



Designing CO₂-Systems

- Danfoss System Solution for CO₂ based Refrigeration

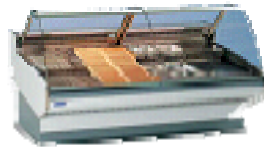


Jens Christian Callesen
Business Development Manager
CO₂ Applications
Danfoss Food Retail

Refrigeration and Air Conditioning



Segment	Household Compressors	Food / Retail Commercial	Industrial Refrigeration	PRS Process Refrigeration Systems
Refrigerant	<p>CO₂ Transcritical</p> <p>Hydro Carbons</p> <p>CFC - HCFC - HFC</p>	<p>CO₂ sub critical</p> <p>Ammonia</p>	<p>CO₂ sub critical</p> <p>Ammonia</p>	<p>Hydro Carbons</p>
System size	Small	Medium	Large	Large





CO2 Applikationen

Food Retail

Sub critical CO2 applications

Valves, Controls, Driers and Safety equipment



Industrial

Sub critical CO2 applications

Valves, Controls, Driers and Safety equipment



Food Retail

Transcritical CO2 applications

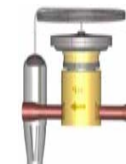
Controls



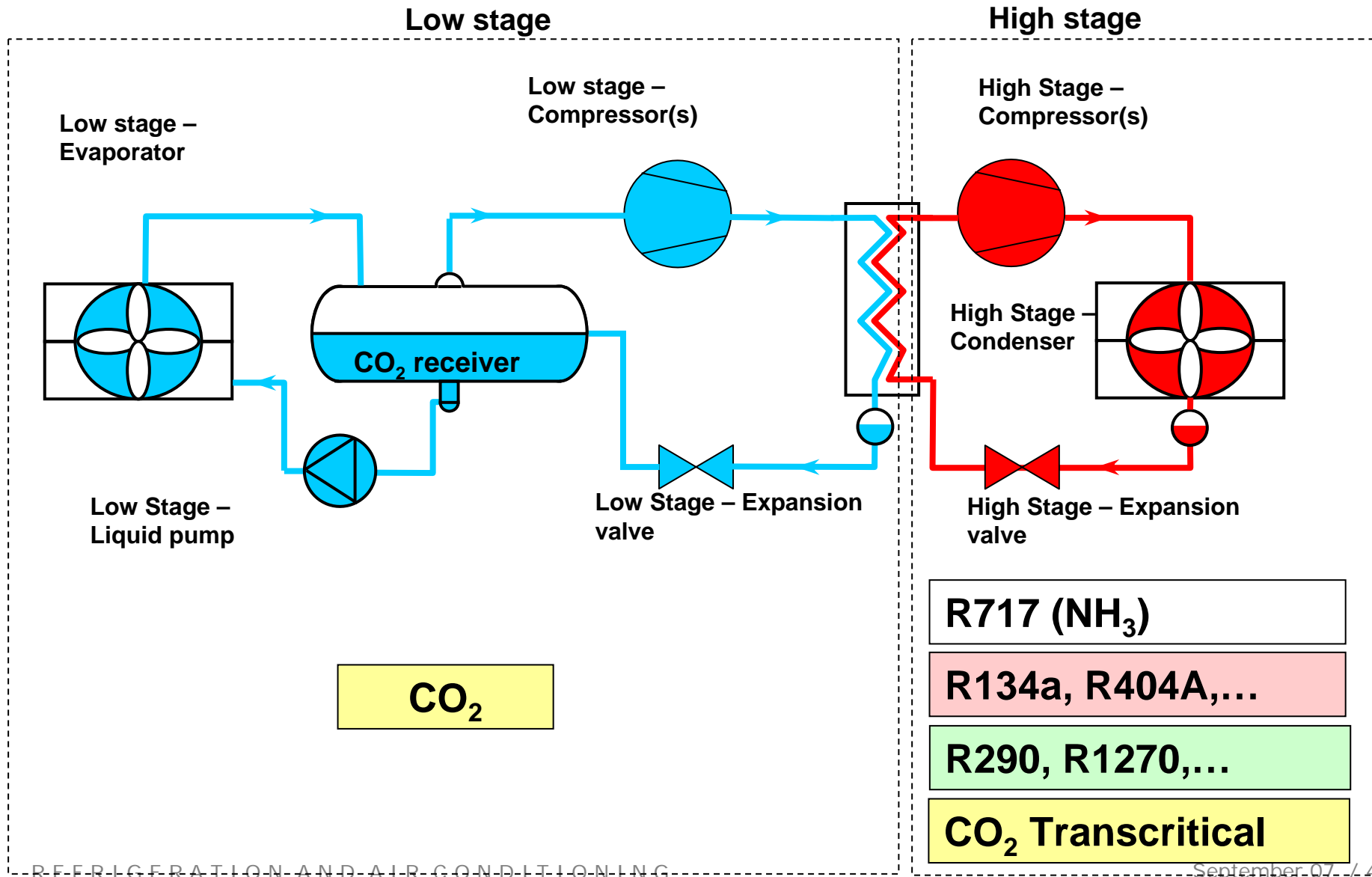
Heat Pumps & Bottle Coolers

Transcritical CO2 applications

Compressors, controls and complete cooling cassettes



CO₂ systems (Food & Retail and Industrial)



High pressure components - CO₂

Danfoss Sub Critical CO ₂ - components		PS 35 bar [508 psi]	PS 42bar [609 psi]	PS 46 bar [667 psi]
"Commercial" product line				
Solenoid Valves	EVR 2, EVR 3			+
	EVRH 6 - EVRH 15			+
Shutoff Valves (Ball Valves)	GBC		(45 bar)	+
Check Valves	NRVH			+
Electrically operated expansion valve	AKV 10 - AKV 15		+	-
Filter drier	DCRH			+
	DCR	+	-	-
	DML		+	-
Moisture indicator	SGN	+	-	-
Pressure controls	KP6		+	-
Pressure transmitters	AKS 3000			+
Controllers for CO₂-applications				
Case controllers:	AKC 114A, AKC 115A, AKC 116A EKC 414A, EKC 414A1 AK2 CC 303			
Evaporator controller	EKC 315A			
Pack controller	EKC 331T, EKC 531D1, AK2 PC 311			



The product can be used in standard version. All products are CE approved



High pressure components - CO₂

"Industrial" product line					PS 40bar [580 psi]	PS 52 bar [754 psi]
			DN			
Main Valves, Solenoid Valves	ICS 1 ICS 3	all	20-65			+
Motor Valves	ICM	all	20-65			+
Multifunction valve	ICF	all	20-40			+
Pilots for ICS Valves	CVP (XP)					#
	EVM			+		#
Stop Valves - SVA ST,LT,HS	SVA	10-65	10-65	+		#
Regulating Valves - REG	REG	all	15 - 65	+		#
Stop Check Valves SCA	SCA	15-65	15-65	+		#
Filters FIA	FIA	15-65	15-65	+		#
Check Valves	CHV	all	15- 40	+		#
Solenoid Valves	EVRS	all	10-25	+		#
	EVRA	all	10-40	+		
Electrically operated expansion valve	AKVA	all	10-40	+		
Safety Valves and Change Over Valves	SFA	15	-	+		
SFV - DSV	DSV	1, 2	20-32	+		
	POV	40, 50, 80	40-80	+		
Filter drier	DCRH	High pressure version		46 bar		#
Liquid level transmitter	AKS 41	-	-			+
Gas detectors	GD					



The product can be used in standard version. All products are CE approved



The product must be manufactured in a special version (higher test pressure, marking and documentation). All products are CE approved



Code no. for these products are description in this application guide

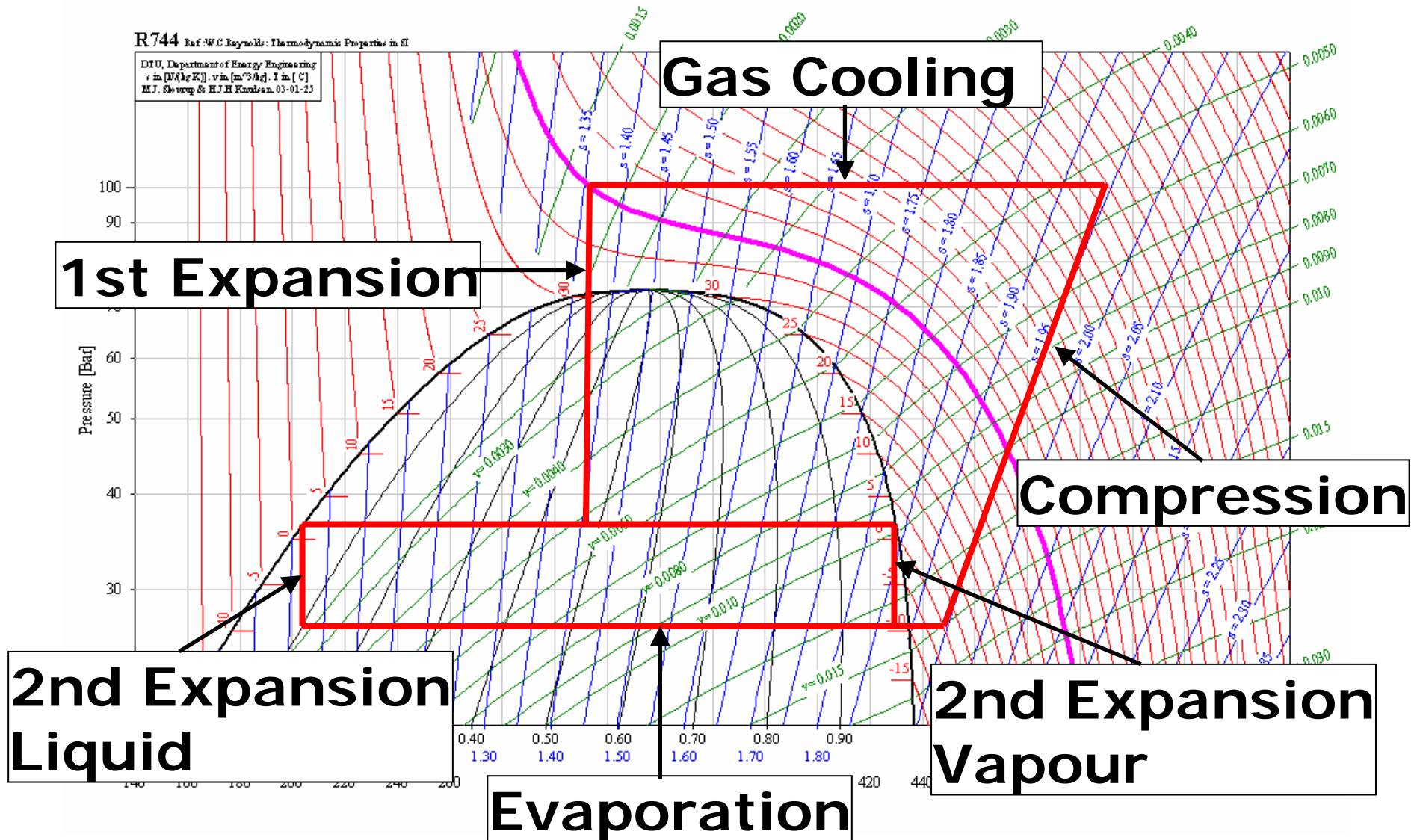


EU "LIFE" Project

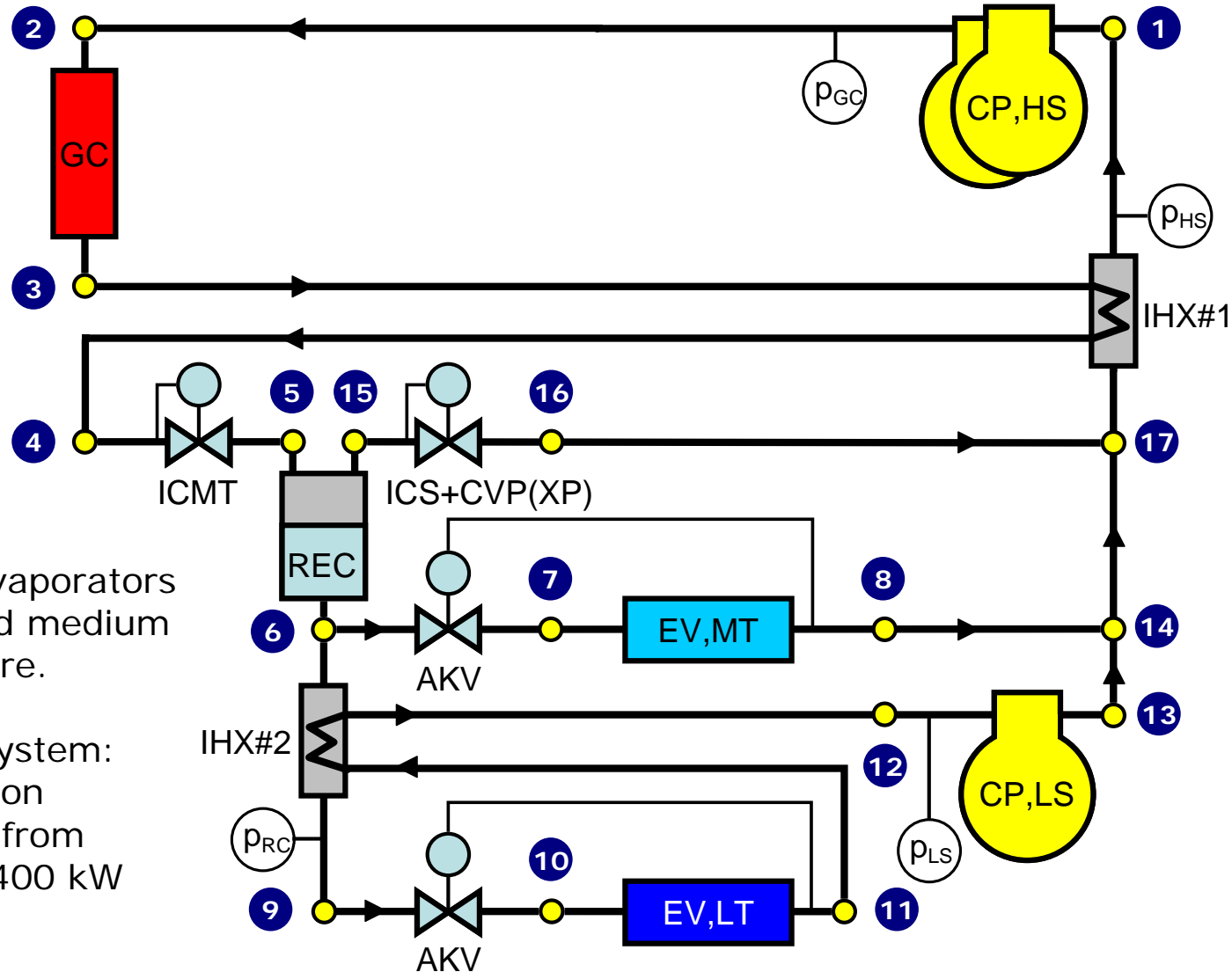
- Objective:
Develop a refrigeration system only using CO₂ as refrigerant.
- Project:
EU-financed Project (EU-Life Environment programme) with 5 Participants.
 - Knudsen Køling , Alu Heat Exchanger, Bock , Danfoss, REMA1000, Danish Technological Institute
- Duration:
October 2005 to October 2007



Trans Critical Cycle with double expansion



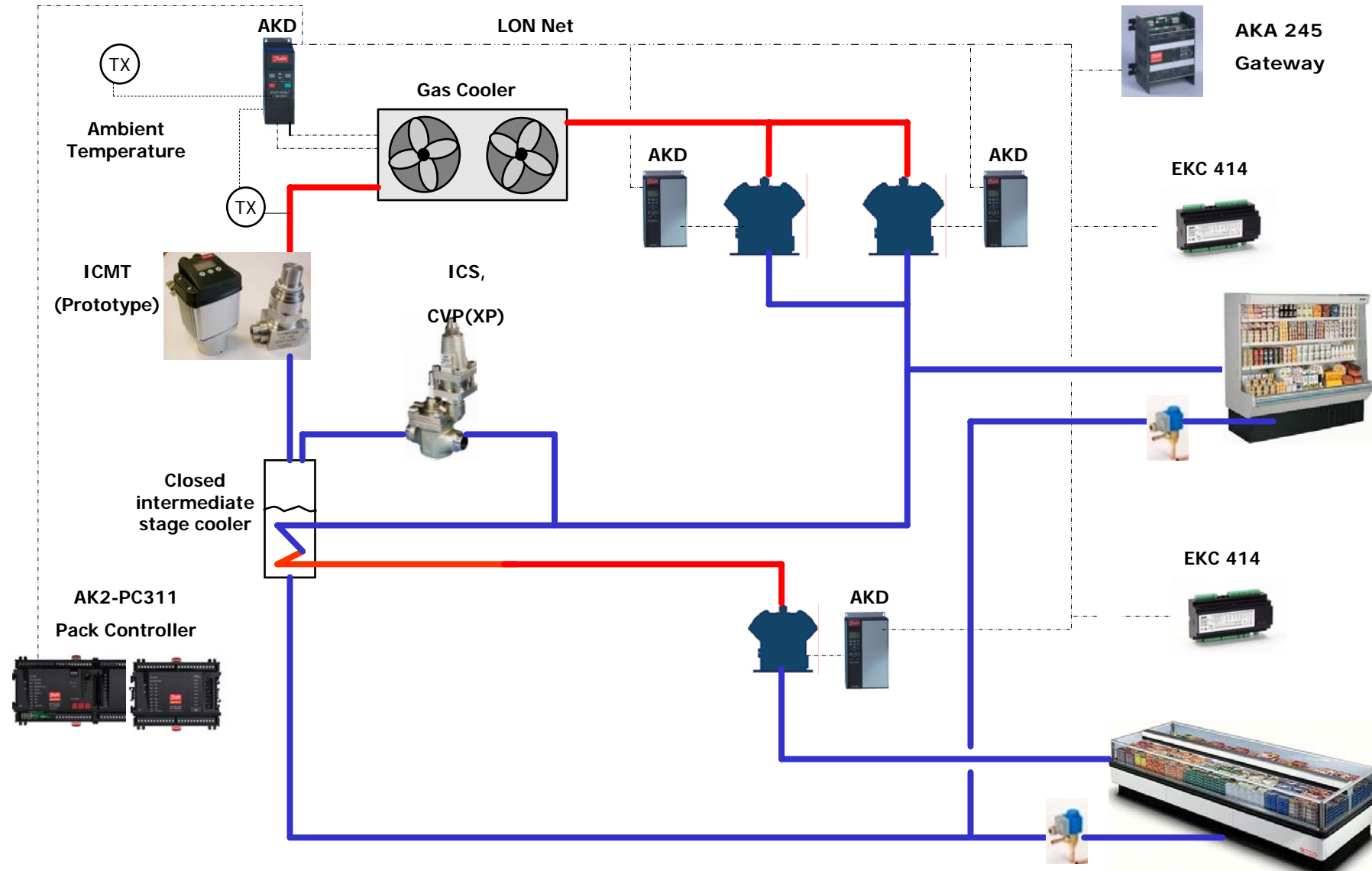
System layout (preliminary)



Multiple evaporators for low and medium temperature.

Scalable system: Refrigeration capacities from 20 kW to 400 kW

Trans-Critical CO₂ Booster Plant



REFRIGERATION AND AIR CONDITIONING

FOOD RETAIL

REMA 1000 in Esbjerg (started 01-03-2007)



Refrigerating capacities

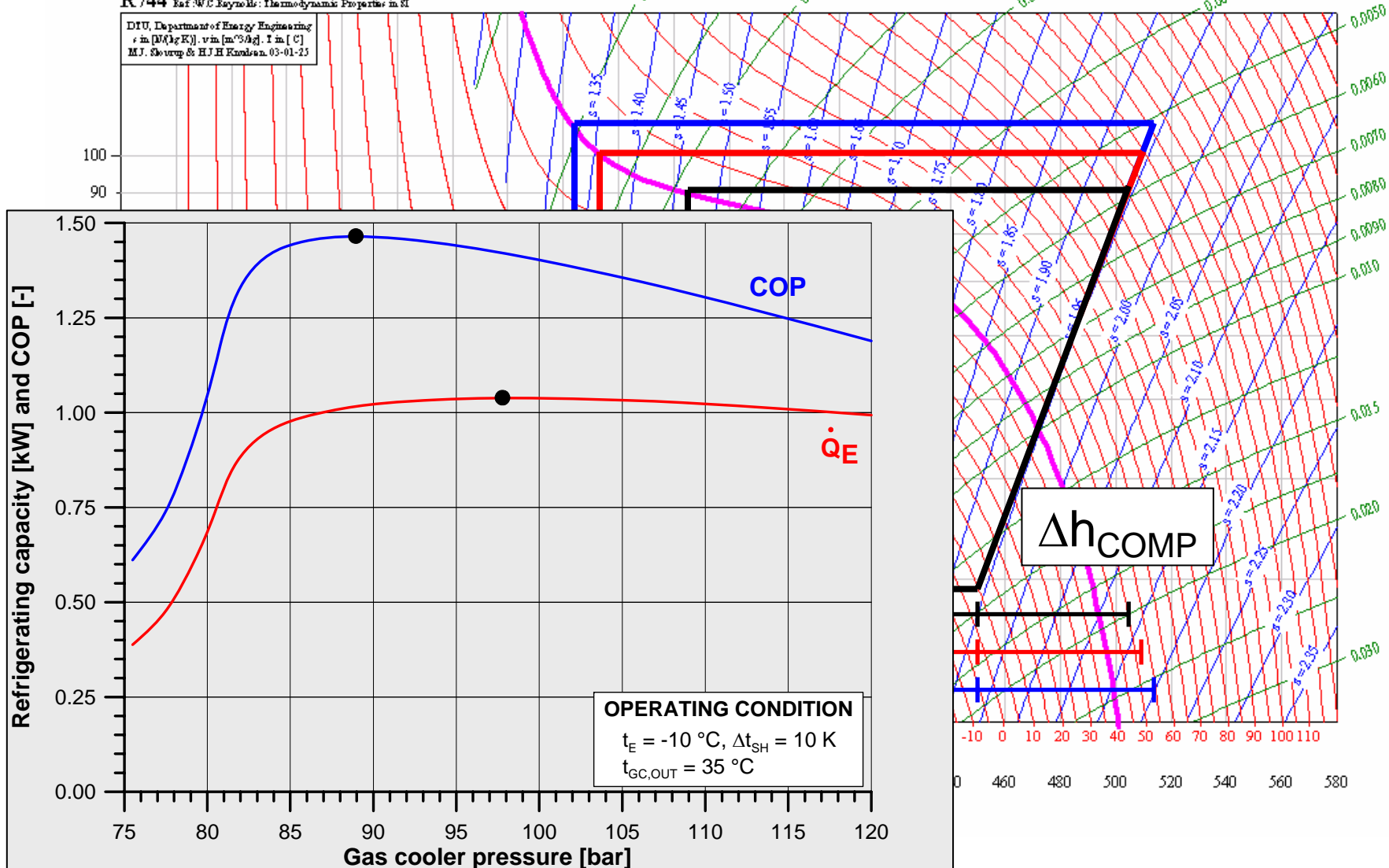
- Medium temperature: 20 kW
- Low temperature: 8 kW



Optimal High Pressure

R744 Ref: W.C. Reynolds: Thermodynamic Properties in SI

DTU, Department of Energy Engineering
 ρ in [kg/m³], v in [m³/kg], T in [°C]
 M.J. Skovrup & H.J.H. Knudsen, 03-01-23



Control of gas cooler pressure



- Danfoss components
 - ICMT main valve (prototype)
 - ICAD actuator
 - EKC controller (prototype)
 - MBS pressure transducer(s)
 - AKS temperature sensor
- Purpose
 - Control pressure in gas cooler according to system optimum relation with gas cooler exit temperature

Prototype ICMT Gas Valve with Controller for Trans Critical CO2



- Optimum pressure compared to gascooler temperature.
- Automatic change-over to sub-critical operation when possible

New concept valve for Trans-critical CO₂ applications

Function:

- Pressure control
- Expansion
- ON / OFF

Maximum working pressure: PS 140 bar

Capacity: Kv 0,6 – 2,4 and 4,6 [m³/h]

Hermetic sealed coupling

Pipe connection:

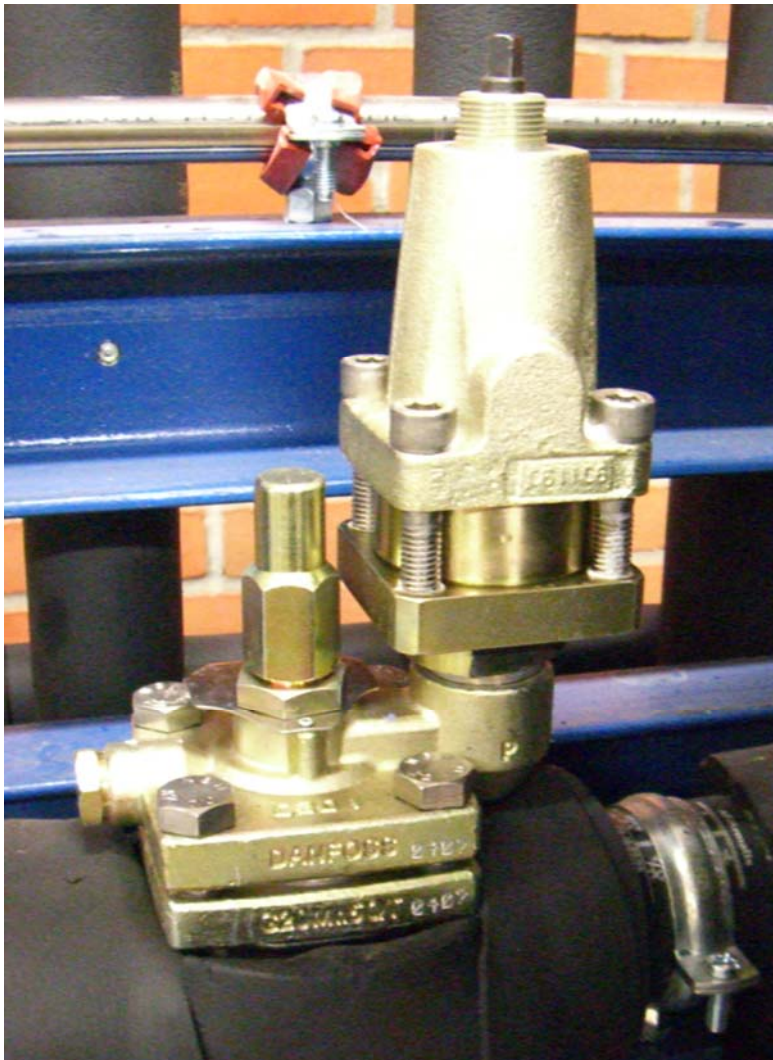
DN 25/ ø33,7 mm (new versions)

Control etc.: See standard ICAD info

Description	Code No
ICMT 20-A, Kv = 0,6:	027H1067
ICMT 20-B, Kv = 2,4:	027H1068
ICMT 20-C, Kv = 4,6:	027H1069
ICAD 600S Actuator :	027H1204
ICMT 20 Manuel opening device	027H0183



Control of receiver pressure



- Danfoss components
 - ICS main valve
 - CVP(XP) pilot valve
- Purpose
 - By-pass of flash-gas from expansion in ICMT while keeping receiver pressure constant

Average Yearly COP, NT

- Based on Yearly temperature profile for Denmark

t_e	CO2	R404	R134
-14/7F	3,71	3,91	4,17
-12/10F	4,07	4,22	4,50
-10/14F	4,51	4,57	4,87

* $t_{sh}=5K$, $t_c=21\text{ C}/70F$, $t_{sc}=2K$, $n_{is}=65\%$

Real comparison due to better evaporator efficiency (2 K)

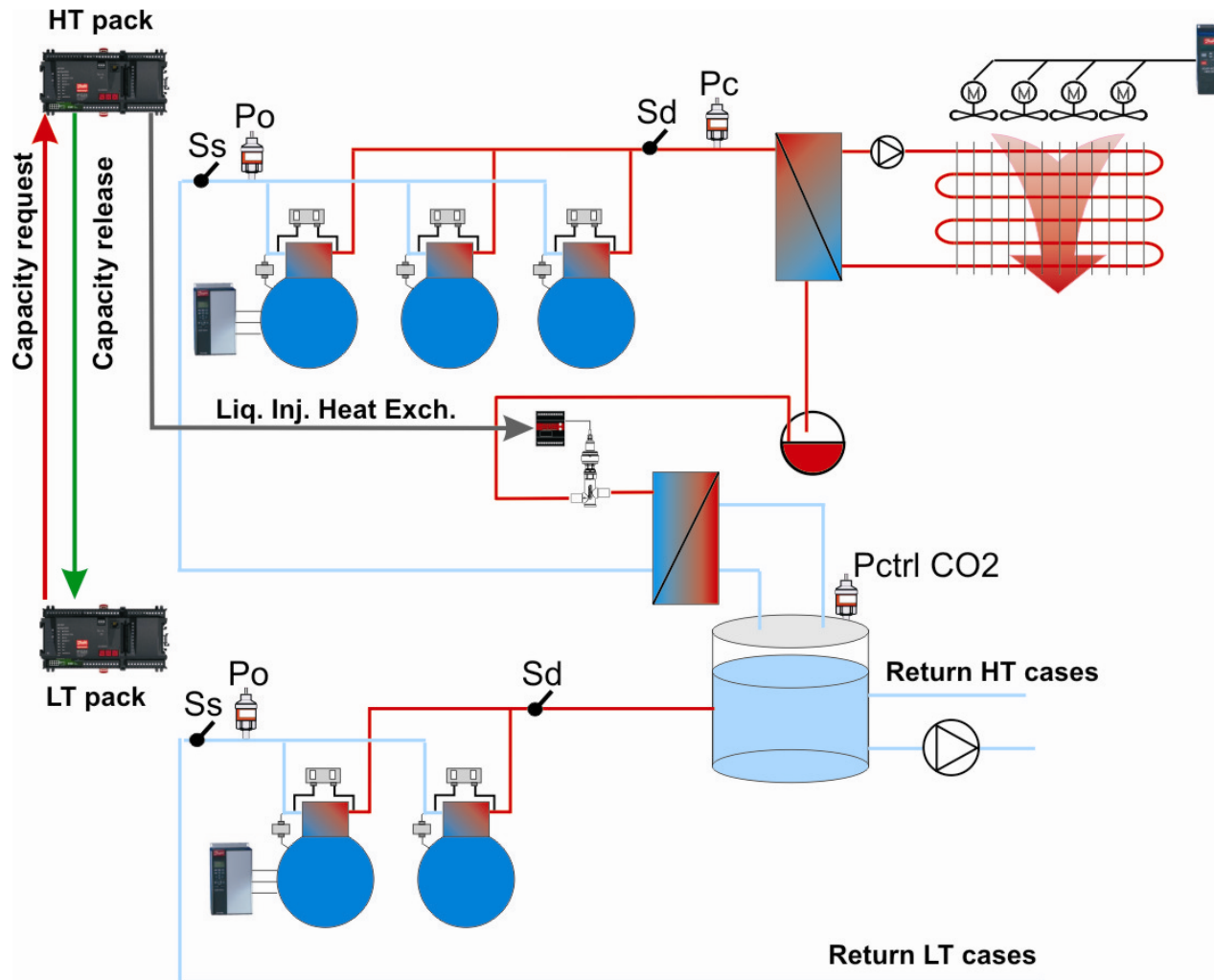
AK-PC 730 Power Pack Controller



REFRIGERATION AND AIR CONDITIONING

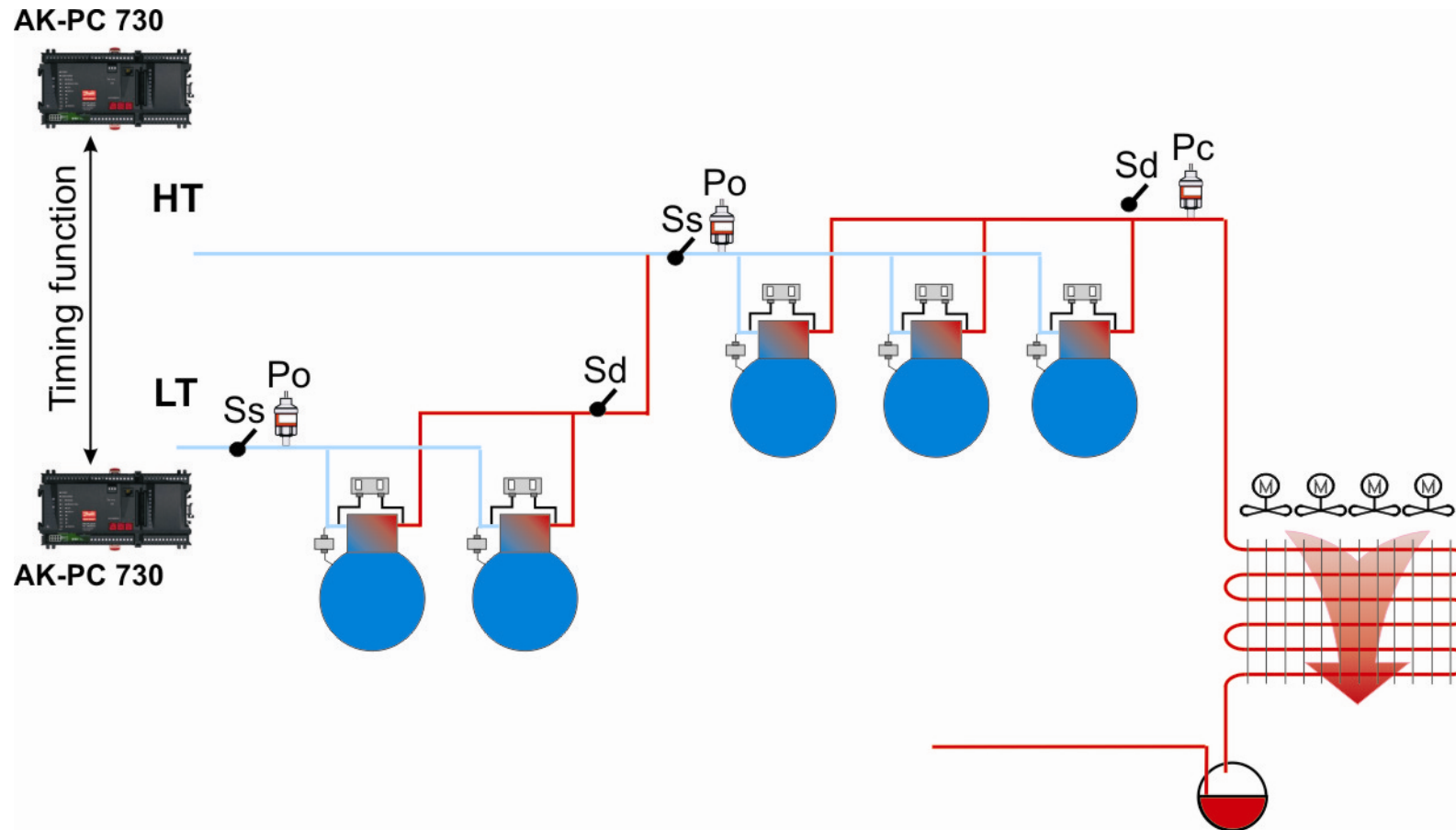
AK-PC 730 – Pack Controller

Application Example 1: Two Suction Group Cascade with Dry Cool



AK-PC 730 – Pack Controller

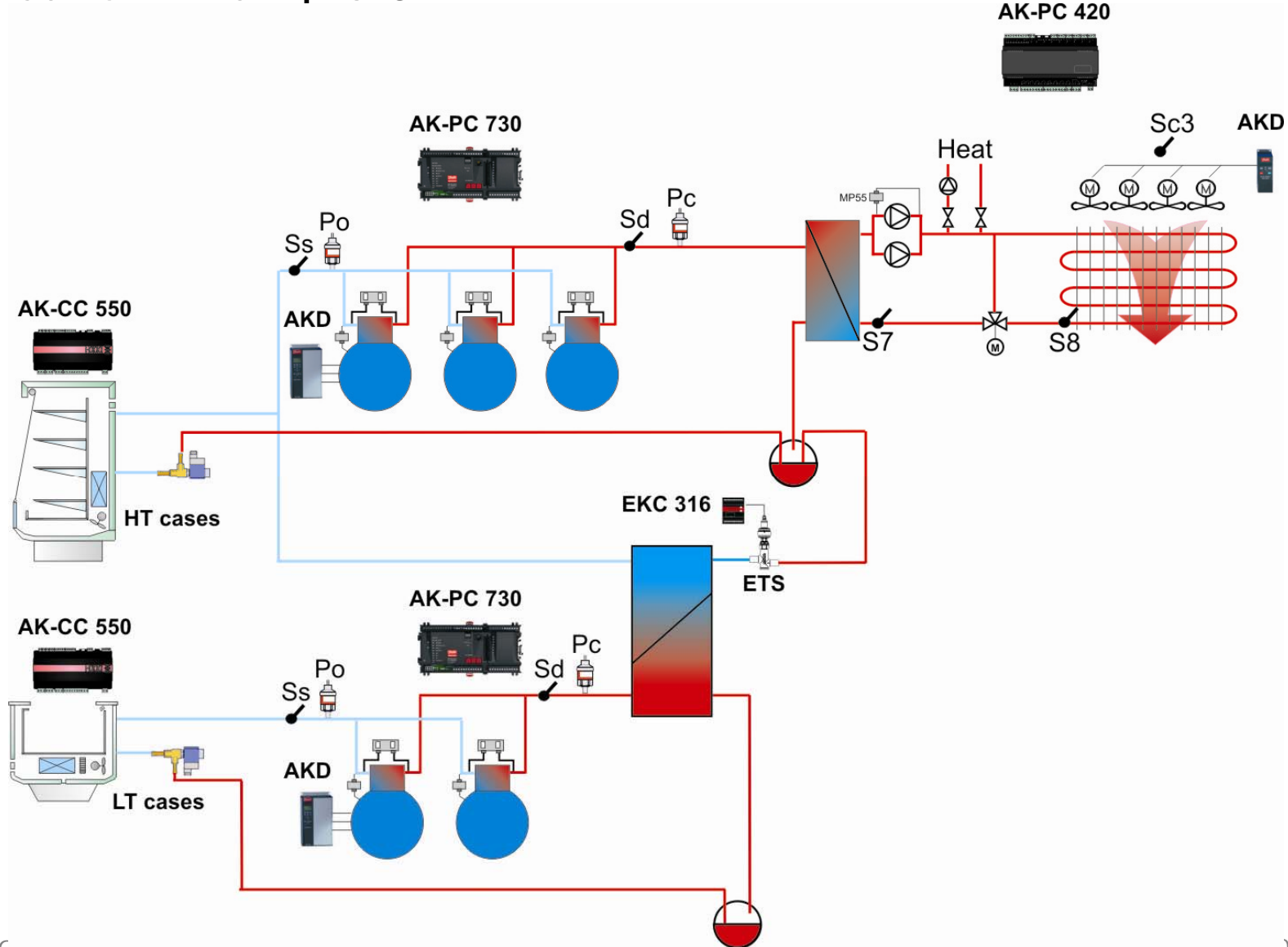
Application Example 2: Booster Set



AK-PC 730 – Pack Controller

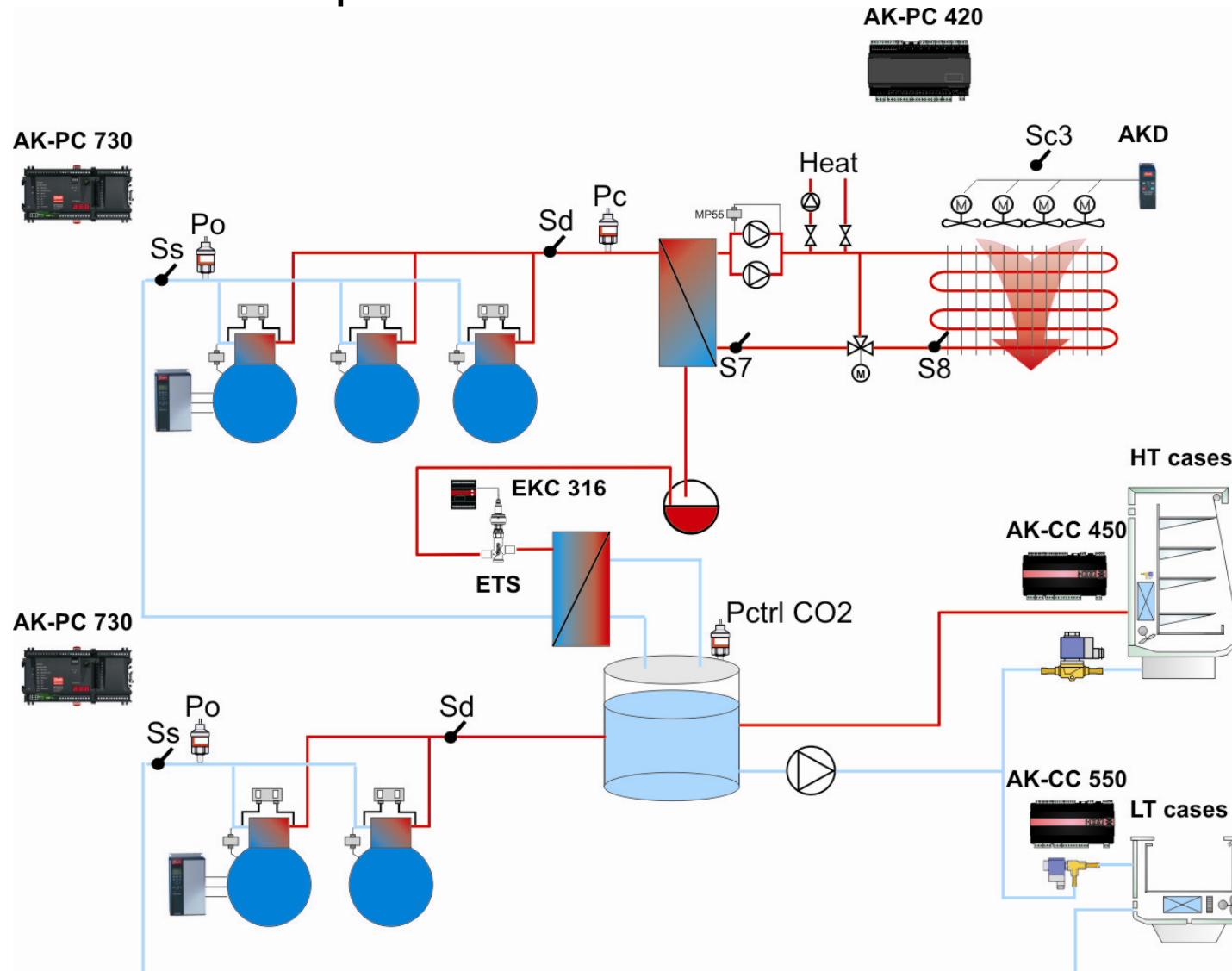


Application Example 3



AK-PC 730 – Pack Controller

Application Example 4



Transcritical CO₂ system for bottle cooling *Danfoss*

"The Black Box"
for cooling...



... a quick way
to change technology

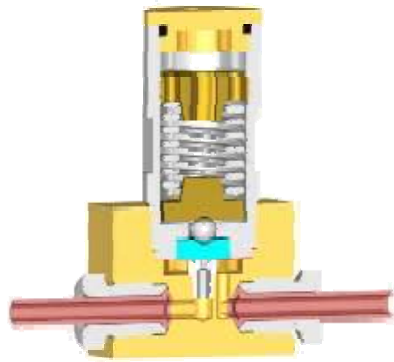
Next Generation CO2 compressor



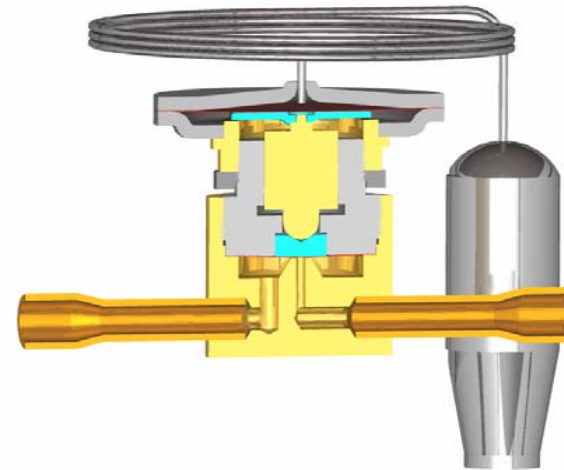
High pressure security valve
Low noise level 62 dbA



CO₂ expansion device



MBR
(**“fixed”** Pressure Regulator)



TBR
(Thermal **Backpressure** Regulator)

Products actually available for CO₂ in transcritical applications:

JKV - Stepper motor expansion valves



Features:

- Available for CO₂ refrigerant
- Available for extreme high pressure
- High sealing frame
- Permanent magnet type direct operating stepping motor

HPV - Solenoid valve



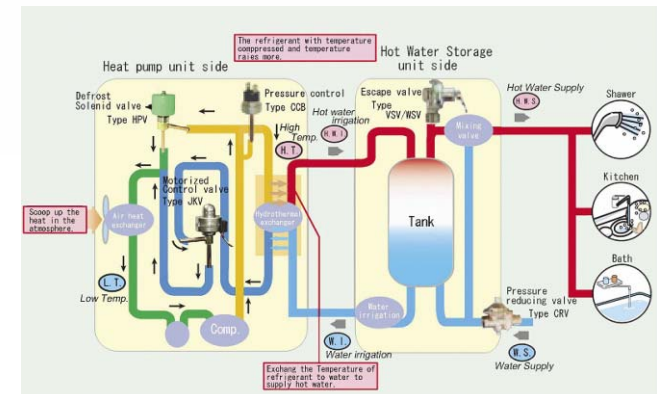
Features:

- Available for CO₂ refrigerant
- Available for extreme high pressure
- Higher sealing construction
- Compact pilot type

CCB - Cartridge pressure control

Features:

- Available for CO₂ refrigerant
- Available for extreme high pressure
- Higher sealing construction
- Compact & lightweight design





CO2 applications

Food Retail

Sub critical CO2 applications

Valves, Controls, Driers and Safety equipment



Industrial

Sub critical CO2 applications

Valves, Controls, Driers and Safety equipment



Food Retail

Transcritical CO2 applications

Controls



Heat Pumps & Bottle Coolers

Transcritical CO2 applications

Compressors, controls and complete cooling cassettes

