



Defrosting procedure for finned heat exchangers

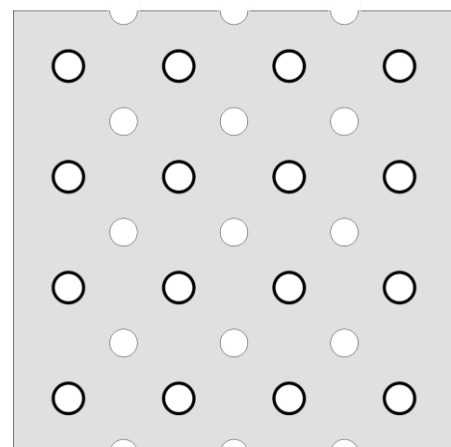
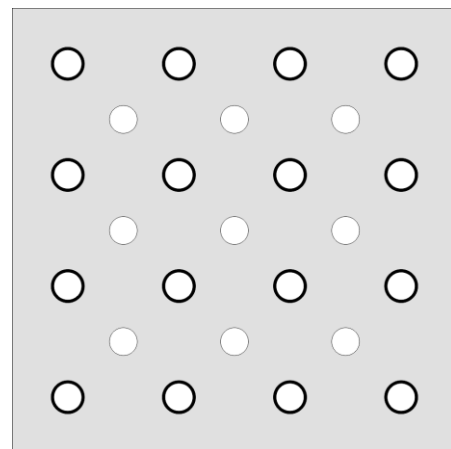
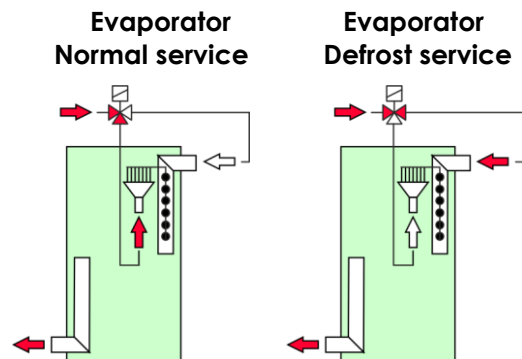
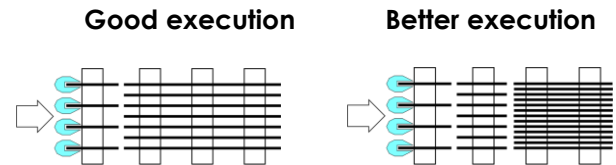
In order to be able to operate heat exchangers for as long as possible without defrosting, they should have twice the fin spacing in the first 2 rows of tubes. It is even better if the first 2 rows of tubes are provided with 4 times the fin spacing and the next 2 rows of tubes with twice the fin spacing, because tulip-like frost forms at the inlet of the heat exchanger, which considerably disturbs the air passage.

If you want to defrost injection evaporators with **hot gases**, we urgently recommend doing this using a changeover valve and a large collector to ensure a short defrosting time. The capillaries are fed through the collector and 10 cm into the heat exchanger tubes.

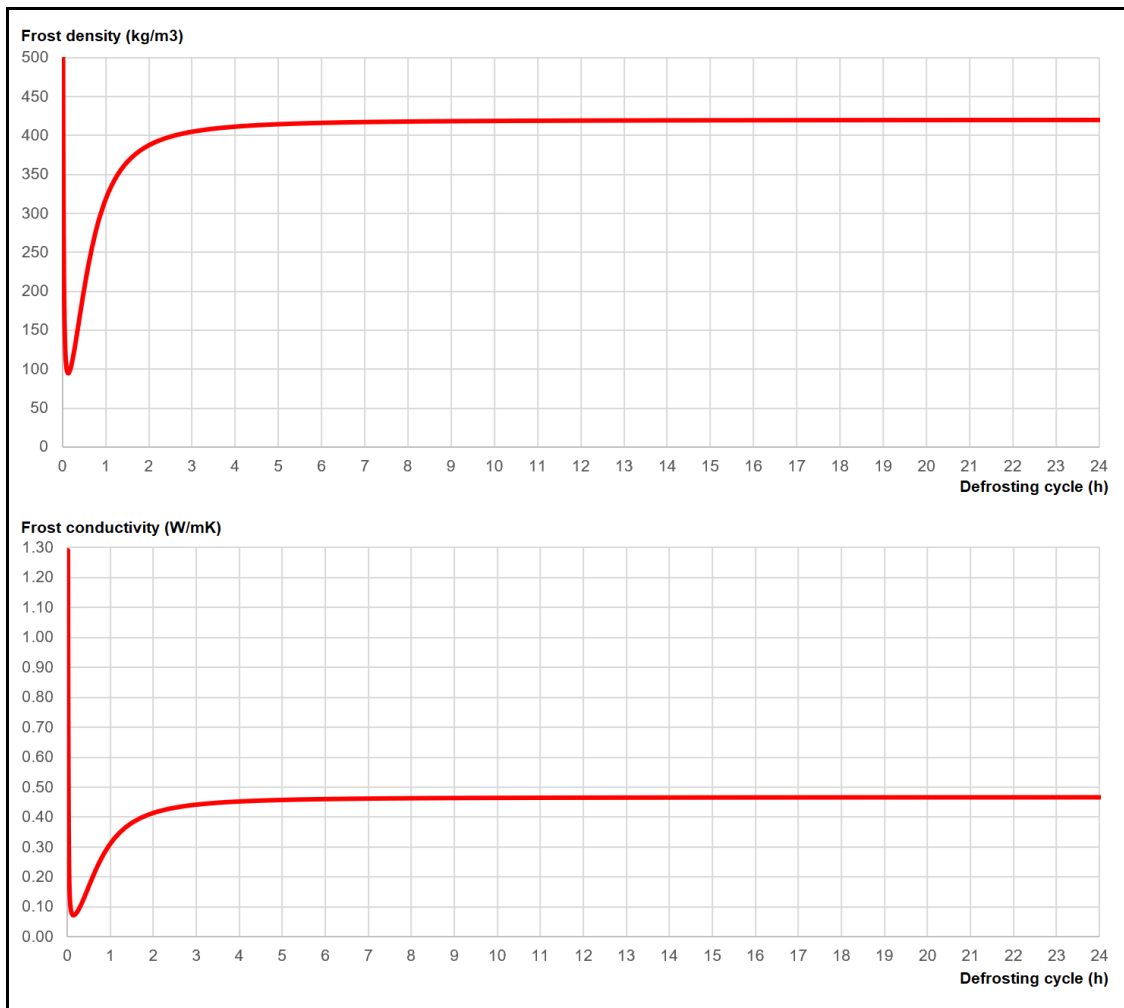
However, if you want to defrost without a changeover valve and thus directly via the capillaries, you have to put up with a very long defrosting time.

If you want to defrost heat exchangers with a **defrost coil**, you should only select heat exchanger tubes in an aligned arrangement and punch the holes in the fins and end plates in the center of each 4 heat exchanger tubes in order to be able to place the defrost coil there. This must be operated with a heat transfer medium at a correspondingly high temperature, as this process can only use heat radiation and convection as defrosting power. Furthermore, the pressure drop on the air side is correspondingly higher than when defrosting with hot gases or electric heating rods.

If you want to defrost heat exchangers with **electric heating rods**, you should only select heat exchanger tubes in an aligned arrangement and punch the holes in the fins and in the end plates in the center of each 4 heat exchanger tubes. Of course, not all the punched holes provided for this are required. However, this ensures that you can later move and add electric heating rods. Under no circumstances should you use electric heating rods in the form of hairpins, which are pushed in from the rear. Straight electric heating rods, which are only inserted from the front, are better.



The density and the thermal conductivity of the frost as a function of the defrosting interval play a dominant role in the calculation. We use the *dissertation by Alexander Schydlo, Hindenburg (Zabrze Poland), Frost formation and growth on cooled tube surfaces.*



Comparison of the 3 defrosting methods

Description	Unit	Hot gas Capillary [1]	Hot gas Collector [2]	Defrost coil ---	El. heating rods ---
Frost energy	kWh	15.93	15.93	14.40	15.93
Defrost capacity	kW	9.50	28.49	10.79	63.00
Defrost interval	h	3.00	3.00	3.00	3.00
Defrost time	h	1.68	0.56	1.34	0.25
Availability	%	44.11	81.33	55.51	91.57
Air pressure drop	Pa	94.30	94.30	206.69	96.48
Heat exchange price	EUR	5'414.00	5'414.00	6'119.00	10'694.00

[1] Only 30% of the effective hot gas capacity was taken into account for the breakdown capacity via capillaries with hot gases because the cross-section of the capillaries is very small.

[2] Only 90% of the effective hot gas capacity was taken into account for the degradation output via the collector with hot gases in order to avoid partial condensation.

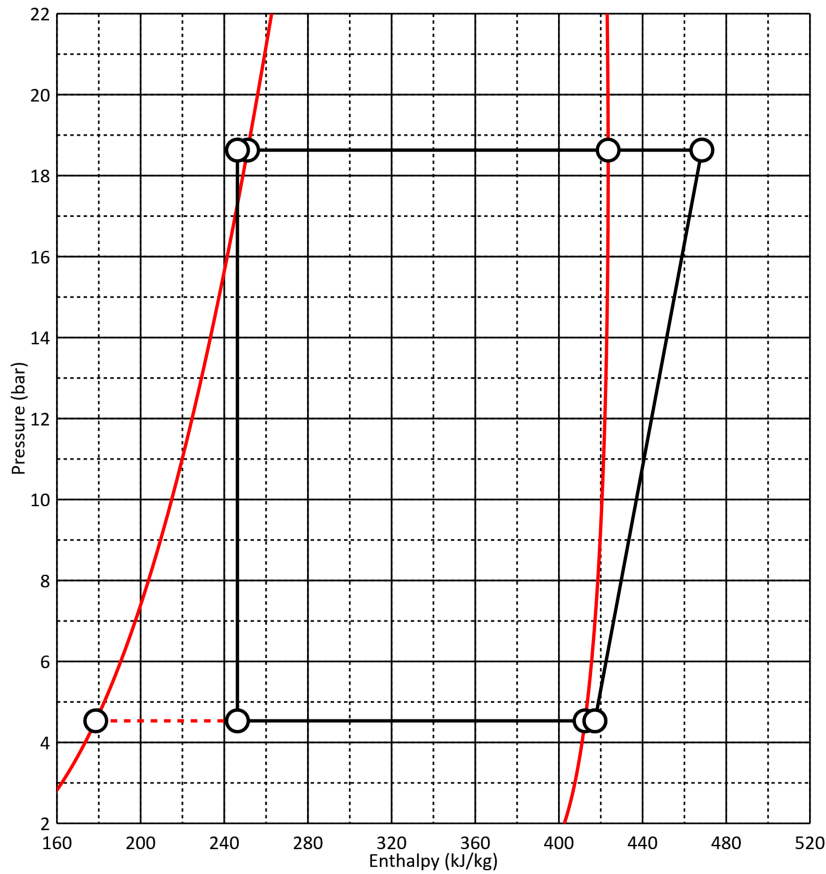
Page 3: Refrigeration process with R410A

Page 4: Evaporator for [1] and [2]

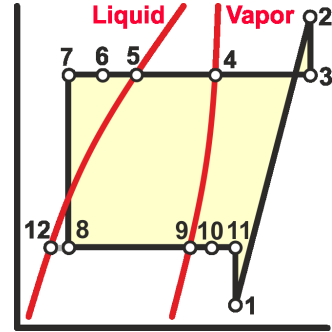
Page 5: Evaporator with defrost coil, evaporator

Page 6: Evaporator with defrost coil, defrost coil

Page 7: Evaporator with electric heating rods

Refrigerant R410A

Description

- 1=Refrig. compressor
- 2=Refrig. compressor
- 3=Hot gas Condenser
- 4=Condensation" (Vapor)
- 5=Condensation' (Liquid)
- 6=Subcooling Condenser
- 7=Subcooling additional
- 8=Evaporator Injection point
- 9=Evaporator" (Vapor)
- 10=Superheating Evaporator
- 11=Superheating additional
- 12=Evaporator' (Liquid)



$$T^n p^{(1-n)} = \text{const}$$

$$x = \frac{n}{1-n} = \frac{\ln(p_2/p_1)}{\ln(T_1/T_2)}$$

$$n = \frac{x}{1+x}$$

Refrig. compressor	bar	°C	kJ/kg	kW	kg/h	(n)	
1=Refrig. compressor	4.302	-13.000	419.772				
2=Refrig. compressor	18.835	67.029	472.604				
Difference			52.832	36.129	2461.832		
Polytrophic exponent (n)							1.222
Condenser	bar	°C	kJ/kg	kW	kg/h	COP	
3=Hot gas Condenser	18.835	67.029	472.604				
4=Condensation" (Vapor)	18.835	30.000	426.319				
5=Condensation' (Liquid)	18.835	29.881	248.205				
6=Subcooling Condenser	18.835	27.000	243.179				
Difference			229.425	156.891	2461.832		4.343
Subcooling additional	bar	°C	kJ/kg	kW	kg/h		
6=Subcooling Condenser	18.835	27.000	243.179				
7=Subcooling additional	18.835	27.000	243.179				
Difference			0.000	0.000	2461.832		
Evaporator	bar	°C	kJ/kg	kW	kg/h	COP	Flashgas
12=Evaporator' (Liquid)	4.302	-18.092	173.196				
8=Evaporator Injection point	4.302	-18.065	243.179				0.290
9=Evaporator" (Vapor)	4.302	-18.000	414.902				
10=Evaporator Superheating	4.302	-13.000	419.772				
Difference			176.593	120.762	2461.832	3.343	
Superheating additional	bar	°C	kJ/kg	kW	kg/h		
10=Superheating Evaporator	4.302	-13.000	419.772				
11=Superheating additional	4.302	-13.000	419.772				
Difference			0.000	0.000	2461.832		
Pressure drop	bar	°C	kJ/kg				
2-3=Pressure drop	0.000						
11-1=Pressure drop	0.000						
Connections	p	v	c max	di min	di eff	da eff	Ø eff
----	kg/m³	m³/h	m/s	m	mm	mm	---
Condensation" (Vapor)	76.445	32.204	5.714	0.045	51.000	54.000	2"
Condensation' (Liquid)	1033.408	2.382	0.694	0.035	39.000	42.000	1 ½"
Evaporator' (Liquid)	1238.374	1.988	0.470	0.039	39.000	42.000	1 ½"
Evaporator" (Vapor)	16.567	148.600	9.778	0.073	84.900	88.900	3"



Capacity	kW	120.762	----- sensible:	79.464
Surface reserve	%	9.485	latent:	35.989
Present surface	m2	778.423	frost:	5.308
Required surface	m2	710.989	0.5 % Oil ISO VG32	
k-coeff.	W/m2K	12.363		
Average temp. diff. (100.00 %)	K	13.738		

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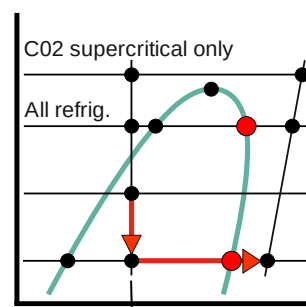
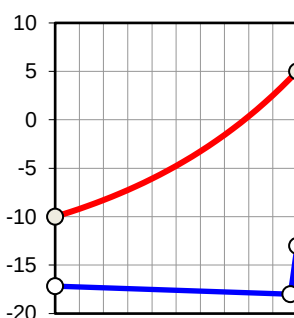
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Plant
Object
Position

Air humid (ff=0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	5.000	-10.000	5.000
Rel. humidity	%	80.000	100.000	80.000
Abs. humidity	g/kg	4.320	1.589	4.320
Density humid	kg/m3	1.265	1.340	1.265
Enthalpy humid	kJ/kg	15.873	-6.118	15.873
Volume flow humid	m3/h	15000.000	14129.250	15000.000
Mass flow dry	kg/h	18900.600	18900.600	18900.600
Condensate flow	kg/h		51.624	
Surface temperature	°C	-3.833	-12.773	
Velocity	m/s	1.628	1.533	1.628
Pressure drop (dry 83 Pa)	Pa		94.304	

R410A Evaporation 4.302 bar (ff=0.00005 m2K/W)

Condensate"	°C	30.000
Condensate'	°C	29.881
Subcooling	°C	27.000
Evaporation"	°C	-18.000
Superheating	°C	-13.000
Mass flow	kg/h	2473.796
Volume flow	m3/h	149.323
Velocity	m/s	7.742
Pressure drop Evaporation	K	0.889
Pressure drop Capillary	bar	3.390

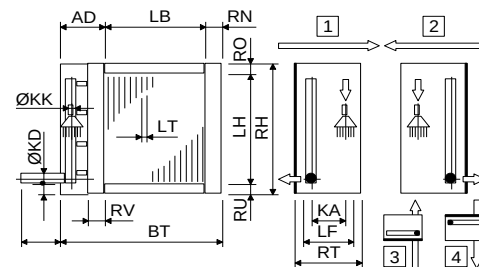


Part of steam on the inject point 28.95 %

Technical data

Tubes total	Piece	384
Tubes blank	Piece	0
Tube rows on the depth	Piece	12
Tube rows on the height	Piece	32
Tube coupling in series	Piece	12
Number of circuits (NC)	Piece	32
Volume	l	122
Weight	kg	414
Cond. connection	KK	mm 35
Steam connection	KD	mm 89
Frame height	RH	mm 1680
Frame width	BT	mm 1840
Frame depth	RT	mm 670
Finned height	LH	mm 1600
Finned width	LB	mm 1600
Finned depth	LF	mm 600
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 covering	AD	mm 175
Collector distance	KA	mm 550
Fin spacing	LT	mm 3.789
Fin thickness	LD	mm 0.200
Tube diameter	DA	mm 15.400
Tube thickness	S	mm 0.400
Tube interval on the height	S1	mm 50.000
Tube interval on the depth	S2	mm 50.000

Tubes:	smooth	Cu
	in line	
Collectors:		Cu
Connections:		Cu
Fins:	smooth	Al
Frame:	2.0 mm	AISI 304
Circulations:	1	Default
Capillary:	6.00 x 1.00 x 1800.00 mm	
Air flow direction:	horizontal	



El. heat rods: without
Frost thickness: 0.492 mm
Fin spacing: 2x12.0+2x6.0+8x3.0 mm

Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
Price net:	EUR 5414.00



Capacity	kW	120.252	----- sensible:	79.464
Surface reserve	%	3.804	latent:	35.989
Present surface	m2	603.479	frost:	4.799
Required surface	m2	581.364	0.5 % Oil ISO VG32	
k-coeff.	W/m2K	14.974		
Average temp. diff. (100.00 %)	K	13.814		

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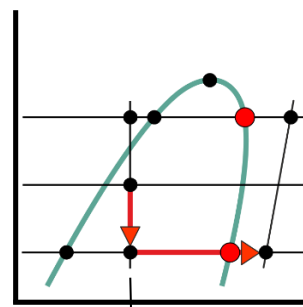
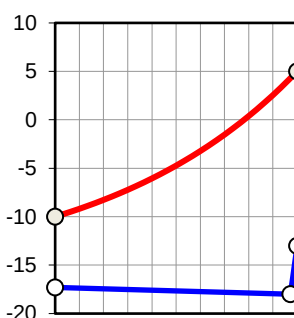
Object

Position

Air humid (ff=0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	5.000	-10.000	5.000
Rel. humidity	%	80.000	100.000	80.000
Abs. humidity	g/kg	4.320	1.589	4.320
Density humid	kg/m3	1.265	1.340	1.265
Enthalpy humid	kJ/kg	15.873	-6.118	15.873
Volume flow humid	m3/h	15000.000	14129.250	15000.000
Mass flow dry	kg/h	18900.600	18900.600	18900.600
Condensate flow	kg/h		51.624	
Surface temperature	°C	0.136	-11.554	
Velocity	m/s	1.628	1.533	1.628
Pressure drop (Frost)	Pa		206.692	

R410A Evaporation 4.302 bar (ff=0.00005 m2K/W)

Condensate"	°C	30.000
Condensate'	°C	29.881
Subcooling	°C	27.000
Evaporation"	°C	-18.000
Superheating	°C	-13.000
Mass flow	kg/h	2463.363
Volume flow	m3/h	148.693
Velocity	m/s	7.710
Pressure drop Evaporation	K	0.763
Pressure drop Capillary	bar	3.364

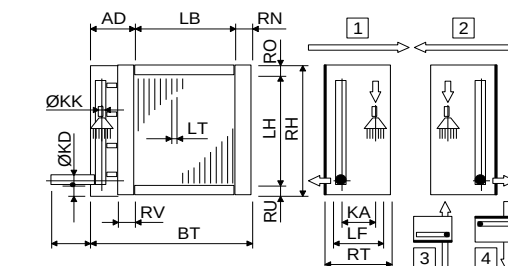


Part of steam on the inject point 28.95 %

Technical data

Frost thickness 0.59 mm - Defr. cycle 3.00 h - Defr. time 1.33 h - Availability 55.53 %

Tubes total	Piece	320	Tubes:	smooth	Cu
Tubes blank	Piece	0		in line	
Tube rows on the depth	Piece	10	Collectors:		Cu
Tube rows on the height	Piece	32	Connections:		Cu
Tube coupling in series	Piece	10	Fins:	smooth	Al
Number of circuits (NC)	Piece	32	Frame:	2.0 mm	AISI 304
Volume	l	103	Circulations:	1	Default
Weight	kg	343	Capillary:	6.00 x 1.00 x 1800.00 mm	
Cond. connection	KK	mm	Protection:		without
Steam connection	KD	mm	Protection:		---
Frame height	RH	mm	Air flow direction:		horizontal
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 (~65mm)	RN	mm			
Collector covering	AD	mm			
Collector distance	KA	mm			
Fin spacing	LT	mm			
Fin thickness	LD	mm			
Tube diameter	DA	mm			
Tube thickness	S	mm			
Tube interval on the height	S1	mm			
Tube interval on the depth	S2	mm			



Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
Price net:	EUR 4576.00

Efficiency: Tubes-Fins	---	0.980
Heat transfer: Tubes-Fins	---	0.865
Bypass: Air-Tubes-Fins	---	0.995
Efficiency: Heat exchanger total	---	0.844
Radiated power	kW	10.791
Inside surface	m2	9.168

Volume flow
from the air humid
= 0.000 m3/h !!!

Radiated power



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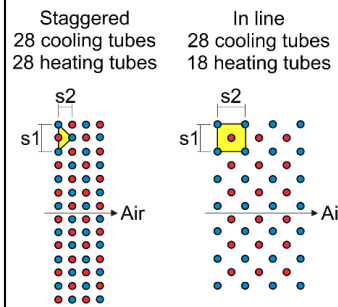
Object

Position

Dowtherm J

Fouling inside	m2K/W	5.000E-05
Temp. in	°C	200.000
Temp. out	°C	195.586
Density	kg/m3	713.427
Spec. heat	kJ/kgK	2.467
Heat cond.	W/mK	0.090
Viscosity	Pas	2.330E-04
Volume flow	m3/h	5.000
Mass flow	kg/h	3567.136
Velocity	m/s	1.331
Pressure drop	kPa	48.938

Example for 4 rows in air direction
and 7 rows on the height



Efficiency: Heat exchanger total $\eta = 0.844$ (---)
Emissivity $\epsilon = 0.500$ (---)

Stefan Boltzmann constant $\sigma = 5.67 \cdot 10^{-8} \text{ (W/m}^2\text{K}^4\text{)}$

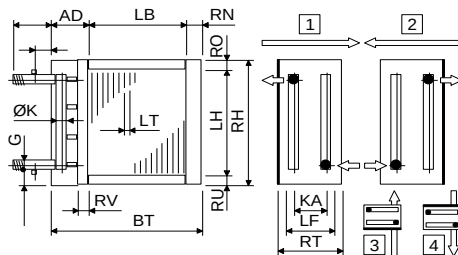
Inside surface $A = 9.168 \text{ (m}^2\text{)}$

Medium radiated temperature $t \sim (t_{in} + t_{out})/2 \text{ (K)}$

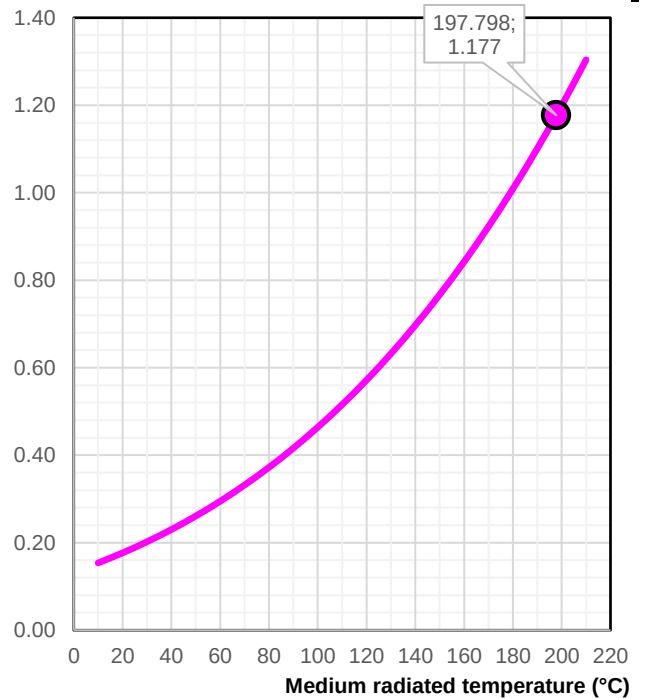
Absolute temperature $T = t + 273.16 \text{ (K)}$

Radiated power $\dot{Q} = \eta \epsilon \sigma A T^4 \text{ (W)}$

Medium radiated temperature $t = \sqrt[4]{\frac{\dot{Q}}{\eta \epsilon \sigma A}} - 273.16 \text{ (}^\circ\text{C)}$



Radiated power (kW/m2)



Technical data

Frost thickness 0.59 mm - Defr. cycle 3.00 h - Defr. time 1.33 h - Availability 55.53 %

Tubes total	Piece	279	Tubes:	smooth	Cu
Tubes blank	Piece	3		in line	
Tube rows on the depth	Piece	9	Collectors:	1.16 m/s	Cu
Tube rows on the height	Piece	31	Connections:	1.16 m/s	Cu
Tube coupling in series	Piece	12	Fins:	smooth	Al
Number of circuits (NC)	Piece	23	Frame:	2.00 mm	AISI 304
Volume	l	26	Circulations:	1	Default
Weight	kg	49	Air flow direction:		horizontal
Collector-Diameter	K	mm			
Connections	G	---			
Finned width	LB	mm			
Fin spacing	LT	mm			
Fin thickness	LD	mm			
Tube diameter	DA	mm			
Tube thickness	S	mm			
Tube interval on the height	S1	mm			
Tube interval on the depth	S2	mm			

Delivery: 5-6 weeks
Validity: 12 weeks
Condit.: net, prepaid address
Payment: 30 days net
Price net: EUR 1543.00



Capacity	kW	120.762	----- sensible:	79.464
Surface reserve	%	8.060	latent:	35.989
Present surface	m2	760.345	frost:	5.308
Required surface	m2	703.629	0.5 % Oil ISO VG32	
k-coeff.	W/m2K	12.492		
Average temp. diff. (100.00 %)	K	13.738		

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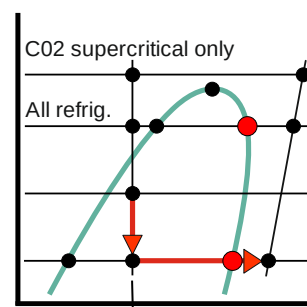
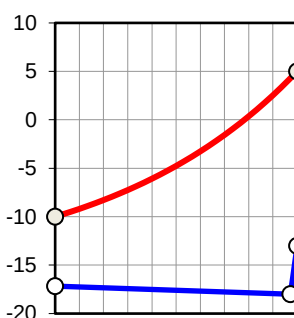
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Object
Position

Air humid (ff=0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	5.000	-10.000	5.000
Rel. humidity	%	80.000	100.000	80.000
Abs. humidity	g/kg	4.320	1.589	4.320
Density humid	kg/m3	1.265	1.340	1.265
Enthalpy humid	kJ/kg	15.873	-6.118	15.873
Volume flow humid	m3/h	15000.000	14129.250	15000.000
Mass flow dry	kg/h	18900.600	18900.600	18900.600
Condensate flow	kg/h		51.624	
Surface temperature	°C	-3.810	-12.765	
Velocity	m/s	1.628	1.533	1.628
Pressure drop (dry 85 Pa)	Pa		96.479	

R410A Evaporation 4.302 bar (ff=0.00005 m2K/W)

Condensate"	°C	30.000
Condensate'	°C	29.881
Subcooling	°C	27.000
Evaporation"	°C	-18.000
Superheating	°C	-13.000
Mass flow	kg/h	2473.796
Volume flow	m3/h	149.323
Velocity	m/s	7.742
Pressure drop Evaporation	K	0.889
Pressure drop Capillary	bar	3.390

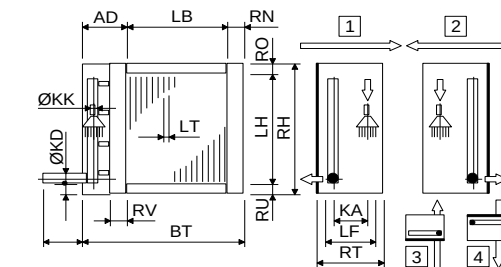


Part of steam on the inject point 28.95 %

Technical data

Frost thickness 0.50 mm - Defr. cycle 3.00 h - Defr. time 0.25 h - Availability 91.57 %

Tubes total	Piece	384	Tubes:	smooth	Cu
Tubes blank	Piece	0		in line	
Tube rows on the depth	Piece	12	Collectors:		Cu
Tube rows on the height	Piece	32	Connections:		Cu
Tube coupling in series	Piece	12	Fins:	smooth	Al
Number of circuits (NC)	Piece	32	Frame:	2.0 mm	AISI 304
Volume	l	122	Circulations:	1	Default
Weight	kg	414	Capillary:	6.00 x 1.00 x 1800.00 mm	
Cond. connection	KK	mm	Air flow direction:	horizontal	
Steam connection	KD	mm			
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 (~65mm)	RN	mm			
Collector covering	AD	mm			
Collector distance	KA	mm			
Fin spacing	LT	mm			
Fin thickness	LD	mm			
Tube diameter	DA	mm			
Tube thickness	S	mm			
Tube interval on the height	S1	mm			
Tube interval on the depth	S2	mm			



El. heat rods: 60 x Ø 8.4 x 1700 mm à 1050 W
Frost thickness: 0.503 mm
Fin spacing: 2x12.0+2x6.0+8x3.0 mm

Delivery: 5-6 weeks
Validity: 12 weeks
Condit.: net, prepaid address
Payment: 30 days net
Price net: EUR 10694.00