

**UNITED NATIONS ENVIRONMENT PROGRAMME
INTERNATIONAL INSTITUTE OF REFRIGERATION
EUROPEAN ENERGY CENTRE
CENTRO STUDI GALILEO**



**14th EUROPEAN CONFERENCE
LATEST TECHNOLOGIES IN RENEWABLE ENERGY,
APPLICATIONS IN HEATING AND COOLING
TO LOWER CO2 EMISSIONS.**

21ST January 2011

Heriot-Watt University – Edinburgh - UK



Presented by Jan Boone

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MAYEKAWA Europe nv/sa

DOC.2011-200 R2

FIELD EXPERIENCE IN HEATING AND COOLING SYSTEMS BY INTEGRATING RENEWABLE AND TRADITIONAL ENERGY

GEOHERMAL SOURCED HEAT PUMP

ADSORPTION CHILLER USING SOLAR ENERGY



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Commitment on Natural Refrigerants



-  **NH₃** Semi-Hermetic Screw Compressor Unit
-  **CO₂** Commercial / Industrial Eco-Cute System
-  **H₂O** Adsorption Chiller
-  **HC** Commercial / Industrial
Air-Conditioning / Water-Supply Heat Pump
-  **Air** Dehumidifying Air Refrigerant System [Air Ref]

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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			
60°C	Utility hot water Heating		Utility hot water Heating HVAC	Heat recovery	
10°C	Chilled water Ice making	Chilled water Ice making		Chiller	
-15°C	Cold storage, Freezer, Fish boat				
-25°C	Specific Refrigeration needs				
-40°C	Freezer, Freeze-dry, Super Low temp storage				
-50°C					
-60°C			Cryogenics		Cryogenics
-100°C					
Notes	•Conventional system	•Eco-Cute •National Projects	•Nat'l Proj. •Butane + Propane	•Nat'l Proj. •Adsorption •Heat recovery	•Nat'l Proj. •Air-cycle

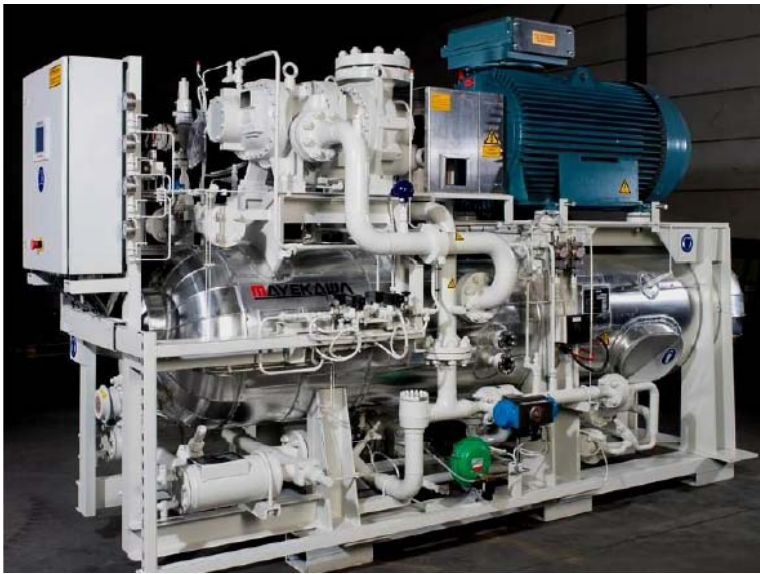
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NH3 heat pumps

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Motor docked to compressor



- Safety improved
- Compact
- High efficiency



Building the stator



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GEO THERMAL SOURCED HEAT PUMP



DESIGN REQUIREMENT

APPLICATION	DISTRICT HEATING	
OUTPUT	HOT WATER	
	Outlet temperature	60°C
	Inlet temperature	40°C
	Capacity	480 kW
HEAT SOURCE	SPRING WATER	
	Inlet temperature	40°C
	Temperature	35°C

EQUIPMENT

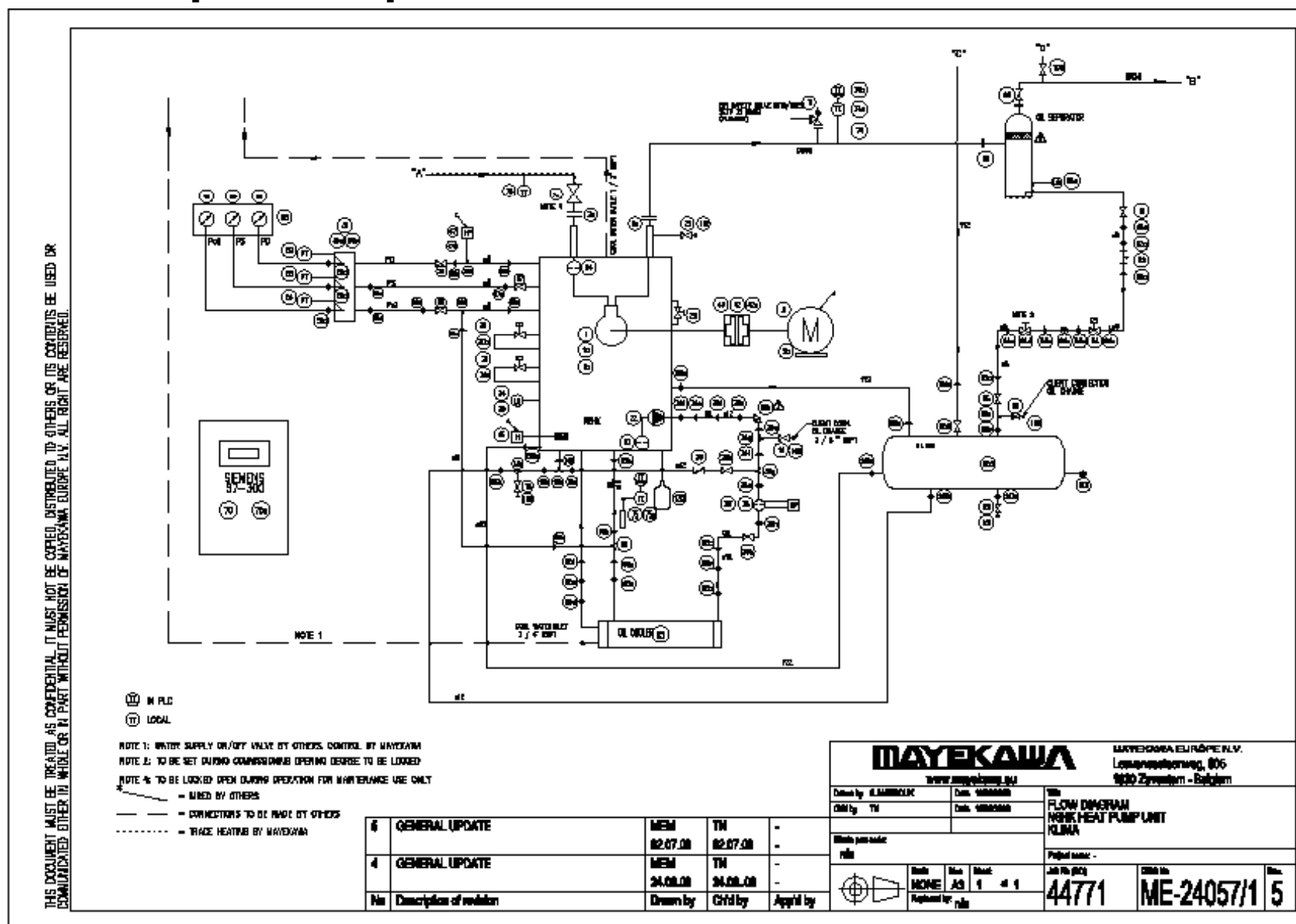
COMPRESSOR	DETAILS		note
TYPE	PISTON		
MODEL	N6HK		NH3 50 bar TE/TC=+30/+65°C PS/PD=11.7/29.1bara
SPEED RANGE	900	1600	(rpm) by FC
HEATING CAPACITY	270	480	(kW)
POWER ABSORBED	40	75	(kW)
	6.75	6.4	

EQUIPMENT

	DETAILS	Note
CONDENSOR	S & P	TC=65°C Tw-in/out=40/60°C
EVAPORATOR SUCTION SEPARATOR	S & P Top mounted vessel	Flooded TE=+30°C Tw-in/out=40/35°C
OIL SEPARATOR	Design 10 ppm/weight	Incl.level switch
OIL TANK OIL RECOVERY SYSTEM		
	Watercooled	
 MAYEKAWA Europe nv/sa	DOC 2011-200 R2 LINEAR VALVE	(on level)

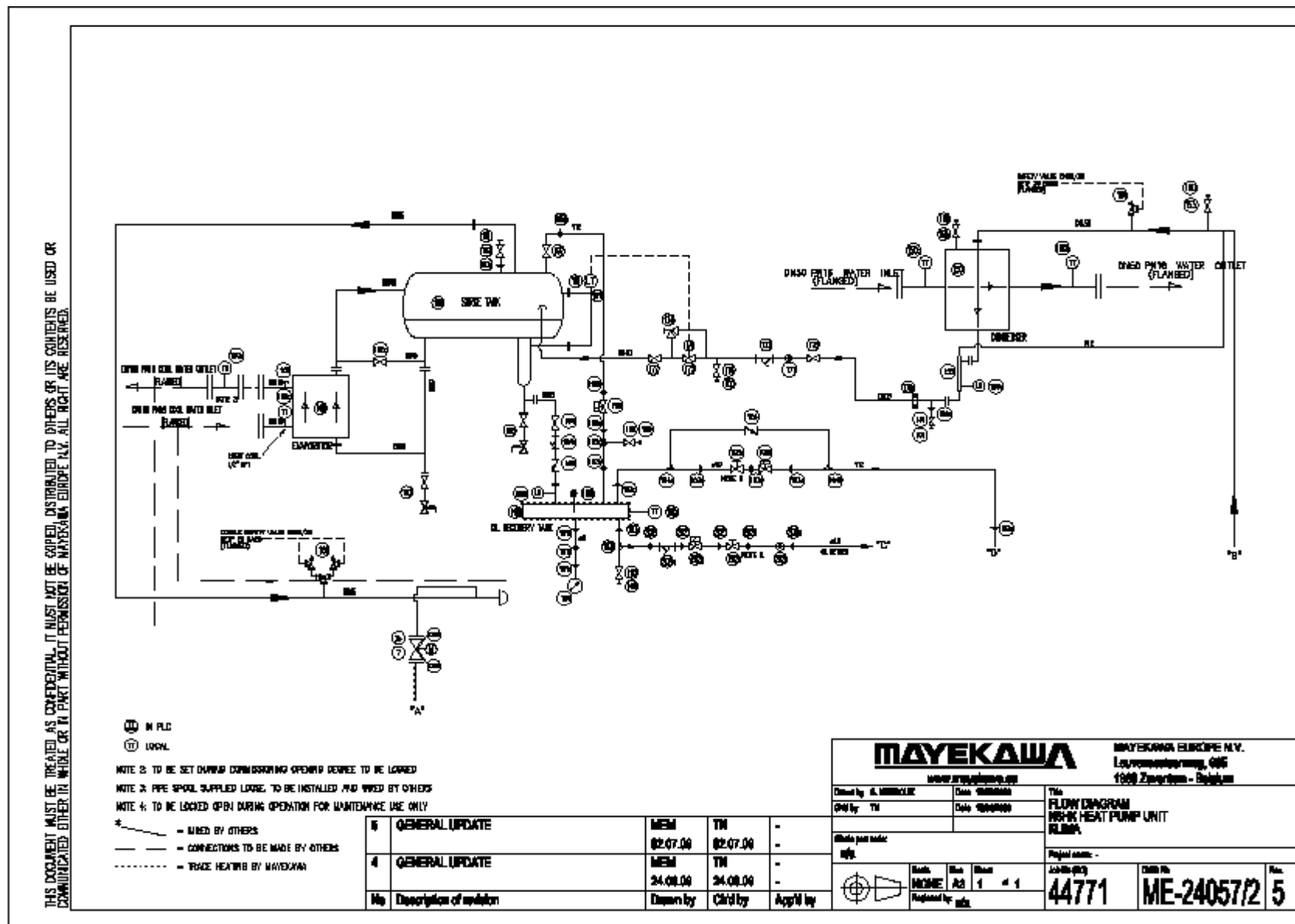
P&ID compressor part

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P&ID heat exchanger part

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Complete package heat pump unit

Specifications;

Heat capacity: 480kW(maximum)

Compressor speed: 900~1600rpm (frequency inverter drive)

Absorbed power:39~75kW

Heating COP=6.4



Hot water conditions
Temperature:40→60°C
Flow rate:20.6m3/h
Application: District heating



Heat source: Hot spring
Temperature:40→35°C
Flow rate:69.8 m3/hr



Compressor datasheet SO 44771

REFRIGERANT	AMMONIA	
BOOSTER		N
CAPACITY	[kW]	405,7
ABSORBED POWER	[kW]	75,2
SPEED	[Rpm]	1600
LOAD	[%]	100
CONDENSING TEMP.	[degC]	65
EVAPORATIVE TEMP.	[degC]	30
SUCTION SUPERHEAT	[degC]	0
LIQUID SUBCOOLING	[degC]	0
SUCTION TEMP.	[degC]	30
SUCTION PRES.	[MPaA]	1,17
DISCHARGE PRES.	[MPaA]	2,91
SWEPT VOLUME	[m3/h]	212
DISCHARGE TEMP.	[degC]	103
REFRIG. FLOW RATE(SUC.)	[m3/h]	172
REFRIG. FLOW RATE(DIS.)	[m3/h]	88,5
REFRIG. FLOW RATE(SUC.)	[Kg/h]	1512
REFRIG. FLOW RATE(DIS.)	[Kg/h]	1512
OIL HEAT REJECTION	[kW]	1,15
JACKET HEAT REJECTION	[kW]	4,17
COP-H		6,39

Installation on the site for district heating plant



COSTS		GAS BOILER	HEAT PUMP
Plant heating capacity	kW	480	480
Efficiency	%	85	
Required energy heating capacity	kW	564	75
Operating hours	hrs	3.000	3.000
Yearly capacity	mWh	1.692	225
Energy per year		1.692.000 kWh	225.000 (kWh) (75kW/hr)
Energy cost	€	84.600 (0,05€/kWh)	33.750 (0,150€/kWh)
Installation cost(compr-motor set excl. plant piping, waterpumps &installation)	€		150.000
Yearly running cost saving	€		50.850
Payback time(energy saving)	years		Approx. 3 y
CO2 emission factor		0,277 kg CO2/kWh	0,55 kg CO2/kWh
CO2 emission	tonCO2/year	468,7	123,8
CO2 emission reduction	tonCO2/year	-	345

ADSORPTION CHILLER USING RENEWABLE ENERGY



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Adsorption Chiller Packaged Unit

2005
~2007 NEDO [Research and Development of New System Utilizing Solar Energy]

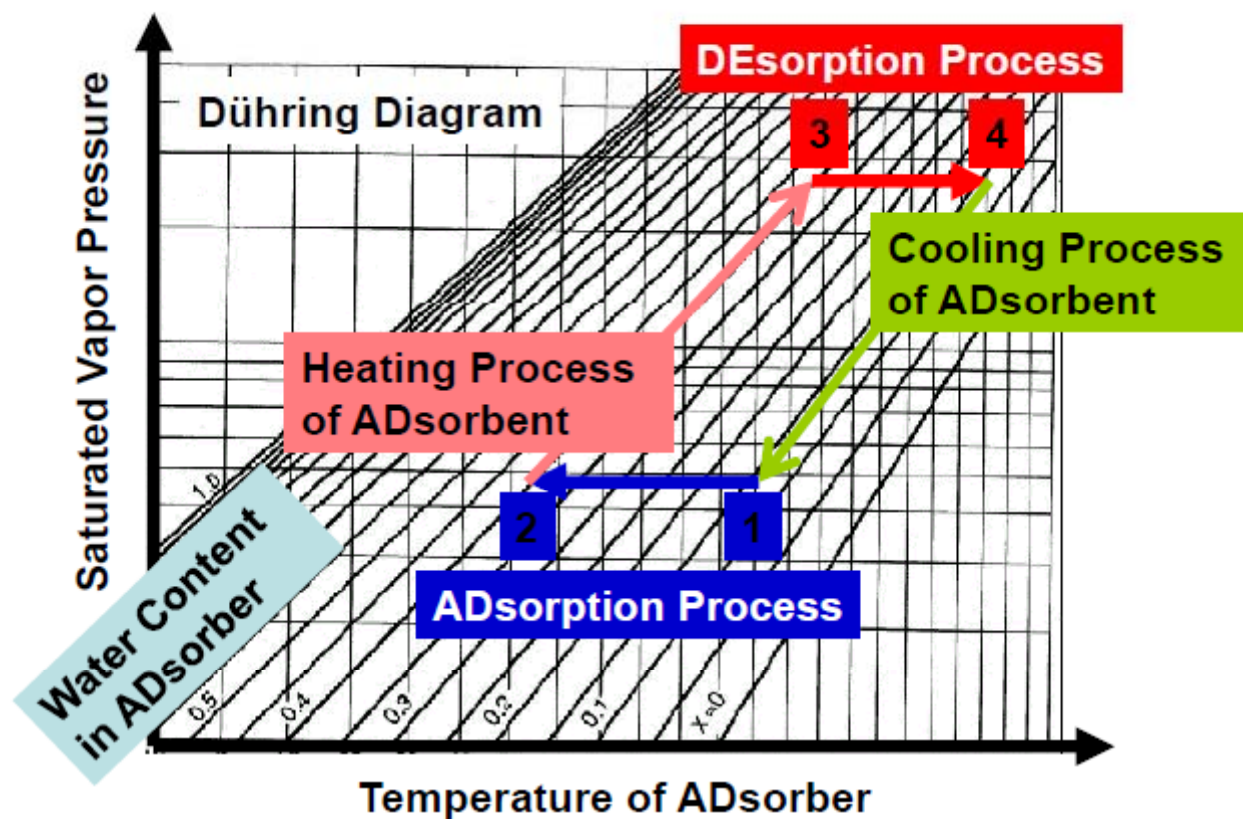


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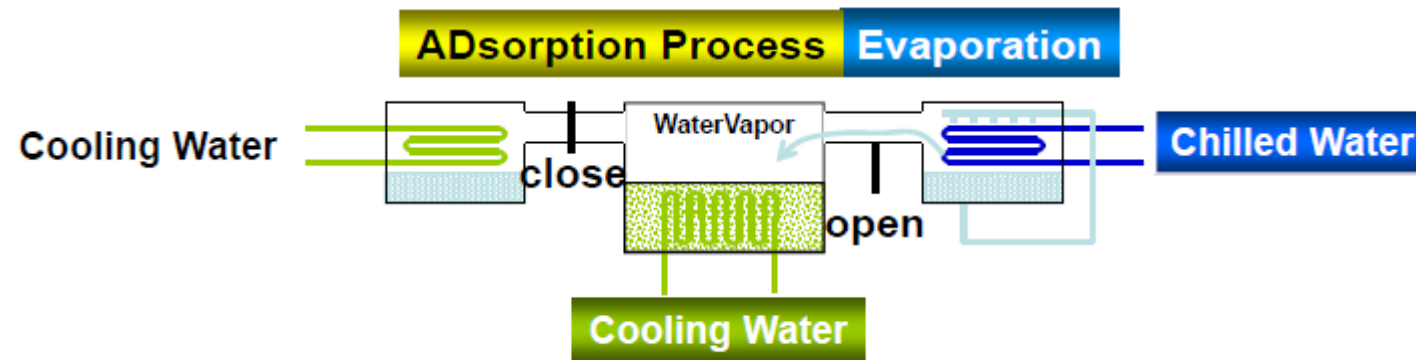
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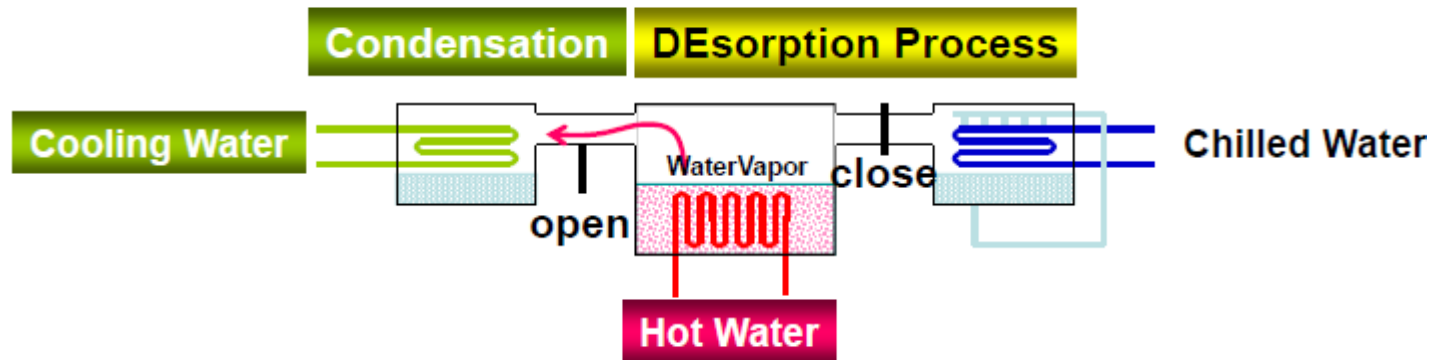
Refrigerant Behavior in ZEOLITE



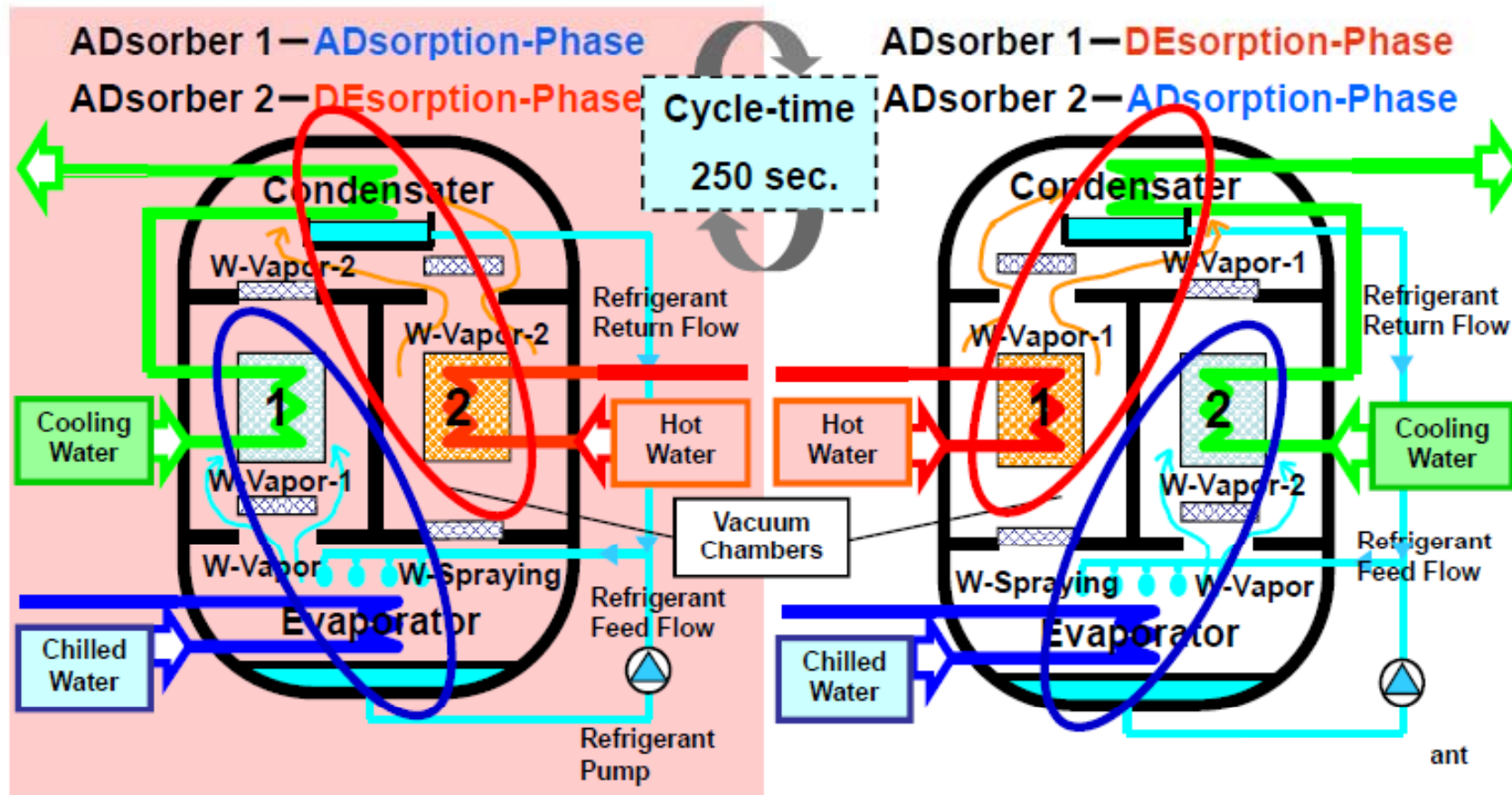
Operating Principle of ADsorbent



Batch Operation in Vacuum  Cycle Time: 250 ~ 600 sec.

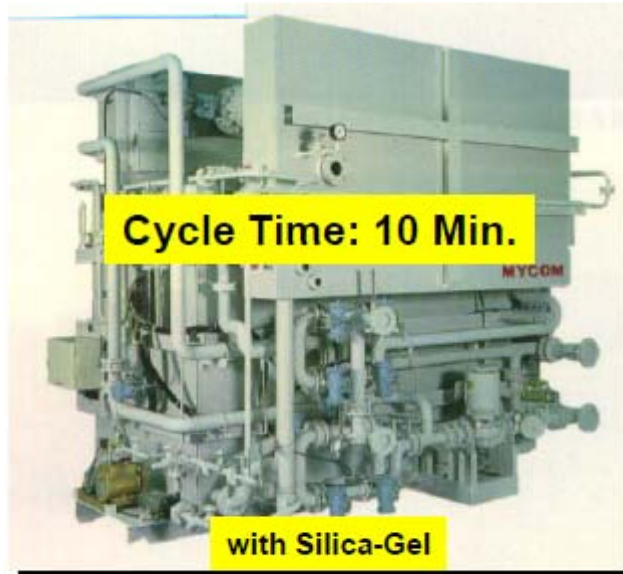


Operating Principle and Batch Operation



Newly-developed Series with ZEOLITE

**Award Winner in Japan:
Technology Prize 2009 of Environ-
ment Protection by Nikkei BP
(Japanese Economic Newspaper)**



Old Series
(from 1990 till 2006)

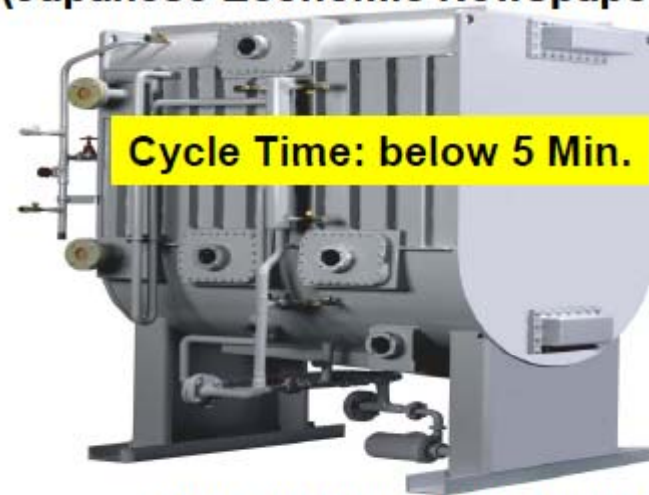


Photo: w/o Valve set, w/o Control Panel

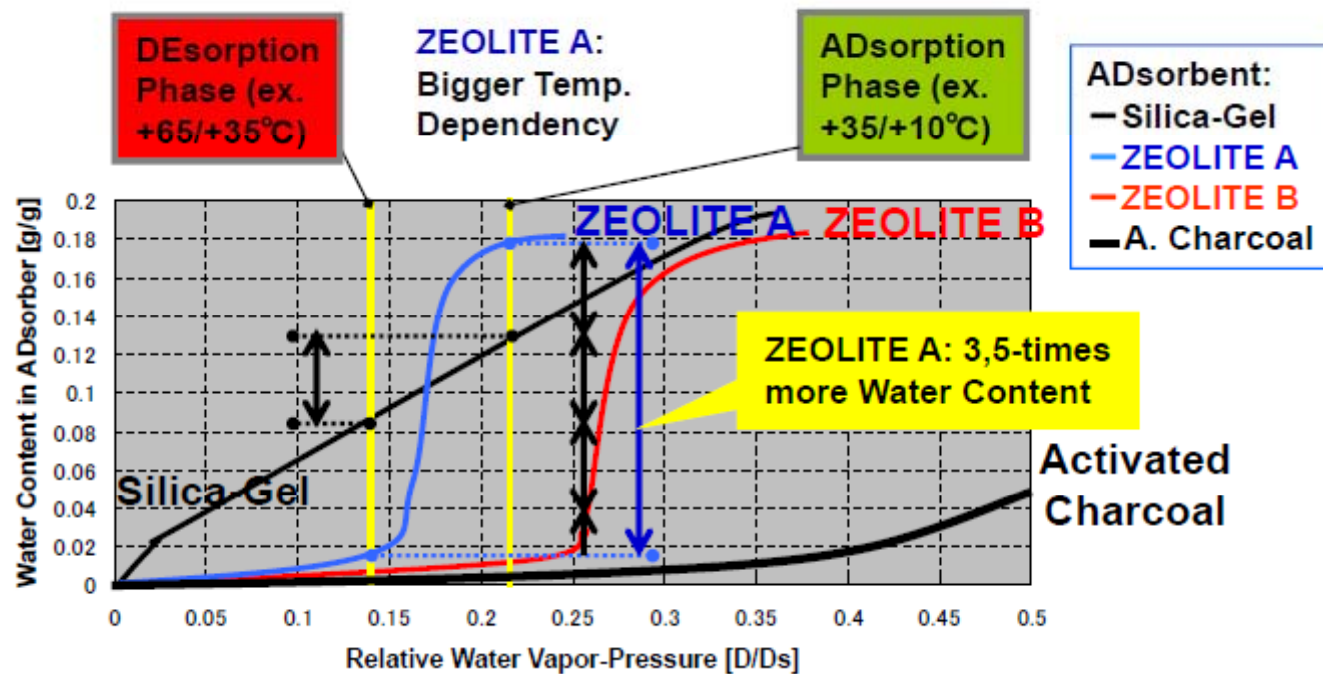
New Series
(since 2009)

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ADsorption Isothermal Curves of Vapor



Relative Water Vapor-Pressure means:
 Ambient Saturated Water Vapor-Pressure / Saturated Water Vapor-Pressure

ZEOLITE-coated Heat Exchanger

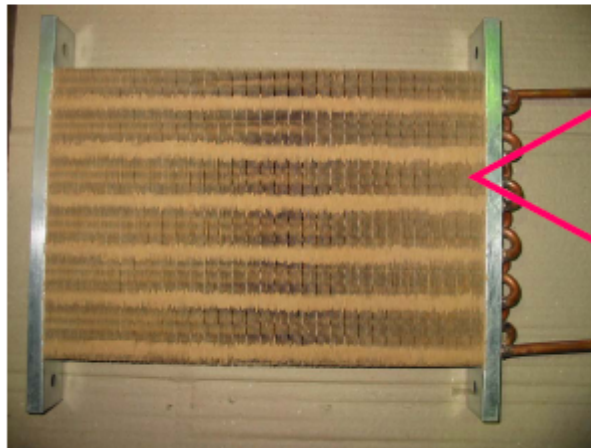
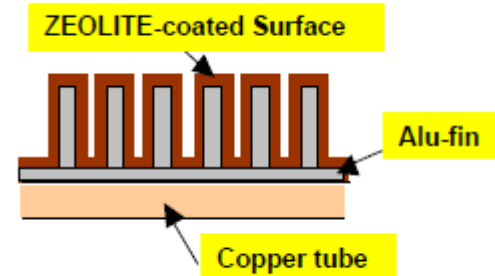
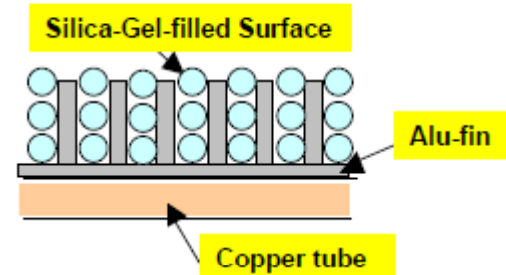


Photo: ALU-fin & Copper tube
Heat Exchanger

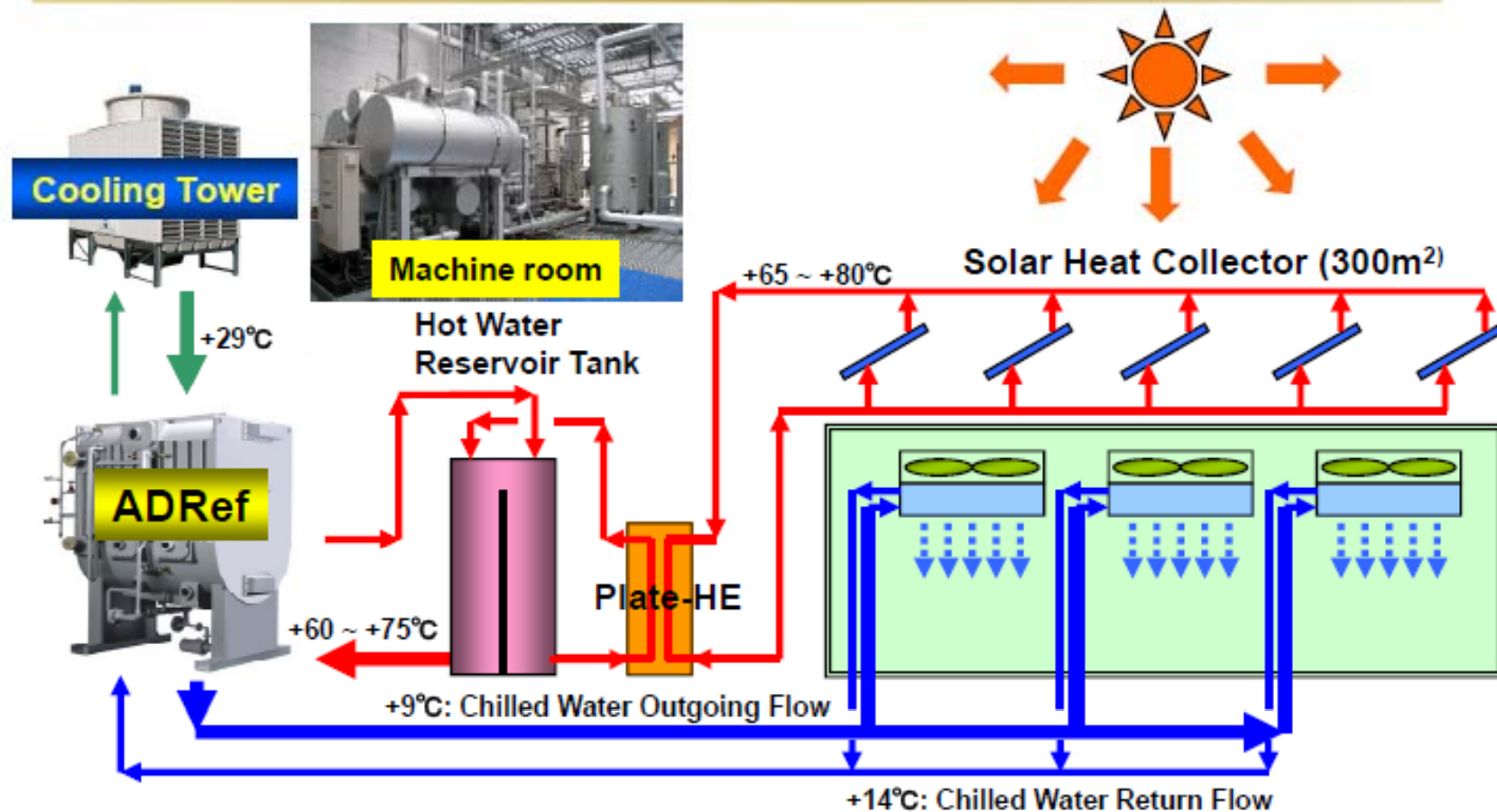


New Series

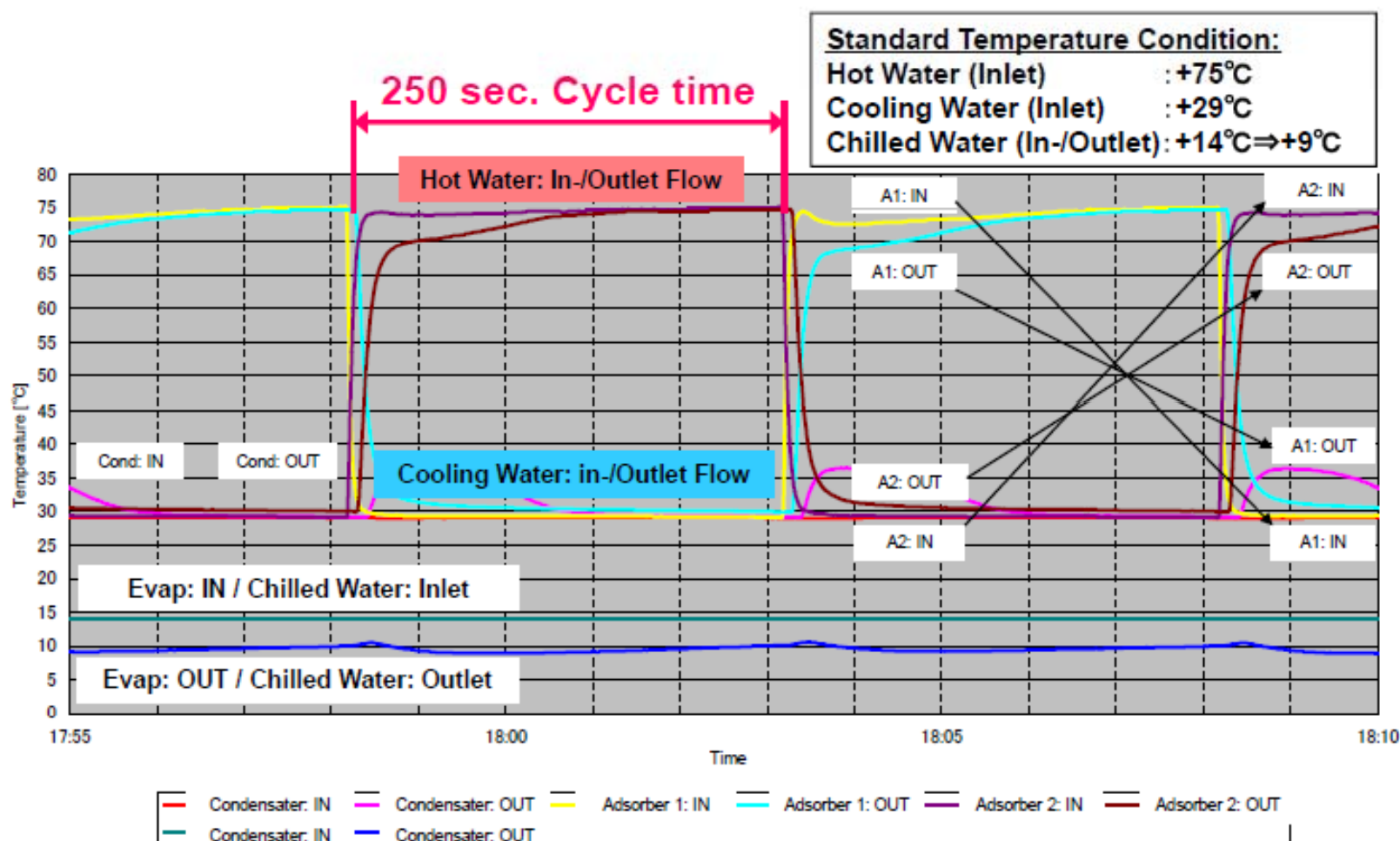


Obsolete Series

Heat Source: Solar Heat Energy
(Application: Air-Conditioning of Shopping Center)



Temperature Variation at Batch Operation



Comparison of Energy-saving Effect

CO2 Emission Factor: Electricity:[0.555]kg-CO2/kWh
Heavy Oil A:[2.71]kg-CO2/L, Operating Hours:[6000]

Calculation Basis:
Capacity: ca. 350 kW, Chilled Water temperature: +7~+9°C

Model: Water Chiller	ADsorption	Centrifugal	Air-cooled	ABsorption
Driving Force: Driving Device:	Waste Heat ZEOLITE	Electricity Compressor	Electricity Compressor	Boiler Steam Lithiumbromid
Refrigerant (GWP):	Water (GWP=0)	R134a (GWP=1,300)	R407c (GWP=1,370)	Water (GWP=0)
Capacity (CWT):	350 kW (+9°C)	387 kW (+7°C)	355 kW (+9°C)	352 kW (+7°C)
Power Requirement: (Power: Auxiliary Devices)	1.1 kW (31.2 kW)	85.0 kW (7.4 kW)	74.0 kW (7.2 kW)	5.2 kW (11.0 kW)
Steam Consumption (Equivalent in kW):	Zero	Zero	Zero	390 kg/Std. (ca. 300 kW)
CO ₂ Emission (t/yr):	ca. 104	ca. 308	ca. 270	ca. 468
System C.O.P.*1	10.8	4.2	4.4	1.1

*1: C.O.P.: Capacity ÷ Total Power Requirement

In case of ABsorption Chiller: Capacity ÷ (Total Power Requirement + Steam Consumption in kW)

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Key Features of ADRef-Z Series

- Use of Natural Refrigerant, i.e. Water (R718): ODP=0, GWP=0
- Heat Source: Low Grade (Waste) Hot Water (Effective for: +60°C~+80°C)
- Production of Chilled Water between +5°C ~ +25°C with the Cycle time of 250 sec.
- Newly Developed Adsorbent, ZEOLITE (Coated thin layer and life-long Usage)
- Very Low Electricity Consumption (Only Refrigerant and Vacuum Pumps)
- Lighter Weight and Compact Dimension compared to Mycom Silica-Gel Version
- Easy Handling and Lower Operation and Maintenance Costs
- No Certified/Qualified Personnel is required.
- No Vibration and Noise Problems

MAYEKAWA MYCOM

WORLDWIDE

- 33 countries / 119 offices
- 8 production plants



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