Addendum

Cooling of humid air below 0°C with formation of condensation

In the software AHH (Air Humid Handling), which includes the Mollier-HX-Diagram and the Carrier-XH-Chart, only the unsaturated area is treated. The following therefore applies:

Description	Equation	Uit	Example	Example
Molecular wight of water	$M_w = 18.015$	kg/kMol	---	---
Molecular wight of air	$M_l = 28.949$	kg/kMol	---	---
Air pressure	p_{lf}	Pa	101325.000	101325.000
Temperature of air humid	t	°C	20.000	-20.000
Partial pressure of water steam	p_d	Pa	2340.000	103.450
Heat capacity of air	cp_l	J/kgK	1006.450	1006.000
Absolute humidity of air	x	kg/kg	0.004000	0.000626
Maximal absolute humidity of air	$x_s = \frac{M_w}{M_l}\frac{p_d}{p_{lf}-p_d}$	kg/kg	0.014711	0.000626
Vaporization heat of water	$r_{o(0°C)} = 2500500.000$	J/kg	---	---
Heat capacity of water	cp_d	J/kgK	1841.400	1832.500
Enthalpy of humid air	$h_{lf} = cp_l t + x(r_o + cp_d t)$	J/kg	30278.312	-18577.630
Mass flow of humid air	$\dot{M}_{lt}$	kg/s	1.000	
Capacity with humid air	$\dot{Q} = \dot{M}_{lt}\Delta h_{lf}$	W	48855.942	

In the software for calculating air coolers, where the outlet is below 0°C and condensate forms, the frost capacity is determined and must be added to the overall cooling capacity.

Solidification heat of water	$s_{o(0°C)} = 333100.000$	J/kg	---
Maximum amount of freezing water	$\Delta x_{max} = x_{ein} - x_{aus}$	kg/kg	0.003374
Maximum frost capacity	$\dot{Q} = \dot{M}_{lt}\Delta x_{max} s_0$	W	1123.879

Effective frost capacity

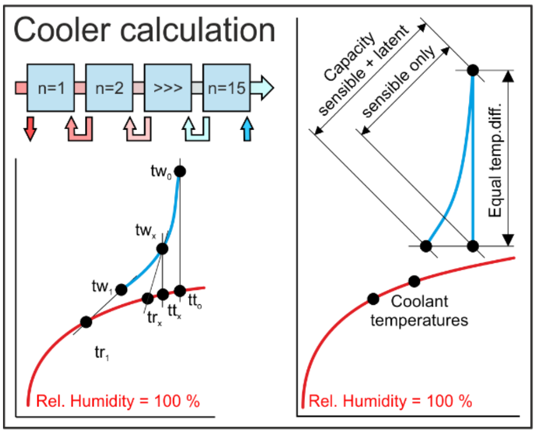
However, the effective frost capacity can be less than the maximum frost capacity, unless all the condensate freezes in the cooler.

That is the reason, why the cooling process is calculated in 15 partial steps in air direction with regard to the cooler installation depth.

The cooler surface temperature is determined in each sub-step.

If this temperature is above 0°C and condensate accumulates, it will not freeze.

If this temperature is below 0°C and condensate accumulates, it freezes.



On the next page is a calculation of the finned heat exchanger, made with the Excel based application.

Cooler: 50/50/15-16R-18T-1200A-6.4PA-9C-Cu/Al/AISI 304				Software by www.zcs.ch
Capacity	kW	49.979	------ sensible:	40.295
Surface reserve	%	0.660	latent:	8.560
Present surface	m2	259.923	frost:	1.124
Required surface	m2	258.219		
k-coeff.	W/m2K	8.333		
Average temp. diff. (94.18 %)	K	23.227		

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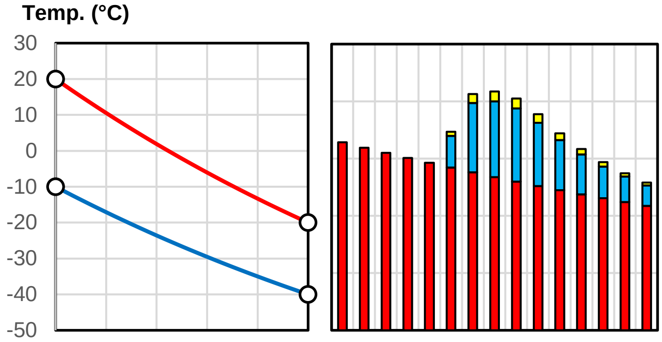
Plant
Object
Position

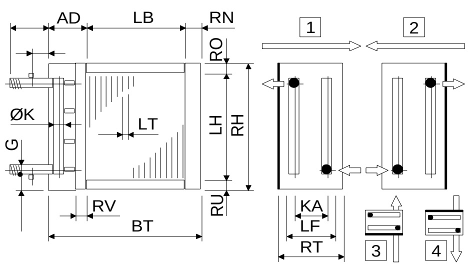
Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	20.000	-20.000	20.000
Rel. humidity	%	27.740	100.000	40.000
Abs. humidity	g/kg	4.000	0.626	5.784
Density humid	kg/m3	1.201	1.394	1.200
Enthalpy humid	kJ/kg	30.277	-18.578	34.805
Volume flow humid	m3/h	3009.582	2584.941	3018.157
Mass flow dry	kg/h	3600.000	3600.000	3600.000
Condensate flow	kg/h		12.145	
Surface temperature	°C	13.887	-24.075	
Velocity	m/s	0.774	0.665	0.776
Pressure drop (dry 42 Pa)	Pa		44.910	

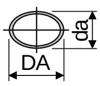
Temper -40 (ff = 0.00005 m2K/W)		
Temp. Inlet	°C	-40.000
Temp. Outlet	°C	-10.000
Temp. Selection	°C	-29.050
Density	kg/m3	1224.491
Spec. heat	kJ/kgK	2.879
Heat cond.	W/mK	0.411
Viscosity	Pas	2.242E-02
Volume flow	m3/h	1.701
Velocity	m/s	0.314
Reynolds	---	250.123
Pressure drop (T/C = 7.419)	kPa	48.182



Technical data — Frost thickness 1.34 mm - Defr. cycle 12.00 h - Defr. time 0.62 h - Availability 94.80 %

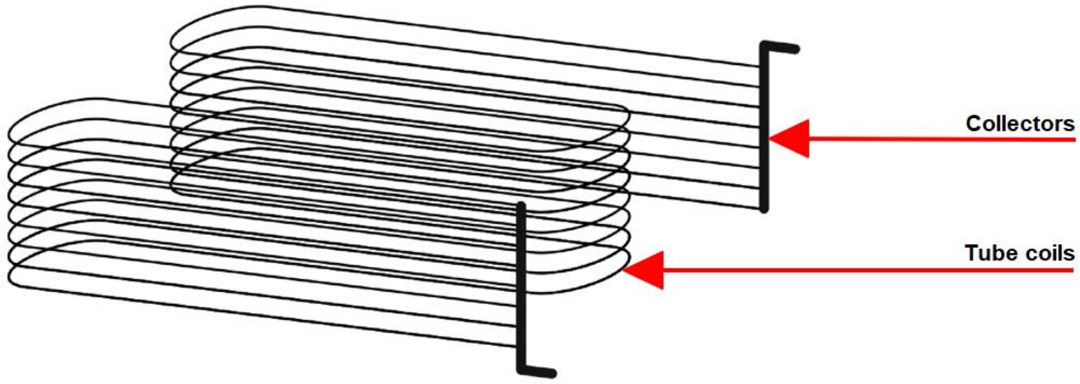
Tubes total		Piece	288	Tubes:	smooth	Cu
Tubes blank		Piece	0	Tubes:		in line
Int. vent./drains		Piece	0	Tubes:		circular
Tube rows on the depth		Piece	16	Collectors:	0.96 m/s	Cu
Tube rows on the height		Piece	18	Connections:	0.96 m/s	Rg7
Tube coupling in series		Piece	32	Fins:	smooth	Al
Number of circuits (NC)		Piece	9	Frame:	2.0 mm	AISI 304
Volume		l	66	Circulations:	1	Default
Weight		kg	212	Protection:		without
Connections	G	---	1"	Protection:		---
Frame height	RH	mm	980	Air flow direction:		horizontal
Frame width	BT	mm	1379			
Frame depth	RT	mm	820			
Finned height	LH	mm	900			
Finned width	LB	mm	1200			
Finned depth	LF	mm	800			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~65mm)	RN	mm	65			
Collector-Diameter	K	mm	28			
Collector covering	AD	mm	114			
Collector distance	KA	mm	750			
Fin spacing	LT	mm	6.400			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	15.400	Delivery:		5-6 weeks
Tube diameter	da	mm	15.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	50.000	Payment:		30 days net
Tube interval on the depth	S2	mm	50.000	**Price net:**	**With el. rods**	**EUR 4713.00**





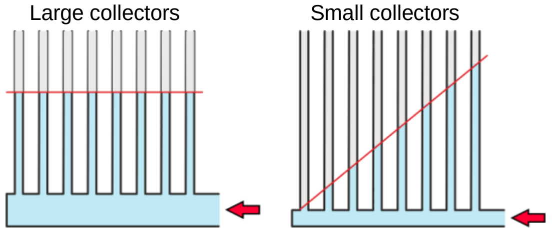
El. heat rods:27 x ø 8.4 x 1300 mm à 800 W
Frost thickness: 1.338 mm
Fin spacing: 2x12.0+14x6.0 mm

With the optimal pressure drop ratio heat exchanger tubes (HET) to collectors (COL), it is important that all heat exchanger tube coils receive the same amount of liquid. This is the only way to achieve an optimum performance of the heat exchanger. This means that the pressure drop in the HET must be higher than in the COL. So it's about the pressure ratio (HET/COL), which should ***exceed the quotient of 5***. So if you really want to worry about optimal liquid distribution, turn to air heaters and air coolers with collector diameters that are too small, but certainly not to heat exchangers for heat recovery systems, where pressure drops of 2 bar per heat exchanger are the standard and therefore the pressure ratio (HET/COL) far ***exceeds the quotient of 20!***



We pointed this out above, that the pressure drop in the heat exchanger tubes must be large and in the collectors small, so that all heat exchanger tube coils receive the same amount of liquid and that this is the only way to achieve an optimum in terms of the performance of the heat exchanger can achieve. ***The ancient Romans already knew this, called it the communicating effect and used the principle for inner-city pressure tubes.***

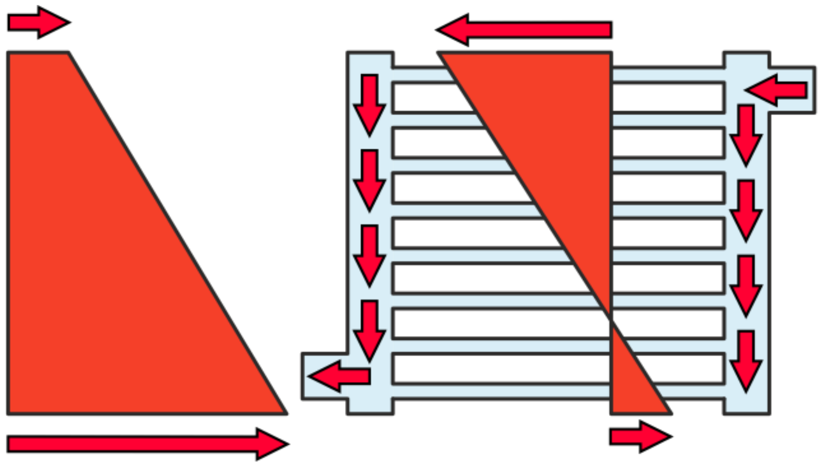
This fundamental basic knowledge must have been swept under the carpet for some manufacturers of finned heat exchangers, like many others, and most likely only for price reasons.



Extensive ***laboratory measurements at a Swiss university*** have shown, what happens, when the diameter of the collectors is too small. The pressure profile in the collectors is of decisive importance with regard to the velocity distribution in the heat exchanger tubes.

Top heat exchanger tube: High inlet pressure, low outlet pressure, high speed in the direction of the outlet
Bottom heat exchanger tube: Low inlet pressure, high outlet pressure, **low speed in the opposite direction in extreme cases**

Pressure in the outlet collector **Velocity in the heat exchanger tubes** **Pressure in the inlet collector**

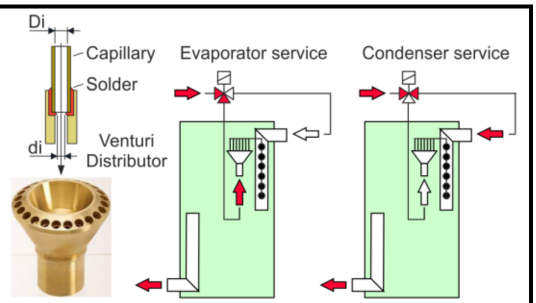


This represents the ***sub-optimal approach of so-called engineers***, to generate performance deficits and is practiced primarily in air conditioning units with built-in air coolers with a small temperature difference of 6/12°C and therefore very large amounts of cooling medium. Because on the one hand the installation dimensions and on the other hand the maximum permissible air velocities are specified, far too often collectors are chosen, that are far too small. It is therefore of central importance ***to maintain the pressure ratio (HET/COL) > 5***, which is only possible if the software calculates both pressure drops separately and also reports them.

A completely ***different kind of even distribution*** of the refrigerant mixture of liquid and gas is necessary with injection evaporators because there ***the pressure drop in the tube coils has to be very small***.

Therefore, Ventui distributors and capillaries are used, which ***generate a very high pressure drop of several bar*** and, together with the throttle valve, have to overcome the pressure difference between the condenser and the injection evaporator.

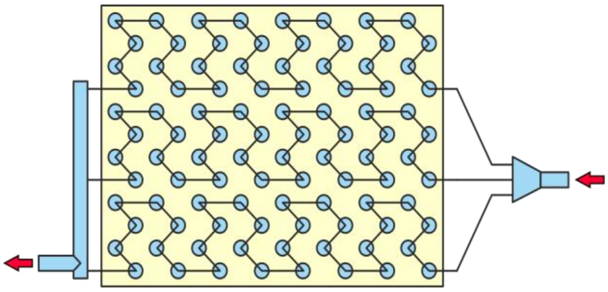
However, this only works correctly if the Venturi distributor ***is arranged vertically*** and the refrigerant is supplied from bottom to top. Furthermore, deflections in front of the Venturi distributor must have a ***correspondingly large distance***.



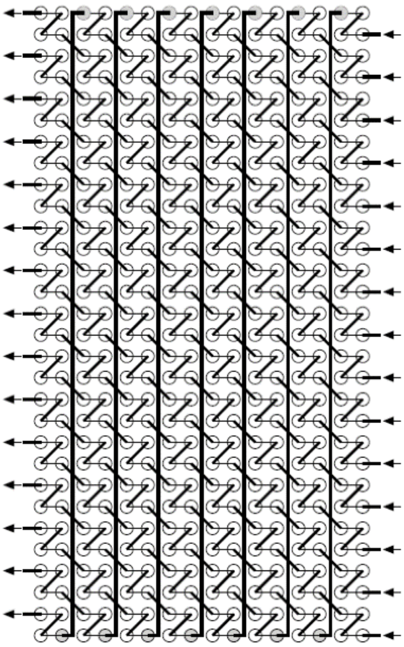
Should someone come up with the stupid idea of using this Venturi principle in heat exchangers instead of a collector, the pressure drop at the inlet would increase, which would result in ***poorer distribution of the liquid*** to the individual tube coils. Furthermore, this interconnection ***could neither be emptied nor vented***.

Many manufacturers of heat exchangers have had our software compared with measurements at TUEV and received the type examination, ***which proves that our software delivers correct results***.

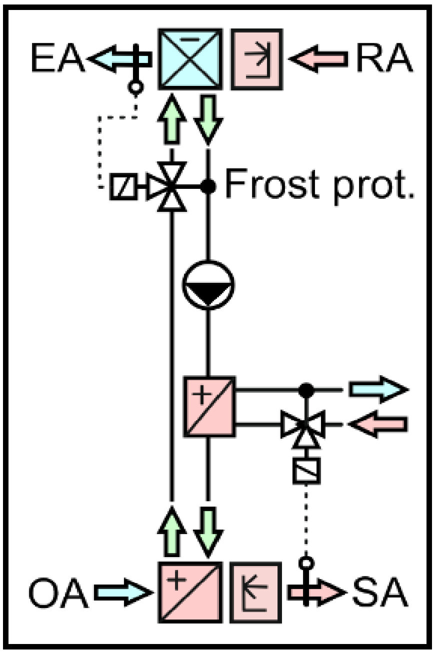
However, there are also companies that ***adorn every offer with a TUEV stamp***, even though they cannot produce a type examination. They have only passed the ISO 9001 test at the TUEV.



Internal hydraulic connection with a maximum proportion of counterflow, invented in 1985 by Grad.-Eng. Marin Zeller TU, VDI, owner of ZCS, see software CCSX.



Heat recovery system CCSD, which reaches the required supply air temperature.



However, this does not mean, that we would even begin to claim, that we can achieve a heat recovery efficiency of 100%. We leave such nonsense to ***so-called engineers***, who publish such monstrous claims about integrated heat pumps, and worse, ***find even more stupid buyers!***

Based on the SFP (Specific Fan Power), we have created the term ***SRP (Specific Recovery Power)***, which states how much power, based on the amount of air, a heat recovery system requires, on winter, summer and according to DIN EN 308. The unit is W/(m3/s).

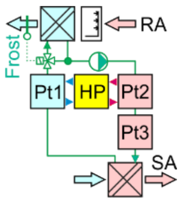
Standard systems, like CCS-B, -D, -F, -J, -K, -M: ***SRP ~ 300 W/(m³/s)***

This says enough about the nonsense caused by the CCSE or CCSN systems with a power requirement of ***7 to 11 times higher***.

In addition, it should be noted, ***that the exhaust air freezes in winter*** if the heat pump were not switched off.

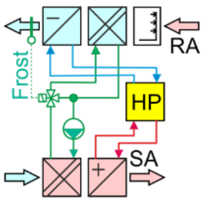
System CCSE

SRP > 2'000 W/(m³/s)



System CCSN

SRP > 3'000 W/(m³/s)

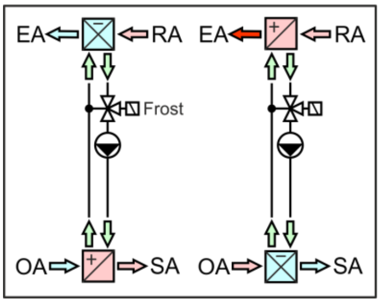


An optimal heat recovery system must therefore have a pressure drop of 2 bar per heat exchanger in order to achieve a maximum of performance. In addition, there is the hydraulic system with a further 2 bar pressure drop. In total, a pressure drop of 6 bar is up for debate, which is not a problem, when choosing the right pump. Nevertheless, far too many ***so-called engineers*** choose centrifugal pumps with a non-linear characteristic. Those familiar with the subject choose gear pumps from www.maag.com with absolutely linear characteristics. This means, for example, that when the speed is reduced to 50%, the flow rate is exactly 50%, so regulation is very easy.

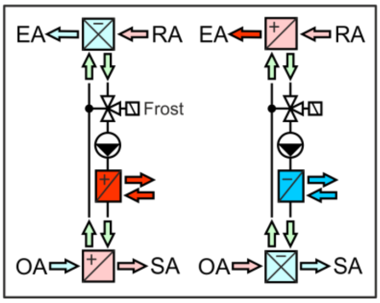
We would like to provide you as reader, with a reference to www.unilab.eu, where it is written: *Unilab is a 100% Italian owned independent software house, and for over 30 years has been providing its clients with high quality heat transfer software. Our solutions are the result of technical and scientific experience, plus extensive IT knowledge, always at the forefront of innovation!* ***We are the only software house with an in-house thermal engineering department****, allowing us to speak the same language as your technical department. Our solutions are used by over 400 customers in more than 65 countries!*

At Unilab, you don't take it too seriously, ***since we have been operating as a neutral software house in exactly the same market since 1987 with currently 7'500 licenses*** and the owner has been exclusively concerned with thermodynamics for heat exchangers and the development of software since 1970. A previous study at a leading Swiss university of applied sciences was completed with a diploma laboratory thesis on an ammonia refrigeration machine with top marks. ***Several of our customers were dissatisfied with Unilab after a short time and bought our software afterwards.*** The calculation of injection evaporators is said to be problematic. With regard to heat recovery, only a minimum should be offered. However, precisely in this regard, the market requires a variety of different systems.

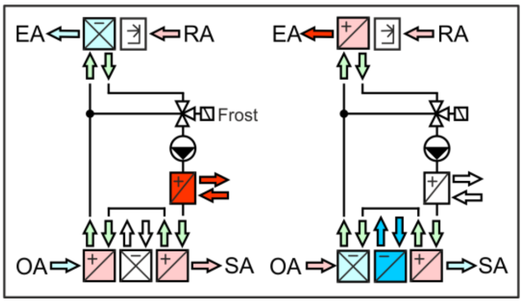
Market is falling continuously
System **CCSB** for winter and summer



Market share is increasing continuously
System **CCSD** for winter and summer



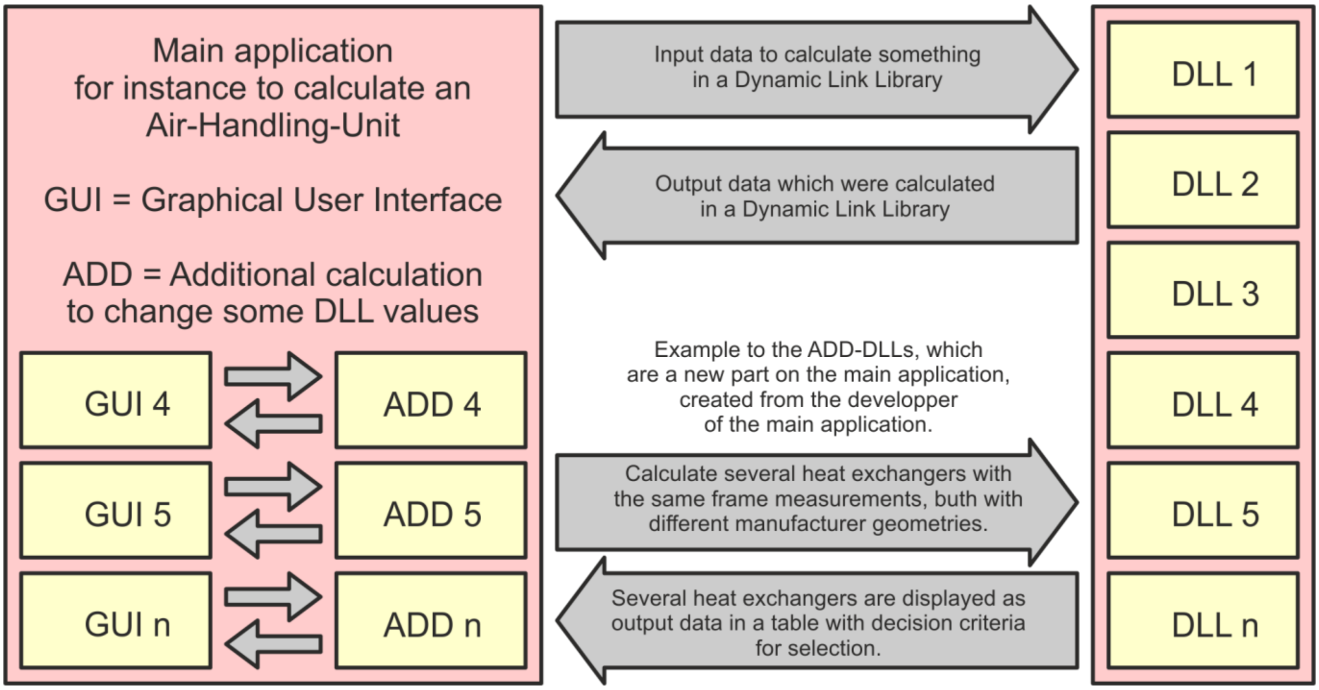
For high dehumidification of the supply air in summer
System **CCSF** for winter and summer



Now the only question, that remains, is why we offer ***all heat recovery systems in Excel and not in high-level language***. The main reason we would like to mention is, that the focus was on the user-friendliness of these extremely complex programs, which could only be accomplished in Excel. Our customers for these Excel-based applications are divided into two groups.

At ***manufacturers of finned heat exchangers***, several employees work several hours a day with these Excel-based applications, to create offers for their customers, most of whom are manufacturers of air conditioning units. The majority of this customer group purchased the unprotected Excel-based applications, in order to be able to implement individual adjustments and extensions. We offer a hand in the form of an ***agreement*** to be signed.

Things are different for ***manufacturers of air conditioning units***. Either you have these heat recovery systems offered by several manufacturers of finned heat exchangers, which takes time and can lead to uncertainties, especially with the smallest changes, or you design these heat recovery systems yourself with our unprotected Excel-based applications, to play it safe sure to go. In your main application programs for calculating air conditioning units, in so-called ***configurators***, you have ***two DLLs from us, one for the air heater and one for the air cooler***, since all of our heat recovery systems only consist of these two components. These components can be entered there in the simplest way, in order to then automatically calculate several manufacturer geometries with the same frame dimensions and to be able to ***make a selection***, based on various decision criteria. The manufacturer geometries are an integral part of our two DLLs and can be freely selected.



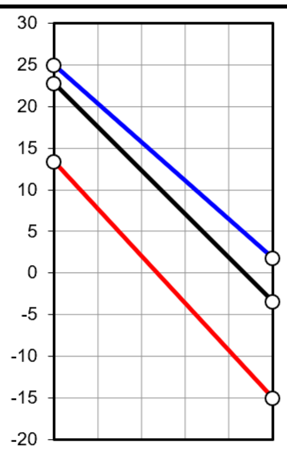
There is tax-free software, where you have to find frequently, that if something does not cost anything, this is also not a lot of value. There is software, which costs only half of it, where you have to say, that this software perhaps offers even half the possibilities only. There is our software, which is used by more than 5’000 engineers worldwide. It can be selected between single licenses and network licenses. In which the price for network licenses depends on how many users want to use the software at the same time at any workplace in the entire network.

Beware of dubious suppliers of heat recovery systems

We regularly receive documents from companies, that don't want to believe the kind of bullshit they've been offered in this regard, even though their website ***says, that they're specialists in heat recovery***. Since these screwed-up companies know, that we know something about this, they'd like to have our take on it. Since we don't want any legal problems, we won't name any names, just facts that can be verified at any time.

The requirement at sea level was:
Temperature efficiency 71%
Supply air 28680 m3/h from -15°C / 90%
Exhaust air 25230 m3/h at 25°C / 40%

Was offered:
Supply air heating to 13.3°C at 126 Pa pressure dro
Exhaust air cooling to 2.5°C / 97% at 121 Pa pressure drop
30% ethylene glycol -3.4 / 22.8°C, 9.54 m3/h, 101 kPa pressure drop per heat exchanger
9 rows of tubes in depth and 54 tube layers in height, 24 circles
Staggered copper tubes of 12.4x0.35 mm, pitch 32 / 27.713 mm
Aluminum fins of 0.15 mm, supply air pitch 2.0 mm, exhaust air pitch 2.6 mm
Laminated height 1728 mm
Laminated width 2000 mm
Frame galvanized 2 mm
Power 272.8 kW
Supply air heat exchanger: 365 kg, EUR 4'400.-
Exhaust air heat exchanger: 323 kg, EUR 4'100.-



The fact, that something must be ***fundamentally rotten***, is already evident from the temperature diagram, since the ethylene glycol is far too close to the exhaust air cooler, which also has less surface area. A recalculation shows, that the supply air heater has a 5% surface reserve and ***the exhaust air cooler has a surface deficit of 99%***, see page 7. ***Effectively, only a temperature efficiency of 56.3% and a capacity of 215.7 kW are achieved, which means, that this enormous Bullshit proves it***, see page 8. In fact, with 18 rows of tubes in depth, ***heat exchangers that are twice as large would be necessary***, which is why we received this case for assessment, see page 9.

CC-System in winter		SA-He	RA-Co	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Efficiency	%	71.000	57.959	
Capacity sensible	kW	271.986	196.609	
Capacity latent	kW	---	75.376	
Capacity frost	kW	---	0.000	
Capacity total	kW	271.986	271.986	
Surface reserve	%	5.208	-99.938	
Present surface	m2	788.172	615.025	

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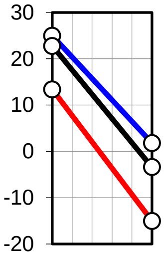
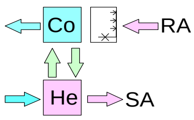
Plant
Object
Position

SA-He (ff = 0 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-15.000	13.400	20.000
Rel. humidity	%	90.000	9.585	40.000
Abs. humidity	g/kg	0.905	0.905	5.784
Volume flow humid	m3/h	25059.731	27816.535	28680.000
Velocity	m/s	2.014	2.236	2.305
Pressure drop	Pa		120.152	

RA-Co (ff = 0 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	25.000	1.816	20.000
Rel. humidity	%	40.000	100.000	40.000
Abs. humidity	g/kg	7.857	4.316	5.784
Volume flow humid	m3/h	25745.004	23609.768	25230.000
Velocity	m/s	2.069	1.898	2.028
Pressure drop wet	Pa		97.396	

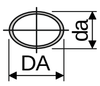




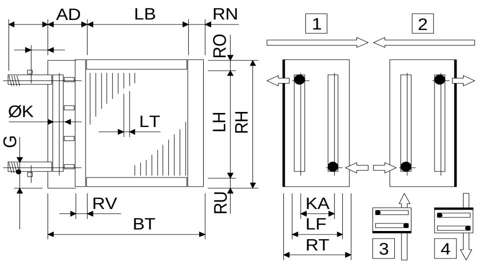
30 V% Et.glycol (ff = 0 / 0 m2K/W)			SA-He	RA-Co
Temp.	in	°C	22.800	-3.400
Temp.	out	°C	-3.400	22.800
Volume flow		m3/h	9.854	9.854
Velocity		m/s	1.061	1.061
Reynolds		---	4361.780	4338.838
Pressure drop		kPa	113.642	113.795

Software by www.zcs.ch

Technical data			SA-He	RA-Co
Tubes total		Piece	486	486
Tubes blank		Piece	6	6
Int. vent./drains		Piece	0	0
Tube rows on the depth		Piece	9	9
Tube rows on the height		Piece	54	54
Tube coupling in series		Piece	20	20
Number of circuits (NC)		Piece	24	24
Volume		l	113	113
Weight		kg	321	287
Connections	G	---	1 ½"	1 ½"
Frame height	RH	mm	1780	1780
Frame width	BT	mm	2148	2148
Frame depth	RT	mm	290	290
Finned height	LH	mm	1728	1728
Finned width	LB	mm	2000	2000
Finned depth	LF	mm	249	249
Frame on top	RO	mm	26	26
Frame on bottom	RU	mm	26	26
Frame in front	RV	mm	35	35
Frame on back (~40/40mm)	RN	mm	35	35
Collector-Diameter	K	mm	42	42
Collector covering	AD	mm	113	113
Collector distance	KA	mm	222	222
Fin spacing	LT	mm	2.000	2.600
Fin thickness	LD	mm	0.150	0.150
Tube diameter	DA	mm	12.400	12.400
Tube diameter	da	mm	12.400	12.400
Tube thickness	S	mm	0.350	0.350
Tube interval on the height	S1	mm	32.000	32.000
Tube interval on the depth	S2	mm	27.713	27.713



	SA-He	RA-Co
Tubes:	Cu	Cu
Tubes:	smooth	smooth
Tubes:	staggered	staggered
Tubes:	circular	circular
Collectors:	Cu	Cu
Collectors:	2.29 m/s	2.29 m/s
Connections:	Rg7	Rg7
Connections:	2.29 m/s	2.29 m/s
Fins:	Al	Al
Fins:	ribbed	ribbed
Frame:	FeZn	FeZn
Air flow direction:	vertical	vertical
Protection:	without	without
Protection:	---	---



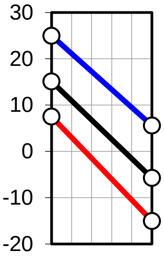
Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net

SA-He: 32/28/12-9R-54T-2000A-2.0PA-24C-Cu/Al/FeZn	**SA-He:**	**EUR**	**4651.00**
RA-Co: 32/28/12-9R-54T-2000A-2.6PA-24C-Cu/Al/FeZn	**RA-Co:**	**EUR**	**4318.00**

CC-System in winter		SA-He	RA-Co	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Efficiency	%	56.300	48.496	
Capacity sensible	kW	215.659	164.863	
Capacity latent	kW	---	50.796	
Capacity frost	kW	---	0.000	
Capacity total	kW	215.659	215.659	
Surface reserve	%	0.466	0.599	
Present surface	m2	788.172	615.025	

SA-He (ff = 0 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-15.000	7.520	20.000
Rel. humidity	%	90.000	14.174	40.000
Abs. humidity	g/kg	0.905	0.905	5.784
Volume flow humid	m3/h	25059.731	27245.760	28680.000
Velocity	m/s	2.014	2.190	2.305
Pressure drop	Pa		118.692	

RA-Co (ff = 0 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	25.000	5.602	20.000
Rel. humidity	%	40.000	96.993	40.000
Abs. humidity	g/kg	7.857	5.471	5.784
Volume flow humid	m3/h	25745.004	23978.888	25230.000
Velocity	m/s	2.069	1.927	2.028
Pressure drop wet	Pa		93.313	



30 V% Et.glycol (ff = 0 / 0 m2K/W)			SA-He	RA-Co
Temp.	in	°C	15.110	-5.730
Temp.	out	°C	-5.730	15.110
Volume flow		m3/h	9.847	9.852
Velocity		m/s	1.060	1.061
Reynolds		---	3701.440	3564.727
Pressure drop		kPa	117.795	118.958

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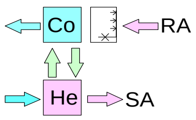
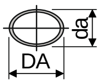
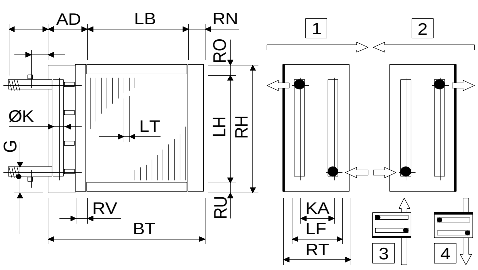
Plant
Object
Position



Software by www.zcs.ch

Technical data			SA-He	RA-Co		SA-He	RA-Co
Tubes total		Piece	486	486	Tubes:	Cu	Cu
Tubes blank		Piece	6	6	Tubes:	smooth	smooth
Int. vent./drains		Piece	0	0	Tubes:	staggered	staggered
Tube rows on the depth		Piece	9	9	Tubes:	circular	circular
Tube rows on the height		Piece	54	54	Collectors:	Cu	Cu
Tube coupling in series		Piece	20	20	Collectors:	2.29 m/s	2.29 m/s
Number of circuits (NC)		Piece	24	24	Connections:	Rg7	Rg7
Volume		l	113	113	Connections:	2.29 m/s	2.29 m/s
Weight		kg	321	287	Fins:	Al	Al
Connections	G	---	1 ½"	1 ½"	Fins:	ribbed	ribbed
Frame height	RH	mm	1780	1780	Frame:	FeZn	FeZn
Frame width	BT	mm	2148	2148	Air flow direction:	vertical	vertical
Frame depth	RT	mm	290	290	Protection:	without	without
Finned height	LH	mm	1728	1728	Protection:	---	---
Finned width	LB	mm	2000	2000			
Finned depth	LF	mm	249	249			
Frame on top	RO	mm	26	26			
Frame on bottom	RU	mm	26	26			
Frame in front	RV	mm	35	35			
Frame on back (~40/40mm)	RN	mm	35	35			
Collector-Diameter	K	mm	42	42			
Collector covering	AD	mm	113	113			
Collector distance	KA	mm	222	222			
Fin spacing	LT	mm	2.000	2.600			
Fin thickness	LD	mm	0.150	0.150			
Tube diameter	DA	mm	12.400	12.400	Delivery:		5-6 weeks
Tube diameter	da	mm	12.400	12.400	Validity:		12 weeks
Tube thickness	S	mm	0.350	0.350	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	32.000	32.000	Payment:		30 days net
Tube interval on the depth	S2	mm	27.713	27.713			





SA-He: 32/28/12-9R-54T-2000A-2.0PA-24C-Cu/Al/FeZn — **SA-He: EUR 4651.00**
RA-Co: 32/28/12-9R-54T-2000A-2.6PA-24C-Cu/Al/FeZn — **RA-Co: EUR 4318.00**

CC-System in winter		SA-He	RA-Co	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Efficiency	%	71.000	57.722	
Capacity sensible	kW	271.986	195.818	
Capacity latent	kW	---	74.751	
Capacity frost	kW	---	1.417	
Capacity total	kW	271.986	271.985	
Surface reserve	%	0.199	0.196	
Present surface	m2	1261.037	1261.037	

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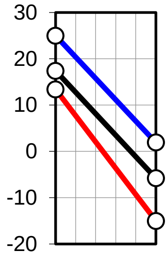
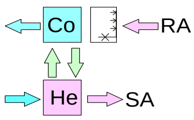
SA-He (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-15.000	13.400	20.000
Rel. humidity	%	90.000	9.585	40.000
Abs. humidity	g/kg	0.905	0.905	5.784
Volume flow humid	m3/h	25059.731	27816.535	28680.000
Velocity	m/s	2.014	2.236	2.305
Pressure drop	Pa		169.932	

RA-Co (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	25.000	1.911	20.000
Rel. humidity	%	40.000	100.000	40.000
Abs. humidity	g/kg	7.857	4.345	5.784
Volume flow humid	m3/h	25745.004	23618.995	25230.000
Velocity	m/s	2.069	1.898	2.028
Pressure drop wet	Pa		173.831	





30 V% Et.glycol (ff = 0.00005 / 0.00005 m2K/W			SA-He	RA-Co
Temp.	in	°C	17.420	-5.800
Temp.	out	°C	-5.800	17.420
Volume flow		m3/h	11.141	11.148
Velocity		m/s	1.066	1.067
Reynolds		---	3818.069	3656.860
Pressure drop		kPa	180.276	182.518

Software by www.zcs.ch

Technical data			SA-He	RA-Co		SA-He	RA-Co
Tubes total		Piece	972	972	Tubes:	Cu	Cu
Tubes blank		Piece	0	0	Tubes:	smooth	smooth
Int. vent./drains		Piece	8	8	Tubes:	staggered	staggered
Tube rows on the depth		Piece	18	18	Tubes:	circular	circular
Tube rows on the height		Piece	54	54	Collectors:	Cu	Cu
Tube coupling in series		Piece	36	36	Collectors:	1.51 m/s	1.52 m/s
Number of circuits (NC)		Piece	27	27	Connections:	Rg7	Rg7
Volume		l	224	224	Connections:	1.51 m/s	1.52 m/s
Weight		kg	647	647	Fins:	Al	Al
Connections	G	---	2"	2"	Fins:	smooth	smooth
Frame height	RH	mm	1780	1780	Frame:	FeZn	FeZn
Frame width	BT	mm	2178	2178	Air flow direction:	horizontal	horizontal
Frame depth	RT	mm	590	590	Protection:	without	without
Finned height	LH	mm	1728	1728	Protection:	---	---
Finned width	LB	mm	2000	2000			
Finned depth	LF	mm	499	499			
Frame on top	RO	mm	26	26			
Frame on bottom	RU	mm	26	26			
Frame in front	RV	mm	35	35			
Frame on back (~40/40mm)	RN	mm	35	35			
Collector-Diameter	K	mm	54	54			
Collector covering	AD	mm	143	143			
Collector distance	KA	mm	503	503			
Fin spacing	LT	mm	2.500	2.500			
Fin thickness	LD	mm	0.200	0.200			
Tube diameter	DA	mm	12.400	12.400	Delivery:		5-6 weeks
Tube diameter	da	mm	12.400	12.400	Validity:		12 weeks
Tube thickness	S	mm	0.350	0.350	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	32.000	32.000	Payment:		30 days net
Tube interval on the depth	S2	mm	27.713	27.713			
SA-He: 32/28/12-18R-54T-2000A-2.5PA-27C-Cu/Al/FeZn					**SA-He:**	**EUR**	**9422.00**
RA-Co: 32/28/12-18R-54T-2000A-2.5PA-27C-Cu/Al/FeZn					**RA-Co:**	**EUR**	**9422.00**