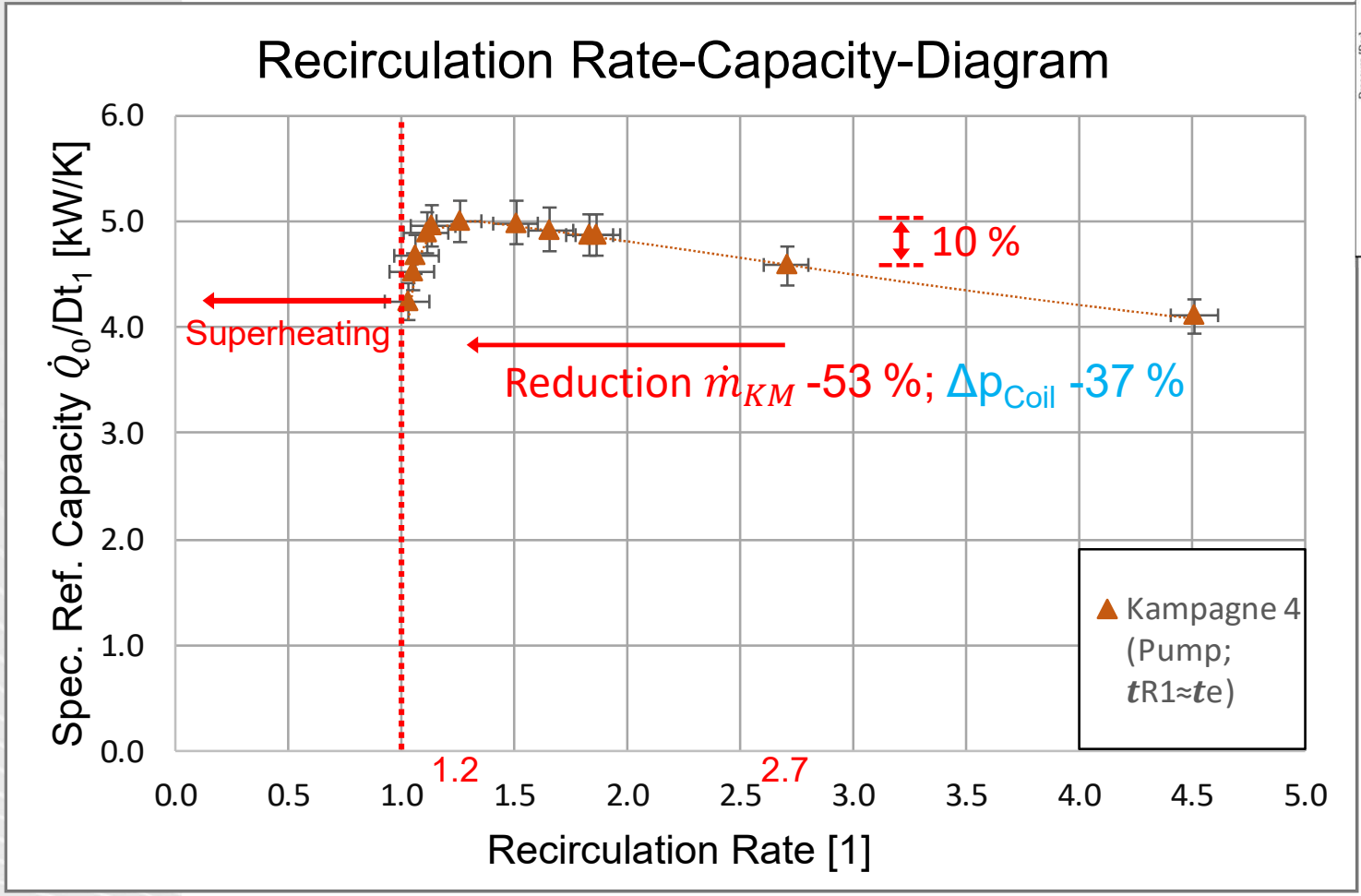




NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

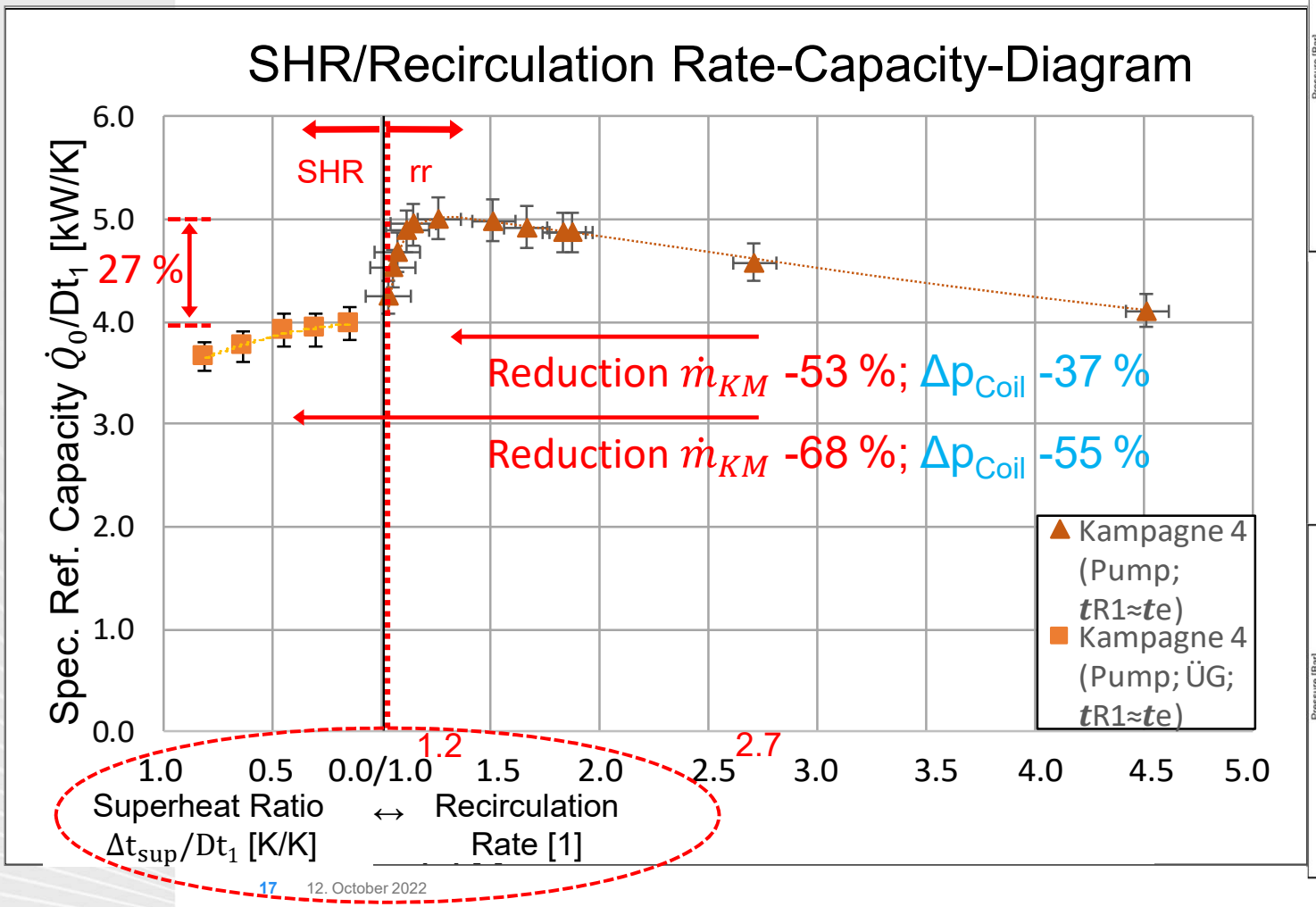
K4 (Pump)

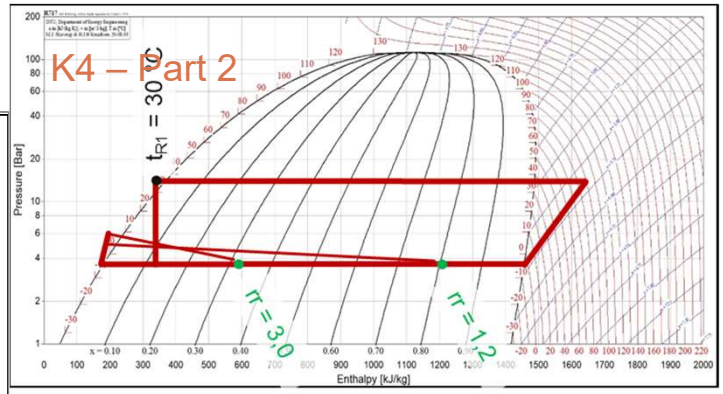


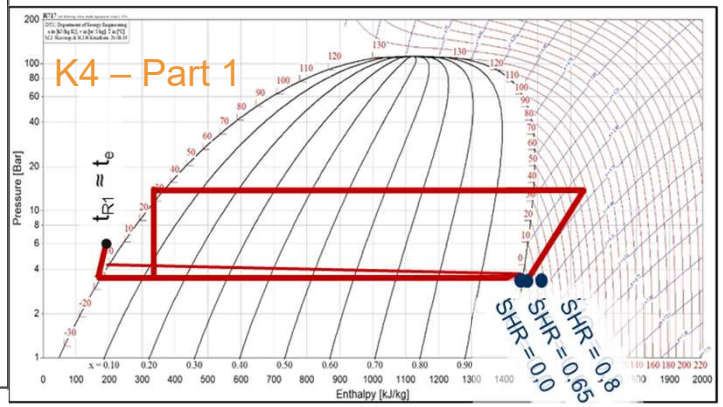


NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

K4 (Pump) VS. K4 (Pump; SHR)

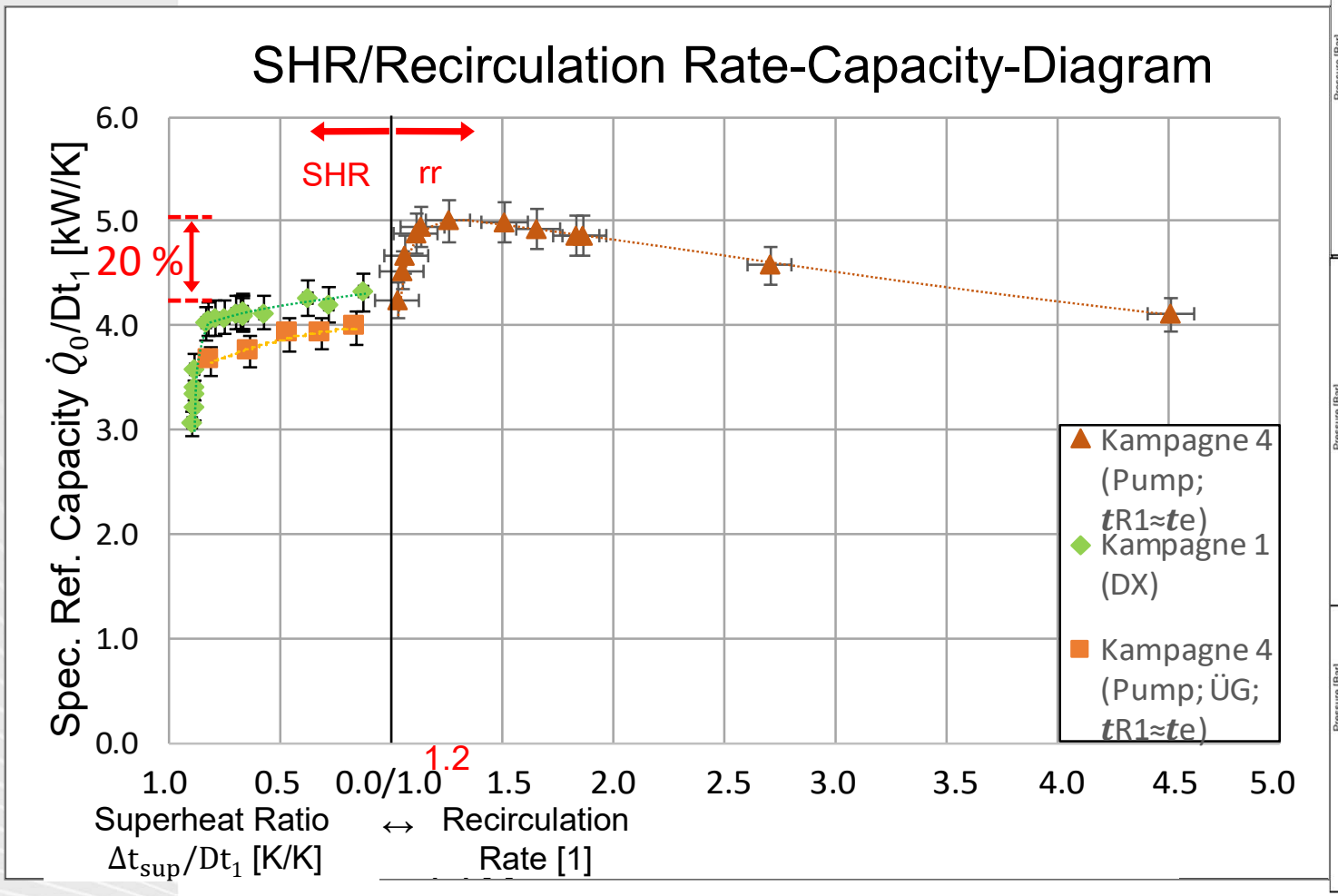


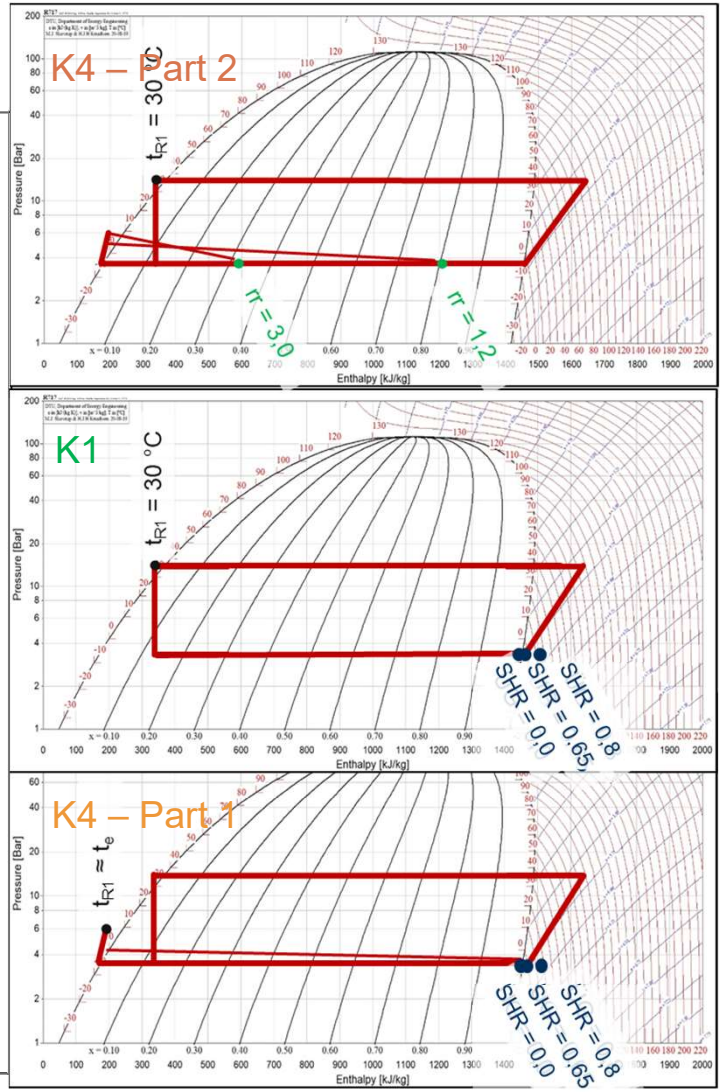




NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

K4 (Pump) VS. K4 (Pump; SHR) VS. K1





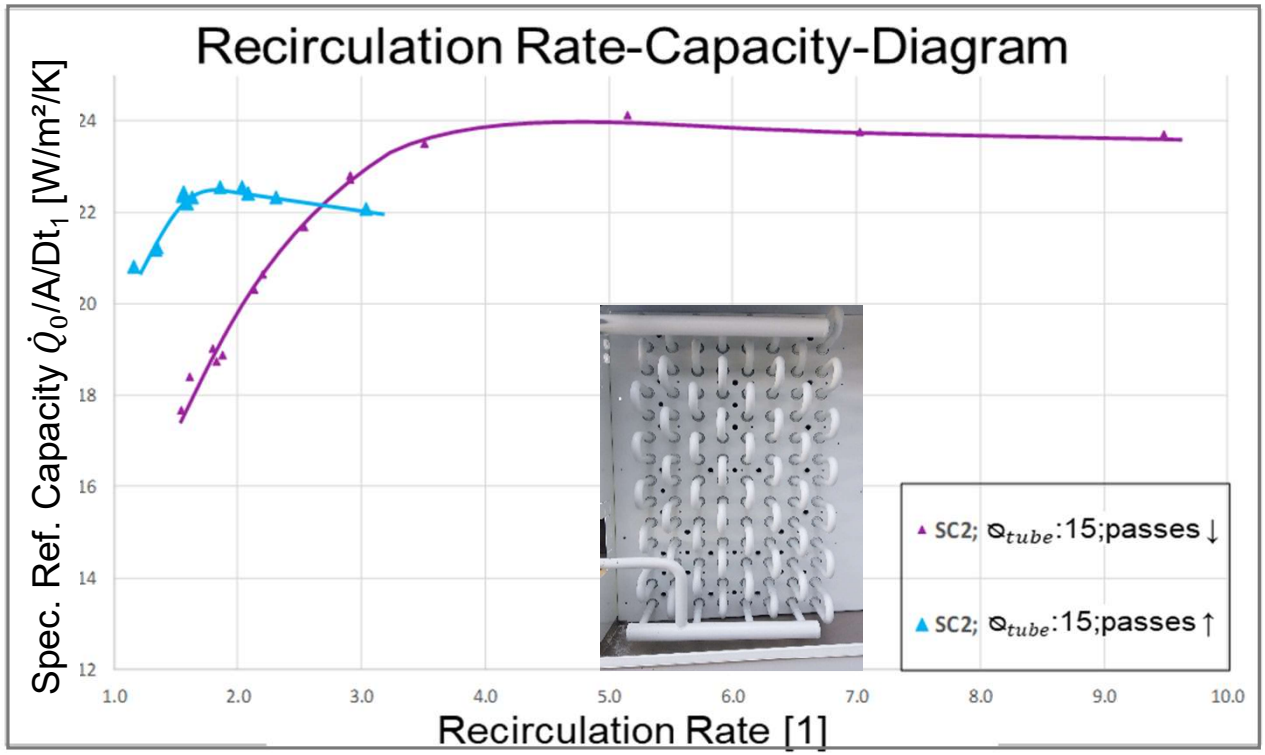
NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

Conclusion

Standard evaporator, pump rr ~ 3:

- Established products in industrial standard
- Great for high load fluctuations
- Low rr (< 2.0)

  → mostly lack in capacity



NH3: TRANSITION FROM SUPERHEATED TO FLOODED OPERATION

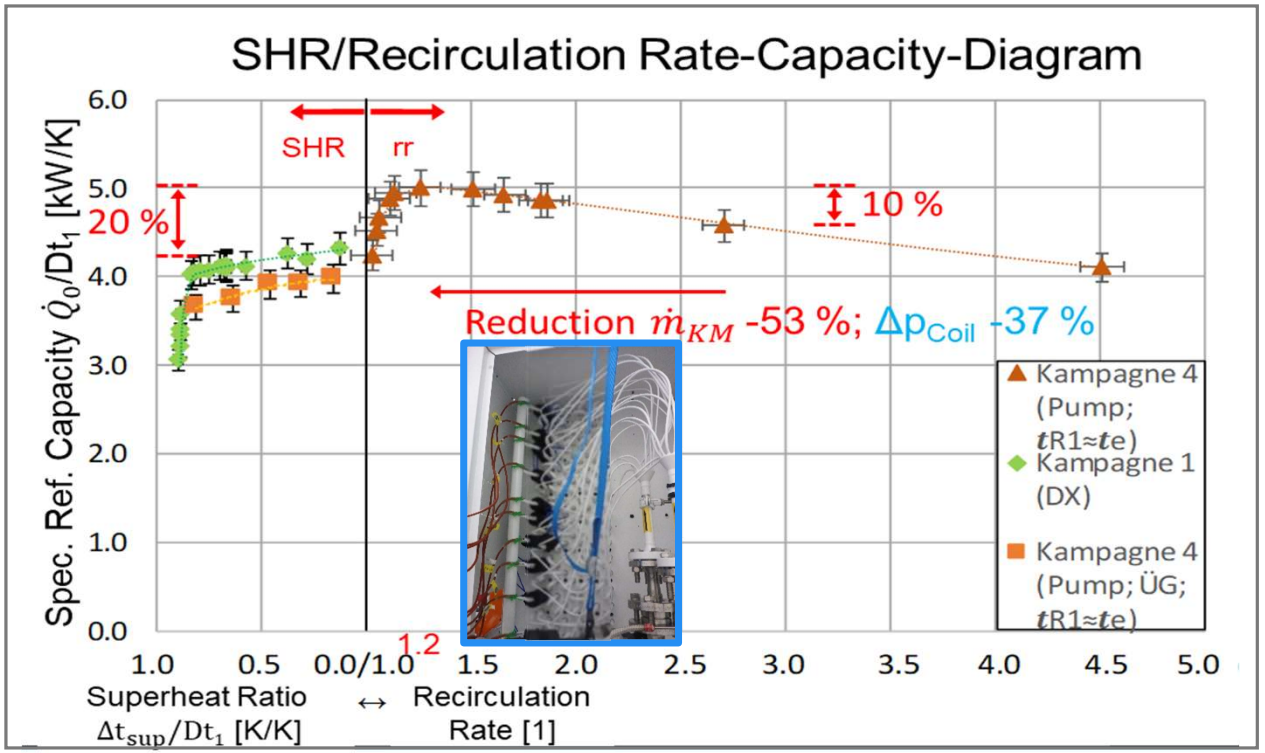
Conclusion

Optimized evaporator, small core tube, balanced Δp_{Coil}:

- Tube volume -60 %
- Reduced charge (NH_3-volume)

- DX
  - Lowest charge (NH_3-flow)
  - No big separator needed
  - Low pressure drop within rising suction pipes

- low rr
  - $\dot{Q}_{o,max}$ at rr ≈ 1.2
  - Capacity +20 % (DX → Pump)



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- DX
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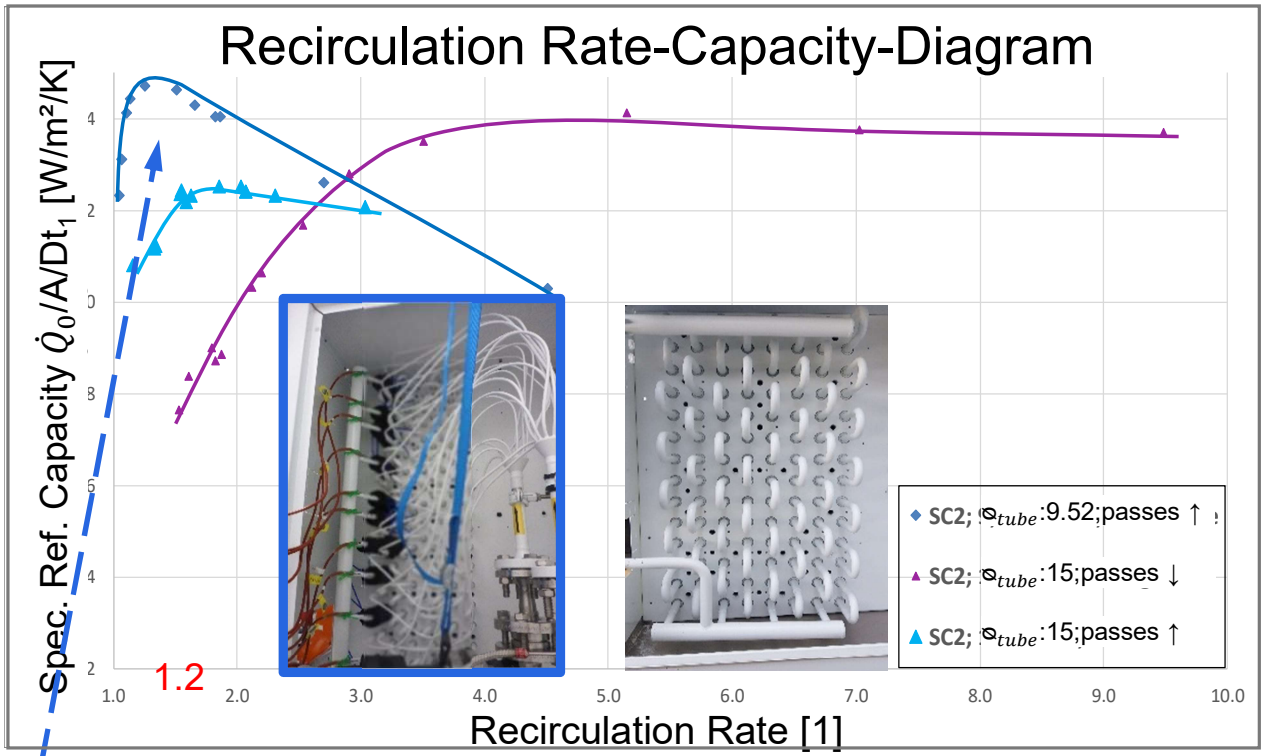
  - No big separator needed
  - Low pressure drop within rising suction pipes

- low rr
  - $\dot{Q}_{o,max}$ at rr ≈ 1.2
  - Capacity +20 % (DX → Pump)
  - Very efficient and cost effective
  - Competitive to standard design



THANK YOU

Franz Sperl | T +49 8141 242 – 132
franz.sperl@guntner.com

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