HyCool eLearning
Hybrid Heat Pump

Lesson 3. System Planning

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eLEARNING COURSE

What questions will this course answer?

What is the general layout of a system with HHP?

What are the placing requirements for a HHP?

What heat transfer fluids a HHP can be filled with?

What are the most important guidelines for planning of installations with a HH*P?*

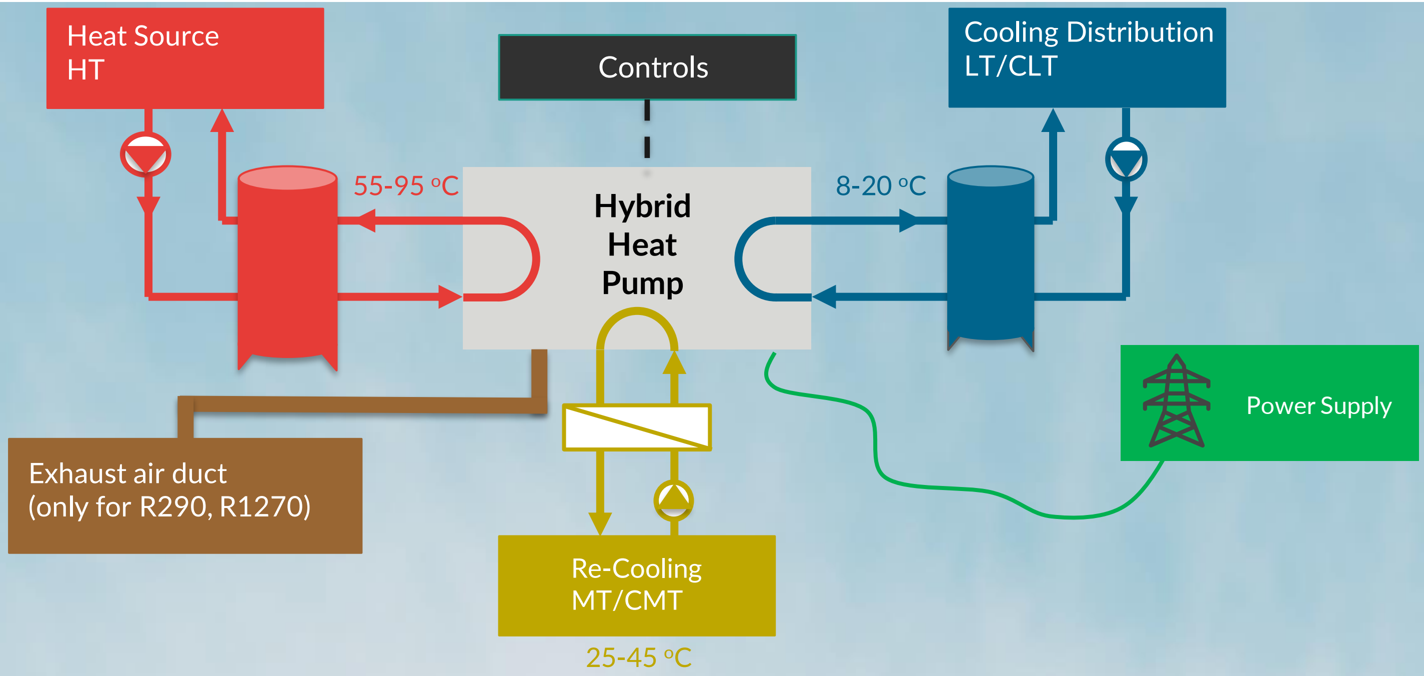
How to integrate the HHP with superior control system (e.g. BEMS)?

Why is proper commissioning by certified staff so important?

How to prepare the installation for the commissioning?

**More detailed information on proper system planning, as well as on operation & maintenance can be found in the operation manuals, which are delivered with the HHP.*

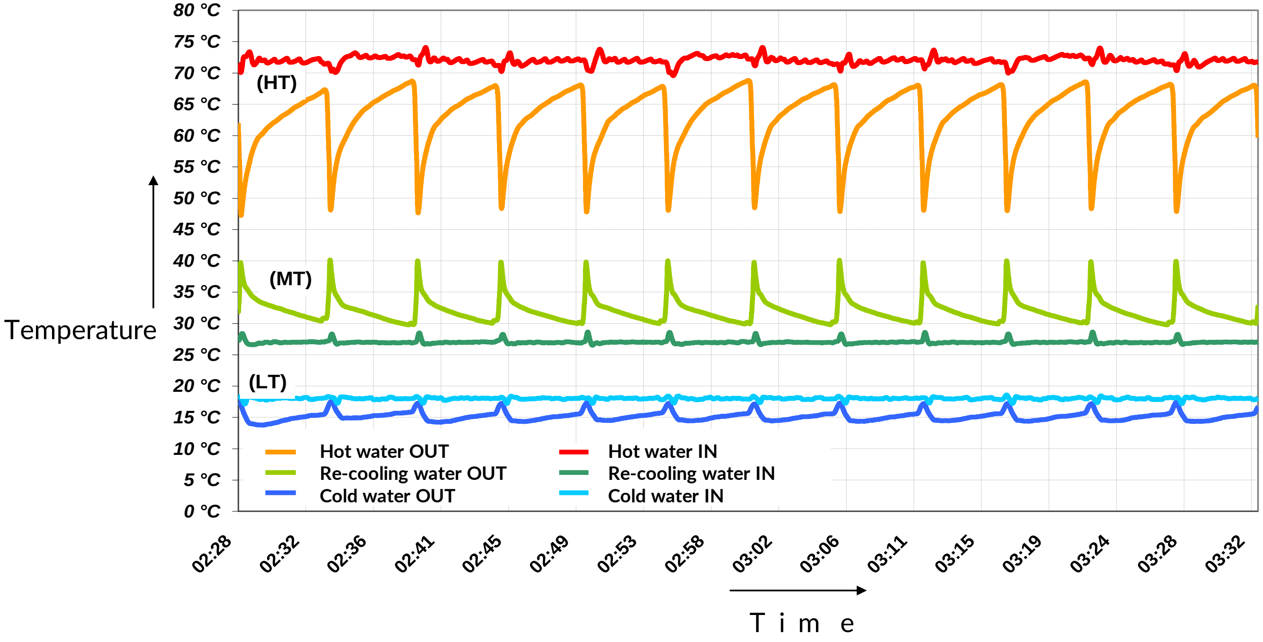
General layout of a system with HHP



General requirements

- The optimal type and size of the HHP is specified based on the available amount of heat, cooling demand, as well as requested and available operating temperature levels.
- The HHP is only suitable for indoor installation in frost-free rooms. Temperature above 5°C must be maintained during transport and storage to avoid damage of the adsorption modules.
- Sufficient installation, operating and maintenance clearance must be maintained around the HHP.

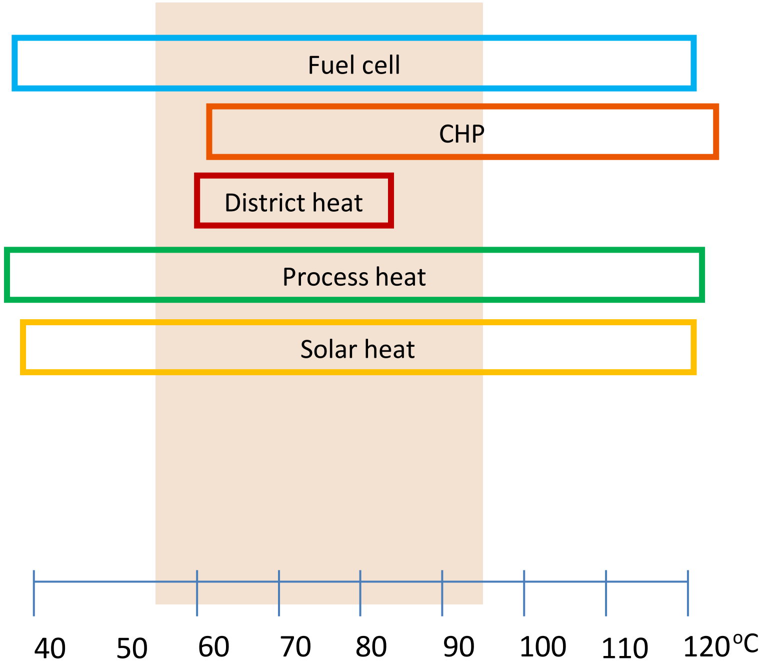
Temperature profile



One of the characteristic features of the adsorption heat pumps, which must be kept in mind during the installation planning, is the temperature profile.

The switch-over from one adsorption module to the other („cycling“) generates the fluctuating temperature profile, which is typical for the adsorption cooling process.
This profile is called “saw tooth” because of its shape.

Drive heat



The HHP (i.e., the adsorption part) is driven by hot water in temperatures 55-95°C.

Lower drive temperatures (down to 55°C) are suitable for silica gel heat pumps. Zeolite heat pumps require higher drive temperatures (above 75°C).

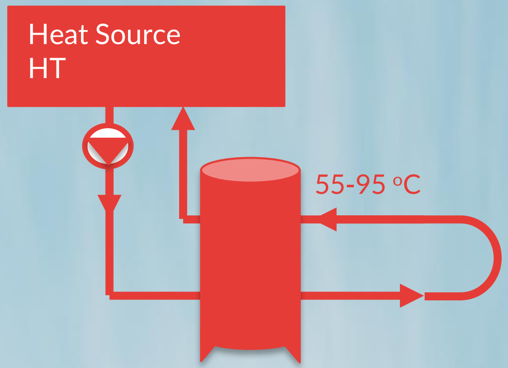
There are many possible sources of drive heat, but the most economically efficient are the sources of „free“ heat e.g., solar heat or waste heat from industrial processes.

Hydraulic connection of the HHP to the heat source

Two important points in planning the hydraulic system connecting of the HHP to the heat source are:

- *ensuring the right supply temperature (as high as possible within the operating limits),*
- *achieving the nominal volume flow (indicated in the technical data sheet).*

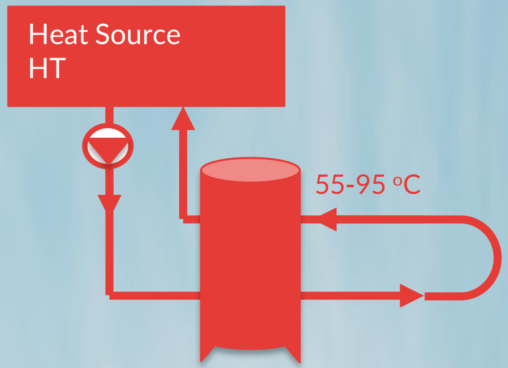
The basic principles of designing hydraulic circuits should be observed, e.g. the use of expansion vessels, safety valves, strainers, appropriate thermal insulation etc.



Hydraulic connection of the HHP to the heat source

- Attention should also be paid to reducing pressure losses and to the use of efficient pumps to optimize the energy consumption of the system. A highly efficient pump is integrated in the HT circuit of the HHP, but if the circuits are separated (see next slide) or the delivery head of the integrated pump is too small for the pressure losses in the installation, an additional pump must be foreseen.

- To facilitate proper connection, the HT inlet (medium entering the HHP) and outlet (medium exiting the HHP) are marked on the technical drawing and directly on the HHP housing (HT_in, HT_out).



Hydraulic connection of the HHP to the heat source

SEPARATION HEAT EXCHANGER

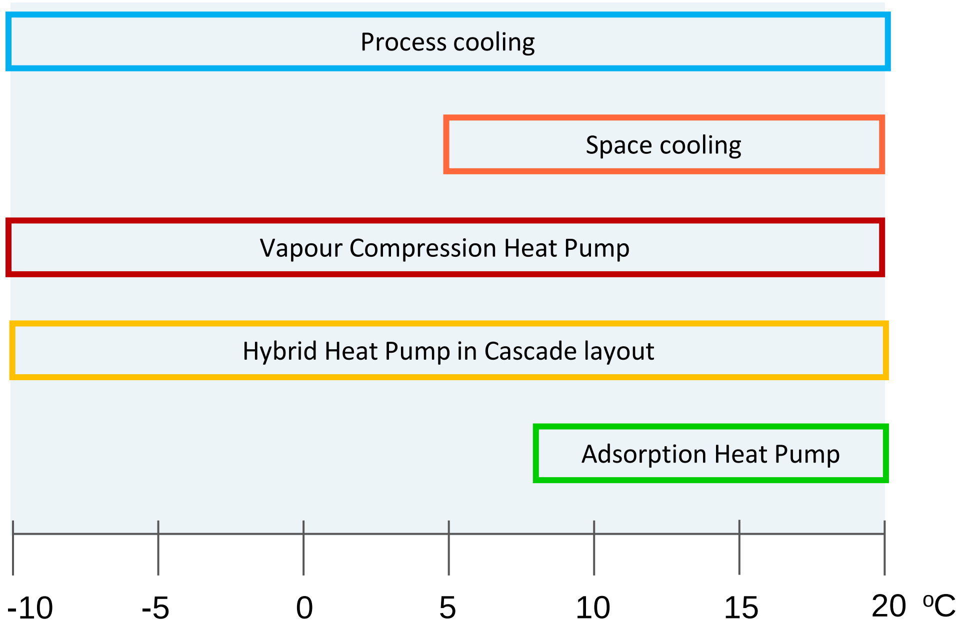
Often, connecting the HHP to a heat source requires the use of a heat exchanger, which separates the heat source from the HHP's internal hydraulic circuits. In some HHP models, such an exchanger is already integrated in the housing. In others, it should be planned for in the external installation. The selection of a separation exchanger should be carried out individually for a given heat source. Plate heat exchangers are usually a good choice. Design heat exchangers generously to avoid performance losses.

Hydraulic connection of the HHP to the heat source

BUFFER TANK

If the heat source provides medium (e.g., pure water) in quality that can be used in the HHP directly, but at different volume flow, good solution is to use a hydraulic clutch. However, if space and budget permits, it is worth equipping the installation with a properly dimensioned buffer tank. The advantages are buffering of peak high or low loads, ensuring nominal volume flow and levelling the temperature profile. Moreover, a temperature sensor installed inside the tank enables more advanced automatic control of the HHP ensuring its better performance.

Cooling distribution



The adsorption heat pump delivers cold water at temperature in range from +8 to +20 °C.

With vapour compression heat pump sub-zero temperatures of cold brine are achievable. (Range from -10 to +20 °C).

The cooling capacity supplied by the HHP can be used in various applications, most common are space cooling and cooling of processes.

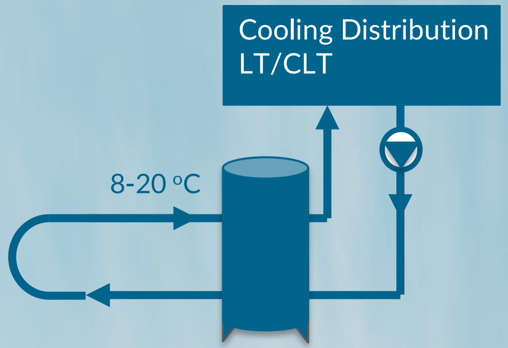
It is very important to choose the right application for the HHP. If there are two or more places with cooling demand in your plant, it is more efficient to use HHP in the place where higher cooling temperatures are required.

Hydraulic connection of the HHP to the cooling distribution

The key tips for planning the cooling distribution circuit are like those for the heat source circuit. The two important points are the same as previously:

- *ensuring the right temperature level (as high as possible within the operating limits),*
- *achieving the nominal volume flow (indicated in the technical data sheet).*

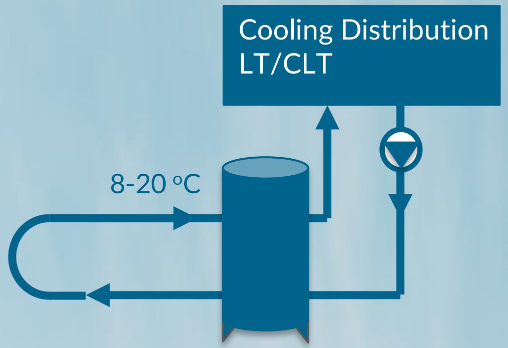
The basic principles of designing hydraulic circuits should be observed, e.g., the use of expansion vessels, safety valves, strainers, appropriate thermal insulation etc.



Hydraulic connection of the HHP to the cooling distribution

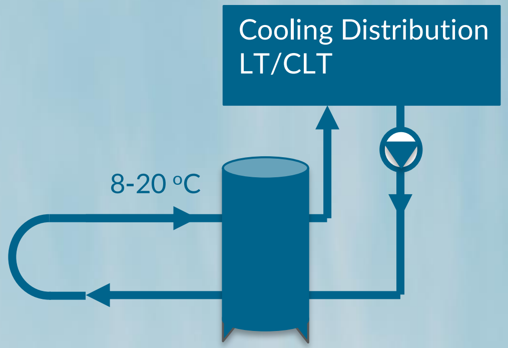
- Keep the pressure losses as low as possible and use efficient pumps in the cooling distribution circuit. A highly efficient pump is already integrated in the LT/CLT circuit of the HHP, but if the circuits are separated (see next slides) or the integrated pump is too small, an additional pump must be foreseen.

- No flow in the cooling distribution circuit could lead to damage of the HHP due to freezing. Therefore, the cooling distribution installation must be planned in such way that nothing (e.g., valve) blocks the flow when the HHP is running / starts running. For safety, the HHP is equipped with a flow switch, which deactivates the HHP if no flow is detected.



Hydraulic connection of the HHP to the cooling distribution

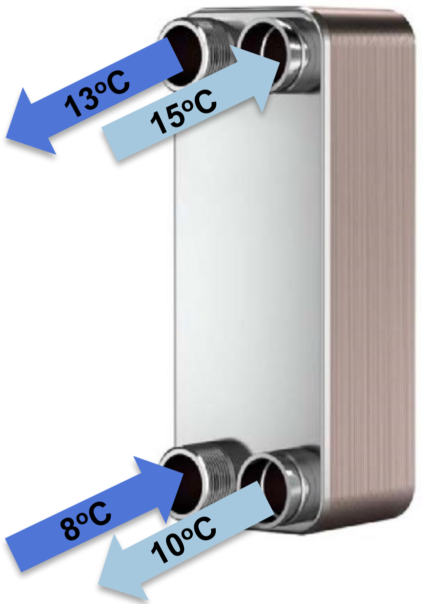
- For cold water/brine temperatures lower than 8 °C, the LT/CLT circuit should be filled with ethylene glycol in a suitable concentration.
- The pipelines in the cooling distribution circuit should be insulated with diffusion-tight insulation to avoid condensation of water on the pipes surface.
- As in case of HT connections, the LT/CLT inlet and outlet are marked on the technical drawing and directly on the HHP housing (LT_in, LT_out or CLT_in, CLT_out).



Hydraulic connection of the HHP to the cooling distribution

SEPARATION HEAT EXCHANGER

Sometimes, the cold water (brine) circuit of the HHP must be separated from the external cooling distribution circuit (e.g., due to different heat transfer medium or for safety issues). In some HHP models, such an exchanger is already integrated in the housing. In others, it should be planned for in the external installation. The selection of a separation exchanger should be carried out individually for a given application. Plate heat exchangers are usually a good choice. Separation heat exchangers must be designed for lowest possible temperature difference between fluids to avoid performance losses.



Hydraulic connection of the HHP to the cooling distribution

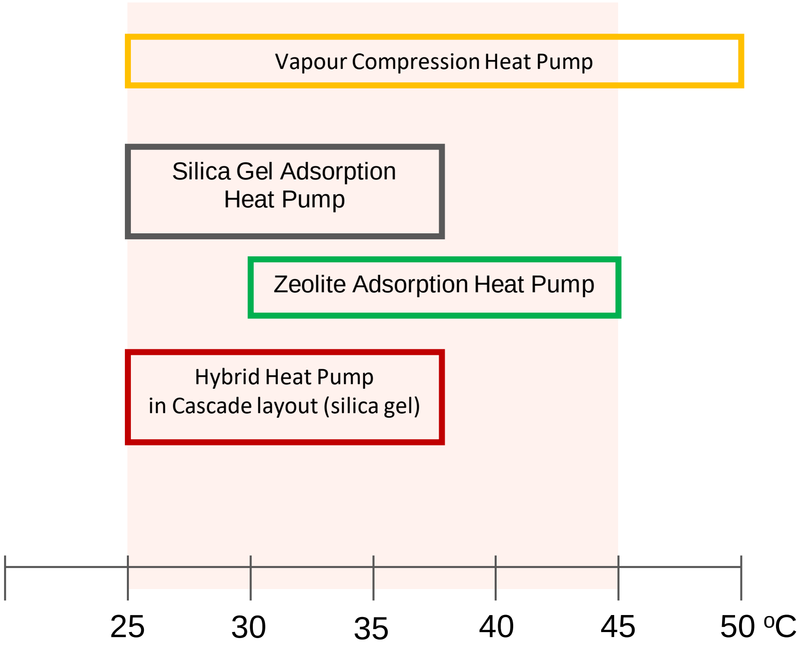
BUFFER TANK

A hydraulic clutch can be used in this circuit if volume flows need to be adjusted. However, just as in case of hot water circuit, if space and budget permits, it is worth equipping the installation with a properly dimensioned buffer tank. The advantages are buffering of peak high or low loads, ensuring nominal volume flow and levelling the temperature profile. Moreover, a temperature sensor installed inside the tank enables automatic control of the HHP and reduces pulsing of the HHP (switching from active cooling to Stand-by).

Re-cooling

- Efficient re-cooling is a very important part of the installation and has major impact on the performance of the overall system.
- The role of the re-cooling is to dissipate the heat of condensation and adsorption to the environment and thus cool down the condenser and adsorber.
- The lower the re-cooling temperature the better for the performance of the HHP.
- The main part of the re-cooling circuit is the heat sink, which can be realized in various options – dry cooler, wet cooling tower open or closed, geothermal probe, swimming pool, wells, rivers etc. It could be any heat dissipation device, which dissipates the heat at required temperature.
- Despite the wealth of different options, a dry cooler is most often chosen for its ease of use and installation.

Re-cooling



In general, the temperature range for the re-cooling circuit is ranging from 25 to 45 °C, but it depends on the sorbent material used and on the HHP layout.

Silica gel sorbent requires lower re-cooling temperatures; thus, it is better suited for moderate climate.

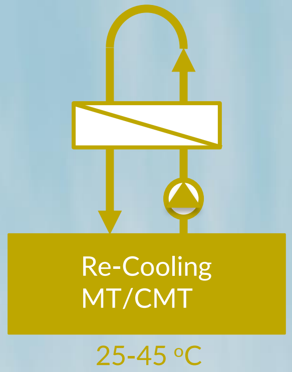
Zeolite sorbent can be applied in hot climates, since it is less sensitive to high re-cooling temperatures.

Hydraulic connection of the HHP to the re-cooling

The key tips for planning the cooling distribution circuit are like those for the heat source circuit. The two important points are the same as previously:

- *ensuring the right temperature level (as low as possible within the operating limits),*
- *achieving the nominal volume flow (indicated in the technical data sheet).*

The basic principles of designing hydraulic circuits should be observed, e.g., the use of expansion vessels, safety valves, strainers, appropriate thermal insulation etc.

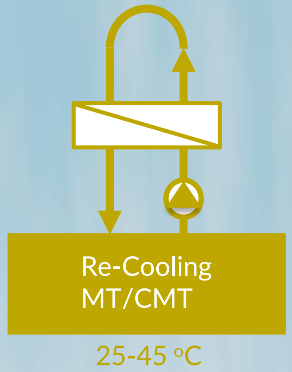


Hydraulic connection of the HHP to the re-cooling

- It is important to reduce pressure losses and to use efficient pumps in the re-cooling circuit. These two measures allow to optimize the energy consumption of the system.

- A highly efficient pump is already integrated in the MT circuit of the HHP, but if the circuits are separated (see next slides) or the delivery head of the integrated pump is too small for the pressure losses in the installation, an additional pump must be foreseen.

- The dry cooler should be placed in shaded area, preferably on the north side of the building. Ensure sufficient free space around the dry cooler to allow free air flow.

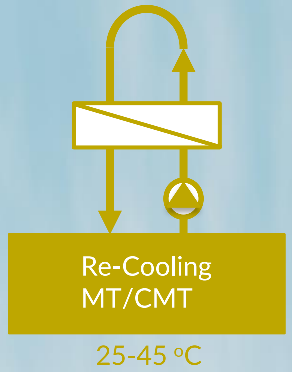


Hydraulic connection of the HHP to the re-cooling

- The dry cooler is one of the largest energy consumers in the HHP system, so it's worth choosing the most energy-efficient option. Additional expenditure is reimbursed by saved electricity consumption.

- HHP controls the rotational speed of the dry cooler fans to adjust its own cooling capacity (during partial loads). Therefore, it is best to use dry coolers with variable speed fans, which can be controlled by a 0-10 V signal.

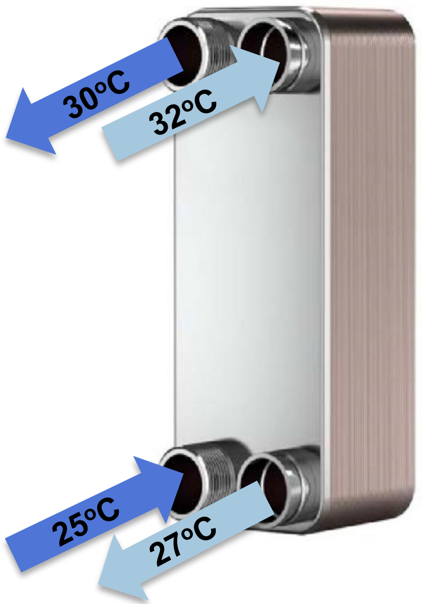
- As in case of HT connections, the MT inlet and outlet are marked on the technical drawing and directly on the HHP housing (MT_in, MT_out).



Hydraulic connection of the HHP to the re-cooling

SEPARATION HEAT EXCHANGER

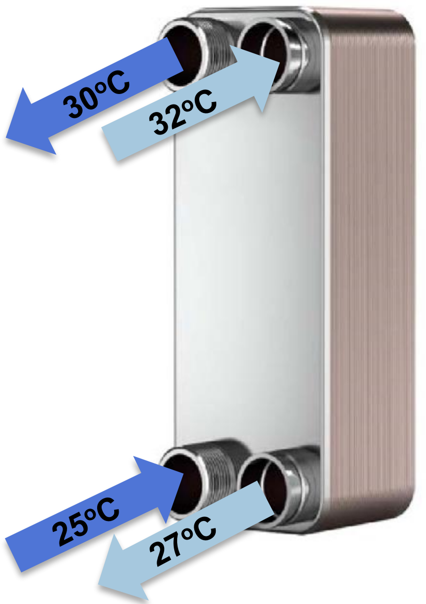
The re-cooling circuit of the HHP is usually filled with pure water. Filling the dry cooler, which is placed outdoors, with pure water can lead to damage of the device due to freezing. Therefore, the dry coolers should be filled with ethylene glycol solution (concentration based on winter air temperature in a given location). The internal circuit (filled with pure water) should be separated from the external circuit (filled with MEG) by means of a plate heat exchanger. Some HHP models contain such an exchanger in the housing as default. If it is not integrated, and freeze protection is required, separation exchanger must be foreseen in the installation.



Hydraulic connection of the HHP to the re-cooling

SEPARATION HEAT EXCHANGER

When dimensioning the heat exchanger, pay attention to the temperature differences between the primary and secondary circuits. It should be as small as possible because a too high temperature difference means a loss on HHP cooling capacity. Plan a speed-controlled pump in the external re-cooling circuit to allow better automatic control of HHP (adjustment of capacity during partial load).



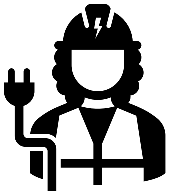
Hydraulic connection of the HHP to the re-cooling

BUFFER TANK

The use of a buffer tank in the re-cooling circuit is not recommended.

Side note!
If you connect the re-cooling circuit directly to the compression heat pump (e.g., in serial or parallel layout of HHP), the system separation is not needed. The hydraulic circuits of the compression heat pump can be filled with glycol solution. The performance drop (glycol vs. pure water) can be partially compensated by higher volume flow.

Power Supply



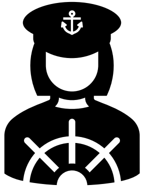
- Sufficient electrical power for HHP (both adsorption and compression heat pump), dry cooler and external pumps must be provided at the respective installation location.

- Adequate mains of protection should be used. Residual current circuit-breakers with a triggering threshold of 300 mA and delayed triggering (super resistant, characteristic K) are recommended. For re-cooling systems, only FI protective devices (type B or B+) which are sensitive to universal currents are permitted. For the compression heat pump, take into account the inrush current.

- The power supply should be planned in accordance with the technical data of the selected device. Most often, adsorption heat pumps are single-phase devices, powered by 230 V, as are smaller dry coolers. Compression heat pumps and larger dry coolers typically require 400 V, 3 phase power.

- Only authorized personnel may carry out electrical connection work. The HHP should be coupled to a single power supply.

Controls



The HHPs are controlled by a Climatix PLC from Siemens, which are specially designed for HVAC applications. There are two basic types of controlling the operation of an HHP in a system (see table on the next slide):

1. **With superior control system (e.g. BEMS)** – the superior control system sends release signals to the HHP. Additionally, values of outside temperature and temperatures of water in storage tanks can be sent to the HHP via communication protocol.

2. **Without superior control system** – the HHP is turned on/off by hand, three additional Pt1000 temperature sensors are connected to the HHP to allow its automatic operation. With the help of the storage sensors (hot and cold-water tanks), the system can automatically switch between operation and standby. The outside temperature is required for the automatic function of free cooling.

Controls

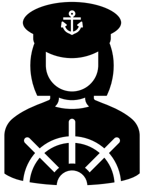
- An important setting for the HHP is the set point for the cold-water outlet temperature. This parameter can be set by hand, sent as an analog 0-10 V signal or via communication protocol.

- The HHP controls the rotational speed of dry cooler fans and external pump to adjust its own cooling capacity (during partial loads). This is done by analog 0-10 V signals.

- There are three communication protocols available for the HHP: BACnet IP, Modbus RTU and Modbus TCP. Using these protocols, the operator can both send parameters to the HHP (inputs) and read information sent by the HHP (outputs). For example, temperatures measured inside the HHP can be sent to the BEMS for monitoring purposes. It is also possible to arrange remote access to the HHP, for setting parameters and monitoring data via Siemens Cloud (internet connection required).

- There are digital outputs available for operating messages, faults messages, faults in individual components and release signals to backup systems. Since the Climatix PLC is equipped with universal I/Os, the hardware can often be adapted to the requirements of the projects without additional hardware.

Controls - IOs



	AUTO (without BEMS)	Superior Controller (BEMS)
INPUTS	▪ **Ambient temperature for the automatic function of free cooling** – Pt1000 or via CP* ▪ **Temperature in the hot water tank for automatic switching between active cooling and Stand-by**– Pt1000 or via CP* ▪ **Temperature in the cold water tank for automatic switching between active cooling and Stand-by** – Pt1000 or via CP*	▪ **Release signal** – potential-free ▪ **Enable free cooling signal** – potential-free ▪ (Additionally, the temperature sensors in tanks can be used for semi-auto operation.)
INPUTS	▪ **Setpoint for cold water temperature** – 0-10 V, via CP* or set on HMI	
OUTPUTS	▪ **Control signal for the re-cooler's fans speed** – 0-10 V (output from HHP) ▪ **Control signal for the external pump's speed** – 0-10 V (output from HHP) ▪ **Operating signal** – potential-free or via CP* (output from HHP) ▪ **Operating parameters (e.g. measured temperatures)** – via CP* (output from HHP) ▪ **Request for a back-up cooling system** – potential-free or via CP* (output from HHP)	

** CP stands for Communication Protocol i.e. BACnet IP, Modbus RTU and Modbus TCP*

Exhaust Air Duct

FOR FLAMMABLE REFRIGERANTS

Exhaust air duct is a part of the safety system, which is integrated in the compression heat pump if it is filled with a flammable refrigerant, such as R290 or R1270.

In case of refrigerant leakage, the exhaust fan is activated, and the mixture of refrigerant and air is sucked off from the heat pump‘s casing. This mixture is then directed through the exhaust air duct to the outside. The exhaust air duct is an elastic, anti-static hose.

The exhaust air duct must be guided in such a way that in case of a leakage, the mixture of propane and air from the ventilated enclosure is safely discharged to the outside. No devices, which form an ignition spark around the venting point, must be located in the range of 3 m and no depressions should exist in which the refrigerant can accumulate.

Exhaust Air Duct

FOR FLAMMABLE REFRIGERANTS

The exhaust hose must be particularly secured against unauthorised access and change. The exhaust air openings in the wall must be visibly marked and not obstructed by other objects or parts of the building.
The exhaust air duct must also be identified as such within the room with the symbol for potentially explosive areas and secured to the ventilated housing and to the duct to the outside environment against unauthorized intervention.

Commissioning

Commissioning is the first start of the machine after its installation. A correctly conducted commissioning consists of several stages:

- *Checking if the HHP has been correctly installed, whether the hydraulic and electric circuits are correctly connected and whether it is possible to ensure the correct working conditions of the HHP (e.g., checking the volume flows). In case of heat pumps with R290 or R1270, checking if the exhaust air duct is properly carried out.*
- *Setting the HHP's operating parameters on the controller in accordance with the requirements of the project.*
- *Turning on the HHP, carrying out the activation process and checking whether the HHP is working properly. Functional testing of the pumps.*
- *Preparation of commissioning protocols. Brief instruction of the user on basic device operation.*

Commissioning aims to ensure the correct operation of the HHP in the system it is installed in and to avoid damage to the machine, which may occur due to misuse. Therefore, it should be performed only by people who know the structure and functions of the HHP well. Only personnel trained and acknowledged by the manufacturer can perform the commissioning (as well as maintenance and repairs) of the HHP.

Preparation for Commissioning

1. The HHP should be placed in its designated location and connected to the external hydraulic circuits.
2. All electrical systems (power supply and building management system) must be completed and connected.
3. All circuits must be filled with the proper heat transfer fluid and properly vented. Make sure that the pressure in the system is correct.
4. The HHP must be connected to the system both hydraulically and electrically. The power supply and water must be available on site (for re-filling of the circuits after venting).
5. It is necessary to ensure an adequate amount of driving heat with a minimum parameter of 60 °C for proper commissioning.
6. During commissioning, the cooling power generated by the HHP must be discharged to avoid freezing (e.g., the cooling distribution system must be turned on).

That‘s all in Lesson 3.

You can now proceed to Lesson 4.