



# Fin efficiency

**Serious factories** know, that the air can be sufficiently heated or cooled down with thick flat fins. **Mafia factories** don't know this, because they don't understand the fin efficiency and think, that all problems can be solved with a lot of surfaces. An example of this is an air heater from **AAA**. The data sheet from **AAA** looks in part as follows:

Lufterhitzer		N/8/48/4.00/2700/ACS/ /035100	
Leistung:	1000.0 kW		
Fläche:	1282.5 m <sup>2</sup>		
Soll-Fläche:	1202.0 m <sup>2</sup>		
Flächenreserve:	6.7 %	Rohranordnung:	fluchtend
K-Wert:	29.10 W/(m <sup>2</sup> ·K)		
LMTD:	28.59 K		
Luft		Wärmeträger: Wasser	
Volumenstrom:	Eintritt 45770 m <sup>3</sup> /h Austritt 55836 m <sup>3</sup> /h	Eintritt:	105.0 °C
Temperatur:	22.0 °C 86.8 °C	Austritt:	65.0 °C
Rel. Luftfeuchte:	50 % 2 %	Volumenstrom:	22.12 m <sup>3</sup> /h
Massenstrom tr.:	53990.8 kg/h		
Luftdruck:	1013 mbar	Massenstrom:	21419 kg/h
Geschwindigkeit:	2.2 m/s		
Druckverlust:	67 Pa	Druckverlust:	0.77 bar
Rohrinhalt:	172.3 l	WT-Rohre:	Kupfer
Lam. Teilung:	4.00 mm	Lamellen:	Aluminium
		Kollektor:	Kupfer
		Rahmen:	Stahl verzinkt
Lamellierte Länge:	2700 mm	Pässe:	14
Lamellierte Höhe:	2400 mm	Stränge:	27
Einbaulänge:	2936 mm		
Rahmenlänge:	2800 mm		
Rahmenhöhe:	2500 mm		
Rahmentiefe:	500 mm		
Rohrreihen Tiefe:	8		
Max. Betriebsdruck:	16.0 bar		

The plant operator found, that the air heater fell up to 12K below the supply air temperature of 87°C, which is necessary for high-quality production. Because **AAA** refused to provide much of the necessary information for a recalculation, this was used in our neutral and TUEV-tested software in such a way, that pressure drops and heat exchanger surface were shown according to **AAA's** data sheet. **AAA** has supplied way too thin fins of only 0.100 mm, which is absurd for air heaters. The internal water-side connection is also unclear. Is emptying and venting guaranteed in the installation position? In this respect too, **AAA** refused to provide the necessary information and only confirmed: Aligned tube pitch 50x50 mm, fin spacing 4 mm, 8 rows of tubes in depth, 48 rows of tubes in width. **Everything beyond that for the execution of the tubes, fins and circuits are internals.** Of course, we were able to find out much more from **AAA's** data sheet without any problems and found, that the plant operator was right with his notice of defects.

## Surface shortage, see page 2

Capacity	kW	1000.000
Surface reserve	%	-42.563
Present surface	m <sup>2</sup>	1282.500
Required surface	m <sup>2</sup>	2232.871
k-coeff.	V/m <sup>2</sup> K	17.081
Average temp. diff. ( 91.51 %	K	26.219

## Reduced capacity, see page 3

Capacity	kW	822.715
Surface reserve	%	0.011
Present surface	m <sup>2</sup>	1282.500
Required surface	m <sup>2</sup>	1282.365
k-coeff.	V/m <sup>2</sup> K	17.051
Average temp. diff. ( 96.92 %	K	37.626

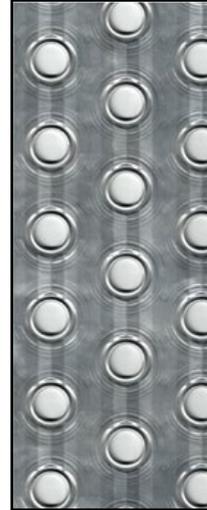
A planned replacement heat exchanger from **BBB** with a smaller surface is therefore an indication of **factory's seriousness**, because thick and flat fins are used, **see page 4.**

Capacity	kW	1000.000
Surface reserve	%	8.627
Present surface	m <sup>2</sup>	846.294
Required surface	m <sup>2</sup>	779.085
k-coeff.	V/m <sup>2</sup> K	45.537
Average temp. diff. ( 98.38 %	K	28.187

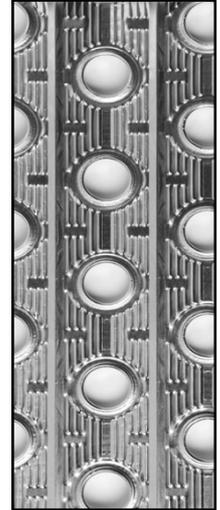


More on page 5!

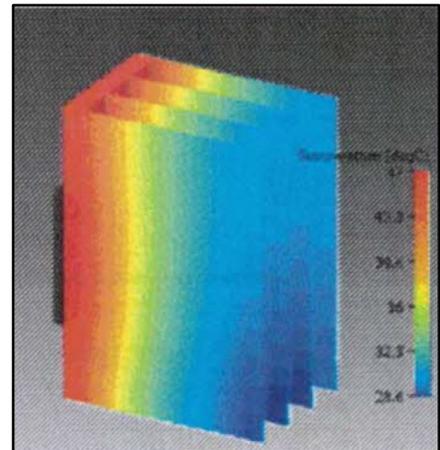
## Serious factories Fin thickness 0.2 mm



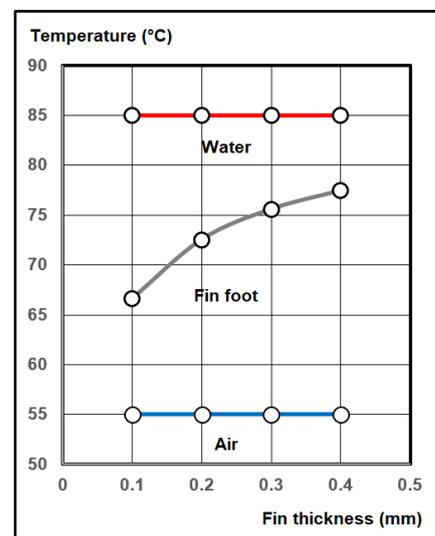
## Mafia factories Fin thickness 0.1 mm



Fin temperature profile



Fin foot temperature





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Capacity	kW	1000.000
Surface reserve	%	-42.563
Present surface	m2	1282.500
Required surface	m2	2232.871
k-coeff.	V/m2K	17.081
Average temp. diff. ( 91.51 %	K	26.219

Phone: +41 79 222 66 42  
 Fax: ---  
 info@zcs.ch  
 www.zcs.ch

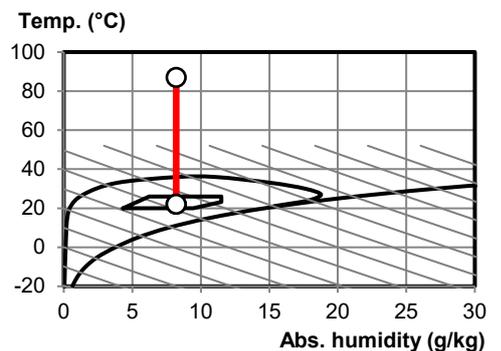
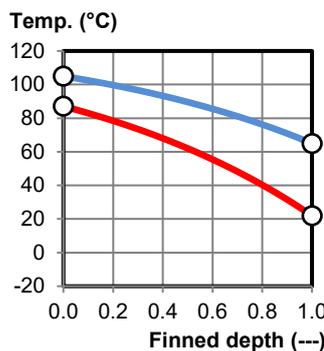
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Dipl.-Ing. Marin Zeller FH, VDI  
 Direktwahl  
 +41 79 222 66 42

Mälzerei  
 Mafia-Hersteller  
 Luftherhitzer

Air humid (ff=0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	22.000	87.083	22.000
Rel. humidity	%	50.000	2.111	50.000
Abs. humidity	g/kg	8.202	8.202	8.202
Density humid	kg/m3	1.190	0.975	1.190
Enthalpy humid	kJ/kg	42.984	109.632	42.984
Volume flow humid	m3/h	45770.000	55862.350	45770.000
Mass flow dry	kg/h	54015.480	54015.480	54015.480
Velocity	m/s	1.962	2.395	1.962
Pressure drop	Pa		67.000	

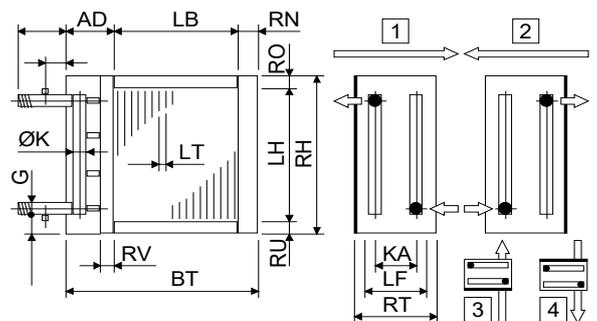
Water (ff=0.00005 m2K/W)		
Temp. in	°C	105.000
Temp. out	°C	65.000
Density	kg/m3	969.945
Spec. heat	kJ/kgK	4.200
Heat cond.	W/mK	0.672
Viscosity	Pas	3.420E-04
Volume flow	m3/h	22.094
Velocity	m/s	1.339
Pressure drop ( T/C = 8.923 )	bar	0.770



**Technical data**

Tubes total	Piece	384	
Tubes blank	Piece	6	
Int. vent./drains	Piece	0	
Tube rows on the depth	Piece	8	
Tube rows on the height	Piece	48	
Tube coupling in series	Piece	14	
Number of circuits (NC)	Piece	27	
Volume	l	206	
Weight	kg	544	
Connections	G	2 1/2"	
Frame height	RH	mm	2480
Frame width	BT	mm	2945
Frame depth	RT	mm	460
Finned height	LH	mm	2400
Finned width	LB	mm	2700
Finned depth	LF	mm	400
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	76
Covering (~162mm)	AD	mm	180
Collector distance	KA	mm	350
Fin spacing	LT	mm	4.000
Fin thickness	LD	mm	0.100
Tube diameter	DA	mm	15.400
Tube diameter	da	mm	15.400
Tube thickness	S	mm	0.350
Tube interval on the height	S1	mm	50.000
Tube interval on the depth	S2	mm	50.000

Tubes:	Cu	
Tubes:	smooth	
Tubes:	in line	
Tubes:	circular	
Collectors:	1.53 m/s	Cu
Connections:	1.53 m/s	Rg7
Fins:	Al	
Fins:	ribbed	
Frame:	4.00 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



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 HVAC Solutions  
 Jurastrasse 35  
 CH-3063 Ittigen

Capacity	kW	822.715
Surface reserve	%	0.011
Present surface	m2	1282.500
Required surface	m2	1282.365
k-coeff.	V/m2K	17.051
Average temp. diff. ( 96.92 %	K	37.626

Air humid (ff=0.00005 m2K/W)		Inlet	Outlet	Definition
Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	22.000	75.568	22.000
Rel. humidity	%	50.000	3.355	50.000
Abs. humidity	g/kg	8.202	8.202	8.202
Density humid	kg/m3	1.190	1.007	1.190
Enthalpy humid	kJ/kg	42.984	97.816	42.984
Volume flow humid	m3/h	45770.000	54076.706	45770.000
Mass flow dry	kg/h	54015.480	54015.480	54015.480
Velocity	m/s	1.962	2.318	1.962
Pressure drop dry	Pa		65.747	

Phone: +41 79 222 66 42

Fax: ---  
 info@zcs.ch  
 www.zcs.ch

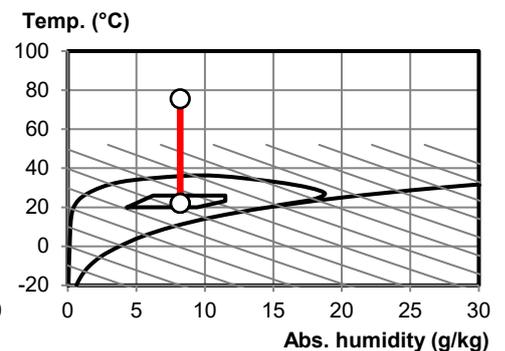
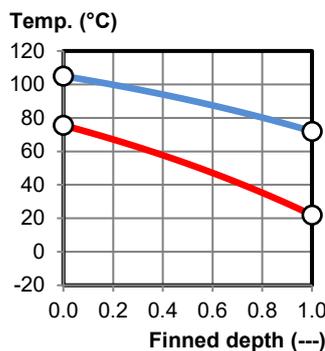
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With the compliments of

Dipl.-Ing. Marin Zeller FH, VDI  
 Direktwahl  
 +41 79 222 66 42

Mälzerei  
 Mafia-Hersteller  
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Water (ff=0.00005 m2K/W)		
Temp. in	°C	105.000
Temp. out	°C	72.023
Density	kg/m3	967.001
Spec. heat	kJ/kgK	4.204
Heat cond.	W/mK	0.674
Viscosity	Pas	3.240E-04
Volume flow	m3/h	22.094
Velocity	m/s	1.339
Pressure drop	bar	0.764

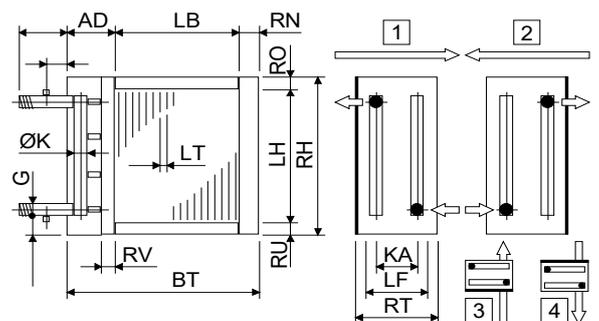


Technical data

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Tube coupling in series	Piece	14	
Number of circuits (NC)	Piece	27	
Volume	l	206	
Weight	kg	544	
Connections	G	2 1/2"	
Frame height	RH	mm	2480
Frame width	BT	mm	2945
Frame depth	RT	mm	460
Finned height	LH	mm	2400
Finned width	LB	mm	2700
Finned depth	LF	mm	400
Frame on top	RO	mm	40
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Frame on back (~65mm)	RN	mm	65
Collector-Diameter	K	mm	76
Covering (~162mm)	AD	mm	180
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Fin spacing	LT	mm	4.000
Fin thickness	LD	mm	0.100
Tube diameter	DA	mm	15.400
Tube diameter	da	mm	15.400
Tube thickness	S	mm	0.350
Tube interval on the height	S1	mm	50.000
Tube interval on the depth	S2	mm	50.000



Tubes:	Cu
Tubes:	smooth
Tubes:	in line
Tubes:	circular
Collectors:	1.52 m/s Cu
Connections:	1.52 m/s Rg7
Fins:	Al
Fins:	ribbed
Frame:	4.00 mm FeZn
Circulations:	1 Default
Protection:	without
Protection:	---
Air flow direction:	horizontal



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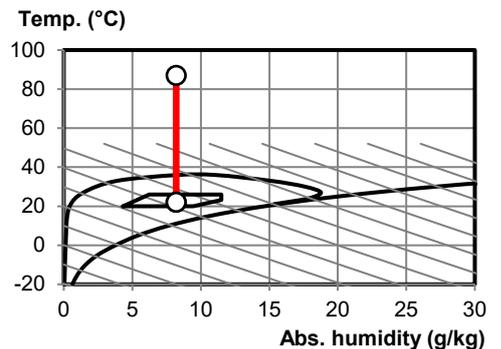
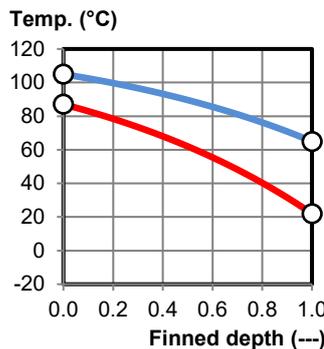
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Height over sea level	m			0.000
Pressure	hPa			1013.250
Temp.	°C	22.000	87.083	22.000
Rel. humidity	%	50.000	2.111	50.000
Abs. humidity	g/kg	8.202	8.202	8.202
Density humid	kg/m3	1.190	0.975	1.190
Enthalpy humid	kJ/kg	42.984	109.632	42.984
Volume flow humid	m3/h	45770.000	55862.350	45770.000
Mass flow dry	kg/h	54015.480	54015.480	54015.480
Velocity	m/s	1.962	2.395	1.962
Pressure drop	Pa		62.566	

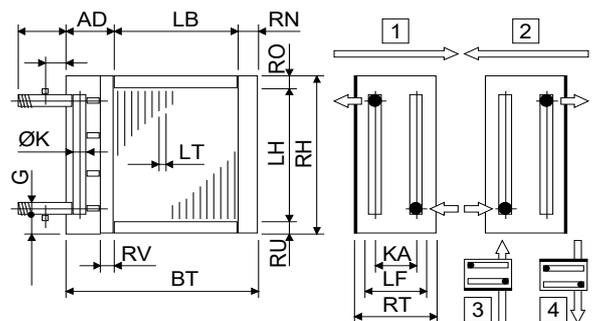
Water (ff=0.00005 m2K/W)		
Temp. in	°C	105.000
Temp. out	°C	65.000
Density	kg/m3	969.945
Spec. heat	kJ/kgK	4.200
Heat cond.	W/mK	0.672
Viscosity	Pas	3.420E-04
Volume flow	m3/h	22.094
Velocity	m/s	0.611
Pressure drop ( T/C = 2.026 )	bar	0.120



**Technical data**

Tubes total	Piece		480
Tubes blank	Piece		0
Int. vent./drains	Piece		0
Tube rows on the depth	Piece		8
Tube rows on the height	Piece		60
Tube coupling in series	Piece		8
Number of circuits (NC)	Piece		60
Volume	l		257
Weight	kg		741
Connections	G	---	3"
Frame height	RH	mm	2480
Frame width	BT	mm	2945
Frame depth	RT	mm	370
Finned height	LH	mm	2400
Finned width	LB	mm	2700
Finned depth	LF	mm	280
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
Covering (~175mm)	AD	mm	180
Collector distance	KA	mm	245
Fin spacing	LT	mm	4.000
Fin thickness	LD	mm	0.300
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

Tubes:		Cu
Tubes:		smooth
Tubes:		staggered
Tubes:		circular
Collectors:	1.10 m/s	Cu
Connections:	1.10 m/s	Rg7
Fins:		Al
Fins:		ribbed
Frame:	4.00 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

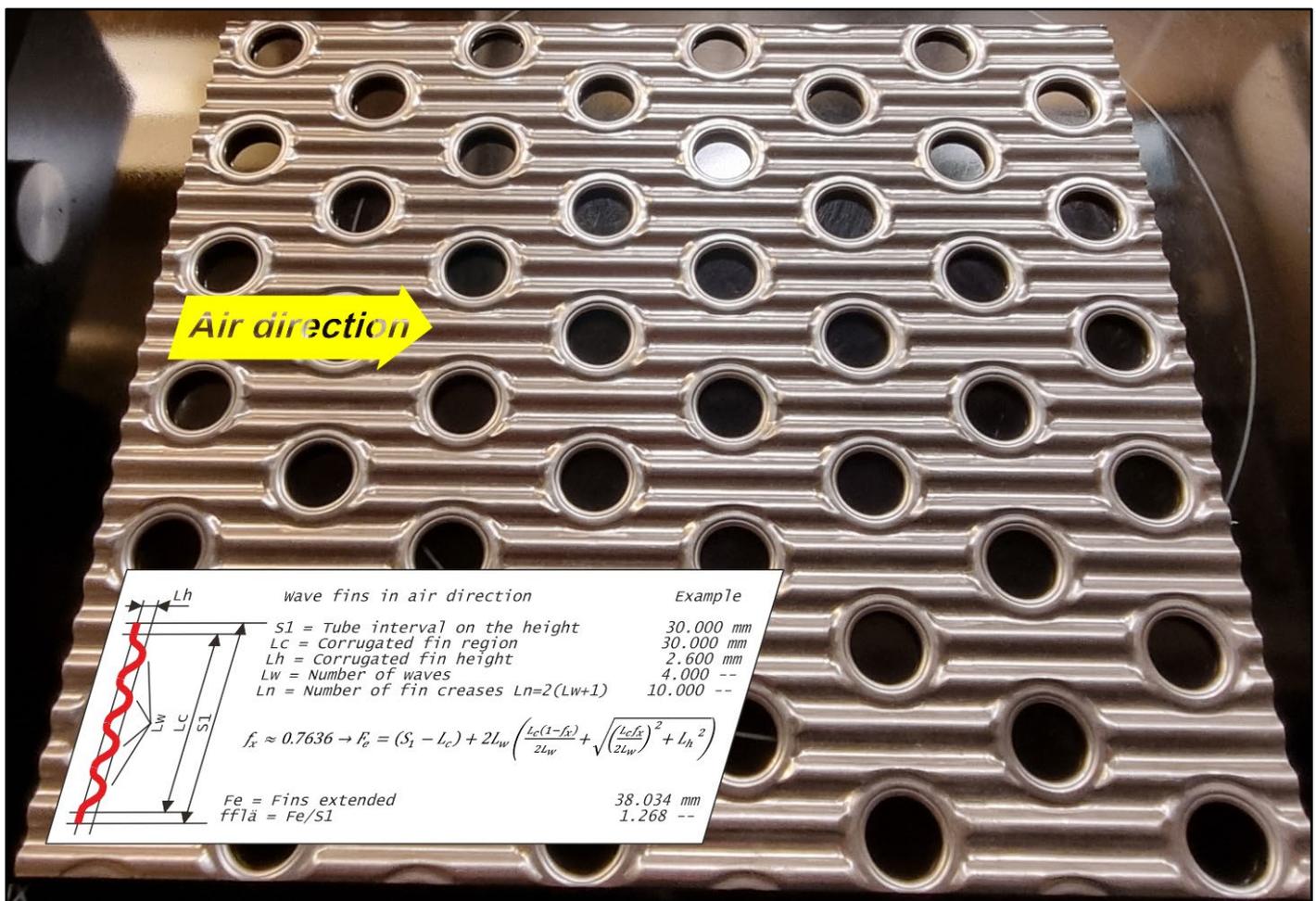
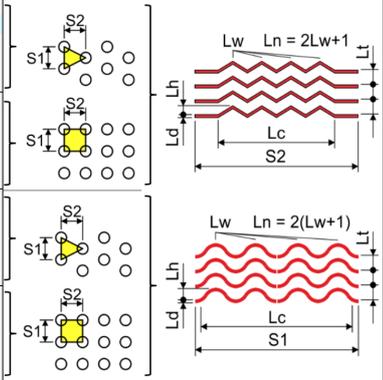
The pressure drop of **0.77 bar** on the water side is also highly negative in the case of the **AAA** air heater, which is **exaggerated by a factor of 6 to 7** for air heaters and therefore results in far too high operating costs. For a few paltry euros more in investment costs, this can be reduced to **0.12 bar**, which is amortized in the first year via the operating costs. So, **AAA** has no clue about this either!

If **AAA** would now use comfortable and flat fins with a thickness of 0.15 mm, the price optimum would have been set at EUR 9,461 of these two **totally crappy geometries** of 50x25x15 mm and 50x50x15 mm would have been aligned, see below highlighted in **blue**.

Unfortunately, neither **AAA** nor **BBB** has yet been able to decide to include sinusoidal fins in the direction of air in production and leaves this lucrative business with much lower prices, smaller air-side pressure drops and smaller installation depths to factories such as **TPS**, **DBM** and **WTS**. They are waiting and currently offering totally ruinous customer discounts as temporary compensation until it is too late.

**The HES software (heater, cooler, condenser, injection evaporator and 3 heat recovery systems) from ZCS, developed in C#, calculates up to 40 different geometries in 1 second and can be purchased as EXE and DLL.**

Heat exchanger: Comparison of different calculations																					
Company	Tube interval on the height		Tube interval on the depth		Tube diameter	Tube thickness	Tube arrangement	Fin stamp	Fin thickness	Corrugated fin height	Corrugated fin region	Fin stamp	Number of fin creases	Price total	Weight total	Volume total	Frame depth total	Fin spacing Min.	Pressure drop total	Pressure drop total	Factor Min.
Selection	S1	S2	DA	da	S	T	F	Ld	Lh	Lc	Lw	Ln	P	W	V	RT	LT	Agent	T/C	---	
---	mm	mm	mm	mm	mm	---	---	mm	mm	mm	Piece	Piece	EUR	kg	l	mm	mm	Pa	kPa	---	
AAA	50.000	25.000	15.400	15.400	0.350	1	1	0.100	0.000	0.000	0	1	10127	628	353	450	4.2	64	12.18	2.08	
AAA	50.000	25.000	15.400	15.400	0.350	1	1	0.150	0.000	0.000	0	1	9461	615	307	400	4.0	57	14.64	2.70	
AAA	50.000	25.000	15.400	15.400	0.350	1	1	0.200	0.000	0.000	0	1	9870	654	307	400	4.3	57	14.64	2.70	
AAA	50.000	25.000	15.400	15.400	0.350	1	1	0.250	0.000	0.000	0	1	10285	694	307	400	4.5	58	14.64	2.70	
AAA	50.000	25.000	15.400	15.400	0.350	1	1	0.300	0.000	0.000	0	1	10325	715	283	370	4.1	57	10.69	1.70	
AAA	50.000	50.000	15.400	15.400	0.350	2	1	0.100	0.000	0.000	0	1	10338	775	307	670	4.0	52	14.65	2.70	
AAA	50.000	50.000	15.400	15.400	0.350	2	1	0.150	0.000	0.000	0	1	10450	806	283	620	4.3	47	10.69	1.70	
AAA	50.000	50.000	15.400	15.400	0.350	2	1	0.200	0.000	0.000	0	1	10395	826	260	570	4.4	44	11.97	2.03	
AAA	50.000	50.000	15.400	15.400	0.350	2	1	0.250	0.000	0.000	0	1	10438	855	237	520	4.2	42	13.67	2.46	
AAA	50.000	50.000	15.400	15.400	0.350	2	1	0.300	0.000	0.000	0	1	10928	906	237	520	4.5	41	13.67	2.46	
TPS	40.000	34.641	16.400	16.400	0.350	1	2	0.200	2.600	40.000	4	10									
TPS	35.000	30.311	12.400	12.400	0.350	1	2	0.200	2.600	35.000	4	10									
TPS	33.333	28.867	12.400	12.400	0.350	1	2	0.200	2.600	33.333	4	10	7981	520	183	300	4.2	46	13.62	2.44	
DBM	30.000	25.981	12.450	12.450	0.350	1	2	0.200	2.600	30.000	4	10	8283	505	202	280	4.5	51	11.82	1.99	
DBM	25.000	21.651	10.400	10.400	0.350	1	2	0.200	2.600	25.000	4	10									
WTS	40.000	40.000	16.400	16.400	0.350	2	2	0.200	2.600	40.000	4	10									
WTS	35.000	35.000	13.100	13.100	0.350	2	2	0.200	2.600	35.000	4	10	8470	581	195	330	4.0	36	11.83	1.99	
WTS	32.000	32.000	12.400	12.400	0.350	2	2	0.200	2.600	32.000	4	10									
WTS	30.000	30.000	12.400	12.400	0.350	2	2	0.200	2.600	30.000	4	10									
WTS	25.000	25.000	10.400	10.400	0.350	2	2	0.200	2.600	25.000	4	10									



**Wave fins in air direction** Example

$S1$  = Tube interval on the height 30.000 mm  
 $Lc$  = Corrugated fin region 30.000 mm  
 $Lh$  = Corrugated fin height 2.600 mm  
 $Lw$  = Number of waves 4.000 --  
 $Ln$  = Number of fin creases  $Ln=2(Lw+1)$  10.000 --

$$f_x \approx 0.7636 \rightarrow F_e = (S1 - Lc) + 2Lw \left( \frac{Lc(1-f_x)}{2Lw} + \sqrt{\left(\frac{Lc f_x}{2Lw}\right)^2 + Lh^2} \right)$$

$F_e$  = Fins extended 38.034 mm  
 $f_{fl\ddot{a}}$  =  $F_e/S1$  1.268 --