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Project Title:

Smart building retrofitting complemented by solar assisted heat pumps integrated within a self-correcting intelligent building energy management system

HEAT4COOL

Heat4Cool

Grant Agreement No: 723925
Collaborative Project

Optimized prototype of solar assisted thermal driven adsorption heat pump

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<tr><td>No & name</td><td colspan="11">D6.9 Documentation and drawing from Engineering and design. Execution of the retrofitting plan for the Solar assisted AHP system in Toledo.</td></tr>
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<tr><td rowspan="2">Planned resources PM</td><td>POLIMI</td><td>Fahrenheit</td><td>Thermowatt Ltd</td><td>HYPERTECH</td><td>TECNALIA</td><td>Sunamp</td><td>AES</td><td>BALKANIKA</td><td>SOL</td><td>SYMELEC</td><td>Total</td></tr>
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0	2015-04-16	SOL jm	Template for deliverable documents and task planning
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1. PUBLISHABLE EXECUTIVE SUMMARY

In the scope of WP 3, a prototype of novel adsorption heat pump with zeolite coating grown directly on the surface of aluminium heat exchangers has been developed. This prototype has then been tested in Kubik and described in Deliverables 3.3 and 3.5. Based on these two reports, the prototype has been improved, which resulted in better performance and stability. Due to characteristic features of the zeolite – good performance at high re-cooling temperatures – the adsorption heat pump with zeolite coating is especially beneficial for the use in hot climates, in which high solar gains are expected as well. Therefore, zeolite technology can be a breakthrough in the field of solar cooling. To fully exploit the potential of this new technology and successfully place the new product on the market, the prototype required further testing under dynamic operating conditions. Such testing will be performed in a senior residence in Toledo (Spain), where an existing field of solar collectors provides high amount of surplus heat in summer.

This report is a summary of the engineering design of the Toledo prototype and describes the pre-retrofit state of the building, proposed new installation, its control system and energy performance monitoring. Moreover, this document contains information about the execution plan, time schedule and responsibilities. The scope of retrofit focuses on the installation of adsorption heat pump prototype with required peripheral components and on integration of the prototype with the existing HVAC system.

The core of the proposed new cooling system is an adsorption heat pump prototype with a nominal cooling capacity of 30 kW. Existing solar collectors are the heat source, and the cooling capacity will be used for comfort cooling of the rooms via existing underfloor heating system. A 3,000 litres buffer tank will be used in the cold water circuit to smoothen the temperature profile and improve the operation of the heat pump. For proper, safe, and efficient operation, the re-cooling circuit contains a dry cooler with 6 EC-fans, which hydraulics is protected from freezing by means of glycol solution. To generate monitoring data during the Heat4Cool project, the prototype will be used in heating mode, which means that the heat pump will provide warm water to the underfloor heating system.

A control software developed especially for the prototype guarantees smooth integration with existing BEMS. The prototype will operate as independently as feasible and will switch from active cooling to Standby mode based on measured parameters. The communication protocol used between the prototype and BEMS is Modbus TCP/IP, although for higher reliability, hardware signals (e.g., 0 -10 V) are also used in the system.

The strategy for energy performance monitoring includes the definition of key performance indicators, which are COP, EER and cooling capacity. All these factors can be evaluated with the measured values. Most of the required sensors are installed inside the prototype, only few additional sensors are placed in the external installation. The gathering of monitoring data takes place via Siemens Climatix Cloud (Climatix IC), which ensures constant remote access to the data.

The responsibilities have been divided between Fahrenheit (manufacturer of the prototype) and Sumersol (ESCo, outside of consortium which takes care of the installation). The works proceed according to the Gantt chart (Figure 8). This deliverable presents the current status of work with a list of completed tasks.

2. Introduction

2.1 Purpose of this report

The purpose of this deliverable is to summarize the engineering design of the Toledo prototype. The report describes the pre-retrofit state of the building, proposed new installation, its control system and energy performance monitoring. Moreover, this document contains information about the execution plan, time schedule and responsibilities. The report includes pictures, which can be used in communication activities of the project (e.g., on the project website).
This report is public and is meant to be a source of valuable information for all interested partners and the coordinator.

2.2 Baseline

The first prototype of the adsorption heat pump has been described in Deliverable 3.1 submitted in February 2018. Due to unforeseen stability problems of the first prototype, which occurred after around 28,000 cycles, a second, improved prototype has been developed and delivered to Kubik in June 2018. On 26th February 2019, the prototype has been successfully commissioned. After few months of testing, Tecnalia has issued Deliverable 3.5 describing the tests results. Based on the results of Tecnalia's as well as internal performance and functionality tests, Fahrenheit has identified the areas of the prototype design, which needed further improvement. All this work results in an improved prototype. To fully exploit the potential of this new technology and successfully place the new product on the market, the prototype required further testing, preferably in a real installation under dynamic operating conditions. Since the zeolite technology requires high driving temperatures (80-90 °C) it could not be tested at the demo site in Valencia, where achieved temperatures from solar collectors do not exceed 70 °C. Therefore, Fahrenheit with the help of one of project's stakeholders has found an opportunity to test the latest prototype in a senior residence in Toledo. This report comprises documentation and drawings of the engineering design of the cooling system (to be) installed in Toledo.

2.3 Relations to other activities

The works on the new prototype and its installation in Toledo is a follow-up of task T3.1. *Solar assisted Thermal driven Adsorption Heat Pump.* Generated test report will be the core of Deliverable 3.9. As an additional testing in real building, this activity can also be seen as an extension to task T6.3. *Execution of the Retrofitting Plan at Demo Sites and Monitoring*. However, it must be underlined, that the scope of works in Toledo is much smaller than in other demo sites. The executed retrofitting plan will serve as a basis for feasibility study showing the expected results of the system during the cooling season, which will be presented in Deliverable 4.7.

3. Cooling System Retrofit

After many months of intensive development, a stable prototype of an adsorption heat pump with zeolite coating has been achieved. This project result has a very high exploitation potential, since there is a huge interest in zeolite technology for solar cooling among Fahrenheit clients. However, to fully exploit the potential of the technology and place the product on the market, further testing in operational environment is needed to bring the prototype from TRL6 to TRL7. A show case will be beneficial for the marketing activities.

Near the end of 2019, a chance has appeared to perform dynamic field testing of the solar cooling application in Toledo (Spain) with one of the project stakeholders – Sumersol S.L. Sumersol is an Energy Services Company (ESCo) that designs, develops, installs, and finances solar thermal projects in Spain. Since 2000, Sumersol has been offering the possibility of replacing fossil fuels with renewable energy by promoting solar thermal installations to provide Domestic Hot Water (DHW), space heating, swimming pool heating etc. Their main clients are hotels, residences and every building that consumes large quantities of hot water.

Toledo is a location with high ambient temperatures and high solar irradiation, which perfectly reflects the target niche of the zeolite technology. The monitoring results from Toledo will complement the data gathered in Kubik and Valencia.

After the project extension, which was granted due to Covid-19 pandemic, the project end is scheduled on 2nd of April 2021. For this reason, our monitoring activity performed in scope of the Heat4Cool project will not include the cooling period (which in Toledo starts late in April). Therefore, the prototype will be firstly thoroughly measured on the test stand in Halle (Fahrenheit's facilities) and then monitored in Toledo for at least 4 weeks in heating mode. Heating mode means that the prototype will support the heating of the residence by providing warm water to be circulated in the underfloor heating system. In such way we will gather enough data to perform a simulation of the cooling period and to report the outcomes in Deliverable 4.7 based on the available experimental data. Nevertheless, Fahrenheit and Sumersol will continue the monitoring of the system for the consecutive cooling period, even after the end of the Heat4Cool project. Outcomes will be shared with the Consortium partners, who express their interest in them. We will also aim at publishing the results in a relevant journal for planners.

The scope of retrofit will focus on the installation of adsorption heat pump prototype with required peripheral components and on integration of the prototype with the existing HVAC system.

3.1 Pre-retrofit state

The prototype will be installed in a senior residence in Toledo (Spain). It is a building with a total area of 4,200 m^2, built in 2006. Figure 1 presents the residence.

Figure 1. Senior residence in Toledo.

The residence is equipped with underfloor heating system at an area of approx. 3,200 m^2 and the main source of heat for heating and DHW are flat collectors. There is a back-up gas boiler available as well. Figure 2 is a photography of the existing solar field. In summer, the existing solar system with flat collectors provides around 80.000 kWh of surplus heat with temperatures above 80°C. To avoid overheating, 30% of the collector's area is covered every summer. Table 1 summarizes the calculation of the amount of available heat for driving the adsorption heat pump.

Figure 2. Existing solar field next to the building

Table 1. Calculation of the solar heat available for thermally driven cooling purposes.

MONTH	June	July	August	September	Average	Total
Hot water + underfloor heating consumption (kWh)	9,159	9,264	9,464	9,354	9,310	37,242
Solar contribution (kWh)	26,508	31,508	31,902	26,914	29,208	116,831
Available energy for cooling (kWh)	17,349	22,244	22,437	17,559	19,897	**79,589**
Energy per day (kWh)	578	718	724	585	651	
Thermal capacity with 8 hours of sun per day (kW)	72	90	90	73	81	

Adjacent to the building there is a spacious machine room, in which the prototype and additional components of the system can be placed. The interior of the machine room is presented in Figure 3.

The building was not equipped with a centralized air conditioning or cooling system. Some rooms (e.g., dining room) are equipped with split air conditioning devices.

Figure 3. Interior of the available machine room.

3.2 Proposed system

Based on the amount of available drive heat (see Table 1) it is decided that the optimal size of the adsorption heat pump is 30 kW of nominal cooling capacity. It translates to the following physical dimensions – 900 x 1,900 x 2,000 mm and 900 kg of empty weight. Figure 4 below presents a 3D design of the prototype. The control cabinet is in front, hydraulic connections are located on the top of the casing and the side panels are removable to facilitate maintenance and repairs.

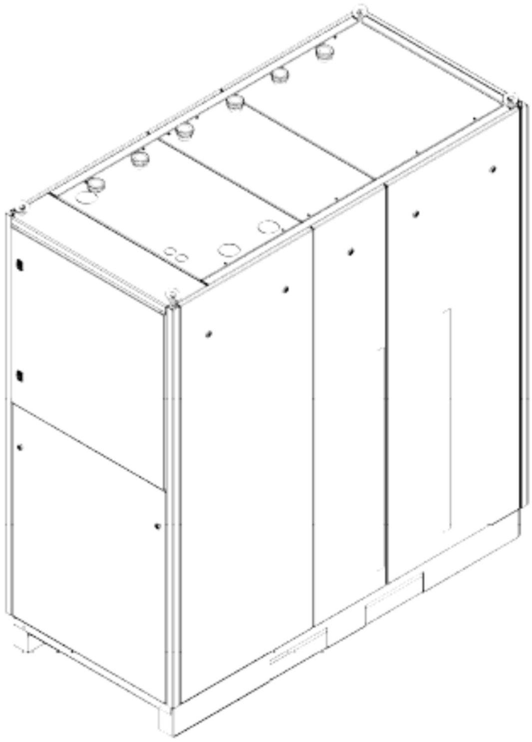


Figure 4. 3D design of the adsorption heat pump prototype.

The heat exchangers inside the process modules are made of aluminium and hydraulics consists mainly of copper elements. Therefore, the heat transfer fluid must be enriched in corrosion inhibitor before filling the machine. Guidelines for filling the machine with corrosion inhibitor are included in Appendix.

The adsorption heat pump must be connected to the following three hydraulic circuits:

- **High temperature (HT) circuit** – drive source of the heat pump.
- **Medium temperature (MT) circuit** – heat dissipation (re-cooling) of the heat pump.
- **Low temperature (LT) circuit** – cold distribution of the heat pump.

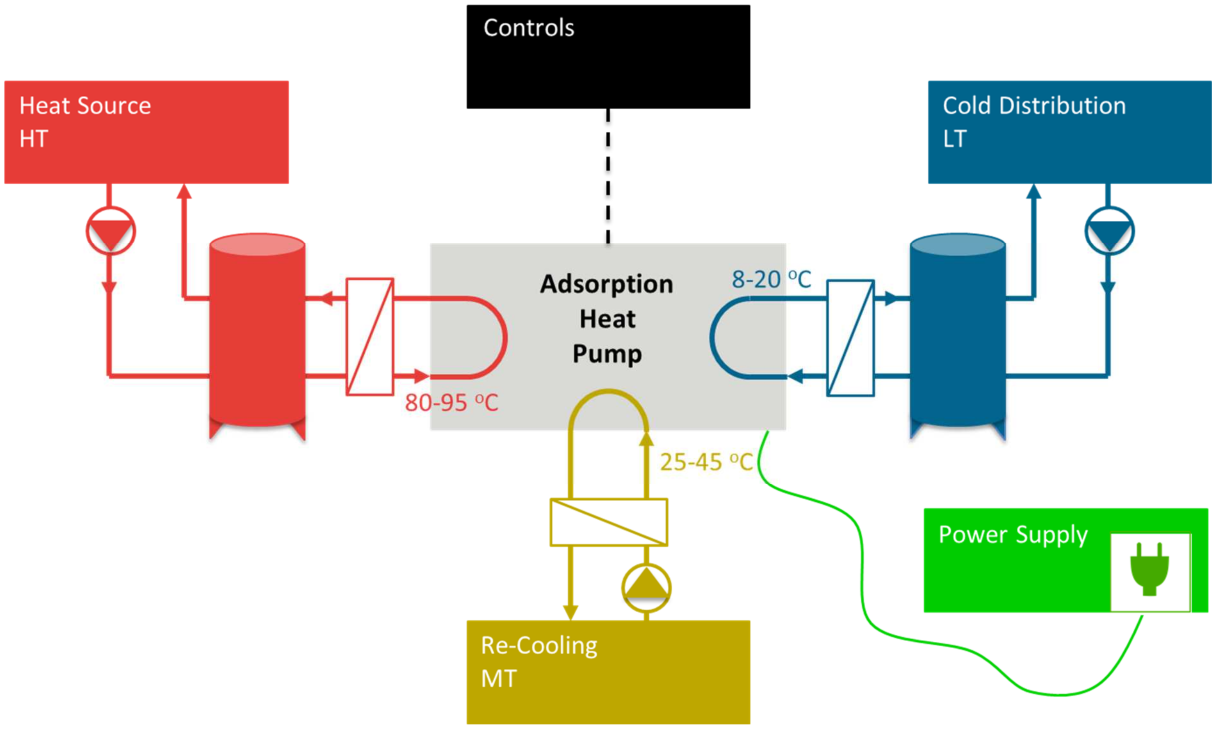


Figure 5. General layout of a system with the adsorption heat pump.

Moreover, the prototype requires connection with power supply (400 V, 3~, 50 Hz). Important is also the development of thoughtful control strategy and integration of the control system with existing Building Energy Management System (BEMS). These installation requirements are schematically depicted in Figure 5. More detailed layout of the system can be found in Appendix.

3.2.1 High temperature circuit of the proposed system

The driving heat for the prototype is coming from the existing field of flat solar collectors. The pre-retrofit system consists of several heat exchangers and buffer tanks. The HT circuit of the prototype will be separated from the existing system by means of a plate heat exchanger. The main reason for such hydraulic separation is the fact that the internal circuits of the prototype must be filled with corrosion inhibitor and there is no need to exchange the working medium in the whole installation. Moreover, adding a heat exchanger to an existing installation is relatively uncomplicated and safe.

Expected supply temperatures are in the range 75-90 °C and the volume flow required on the primary side (prototype side) is 5,000 l/h. On the secondary side (solar collectors' side) there is a hydraulic pump which will ensure the circulation in that circuit. Moreover, there is a gas boiler that will serve as a back-up heat source for the adsorption heat pump mainly on cloudy days in winter.

3.2.2 Medium temperature circuit of the proposed system

The core element of the medium temperature circuit is the dry cooler. It includes six speed-regulated EC-fans controllable by external 0 – 10 V signal. The nominal re-cooling capacity of the dry cooler is 110 kW, and its dimensions are 2,300 x 6,200 x 1,500 mm and empty weight 1,200 kg. Figure 6 presents the 3D design of the dry cooler to be installed in Toledo.

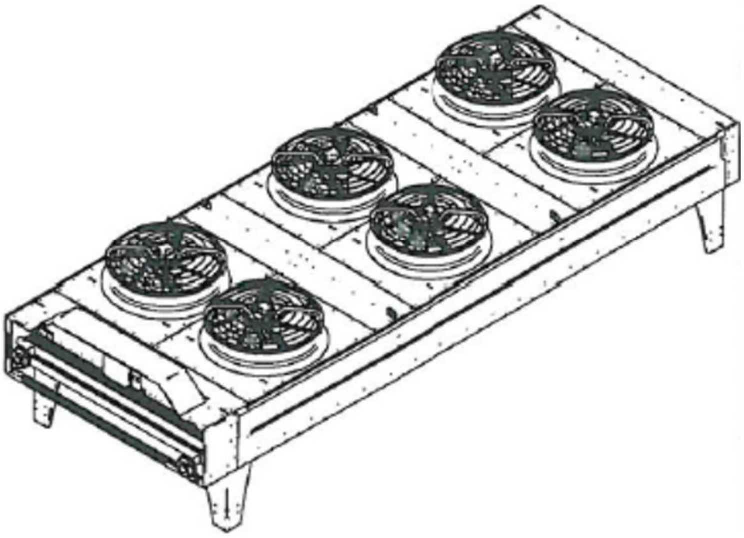


Figure 6. 3D drawing of the dry cooler.

The dry cooler is going to be placed outside, near to the building and the parking lot, in a shaded area. In Toledo, we expect high solar gains and high ambient temperatures in summer (35-38 °C) which means very high temperatures of water in MT circuit (35-42 °C). Due to high re-cooling temperatures expected, the prototype is equipped with zeolite adsorption modules.
The climate in Toledo is warm, frost in winter is observed very rarely. However, the dry cooler must be protected from freezing. Sufficient protection is achieved by filling the hydraulics of the dry cooler with mixture of water and mono-ethylene glycol. The dry cooler filled with glycol solution must be hydraulically separated from the prototype which is filled with pure water and corrosion inhibitor. This is done by means of another plate heat exchanger installed in MT circuit (inside the machine room). The separated, external circuit requires an additional hydraulic pump to ensure circulation. The volume flows are 14,000 l/h and 16,500 l/h in primary and secondary circuits, respectively.

Important feature of the MT circuit are the 3-way valves, which are foreseen in the installation to allow switching the adsorption heat pump from heating to cooling mode. In heating mode, the MT circuit is connected with the floor heating circuit supplying warm water directly to the heating system. The expected temperatures in the floor heating system are 35/30 °C. The water from the LT circuit of the prototype is then directed to the dry cooler (more specific to the MT separation heat exchanger). In heating mode, the dry cooler serves as a low-grade heat source. The interconnection and positioning of the 3-way valves can be seen on the system layouts in Appendix.

3.2.3 Low temperature circuit of the proposed system

The cold water produced in the adsorption heat pump will be used for room cooling via an existing floor heating system. This existing system consists of pipes laid under the floor on an area of 3,100 m^2. To avoid condensation of water on the underfloor piping, the temperature of water circulating in this pipeline is 17/22 °C (supply/return).

The peripheral components in the LT circuit are buffer tank with 3000 litres of volume, plate heat exchanger for the separation of the prototype's hydraulics from the underfloor heating system, and a hydraulic pump on the secondary side to ensure the flow. Exact positioning is presented on the system layouts drawings in Appendix. All circuits (HT, MT, LT) are also equipped with proper expansion vessels, safety valves, air release valves, shut off valves, and dirt traps.

Due to the presence of a separation heat exchanger, the temperature setting on the prototype is lower than the design temperature in the cold distribution system and is set as 14 ºC. The volume flow is designed to be 6,000 l/h on both sides (primary and secondary).

As mentioned in previous sub-section, in the heating mode, the flow in the LT circuit is redirected by means of additional 3-way valves that connect LT and MT circuits.

4. CONTROL STRATEGY

The senior residence in Toledo is already equipped with a Building Energy Management System (BEMS). The development of the control strategy will comprise of the interconnection between the existing BEMS and the controller of the adsorption heat pump. For the ease of use, we decided to not interfere in the BEMS and keep the controller of the adsorption heat pump as independent as possible. This means, for example, that the controller of the adsorption heat pump will decide itself if the heat pump should go in standby or in free-cooling mode.
Some of the information will be exchanged between BEMS and prototype by hardware signals and some by communication protocol – Modbus TCP/IP. List of data points exchanged by Modbus can be found in the Appendix. Table 2 below presents the signals, which are of utmost importance for the control of the cooling system.

Table 2. IOs list of the adsorption heat pump controller.

No.	Description	I/O?	Signal	Comments
1	External unlocking signal	Input	-	AdHP will be turned on manually
2	Set point for cold water temperature (summer)	Input	HMI	Will be set manually on the HMI
3	Set point for warm water temperature (winter)	Input	HMI	Will be set manually on the HMI
4	Ambient temperature sensor	Input	Hardware (Pt1000)	Required for free-cooling mode
5	Temperature sensor in cold water tank	Input	Hardware (Pt1000)	Used as condition for Standby mode
6	Temperature sensor in the hot water tank	Input	Modbus TCP/IP	Used as condition for Standby mode
7	Enabling signal for the HT pump	Output	Hardware (potential free)	Switches the pump on and off
8	Control signal for the external cold water pump	Output	Hardware (0-10V)	Sets the speed of the pump
9	Control signal for the external re-cooling water pump	Output	Hardware (0-10V)	Sets the speed of the pump
10	Control signal for the dry cooler	Output	Hardware (0-10V)	Sets the speed of the fans
11	Control signals for the 3-way valves (4 pieces)	Output	-	Will be switched manually

The IOs list translates into the cable list with all the wires needed to connect the prototype.

Additional information send to BEMS by the adsorption heat pump via Modbus are used by the system operator for monitoring purposes. The data for performance evaluation is collected in Cloud, as described in section 5.2.

Turning the adsorption heat pump on and off
There is a possibility to turn the prototype on and off by an external unlocking signal. However, as decided with the end user of the machine, in case of the Toledo prototype will be turned on manually and then the heat pump controller will decide about standby and free-cooling mode.

Set point temperatures
In case of the Toledo prototype, there are two separate set point temperatures. The first one is for the cooling mode and the second one for the heating mode. Both are going to be set manually on the HMI.

Standby mode
The adsorption heat pump switches to standby mode when the temperature of water in the cold water buffer tank has reached the set point temperature. Therefore, a Pt1000 sensor in the cold water tank is needed.
The controller of the adsorption heat pump will also use the temperature in the hot water tank. If this temperature rises above or falls below set limits, the heat pump will switch to standby as well. In the first case to protect itself from too high temperatures, in the latter to allow the tank to heat up to the temperature at which the operation of prototype is efficient.

Free cooling mode
Free cooling in general is a method of using low external air temperatures to assist in chilling water. When outdoor temperatures are lower than the desired temperatures in the cold distribution circuit, the system utilizes the cool outdoor air as a free cooling source. The water from cold water circuit is cooled directly in the dry cooler. The heat from the cold distribution circuit can be transferred to the dry cooler directly via hydraulics of the adsorption heat pump. The 3-way valves inside the prototype are switched to create this "by-pass" if the ambient temperature falls below a set value (usually 4 K lower than set point for cold water temperature). A Pt1000 sensor placed outside of the building, in the vicinity of the dry cooler is used as an indication of the ambient temperature.

Control of the peripheral components
Two of three external hydraulic pumps – the ones in LT and MT circuits – are pumps with variable speed. Speed of these pumps is controlled by the adsorption heat pump by means of 0-10 V hardware signal. The third pump – in HT circuit – is an existing pump and is turned on by the adsorption heat pump when the drive heat is required.
The adsorption heat pump will also control the rotational speed of fans in the dry cooler. This will be done by means of 0-10 V hardware signal. Control of the fan speed is an important feature as it serves as one of the ways to adjust the capacity of the prototype in case of partial load.

Changing from heating to cooling mode
In winter, the prototype will be tested in heating mode, as a thermally driven heat pump. For the cooling season, the heat pump will serve as a chiller to provide cold water for floor cooling system. To make such switching between heating and cooling mode possible, four 3-way valves connecting the LT and MT circuits are needed (depicted on the system layout scheme in Appendix). These valves will not be controlled automatically. Since the switching will happen only twice a year it will be done manually and will be combined with inspection of the system. The corresponding operating mode must be also switched manually on the HMI.

5. Energy performance monitoring

The goal of the energy performance monitoring is to evaluate the performance of the new adsorption heat pump prototype under real (dynamic) operating conditions. This will give us an insight into the strengths and shortcomings of the prototype and tell us what needs to be improved before launching this product on the market. Furthermore, we aim at collecting the information about the advantages of the prototype (e.g., generated energy savings) which will be used for marketing activities.
The performance of the prototype will be assessed mainly with three parameters – cooling capacity, COP and EER – described in detail in the next section. In a long term, also the stability and reliability of the prototype will be evaluated. In detail, it will be observed if there are any losses of cooling capacity of one or both module pairs in time. Such behaviour indicates a pressure increase in the process module(s) due to a leak. One of the most critical steps in the development of the prototype was to keep the process modules tight in a long-term operation. This monitoring activity will show us if the solutions adopted in the tested prototype have coped with this challenge.
In the scope of Heat4Cool project and due to project time constraint, it was planned to monitor the operation of the prototype for 4 weeks in March. Since March is not a cooling season in Spain, the prototype must be tested in heating mode (as a thermally driven heat pump). After the end of Heat4Cool, the monitoring of the cooling season will be continued at least till October 2021. Outcomes will be shared with the interested Consortium partners and published in relevant journals and platforms. If the end user is satisfied with the performance of the prototype and whole installation, it will be left there for further years of operation. This installation will be used as a showcase for potential customers in Spain.

5.1 Performance evaluation

As mentioned before, the three main parameters used in the performance evaluation of the prototype are cooling capacity, Coefficient of Performance (COP) and Energy Efficiency Ratio (EER).

Cooling capacity Q_{LT}, as well as heating power provided to the prototype Q_{HT} and heat rejection power dissipated in the re-cooler Q_{MT}, is calculated as:

$$\dot{Q} = \dot{m} c_p (T_{in} - T_{out}) \tag{1}$$

Where $\dot{Q}$ is the instant power in kW, $\dot{m}$ is the mass flow rate in the circuit in kg/s, c_p is the specific heat capacity of the heat transfer fluid and T_{in} and T_{out} are the inlet and outlet temperatures of the circuit considered. Knowing the density and specific heat capacity, which are characteristic parameters of the heat transfer fluid, the cooling capacity can be estimated by measurement of inlet and outlet temperatures and volume flow of the cold water circuit. Similarly, the same parameters should be measured in the other two circuits (hot water and re-cooling water). High cooling capacity means high power density which translates into the heat pump size. A heat pump of small size, which offers high cooling capacity, will be more attractive to end users and also cheaper to produce and transport.

The thermal COP is defined as the ratio of the useful effect provided by the prototype (cooling capacity) and the heat input to its driving circuit (heating power).

$$COP_{cooling} = \frac{\int_0^{\tau_{cycle}} \dot{m}_{LT} c_p (T_{LTin} - T_{LTout})\, d\tau}{\int_0^{\tau_{cycle}} \dot{m}_{HT} c_p (T_{HTin} - T_{HTout})\, d\tau} \tag{2}$$

Higher COP means more effective use of the driving heat. One might suppose that in the case of waste heat, or heat from renewable energy sources, when heat is cheap or even free, the COP is not important. However, this is a mistake, we always strive for the highest COP to use energy as efficiently as possible.

When the prototype is in heating mode, the COP is also defined as the useful effect provided by the prototype and the heat input to its driving circuit. However, in this case the useful effect is not the cooling capacity but the heat rejection capacity (MT circuit).

$$COP_{heating} = \frac{\int_0^{\tau_{cycle}} \dot{m}_{MT} c_p (T_{MTin} - T_{MTout})\, d\tau}{\int_0^{\tau_{cycle}} \dot{m}_{HT} c_p (T_{HTin} - T_{HTout})\, d\tau} \tag{3}$$

$COP_{heating}$ can be also calculated with the same formula as $COP_{cooling}$ and increased by 1.

$$COP_{heating} = COP_{cooling} + 1 \tag{4}$$

Measurements required for the evaluation of COP are, like in case of cooling capacity, the inlet and outlet temperatures and volume flows of each circuit.

The EER is defined as the ratio between the useful effect provided by the prototype and the electric consumption needed to produce the said effect. For the monitoring and evaluation purposes, we distinguish two EER values. The first considered EER value takes into account the electric consumption of the prototype only ($P_{el,AdHP}$). This power consumption is made up of hydraulic pumps installed inside the prototype, valve actuation and controller.

$$EER_{AdHP} = \frac{\int_0^{\tau_{cycle}} \dot{m}_{LT} c_p (T_{LTin} - T_{LTout})\, d\tau}{\int_0^{\tau_{cycle}} P_{el,AdHP}\, d\tau} \tag{5}$$

This value shows how many kWh of cooling we get from one kWh of electrical power used by the adsorption heat pump. It depends to some extent on the external installation, which, in most of the commercial projects, is beyond Fahrenheit's control as the manufacturer of the heat pump. The higher the pressure loss in the external installation, the higher pump speed is required to obtain the nominal volume flows and thus the higher the energy consumption of the pumps. On the other hand, Fahrenheit strives to keep the internal pressure losses of the adsorption heat pump low to obtain the best possible EER. The value of EER_{AdHP} can be used to compare the adsorption heat pump with commonly used compression chillers.

For proper operation, the adsorption heat pump needs some peripheral components. The main one is a heat dissipation device (also called re-cooler), which in Toledo is a dry cooler. The power consumption of dry cooler fans can be described as high in comparison to the power consumption of adsorption heat pump alone. Therefore, it is important to also consider this consumption ($P_{el,RC}$) while evaluating the performance of the system. There may be also other peripheral consumers, in case of Toledo there are two external hydraulic pumps in cold-water and re-cooling water circuits ($P_{el,Pumps}$).

The second type of EER is the one calculated for the overall system:

$$EER_{overall} = \frac{\int_0^{\tau_{cycle}} \dot{m}_{LT} c_p (T_{LTin} - T_{LTout})\, d\tau}{\int_0^{\tau_{cycle}} P_{el,AdHP} + P_{el,RC} + P_{el,Pumps}\, d\tau} \tag{6}$$

Measurements required for the evaluation of both EERs are the power consumption of the adsorption heat pump (separately) and the power consumption of the re-cooler and of the external hydraulic pumps.

5.2 Monitoring strategy

The adsorption heat pump prototype to be tested in Toledo is equipped with sensors and meters that will measure the following parameters, which were named necessary in the previous section:

- **Immersion temperature sensors** SIKA type W06 with Pt1000 sensor element in inlets and outlets of all circuits of the prototype. In total 6 pieces.
- **Magnetic inductive flow sensors** SIKA series induQ VMM (in MT circuit) and VMI (in LT and HT circuits) in all three circuits of the prototype. In total 3 pieces.
- **Energy meters** Siemens series SENTRON type 7KT1651 to measure the energy consumption of 1 phase components such as adsorption heat pump, MT and LT external hydraulic pumps. In total 3 pieces.
- **Energy meter** Siemens series SENTRON type 7KT1665 to measure the energy consumption of 3 phases dry cooler. In total 1 piece.

To facilitate the measurement of peripheral energy consumption, the external hydraulic pumps and the dry cooler will be connected to the power supply through the electrical cabinet of the prototype. In such way the energy meters can be installed in this cabinet and indications of the meters will be collected along the indications of the rest of the sensors.

Since all relevant sensors are installed inside the prototype, it will not be necessary to install many additional sensors in the external installation. This will facilitate the installation and result in shorter time from delivery till commissioning. The few external sensors are:

- Temperature in cold water tank – Pt1000 sensor will be connected directly to the prototype.
- Temperature in hot water tank – value will be sent to the prototype from BEMS by Modbus TCP/IP.
- Ambient temperature – Pt1000 sensor will be connected directly to the prototype.

The prototype will have an internet connection via Ethernet cable. Therefore, all data will be stored and visualized in a Siemens Cloud portal. This will grant a remote monitoring of the system, which is especially important during the pandemic. It will be also possible to change settings remotely via Cloud portal, which allows us to check and adjust the operation of the prototype on a regular basis. The data stored in the Cloud go far beyond the indications of the sensors and meters mentioned above. With this extensive set of information, we can very accurately evaluate how the adsorption heat pump works and what are the common problems (if any).

6. Retrofitting

6.1 Responsibilities, time schedule and budget

The responsibilities are shared between Fahrenheit (Heat4Cool Consortium Partner) and Sumersol (Heat4Cool Stakeholder) in the following manner:

Fahrenheit's responsibilities:

- Development and manufacturing of the prototype.
- Development of the prototype's control software, setting the Cloud and data exchange via communication protocol.
- Definition and dimensioning of auxiliary components.
- Suggestion of the system layout.
- Preparation of operating manuals and other technical documentation.
- Testing of the prototype at Fahrenheit's facility.
- Organizing the delivery of the prototype and auxiliaries to Toledo.
- Bearing the cost of delivered components and the cost of shipping to installation site.
- Development of the strategy for energy performance monitoring.
- Collection and analysis of the monitoring data.
- Coordination of communication with the Consortium and Project Coordinator.

Sumersol's responsibilities:

- Coordination of communication with the end users (owners of the residence).
- Engineering design of the hydraulics.
- Receiving the delivery, unloading, placing of equipment.
- Installation works (connecting the hydraulic and electrical connections, necessary civil works, filling the installation with proper fluid, installation of required sensors).
- Integration of the prototype with BEMS.
- Bearing the cost of installation works and necessary consumables.

The time schedule is presented in Figure 7 in form of Gantt chart. The completed activities and their duration are marked green, planned activities are grey. The main constraints considered in the time schedule are the minimum monitoring period (4 weeks), manufacturing capacity of Fahrenheit, end of the Heat4Cool project and due dates of the Deliverables. Unfortunately, on 25th of January we were informed about the force majeure due to which the delivery of the equipment and the installation works must be delayed. Since it is uncertain when the works can be safely continued, we must implement a mitigation plan, which is to thoroughly test the chiller at Fahrenheit's facilities to allow simulations, perform the installation works as soon as it is possible and continue with the monitoring after the Heat4Cool project end. The presented Gantt chart is the latest version that includes the delays caused by manufacturing difficulties (e.g. delayed deliveries from suppliers) and mentioned force majeure. The activities to be performed after the end of Heat4Cool project are marked light blue.

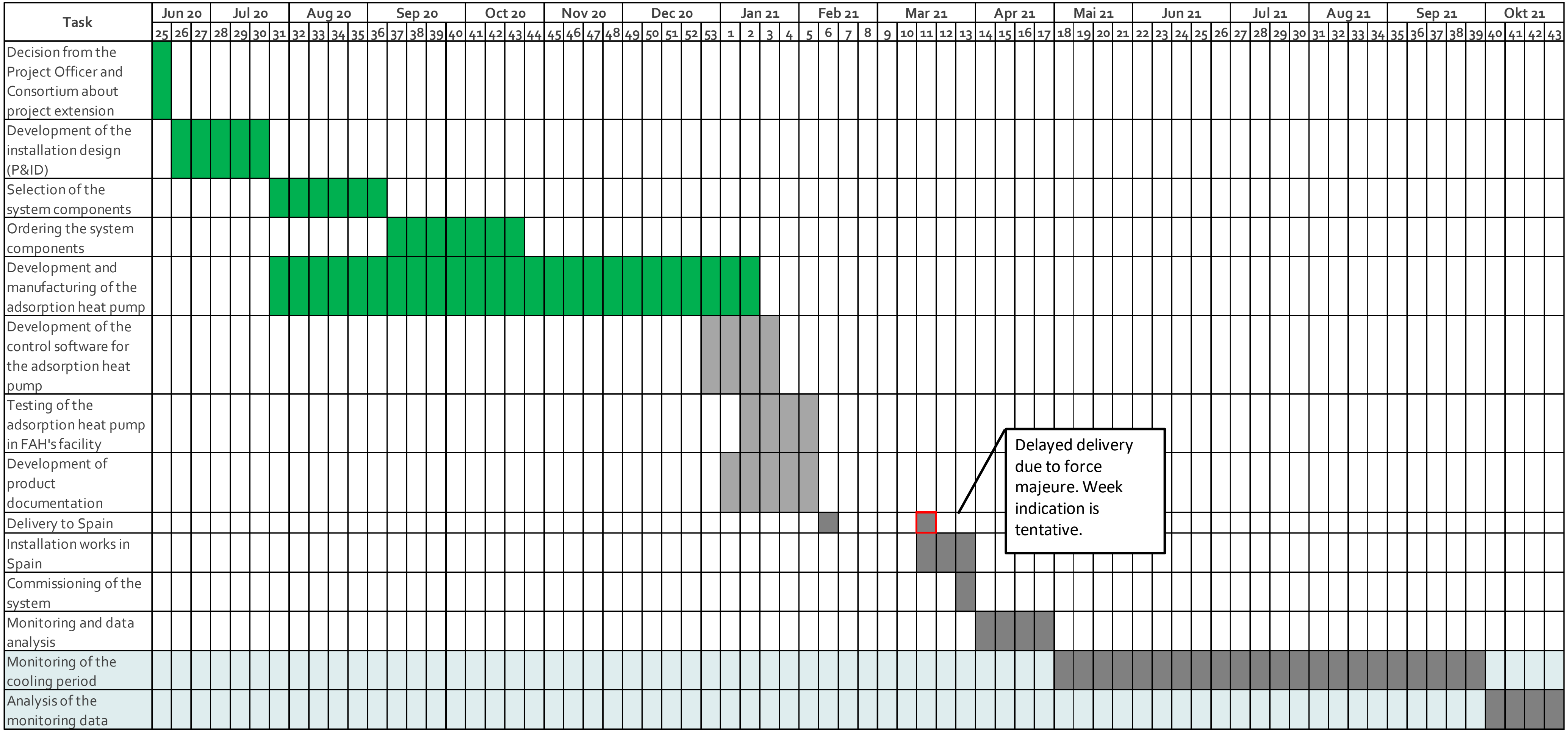


Figure 7. Updated Gantt chart.

Regarding the budget, only costs incurred by Fahrenheit will be reported to the Heat4Cool project.

6.2 Execution

At the date of submission of this Deliverable, the execution works on site have not been started yet. Therefore, a supplement to this report documenting the course of installation works will be handed at a later stage.

The activities completed and partially completed up to date are:

- **Development and manufacturing of the prototype – completed.** The most time-consuming activity, during completion of which we have experienced the most difficulties and delays (main reasons were reduced capacity due to workers in quarantine and delayed critical deliveries from suppliers). Nevertheless, the prototype has been finished and is ready for delivery. Figure 8 presents the prototype at an early stage without integrated hydraulics and Figure 9 shows the prototype connected to the test stand at Fahrenheit's premises.

Figure 8. Prototype at an early stage of manufacturing (process modules in frames without external hydraulics and controller).

Figure 9. Completed prototype at test stand (side panels of the casing removed).

- **Development of the prototype's control software, setting the Cloud and data exchange via communication protocol – completed.** The outcomes of this activity have been presented in section 4 and in Appendix in form of cable list, Cloud monitoring list and Modbus TCP/IP communication list.

- **Definition and dimensioning of auxiliary components – completed**. The auxiliary components, such as dry cooler, buffer tank, plate heat exchangers and external hydraulic pumps have been selected to optimally cooperate with the prototype. All components have been ordered and are ready for delivery. The data sheets of these components are to be found in Appendix.

- **Suggestion of the system layout – completed.** Suggestion of the system layout was evolving – different options for the integration with solar field and for the freeze protection of the dry cooler have been analysed. The latest version (v.5) of system layout is attached in Appendix. There are two drawings – one for heating mode and one for cooling mode. The difference between them is the setting of 3-way valves between MT and LT circuits.

- **Preparation of operating manuals and other technical documentation – completed.** The documentation of the prototype is prepared and can be found in Appendix.

- **Testing of the prototype at Fahrenheit's facility – partially completed.** The machine has been tested in part of the operating conditions. More operating points must be tested, and some measurements must be repeated. The control software has been functionally tested.

- **Development of the strategy for energy performance monitoring – completed.** KPIs are defined, list of required data points is developed, and the prototype is equipped with needed sensors. The concluded strategy for energy performance monitoring is described in detail in section 5.

- **Engineering design of the hydraulics – completed.** Based on the Fahrenheit's suggestions of the system layout, Sumersol engineers have elaborated a detailed P&ID which will be used during the installation works.

7. CONCLUSIONS

7.1 Summary of achievements

During the last 8 months of working on this additional testing activity, Fahrenheit has developed and manufactured a stable prototype of 30 kW adsorption heat pump to be installed in Toledo. Several possible system layouts have been analysed and the best option has been chosen. The auxiliary components have been selected and respective orders have been placed. Moreover, control software, strategy for energy performance monitoring and technical documentation of the prototype have been completed. The engineering design has been completed as well. The final prototype undergoes last testing at Fahrenheit's facilities and can be then shipped to Toledo. 2-3 weeks are required for the installation works and commissioning of the heat pump. The monitoring period was originally planned for the 4 weeks in March. Unfortunately, due to the force majeure, the delivery and installation works must be delayed. The works will be continued as soon as possible. The current expectation is to finish the installation in March / April and to monitor the full cooling period (May - September 2021).

7.2 Other conclusions and lessons learned

Silica gel adsorption modules installed in Valencia show poor performance due to high ambient temperatures. Therefore, it is justified to use zeolite adsorption modules in locations with such warm climate like Valencia. Using a different sorbent, we expect to resolve the problem of poor performance caused by high re-cooling temperatures and observe much better results in Toledo.

Due to the imminent end of the Heat4Cool project, the next reports will be based on the simulation of cooling period and monitoring data from heating mode. After the end of Heat4Cool project we will continue to monitor the system for the whole succeeding cooling season. If the end user shows interest in further using the prototype, it will be left on-site.

Gathered monitoring data will be used for evaluation of the prototype performance and reliability (stability). We aim at learning about the strengths and shortcomings of the prototype and defining the areas that need improvement before launching this product on the market. Furthermore, we plan to collect the information about the advantages of the prototype (e.g., generated energy savings) which will be used for marketing activities. Close cooperation with an installation company will give us further insight in main difficulties they are facing with our technology. This will help us to properly address the common installers' problems by adjusting the technology and providing comprehensive training material and guidelines.

ACRONYMS AND TERMS

AdHP..	Adsorption Heat Pump
BEMS..	Building Energy Management System
COP..	Coefficient of Performance
DHW..	Domestic Hot Water
EC..	Electronically Commutated
EER..	Energy Efficiency Ratio
HMI..	Human Machine Interface
HT..	High temperature
HVAC..	Heating, Ventilation and Air Conditioning
LT..	Low temperature
MT..	Medium temperature
TRL..	Technology Readiness Level

APPENDIX

System layout (cooling)

System layout (heating)

Technical Data & Installation Manual of the prototype

Corrosion Inhibitor Quick Manual

General Operating Manual

Can be downloaded from https://fahrenheit.cool/en/downloads/#tab-id-1

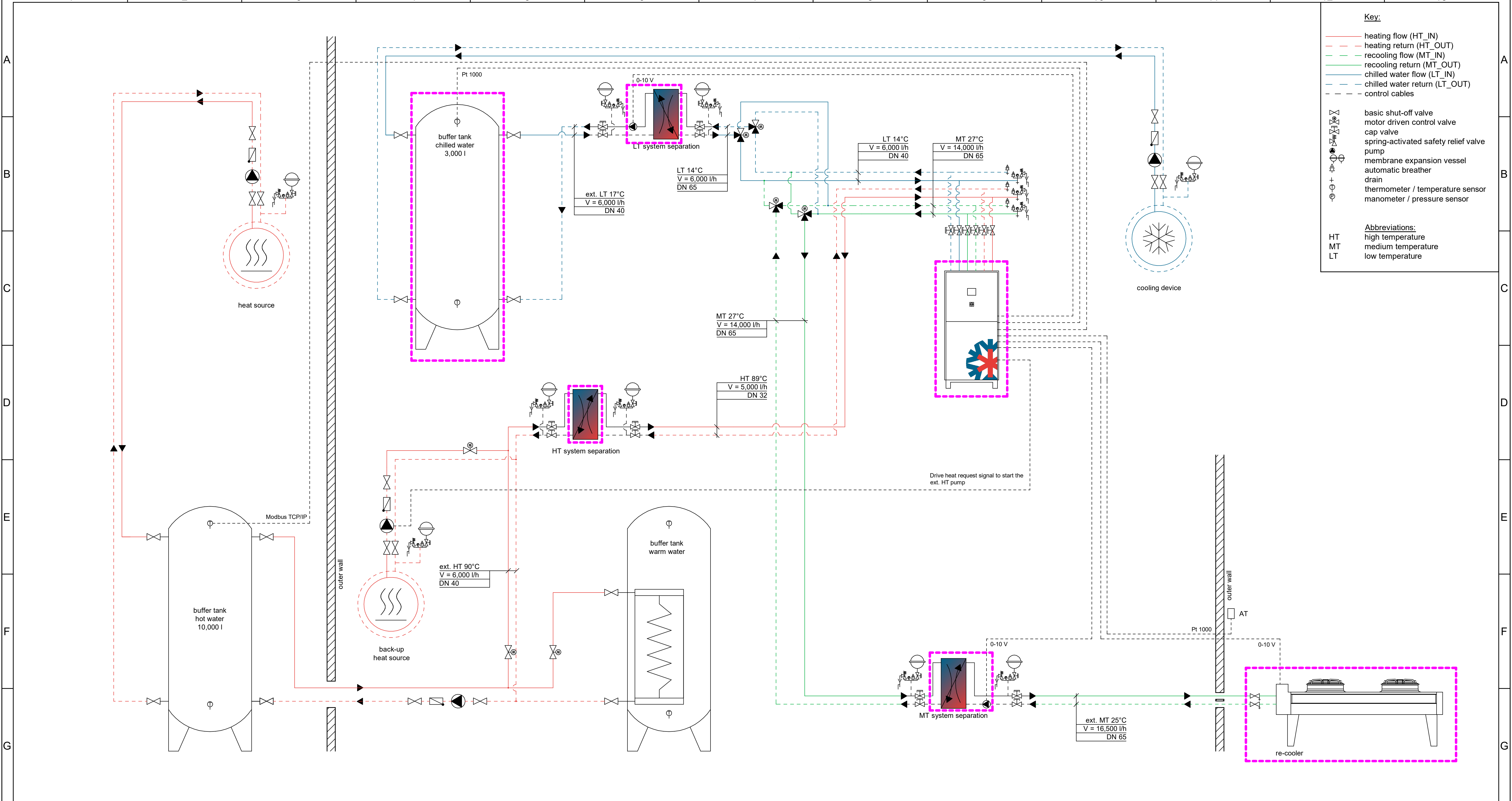
Technical data of the auxiliary components

Data sheets of the system separation heat exchangers

Data sheet of the dry cooler

Data sheets of the external circulation pumps

Drawing of LT buffer tank



NOTE: Solid lines symbolize the warmer medium, dashed lines symbolize the colder medium!

NOTE: The location of the connections can be found in the "TDI - Technical Data and Installation Manual"!

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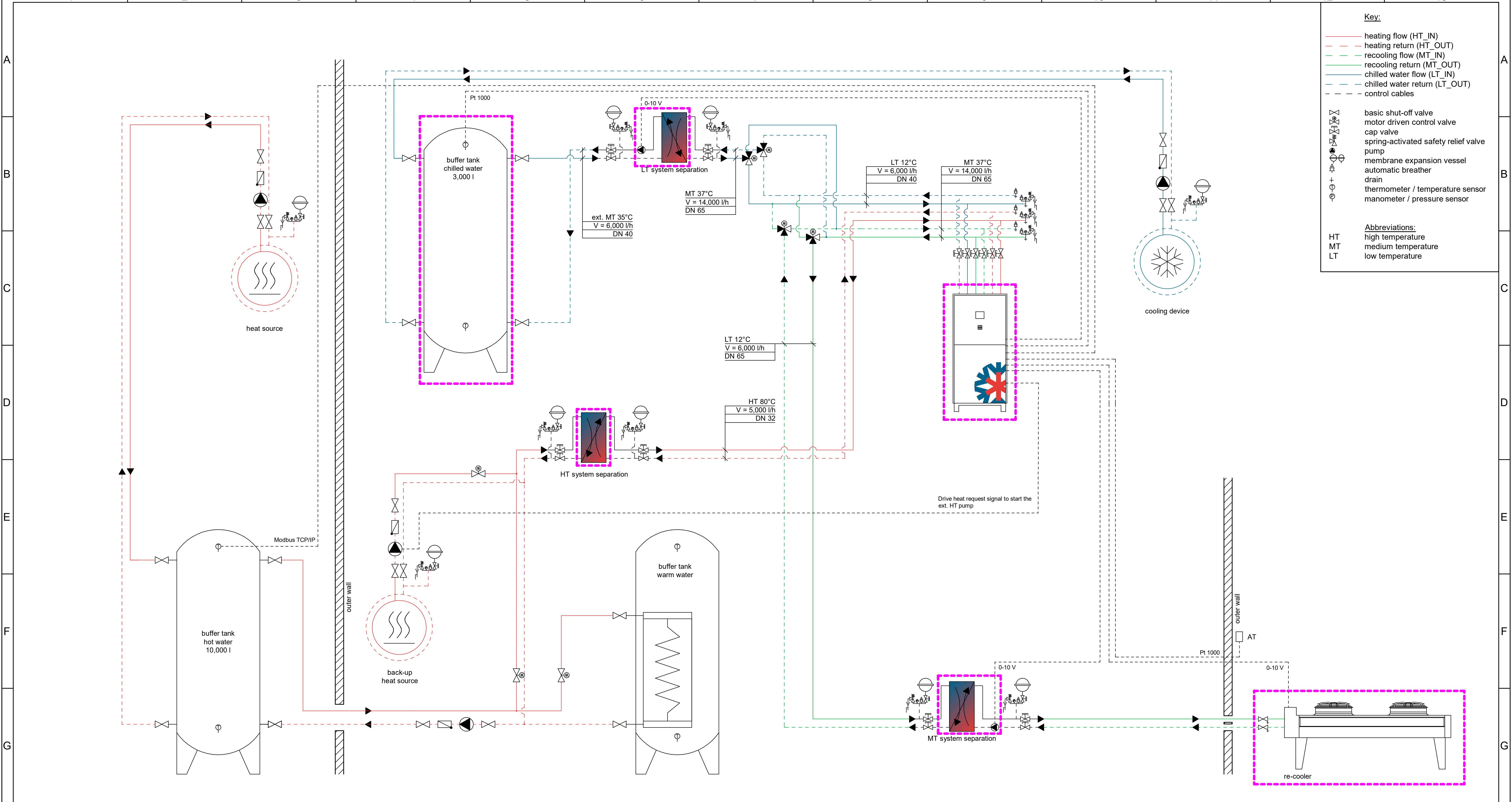

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Cooling Innovation.

Technical Data & Installation Manual (TDI)

Heat4Cool ZeoM20

TDI - Z1-A0-C2-2.00-K-0W-1C0

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We work continuously on our documents to keep them up-to-date and error-free. Despite all efforts, mistakes can never be ruled out completely. Any hint is welcome.

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List of Figures

List of Tables

Abbreviations

AdKA ..... *Adsorption Chiller*
COM ..... *Controller & Operation Manual*
GOM ..... *General Operating Manual*
HT ..... *High Temperature*
IFC ..... *Instructions for Commissioning*
LT ..... *Low Temperature*
MT ..... *Middle Temperature*
TDI ..... *Technical Data & Installation Manual*

1 Usage of Documents

The operating and installation manuals include all information regarding the proper installation and use of an adsorption chiller (AdKA) from Fahrenheit GmbH.

The operating and installation manuals for AdKA consist of several parts:

» General Operating Manual - GOM

General information about planning, installation and maintenance of the system. Additionally, this document includes a general description of the working principle and operation of AdKA from Fahrenheit GmbH.

» Technical Data & Installation Manual – TDI

Detailed technical information about the specific model of AdKA. This document provides information about dimensions, weight and space requirements as well as more detailed installation instructions.

» Controller & Operation Manual - COM

Operating manual for the controller of AdKA. This manual provides information on how to change the settings and configure the system to meet user-specific requirements. Furthermore, it explains the meaning of the measured and calculated values displayed on the control panel.

Additional documents such as the system recommendation, circuit diagrams and data point lists for various communication protocols, are created specifically for the project and, if available, are also part of the operating and installation manuals. For the proper planning and exploitation of the system, refer to the operating and installation instructions of the re-cooler as well.

Make sure that all parts of the operating and installation manuals for your system are available. If the operating and installation manuals are incomplete, please contact Fahrenheit GmbH.

These operating and installation manuals are intended for trained personnel of the device distributor and / or the company performing installation works.

The operating and installation manuals are an integral part of AdKA and must be kept at the installation site throughout its lifetime, at a location accessible and recognizable to the user. If AdKA is handed over to a new owner, these manuals must be included as well.

Proper commissioning is required for trouble-free operation of the system. The minimum requirements and the most important steps are described in the optional document "Instructions for Commissioning" - IFC. The commissioning performed by a non-certified person may cause damage and will void the warranty.

AdKA should only be operated if all parts of the operating and installation manuals are available to the user and they have been read and understood completely.

2 Product Description

The Heat4Cool ZeoM20 is AdKA of Fahrenheit GmbH, utilizing zeolite as the adsorption material.

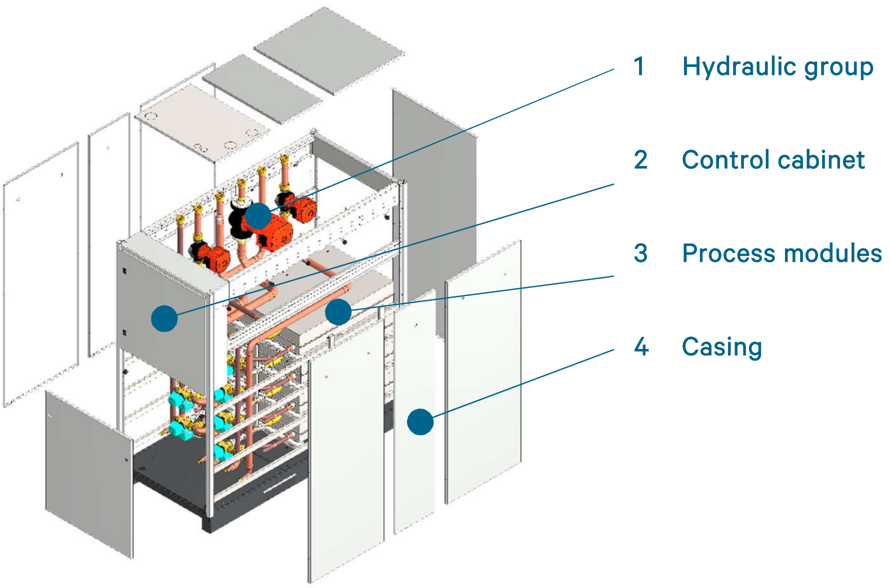


Abb. 1. Structure of the Heat4Cool ZeoM20

1 Hydraulic group

The hydraulic group consists of three circuits, the drive circuit (HT), the re-cooling circuit (MT), and the cold water circuit (LT). For each circuit, the connections of the supply and return lines are located at the top of the unit. The corresponding nominal diameters are listed in chapter 3.2. The hydraulic group includes also high efficiency pumps – one in each circuit. The lower part of the hydraulic group contains three-way valves and contact temperature sensors for controlling and monitoring the operation of AdKA.

2 Control cabinet

The control cabinet of AdKA consists essentially of a controller with an operating panel (HMI) and a main switch. The controller monitors and controls the operating processes and enables the operation of AdKA. Information about operating state, as well as the fault messages are displayed on the operating panel (HMI). The power supply of AdKA is disconnected with the use of the main switch.

3 Process modules

The Heat4Cool ZeoM20 consists of four identical, vacuum-tight, welded, and diffusion-tight insulated process modules. Two process modules each form a module pair. In each pair, individual modules alternate between adsorption and desorption processes.

4 Casing

The casing protects the process modules and the hydraulic group from damage. For commissioning or maintenance tasks, the side panels can be removed. Do not remove the panels during operation.

3 Technical Data

3.1 General Information

Performance data	
Nominal cooling capacity[1]	Up to 40.0 kW
Thermal COP	Up to 0.55
Dimensions & Weight	
Width x Depth x Height	875 x 1,847 x 2,003 mm
Footprint	1.62 m²
Required space including operating and maintenance areas	3.68 m²
Empty weight	900 kg
Required free space	
In front	min. 800 mm
On both sides	min. 500 mm
Other details	
Max. operating pressure	2 bar
Integrated circuit separation	No
Integrated compression chiller	No
Real water content	75 litres

Tab. 1. General technical data.

Pay attention to the transport instructions of AdKA given in GOM.

3.2 Connections

Electrical connection	
Max. power consumption	1,600 W
Power supply	230 V AC ~ 50-60 Hz (1P)
Power supply terminal	max. 2.5 mm^2
Hot water circuit HT	
Volume flow rate	5.0 m³/h
Available delivery head	780 mbar
Connection	2” male thread, add a flat sealing
Water content for expansion vessels	30 litres
Re-cooling water circuit MT	
Volume flow rate	13.0 m³/h
Available delivery head	510 mbar
Connection	2” male thread, add a flat sealing
Water content for expansion vessels	61 liters
Cold water circuit LT	
Volume flow rate	6.0 m³/h
Available delivery head	490 mbar
Connection	2” male thread, add a flat sealing
Water content for expansion vessels	36 liters

Tab. 2. Hydraulic and electrical connections.

The heat transfer fluid and the operating pressure for the hot (HT), re-cooling (MT), and cold (LT) water circuits must be the same, because these circuits are hydraulically connected with each other! The internal circuits of AdKA should be filled with pure water mixed with corrosion inhibitor (e.g. Thermogard 5%)!

4 Appendix

4.1 Installation Guidelines

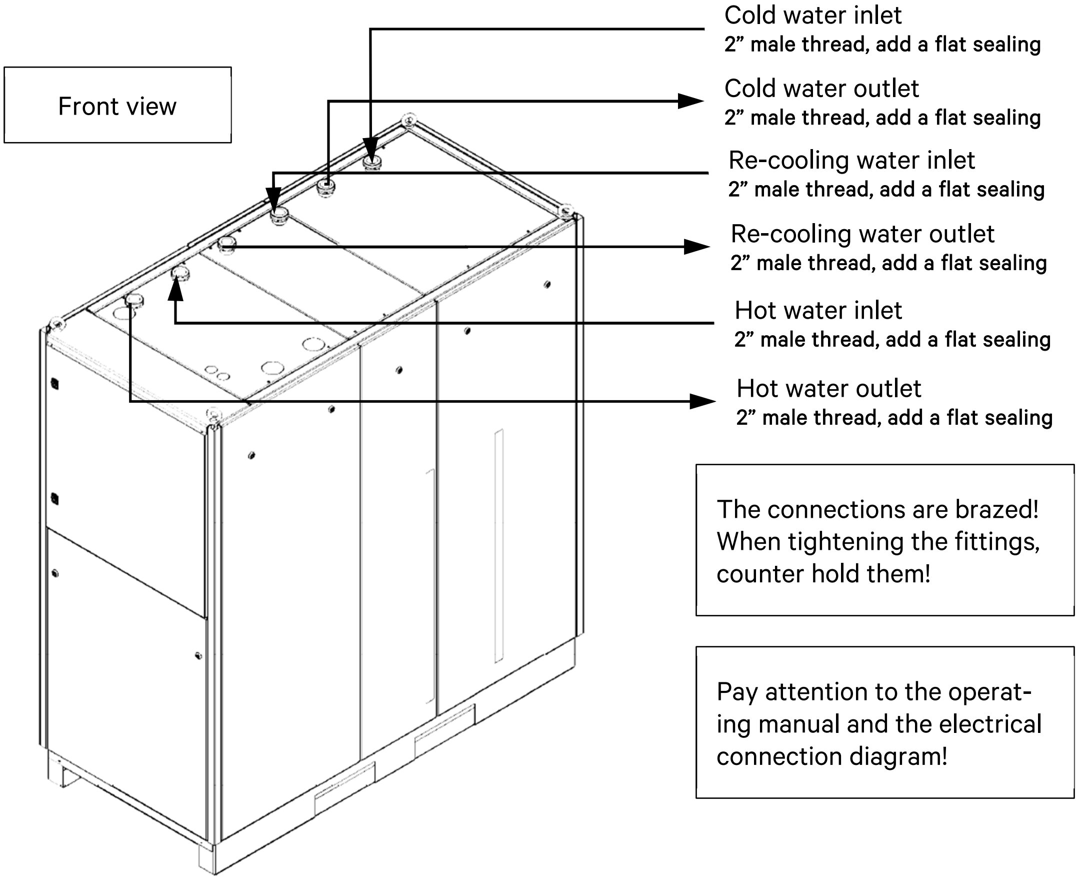


Abb. 2. Hydraulic connections and cable entries

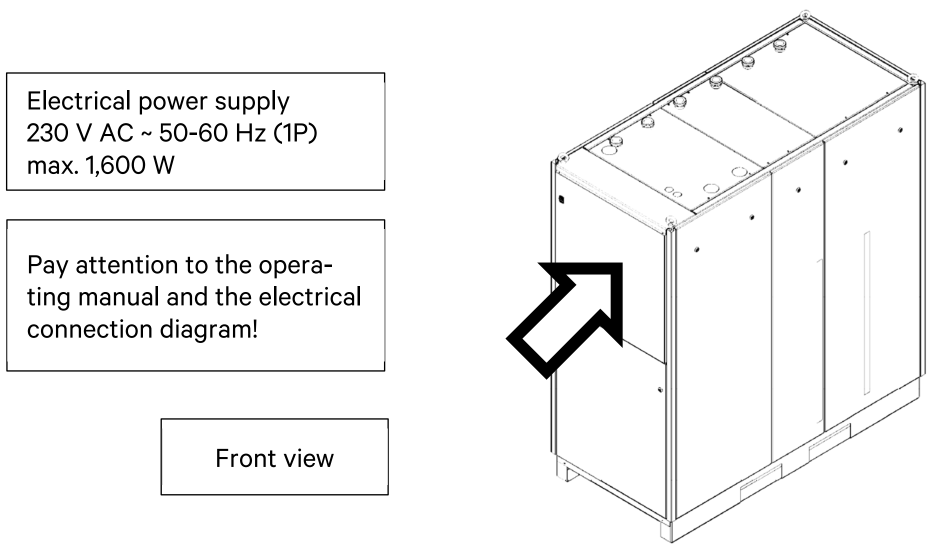
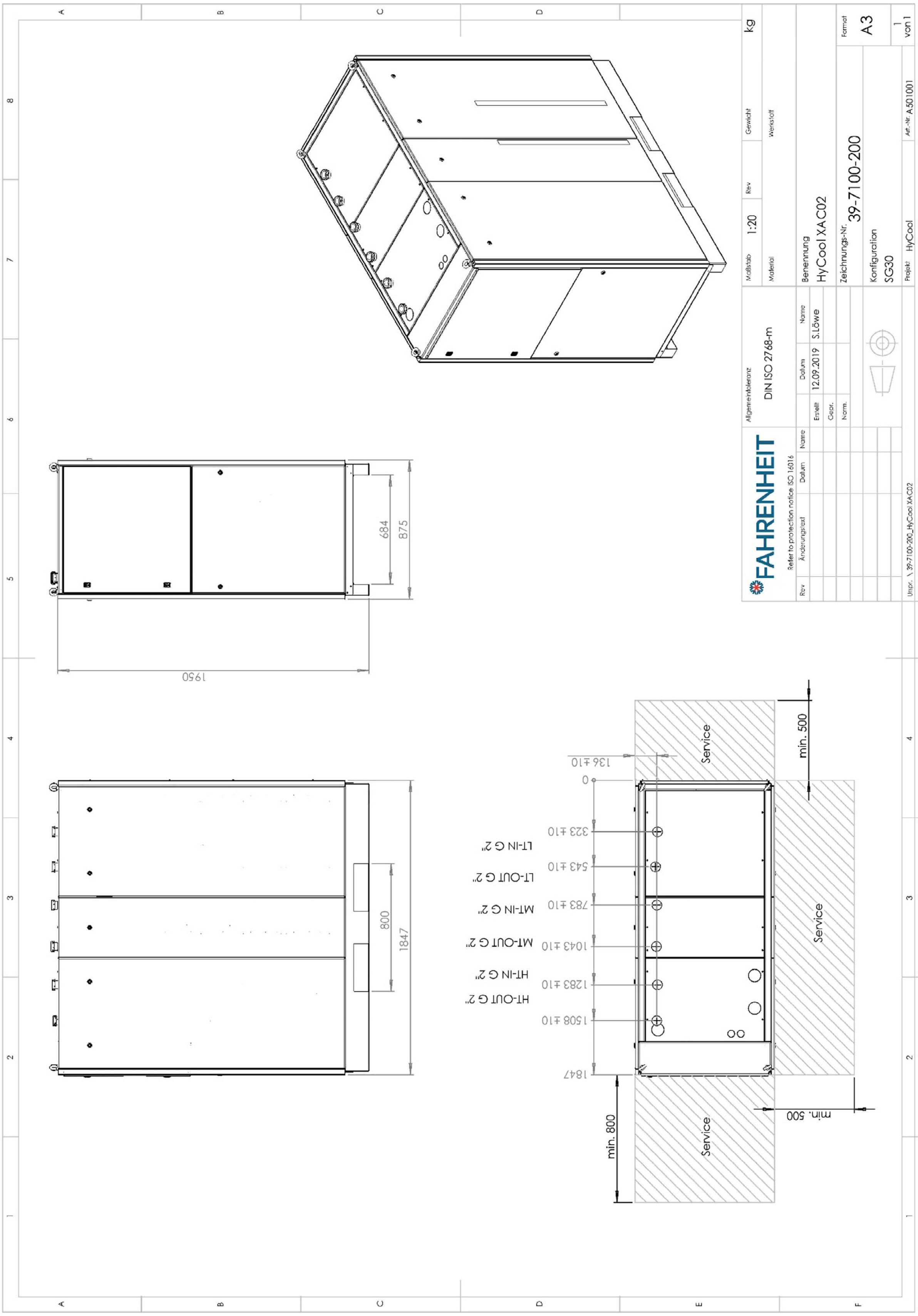


Abb. 3. Power supply connection

4.2 Technical Drawing



F

Quick Manual

Filling of Fahrenheit chiller with corrosion inhibitor (CI) solution

Fahrenheit GmbH, 20.01.2021 (v 2.0)

Contents

1 Specification of water quality

1.1 Target values

- To minimise scaling and corrosion especially of the aluminium adsorber, the following target water parameters are relevant according to German guideline VDI2035-2:
  - pH value 8.2-8.5
  - Electrical conductivity < 100 µS/cm
  - Chloride and sulfate < 50 mg/L
  - Oxygen < 0,1 mg/L
  - Free of suspended solids

1.2 Water and corrosion inhibitors to be used

- Preferably deionized water (DI water) with an electrical conductivity of < 10 µS/cm is to be used.
- Only if the use of DI water is not possible, soft drinking water can be used, if the electrical conductivity is below 250 µS/cm and both chloride and sulphate content are below 50 mg/L. (These values may be obtained from the local water supplier.)

> The use of water not meeting this specification (also e.g. including the addition of glycol) must be discussed with Fahrenheit prior to the filling of the system.

- To further protect against corrosion, the filling water must be treated with a corrosion inhibitor (CI). These are:
  - Aqua Concept Coracon **VE9** for the application with DI water.
    The concentration is 0.5 mass-% (50 mL CI with 10 L water) and results in a conductivity increase of ~55 µS/cm and a pH value of 8.6 ± 0,2.
  - Aqua Concept Coracon **HE6** for the application with tap water.
    The concentration is 0.5 mass-% (50 mL CI with 10 L water) and results in a conductivity increase of ~600 µS/cm and a pH value of 8.5 ± 0,2.
- Both CI concentrates are declared as not dangerous. The usual safety measures for handling chemicals are to be considered. Please refer to the safety data sheets for further information. Country-specific regulations may apply.
- Both CI concentrates are declared as low hazardous to water (German classification WGK1). Prevent contamination of soil and water and to not dispose of via the sewage system. Country-specific regulations may apply.
- The concentrates as well as the CI mixtures are to be stored in a closed container (no entry of oxygen).

> During flushing, filling, or storing, a colouring of the mixture (greenish/brownish, possibly with foam) may occur. This is an indication for a biofilm already present in the system. The biofilm can metabolize components from the CI mixture and grow below ~60 °C.
> As a precaution, avoid contact with the contaminated mixture and do not inhale aerosols. In case of heavy contamination, a cleaning of the system using a biocide has to be considered.

2 Flushing and filling of chiller and connected devices

2.1 Prerequisites and connection

- A measuring device for electrical conductivity (minimum range up to 1000 µS/cm) is needed to apply the correct concentration of CI.
- A filling station (mixing tank with pump and appropriate hoses) is needed.
- The system to be filled with hydraulic fluid – i.e. the Fahrenheit chiller and all hydraulically connected peripherals and piping – as well as the filling station must be clean.
- The filling station must be connected to the system in a way that facilitates exchange and mixing of the complete circulating fluid. The fill and drain valves (KFE valves) on the MT-IN and MT-OUT pipes of the chiller may be used for connecting the filling station (in parallel to the system).

2.1.1 Flushing and filling

- The system must be flushed and pressurised with appropriate water according to section 1.2.
  - On the chiller HMI, option “Valve run” must be activated and pumps must be turned on (in “Input” menu).
  - If applicable, appropriate measures must be taken to also thoroughly flush secondary or bypass lines in the system, e.g. by switching valves.
- The conductivity of the circulating fluid must be measured continuously. After several minutes of flushing, after the conductivity has become stable, this value should be noted as the base value.
- If the base value meets the specifications given in section 1.2, it can be proceeded with the addition of the CI. Otherwise, the flushing water must be replaced until the specification is met.

2.1.2 Addition of the CI

- The CI concentrate must be added stepwise to the mixing tank. The correct mixture is reached, when the conductivity increase (compared to the base value) matches the value given in section 1.2. The conductivity of the mixture increases nearly proportional to the added amount of CI.
- In case of over-dosing (conductivity much too high), mixture must be drained from the system and the remaining fluid must be diluted by addition of appropriate water.

2.1.3 Adding CI mixture for maintaining system pressure

- If the system has been running with the CI mixture before, and the circulating fluid still meets the specification, freshly made mixture can be pressed into the system to maintain system pressure.

2.1.4 Storage

- Both concentrate and mixture must be stored in a closed tank (no entry of oxygen).

3 Appendix

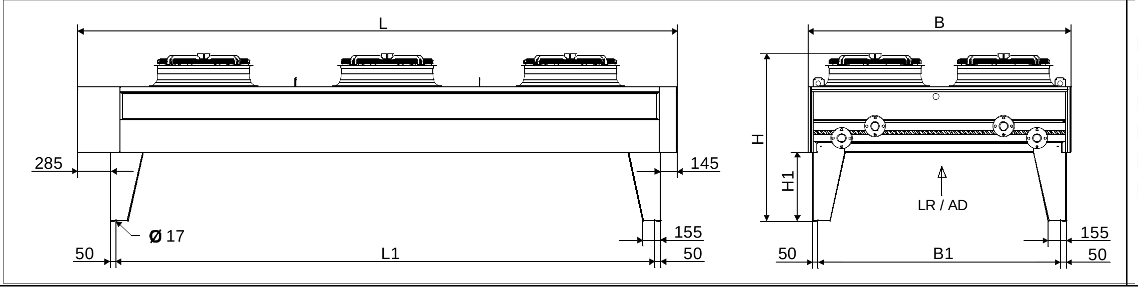
- Safety data sheet Aqua Concept Coracon HE6
- Safety data sheet Aqua Concept Coracon VE9

Circuit separation: Technical data.

Model	ST-10	ST-10X	ST-20	ST-20X	ST-30X	ST-40X
Article number	A600026	A600020		A600025	A600024	A600022
General data						
Capacity	40 kW	60 kW	80 kW	111.6 kW	180 kW	242 kW
Connections	2“ gland, soldering 42 mm	2“ gland, soldering 42 mm	2“ gland, soldering 42 mm	Compact Flange DN 65, 2 ½“ IG	Compact Flange DN 80, 2 ½“ IG	Compact Flange DN 80, 2 ½“ IG
Heat transfer medium (internal side)	Water	Water	Water	Water	Water	Water
Heat transfer medium (external side)	Ethylene glycol - water (34%)	Ethylene glycol - water (34%)	Ethylene glycol - water (34%)	Ethylene glycol - water (34%)	Ethylene glycol - water (34%)	Ethylene glycol - water (34%)
Heat exchanger surface	7.66 m²	11.4 m²	15.6 m²	19.6 m²	37.8 m²	54.7 m²
Dimensions						
W x D x H	243 x 151 x 525 mm	243 x 220 x 525	243 x 289 x 525	243 x 331 x 525 mm	304 x 421 x 694	304 x 600 x 694
Footprint	0.037 m²	0.054 m²	0.07 m²	0.094 m²	0.13 m²	0.184 m²
Weight						
Empty weight	35.4 kg	47.5 kg	59.6 kg	77.2 kg	135 kg	185 kg
Filled weight	49.9 kg	69.4 kg	88.9 kg	108 kg	207 kg	289 kg
Pressure drop						
Internal side	56.4 mbar	63.9 mbar	75.7 mbar	82.1 mbar	87.2 mbar	104 mbar
External side	89.7 mbar	102.0 mbar	119.0 mbar	126.0 mbar	104 mbar	105 mbar
Filling volume						
Internal side	6.99 liter	10.6 liter	14.2 liter	15.2 liter	35.1 liter	50.8 liter
External side	7.23 liter	10.8 liter	14.5 liter	15.0 liter	35.5 liter	51.2 liter

eRec 30|120 – X – TDH.3-091-23-B-E-DE-BD-04
Dry cooler

Capacity	**110.0 kW**		**Medium**	**Water**
Surface reserve:	50.1 %		Inlet temperature:	33.8 °C
Air:	Inlet	Outlet	Outlet temperature:	27.0 °C
Temperature:	25.0 °C	28.4 °C	Mass flow:	13931.09 kg/h
Volume flow:	98074 m³/h	99349 m³/h	Volume flow:	14.0 m³/h
Altitude:	0 m		Pressure drop:	0.081 bar
Fans[1]:	**6x3~400V 50Hz (EC)**			
Article No.:	KT0009332			
Data per motor:	Nominal data	Operating data		
Speed:	670 1/min	670 1/min	Noise pressure levell[3]:	45 dB(A)
Capacity:	0.70 kW	0.70 kW	Distance:	10 m
Current:	1.10 A	1.11 A	Noise power level[3]:	77 dB(A)
Fin pitch:	2.4 mm		Max. working pressure:	10 bar
Surface:	1739.2 m²		Test pressure:	11 bar
Tube volume:	179.5 l			
Empty weight:	1150 kg			
Tube material[4]:	Copper		Inlet tube:	1 x 64.0 * 2.0 mm
Fin material[4]:	Aluminium		Outlet tube:	1 x 64.0 * 2.0 mm
Casing material[4]:	Galvanized steel, powder-coated RAL 7035		Passes	4



L	6130	mm
B	2290	mm
H	1510	mm
H1	600	mm
L1	5605	mm
B1	2115	mm

Dimensions and weights are not valid for all possible options and accessories.

Accessories/Execution:

- 02 x lapped flanges DN 65/PN 10 in aluminium with counter flanges in steel
- 06 x EC-fans, controllable by external 0-10 V signal
- 01 x current distribution incl. 03 x motor protection devices

Our general terms of sales and delivery apply.

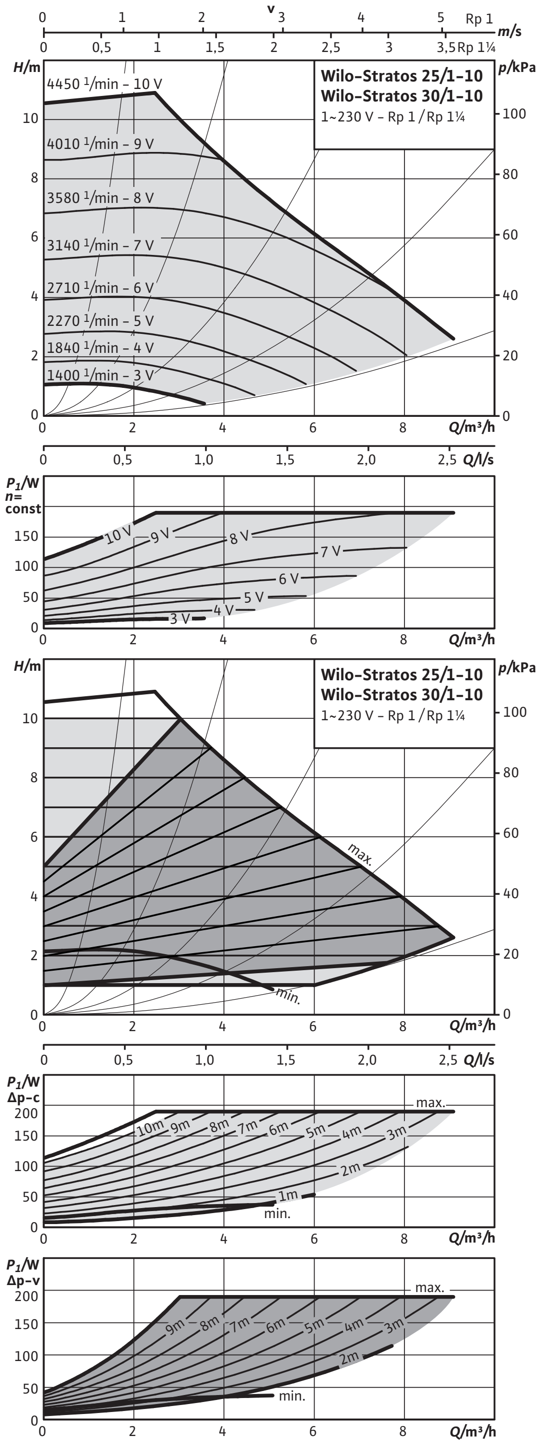
Design according to Machinery Directive 2006/42/EEC as well as pressure equipment directive 2014/68/EU (definite classification of the unit category in case of order processing).
Electrical equipment according to EN 60204-1
(1) The used fans comply with the efficiency requirements of the ErP Directive (according to EC directive N° 327/2011).
Depending on the fluid temperature and on mains voltage fluctuations, current and power consumption can deviate.
AC fans are controllable via frequency converter with all-pole sinus filter (phase to phase / phase to protective earthing conductor).
(3) The sound pressure is calculated with the enveloping surface method according to the EN 13487 (tolerance ±2dB(A)).
The given values only apply to the sound power level generated by the fans (1). Additional sound sources such as control units (excepting frequency converters or EC controller) or humidification system, etc. are not considered.
(4) Possibly, material selection and coating do not apply to the given environmental and corrosive conditions (inshore, industrial atmosphere, cleaning agents, etc.).

Freie convection

Capacity	**30.7 kW**		**Medium**	**Water**
Surface reserve:	0.0 %		Inlet temperature:	9.3 °C
Air:	Inlet	Outlet	Outlet temperature:	4.0 °C
Temperature:	-4.0 °C	8.0 °C	Mass flow:	4998.95 kg/h
Volume flow:	7000 m³/h	7313 m³/h	Volume flow:	5.0 m³/h
Altitude:	0 m		Pressure drop:	0.016 bar
Fans[1]:	**6x3~400V 50Hz (EC)**			
Article No.:	KT0009332			
Data per motor:	Nominal data	Operating data		
Speed:			Noise pressure levell[3]:	45 dB(A)
Capacity:			Distance:	10 m
Current:			Noise power level[3]:	77 dB(A)
Fin pitch:	2.4 mm		Max. working pressure:	10 bar
Surface:	1739.2 m²		Test pressure:	11 bar
Tube volume:	179.5 l			
Empty weight:	1150 kg			
Tube material[4]:	Copper		Inlet tube:	1 x 64.0 * 2.0 mm
Fin material[4]:	Aluminium		Outlet tube:	1 x 64.0 * 2.0 mm
Casing material[4]:	Galvanized steel, powder-coated RAL 7035			
			Passes	4

Data sheet: Wilo-Stratos 30/1-10

Pump curves



Approved fluids (other fluids on request)

Heating water (in accordance with VDI 2035)	•
Water-glycol mixtures (max. 1:1; above 20% admixture, the pumping data must be checked)	•

Permitted field of application

Temperature range at max. ambient temperature +40 °C		-10...+110 °C
Maximum permissible operating pressure	P_{max}	10 bar

Pipe connections

Threaded pipe union		Rp 1¼
Thread		G 2
Overall length	l_0	180 mm

Motor/electronics

Energy efficiency index (EEI)		≤ 0.20
Electromagnetic compatibility		EN 61800-3
Emitted interference		EN 61000-6-3
Interference resistance		EN 61000-6-2
Speed control		Frequency converter
Protection class		IP X4D
Insulation class		F
Mains connection		1~230 V, 50/60 Hz
Nominal motor power	P_2	140.00 W
Speed	n	1400 - 4450 rpm
Power consumption	P_1	9 - 190 W
Current consumption	I	0.13 - 1.30 A
Motor protection		integrated
Threaded cable connection	PG	1x7/1x9/1x13.5

Materials

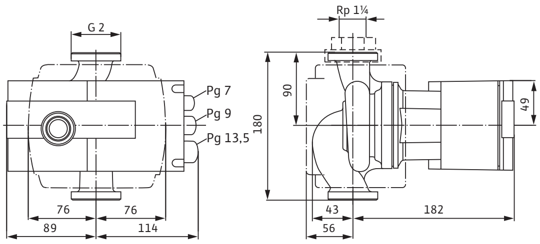
Pump housing	Grey cast iron (EN-GJL-200)
Impeller	Plastic (PPE - 30% GF)
Pump shaft	Stainless steel (X30CR13)
Bearing	Carbon, metal impregnated

Minimum suction head at suction port for avoiding cavitation at water pumping temperature

Minimum suction head at 50 / 95 / 110 °C	3 / 10 / 16 m

Data sheet: Wilo-Stratos 30/1-10

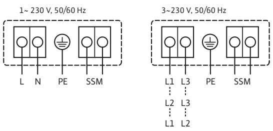
Dimension drawing



Information for order placements

Make		Wilo
Type		Stratos 30/1-10
Art no.		2103616
Weight approx.	*m*	4 kg

Terminal diagram

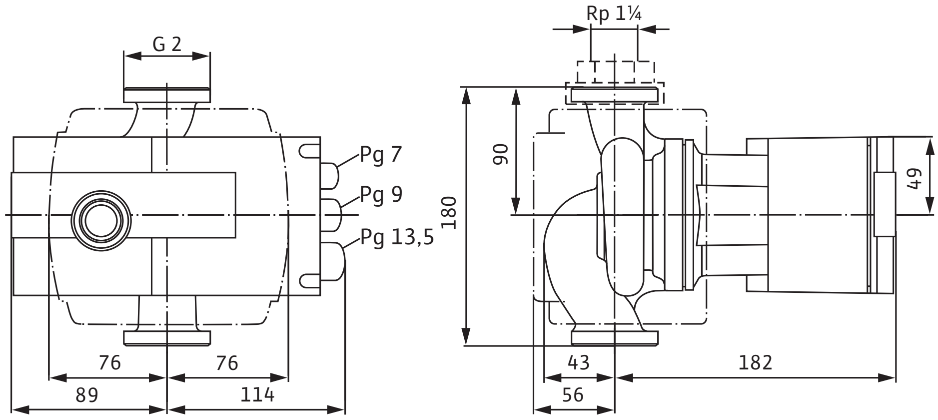


SSM:	Collective fault signal (NC contact according to VDI 3814, load capacity 1 A, 250 V ~) For function, see Wilo catalogue, chapter "Pump management Wilo-Control, consulting guide"

ErP READY APPLIES TO EUROPEAN DIRECTIVE FOR ENERGY RELATED PRODUCTS

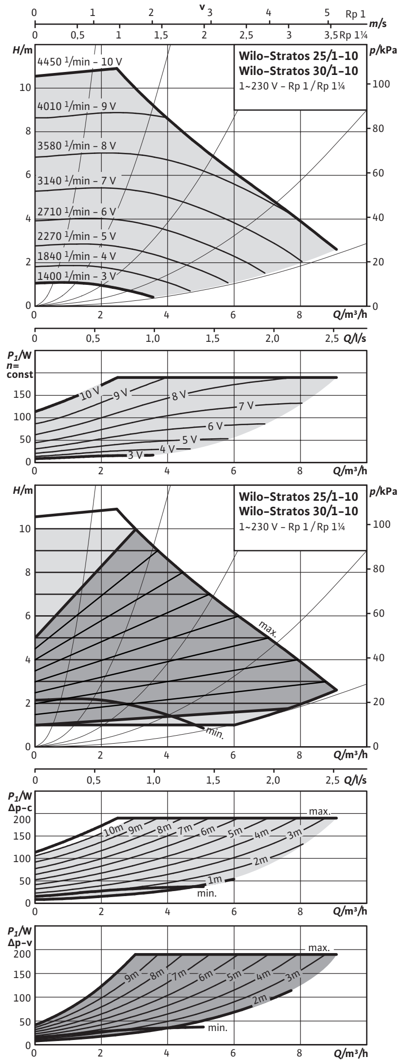
Dimensions and dimension drawings: Wilo-Stratos 30/1-10

Dimension drawing



Pump curves: Wilo-Stratos 30/1-10

Pump curves



Technische Daten

Nassläufer-Premium-Hocheffizienzpumpe
Stratos 40/1-16 PN 6/10

Ansprechpartner
E-Mail
Telefon

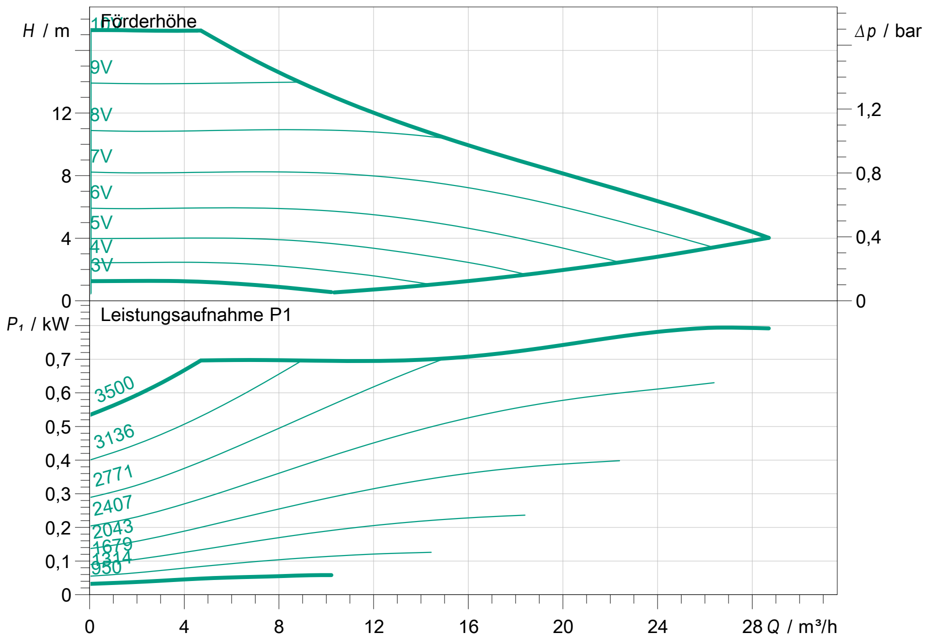
Kunde

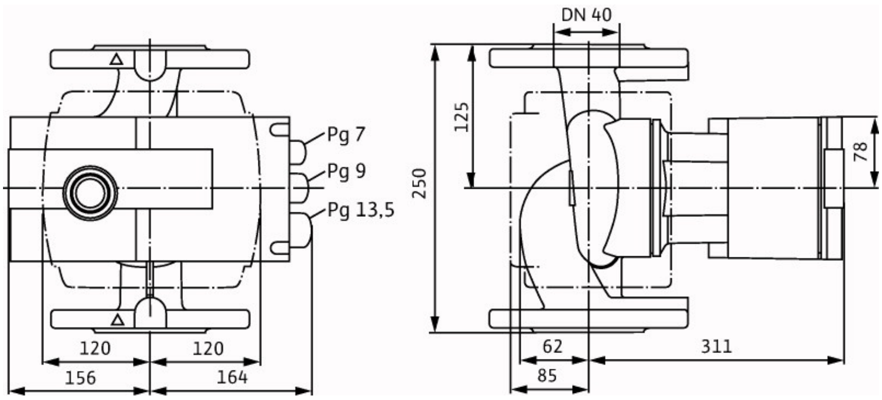
Ansprechpartner
E-Mail
Telefon

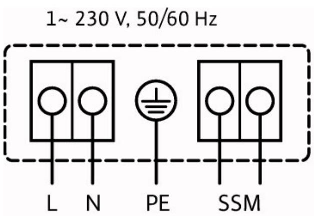
Projektname	Unbenanntes Projekt 2019-05-28 14:25:13.485
Projektnummer	
Einbauort	
Kunden Pos.-Nr	

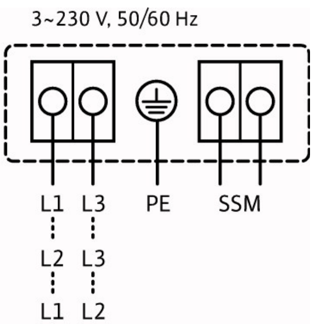
Datum 28.05.2019

Kennfeld









Betriebsdatenvorgabe

Förderstrom	
Förderhöhe	
Fördermedium	Wasser 100 %
Medientemperatur	20,00 °C
Dichte	998,30 kg/m³
Kinematische Viskosität	1,00 mm²/s

Hydraulische Daten (Betriebspunkt)

Förderstrom	
Förderhöhe	
Leistungsaufnahme P1	

Produktdaten

Nassläufer-Premium-Hocheffizienzpumpe
Stratos 40/1-16 PN 6/10

Betriebsart	n_const_0-10V
Max. Betriebsdruck	10 bar
Medientemperatur	-10 °C ... + 110 °C
Max. Umgebungstemperatur	40 °C
Mindestzulaufhöhe bei 50 / 95 / 110°C	7/ 15/ 23 m

Motordaten pro Motor/Pumpe

Motorbauart	EC-Motor
Energieeffizienzindex (EEI)	≤ 0.20
Netzanschluss	1~ 230 V / 50 Hz
Zulässige Spannungstoleranz	±10 %
Max. Drehzahl	3500 1/min
Leistungsaufnahme P1	0,8 kW
Stromaufnahme	3,5 A
Schutzart	IP X4D
Isolationsklasse	F
Motorschutz	integriert
Elektromagnetische Verträglichkeit	
Störaussendung	EN 61800-3;2004+A1;20
Störfestigkeit	EN 61800-3;2004+A1;20
Kabelverschraubung	1x7/1x9/1x13.5

Anschlussmaße

Rohranschluss saugseitig	DN 40, PN 6/10
Rohranschluss druckseitig	DN 40, PN 6/10
Baulänge	250 mm

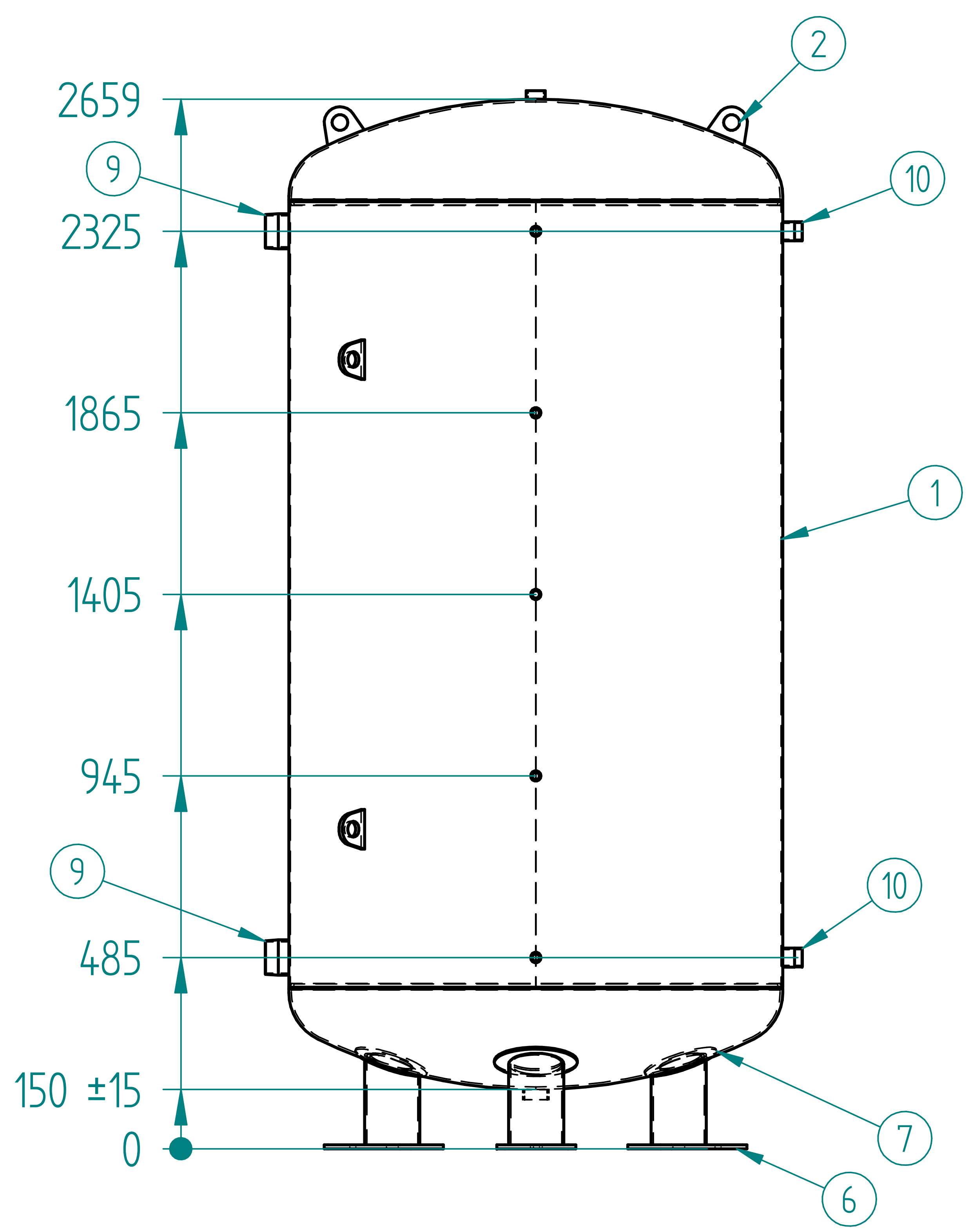
Werkstoffe

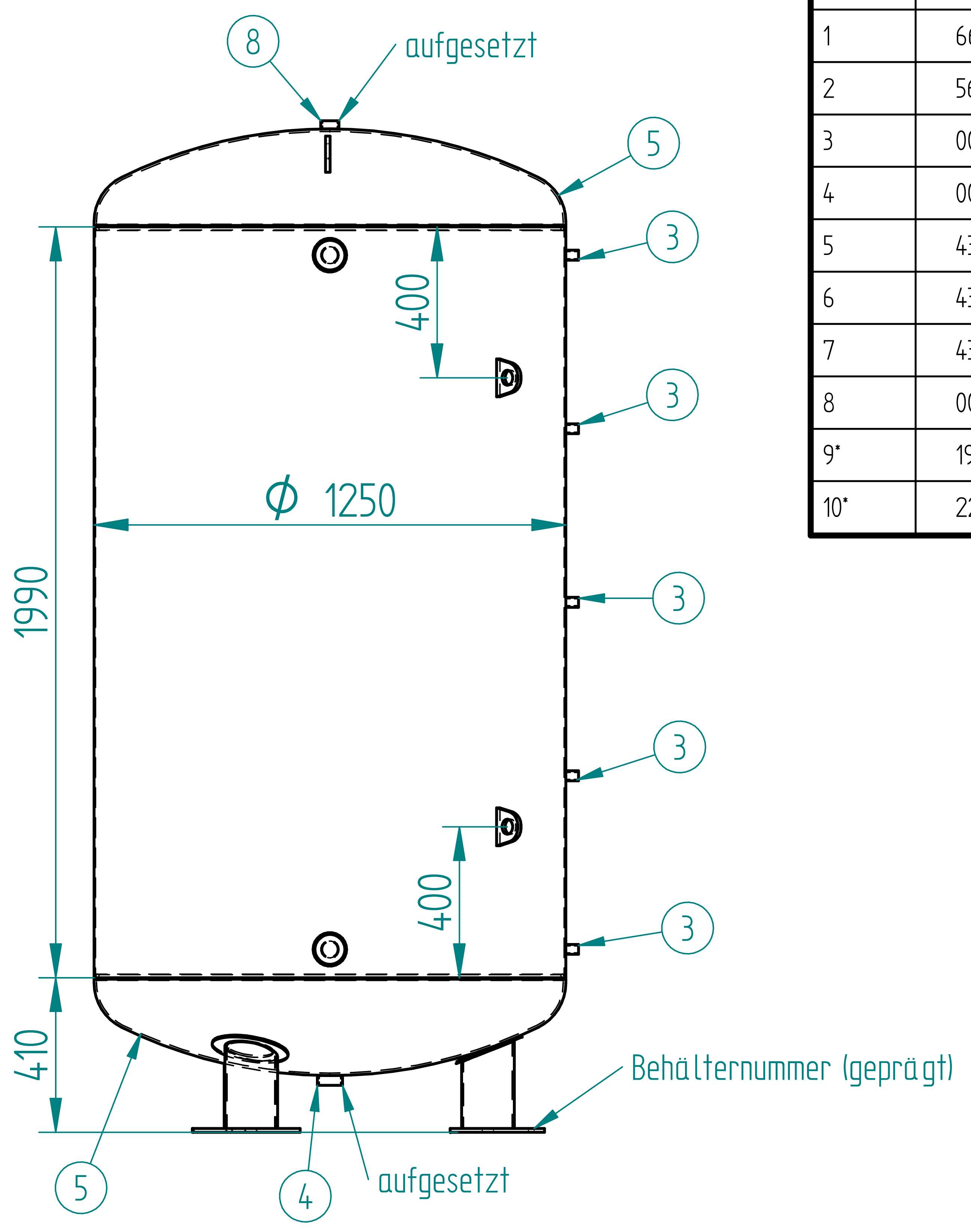
Pumpengehäuse	Grauguss (EN-GJL-250)
Laufrad	Kunststoff (PPE - 30% GF)
Pumpenwelle	Edelstahl (X30Cr13/X46Cr13)
Lager	Kohle, metallimprägniert

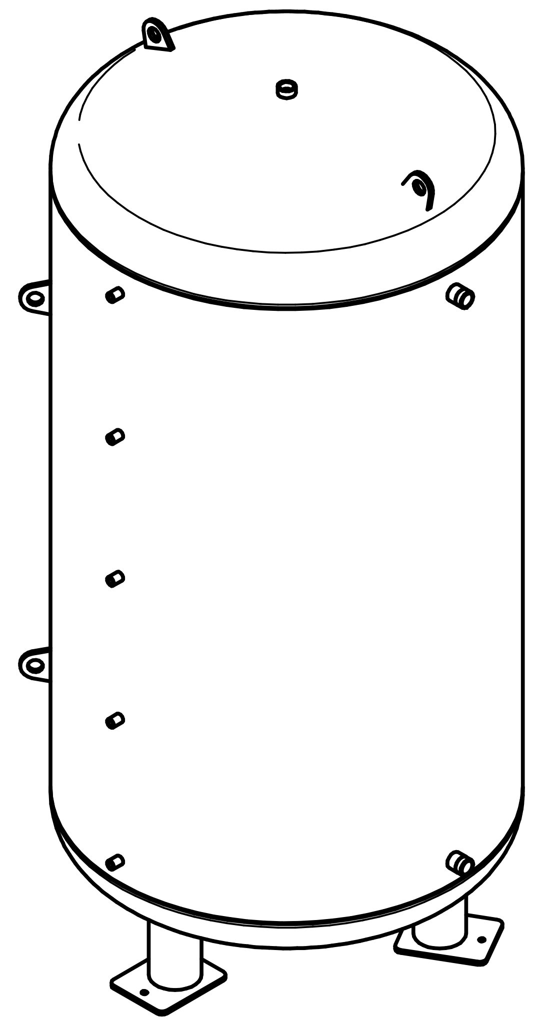
Bestellinformationen

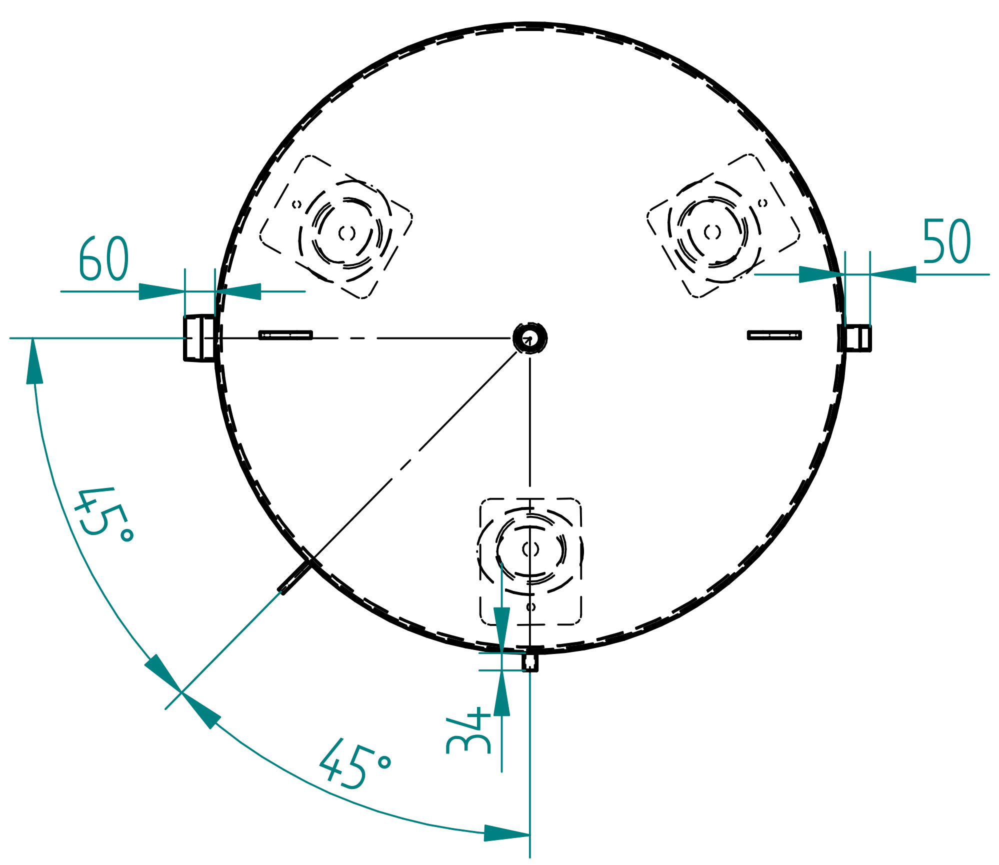
Gewicht netto ca.	23,5 kg
Artikelnummer	2150570

Pos.	Artikel	Anzahl	Beschreibung	Beschreibung2	Material
	66061		Behälter Sonder	KWP 3000 6 bar Φ1250 roh	
1	66060	1	Mantelblech Φ1250	4 x 1990 x 3900	S235JR+N (1.0038)
2	56964	4	Hiß-Öse (NC- Oese)	für Grossbehälter	S235JR+N (1.0038)
3	00174	5	Muffe	Rp 1/2" ganze (Da=26,4)	P235TR2 / P355N
4	00189	1	Muffe	Rp 2" halbe (Da=69)	P235TR2 / P355N
5	43478	2	Klöpperboden XT	1250 x 6 (NW) mat. gesickt ILA	S235JR+N (1.0038)
6	43587	3	Sonderteil Rohrfuß m.Platte(3)	⌀139,7 x 232 x 68° BF=150	
7	43709	3	Verstärkungsblech	Oval 210 x 185 x 5	S235JR+N (1.0038)
8	00187	1	Muffe	Rp 1 1/4" halbe (Da=48,3)	P235TR2
9*	19442	2	Rohrnippel / Anschweißende	R 3" 60 lang (DIN 2999)	P235TR1/TR2 (1.0254)
10*	22167	2	Rohrnippel / Anschweißende	G 1 1/2" 50 lang (20mm Gew.)	Stahl









Behälter - Spezifikationen	
Ausführung:	RL2014/68/ Art.4 Abs.3
Berechnung:	Werksnorm / i.A. AD2000
Medium:	Wasser ohne Luftpolster
zul. Betriebsüberdruck	6 bar
Prüfdruck:	7,8 bar
zul. Betriebtemperatur:	-10°C bis 50°C
Korrosionsschutz:	innen roh außen grundiert (KH-Grundlack schwarz)
Kippmaß:	< 2850 mm
Nenninhalt:	3000 Liter
Cooldämmung:	25mm Elastomer

"Kaltwasserpufferspeicher sind ausschließlich zum Einsatz als Pufferspeicher für Wasser (VDI2035) oder Wasser-Glykol Gemisch bestimmt.
Planung und Errichtung der Heizanlage erfolgt nach technischen Regeln zur Vermeidung von Sauerstoffkorrosion (z.B. VDI 2035, DIN EN 12828(3), DIN 4726..)"

Kunde: Fehler: Keine Referenz

Zulässige Abweichungen: ISO 13920-DH, ISO 9013-442

Status: In Bearbeitung

Maßstab 1:15 | Gewicht: 461,857 kg | - A2 -

Halbzeug / Werkstoff:

	Datum	Name
Bearb.	14.09.2020	sm
Gepr.	14.09.2020	a.kamchen
Norm		
CAD	66061.dft	

Zust.	Änderung	Datum	Name

Benennung:
Behälter Sonder
Behälter Sonder
KWP 3000 6 bar Ø1250 roh

Zeichnungsnummer / Artikelnummer: 66061

Blatt 1 / 1
Revision A

Ursprungszeichnung: Fehler: Keine Referenz