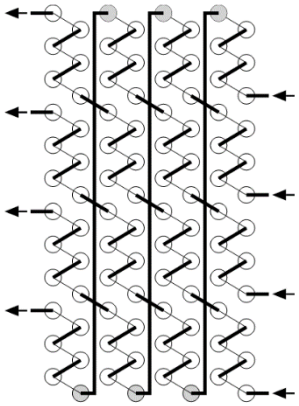
# Internal coupling for finned heat exchangers

**Software CCSX**

In 1987 Cert.-Eng. Marin Zeller TU, VDI, the owner of the company www.zcs.ch, invented this circuit. As of 2022, the software he developed for finned heat exchangers in heat recovery systems has been on the market for more than 25 years and has been accepted by the majority of manufacturers.

Its characteristic was the achievement of a maximum of cross-counterflow, taking into account the venting and draining in the installation position. We support in line and staggered tube arrangements.



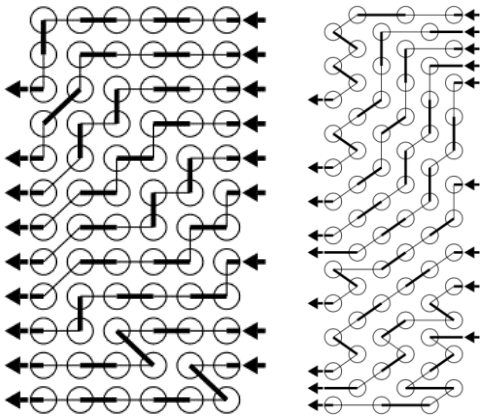
However, it remained open as of 2022 - and also for 25 years! - an internal circuit software for all other types of finned heat exchangers such as air heaters, air coolers, condensers and evaporators. There are some applications on the market for this, but they were never able to cover the requirements. It was switched up and down freshly and happily, without taking into account the necessary venting and draining, and the individual couplings sometimes did not have the same number of tubes, with the flimsy justification of wanting to prevent blind tubes. Under these circumstances, the manufacturers of finned heat exchangers had no choice but to create databases of hydraulic circuits that had already been manufactured and laboriously generate new circuits. We were therefore approached with a request to develop software that would eliminate all these shortcomings.

**Software SIC**

In September 2022, after an intensive development phase by 3 engineers over a period of 1 year, we are now able to offer an application for this as well

Get supported:

| | |
|---|---|
| Air direction | horizontal |
| Tube arrangement | in line and staggered |
| Tubes on depth | 2 to 12 pieces |
| Tubes on height | 6 to 60 pieces |
| Max. blind tubes | 2 pieces or maximal 2% |



Until the end of August 2022, we offered companies that supported us in the development a discount of 25%, which unfortunately only 1 manufacturer of finned heat exchangers took advantage of. That's the way it is, unfortunately, many are crying out for a solution and few support it.

Since both applications can now be downloaded from our FTP server on request, installed and tested as trial versions for 3 days with a maximum of 6 executions, we are offering interested companies who would like to purchase both applications a discount of 25% until end of October 2022.

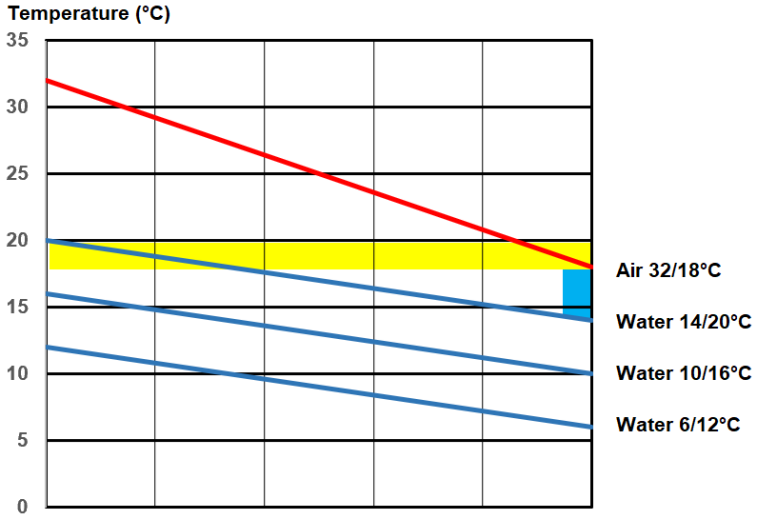
**CCSX & SIC, 1 Single-License each, EUR 11'784 less 25% = EUR 8'838 until end of October 2022**

## When do we need which internal hydraulic coupling?

Using the example of cooling hot air in summer from 32°C to 18°C with cold water at various temperature levels, two problems become apparent.

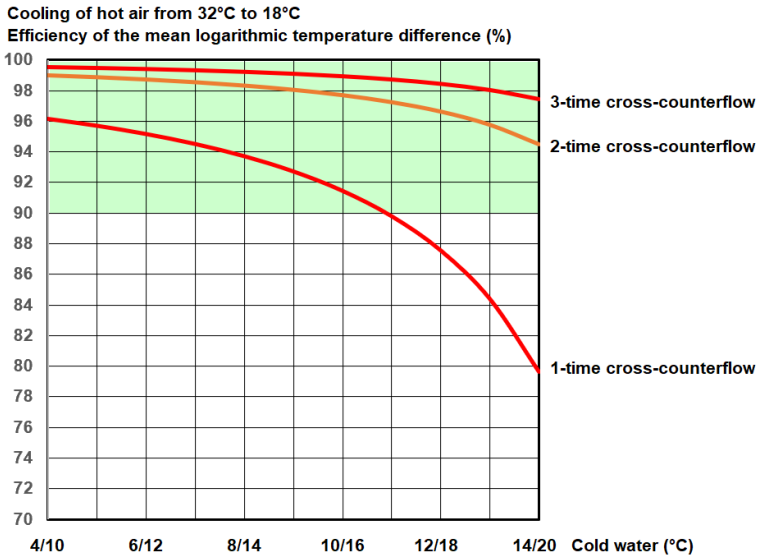
The closer the cold water inlet is to the hot air outlet (blue field), the more multiple cross-counterflow is required.

If the cold water leaving temperature is higher than the hot air leaving temperature (yellow field), the more multiple cross-counterflow is required.




How much multiple cross-counterflow is required is shown by not losing more than 10% of mean logarithmic temperature difference compared to pure counterflow (green field).

This is still possible with 2-fold cross-countercurrent with cold water of 14/20°C, but no longer with 1-fold cross-countercurrent.



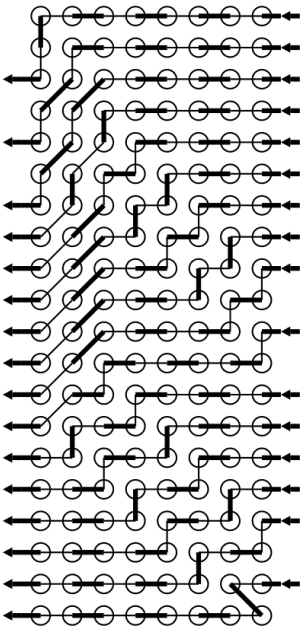

### In line or staggered tube rows?

The pictures on the right and the following pages show that in this example the 8 tube rows in line have significantly more cross-countercurrent packages than the 8 staggered tube rows.

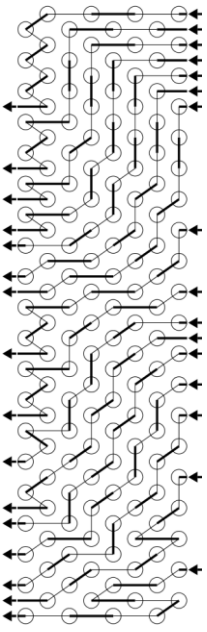
In addition, you can get by with the standard coupling, offered by the SIC software, and you don't have to switch to the special coupling, offered by the CCSX software.

However, this would change abruptly if the cold water spread was greater than just the usual 6K!

**8 in line tube rows**



**8 staggered tube rows**

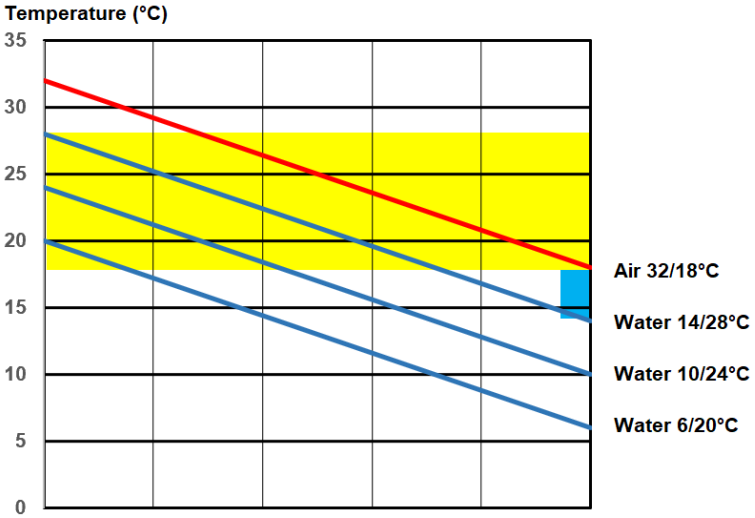


## When do we need which internal hydraulic coupling?

Using the example of cooling hot air in summer from 32°C to 18°C with cold water at various temperature levels, two problems become apparent.

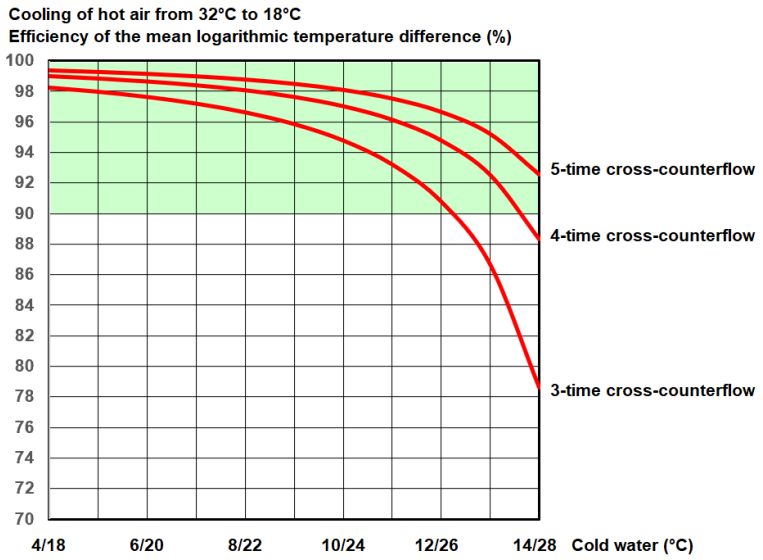
The closer the cold water inlet is to the hot air outlet (blue field), the more multiple cross-counterflow is required.

If the cold water leaving temperature is higher than the hot air leaving temperature (yellow field), the more multiple cross-counterflow is required.




How much multiple cross-counterflow is required is shown by not losing more than 10% of mean logarithmic temperature difference compared to pure counterflow (green field).

This is still possible with 5-fold cross-countercurrent with cold water of 14/28°C, but no longer with 3-fold or 4-fold cross-countercurrent.

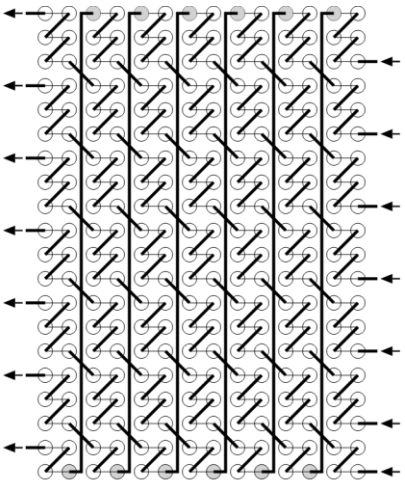



## In line or staggered tube rows?

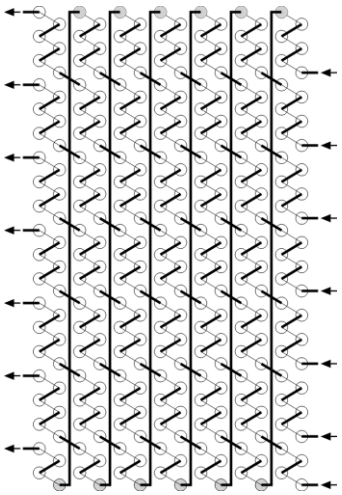
The pictures on the right and the following pages show, that in this example the 14 in line tube rows have the same cross-countercurrent packages like the 14 staggered tube rows.

In addition, you need the special circuit offered by the CCSX software and you can no longer use the standard circuit offered by the SIC software.

**14 in line tube rows**



**14 staggered tube rows**



**Cooler: 35/35/12-8R-20T-992A-2.8PA-16C-Cu/Al/AISI 304** — **Software by www.zcs.ch**

| | | | | |
|---|---|---|---|---|
| Capacity | kW | 25.205 | ------ sensible: | 23.849 |
| Surface reserve | % | 1.941 | latent: | 1.356 |
| Present surface | m2 | 130.930 | frost: | 0.000 |
| Required surface | m2 | 128.437 | | |
| k-coeff. | W/m2K | 28.886 | | |
| Average temp. diff. ( 93.30 % ) | K | 6.794 | | |

LOGO

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| **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 | 18.000 | 20.000 |
| Rel. humidity | % | 40.000 | 89.567 | 40.000 |
| Abs. humidity | g/kg | 11.860 | 11.541 | 5.784 |
| Density humid | kg/m3 | 1.148 | 1.204 | 1.200 |
| Enthalpy humid | kJ/kg | 62.569 | 47.355 | 34.805 |
| Volume flow humid | m3/h | 5255.023 | 5011.407 | 5000.000 |
| Mass flow dry | kg/h | 5963.904 | 5963.904 | 5963.904 |
| Condensate flow | kg/h | | 1.907 | |
| Surface temperature | °C | 23.328 | 15.109 | |
| Velocity | m/s | 2.102 | 2.005 | 2.000 |
| Pressure drop (dry 45 Pa) | Pa | | 46.003 | |

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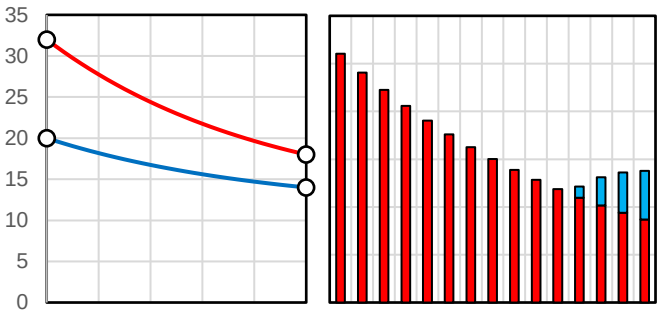
Plant
Object
Position

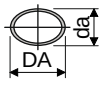
| **Water ( ff = 0.00005 m2K/W )** | | |
|---|---|---|
| Temp. Inlet | °C | 14.000 |
| Temp. Outlet | °C | 20.000 |
| Temp. Selection | °C | 16.190 |
| Density | kg/m3 | 998.920 |
| Spec. heat | kJ/kgK | 4.184 |
| Heat cond. | W/mK | 0.592 |
| Viscosity | Pas | 1.103E-03 |
| Volume flow | m3/h | 3.618 |
| Velocity | m/s | 0.594 |
| Reynolds | --- | 6244.182 |
| Pressure drop ( T/C = 9.114 ) | kPa | 7.919 |

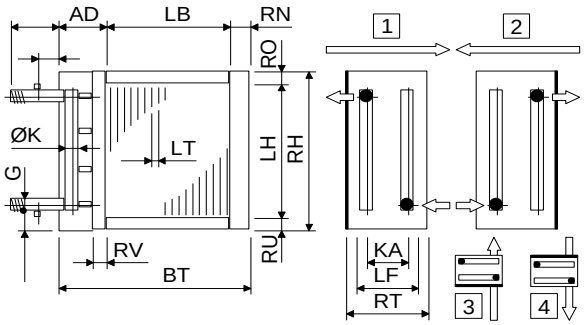
**Temp. (°C)**




**Technical data**

| | | | | | | |
|---|---|---|---|---|---|---|
| Tubes total | | Piece | 160 | Tubes: | | Cu |
| Tubes blank | | Piece | 0 | Tubes: | | smooth |
| Int. vent./drains | | Piece | 0 | Tubes: | | in line |
| Tube rows on the depth | | Piece | 8 | Tubes: | | circular |
| Tube rows on the height | | Piece | 20 | Collectors: | 0.49 m/s | Cu |
| Tube coupling in series | | Piece | 10 | Connections: | 0.49 m/s | Rg7 |
| Number of circuits (NC) | | Piece | 16 | Fins: | | Al |
| Volume | | l | 23 | Fins: | | smooth |
| Weight | | kg | 86 | Circulations: | 1 | Default |
| Connections | G | --- | 2" | Frame: | 2.0 mm | AISI 304 |
| Frame height | RH | mm | 780 | Protection: | | without |
| Frame width | BT | mm | 1170 | Protection: | | --- |
| Frame depth | RT | mm | 330 | Air flow direction: | | horizontal |
| Finned height | LH | mm | 700 | | | |
| Finned width | LB | mm | 992 | | | |
| 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 (~53mm) | RN | mm | 53 | | | |
| Collector-Diameter | K | mm | 54 | | | |
| Collector covering | AD | mm | 125 | | | |
| Collector distance | KA | mm | 245 | | | |
| Fin spacing | LT | mm | 2.800 | | | |
| Fin thickness | LD | mm | 0.200 | | | |
| Tube diameter | DA | mm | 12.400 | Delivery: | | 5-6 weeks |
| Tube diameter | da | mm | 12.400 | Validity: | | 12 weeks |
| Tube thickness | S | mm | 0.400 | Condit.: | | net, prepaid address |
| Tube interval on the height | S1 | mm | 35.000 | Payment: | | 30 days net |
| Tube interval on the depth | S2 | mm | 35.000 | **Price net:** | | **EUR 1362.00** |



**Cooler: 35/30/12-8R-20T-992A-3.0PA-16C-Cu/Al/AISI 304** — **Software by www.zcs.ch**

| | | | | |
|---|---|---|---|---|
| Capacity | kW | 25.193 | ------ sensible: | 23.850 |
| Surface reserve | % | 2.305 | latent: | 1.343 |
| Present surface | m2 | 105.248 | frost: | 0.000 |
| Required surface | m2 | 102.877 | | |
| k-coeff. | W/m2K | 36.149 | | |
| Average temp. diff. ( 93.03 % ) | K | 6.774 | | |

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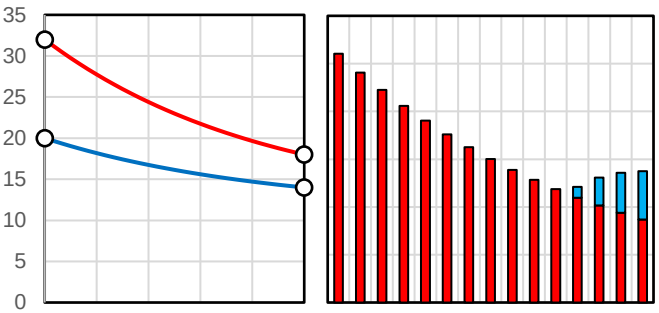
Plant
Object
Position

| **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 | 18.000 | 20.000 |
| Rel. humidity | % | 40.000 | 89.590 | 40.000 |
| Abs. humidity | g/kg | 11.860 | 11.544 | 5.784 |
| Density humid | kg/m3 | 1.148 | 1.204 | 1.200 |
| Enthalpy humid | kJ/kg | 62.569 | 47.362 | 34.805 |
| Volume flow humid | m3/h | 5255.023 | 5011.430 | 5000.000 |
| Mass flow dry | kg/h | 5963.904 | 5963.904 | 5963.904 |
| Condensate flow | kg/h | | 1.889 | |
| Surface temperature | °C | 23.353 | 15.118 | |
| Velocity | m/s | 2.102 | 2.005 | 2.000 |
| Pressure drop (dry 56 Pa) | Pa | | 56.664 | |

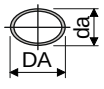
| **Water ( ff = 0.00005 m2K/W )** | | |
|---|---|---|
| Temp. Inlet | °C | 14.000 |
| Temp. Outlet | °C | 20.000 |
| Temp. Selection | °C | 16.190 |
| Density | kg/m3 | 998.920 |
| Spec. heat | kJ/kgK | 4.184 |
| Heat cond. | W/mK | 0.592 |
| Viscosity | Pas | 1.103E-03 |
| Volume flow | m3/h | 3.616 |
| Velocity | m/s | 0.594 |
| Reynolds | --- | 6241.082 |
| Pressure drop ( T/C = 9.114 ) | kPa | 7.912 |

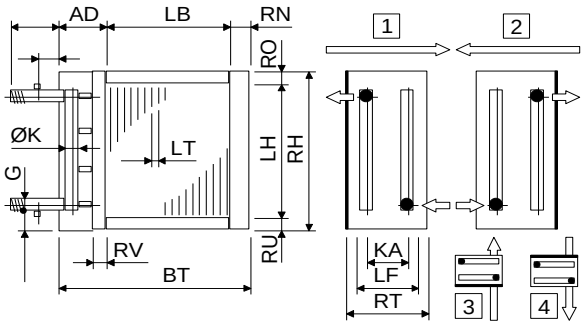
**Temp. (°C)**




**Technical data**

| | | | | | | |
|---|---|---|---|---|---|---|
| Tubes total | | Piece | 160 | Tubes: | | Cu |
| Tubes blank | | Piece | 0 | Tubes: | | smooth |
| Int. vent./drains | | Piece | 0 | Tubes: | | staggered |
| Tube rows on the depth | | Piece | 8 | Tubes: | | circular |
| Tube rows on the height | | Piece | 20 | Collectors: | 0.49 m/s | Cu |
| Tube coupling in series | | Piece | 10 | Connections: | 0.49 m/s | Rg7 |
| Number of circuits (NC) | | Piece | 16 | Fins: | | Al |
| Volume | | l | 23 | Fins: | | smooth |
| Weight | | kg | 77 | Circulations: | 1 | Default |
| Connections | G | --- | 2" | Frame: | 2.0 mm | AISI 304 |
| Frame height | RH | mm | 780 | Protection: | | without |
| Frame width | BT | mm | 1170 | Protection: | | --- |
| Frame depth | RT | mm | 300 | Air flow direction: | | horizontal |
| Finned height | LH | mm | 700 | | | |
| Finned width | LB | mm | 992 | | | |
| Finned depth | LF | mm | 242 | | | |
| 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 | 54 | | | |
| Collector covering | AD | mm | 125 | | | |
| Collector distance | KA | mm | 213 | | | |
| Fin spacing | LT | mm | 3.000 | | | |
| Fin thickness | LD | mm | 0.200 | | | |
| Tube diameter | DA | mm | 12.400 | Delivery: | | 5-6 weeks |
| Tube diameter | da | mm | 12.400 | Validity: | | 12 weeks |
| Tube thickness | S | mm | 0.400 | Condit.: | | net, prepaid address |
| Tube interval on the height | S1 | mm | 35.000 | Payment: | | 30 days net |
| Tube interval on the depth | S2 | mm | 30.311 | **Price net:** | **EUR** | **1297.00** |



**Cooler: 35/35/12-14R-20T-1000A-2.7PA-7C-Cu/Al/AISI 304** — **Software by www.zcs.ch**

| | | | | |
|---|---|---|---|---|
| Capacity | kW | 24.499 | ------ sensible: | 23.857 |
| Surface reserve | % | 1.688 | latent: | 0.642 |
| Present surface | m2 | 239.127 | frost: | 0.000 |
| Required surface | m2 | 235.156 | | |
| k-coeff. | W/m2K | 28.296 | | |
| Average temp. diff. ( 92.05 % ) | K | 3.682 | | |

LOGO

Company
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| **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 | 18.000 | 20.000 |
| Rel. humidity | % | 40.000 | 90.849 | 40.000 |
| Abs. humidity | g/kg | 11.860 | 11.709 | 5.784 |
| Density humid | kg/m3 | 1.148 | 1.204 | 1.200 |
| Enthalpy humid | kJ/kg | 62.569 | 47.781 | 34.805 |
| Volume flow humid | m3/h | 5255.023 | 5012.737 | 5000.000 |
| Mass flow dry | kg/h | 5963.904 | 5963.904 | 5963.904 |
| Condensate flow | kg/h | | 0.903 | |
| Surface temperature | °C | 29.124 | 15.124 | |
| Velocity | m/s | 2.085 | 1.989 | 1.984 |
| Pressure drop (dry 80 Pa) | Pa | | 80.414 | |

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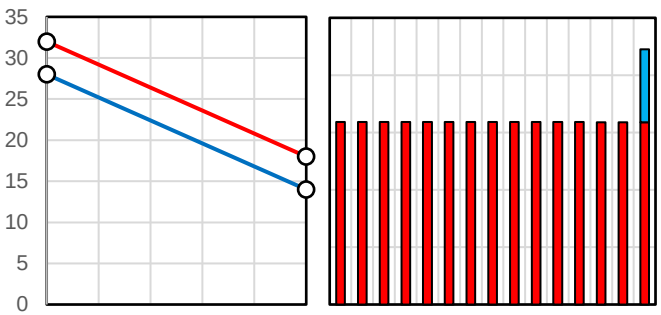
Plant
Object
Position

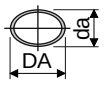
| **Water ( ff = 0.00005 m2K/W )** | | |
|---|---|---|
| Temp. Inlet | °C | 14.000 |
| Temp. Outlet | °C | 28.000 |
| Temp. Selection | °C | 19.110 |
| Density | kg/m3 | 998.389 |
| Spec. heat | kJ/kgK | 4.182 |
| Heat cond. | W/mK | 0.597 |
| Viscosity | Pas | 1.024E-03 |
| Volume flow | m3/h | 1.509 |
| Velocity | m/s | 0.567 |
| Reynolds | --- | 6407.427 |
| Pressure drop ( T/C = 10.201 ) | kPa | 28.497 |

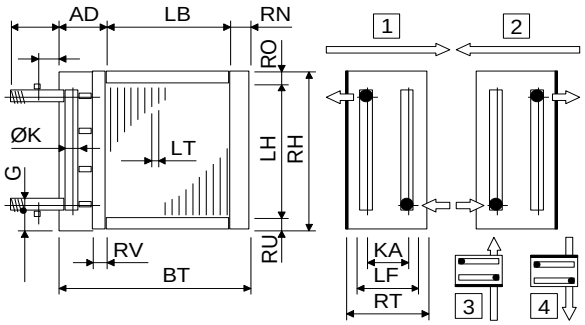
**Temp. (°C)**




**Technical data**

| | | | | | | |
|---|---|---|---|---|---|---|
| Tubes total | | Piece | 280 | Tubes: | | Cu |
| Tubes blank | | Piece | 0 | Tubes: | | smooth |
| Int. vent./drains | | Piece | 6 | Tubes: | | in line |
| Tube rows on the depth | | Piece | 14 | Tubes: | | circular |
| Tube rows on the height | | Piece | 20 | Collectors: | 0.85 m/s | Cu |
| Tube coupling in series | | Piece | 40 | Connections: | 0.85 m/s | Rg7 |
| Number of circuits (NC) | | Piece | 7 | Fins: | | Al |
| Volume | | l | 34 | Fins: | | smooth |
| Weight | | kg | 139 | Circulations: | 1 | Default |
| Connections | G | --- | 1" | Frame: | 2.0 mm | AISI 304 |
| Frame height | RH | mm | 780 | Protection: | | without |
| Frame width | BT | mm | 1170 | Protection: | | --- |
| Frame depth | RT | mm | 510 | Air flow direction: | | horizontal |
| Finned height | LH | mm | 700 | | | |
| Finned width | LB | mm | 1000 | | | |
| Finned depth | LF | mm | 490 | | | |
| 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 | 28 | | | |
| Collector covering | AD | mm | 117 | | | |
| Collector distance | KA | mm | 455 | | | |
| Fin spacing | LT | mm | 2.700 | | | |
| Fin thickness | LD | mm | 0.200 | | | |
| Tube diameter | DA | mm | 12.400 | Delivery: | | 5-6 weeks |
| Tube diameter | da | mm | 12.400 | Validity: | | 12 weeks |
| Tube thickness | S | mm | 0.400 | Condit.: | | net, prepaid address |
| Tube interval on the height | S1 | mm | 35.000 | Payment: | | 30 days net |
| Tube interval on the depth | S2 | mm | 35.000 | **Price net:** | | **EUR 2322.00** |



**Cooler: 35/30/12-14R-20T-1000A-2.9PA-7C-Cu/Al/AISI 304** — **Software by www.zcs.ch**

| | | | | |
|---|---|---|---|---|
| Capacity | kW | 24.495 | ------ sensible: | 23.857 |
| Surface reserve | % | 1.998 | latent: | 0.639 |
| Present surface | m2 | 191.696 | frost: | 0.000 |
| Required surface | m2 | 187.941 | | |
| k-coeff. | W/m2K | 35.390 | | |
| Average temp. diff. ( 92.07 % ) | K | 3.683 | | |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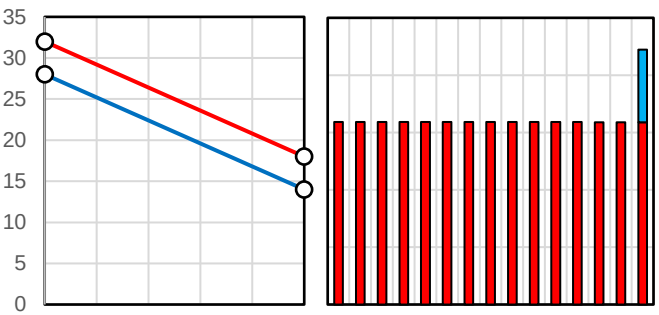
xxxxxxxxxx

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 | 18.000 | 20.000 |
| Rel. humidity | % | 40.000 | 90.856 | 40.000 |
| Abs. humidity | g/kg | 11.860 | 11.710 | 5.784 |
| Density humid | kg/m3 | 1.148 | 1.204 | 1.200 |
| Enthalpy humid | kJ/kg | 62.569 | 47.783 | 34.805 |
| Volume flow humid | m3/h | 5255.023 | 5012.744 | 5000.000 |
| Mass flow dry | kg/h | 5963.904 | 5963.904 | 5963.904 |
| Condensate flow | kg/h | | 0.898 | |
| Surface temperature | °C | 29.128 | 15.128 | |
| Velocity | m/s | 2.085 | 1.989 | 1.984 |
| Pressure drop (dry 97 Pa) | Pa | | 97.886 | |

| **Water ( ff = 0.00005 m2K/W )** | | |
|---|---|---|
| Temp. Inlet | °C | 14.000 |
| Temp. Outlet | °C | 28.000 |
| Temp. Selection | °C | 19.110 |
| Density | kg/m3 | 998.389 |
| Spec. heat | kJ/kgK | 4.182 |
| Heat cond. | W/mK | 0.597 |
| Viscosity | Pas | 1.024E-03 |
| Volume flow | m3/h | 1.509 |
| Velocity | m/s | 0.567 |
| Reynolds | --- | 6406.499 |
| Pressure drop ( T/C = 10.201 ) | kPa | 28.490 |

**Temp. (°C)**




**Technical data**

| | | | | | | |
|---|---|---|---|---|---|---|
| Tubes total | | Piece | 280 | Tubes: | | Cu |
| Tubes blank | | Piece | 0 | Tubes: | | smooth |
| Int. vent./drains | | Piece | 6 | Tubes: | | staggered |
| Tube rows on the depth | | Piece | 14 | Tubes: | | circular |
| Tube rows on the height | | Piece | 20 | Collectors: | 0.85 m/s | Cu |
| Tube coupling in series | | Piece | 40 | Connections: | 0.85 m/s | Rg7 |
| Number of circuits (NC) | | Piece | 7 | Fins: | | Al |
| Volume | | l | 34 | Fins: | | smooth |
| Weight | | kg | 123 | Circulations: | 1 | Default |
| Connections | G | --- | 1" | Frame: | 2.0 mm | AISI 304 |
| Frame height | RH | mm | 780 | Protection: | | without |
| Frame width | BT | mm | 1170 | Protection: | | --- |
| Frame depth | RT | mm | 450 | Air flow direction: | | horizontal |
| Finned height | LH | mm | 700 | | | |
| Finned width | LB | mm | 1000 | | | |
| Finned depth | LF | mm | 424 | | | |
| 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 | 28 | | | |
| Collector covering | AD | mm | 117 | | | |
| Collector distance | KA | mm | 395 | | | |
| Fin spacing | LT | mm | 2.900 | | | |
| Fin thickness | LD | mm | 0.200 | | | |
| Tube diameter | DA | mm | 12.400 | Delivery: | | 5-6 weeks |
| Tube diameter | da | mm | 12.400 | Validity: | | 12 weeks |
| Tube thickness | S | mm | 0.400 | Condit.: | | net, prepaid address |
| Tube interval on the height | S1 | mm | 35.000 | Payment: | | 30 days net |
| Tube interval on the depth | S2 | mm | 30.311 | **Price net:** | | **EUR 2200.00** |