



kongres

**45th HVAC&R CONGRES AND EXHIBITION :
IMPROVING ENERGY EFFICIENCY IN CLIMATE AND OZONE FRIENDLY LATEST
REFRIGERATION TECHNOLOGIES**

3 – 5 . XII 2014 . Beograd, Srbija



NATURAL REFRIGERANTS

*Energy improvement by using 90 ° C hot
water NH3 heat pumps in Dairy Plants*

presentation by : Jan Boone

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"Natural Five" Refrigerants and Product Solutions

Refrigerant (Natural Five)	NH ₃ R-717	CO ₂ R-744	HC Hydrocarbon	H ₂ O R-718	Air R-728
90°C	Utility hot water	Utility hot water		Heat recovery	
60°C			Utility hot water Heating HVAC	Chiller	
10°C	Chilled water Ice making	Chilled water Ice making			
-15°C	Cold storage, Freezer, Fish boat				
-25°C	Specific Refrigeration needs				
-40°C	Freezer, Freeze-dry, Super Low temp storage				
-50°C			Cryogenics		Cryogenics
-60°C					
-100°C					
Notes	• Conventional system • National Projects	• Eco-Cute	• Nat'l Proj. • Butane + Propane	• Nat'l Proj. • Adsorption • Heat recovery	• Nat'l Proj. • Air-cycle

COMBINED NH3 CHILLER / HOT WATER HEAT PUMP



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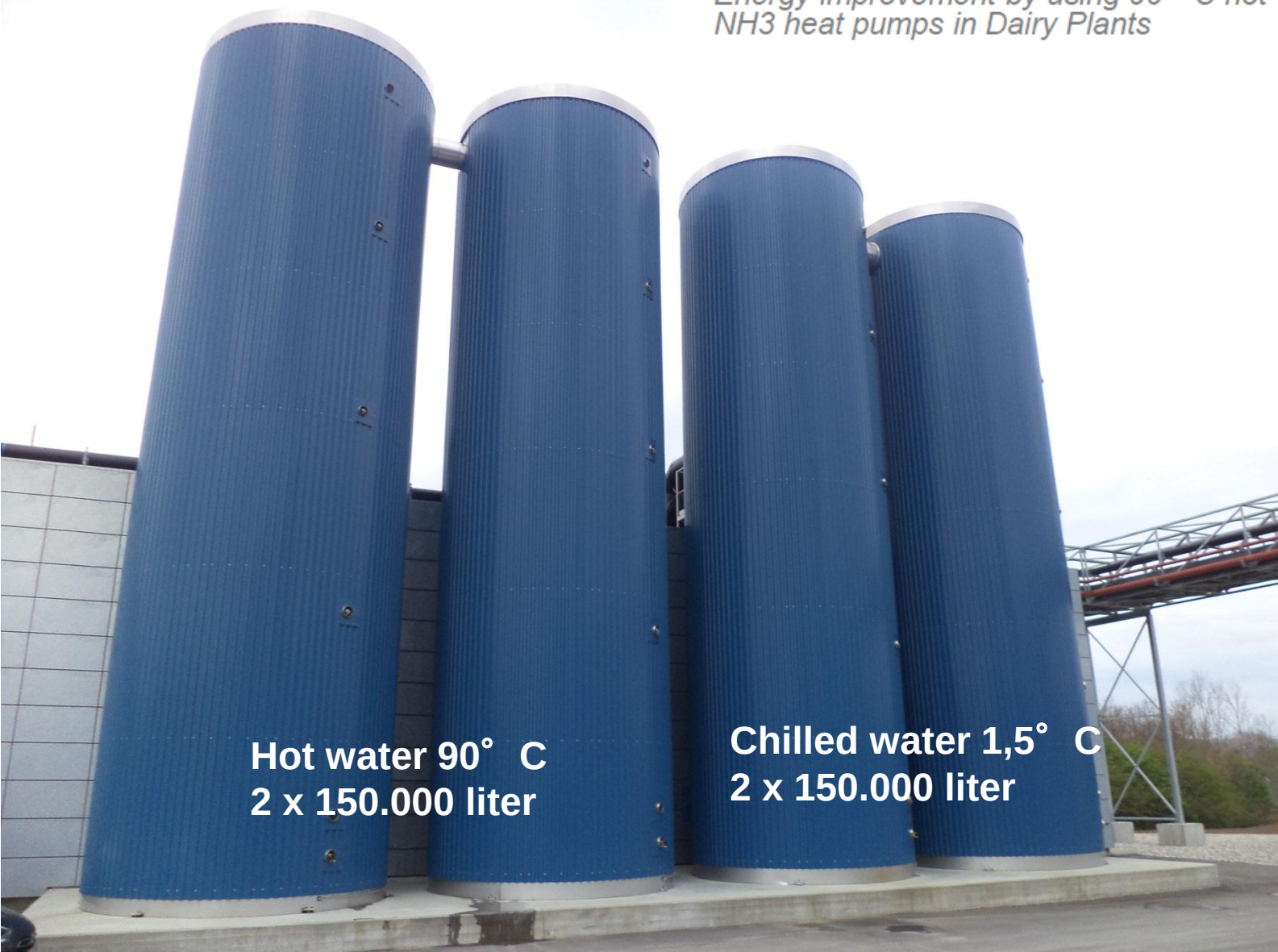
FIELD CASE

INTRODUCTION

STARTING POINT	
2 Mw 1,5°C	Chiller units to produce 2000 kW (MASTER function) contractor : SVEDAN INDUSTRI DENMARK
3 Mw 90°C max.	Hot water heat pump 3000 kW using chiller heat rejection as heat source (SLAVE function)
CHOICE	NH3 2 stage reciprocating compressor system 2 sets of each 1000kW chilling & 1500kW heating complete factory produced modules with minimum site works using N8M 30 bar piston for the chiller using N6HS 66 bar piston for the heat pump
TIME FRAME	start up February 2014.

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Hot water 90° C
2 x 150.000 liter

Chilled water 1,5° C
2 x 150.000 liter

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OVERCOMPRESSION HOT WATER HEAT PUMP



Total Cooling capacity : 2060 kW
Outlet water temperature : 1.5 C

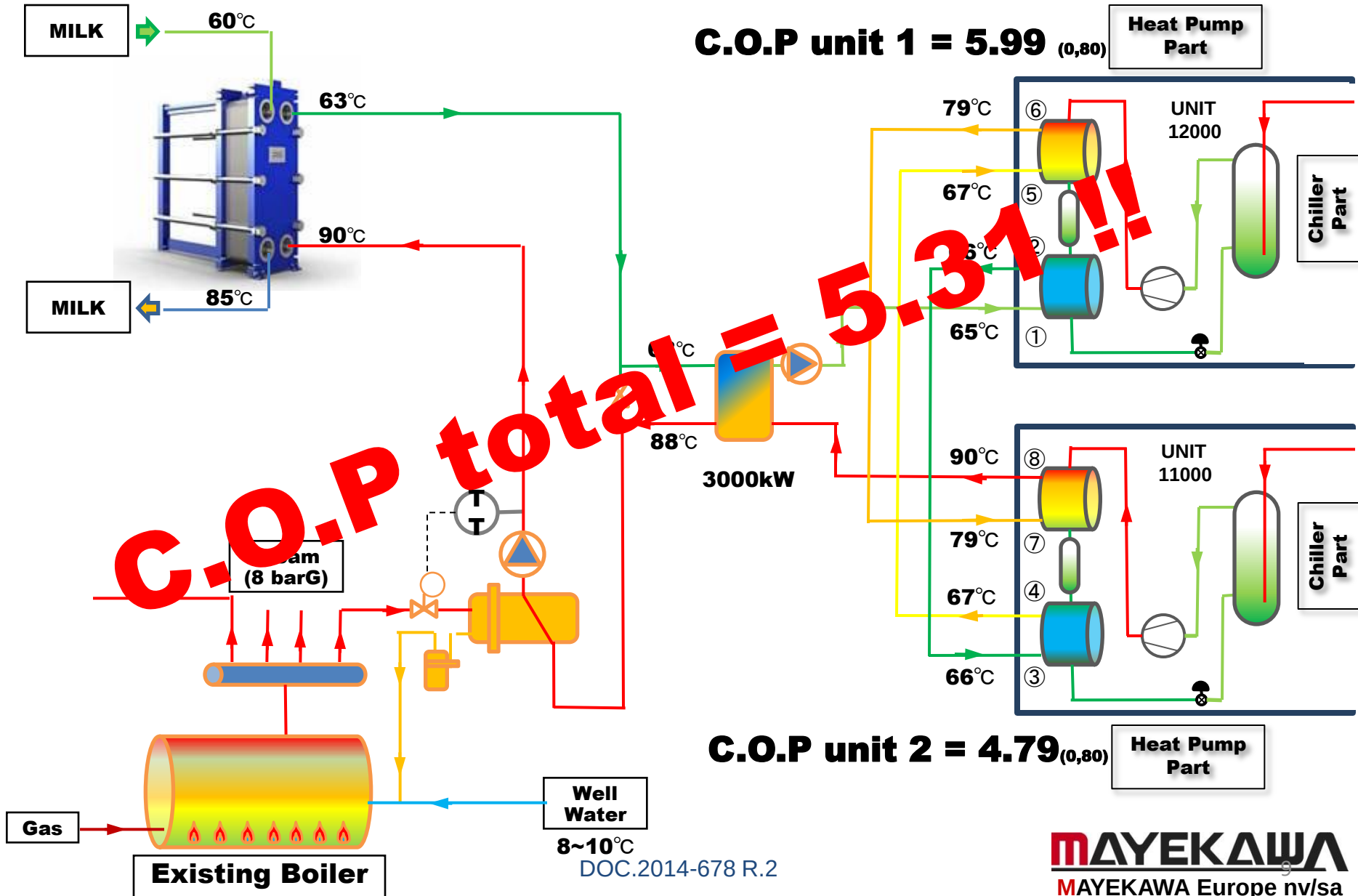
Total Heating capacity : 2950 kW
Outlet water temperature : 90 C

SPECIFICATION OF UNIT

		UNIT 1	UNIT 2	TOTAL
CHILLER PART				
Cooling Capacity	[kW]	1030.1	1030.1	2060.2
Evaporative Temperature	[C]	0.0	0.0	
Inlet Water Temperature	[C]	10.0	10.0	
Outlet Water Temperature	[C]	1.5	1.5	
Intermediate Temperature	[C]	45.0	45.0	
HEAT PUMP PART				
Heating Capacity	[kW]	1452.6	1496.0	2948.6
Condensing Temperature	[C]	81.0	92.0	
Condenser				
Inlet Water Temperature	[C]	67.1	78.7	
Outlet Water Temperature	[C]	78.7	90.0	
Liquid Sub Cooler				
Inlet Water Temperature	[C]	65.0	65.7	
Outlet Water Temperature	[C]	65.7	67.1	
C.O.P cooling	[-]	4.22	4.22	4.22
C.O.P heating	[-]	7.49	5.99	6.64

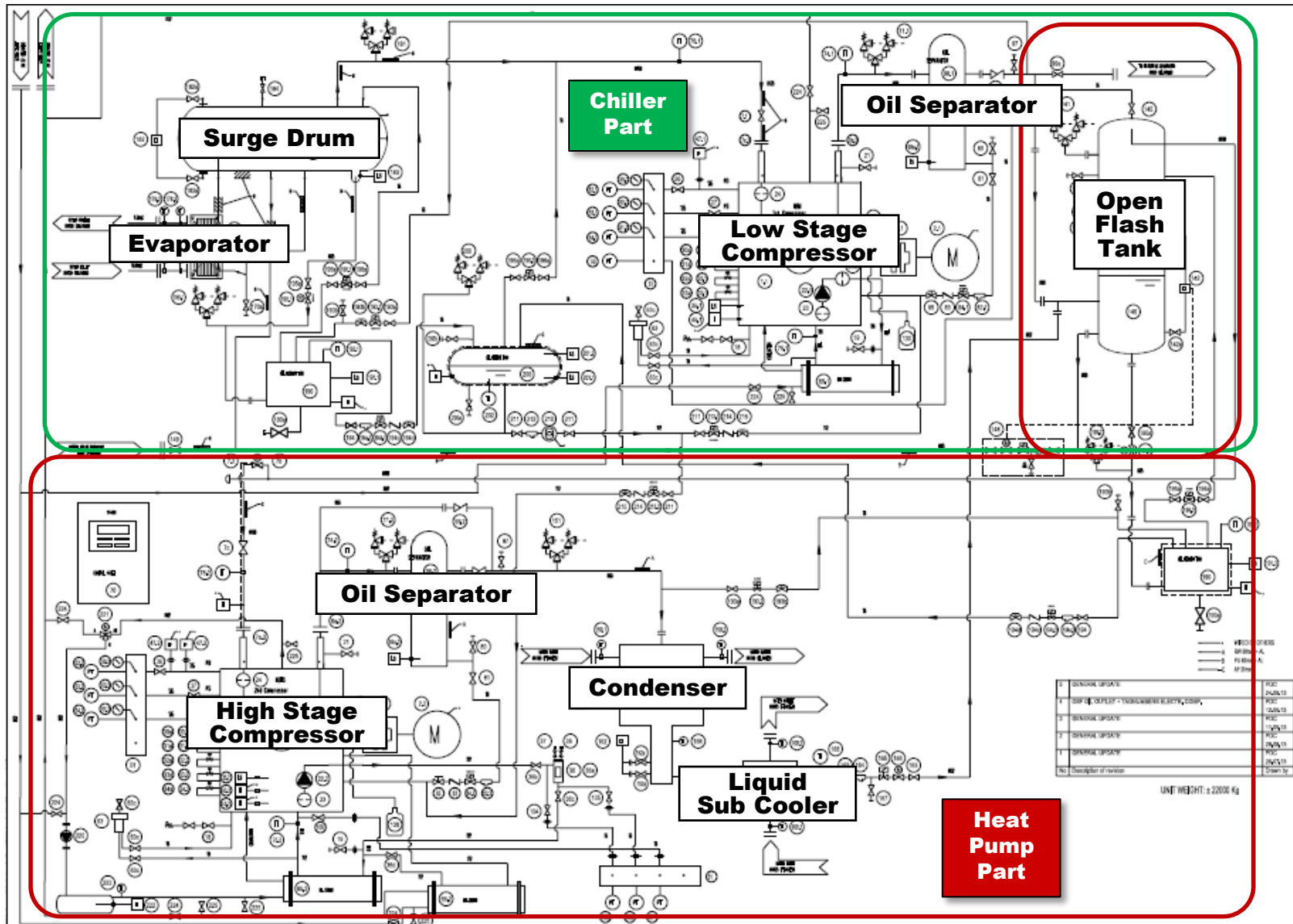
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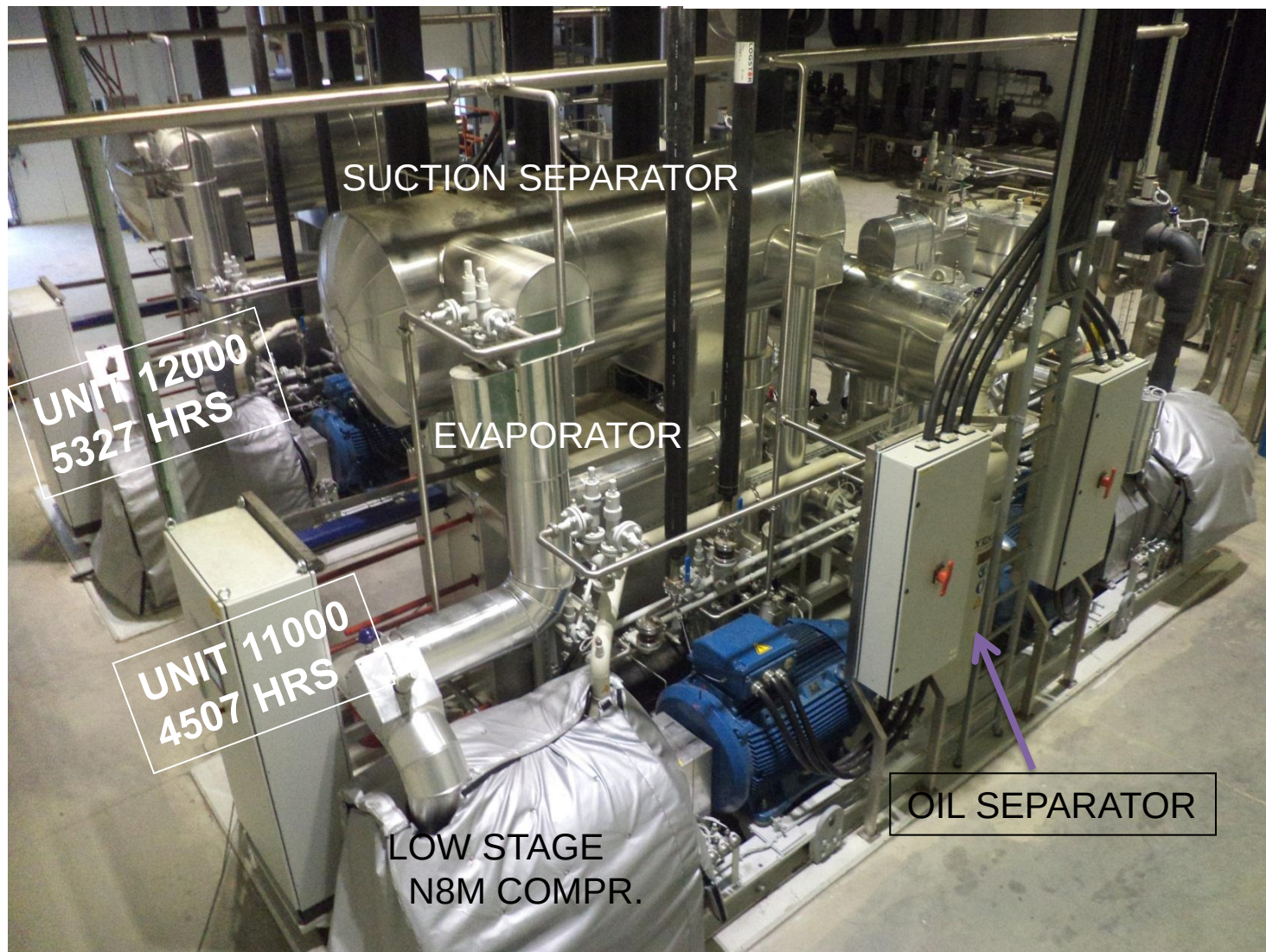
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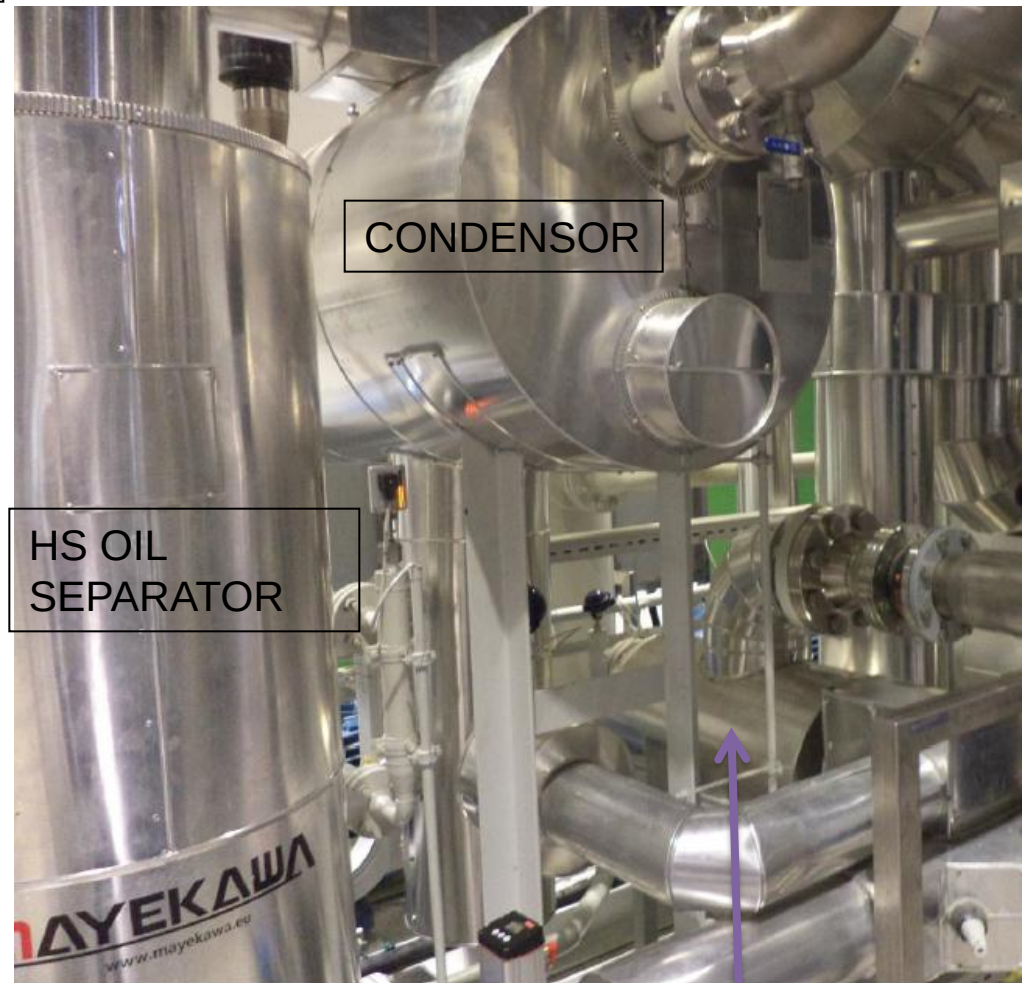
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N6HS HIGH STAGE COMPRESSOR



HEAT SOURCE FLASH TANK



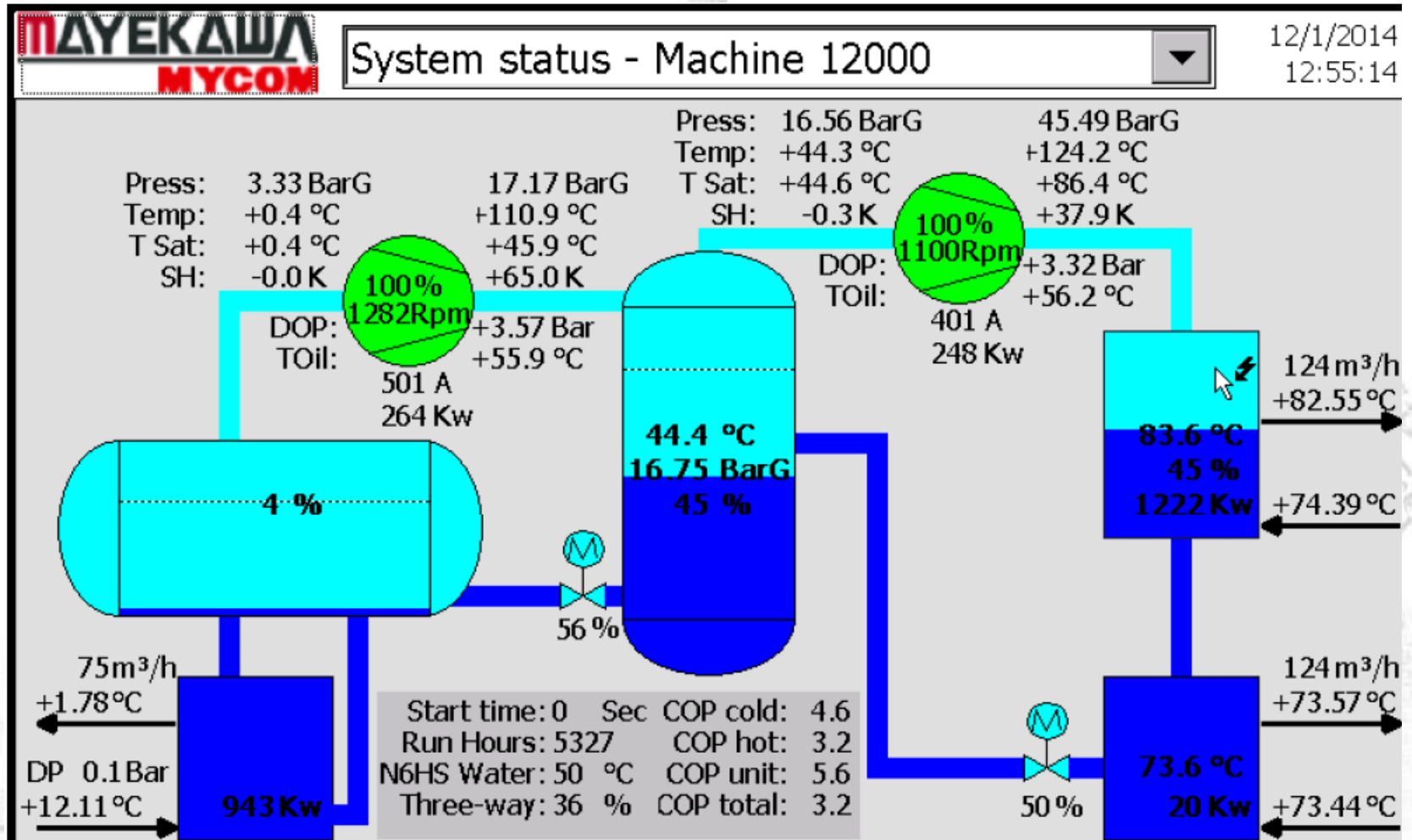
HS OIL
SEPARATOR

CONDENSOR

LIQUID SUBCOOLER

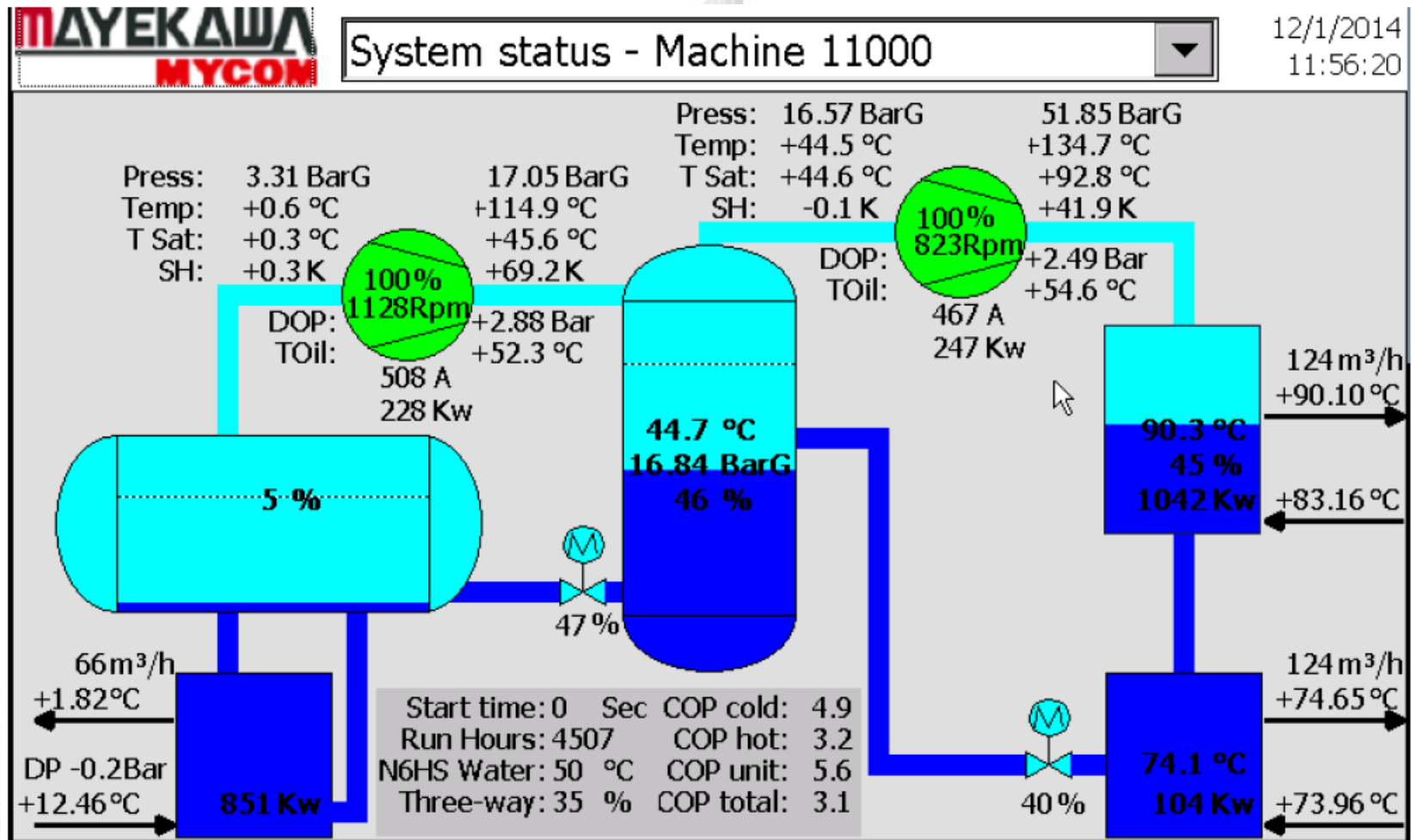
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UNIT NR				12000		11000			note
				LS	HS	LS	HS	TOTAL	
MODEL				N8M	N6HS	N8M	N6HS		
CAPACITY		CHILLING HEATING	kW kW	851	1146	943	1242	1794 2388	
MOTOR	POWER	nominal shaft* measured	kW kW kW	355 173 228	315 185 247	355 207 264	315 186 248		
	cos phi efficiency total			0,795 0,957 0,761	0,78 0,958 0,747	0,818 0,958 0,784	0,781 0,958 0,748		
COP	screen	heating chilling total/unit total heating		4,91 5,58	3,20	4,56 5,57	3,16	3,18	ls+hs bkw ls bkw total bkw idem
	measured	heating chilling total/unit total heating		3,73 4,20	2,41	3,57 4,27	2,43	2,42	ls+hs elec ls elec total elec idem
	measured	heating			4,64		5,01	4,82	hs bkw

MERIT of HIGH STAGE HEAT PUMP

Gas Boiler

Heating capacity (day)	kWh/day	58,972
efficiency of boiler	-	0.85
Heating Capacity	kWh/day	69,378
Unit Price	€/kWh	0.064
Consumption(year)	kWh/yr	21,507,296
Running cost (day)	€/day	4440.2
Operating days	day/year	310
Running cost(year)	€/year	1,376,462

High Stage Heat Pump

Heating capacity	kW	2948.6
Running time (day)	hrs/day	20.0
Break kilowatto(/0,75)	BkW	592
Power Comsumption(day)	kWh/day	11.840
Heating capacity (day)	kWh/day	58972
Unit price	€/kWh	0.1
COP		4.97
Consumption(year)	kWh/year	3.670.000
Running cost(day)	€/day	1.184
Operated days	day/year	310
Running cost(year)	€/year	367.040
Merit (vs GAS Boiler)	€/year	1.009.422

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CONCLUSION

1	NATURAL REFRIGERANTS ARE THE MAIN TREND FOR REFRIGERATION AND HOT WATER PRODUCTION IN FOOD INDUSTRY TO-DAY HOT WATER TEMPERATURES OF 90°C ARE ACHIEVED
2	THE FIELD CASE SHOWS OPERATING HOURS COVER THE DESIGN. ALTHOUGH 2 YEARS OPERATION IS REQUIRED FOR FINAL ANALYSIS OF THE PACKAGES. IT SHOWS ALSO THE DIFFERENT APPROACHES HOW TO PRESENT THE COP-VALUES VARYING IN FUNCTION OF OPERATING- AND LOAD-REGIME.
3	POSSIBLE BARRIERS : NH3 AT HIGH PRESSURES LUBRICATION OIL QUALITY EQUIPMENT SUITABILITY OPERATION FINETUNING & CONTINUOUS SUPERVISION



Thank you very much!



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MARKET AVAILABILITY

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