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Training course – ACS in Solar Cooling System

solarcombi+

Halle / Saale, 2009

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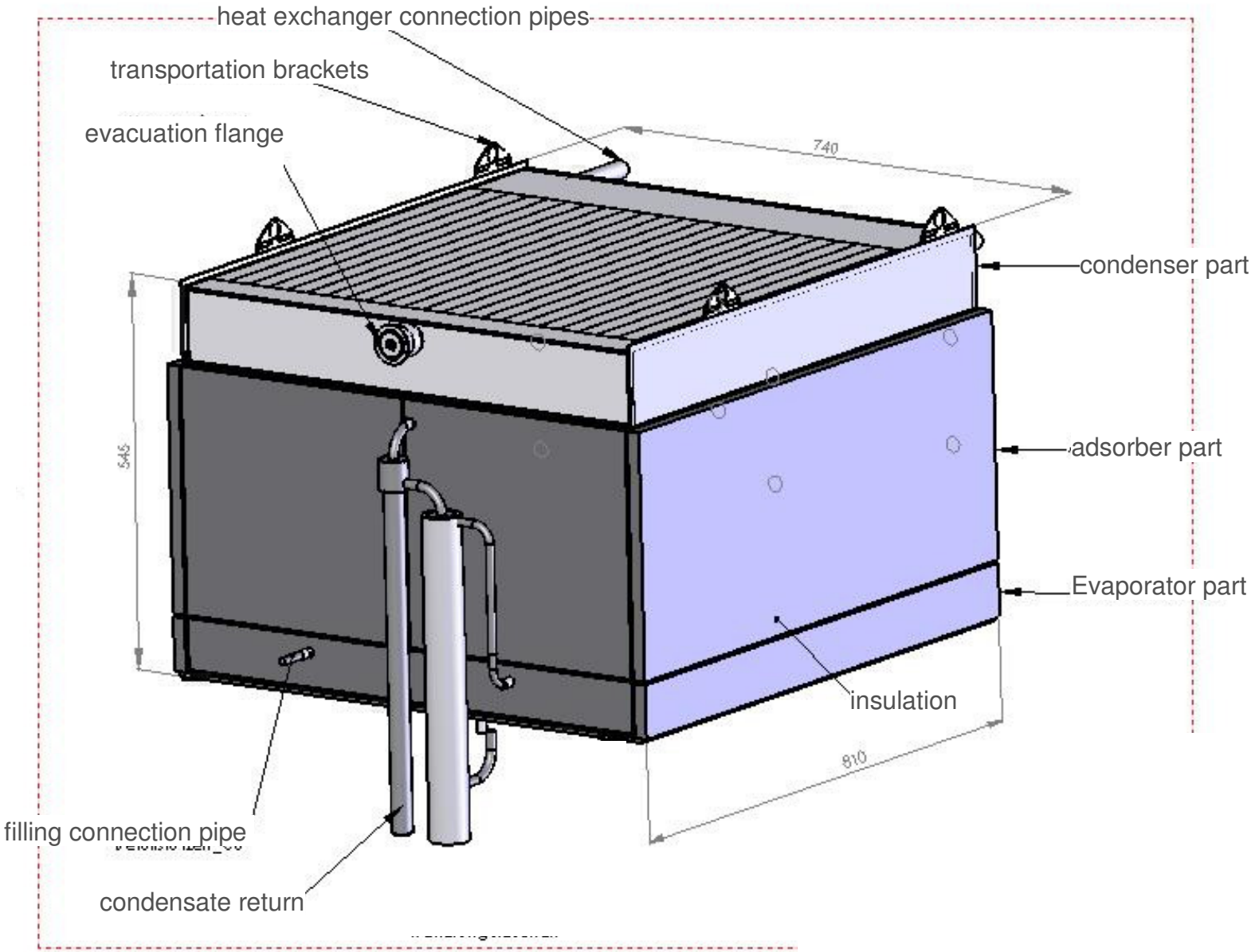
Construction of ACS-Module



Construction of ACS-Module

Adsoption process using water / silica gel

“4-Chamber-Principle”

Self-acting steam flaps

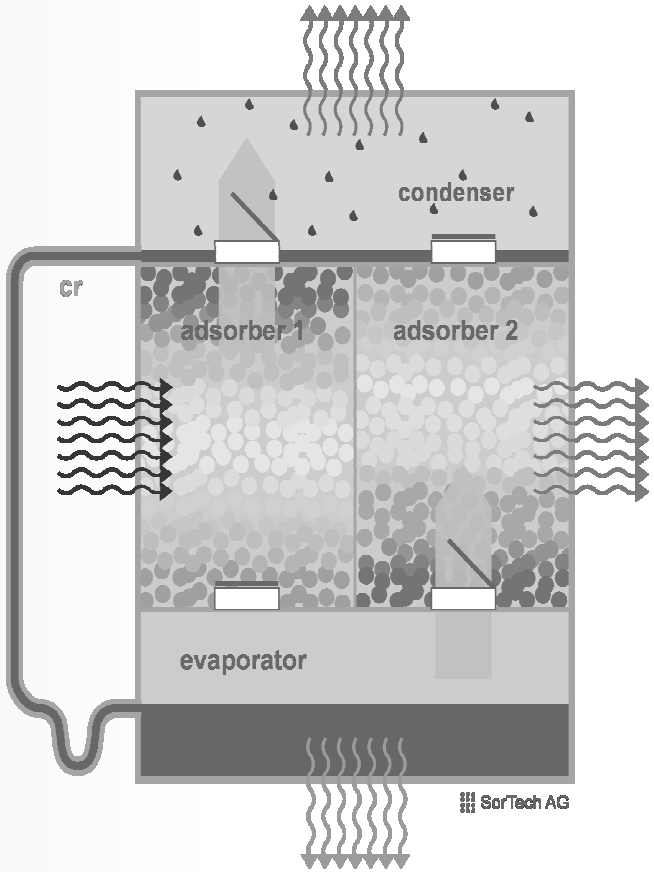
Coated adsorber heat exchangers

Light and compact

self supporting construction

Thin and light vacuum housing

External condensate return

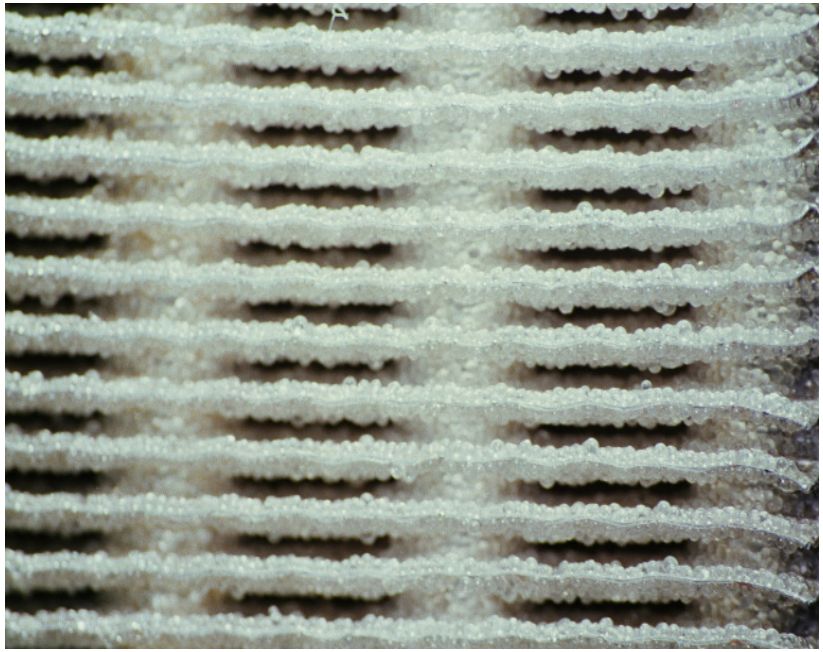


Innovative Coating of Adorber Heat Exchangers

→Epoxy Resin Bonding

(stationary application)

- Heat exchanger surface is pasted with *silica gel* with the aid of epoxy resin
- Optimized processing
- Pilot production is running



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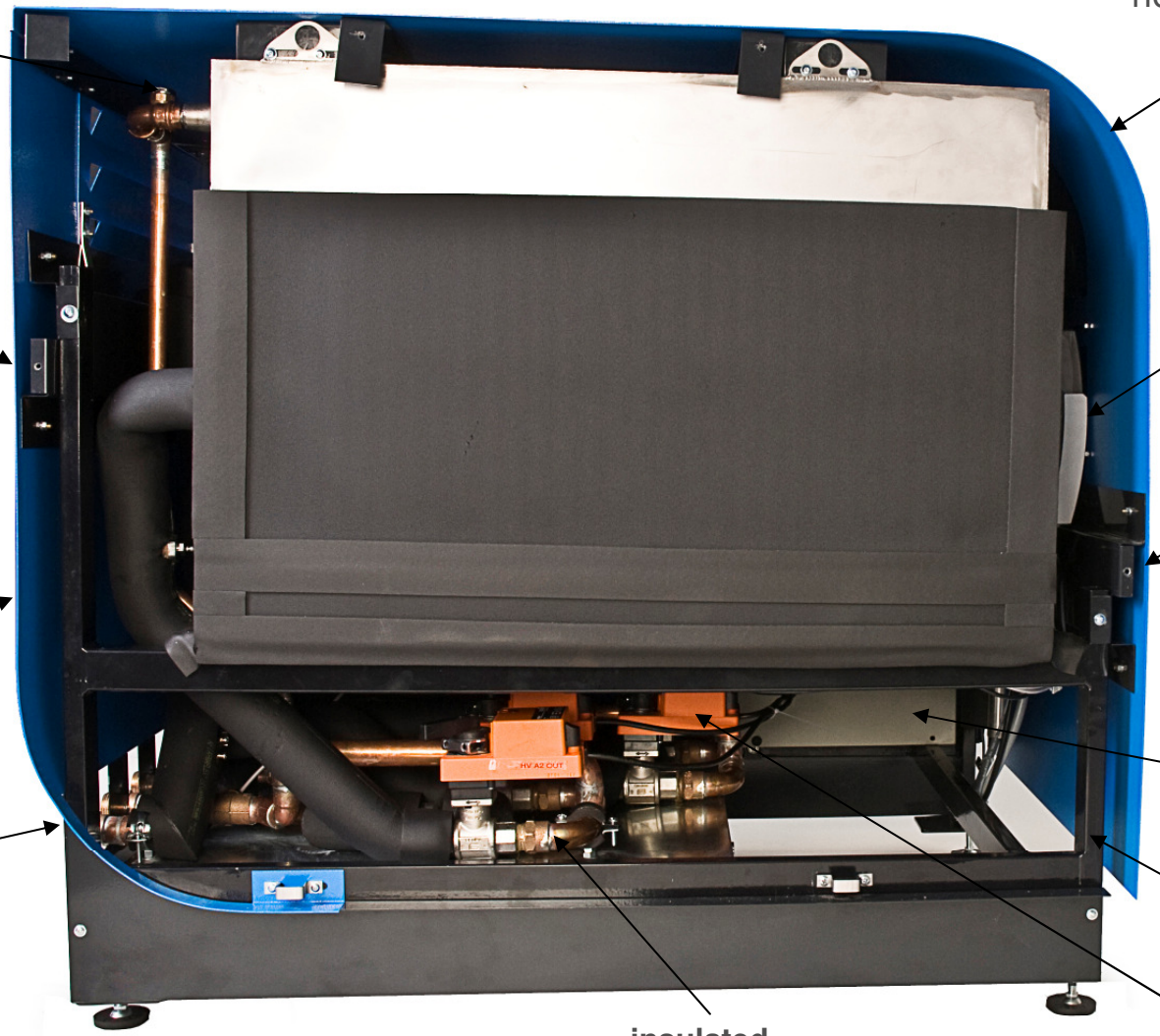
Assembly of the ACS 08



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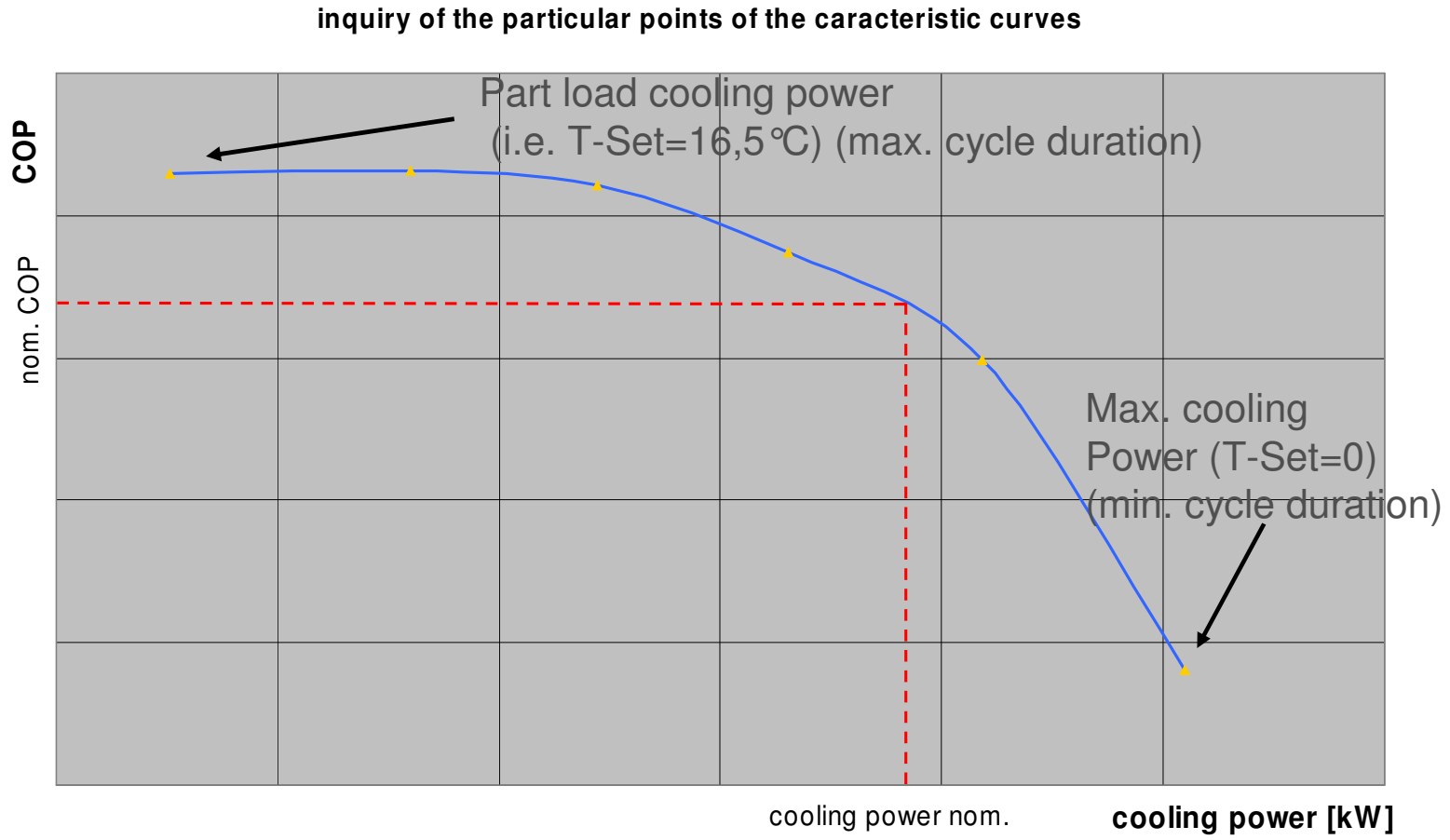
Function

Controlling strategy – „cool down and part load shifting“



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Technical Data - ACS 08

Technical Data (nominal):

Cooling Capacity	7.5 kW
Thermal COP	0.56
Cold Water Circuit	18/15 °C
range	*6…20 °C*
Re-Cooling Circuit	27/32 °C
range	*22…37 °C*
Heat Supply Circuit	72/67 °C
range	*60…95 °C*
Weight	appr.260 kg
Dimensions	790 x 1060 x 940 mm

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Modular design enables a broad range of applications

	Basic module ACS 08	"Twin"-module ACS 15	Parallel connection of multiple modules
			
	7.5 kW	15 kW	60 kW (Example)
Typical applications	• One-family house • Single offices/ apartment	• Larger one-family house • Two family house • 2-3 apartments	• Multi-family house • Small office buildings • Industrial applications
		• Decentralized industrial cooling applications	

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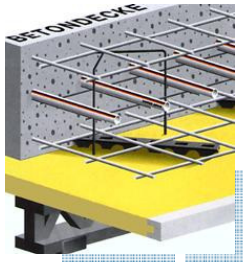
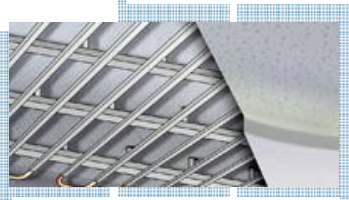
Possible cold distribution in combination with SorTech adsorption machines

- High efficiency at high cold water temperatures (>15°C)
- FanCoil applications suitable for 10/15°C
- 7/12°C possible with wet cooling



Concrete Core activation



Cooling ceilings

Low cooling fans

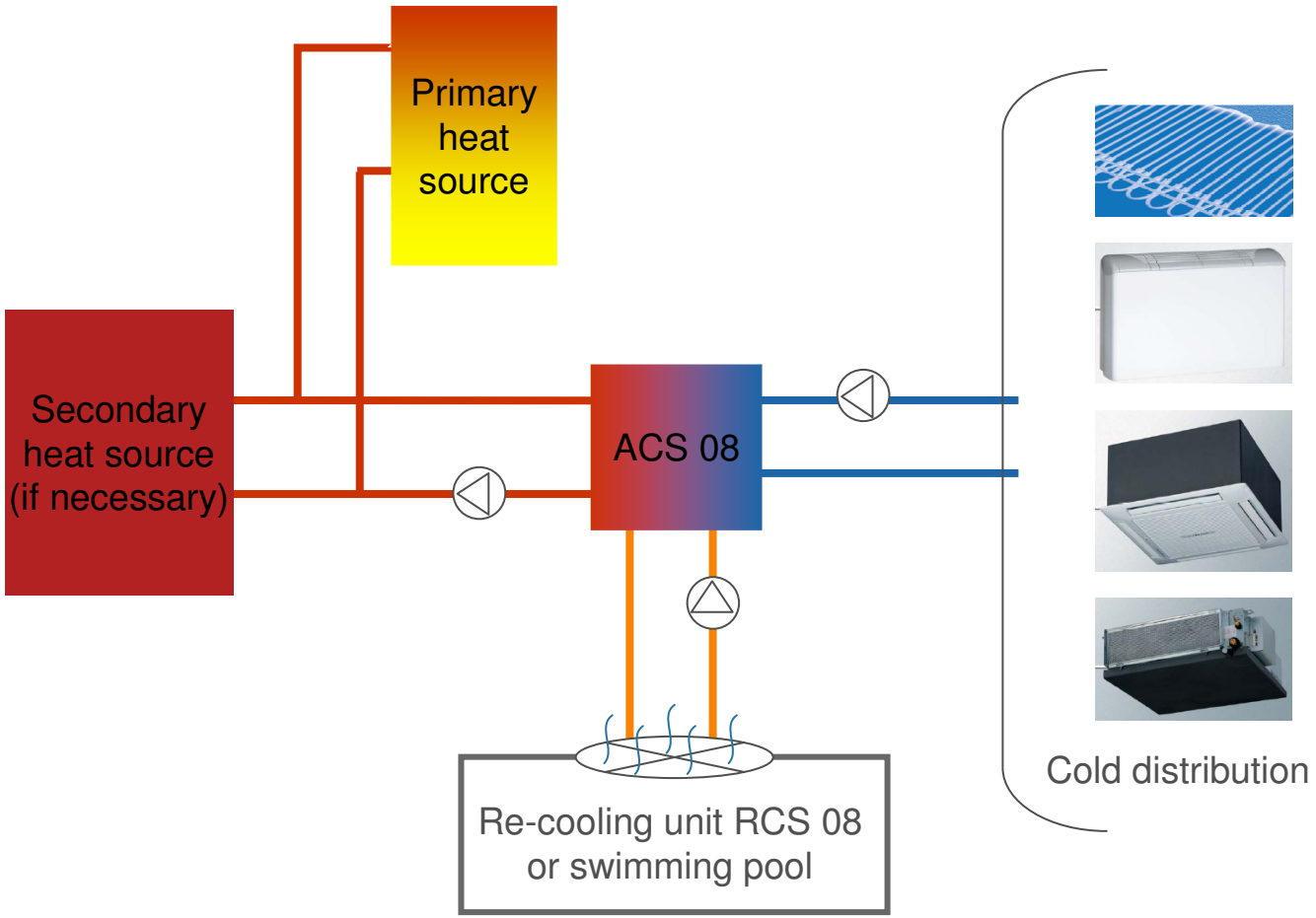
Floor / wall cooling

FanCoil

Cold water spread °C

7/12 **10/15** **15/18** **17/20** **19/22**

Integration of subsystem in an overall system and cold distribution in the building



Chilled-water based cold distribution as main application

- Floor heating / cooling (17/20 or 18/21)
- Concrete core temperature control (17/20 or 18/21)
- Radiant floor (15/18)
- FanCoils (10/15)

Central air-handling units in combination with specific re-cooling solutions (wet cooling tower, bore holes)

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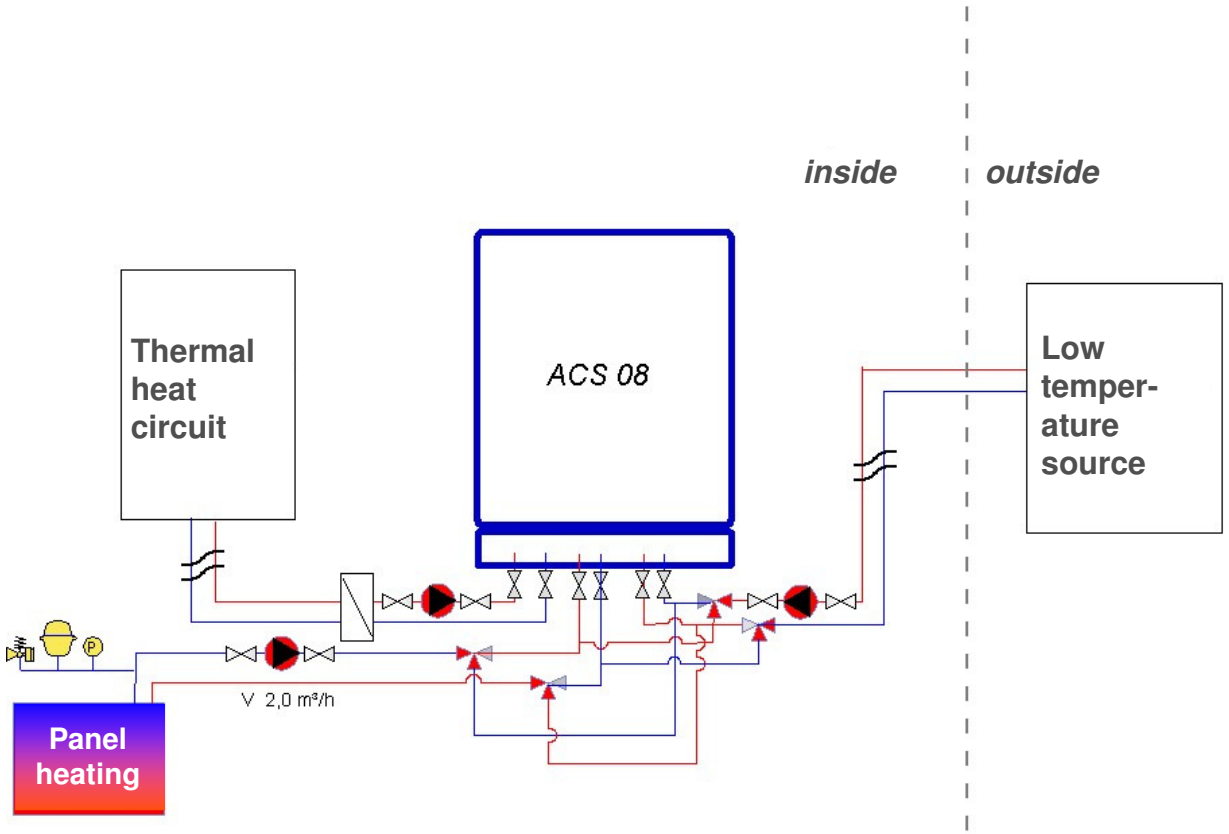
Example Scheme for Heat Pump Mode



- Depending on the low temperature source, the system should be operated with a water-glycol-mixture; in that case an additional heat exchanger is necessary
- Valves for changing hydraulics of LT and MT circuit need to be realized externally

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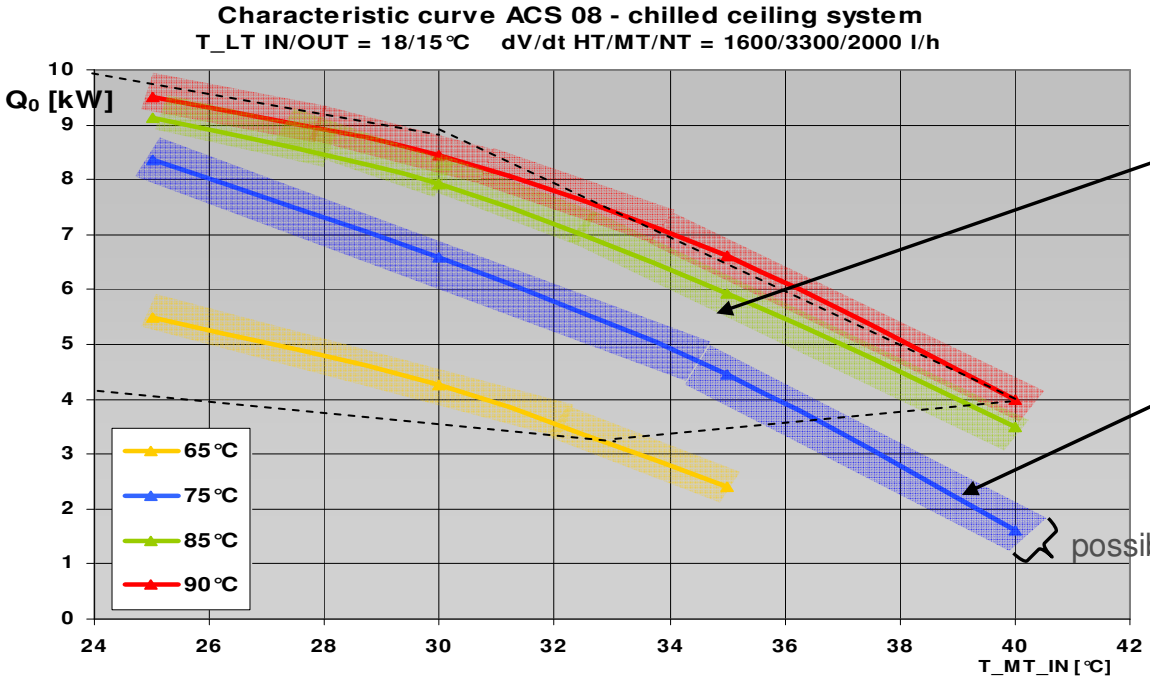
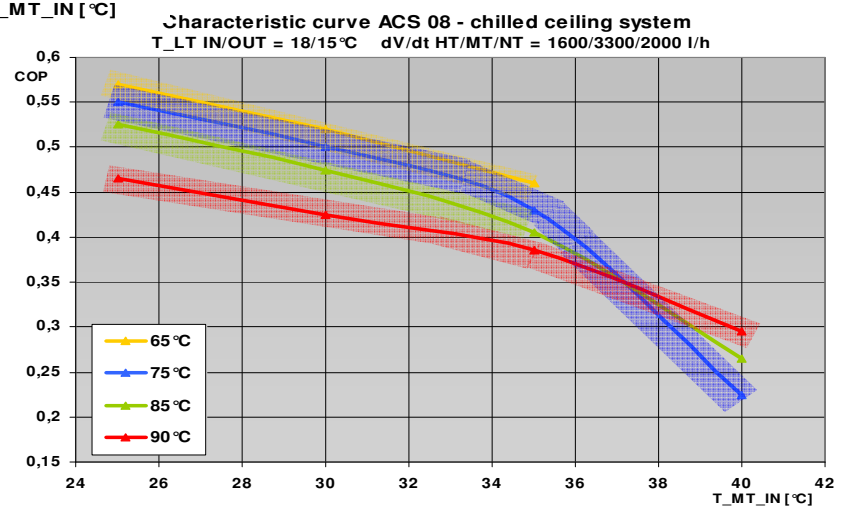
Technical Data – performance curve*



Recommended working range

Average performance curve for system dimensioning

possible range at acertain working point



Case I: chilled ceiling

(average temp spread: 3 K)

(*taken from real measurements)

Performance of cooling system

Performance depends on:

- Cold distribution system (cold water temperature)
- Recooling system
- Driving temperature

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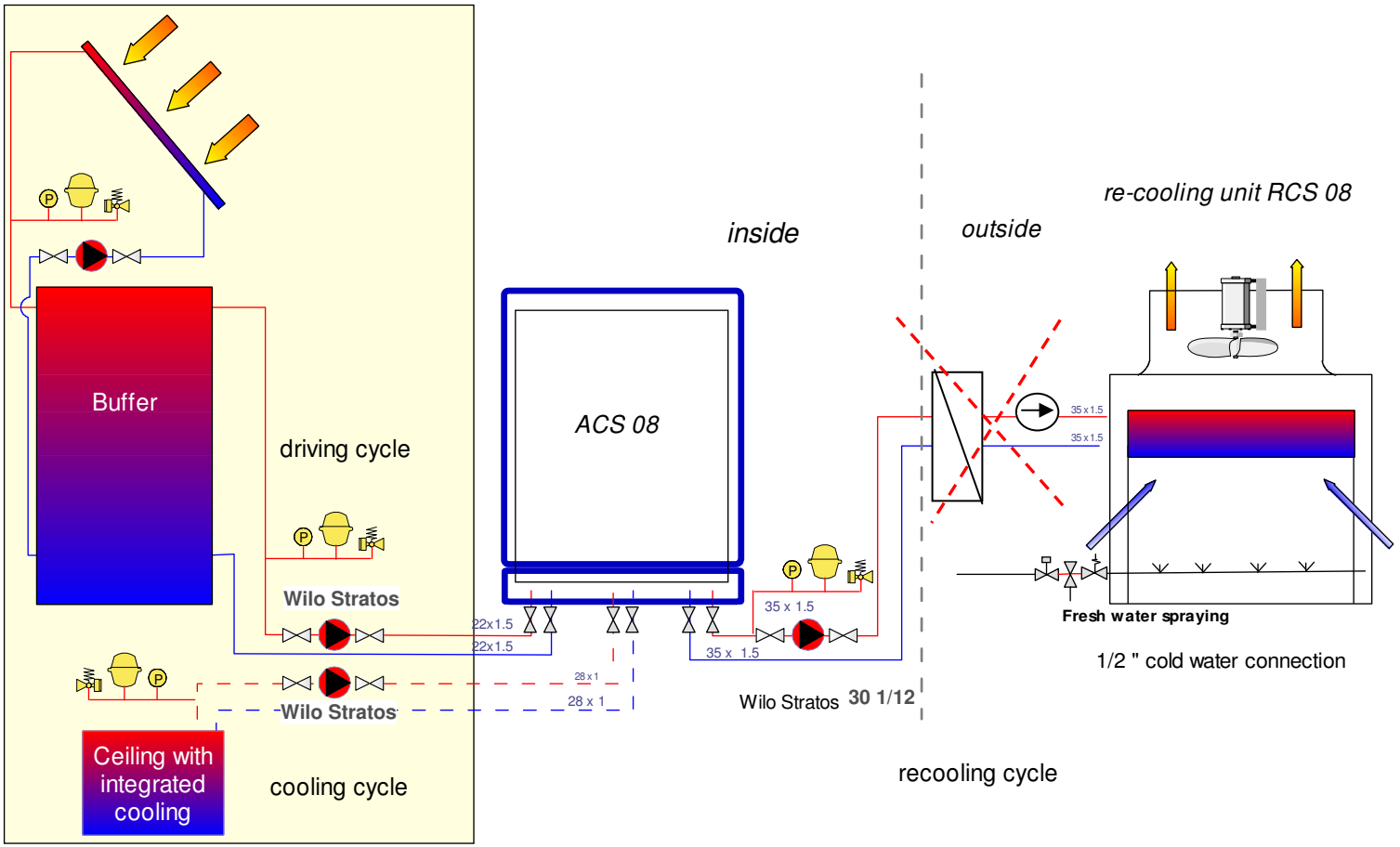
Integration within the SC-system



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Cooling – *Temperature range* - ACS 08

- Solar panel
- District heat
- Micro-cogeneration
- Process heat

60-95 °C

5-10 kW performance

22-37 °C

Re-cooling

6-20 °C

Cooling

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Cooling - *Temperature pairs at nominal conditions* - ACS 08

- Solar panel
- District heat
- Micro-cogeneration
- Process heat

72 °C in
65 °C out

7.5 kW cooling capacity
0.56 therm. COP

18 °C in
15 °C out

Cooling

27 °C
in
32 °C
out

Re-cooling

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Cooling – *Energy flows at nominal conditions* - ACS 08

- Solar panel
- District heat
- Micro-cogeneration
- Process heat

13.5 kW

9 W electricity consumption

7.5 kW

Cooling

21 kW

Re-cooling

Integration within the SC-system

Requirements:

1.) Pumps

→Strictly use high efficiency pumps (Wilo Stratos) in all circuits in order to provide a energy efficient function and to ensure an adequate amortisation time compared to conventional chillers (possible annual system efficiency = appr. 14 vs. compression chillers appr. 3)

2.) Volume flow

→Since the performance of the ACS sensitively depends on sufficient volume flows in all 3 circuits it is necessary to choose the right pipe diameters and to minimize pipe bends and additional pressure losses! (nominal volume flows:

high-temp. circuit:	1.6 m^3/h (-15%)
re-cooling ciruit:	3.7 m^3/h (-10%)
low-temp. circuit:	2,0 m^3/h (-10%)

Only appropriate volume flows ensure the maximum cooling power and COP!

Integration within the SC-system

Requirements:

3.) Fluids

→If possible strictly try to use pure water in all circuits in case of using the ACS 08 only in cooling mode since the lower specific heat capacity lowers the heat transfer to the chiller up to a loss of appr.17% cooling power / COP depending on the mixture rate of glycol.

→Therefore a complete emptying of the outside installation is needed if the ambient temperatures can fall down 0°C. Additional SorTech provides either a thermostatic safety activation of the re-cooling pump or a new device which automatically changes water to a water-glycol-mixture after the end of the cooling period to improve the comfort and security.

→Please note, that inside the ACS during the heat recovery phase HT and MT-fluid is mixed! Therefore one fluid type for both circuits is needed.

4.) Buffer / Storages

→For Solar Cooling applications only a storage in the hot water circuit is needed and used.

→For comfort reasons it may be helpful to add a small storage in the cold water circuit.

Integration within the SC-system

Requirements:

6.) Temperature levels

→cold water circuit

Since the efficiency decreases with a lower cold water temperature driven it should be considered to choose an appropriate cold distribution device. If the cold is used via fan coils a minimum temperature of 10°C should be attempted.

→High temperature circuit

The only limitation to high temperatures is the stability of the 3-way-swiching valves. Therefore the maximum temperature should continuously not rice over 95°C. The minimum temperature for an acceptable performance is app. 60°C depending on the re-cooling temperature. There is no “switch-of-temperature” since i.e. the ACS can not decide if a backup burner should be activated.

→Re-Cooling circuit

It is necessary to provide a lower cold water temperature than the re-cooling temperature. Otherwise the ACS “pumps” hot water to the re-cooling circuit to achieve a positive difference between HT and MT.

Re-Cooling

- The re-cooling circuit is the most important part of the system concerning the system efficiency number since it is the basic difference/addition to conventional chillers.

- Alternative types of re-cooling (swimming pool, bore hole, river-/sea-heat exchanger, wet cooling tower…) may be interesting concerning electricity consumption and investment costs. Details to those projects have to be communicated to SorTech in advance.

- The standard re-cooling device RCS 08, a dry re-cooler with water spray function and speed controlled high efficiency EC-fans, is the optimum of costs, electricity consumption and performance. As well the fan speed as the water sprayed to the air flow is controlled by the controller of the ACS and meets exactly the needs.

- Since the re-cooling circuit is defined as a standard the installation is simple and – if the recommendations of SorTech are realized – mistakes can be avoided.

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Technische Daten ACS 08 und ACS 15

Werte der ACS 08 durch Messungen bestätigt

Fraunhofer Institut Solare Energiesysteme ISE

	Einheit	Nennarbeitspunkt	
		ACS 08	ACS 15
Kälteleistung, nominal	kW	**7,5**	**15**
Kälteleistung, effektiv	kW	**5 - 10**	**10 - 20**
COP, nominal		**0,56**	**0,56**
Kaltwasserkeislauf Temperaturbereich (aus): 6-20°C			
Temperatur ein/aus	°C	**18/15**	**18/15**
Volumenstrom	m³/h	2,0	4,3
Druckverlust	mbar	350	450
Rückkühlkreislauf Temperaturbereich (ein): 22-37°C			
Temperatur ein/aus	°C	**27/32**	**27/32**
Volumenstrom	m³/h	3,7	7,4
Druckverlust	mbar	610	650
Heißwasserkeislauf Temperaturbereich (ein): 60-95°C			
Temperatur ein/aus	°C	**72/65**	**72/66**
Volumenstrom	m³/h	1,6	3,8
Druckverlust	mbar	300	500
Elektrische Spannungsversorgung			
Spannung	V	230 ~	230 ~
Frequenz	Hz	50	50
Leistungsaufnahme Ø	W	9	12
Abmessungen			
Breite x Tiefe x Höhe	mm	790 x 1060 x 940	790 x 1350 x 1450
Gewicht	kg	ca. 260	ca. 510

Änderungen vorbehalten

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Technische Daten RCS 08 und RCS 15

	Einheit	Nennarbeitspunkt	
		RCS 08	RCS 15
Leistung Rückkühlstrang	kW	21	42
Ventilatoren		2xEC Ventilator 650	3xEC Ventilator 650
Schalldruckpegel in 10 m	dB(A)	43	45
Rückkühlmedium		Wasser	Wasser
Wasserverbrauch, max.	l/Bh	20	30
Nennvolumenstrom	m³/h	3,7	7,4
Druckverlust bei Nennvolumenstrom	mbar	150	200
Steuerspannung Standardsignal Drehzahlregelung	V	0 – 10	0 – 10
Hydraulischer Anschluss Eintritt/ Austritt	mm	35,0 * 1,5	42,0 * 1,6
Wasseranschluss (für Besprühung)			
Betriebsdruck	bar	min. 3–6	min. 3–6
Anschluss	mm	22,0 * 1,0	22,0 * 1,0
Elektrischer Anschluss	V	230 ~	230 ~
	Hz	50	50
Elektrische Leistungsaufnahme, max.	kW	0,65	0,89
Abmessungen (BreitexTiefexHöhe)	mm	2000 x 1145 x 950	4125 x 1145 x 950
Gewicht	kg	ca. 188	ca. 330

Änderungen vorbehalten

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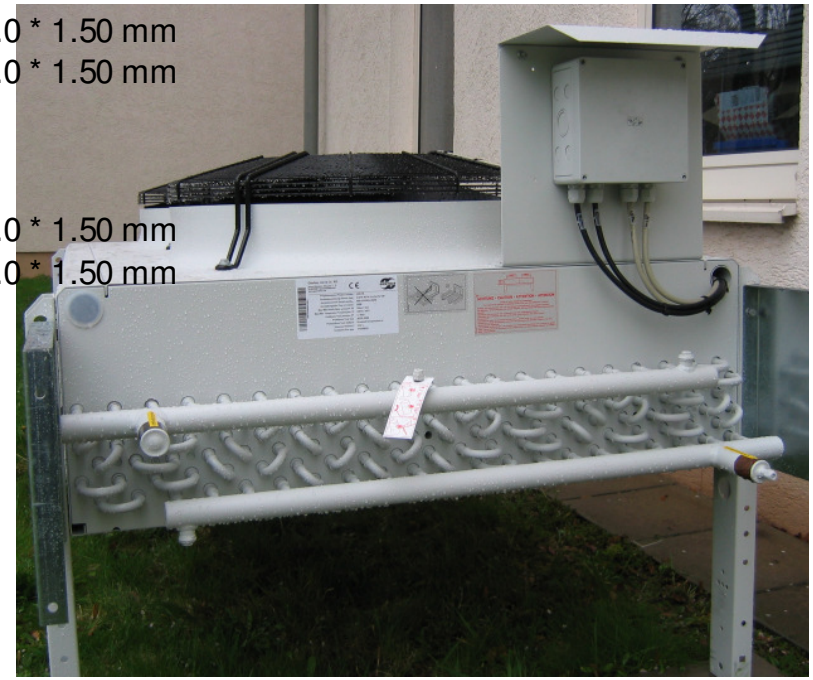
Re-Cooling – RCS 08 (technical data)

fans:	2 x EC	Noise pressure level:	45 dB(A)
		Distance:	10.0 m
		Noise power:	75 dB(A)
All-over power input	0.65 kW	Energy efficiency class:	D
case:	Steel zinc-coated, RAL 7035	Heat Echanger tubes:	Copper
Exchanging surface:	221.4 m²	fins:	Epoxy
volume:	31 l	Connection pipes:	
Fin seperation:	2.40 mm	Inlet:	35.0 * 1.50 mm
Empty weight:	188 kg	outlet:	35.0 * 1.50 mm
Max. operation pressure:	16.0 bar		
Dimensions:[4]			
lenght:	2000 mm	Collecting pipe:	35.0 * 1.50 mm
wide:	1145 mm	Spreading pipe:	35.0 * 1.50 mm
height:	950 mm	Rows:	10
Numer of feet:	4	Circuits:	1N



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Recooling: SorTech RCS family

- Dry recooler with water spray system
- Spraying limited 300 h per year>>100 h full load
- Dry recooling temperature 2°C above ambient temperature
- With spraying equal to ambient temperature
- Very energy efficient (EC technology, machines controls recooler)
- Low water consumption

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Wet cooling towers

- Recooling temperature 3 Kelvin over wet bulb temperature
- Wet bulb temperature maximum 29°C for Andalusia
- Wet bulb temperature maximum 21°C for Germany
- High water consumption
- Danger of legionnaires' disease
- Low recooling temperatures
- Lower investment for high cooling loads >20kW

Other recooling posibilities

Drill hole

- 9-12 °C recooling temperature
- High investment cost

Swimming pool

- temperature depends on ambient temperature
- Difficult when very hot outside
- Good for in-house pools
- Low investment, low electricity consumption (no ventilators)

Sea water, spring, river

- If available good option, low electricity consumption

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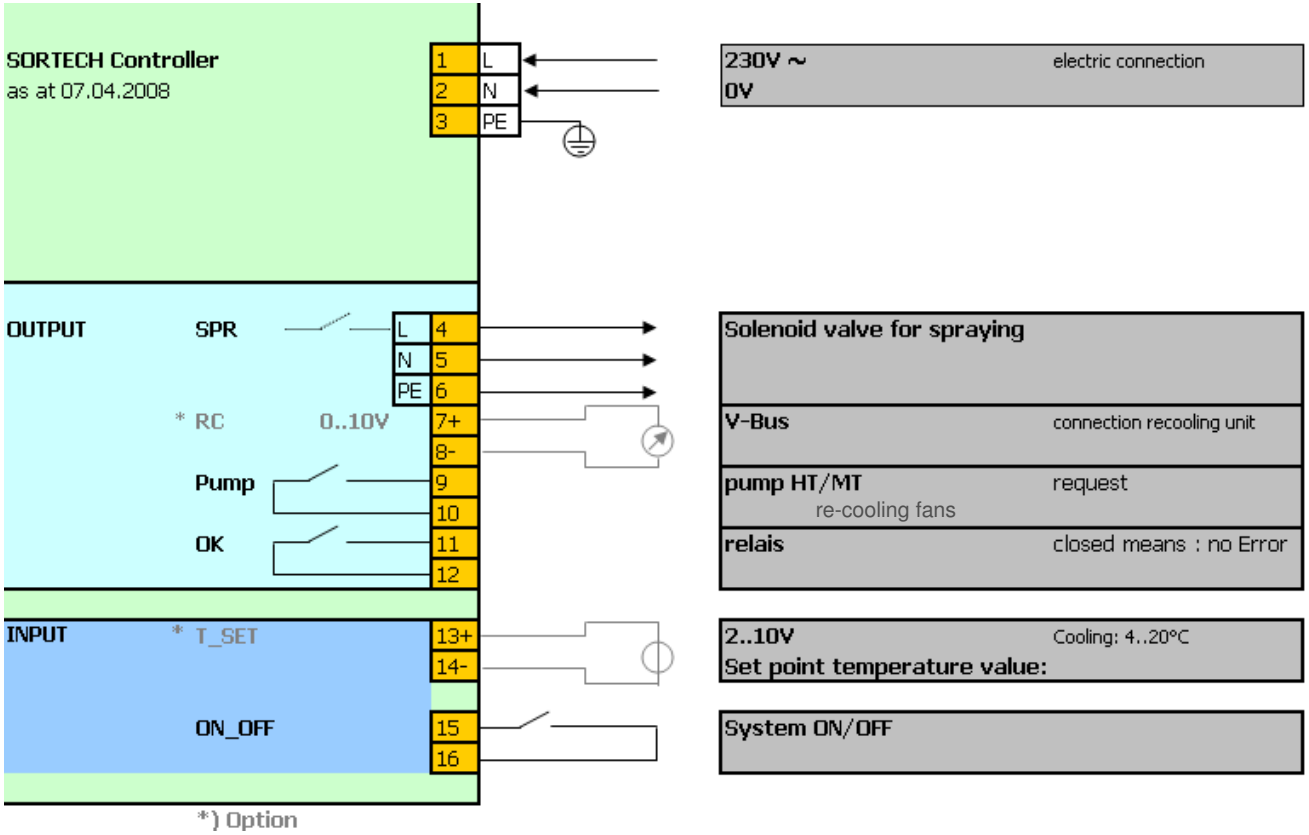
Electrical and signal connection



Output specification:

- Output solenoid valve for spraying: 220…240V, max. 1A switching power
- Output pump demand: potential-free contact, 220…240V (6A)
- reporting relays “ok”: potential-free contact, 220…240V, max. 1A
- 0…10V standard signal

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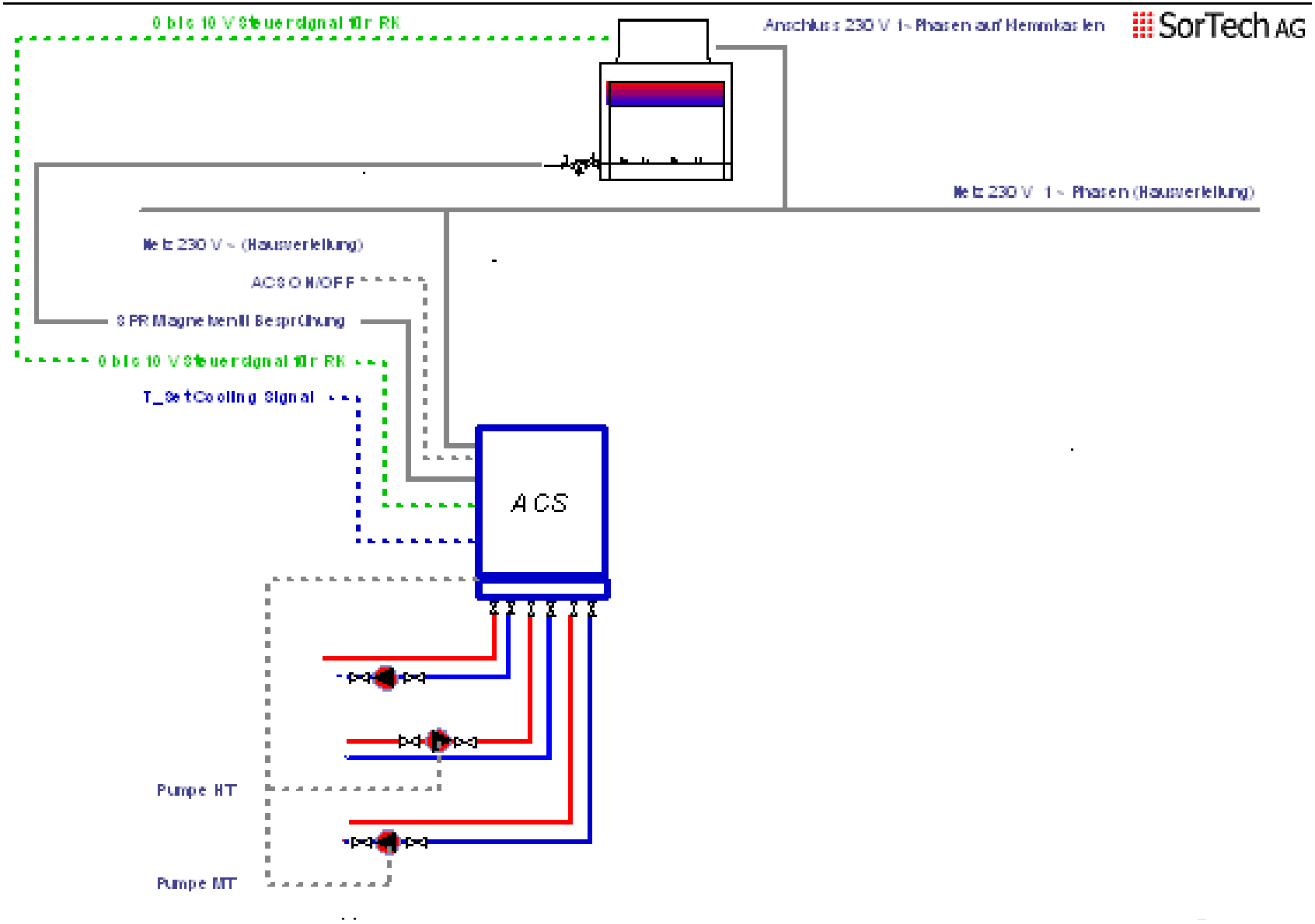
Electrical and signal connection



Controlling strategy

→Two ways to realize the interface user/machine:

1.) „Master“:
-ACS works without a separat controlller
-On/Off and set point adjustion to be done manuell by user
-Pumps and re-cooler controlled by the ACS

2.) „Slave“:
-ACS is connected to a separate controller
-On/Off and set point adjustion done by the separate controller
-pumps and re-cooler controlled by the ACS or the separate controller

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Operation of the ACS 08

Via the controller the ACS can be serviced and influenced:

Main menu:

Line	Content	Meaning	Example
	Main Menu		
1	Measurement data	*Output of measured data*	
2	User Input	*Input of user parameters*	
3	Messages	*Output of system messages*	
4	Manual Use	*Manual use of the system*	
5	Service Menu Code	*After entering the operator code, the service menu is accessible*	*1234*

Operation of the ACS 08

Measurement data Level 0 (User)

Table 5.3.1: Measurement data

Line	Content	Meaning	Example
1	Anlage	Operation	ON
2	Modus	Cooling	cooling
3	Kühlsoll	Set Temp Value cold water outlet	13,0 °C
4	T_LT	Measured temperature (cold water outlet)	12,4 °C
5	Datum	Date	
6	Uhrzeit	Time	
7	Kernversion	Version of the controlling algorithm	2.05
8	Regler SW	Version of the controlling software	1.01

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Operation of the ACS 08

User Input Level 0 (User)

Table 5.3.2: User input for cooling mode

Line	Content		Example
1	ON/OFF		ON
2	T SET (COOLING)	*(manual)*	13,0 °C
3	Date		
4	Time		

Messages (User)

Table 5.3.3: Messages

Line	Content	Significance / Errorcode
1	System ok.	
2	Freeze dV	Flow guard reports no or not enough volume flow in LT_cycle
3	Freeze min T	Temperature LT is below minimal temperature
4	Condensation	LT Temp. is higher than MT-Temp. → Condensation prevention
5	Sensor T_A1	Broken sensing device / short-circuit
	Sensor T_A2	Broken sensing device / short-circuit
	Sensor T_MT	Broken sensing device / short-circuit
	Sensor T_LT	Broken sensing device / short-circuit

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Operation of the ACS 08

Service menu (locked for user)

“Because of changeable parameters concerning operating characteristics, the access to the service menu is denied for users. “

Table 5.3.4: Service menu output parameters

Line	Content A - output	Significance	Range / unit
1	System	State of system	ON
2	Mode	Cooling mode	cooling
3	Phase	current Phase	[V]
4	Cycles	Amount of cycles	[°C]
5	W_set	Changing value for external set point value	[°C]
6	Set cool	Current setpoint value temperature LT	[°C]
7	Set cool ext. **	External setpoint value	[°C]
8	T_LT	Temperature input	[°C]
9	LTS_AVG	Average temperature cooling cycle	[°C]
10	T_MT	temperature Recooling	[°C]
11	MTS_AVG	Average temperature recooling cycle	[°C]
12	T_A1	temperature Adsorber 1	[°C]
13	T_A2	temperature Adsorber 2	[°C]
14	Year of reading	Year of last reading	e.g.7 for 2007
15	t_spray	All over time of spraying	[s]
16	Error code	Errorcode	
17	Date		
18	time		

Errors

Showed errors in the display:

Table 6: Errorcodes and recovery

Message (Display)	Error	Reason	removal
Freeze protection	temperature cold water outlet is understate (→ 0°C) **T_LT_OUT < 2°C**	No cooling load	Withdraw of cold can recover the system when temperature > 2°C
Freeze protection	Volume flow of cold water outlet is understate, no signal from flow guard **dV_LT < 300 l/h**	Failure of LT-Pump, LT cycle contains air	Providing volume flow >300 l/h
Cond-protection	temperature LT outlet is above temperatur MT outlet (Recooling cycle) **T_LT_OUT>T_MT_OUT**	Low re-cooling temperature, high cooling temperature	Can be left after some cycles when normal conditions are reached
T_A1 (A2,LT) failure	Broken sensing device **Temp.-Sensor**	Broken sensing device or failure in wiring	Changing sensing device or broken wiring

Errors

Further problems/errors:

-No significant cooling power:
→vacuum spoiled by inert gas (evacuating necessary)

-ACS does not leave the start phase (11 /12):
→hot water temperature to low (see D133)

-while ACS is in operation cold water temperature decreases till „safety-switch off“:
→nor adequate cooling load (there is no limitation of the c water temperature downward)

…further problems / questions?

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Initiation of the ACS 08

→ The commisioning checklist_I:

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Commisioning Checklist for Adsorption Chiller ACS08

Serial number ACS 08:

Please send a filled copy of the maintenance checklist to SolarNext AG and to SorTech AG

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Fax: +49(0)345 [illegible]

	Place, Date:					
	Commissioned by:					
	Place of installation / customer:					

No.		Test tool or method	product	accuracy of measurement	value	yes/no checked ok	comment / unit
1	[illegible]						
1.1	System on plane level (both sides)?	Spirit level			+/- 2°		
1.2	hydraulic connections tight?						
1.3	Electric power supply installed correct and insulated?						
1.4	Triggering cable "T_Set" and "ON_OFF" connected as described in connection scheme?	compare to service manual page [illegible]					
1.5	Connection of triggering cable for recooling unit? (V-BUS to clamps 7 and 8)	compare to service manual page 17					
1.6	Connection of triggering cable for water spraying? (clamps 4, 5 and 6)	compare to service manual page 17					
2	Connection recooling unit						
2.1	type of recooling unit	Serial number of unit					
2.2	recooling unit on plane level (horizontal)?						
2.3	Electric power consumption each fan?						
2.4	hydraulic connections tight?						
2.5	Electric power supply installed correct and insulated?						
2.6	Connection of triggering cable inside the connection box of the recooling unit?	compare to service manual page [illegible]					

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Initiation of the ACS 08

→ The commisioning checklist_II

3.1		Erasing code for service manual (OFF)	compare to service manual page 20					
3.2		Checking parameter Line x-all	compare to service manual page 20					
3.3		Start/ Stop of the System via external contact possible ? (please x in and out)						
3.4		Is signal "If_Ext" transmitted correctly? Variation of external Signal shown in Controller/Service Menu line 4 ?	compare to messages in service manual page 22					
3.5		Operating mode chosen : Cooling "2" or Heating "1" ?	compare to messages in service manual page 20					
3.6		Entered recooling parameter? (distance of spraying for size of installation ?)	compare to service manual page 20					
3.7		Are there any Error codes ? (purge : "System ok")	compare to messages in service manual page 20					
4.1		Close valve of the vacuumpump and vacuumpump running approx. 20 min . Flange of drainage of the ACS keeps closed.						
4.2		Open valve of the vacuumpump for evacuating vacuum hose to 0 mbar	manometer					mbar
4.3		Close valve of vacuumpump and turn plug out of the drainage flange; manometer at vacuumpump shows pressure of the ACS08 for evacuation.	and pressure reached:					
4.4..		Open valve of the vacuumpump and evacuate for approx... 10 minutes.	and pressure reached:					mbar
4.5		Turn plug into drainage flange, close valve of the vacuumpump and keep running vacuumpump for approx. 20 minutes.						
5.1		All hydraulic cycles are filled to pressure of 3 bar and bled out						
5.2		Starting LT-,MT-, HT- Pumps one after another keep bleeding and flushing.						
5.3		System bled out correctly?						
5.4		Volume flow:	HT	volume flow sensing device				ml/h
5.5			MT	volume flow sensing device				ml/h
5.6			LT	volume flow sensing device				ml/h
5.7		Type of Pumps:	HT					
5.8			MT					
5.9			LT					

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Initiation of the ACS 08

→ The commisioning checklist_III

7.	Recooling cycle					
7.1		Temperature limit:				
7.2		Power , all-over:				
7.3		Controlled by? :				
8.	Driving cycle					
8.1		Temperature limit:				°C
8.2		power, all-over:				kW
8.3		Size of buffer:				m³
8.4		Size of collectors :				m²
8.5		Backup burner:				
9.	Cold water cycle:					
9.1		Temperature limit:				°C
9.2		Power, all-over:				kW
9.3		Controlled by?:				
10.	Test run	T_HT_IN: °C	T_MT_IN: °C	T_LT_IN: °C		
10.1		Read out Cycle Counter fill in value into checklist	compare to service manual page 22			
10.2		Running 3 whole cycles, cycle Counter has to increase by 3		T_MT_OUT: T_LT_OUT:		°C

SorTech AG

Initiation of the ACS 08

→ The commisioning checklist_IV

10.	Test run	T_HT_IN: °C	T_MT_IN: °C	T_LT_IN: °C			
10.1	Read out Cycle Counter fill in value into checklist	compare to service manual page 22					
10.2	Running 3 whole cycles, cycle Counter has to increase by 3		T_MT_OUT:	T_LT_OUT:			°C
11.	Evacuate (2)						
11.1	at T_HT > 70 °C and constant, T_LT as low as possible and constant		T_HT_IN:	T_MT_IN:			°C
11.2	Start Activation (Activation has to be set in service Menu)	30 min	T_MT_OUT:	T_LT_OUT:			°C
11.3	Open valves of vacuumpump and vacuum flange and evacuate	approx. 5 min, end pressure [mbar] has to be filled in Checklist					mbar
11.4	Turn plug into vacuum flange, close valve of the vacuumpump		T_MT_OUT:	T_LT_OUT:			°C
11.5	Keep running vacuum pump for approx. 30 minutes		T_MT_OUT:	T_LT_OUT:			°C
11.6	End Activation (Activation has to be ended in service Menu)						
12.	Functional test	T_HT_OUT °C	T_MT_OUT: °C	T_LT_OUT: °C			
12.1	Read out Cycle Counter and fill into checklist	compare to service manual page 22					
12.2	Running 5 whole cycles, cycle Counter has to increase by 5	temperatures after 5 cycles	T_MT_OUT:	T_LT_OUT:			°C
12.3	Check: LT, ... cooling load ... [illegible] ACS 08 is released						
12.4	Check: LT- stop pump LT --> release freeze protection by flowguard of the ACS 08						
12.5	Variate set point value temperature T_Set (Change of T_Set_Ext has to be shown in service menu line 4 and different outlet temperature has to arise)		T_MT_OUT:	T_LT_OUT:			°C
12.6	Activation of heating mode if feasible, check if T_SET is changing (25 - 60°C)						
12.7	Checking [illegible] system						
13.	Comments, Legend:						
	T_HT_IN: Inlet temperature driving cycle T_HT_OUT: Outlet temperature driving cycle T_MT_IN: Inlet temperature recooling cycle T_MT_OUT: Outlet temperature recooling cycle T_LT_IN: Inlet temperature cooling cycle T_LT_OUT: Outlet temperature cooling cycle						
14.	Name:						
15.	Date:						
16.	Sign:						