



Energy recovery with regenerators

Energy recovery can be carried out in many ways, with only the circuit connect system, short CC-System, the supply air and exhaust air do not have to be combined, so that you can save considerable costs with regard to the air ducts.

Furthermore, only the CC-System and the plate heat exchanger may be used in hospitals, because only with these two systems can air mixing and bacterial moisture transfer be ruled out.

Because the two air handling units must form a square with the rotor heat exchanger, this is also assumed here for all energy recovery systems as an example for comparison purposes.

Furthermore, the size of the air handling units was chosen so that standard filter units of 610 x 610 mm can be used. In the picture on the right, 3 x 6 filters are provided, resulting in dimensions of 1,830 x 3,660 mm. With a maximum prescribed air speed of 2.00 m/s, this results in an air volume flow of 48,224 m³/h, which, however, cannot be maintained in all energy recovery systems with regard to the inflow area.

On the following pages, 43,350 m³/h is calculated for the supply air and 39,020 m³/h for the exhaust air, i.e. 10% less, which is mostly the case in practice. With the CC-System type CCSD, a temperature efficiency of 76.40% is achieved in winter with a construction depth of 950 mm and air-side pressure drops of 135 Pa. No finned heat exchangers are required for post-heating in winter and for post-cooling in summer.

With the **thermic regenerator**, a temperature efficiency of 73.56% is achieved in winter, with the overall depth of 2,008 mm exceeding the CC-System by a factor of 2.11.

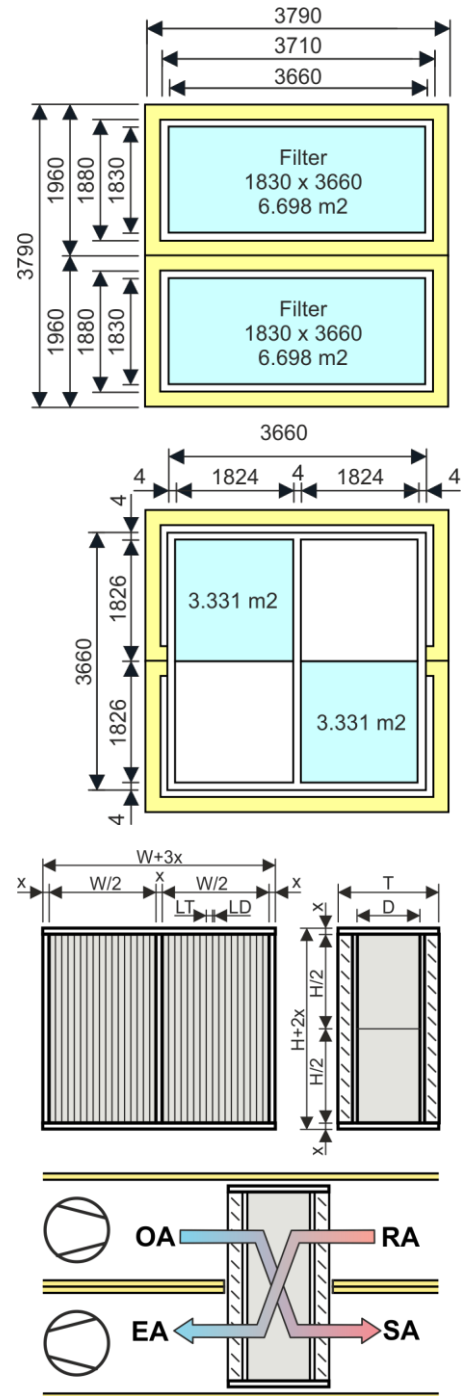
The pressure drop on the exhaust air is 126 Pa and in the supply air 147 Pa. In the supply air, there is an additional 45 Pa for the reheater and the recoler, which results in a total pressure drop of 192 Pa, i.e. it exceeds the CC-System by a factor of 1.42.

In winter, 156.70 kg/h of condensate are separated out in the exhaust air, which, with an air mixture of 5%, still accounts for 7.84 kg/h. This condensate can be contaminated with bacteria and gets into the supply air.

Furthermore, the regular pressure surges that occur every 20 seconds as a result of the flap switchovers, which are perceived as a disruptive influence, are repeatedly complained about.

Although these pressure surges can be reduced by setting the flaps with a corresponding delay, this has the disadvantage that air mixing can increase from 5% to 20%.

The **sorptive regenerator** is deliberately not discussed here because the entire bacteria-contaminated condensate of 156.7 kg/h is introduced into the supply air there. It is admittedly cheeky, bordering on stubborn, that only water and no bacteria would be transferred, which would have to do with the different molecular sizes. With the appropriate membrane design, this would be completely under control.



Following pages

- Page 2: **CC-System:** Heat recovery in winter, supply air pressure drop 132 Pa, extract air pressure drop 136 Pa
- Page 3: **CC-System:** Heat recovery in winter without plate heat exchanger in the intermediate carrier, temp. efficiency 76.40%
- Page 4: **CC-System:** Heat recovery in winter without the risk of frost with the correct bypass arrangement
- Page 5: **Thermic regenerator:** Heat recovery in winter, supply air pressure drop 147 Pa, extract air pressure drop 126 Pa
Heat recovery in winter, temperature efficiency 73.56%
- Page 6: **Reheater:** Pressure drop 14 Pa, overall depth 230 mm
- Page 7: **Aftercooler:** Pressure drop 31 Pa, overall depth 310 mm

CC-System in winter		SA-He	Pt	RA-Co	Definition
Height over sea level	m				106.000
Pressure	hPa				1000.564
Capacity	%	100.000	36.602	63.398	
Capacity sensible	kW	514.913	188.468	258.483	
Capacity latent	kW	---	---	65.720	
Capacity frost	kW	---	---	2.243	
Capacity total	kW	514.913	188.468	326.445	
Surface reserve	%	0.100		0.435	
Present surface	m2	3795.681		3795.681	



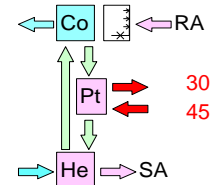
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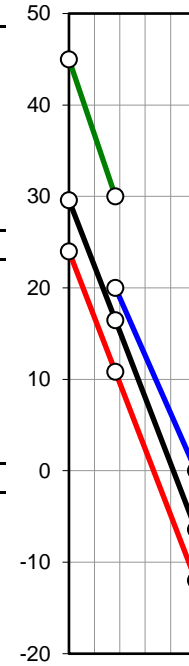
Plant
Object
Position



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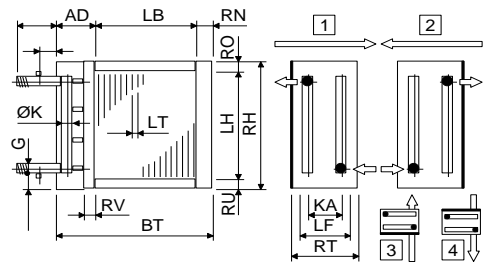
SA-He (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-12.000	24.000	20.000
Rel. humidity	%	90.000	6.517	40.000
Abs. humidity	g/kg	1.208	1.208	5.858
Volume flow humid	m3/h	38332.221	43616.185	43350.000
Velocity	m/s	1.768	2.012	2.000
Pressure drop	Pa		131.968	

RA-Co (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	20.000	0.020	20.000
Rel. humidity	%	40.000	99.747	40.000
Abs. humidity	g/kg	5.858	3.829	5.858
Volume flow humid	m3/h	39020.000	36243.171	39020.000
Velocity	m/s	1.800	1.672	1.800
Pressure drop (dry 125 Pa)	Pa		135.213	



25 V% Et.glycol		SA-He	Pt	RA-Co
Temp. in	°C	29.587	16.477	-6.413
Temp. out	°C	-6.413	29.587	16.477
Volume flow	m3/h	13.340	13.385	13.337
Velocity	m/s	0.948		0.947
Reynolds	---	4818.823		3925.386
Pressure drop	kPa	186.535		197.132

Technical data		SA-He	RA-Co	SA-He	RA-Co
Tubes total	Piece	1200	1200	Tubes:	Cu
Tubes blank	Piece	16	16	Tubes:	smooth
Int. vent./drains	Piece	11	11	Tubes:	in line
Tube rows on the depth	Piece	24	24	Tubes:	circular
Tube rows on the height	Piece	50	50	Collectors:	Cu
Tube coupling in series	Piece	32	32	Collectors:	0.91 m/s
Number of circuits (NC)	Piece	37	37	Connections:	Rg7
Volume	l	466	466	Connections:	0.91 m/s
Weight	kg	1739	1739	Fins:	Al
Connections	G	---	2 1/2"	Fins:	smooth
Frame height	RH	mm	1830	Frame:	AISI 304
Frame width	BT	mm	3660	Air flow direction:	horizontal
Frame depth	RT	mm	950	Protection:	without
Finned height	LH	mm	1750	Protection:	---
Finned width	LB	mm	3441		
Finned depth	LF	mm	840		
Frame on top	RO	mm	40		
Frame on bottom	RU	mm	40		
Frame in front	RV	mm	30		
Frame on back (~53/53mm)	RN	mm	53		
Collector-Diameter	K	mm	76		
Collector covering	AD	mm	166		
Collector distance	KA	mm	844		
Fin spacing	LT	mm	2.500		
Fin thickness	LD	mm	0.200		
Tube diameter	DA	mm	12.400		
Tube diameter	da	mm	12.400		
Tube thickness	S	mm	0.400		
Tube interval on the height	S1	mm	35.000		
Tube interval on the depth	S2	mm	35.000		
SA-He: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304				SA-He:	EUR 23126.00
RA-Co: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304				RA-Co:	EUR 23126.00



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

CC-System in winter without Pt		SA-He	RA-Co	Definition
Height over sea level	m			106.000
Pressure	hPa			1000.564
Efficiency	%	76.400	65.279	
Capacity sensible	kW	349.625	270.107	
Capacity latent	kW	---	74.751	
Capacity frost	kW	---	4.767	
Capacity total	kW	349.625	349.625	
Surface reserve	%	0.099	0.095	
Present surface	m2	3795.681	3795.681	



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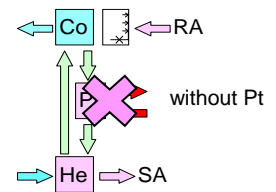
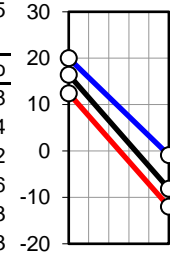
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SA-He (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-12.000	12.448	20.000
Rel. humidity	%	90.000	13.436	40.000
Abs. humidity	g/kg	1.208	1.208	5.858
Volume flow humid	m3/h	38332.221	41920.619	43350.000
Velocity	m/s	1.768	1.934	2.000
Pressure drop	Pa		128.221	

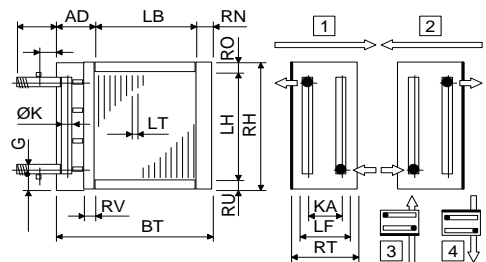
RA-Co (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	20.000	-0.889	20.000
Rel. humidity	%	40.000	100.000	40.000
Abs. humidity	g/kg	5.858	3.550	5.858
Volume flow humid	m3/h	39020.000	36106.438	39020.000
Velocity	m/s	1.800	1.666	1.800
Pressure drop (dry 126 Pa)	Pa		137.245	

25 V% Et.glycol		SA-He	RA-Co
Temp.	in °C	16.424	-8.148
Temp.	out °C	-8.148	16.424
Volume flow	m3/h	13.312	13.312
Velocity	m/s	0.946	0.946
Reynolds	---	3803.442	3785.743
Pressure drop	kPa	198.103	198.383



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Technical data		SA-He	RA-Co	SA-He	RA-Co
Tubes total	Piece	1200	1200	Tubes:	Cu
Tubes blank	Piece	16	16	Tubes:	smooth
Int. vent./drains	Piece	11	11	Tubes:	in line
Tube rows on the depth	Piece	24	24	Tubes:	circular
Tube rows on the height	Piece	50	50	Collectors:	Cu
Tube coupling in series	Piece	32	32	Collectors:	0.91 m/s
Number of circuits (NC)	Piece	37	37	Connections:	Rg7
Volume	l	466	466	Connections:	0.91 m/s
Weight	kg	1739	1739	Connections:	0.91 m/s
Connections	G	---	2 1/2"	Fin:	Al
Frame height	RH	mm	1830	Fin:	smooth
Frame width	BT	mm	3660	Frame:	AISI 304
Frame depth	RT	mm	950	Air flow direction:	horizontal
Finned height	LH	mm	1750	Protection:	without
Finned width	LB	mm	3441	Protection:	---
Finned depth	LF	mm	840		
Frame on top	RO	mm	40		
Frame on bottom	RU	mm	40		
Frame in front	RV	mm	30		
Frame on back (~53/53mm)	RN	mm	53		
Collector-Diameter	K	mm	76		
Collector covering	AD	mm	166		
Collector distance	KA	mm	844		
Fin spacing	LT	mm	2.500		
Fin thickness	LD	mm	0.200		
Tube diameter	DA	mm	12.400		
Tube diameter	da	mm	12.400		
Tube thickness	S	mm	0.400		
Tube interval on the height	S1	mm	35.000		
Tube interval on the depth	S2	mm	35.000		



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

SA-He: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304

SA-He: EUR 23126.00

RA-Co: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304

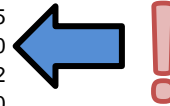
RA-Co: EUR 23126.00



CC-System in winter		SA-He	Pt1	RA-Co	Definition
Height over sea level	m				106.000
Pressure	hPa				1000.564
Capacity	%	100.000	44.786	55.214	
Capacity sensible	kW	514.913	230.611	235.687	
Capacity latent	kW	---	---	48.615	
Capacity frost	kW	---	---	0.000	
Capacity total	kW	514.913	230.611	284.302	
Surface reserve	%	0.100		0.090	
Present surface	m2	3795.681		3795.681	



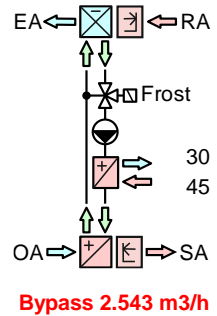
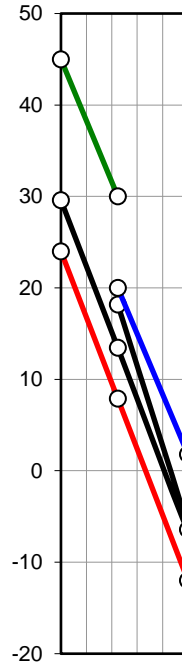
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SA-He (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	-12.000	24.000	20.000
Rel. humidity	%	90.000	6.517	40.000
Abs. humidity	g/kg	1.208	1.208	5.858
Volume flow humid	m3/h	38332.221	43616.185	43350.000
Velocity	m/s	1.768	2.012	2.000
Pressure drop	Pa		131.968	

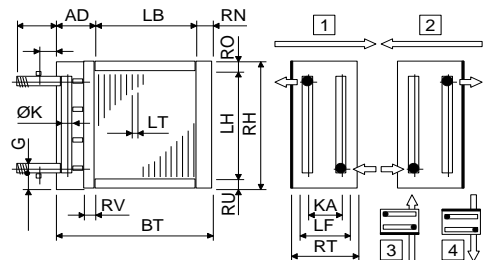
RA-Co (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Temp.	°C	20.000	1.800	20.000
Rel. humidity	%	40.000	99.799	40.000
Abs. humidity	g/kg	5.858	4.357	5.858
Volume flow humid	m3/h	39020.000	36510.097	39020.000
Velocity	m/s	1.800	1.684	1.800
Pressure drop (dry 123 Pa)	Pa		131.290	

25 V% Et.glycol		SA-He	Pt1	RA-Co
Temp. in	°C	29.587	13.463	-6.413
Temp. out	°C	-6.413	29.587	18.183
Volume flow	m3/h	13.340	13.380	10.797
Velocity	m/s	0.948		0.767
Reynolds	---	4818.823		3456.202
Pressure drop	kPa	186.535		133.628



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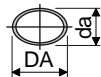
Technical data		SA-He	RA-Co	SA-He	RA-Co
Tubes total	Piece	1200	1200	Tubes:	Cu
Tubes blank	Piece	16	16	Tubes:	smooth
Int. vent./drains	Piece	11	11	Tubes:	in line
Tube rows on the depth	Piece	24	24	Tubes:	circular
Tube rows on the height	Piece	50	50	Collectors:	Cu
Tube coupling in series	Piece	32	32	Collectors:	0.91 m/s
Number of circuits (NC)	Piece	37	37	Connections:	Rg7
Volume	l	466	466	Connections:	0.91 m/s
Weight	kg	1739	1739	Fins:	Al
Connections	G	---	2 1/2"	Fins:	smooth
Frame height	RH	mm	1830	Frame:	AISI 304
Frame width	BT	mm	3660	Air flow direction:	horizontal
Frame depth	RT	mm	950	Protection:	without
Finned height	LH	mm	1750	Protection:	---
Finned width	LB	mm	3441		
Finned depth	LF	mm	840		
Frame on top	RO	mm	40		
Frame on bottom	RU	mm	40		
Frame in front	RV	mm	30		
Frame on back (~53/53mm)	RN	mm	53		
Collector-Diameter	K	mm	76		
Collector covering	AD	mm	166		
Collector distance	KA	mm	844		
Fin spacing	LT	mm	2.500		
Fin thickness	LD	mm	0.200		
Tube diameter	DA	mm	12.400		
Tube diameter	da	mm	12.400		
Tube thickness	S	mm	0.400		
Tube interval on the height	S1	mm	35.000		
Tube interval on the depth	S2	mm	35.000		



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

SA-He: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304
RA-Co: 35/35/12-24R-50T-3441A-2.5PA-37C-Cu/Al/AISI 304

SA-He: EUR 23126.00
RA-Co: EUR 23126.00



Regenerator: 3648-3652-1900		Cold air	Hot air	Definition
Height over sea level	m			106.000
Pressure	hPa			1000.564
Capacity total	kW			446.381
Present surface	m ²			12628.616
Cold air switchover loss	%			5.000
Cold air switchover loss	m ³ /h			2167.500
Switchover	sec			20.000
Temp. efficiency	%	73.558	78.875	
Efficiency humid	%	66.010	73.335	



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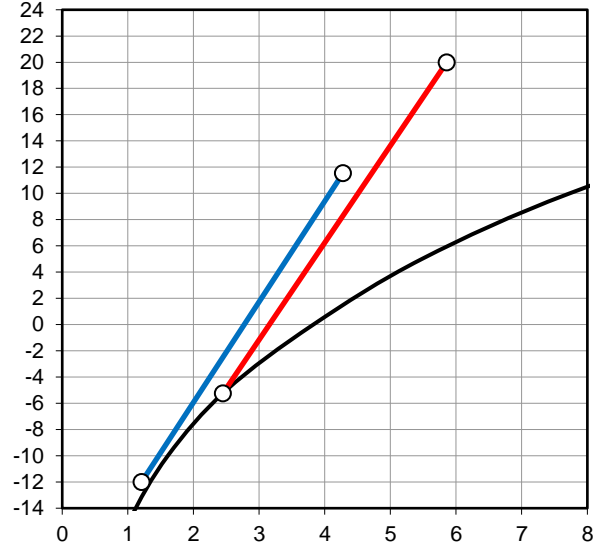
Cold air	Inlet	Outlet	Definition
Fouling	m ² K/W		5.000E-05
Temp.	°C	-12.000	11.539 20.000
Rel. humidity	%	90.000	50.250 40.000
Abs. humidity	g/kg	1.208	4.278 5.858
Density	kg/m ³	1.333	1.221 1.185
Enthalpy humid	kJ/kg	-9.078	22.398 34.992
Volume flow humid	m ³ /h	38332.221	41992.851 43350.000
Mass flow dry	kg/h	51053.643	51053.643 51053.643
Velocity	m/s	3.136	3.366 3.546
Pressure drop dry	Pa		132.693
Pressure drop wet	Pa		146.808

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Hot air	Inlet	Outlet	Definition
Fouling	m ² K/W		5.000E-05
Temp.	°C	20.000	-5.240 20.000
Rel. humidity	%	40.000	100.000 40.000
Abs. humidity	g/kg	5.858	2.448 5.858
Density	kg/m ³	1.185	1.299 1.185
Enthalpy humid	kJ/kg	34.992	0.826 34.992
Volume flow humid	m ³ /h	39020.000	35466.905 39020.000
Mass flow dry	kg/h	45954.168	45954.168 45954.168
Condensate flow	kg/h		156.700
Surface temperature	°C	14.245	-8.259
Velocity	m/s	3.192	2.843 3.192
Pressure drop dry	Pa		114.094
Pressure drop wet	Pa		125.833

Temp. (°C)



Abs. humidity (g/kg)

Technical data Software www.zcs.ch

Regenerator	---	---	Al
Sorbent	---	---	No
Type	---	---	No

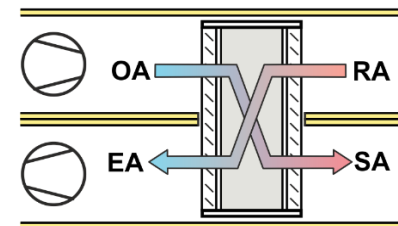
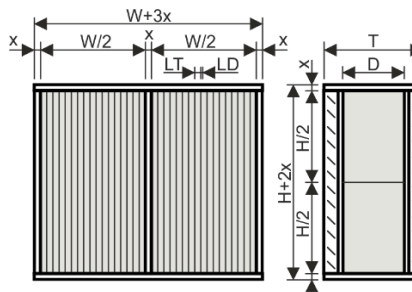
Material density	---	kg/m ³	2660.000
Material specific heat	---	J/kgK	900.000
Material thermal conductivity	---	W/mK	236.000

Fin spacing	LT	mm	4.000
Fin thickness	LD	mm	0.200
Finned height	H	mm	3652.000
Finned width	W	mm	3648.000
Finned depth	D	mm	1900.000

Box / Damper parts --- --- AISI 316

Frame height	---	mm	3660.000
Frame width	---	mm	3660.000
Frame depth	T	mm	2008.000
Frame thickness	x	mm	4.000

Weight empty total --- kg 6140.000



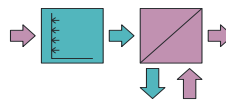
Both fans are to be arranged in such a way, that the pressure in the supply air in the area of the regenerator is higher than in the exhaust air. In addition, a marginally asynchronous damper position can minimize the exhaust air in the supply air.

Delivery: 7-8 weeks
Validity: 12 weeks
Condit.: net, prepaid address
Payment: 30 days net

Price net: EUR 48730.00



Capacity	kW	178.233	----- sensible:	178.233
Surface reserve	%	4.616	latent:	0.000
Present surface	m ²	279.715		
Required surface	m ²	267.372		
k-coeff.	W/m ² K	34.000		
Average temp. diff.	K	19.606		



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Air humid (ff=0.00005 m ² K/W)		Inlet	Outlet	Definition
Height over sea level	m			106.000
Pressure	hPa			1000.564
Temp.	°C	11.543	24.000	20.000
Rel. humidity	%	14.259	6.516	40.000
Abs. humidity	g/kg	1.208	1.208	5.858
Density humid	kg/m ³	1.223	1.172	1.185
Enthalpy humid	kJ/kg	14.662	27.230	34.992
Volume flow humid	m ³ /h	41787.784	43616.182	43350.000
Mass flow dry	kg/h	51053.643	51053.643	51053.643
Velocity	m/s	1.924	2.008	1.996
Pressure drop dry	Pa		14.195	
Pressure drop wet	Pa		14.195	
Evaporation total	kg/h		0.000	(15.000 °C)

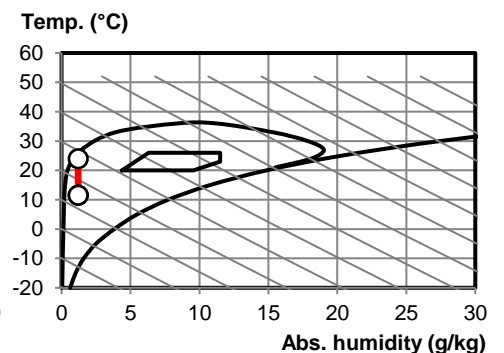
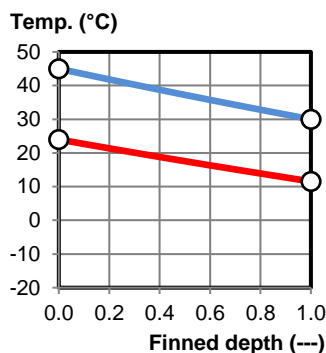
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Water (ff=0.00005 m ² K/W)	
Temp. in	°C 45.000
Temp. out	°C 30.000
Density	kg/m ³ 993.154
Spec. heat	kJ/kgK 4.177
Heat cond.	W/mK 0.627
Viscosity	Pas 6.852E-04
Volume flow	m ³ /h 10.312
Velocity	m/s 0.542
Pressure drop (T/C = 6.941)	kPa 6.992

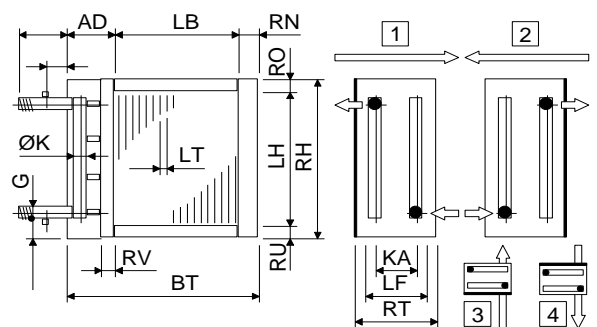


Technical data

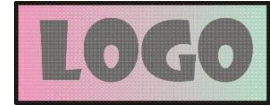
Tubes total	Piece	200
Tubes blank	Piece	0
Int. vent./drains	Piece	0
Tube rows on the depth	Piece	4
Tube rows on the height	Piece	50
Tube coupling in series	Piece	4
Number of circuits (NC)	Piece	50
Volume	l	97
Weight	kg	242
Connections	G	3"
Frame height	RH	mm 1830
Frame width	BT	mm 3660
Frame depth	RT	mm 230
Finned height	LH	mm 1750
Finned width	LB	mm 3447
Finned depth	LF	mm 140
Frame on top	RO	mm 40
Frame on bottom	RU	mm 40
Frame in front	RV	mm 30
Frame on back (~53mm)	RN	mm 53
Collector-Diameter	K	mm 89
Collector covering	AD	mm 160
Collector distance	KA	mm 109
Fin spacing	LT	mm 6.000
Fin thickness	LD	mm 0.200
Tube diameter	DA	mm 12.400
Tube diameter	da	mm 12.400
Tube thickness	S	mm 0.400
Tube interval on the height	S1	mm 35.000
Tube interval on the depth	S2	mm 35.000



Tubes:	Cu
Tubes:	smooth
Tubes:	in line
Tubes:	circular
Collectors:	0.51 m/s Cu
Connections:	0.51 m/s Rg7
Fins:	Al
Fins:	smooth
Frame:	2.00 mm FeZn
Circulations:	1 Default
Protection:	without
Protection:	---
Air flow direction:	horizontal



Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
Price net:	EUR 3597.00



Capacity	kW	209.495	----- sensible:	98.982
Surface reserve	%	3.476	latent:	110.513
Present surface	m2	492.699	frost:	0.000
Required surface	m2	476.149		
k-coeff.	W/m2K	43.130		
Average temp. diff. (98.14 %)	K	10.201		

Company
Branch
Street
Country / ZIP / City

Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			106.000
Pressure	hPa			1000.564
Temp.	°C	22.800	16.000	20.000
Rel. humidity	%	78.000	92.831	40.000
Abs. humidity	g/kg	13.725	10.660	5.858
Density humid	kg/m3	1.168	1.198	1.185
Enthalpy humid	kJ/kg	57.842	43.070	34.992
Volume flow humid	m3/h	44312.157	43085.383	43350.000
Mass flow dry	kg/h	51053.643	51053.643	51053.643
Condensate flow	kg/h		156.479	
Surface temperature	°C	15.161	8.927	
Velocity	m/s	2.052	1.995	2.007
Pressure drop (dry 24 Pa)	Pa		30.682	

Phone: xxxxxxxxxx
Fax: xxxxxxxxxx
E-Mail
Homepage

City, 14.4.2022
With the compliments of

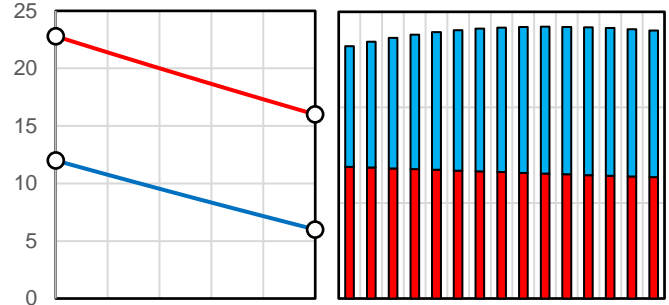
Representative
Direct dialing
xxxxxxxxxx

Plant
Object
Position

25 V% Et.glycol (ff = 0.00005 m2K/W)

Temp. Inlet	°C	6.000
Temp. Outlet	°C	12.000
Temp. Selection	°C	8.190
Density	kg/m3	1041.558
Spec. heat	kJ/kgK	3.701
Heat cond.	W/mK	0.459
Viscosity	Pas	2.635E-03
Volume flow	m3/h	32.609
Velocity	m/s	1.143
Reynolds	---	5240.183
Pressure drop (T/C = 8.545)	kPa	36.435

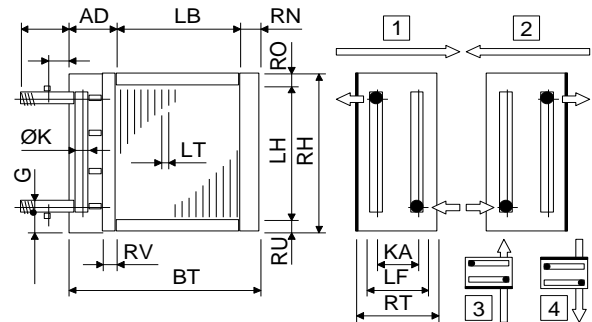
Temp. (°C)



Technical data

Tubes total	Piece	300
Tubes blank	Piece	0
Int. vent./drains	Piece	0
Tube rows on the depth	Piece	6
Tube rows on the height	Piece	50
Tube coupling in series	Piece	4
Number of circuits (NC)	Piece	75
Volume	l	144
Weight	kg	366
Connections	G	---
Frame height	RH	mm
Frame width	BT	mm
Frame depth	RT	mm
Finned height	LH	mm
Finned width	LB	mm
Finned depth	LF	mm
Frame on top	RO	mm
Frame on bottom	RU	mm
Frame in front	RV	mm
Frame on back (~53mm)	RN	mm
Collector-Diameter	K	mm
Collector covering	AD	mm
Collector distance	KA	mm
Fin spacing	LT	mm
Fin thickness	LD	mm
Tube diameter	DA	mm
Tube diameter	da	mm
Tube thickness	S	mm
Tube interval on the height	S1	mm
Tube interval on the depth	S2	mm

Tubes:	Cu
Tubes:	smooth
Tubes:	in line
Tubes:	circular
Collectors:	1.09 m/s Cu
Connections:	1.09 m/s Rg7
Fins:	Al
Fins:	smooth
Circulations:	1 Default
Frame:	2.0 mm AISI 304
Protection:	without
Protection:	---
Air flow direction:	horizontal



Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
Price net:	EUR 5762.00

