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Ammonia Low Charge Large Industrial Refrigeration Systems

Analysis and Development

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NH3 as a refrigerant: **Main trends / drivers**

NH3

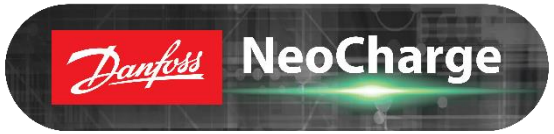
- Is a natural refrigerant.
- GWP=0, ODP=0.
- However it's classified as a toxic and flammable refrigerant.

There are 3 main drivers for **low charge ammonia** systems

- Increased focus on risk mitigation of large ammonia charges in populated areas.
- New rules with lower charges are implemented in several countries over the world
- Ammonia is a **very effective and natural** refrigerant

This presentations shows different solutions to reduce the NH3 charge

- We also present Danfoss new low charge ammonia solution



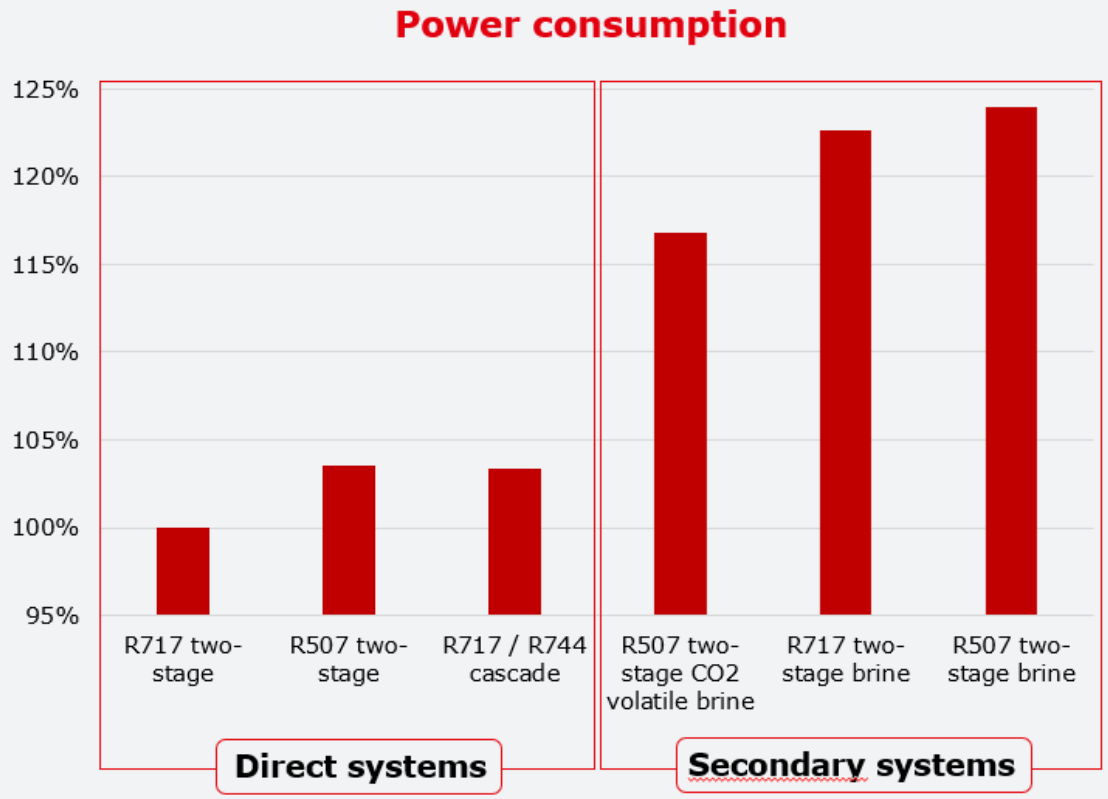
Efficiency study of different systems
NH3 charge reduction and efficiency penalty

Calculation parameters

- Location: Central Europe
- Flooded evaporators: 8K temperature difference to air inlet
- Evaporative condensors: 7K temperature difference to wet bulb temperature
- Suction line losses: CO_2: 0K, all others: 1 K
- Cascade coolers: 3 K temperature difference
- All systems equipped with economizers
- MT load / LT load: 75%/25%

Conclusion

- **Secondary systems** significantly **reduce the refrigerant charge** but generally **increase the power consumption**
- So from an **efficiency point of view** it makes sense to use **direct systems**
- **NH3/CO2 cascade generally reduces the charge and still gives good system efficiency**
- **NH3 gives the best performance.** Can we reduce the charge?
- **Yes!** This can be done by **Danfoss NeoCharge** control

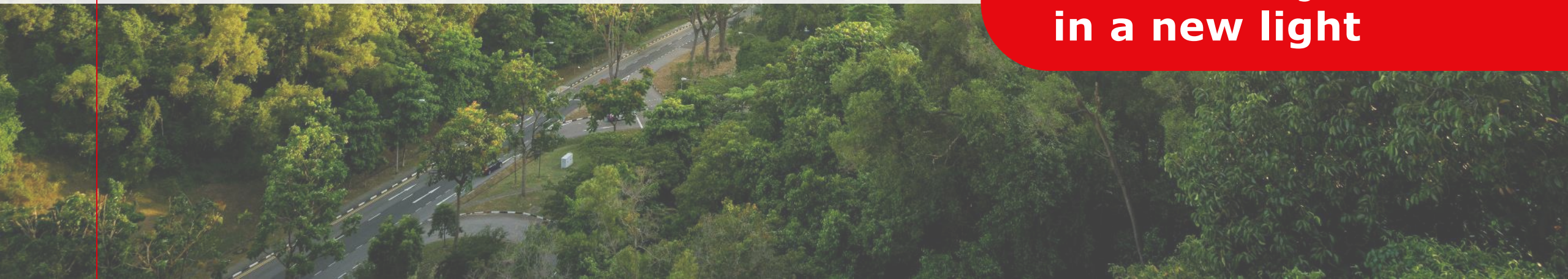


- Calculations performed by Thomas Lund, Danfoss

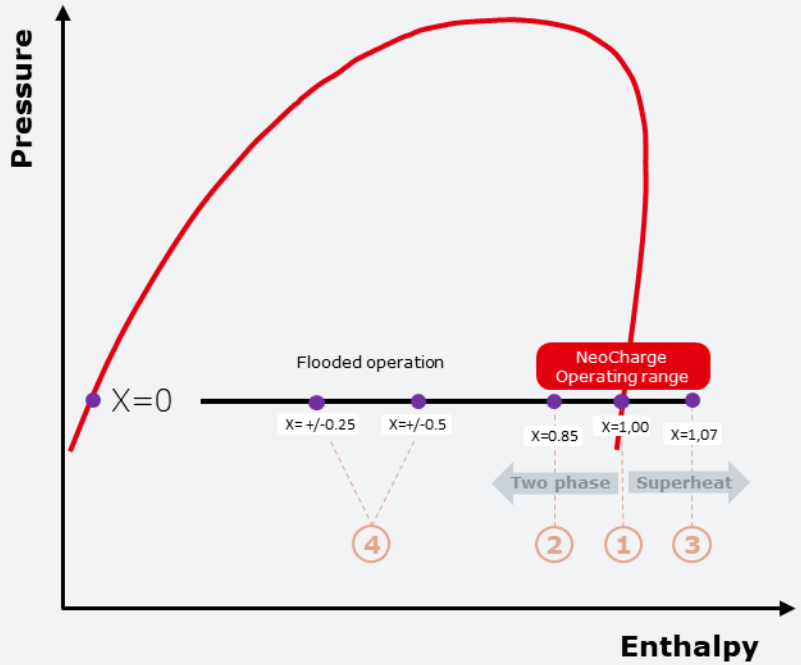
Danfoss NeoCharge

- for ammonia recirculated evaporators (flooded/pump system)
- for ammonia direct expansion (DX) evaporators

See low charge controls
in a new light



Danfoss NeoCharge
What does it do?



NH3 recirculated evaporators

It controls the circulation rate in evaporators (air coolers)

- The circulation rate will be reduced from high to almost no circulation rate, ie from point 4 to point 2
- **NH3 charge reduced by up to 40%**
- **Efficiency gain**

NH3 DX evaporators

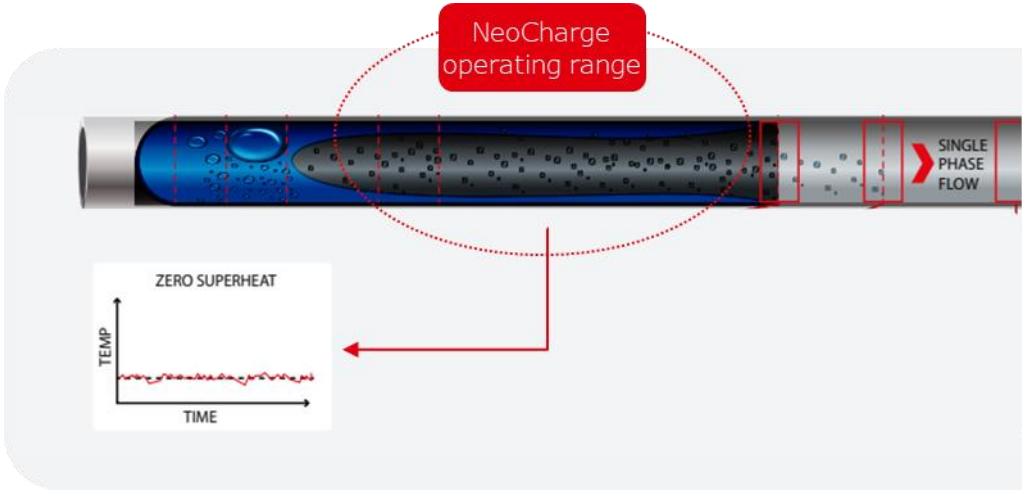
It generates ultra low superheat in evaporators (air coolers)

- Superheat will be reduced from standard to very low, ie from point 3 to point 1
- **Efficiency gain up to 15%**

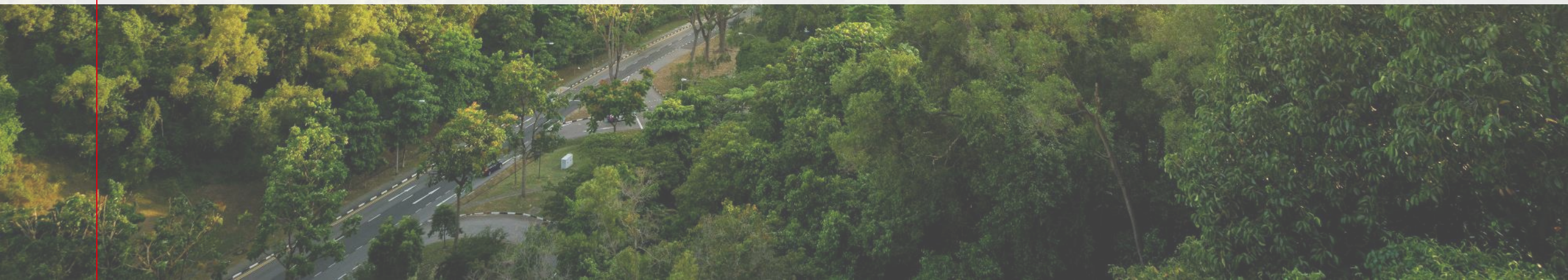
Principle elements of NeoCharge solution

- Traditional superheat measurement
- **Danfoss Heated Sensor**
- **Danfoss Neo Charge controller**
- Control valves (stepper motor or PWM)

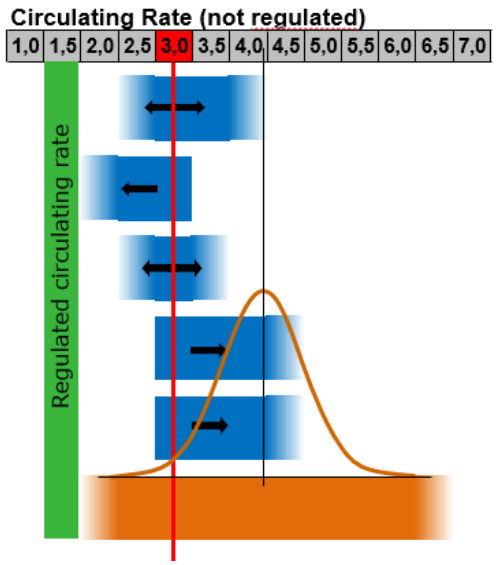
Danfoss NeoCharge feeds each evaporator with the **right charge** required



Recirculated evaporators
(Pump systems)



Uncontrolled Recirculated evaporator feed



1 - Tolerance of adjusted circulating rate.
Higher circulating rates are selected to ensure sufficient capacity

2 - Effect of high load (e.g. hot goods entering the freezing room)

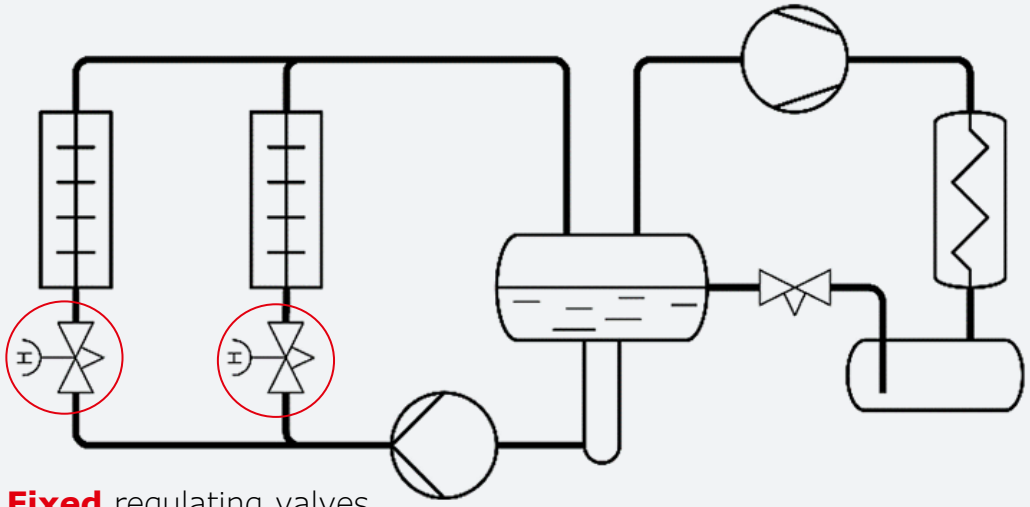
3 - Effect of temperature variation within the temperature band (e.g. ± 1,5°C)

4 - Effect of pressure variation due to parallel evaporators on the same pump are off / defrosted

5 - Effect of capacity reduction due to ice formation on evaporator surface

6 - Estimated accumolated circulation rate variation
Note: VFD not included

Principle **uncontrolled** circulating rate

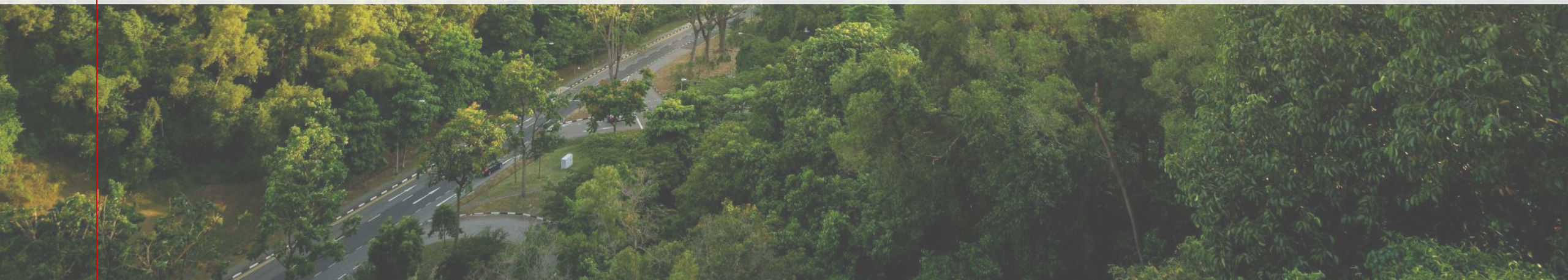


Fixed regulating valves

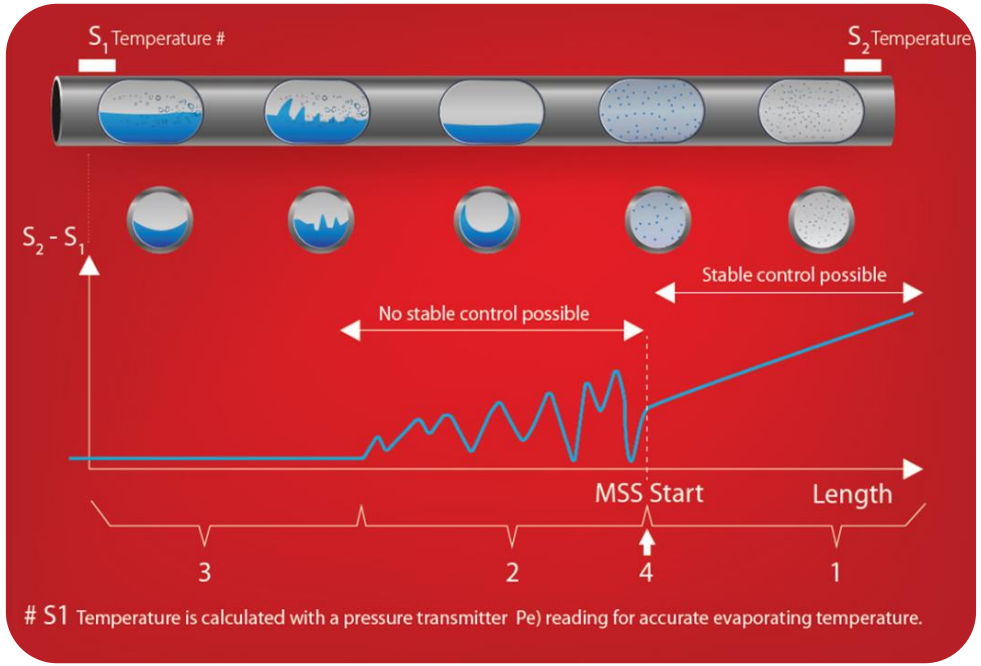
- Pump systems with **uncontrolled circulation rate**, tend to run with **higher circulation rates** as designed
- This will negatively impact the NH3 charge of the system
- This will negatively impact the efficiency of the system

- Fixed regulating valves can't adjust system dynamics
- **Over time**, the circulation rates will **increase up** higher then the design operation

Direct expansion (DX) evaporators

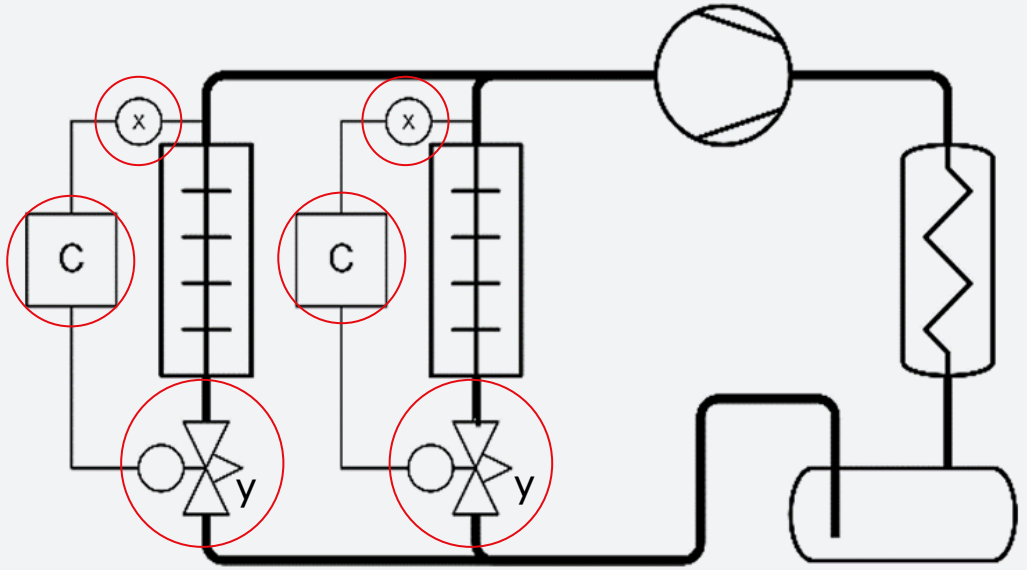


Traditional Danfoss direct expansion evaporator feed



- The minimum stable superheat allows for the system to perform well.
- Superheat however, requires the evaporating temperature to be lower to compensate.
- It results in a ~ 5 to 15% higher energy consumption

Principle **traditional direct expansion control**



x Standard superheat measurement (pressure transmitter + temp. sensor)

c Standard superheat control

y (Electronic) Expansion valves

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