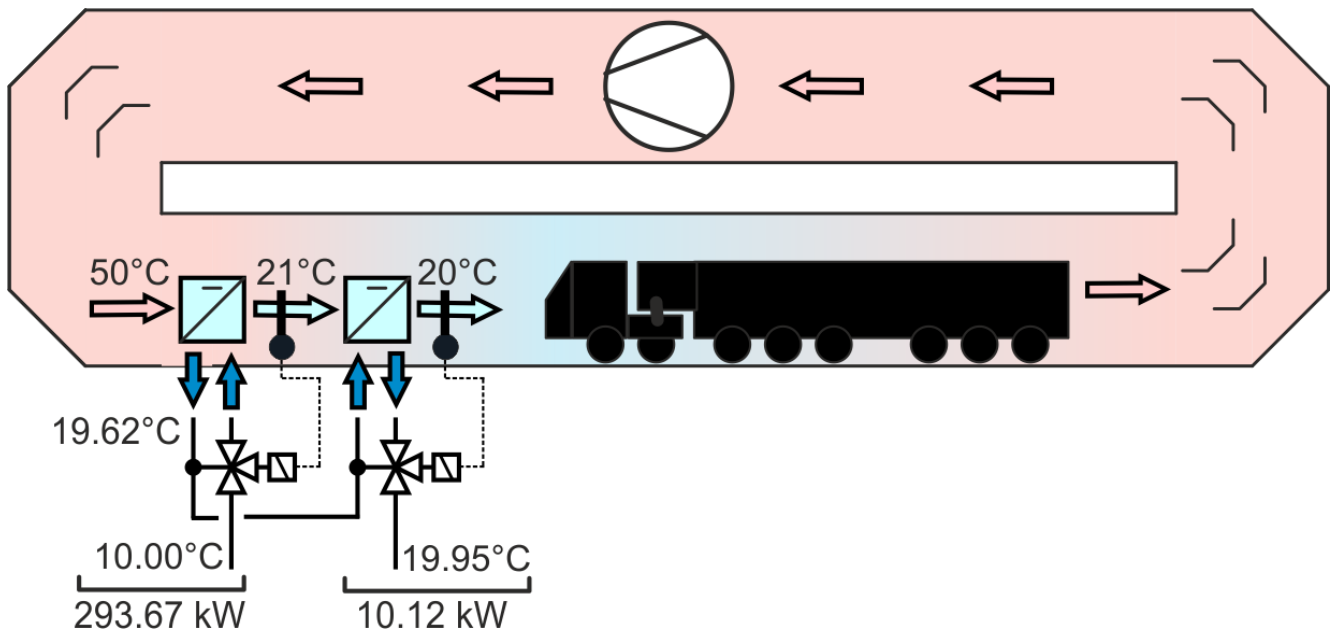




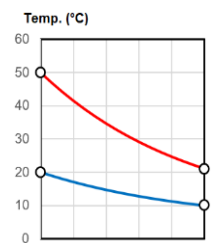
# Stable Air outlet temperature

In aerodynamics test laboratories, air ducts are required, that can keep the supply air temperature very precisely stable to the object to be tested, such as a scale miniaturized articulated lorry, **for the purpose of studying the flow behavior and measuring the air resistance**, with a maximum bandwidth deviation of 0.1K to ensure reproducibility. Because the air is heated by the object to be tested, the duct deflections, expansions, constrictions and by the fans, air coolers in the form of finned heat exchangers are installed upstream of the object to be tested, which must provide this level of accuracy.

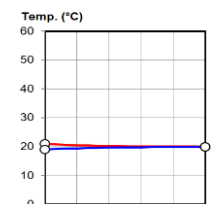


It is impossible to achieve this level of accuracy with 1 heat exchanger with a capacity of 303.79 kW in the usual cross-**counterflow**, even with the most complex regulation, but attempts have been made several times and have failed again and again. The problem here is the very large mean logarithmic temperature difference of 17.71 K, which means **far too much leeway for sensible and stable regulation**, see page 2.

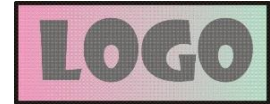
Experiments have shown, that the required temperature accuracy and stability can only be achieved with 2 heat exchangers, with the first being connected in the usual **counter-current flow** and, with 293.67 kW, still providing **96.67% of the total cooling capacity**. The still very large mean logarithmic temperature difference of 18.62 K does not pose a problem, because at 21°C the required air outlet temperature of 20°C is only cooled down to 1K, see page 3.



In the second stage, a cross-**co-current flow** heat exchanger is used, which with 10.12 kW only has to generate **3.33% of the total cooling capacity**. The very small average logarithmic temperature difference of 0.44 K ensures, that the air outlet temperature can be maintained at exactly 20°C, **so to speak, automatically self-regulating** with a temperature difference of 0.1K at the outlet, see page 4.



Capacity	kW	303.792	----- sensible:	303.792
Surface reserve	%	1.920	latent:	0.000
Present surface	m <sup>2</sup>	435.450	frost:	0.000
Required surface	m <sup>2</sup>	427.248		
k-coeff.	W/m <sup>2</sup> K	40.140		
Average temp. diff. ( 97.21 % )	K	17.714		



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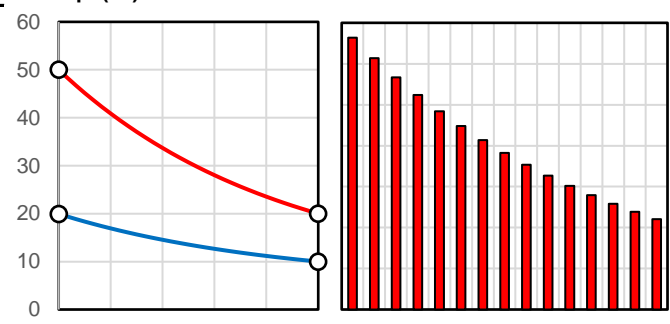
Plant  
Object  
Position

**Air humid ( ff = 0.00005 m2K/W )**

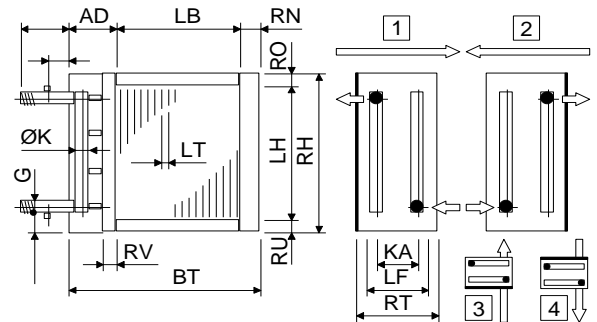
		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	50.000	20.000	20.000
Rel. humidity	%	8.000	42.106	40.000
Abs. humidity	g/kg	6.092	6.092	5.784
Density humid	kg/m <sup>3</sup>	1.088	1.199	1.200
Enthalpy humid	kJ/kg	66.148	35.585	34.805
Volume flow humid	m <sup>3</sup> /h	33086.192	30014.692	30000.000
Mass flow dry	kg/h	35783.425	35783.425	35783.425
Condensate flow	kg/h		0.000	
Surface temperature	°C	25.554	11.865	
Velocity	m/s	2.279	2.068	2.067
Pressure drop (dry 47 Pa)	Pa		46.686	

**Water ( ff = 0.00005 m2K/W )**

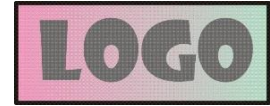
Temp. Inlet	°C	10.000
Temp. Outlet	°C	19.950
Temp. Selection	°C	13.632
Density	kg/m <sup>3</sup>	999.304
Spec. heat	kJ/kgK	4.187
Heat cond.	W/mK	0.587
Viscosity	Pas	1.181E-03
Volume flow	m <sup>3</sup> /h	26.269
Velocity	m/s	1.211
Reynolds	---	14962.753
Pressure drop ( T/C = 5.824 )	kPa	35.115

**Temp. (°C)****Technical data**

Tubes total	Piece	288	Tubes:	Cu
Tubes blank	Piece	0	Tubes:	smooth
Int. vent./drains	Piece	0	Tubes:	staggered
Tube rows on the depth	Piece	6	Tubes:	circular
Tube rows on the height	Piece	48	Collectors:	1.29 m/s Cu
Tube coupling in series	Piece	8	Connections:	1.29 m/s Rg7
Number of circuits (NC)	Piece	36	Fins:	Al
Volume	l	131	Fins:	smooth
Weight	kg	296	Circulations:	1 Default
Connections	G	---	Frame:	2.0 mm AISI 304
Frame height	RH	mm 2000	Protection:	without
Frame width	BT	mm 2340	Protection:	---
Frame depth	RT	mm 290	Air flow direction:	horizontal
Finned height	LH	mm 1920		
Finned width	LB	mm 2100		
Finned depth	LF	mm 210		
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 89		
Collector covering	AD	mm 175		
Collector distance	KA	mm 175		
Fin spacing	LT	mm 3.600		
Fin thickness	LD	mm 0.200		
Tube diameter	DA	mm 15.400		
Tube diameter	da	mm 15.400		
Tube thickness	S	mm 0.400		
Tube interval on the height	S1	mm 40.000		
Tube interval on the depth	S2	mm 35.000		
			Delivery:	5-6 weeks
			Validity:	12 weeks
			Condit.:	net, prepaid address
			Payment:	30 days net
			<b>Price net:</b>	<b>EUR 4456.00</b>



Capacity	kW	293.673	----- sensible:	293.673
Surface reserve	%	2.442	latent:	0.000
Present surface	m <sup>2</sup>	394.831	frost:	0.000
Required surface	m <sup>2</sup>	385.420		
k-coeff.	W/m <sup>2</sup> K	40.922		
Average temp. diff. ( 97.60 % )	K	18.620		



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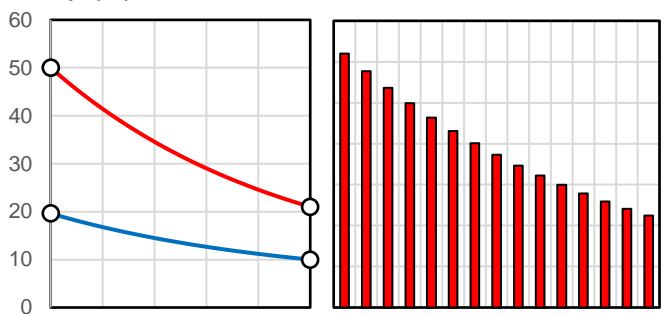
Plant  
Object  
Position

Air humid ( ff = 0.00005 m <sup>2</sup> K/W )		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	50.000	21.000	20.000
Rel. humidity	%	8.000	39.594	40.000
Abs. humidity	g/kg	6.092	6.092	5.784
Density humid	kg/m <sup>3</sup>	1.088	1.195	1.200
Enthalpy humid	kJ/kg	66.148	36.603	34.805
Volume flow humid	m <sup>3</sup> /h	33086.192	30117.076	30000.000
Mass flow dry	kg/h	35783.425	35783.425	35783.425
Condensate flow	kg/h		0.000	
Surface temperature	°C	24.883	11.906	
Velocity	m/s	2.279	2.075	2.067
Pressure drop (dry 45 Pa)	Pa		44.563	

### Water ( ff = 0.00005 m<sup>2</sup>K/W )

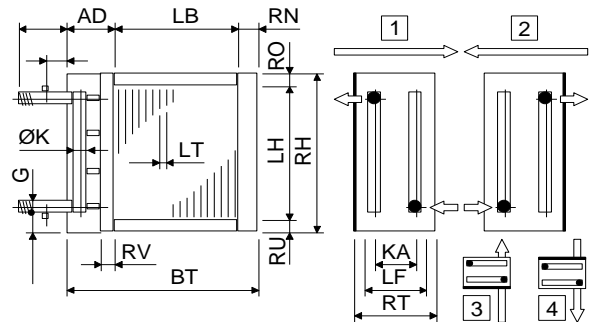
Temp. Inlet	°C	10.000
Temp. Outlet	°C	19.618
Temp. Selection	°C	13.511
Density	kg/m <sup>3</sup>	999.320
Spec. heat	kJ/kgK	4.187
Heat cond.	W/mK	0.587
Viscosity	Pas	1.184E-03
Volume flow	m <sup>3</sup> /h	26.269
Velocity	m/s	1.211
Reynolds	---	14913.979
Pressure drop ( T/C = 5.828 )	kPa	35.136

### Temp. (°C)



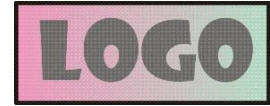
### Technical data

Tubes total	Piece	288	Tubes:	Cu
Tubes blank	Piece	0	Tubes:	smooth
Int. vent./drains	Piece	0	Tubes:	staggered
Tube rows on the depth	Piece	6	Tubes:	circular
Tube rows on the height	Piece	48	Collectors:	1.29 m/s Cu
Tube coupling in series	Piece	8	Connections:	1.29 m/s Rg7
Number of circuits (NC)	Piece	36	Fins:	Al
Volume	l	131	Fins:	smooth
Weight	kg	285	Circulations:	1 Default
Connections	G	---	Frame:	2.0 mm AISI 304
Frame height	RH	mm 2000	Protection:	without
Frame width	BT	mm 2340	Protection:	---
Frame depth	RT	mm 290	Air flow direction:	horizontal
Finned height	LH	mm 1920		
Finned width	LB	mm 2100		
Finned depth	LF	mm 210		
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 89		
Collector covering	AD	mm 175		
Collector distance	KA	mm 175		
Fin spacing	LT	mm 4.000		
Fin thickness	LD	mm 0.200		
Tube diameter	DA	mm 15.400		
Tube diameter	da	mm 15.400		
Tube thickness	S	mm 0.400		
Tube interval on the height	S1	mm 40.000		
Tube interval on the depth	S2	mm 35.000		



Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
<b>Price net:</b>	<b>EUR 4359.00</b>

Capacity	kW	10.119	----- sensible:	10.119
Surface reserve	%	0.453	latent:	0.000
Present surface	m <sup>2</sup>	614.173	frost:	0.000
Required surface	m <sup>2</sup>	611.405		
k-coeff.	W/m <sup>2</sup> K	37.427		
Average temp. diff. ( 66.93 % )	K	0.442		



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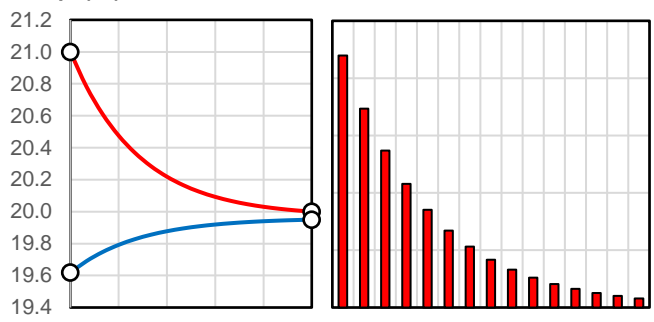
Plant  
Object  
Position

**Air humid ( ff = 0.00005 m2K/W )**

	Inlet	Outlet	Definition
Height over sea level	m		0.000
Pressure	hPa		1013.250
Temp.	°C	21.000	20.000
Rel. humidity	%	39.594	40.000
Abs. humidity	g/kg	6.092	5.784
Density humid	kg/m <sup>3</sup>	1.195	1.200
Enthalpy humid	kJ/kg	36.603	34.805
Volume flow humid	m <sup>3</sup> /h	30117.076	30000.000
Mass flow dry	kg/h	35783.425	35783.425
Condensate flow	kg/h		0.000
Surface temperature	°C	19.940	19.962
Velocity	m/s	2.075	2.067
Pressure drop (dry 54 Pa)	Pa		53.924

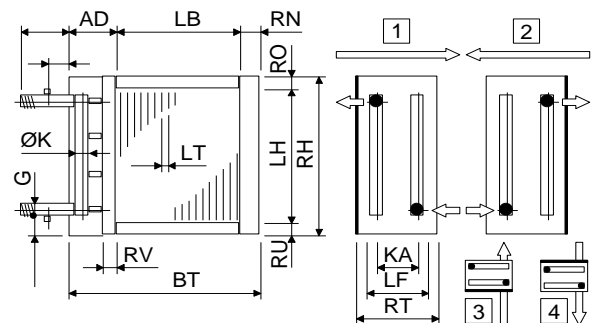
**Water ( ff = 0.00005 m2K/W )**

Temp. Inlet	°C	19.618
Temp. Outlet	°C	19.950
Temp. Selection	°C	19.739
Density	kg/m <sup>3</sup>	998.263
Spec. heat	kJ/kgK	4.181
Heat cond.	W/mK	0.598
Viscosity	Pas	1.008E-03
Volume flow	m <sup>3</sup> /h	26.289
Velocity	m/s	1.212
Reynolds	---	17513.570
Pressure drop ( T/C = 5.651 )	kPa	34.193

**Temp. (°C)****Technical data**

Tubes total	Piece	288
Tubes blank	Piece	0
Int. vent./drains	Piece	0
Tube rows on the depth	Piece	6
Tube rows on the height	Piece	48
Tube coupling in series	Piece	8
Number of circuits (NC)	Piece	36
Volume	l	131
Weight	kg	352
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 (~65mm)	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:	staggered
Tubes:	circular
Collectors:	1.29 m/s Cu
Connections:	1.29 m/s Rg7
Fins:	Al
Fins:	smooth
Circulations:	1 Default
Frame:	2.0 mm AISI 304
Protection:	without
Protection:	---
Air flow direction:	horizontal

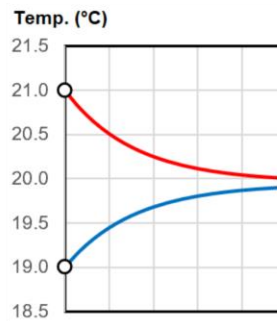


Delivery:	5-6 weeks
Validity:	12 weeks
Condit.:	net, prepaid address
Payment:	30 days net
Price net:	EUR 4958.00

Air 30000 m3/h on 20°C/40% on sea level  
Cooling from 50.00°C/8.00% on 20.00°C/42.11%  
303.792 kW = 100.00%

293.673 kW = 96.669%

10.119 kW = 3.331%



Water 19.618°C  
26.269 m3/h

Water 19.950°C  
26.269 m3/h

50.00°C/8.00%

21.00°C/39.59%

20.00°C/42.11%

Water 19.618°C  
26.269 m3/h

Water 10.000°C  
26.269 m3/h

