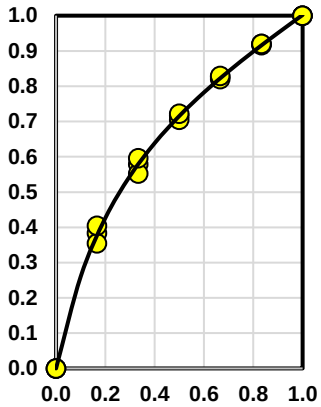
Cooler part-load behavior

If you want to know exactly, how a cooler behaves with regard to part-load, you cannot avoid making calculations with the air cooler program, which takes all aspects into account, such as velocities and pressure drops of the air and the cooling medium and the geometry of the heat exchanger.

However, if you only want to make an approximate calculation with the AHH (Air Humid Handling) software, the Mollier-HX-Diagram, you can use the coefficient as a guide, which, however, is not constant with reduced air volume, as the heat transfer coefficient decreases.

Coefficient = k-coefficient x Heat exchanger surface = Capacity / Mean temperature difference

It is therefore important to know to what extent the k-value (heat transfer coefficient) decreases. In the diagram below, the yellow dots indicate calculations using the air cooler program and the black curve represents an approximate polynomial-based equation.



Air flow = x	k-coeff. = y
1.000	1.002
0.900	0.951
0.800	0.898
0.700	0.842
0.600	0.782
0.500	0.716
0.400	0.639
0.300	0.546
0.200	0.426
0.100	0.260
0.000	0.000

$y = (a+cx)/(1+bx+dx^2)$

a =	0.000000
b =	3.089842
c =	3.389227
d =	-0.707400

In the software AHH (Air Humid Handling), the Mollier-HX-Diagram, this characteristic value is displayed for the air cooler and the heat recovery systems.

Example for the air cooler

Coefficient for nominal air flow 10'000 m3/h = **6.367**
Coefficient for part-load air flow 5'000 m3/h = **6.367 x 0.716 = 4.559**

Nominal air flow

1) Cooling of air - Partition of fins (2.5 - 3.5 mm)			
Capacity	kW	83.385	
Mean temp.diff.	K	13.096	
Coefficient	**kW/K**	**6.367**	
Coolant In	°C	6.000	
Coolant Out	°C	12.000	
		Air In	Air Out
Temperature	°C	32.000	14.000
Rel. humidity	%	40.000	87.705
Abs. humidity	g/kg	11.856	8.717
Density humid	kg/m³	1.148	1.223
Enthalpy humid	kJ/kg	62.559	36.110
Volume flow humid	**m³/h**	**10000.000**	**9363.545**
Massflow dry	kg/h	11349.535	11349.535
Condensed water	kg/h		35.631
Surface temperature	°C		8.080

Part-load air flow

2) Cooling of air - Partition of fins (2.5 - 3.5 mm)			
Capacity	kW	49.923	
Mean temp.diff.	K	10.95	
Coefficient	**kW/K**	**4.559**	
Coolant In	°C	6.000	
Coolant Out	°C	12.000	
		Air In	Air Out
Temperature	°C	32.000	11.155
Rel. humidity	%	40.000	94.668
Abs. humidity	g/kg	11.856	7.800
Density humid	kg/m³	1.148	1.236
Enthalpy humid	kJ/kg	62.559	30.889
Volume flow humid	**m³/h**	**5000.000**	**4628.649**
Massflow dry	kg/h	5674.768	5674.768
Condensed water	kg/h		23.020
Surface temperature	°C		7.340

The air outlet temperature must therefore be changed iteratively for the part-load air flow, until the characteristic value of **4.559** is obtained, i.e. from 14,000°C to **11.155°C**, which corresponds fairly well to the correct calculation with the air cooler program at 11.473°C, see the following pages .

Cooler: 40/35/16-5R-26T-1190A-2.5PA-13C-Cu/Al/AISI 304 — **Software by www.zcs.ch**

Capacity	kW	83.749	------ sensible:	58.045
Surface reserve	%	0.000	latent:	25.704
Present surface	m2	152.629	frost:	0.000
Required surface	m2	152.629		
k-coeff.	W/m2K	46.527		
Average temp. diff. (90.05 %)	K	11.793		

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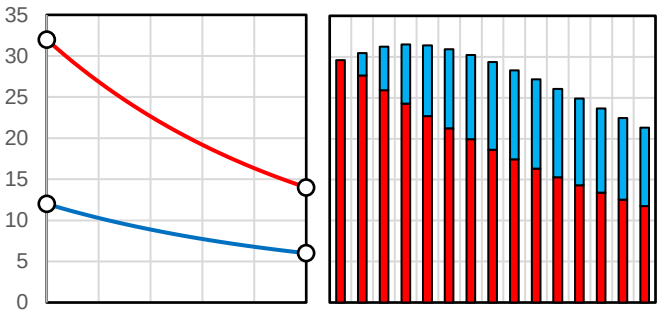
Plant
Object
Position

Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	32.000	14.000	32.000
Rel. humidity	%	40.000	87.257	40.000
Abs. humidity	g/kg	11.860	8.675	11.860
Density humid	kg/m3	1.148	1.223	1.148
Enthalpy humid	kJ/kg	62.569	36.003	62.569
Volume flow humid	m3/h	10000.000	9362.871	10000.000
Mass flow dry	kg/h	11348.960	11348.960	11348.960
Condensate flow	kg/h		36.153	
Surface temperature	°C	16.823	7.929	
Velocity	m/s	2.245	2.102	2.245
Pressure drop (dry 54 Pa)	Pa		60.901	

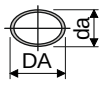
Water (ff = 0.00005 m2K/W)		
Temp. Inlet	°C	6.000
Temp. Outlet	°C	12.000
Temp. Selection	°C	8.190
Density	kg/m3	999.850
Spec. heat	kJ/kgK	4.196
Heat cond.	W/mK	0.577
Viscosity	Pas	1.378E-03
Volume flow	m3/h	11.978
Velocity	m/s	1.339
Reynolds	---	15158.954
Pressure drop (T/C = 13.653)	kPa	30.539

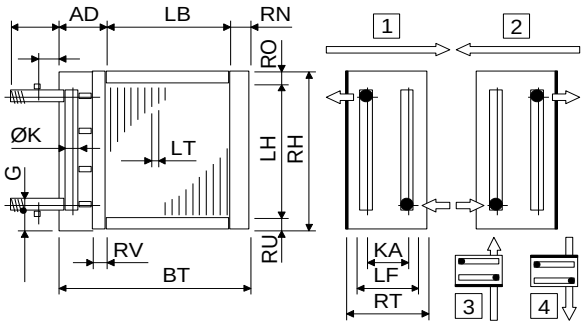
Temp. (°C)



Technical data

Tubes total		Piece	130	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	0	Tubes:		staggered
Tube rows on the depth		Piece	5	Tubes:		circular
Tube rows on the height		Piece	26	Collectors:	0.81 m/s	Cu
Tube coupling in series		Piece	10	Connections:	0.81 m/s	Rg7
Number of circuits (NC)		Piece	13	Fins:		Al
Volume		l	42	Fins:		smooth
Weight		kg	107	Circulations:	1	Default
Connections	G	---	2 ½"	Frame:	2.0 mm	AISI 304
Frame height	RH	mm	1120	Protection:		without
Frame width	BT	mm	1410	Protection:		---
Frame depth	RT	mm	240	Air flow direction:		horizontal
Finned height	LH	mm	1040			
Finned width	LB	mm	1190			
Finned depth	LF	mm	173			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~69mm)	RN	mm	53			
Collector-Diameter	K	mm	76			
Collector covering	AD	mm	167			
Collector distance	KA	mm	139			
Fin spacing	LT	mm	2.500			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	16.400	Delivery:		5-6 weeks
Tube diameter	da	mm	16.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	34.641	**Price net:**		**EUR 1642.00**





Cooler: 40/35/16-5R-26T-1190A-2.5PA-13C-Cu/Al/AISI 304 — **Software by www.zcs.ch**

Capacity	kW	48.932	------ sensible:	33.050
Surface reserve	%	0.000	latent:	15.882
Present surface	m2	152.629	frost:	0.000
Required surface	m2	152.629		
k-coeff.	W/m2K	33.401		
Average temp. diff. (85.62 %)	K	9.598		

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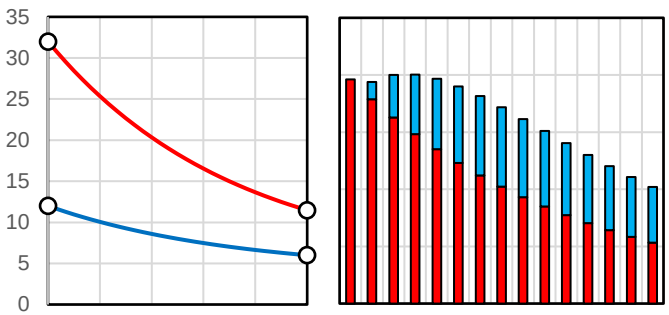
Plant
Object
Position

Air humid (ff = 0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	32.000	11.473	32.000
Rel. humidity	%	40.000	94.122	40.000
Abs. humidity	g/kg	11.860	7.924	11.860
Density humid	kg/m3	1.148	1.234	1.148
Enthalpy humid	kJ/kg	62.569	31.526	62.569
Volume flow humid	m3/h	5000.000	4634.718	5000.000
Mass flow dry	kg/h	5674.480	5674.480	5674.480
Condensate flow	kg/h		22.338	
Surface temperature	°C	17.217	7.428	
Velocity	m/s	1.123	1.041	1.123
Pressure drop (dry 19 Pa)	Pa		22.146	

Water (ff = 0.00005 m2K/W)		
Temp. Inlet	°C	6.000
Temp. Outlet	°C	12.000
Temp. Selection	°C	8.190
Density	kg/m3	999.850
Spec. heat	kJ/kgK	4.196
Heat cond.	W/mK	0.577
Viscosity	Pas	1.378E-03
Volume flow	m3/h	6.998
Velocity	m/s	0.782
Reynolds	---	8856.917
Pressure drop	kPa	11.387

Temp. (°C)



Technical data

Tubes total		Piece	130	Tubes:		Cu
Tubes blank		Piece	0	Tubes:		smooth
Int. vent./drains		Piece	0	Tubes:		staggered
Tube rows on the depth		Piece	5	Tubes:		circular
Tube rows on the height		Piece	26	Collectors:	0.48 m/s	Cu
Tube coupling in series		Piece	10	Connections:	0.48 m/s	Rg7
Number of circuits (NC)		Piece	13	Fins:		Al
Volume		l	42	Fins:		smooth
Weight		kg	107	Circulations:	1	Default
Connections	G	---	2 ½"	Frame:	2.0 mm	AISI 304
Frame height	RH	mm	1120	Protection:		without
Frame width	BT	mm	1410	Protection:		---
Frame depth	RT	mm	240	Air flow direction:		horizontal
Finned height	LH	mm	1040			
Finned width	LB	mm	1190			
Finned depth	LF	mm	173			
Frame on top	RO	mm	40			
Frame on bottom	RU	mm	40			
Frame in front	RV	mm	30			
Frame on back (~32'000mm)	RN	mm	53			
Collector-Diameter	K	mm	76			
Collector covering	AD	mm	167			
Collector distance	KA	mm	139			
Fin spacing	LT	mm	2.500			
Fin thickness	LD	mm	0.200			
Tube diameter	DA	mm	16.400	Delivery:		5-6 weeks
Tube diameter	da	mm	16.400	Validity:		12 weeks
Tube thickness	S	mm	0.400	Condit.:		net, prepaid address
Tube interval on the height	S1	mm	40.000	Payment:		30 days net
Tube interval on the depth	S2	mm	34.641	**Price net:**	**EUR**	**1642.00**