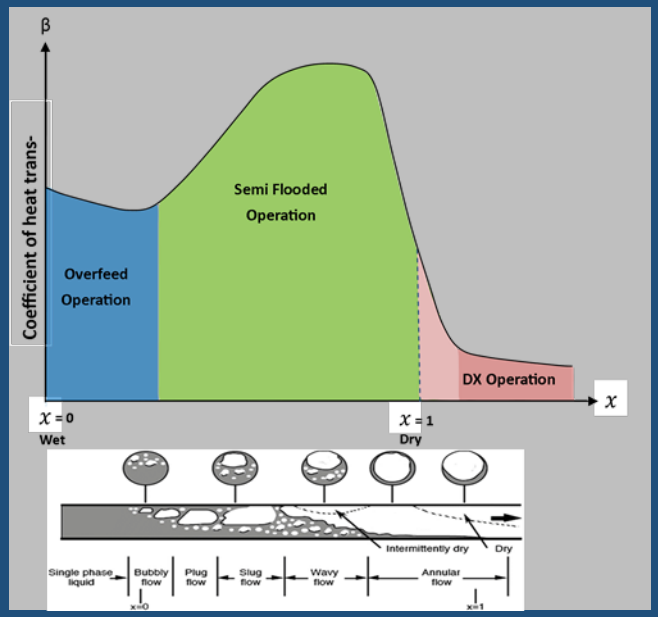
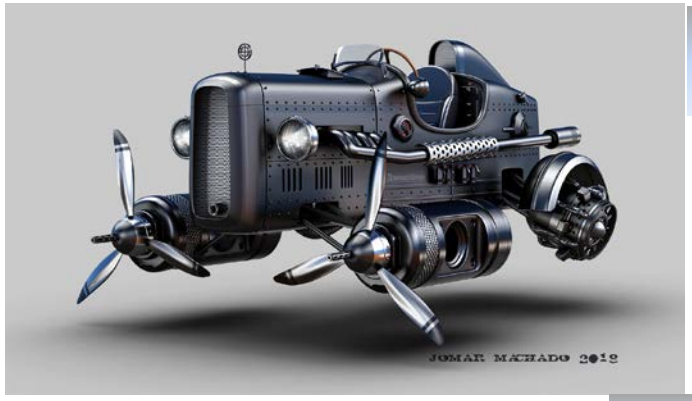
New sensor technologies optimize evaporator performance on both DX, flooded and pump circulation systems.



Michael Elstroem, BTecMan & MarEng.
Technical Manager HB Products A/S

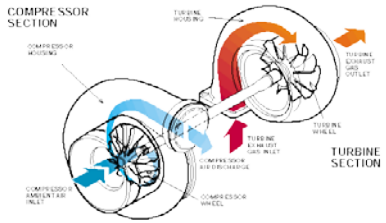
ChillVenta 2018

Aircraft & Automobile technology in comparison with a cooling system shows that we are far behind in using sensors for energy optimization and increased safety.



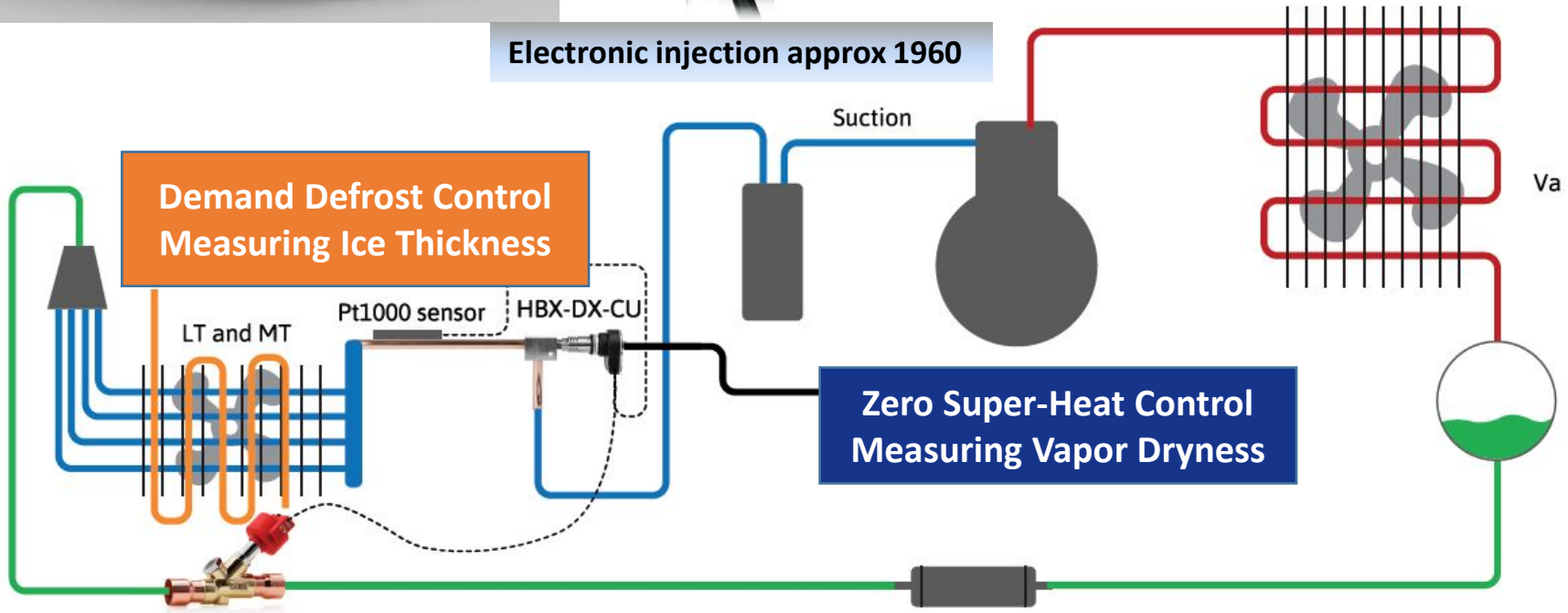
Controlled by air flow and knocking sensors

Controlled by vacum sensors



Turbo chargers approx 1970

Electronic injection approx 1960



HB Products

Introduction

7 years of cooperation with leading pioneers in the design of **Low Charge Ammonia systems** has proved, that the key to the future's evaporator control is now ready to optimize all types of systems with **High Safety** and **Increased System Efficiency**.

- **Measures Vapor Quality (dryness) and phase of the refrigerant**
- **Measuring ice thickness on the evaporator surface**
- **Works as an electronic sight glass**

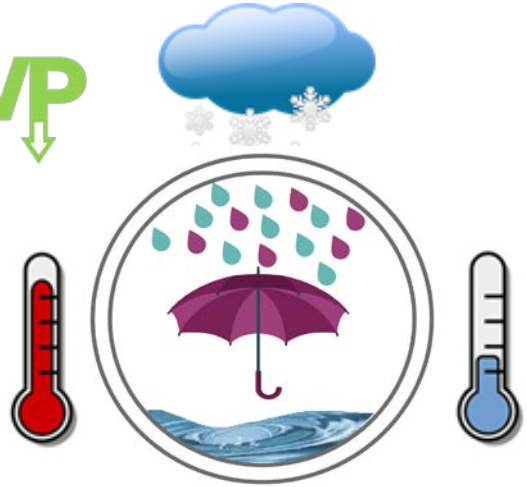
Reference:

Scantec® REFRIGERATION

NXTCOLD™

COLMAC COIL Manufacturing Inc.

GWP



HB Products

Capacitive Sensing Technology

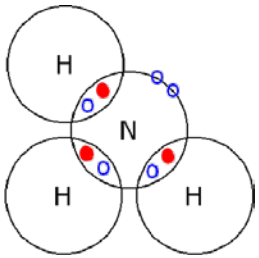
Capacitors are designed with minimum two conducting plates separated by a non-conductive media (Vapor and liquid mixture). Hereby the ratio between vapor and liquid amounts is measured without delay, as a **volume based Void Fraction** measurement.

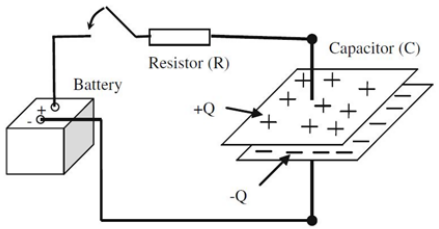
Dielectric constant

Is a unique value on a scale of 1 to 100. The value can be used as a media's DNA, because it`s unique and related to the molecular structure/polarization

Media	ε_r dielectric constant of	
Ammonia	Liquid,	17 to 25
CO2	Liquid,	1.4 to 1.7
Ice	Solid black,	3.2
Air/Vapor	Dry gas,	1.0

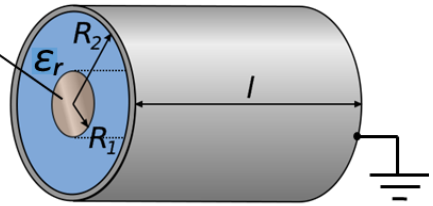
ε_r varies with temperature and pressure





$$C = \frac{q\,\varepsilon_o\,\varepsilon_r}{l}$$

Sensor area



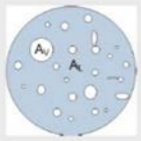
Coaxial sensor design

*Where **C** is the charge stored in Farad*
***q** is the sensing area in m2*
ε_o is the dielectric constant, dry air
ε_r is the dielectric constant, media
***l** is the length of the coaxial sensor*

Void fraction

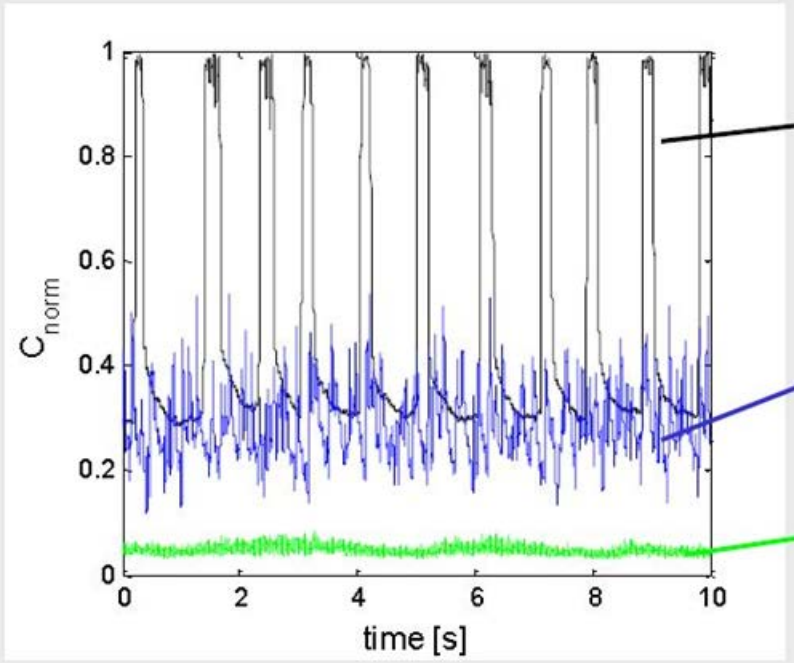
- Ratio of vapour cross section and total cross section

$$\varepsilon = \frac{A_V}{A_V + A_L}$$



HB Products

Flow vs. capacitance



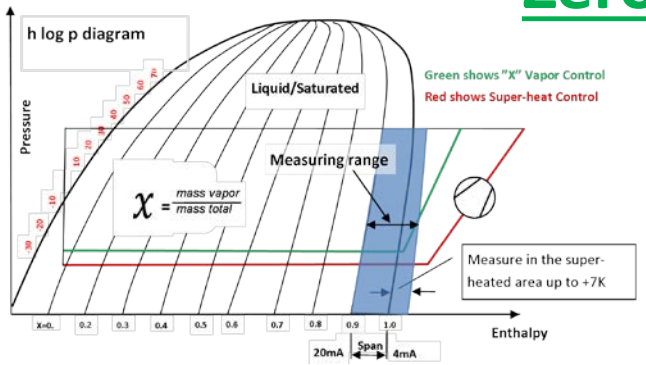
Comparison between flow pattern and the capacitive measurement signal shows a strong relationship.

The figure above shows flow vs. capacitance (C_{norm}) for different flow patterns measured at **Gent University**. For two phase flow, the dielectric constant of both phases, strongly influences the measured capacity. Therefore, the dielectric constants of both phases are derived from actual measurements of the capacitive signal in pF (De Kerpel, 2013).

HB Products

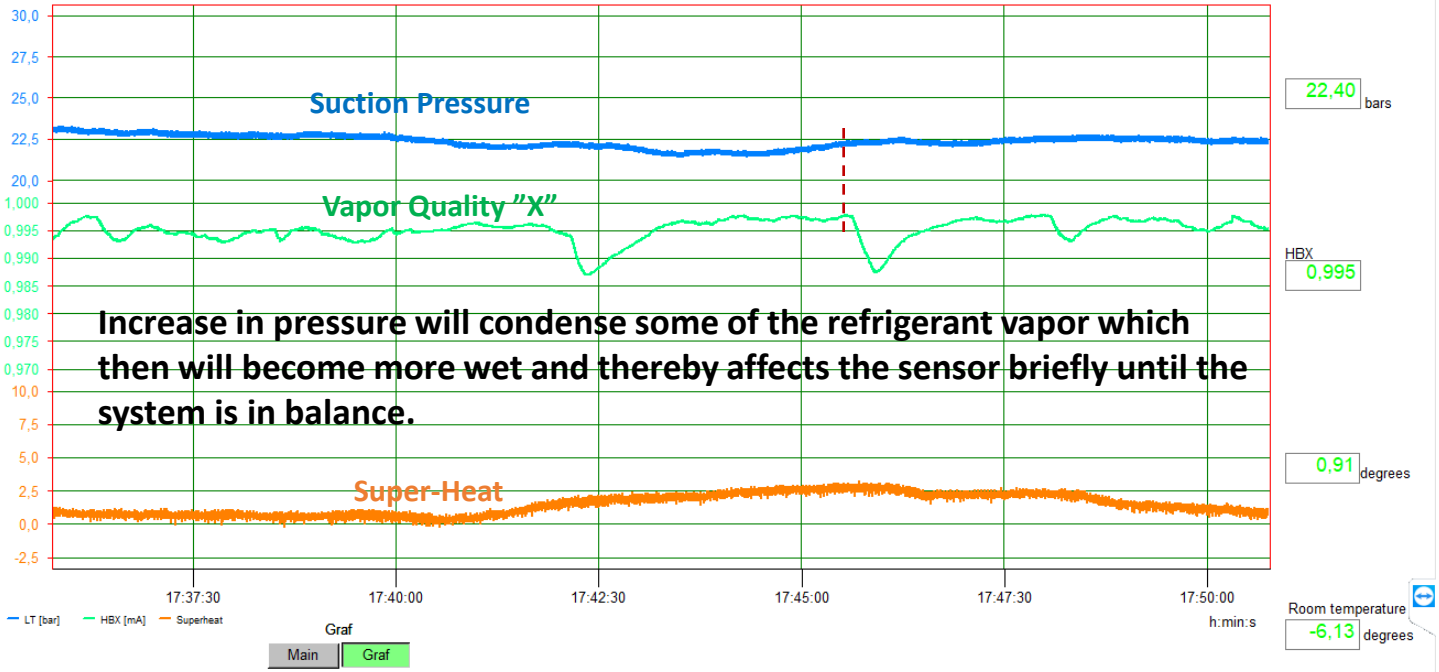
Zero Superheat Control

CO2 READY



Transcritical CO2 system Controlled by Vapor Quality Sensors

HB Products WE INCREASE UPTIME AND EFFICIENCY IN THE REFRIGERATION INDUS

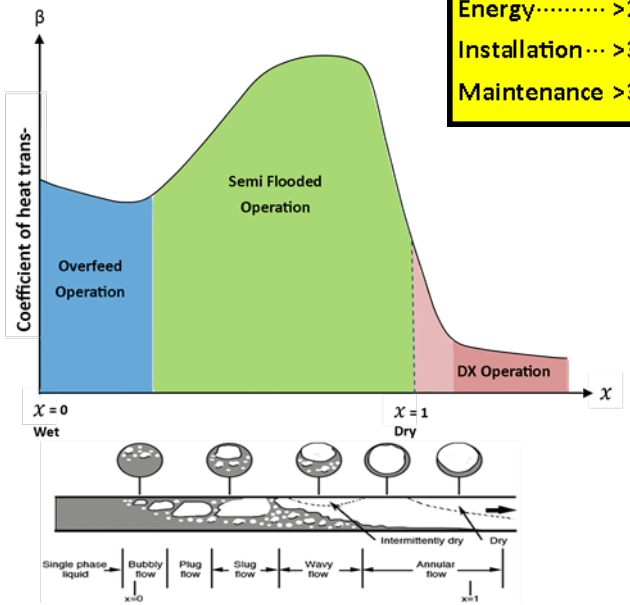


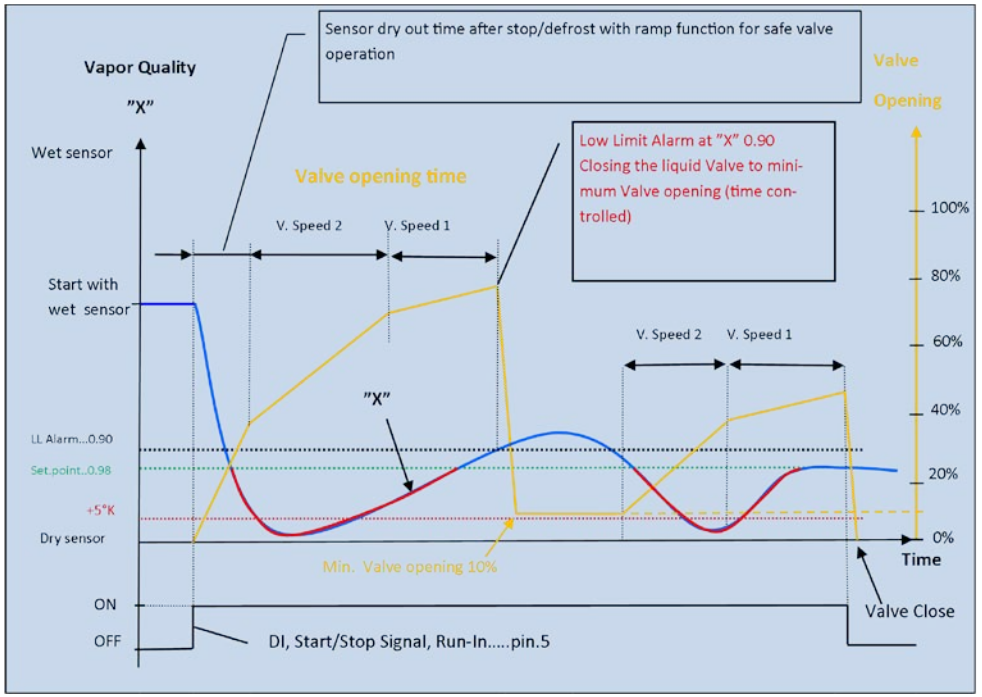
Increase in pressure will condense some of the refrigerant vapor which then will become more wet and thereby affects the sensor briefly until the system is in balance.

HB Products

Zero Superheat Control

Savings:
Energy····· >20%
Installation··· >30%
Maintenance >30%





Semi flooded operation ensures optimal efficiency as the entire evaporator area is wet for enabling the best possible heat transfer.

- **Increased evaporation temperature**
- **Lower discharge temperature**
- **Optimal performance in all climates**
- **Compressor protection**

The sensor has built-in advanced control where it is possible to control all types of evaporators, expansion valve open and closing times, Start-up with ramp function and sensor drying ensure secure startup, low limit safety alarm for fast closing of the liquid valve to minimum opening.

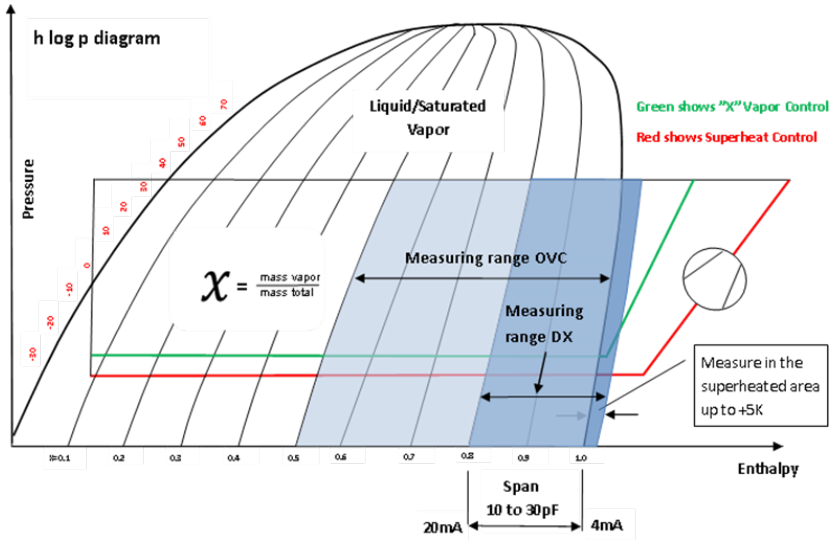
HB Products

DX

Low Charge DX systems

The technology allows design and safe operation of Ultra Low Charge DX System when using Ammonia and CO2 as refrigerant

- **Charge reduction up to 1000 times(NXTCOLD Ultra-Low Charge Ammonia Technology).**
- **Water content is no barrier for the measurement (*1% Water affects the boiling point +5°K (False Super-Heat)).**
- **Zero Super Heat Control.**
- **Increased suction pressure.**
- **Energy Saving up to 25% (wet suction).**

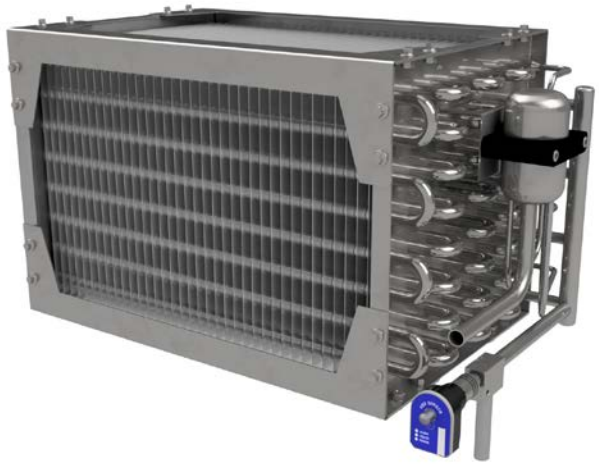


*Reference, Colmac Coil

HB Products

Low Charge Ammonia

The desire to use **the World's most energy-efficient refrigerant Ammonia** in DX-designed refrigeration systems, has led to many challenges and has rightfully earned the reputation of being a poor solution that does not always work well. **Thanks to new sensor technology**, it`s now possible to design an ammonia DX system, even more energy efficient than flooded and pump circulation systems.
Optimal and safe operation at low temperature in combination with **Vapor Quality Control is obtained by using liquid distribution that works by gravity**, designed as small tanks/pots without pressure drop as an **Küba-CAL and Colmac Coil tank distributor system.**



DX Air-cooler with tank distributer

Cold store in Melbourne:

- 60kW: 3 DX evaporators -31°C/-24°F charge: **1.42kg**/3lb per evaporator.
  37kW: 1 DX evaporator -3°C/26.6°F charge **2.5kg**/5lb.
- 58kW: 2 DX evaporators, - 3°C/26.6°F charge **4.4kg**/9lb per evaporator.
  Reference: SCANTEC, Australia

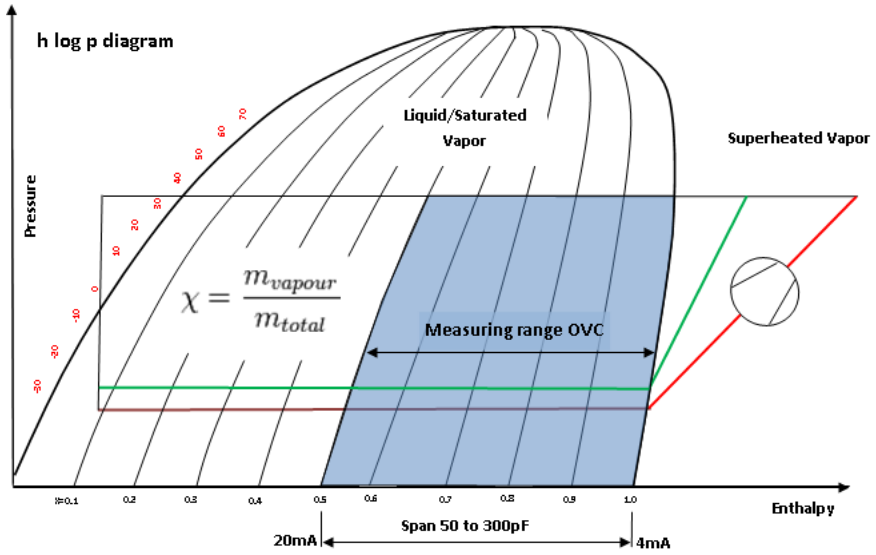
HB Products

OVC

Optimum Vapor Control

By controlling the circulation rate it`s possible to minimize pressure drop in risers and wet suction lines. Test has shown, that the freezing capacity, is not affected by reduce the circulation rate down to CR1.5 (“X” 0.67) on existent systems.

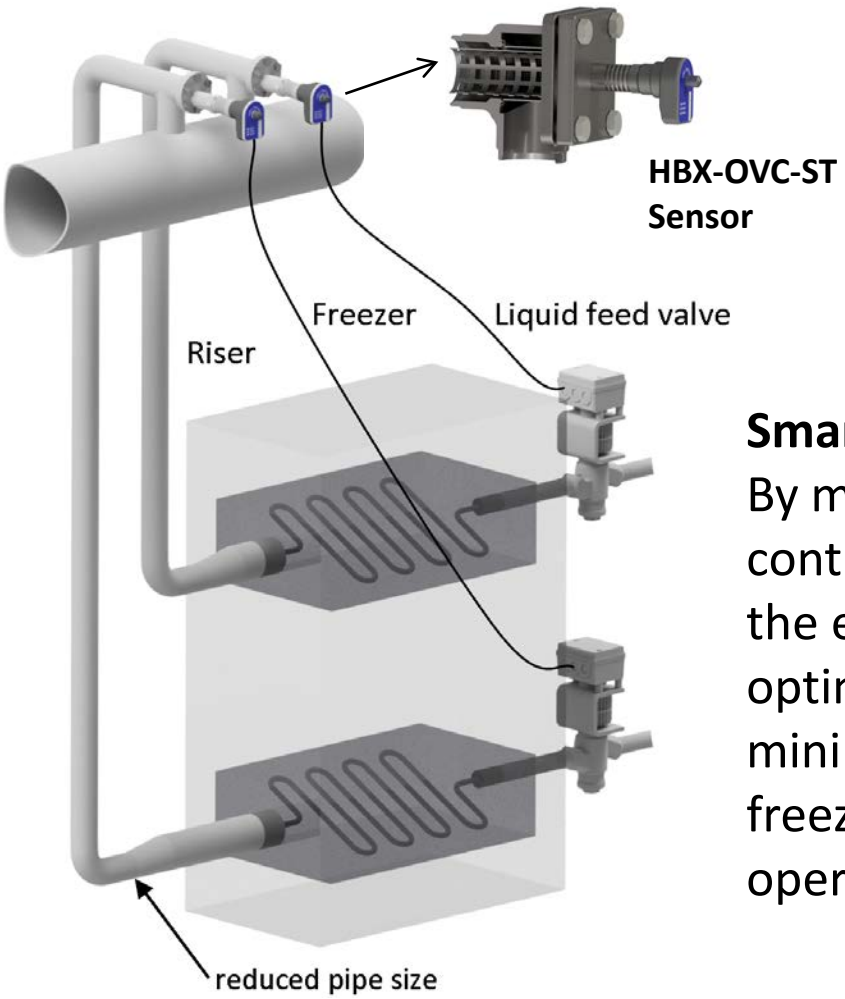
- **Charge Reduction.**
- **Expanding freezing capacity with existent liquid separators.**
- **Enabling optimised Riser Control.**
- **Optimised Freezing Capacity.**
- **Smart Control of Batch Freezers.**
- **Measuring range, “X” 0.5 to 1.0.**
- **Energy Saving up to 25%.**

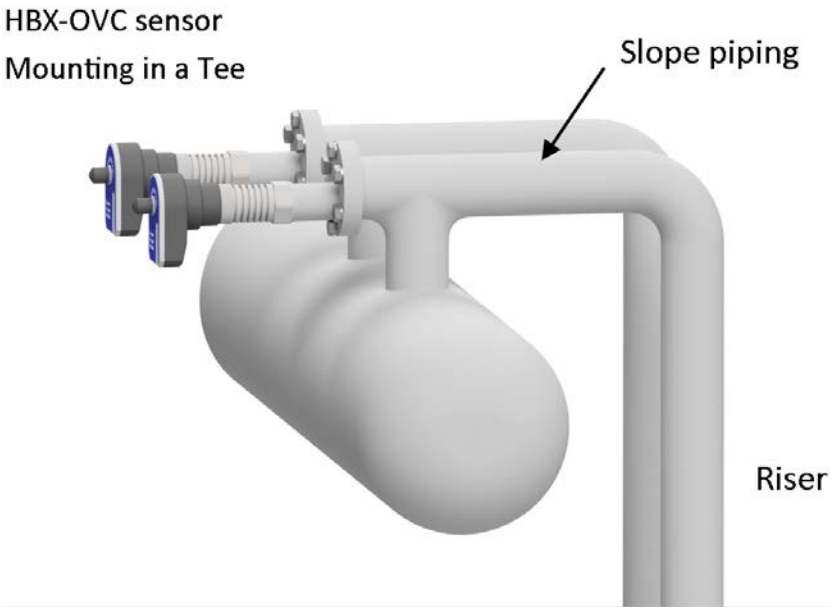


HB Products

OVC

Installation example





Smart Riser Control:

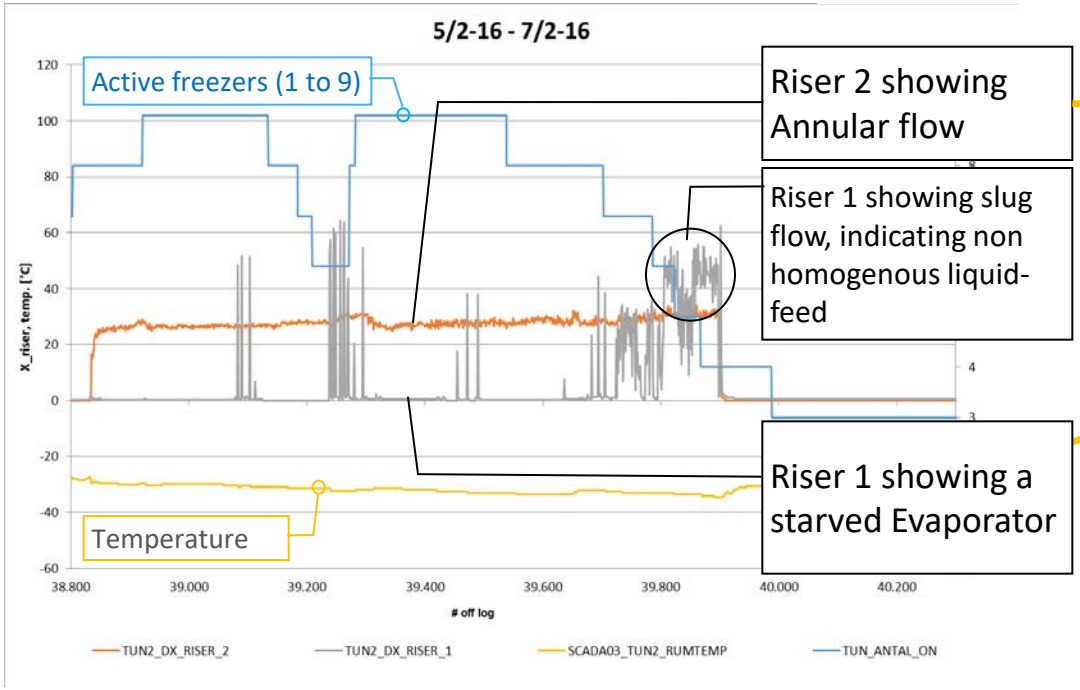
By measuring the **Vapor Quality** and control the refrigerant feed according to the evaporator load, it`s possible to optimize the riser function and ensure minimum pressure drop with optimal freezing capacity during part load operation.

HB Products

Field-test at Claus Sørensen A/S:

- Pump circulation.
- Clear reflections of flow patterns in measurements.
- Alignment between measured flow and pipe-icing.

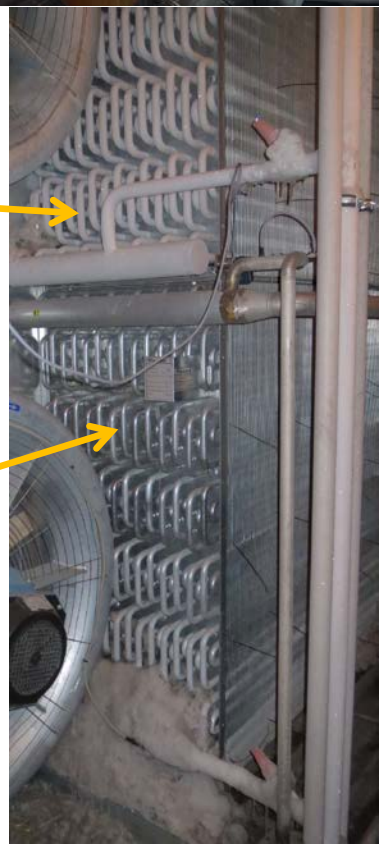
Four HBX-OVC Sensors mounted on the top of an 8m riser-pipe



Riser 2 showing Annular flow

Riser 1 showing slug flow, indicating non homogenous liquid-feed

Riser 1 showing a starved Evaporator

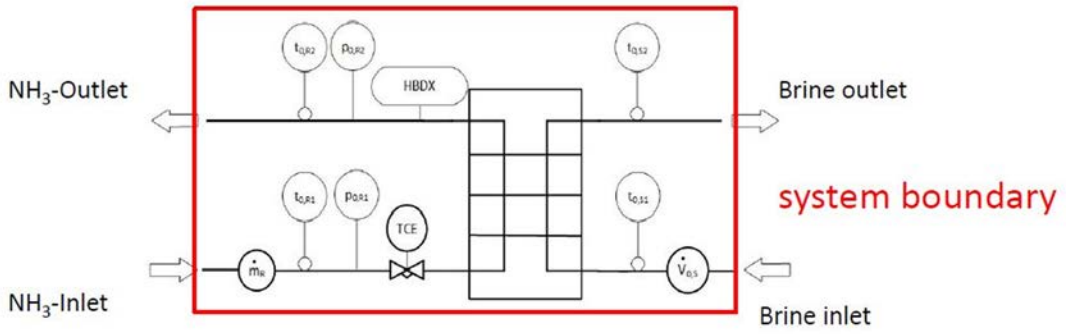


The riser-test is performed by Danish Technological Institute

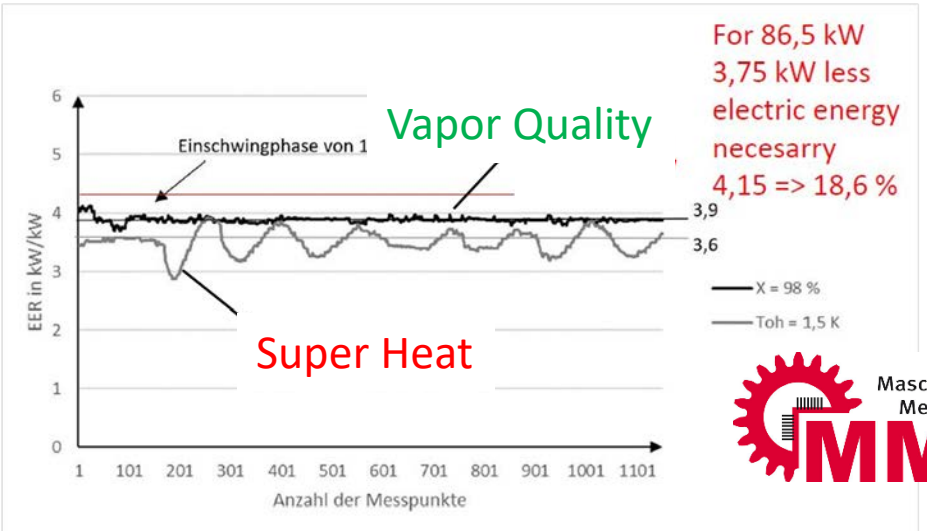
HB Products

Validation by Oliver Kacic

Ammonia heat-pump, 100kW: Test of the HB-Products **Vapor Quality Sensor** as well as an efficiency analysis of a direct-expansion R717 refrigeration system with gas quality sensor in **comparison to superheat control.**



Energy Efficiency Ratio:
At 14°C evaporation temperature, control variables of X = 98 % and Toh = 1,5 K, load 100%. For maximum cooling load there was an EER increase of 18,6% possible (EER = Energy efficiency Ratio).



Conclusion: It is a great advantage to apply the **Vapor Quality principle** for controlling plate heat exchangers. Both DX and flooded systems can be controlled very accurately with homogeneous vapor quality and very small pressure variations as a consequence.

Bachelor thesis by Oliver Kacic, Karlsruhe University

HB Products

Transavia in Romania, the leader in poultry industry

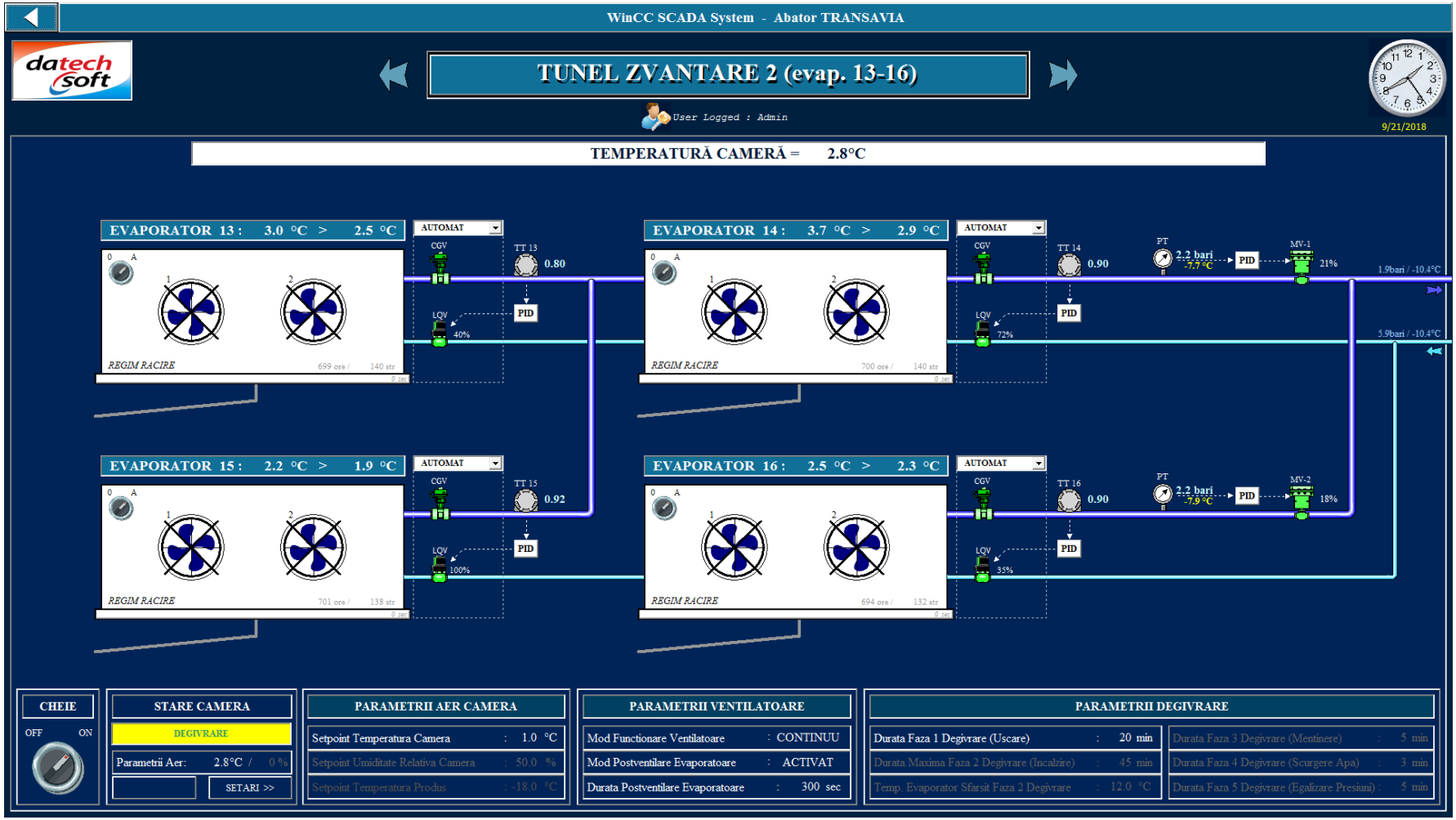
Installing new chilling line and converted existing cooling and freezing tunnels in order to minimize the pressure drop in the wet suction lines, and lower the refrigerant charge by using HBX-OVC Vapor Quality sensors in the evaporator outlet.

AB Tehnic Profesional
Vă ajutăm să reduceți costurile și să faceți economii

- **18 pcs evaporators 50kW (-10C), for the new chilling line is used Cabero Heat Exchangers Type IEHSA 10 E 2/91.ECZ-2600A-A-X, circulation rate 1.1**
- **12 pcs evaporators 79,1kW (-40C), 8 pcs evaporators 70kW (-10C)**
- **The system is designet by AB Tehnic , Adrian Balaoi.**

HB Products

Transavia in Romania, the leader in poultry industry

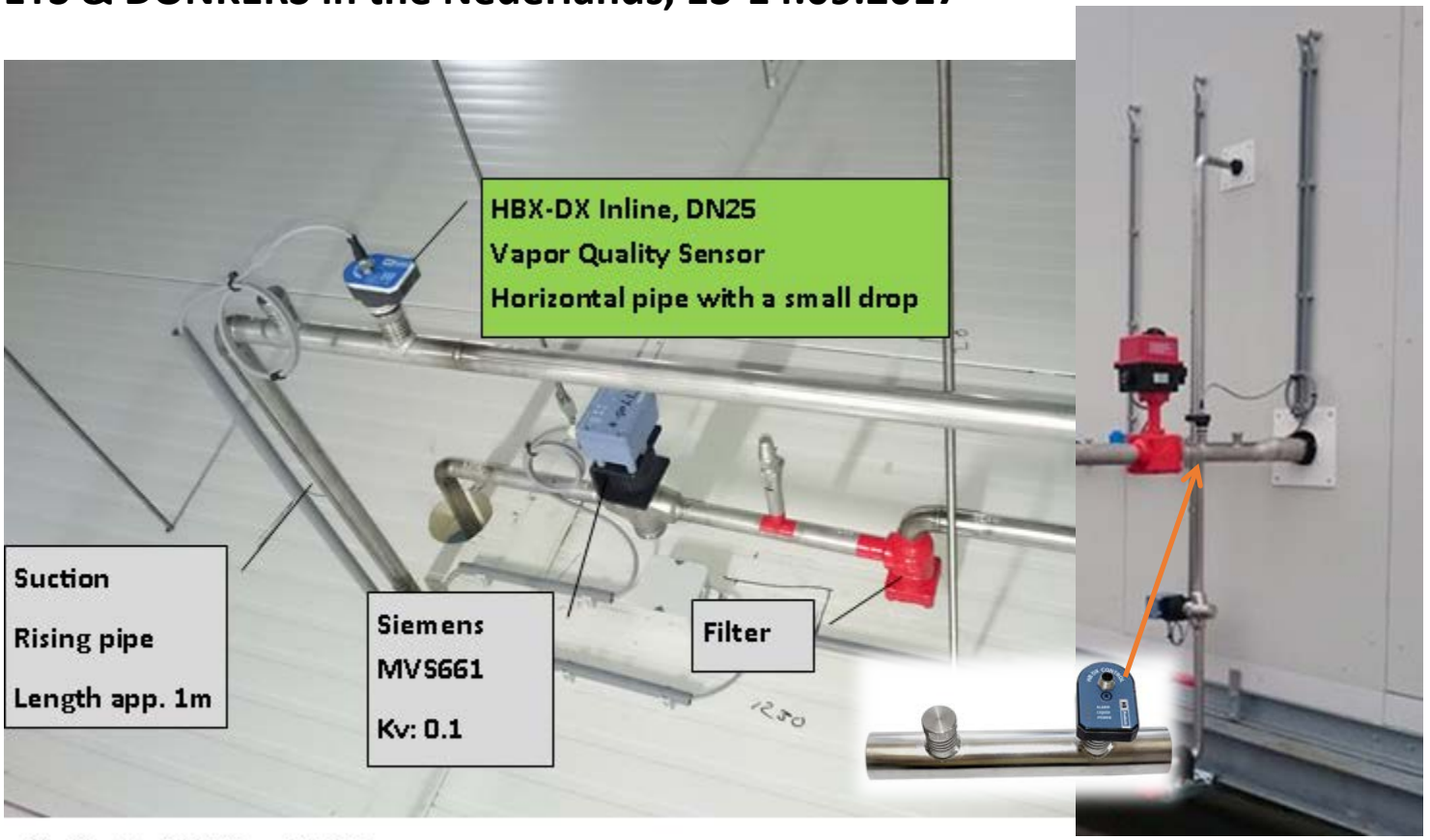


The type of liquid control valves are Danfoss AKVA, pulse modulating, Ammonia pump pressure 3bar

Settings of the desired dryness is set to "X" 0.9, (CR1.1).
Observations showed that there was a good correlation between the evaporator performance and the dryness of the refrigerant/vapor in the outlet of the evaporator.

HB Products

Low Charge Ammonia system designed by the Air-Handling specialist VOETS & DONKERS in the Nederlands, 13-14.09.2017



Air-Cooler 38KW no. 05-11

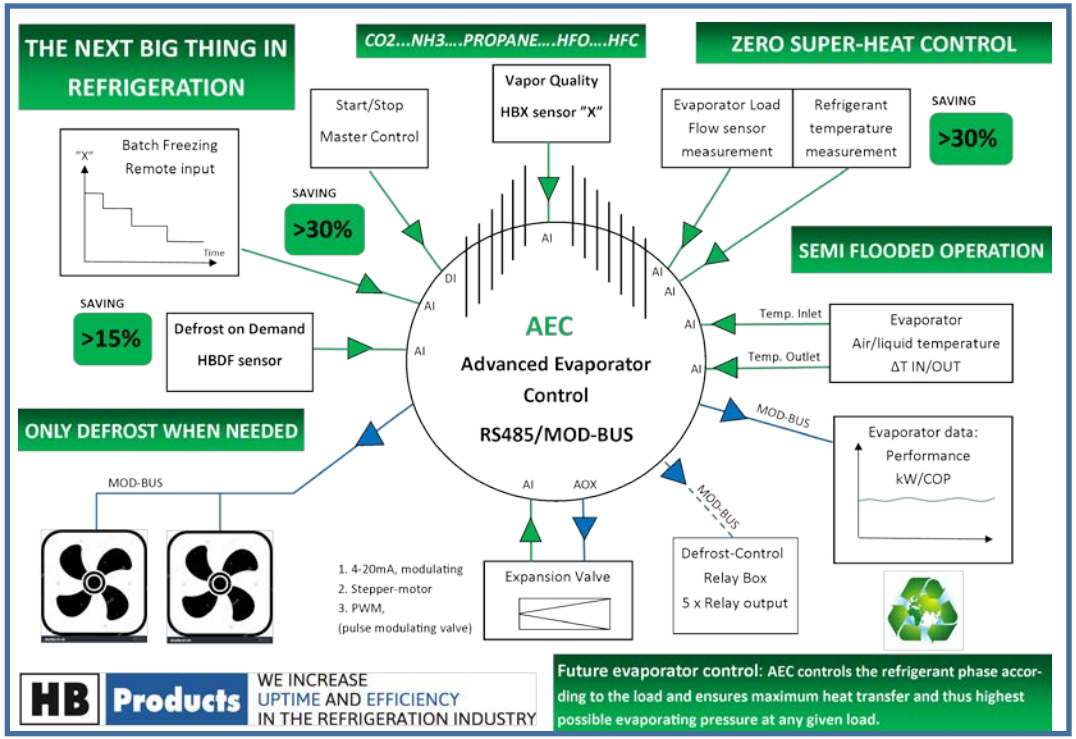
System Capasity	500KW
Evaporator Control	DX, HBX-DX Vapor Quality Sensors
Charge of Ammonia	400Kg
Operation data	-2/+30grd.C

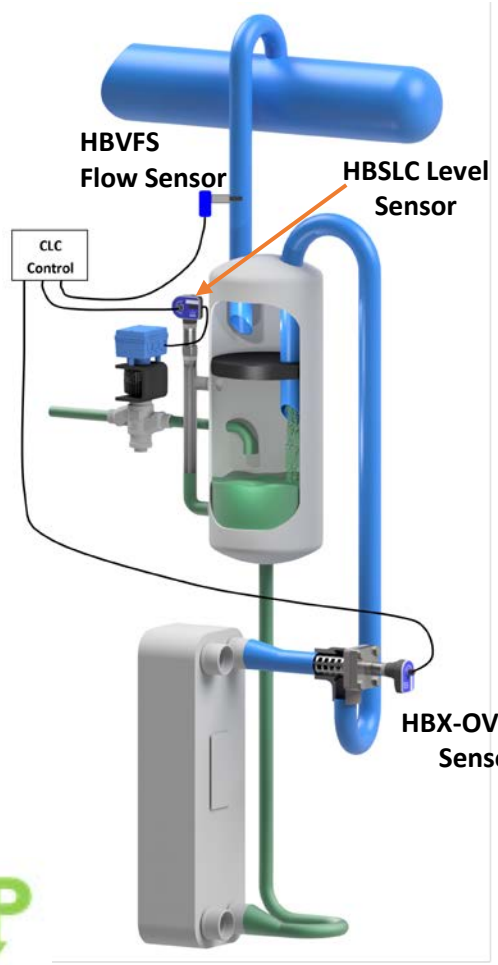
There was a good relation to the Super-Heat in the range 0.5 to 2˚K.

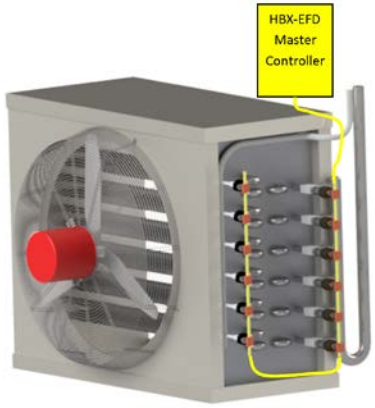
HB Products

INOVATION

Future cooling systems can be optimized by using sensors for controlling and monitoring of many processes in a new smart way

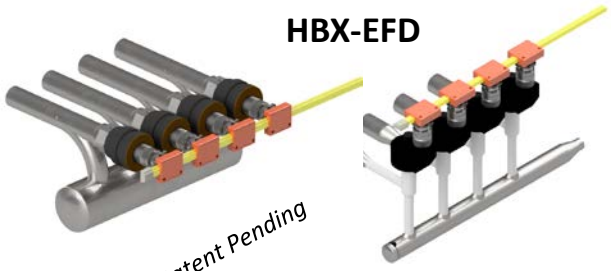






Distribute the refrigerant evenly at all loads depending on dryness of the vapor

HBX-EFD



Patent Pending

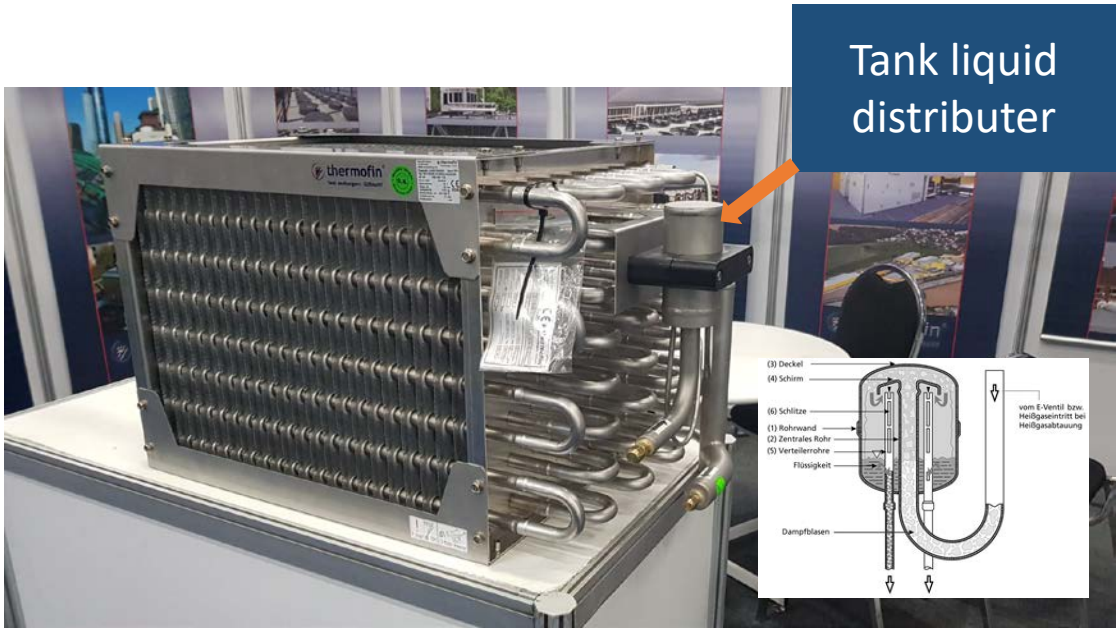
GWP

HB Products

Facts & Summery

600 HBX sensors is sold and installed World Wide, **It`s extremely robust** with molded-In electronic and built-in heating element to avoid stress and condensation.
The setting is simple and can be delivered as a plug and play unit.

- Allows design of safe Ammonia & CO2 DX system, with zero superheat control.
- Semi Flooded evaporator operation ensures optimum heat transfer at all loads.
- By controlling the circulation rate it`s possible to minimize pressure drop in risers and wet suction lines.
- **Energy saving > 20% - Lower discharge temperature – Optimal performance in all climates.**
- **Lower installation cost – Compressor protection – Closed loop evaporator control.**

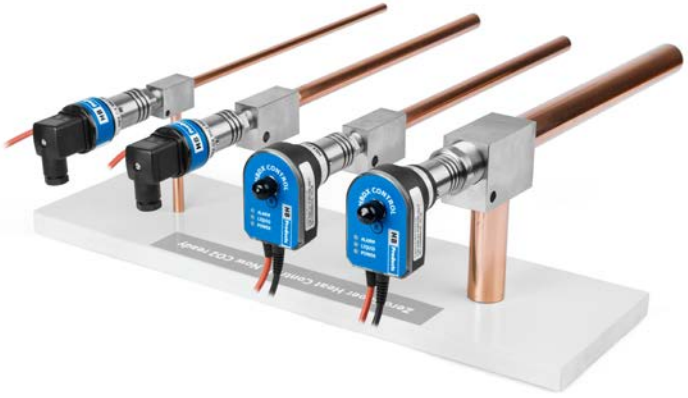


Our recommendation for optimal and safe operation in combination with Vapor Quality Control for low temperature NH3 DX evaporators is to use liquid distribution works by gravity, designed as small tanks/pots without pressure drop as Küba CAL and Colmac Coil tank distributor.

HB Products

And now, questions please

7 years with NH3 and 1 year with CO2



A statement from the world's leading Low Charge Ammonia company Scantec in Australia:
Using electronically controlled refrigerant injection based on refrigerant Vapor Quality at evaporator exit for optimized evaporator performances:
Positive superheat for 0.95 < X < 0.99
X (Quality based) control more stable than superheat based
Holding freezer temperature at -22°C for -27.9°C SST

A statement from the world's leading heat exchanger company Alfa Laval:
"To obtain optimum heat transfer adopt a Vapor Quality Sensor in the outlet."
Optimum circulations rate (flooded) "X" 0.7 to 0.85……CR 1.2 to 1.4

HB Products


HB Products
WE INCREASE UPTIME, SAFETY AND EFFICIENCY
There is no planet B
think green and save the Earth
USE
• HB sensor solutions to optimize the efficiency
• Natural refrigerants

HB Products

HB Products

CHILLVENTA

HB presentation program

Hall 5, Stand 5-120

www.hbproducts.dk

Time	Day 1 Tuesday October 16 2018	Program, Day 2 Wednesday October 17 2018	Program, Day 3 Thursday October 18 2018
10.30	**HB Products** *Claus Munkholm* Title: "Defrost on demand, HBDF How to optimize defrosting cycles and intervals and obtain big savings 	**HB Products** *Martin Mozart* Title: Advanced Evaporator Control, MOD-BUS with HBX & HBDF sensors 	**Scantec Refigeration** Technologies PTY LTD *Stefan Jensen* Title: "High Performance Energy with Low Charge NH_3 Systems" 
11.30	**HB Products** *Michael Elstrøm* Title: New sensor technology optimizes evaporator performance especially during part load on both DX, flooded and pump circulation systems. 	**EKA**, specialized in CO_2 technology *Jörgen Rogstam* Title: Practical aspects of low superheat control and experimental test of a CO_2 Systems. 	**Hochschule Karlsruhe** *Oliver Kacic* Title: Bachelor thesis, efficiency analysis of a DX R717 refrigeration system with Vapor Quality Sensor in comparison to Superheat control. 
13.30	**HB Products** *Martin Mozart* Title: Advanced Evaporator Control, MOD-BUS with HBX & HBDF sensors 	**HB Products** *Michael Elstrøm* Title: New sensor technology optimizes evaporator performance especially during part load on both DX, flooded and pump circulation systems. 	**Hochschule Karlsruhe** *Oliver Kacic* Title: Bachelor thesis, efficiency analysis of a DX R717 refrigeration system with Vapor Quality Sensor in comparison to Superheat control. 
15.00	**Scantec Refigeration** Technologies PTY LTD *Stefan Jensen* Title: "High Performance Energy with Low Charge NH_3 Systems" 	**HB Products** *Claus Munkholm* Title: "Defrost on demand, HBDF How to optimize defrosting cycles and intervals and obtain big savings 	**HB Products** *Michael Elstrøm* Title: New sensor technology optimizes evaporator performance especially during part load on both DX, flooded and pump circulation systems. 

This program may be subject to change

HB Products