

31 December 2025

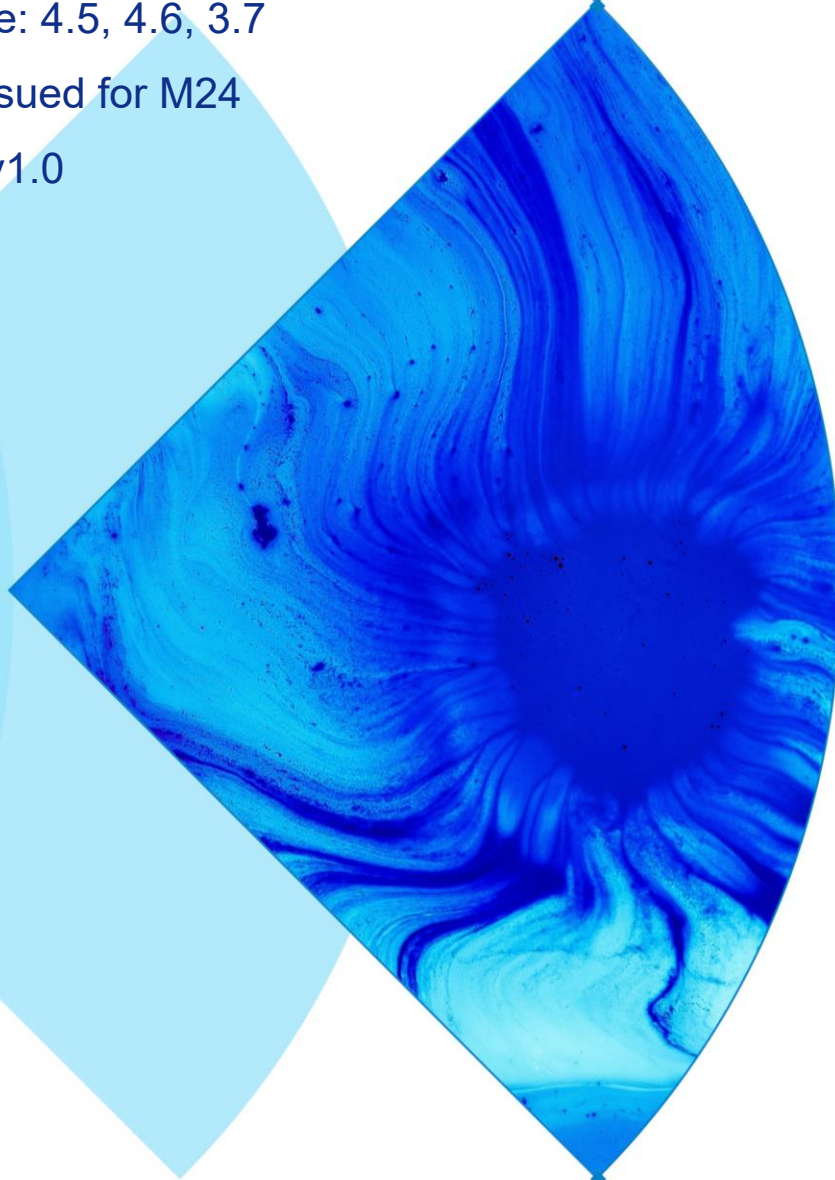
MISD Edge Data Centres

Advanced Thermal Management

Deliverable: 4.5, 4.6, 3.7

Status: Issued for M24

Version: v1.0



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Version

Version	Date	Author(s)	Description
v1.0	24 December 2025	AM, TN, RR, JF	First Issue

1 Introduction

1.1 Background

The demand for Edge Data Centres (EDCs) is rapidly growing, with a clear need for their widespread adoption across the Netherlands and Europe. The accelerating rise of AI-driven services, paired with constraints in both physical space and power availability for large-scale data centre developments, underscores the necessity for innovative solutions. EDCs address these challenges by decentralizing data processing and reducing dependence on core and hyperscale facilities. By positioning computational resources closer to end users, they deliver low-latency performance while supporting the sustainable growth and scalability of digital infrastructure.

One key area of innovation is thermal chemical heat storage technology for improving energy efficiency and resource utilization in data centre operations. This technology, which uses solid-gas sorption heat pumps with ammonia (NH_3) as the working fluid, offers a promising solution for optimizing heat recovery and reuse. Through a controlled adsorption process, low-temperature heat sources can be upgraded to higher temperatures, enabling efficient energy integration within EDC systems.

This report examines the design principles and integration strategies of advanced thermal storage systems, focusing on Deerns' role in developing the interface between Asperitas immersion cooling technology and the adsorption-based heat storage reactors from the University of Twente. By addressing performance requirements, hydraulic design, safety measures, and maintenance considerations, this work aims to support the deployment of energy-efficient, decentralized Edge Data Centre networks across the Netherlands and Europe.

1.2 Key Objectives

The design of the edge data center and associated cooling system must meet a set of clear performance objectives. These objectives are intended to balance technical reliability, operational flexibility, and sustainability while aligning with industry best practices. The key objectives are:

1.2.1 Reliability and Safety

The system must ensure continuous and safe operation under all expected conditions. Reliability is critical for maintaining uptime of IT equipment, while safety measures (e.g., leak containment and pressure relief) protect infrastructure.

1.2.2 Modularity and Serviceability

The design shall adopt a modular approach, enabling equipment to be installed, replaced, or expanded with minimal disruption. Modular components (e.g., standardized pipe lengths, tanks in parallel, skid-mounted systems) enhance flexibility and allow for quicker interventions. Serviceability is addressed through clear replacement routes, isolation strategies, and redundancy built into the system.

1.2.3 Thermal Performance – DFCX2 Requirements

The design shall support DFCX2 loads of typically 30 kW at 32 °C, with power densities of approximately 3.7 kW/U and up to 5 kW/U in high-performance scenarios. The DFCX4 employs a direct forced convection (DFC) immersion cooling principle, utilizing active liquid circulation through integrated cooling distribution units (CDUs) to remove more than 97% of the heat into the dielectric fluid (Shell S3X). Each CDU is designed for redundant operation (2N configuration) with dual pumps and independent control loops, allowing continuous operation and full maintainability under load. Cooling water is supplied at 32 °C and returned at 42 °C, with a maximum operating pressure of 10 bar(g).

The system interfaces with the facility water system (FWS) through 2 × DN50 tri-clamp stainless steel (SS316) feed and return connections, enabling efficient heat transfer from the dielectric loop to the building's secondary cooling circuit. The CDU acts as the thermal and hydraulic interface between the immersion tanks and the FWS, ensuring stable operation under varying IT loads and ambient conditions. These parameters guide the sizing of the CDUs, pipework, and buffer tank volumes, as well as the integration of monitoring, control, and redundancy provisions within the overall facility cooling design.

1.2.4 Tank Redundancy

To be redundant, the system will include multiple tanks arranged in parallel. This configuration allows one tank to be isolated and removed for maintenance or replacement while the remaining tanks continue operation, maintaining system availability.

1.2.5 Tier Ambition

Following Deerns' recommendation, the facility should target Tier II. The Tier classification reflects the level of fault tolerance and redundancy within the data center. Tier II provides redundancy in system components but not concurrent maintainability.

2 Advanced Thermal Storage System

2.1 Requirements

2.1.1 System Description and Requirements

The staging lab (See work package 1) is located at Eurofiber in Arnhem, the Netherlands. For the determination of outdoor design conditions, reference is made to the ASHRAE Handbook – Fundamentals (SI), 2021, applying the N = 20 year return period values for peak ambient conditions. The ambition is to place edge datacenters throughout the Netherlands, therefore the meteorological weather data has been reviewed for the whole country, whereby the most extreme temperatures have been taken. This ensures that the same, modular design can be delivered anywhere in the country.

Based on ASHRAE design conditions and the weather station data, the following peak conditions are considered (see Table 1):

- Summer design conditions: dry-bulb and wet-bulb temperatures used for sizing heat rejection equipment.

Table 1: The extreme annual design conditions (N=20)

	Min	Max
Dry-Bulb Temperature	-19.2	38.9
Wet-Bulb Temperature	-19.5	26.0

([ashrae](#)),

Glycol is required in the cooling circuits to protect against freezing during extreme winter conditions. The percentage of glycol in the system is determined based on the minimum outdoor dry-bulb temperature (-19,5°C). When looking at Table 2 the Glycol percentage should be between 35% and 40%. To be sure the right glycol percentage will always be met, 40% has been chosen.

Table 2:

Temperature	Glycol percentage
0	0%
0	15%
-3	20%
-7.9	25%
-13.7	30%
-18.6	35%
-23.5	40%
-36.8	50%
-52.8	60%

Apart from these values, a certain fixed number of values from ASHREA TC 9.9 should also be followed. These values explain certain requirements for the internal climate conditions of the data center itself and can be seen in Table 3.

Table 3

Temperature	20°C - 32°C (set point 27°C)
Humidity	20% - 80%

To complete the requirements, regulations also need to be taken into consideration. It is important that the following regulations will be followed:

- The system should meet European energy targets; PUE < 1.2
- The system should align with ASHRAE standards
- The system should align with NEN standards
- The system should align with TIA-942 standards

2.1.2 Technology principles

As a consortium member, and work package leader, Asperitas provides immersion cooling technology. The machines considered for use in this project is the DFCX2. The DFCX2 will use a shared Cooling Distribution Unit (CDU), which can operate a maximum of 8 DFCX2 units (whereby one unit is 44 kW). All the known information about the Asperitas DFCX2 can be found in Table 4.

Table 4: Specifications of DFCX2

Asperitas DFCX2	
ASHRAE W3 solution footprint at max operating temperature (32°C) [kW/m²]	27
Power capacity (at 2N) [kW]	353
Cooling capacity at maximum operating temperature [kW]	353
Cooling capacity per unit (maximum) [kW/U]	5
Non-IT power [W]	2400
Maximum heat dissipation per chip [W]	700
Dielectric liquid volume minimum (IT-dependent) [L]	4000
Dielectric liquid volume maximum (IT-dependent) [L]	4500
Water input (typical) [°C]	32
Water output (typical) [°C]	42
Water flow (nominal) [L/s]	8,4
Maximum operating pressure [kPa]	1000

The dielectric fluid that will be used is Shell S3X. The properties of S3X can be seen in Table 4. S3X is a synthetic, single phase immersion cooling fluid designed for the needs of high-performance computing, edge computing and AI applications.

Table 5: Properties of S3X fluid

Properties	Fluid S3X
Flash Point (°C) Method ASTM D92	198
Pour Point (°C) Method ASTM D97	-42
Kinematic Viscosity (mm ² /s) @40°C Method ASTM D445	9.9
Kinematic Viscosity (mm ² /s) @0°C Method ASTM D7042	52.3
Neutralisation Value (mg KOH/g)	<0.01
Upper Explosion Limit (UEL)	Typical 10%(V)
Lower Explosion Limit (LEL)	Typical 1%(V)
Auto-ignition temperature (°C)	>320
Vapour Pressure (Pa)	< 0.5 Pa (20 °C / 68 °F) estimated value(s)
Relative Vapour density	>5
Density (kg/m ³) @15°C Method ASTM D4052	808

([s3x data center](#); [S3X Safety Sata Sheet](#))

Quality considerations from Asperitas, Facility Water System (FWS) may necessitate glycol use to ensure compatibility with immersion cooling equipment and to avoid scaling, corrosion, or biological growth.

The choice of fluid must also consider water quality requirements, especially when interfacing with the Technology Cooling System (TCS) of the Asperitas immersion cooling systems. Two standards are relevant, also shown in Table 6:

Table 6: Quality requirements for FWS and TCS

Parameter	FWS (Table 5.3 ASHRAE 2014)	TCS (Table 6.2 ASHRAE 2014)
pH	7 to 9	8 to 9.5
Corrosion inhibitor(s)	Required	Required
Biocide	-	Required
Sulfide	<10 ppm	<1 ppm
Chloride	<100 ppm	<10 ppm
Bacteria	<1000 CFUs/ml	<100 CFUs/ml
Total Hardness	<200 ppm	<20 ppm
Conductivity	-	0.2 to 20 micromho/cm
Total suspended solids	-	<3 ppm
Residue after evaporation	<500 ppm	<50 ppm
Turbidity	<20 NTU (Nephelometric)	<20 NTU (Nephelometric)
Strainer	35 to 40 mesh (or 500 to 400 µm)	

The TCS that will be used for MISD work package 4 is dielectric fluid and the FWS medium will be water.

2.1.3 Performance Requirements

The performance requirement depends on the Tier ambition and energy efficiency. These are described below:

- Tier

A Tier I data center offers basic capacity, with a single path for power and cooling distribution and little to no redundancy. Maintenance or equipment failures can result in downtime, which makes Tier I suitable only for non-critical applications where interruptions are acceptable.

A Tier II data center builds on this by adding redundant capacity components, such as extra pumps, chillers, or UPS modules. While this reduces the risk of downtime, the facility still relies on a single distribution path, meaning that maintenance or unexpected failures can still interrupt operations.

A Tier III data center is concurrently maintainable with redundant components as a key differentiator, with redundant distribution paths to serve the critical environment. Unlike Tier I and Tier II, these facilities require no shutdowns when equipment needs maintenance or replacement. The components of Tier III are added to Tier II components so that any part can be shut down without impacting IT operation.

A Tier IV data center has several independent and physically isolated systems that act as redundant capacity components and distribution paths. The separation is necessary to prevent an event from compromising both systems. The environment will not be affected by a disruption from planned and unplanned events. However, if the redundant components or distribution paths are shut down for maintenance, the environment may experience a higher risk of disruption if a failure occurs. Tier IV facilities add fault tolerance to the Tier III topology. When a piece of equipment fails, or there is an interruption in the distribution path, IT operations will not be affected. All of the IT equipment must have a fault-tolerant power design to be compatible. Tier IV data centers also require continuous cooling to make the environment stable.

It is advised that individual Edge Data Centres (EDCs) will typically be designed to meet Tier I or Tier II standards, providing basic to moderate redundancy, and the national strategy should aim for Tier IV resilience across the network. The ambition for this project will be a singular Tier II EDC.

The redundancy considered is:

- IT equipment: minimum N+1
- External equipment: minimum N+20%
- Electrical equipment: 1 battery back-up for CDUs (Coolant Distribution Unit)
- Energy Efficiency:
Energy performance is a key driver for this project. A target value for energy efficiency (e.g., Power Usage Effectiveness, PUE) has been set as <1.2 during the design phase. This target will serve as a benchmark for selecting and optimizing system components, ensuring that the facility operates at high efficiency while minimizing operational costs and environmental impact.

2.2 Modularity and Scalability

2.2.1 Standardized Interfaces (Piping, Valves, Controls)

The hydraulic design will be coordinated with the overall floor plan and 3D model, ensuring that all interfaces for piping, valves, and controls are standardized and spatially integrated. To achieve this, the design will follow the principles outlined in the ASHRAE Handbook.

- **Standardized Pipe Sizes:**
Pipe diameters shall be selected from a limited, predefined range of sizes in accordance with ASHRAE recommendations for hydraulic system design. This reduces complexity, ensures consistency, and simplifies procurement and installation.
- **Modular Pipe Lengths**
Straight pipe sections will be standardized to 1-meter modules wherever practical.

2.2.2 Space Planning Considerations

Effective space planning is critical in EDCs. The key driver is space optimization to provide operational efficiency, security, and allow safe handling of equipment during installation, relocation, or replacement.

- Access & replacement strategy:
- Redundancy and temporary distribution during replacement
- Containment, safety & leak management
- Service clearances and working space
- Structural loading & floor capacity (what the structural engineer needs)
- Crane & lifting provisions
- Modularity & quick replacement features
- Operational & commissioning considerations

2.3 Hydraulic System Design

In the design phase of this project, the requirements will be met, while keeping the design simple and cost-effective. This design phase has been split into different chapters, whereby each chapter brings the design closer to the desired end state.

2.3.1 Starting points assumptions

With power grid congestion across The Netherlands, it is important to consider smaller power supplies that can be integrated into the existing net. Applications for new, large power supplies are often denied or put on a long waiting list (restricted) until future developments bring the increased capacity available to the net.

To understand how the DFCX2 can be used modularly, all the optimized scenarios should be found. These scenarios should include the following:

Option 1 (smallest); the power supply available without restriction.

3-phase/80-ampere supply (biggest domestic power supply on consumer power net) (52,65 kW)

- The smallest power supply feasible on the consumer power net should be looked at, because it is important to know the IT capacity achievable at sites with limited power availability.

Option 2; max power singular DFCX2

The maximum IT-power of one complete DFCX2 unit/full container (8 units) (353 kW)

- The maximum IT-power of one complete DFCX2/one full container is important to know, so it is possible to see how much power you can maximally concentrate on one singular machine.

Option 3; modular solution (6 x DFCX2)

The overall maximum IT-power of the complete MISD EDGE-datacenter (following the package of requirements) (2 MW/6 x 353 kW = 2118 kW)

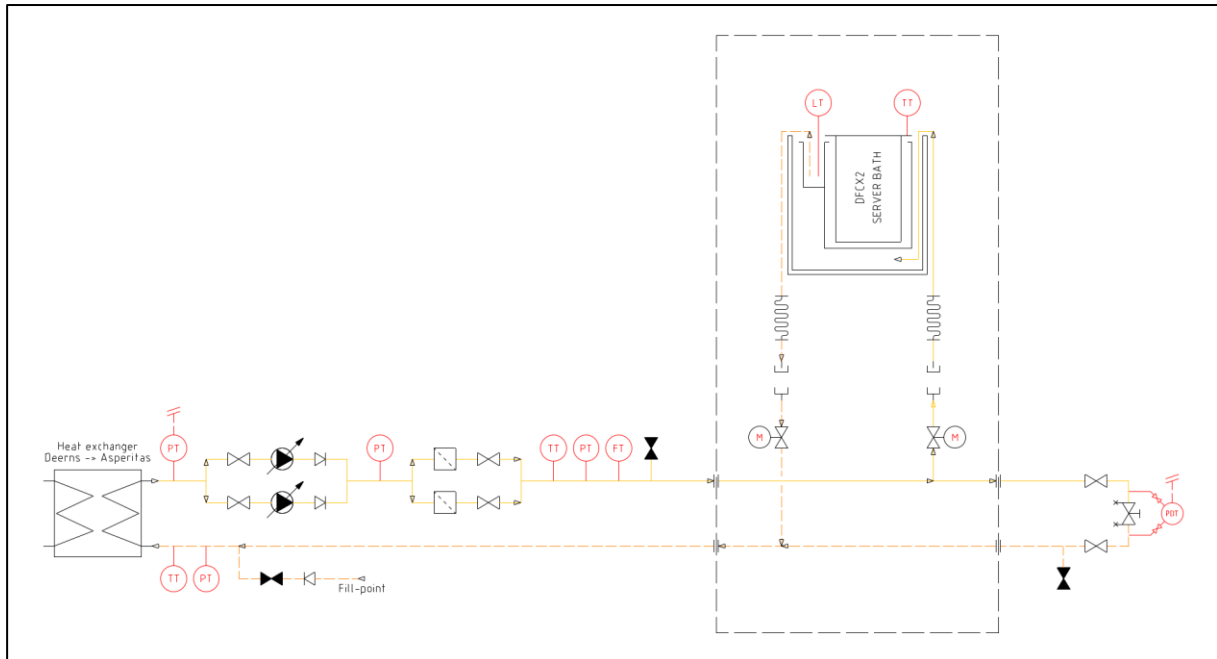
- The overall maximum IT-power is important to know, because this would be the absolute maximum the MISD EDGE-datacenters should be able to handle. Next to this reason this is also a requirement which needs to be met to complete the design requirements correctly.

After identifying the relevant optimized unit structures, these configurations are further developed and grouped into three scenarios, each consisting of three solutions, which are discussed in the following sections.

To achieve a target Power Usage Effectiveness (PUE) of approximately 1.2, the facility's non-IT power consumption is limited relative to the IT load. For an IT load of 1 MW, this corresponds to a maximum of 0.2 MW of additional facility power, largely attributed to cooling. Other facility loads are comparatively small and have less of an impact on the overall power budget.

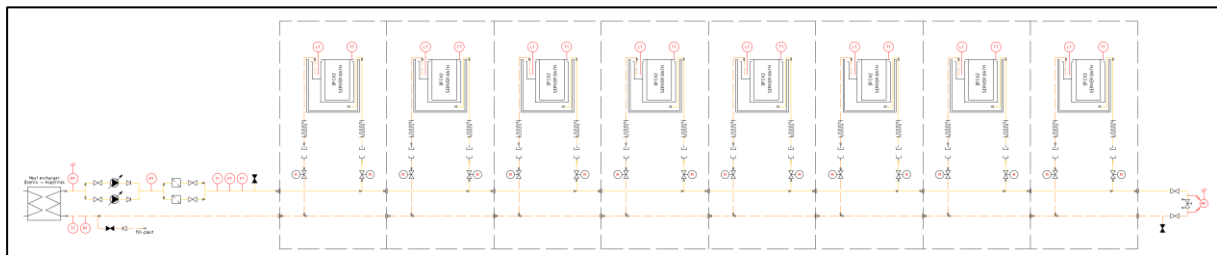
Option 1; smallest option: Consumer power network

The 3-phase/80-ampere supply can have a maximum power consumption of 52,65 kW, whereby the DFCX2 can only consist of one bath of 44 kW, whereby a total of $44 \times 0.2 = 8.8$ kW is needed to cool the facility water and operate the MISD. This would look like one complete circuit with all the requirements to be a Tier 2 datacenter. This singly occupied DFCX2 will have its own cooling system, connecting to the CDU, which can be seen in the figure below at the left side.



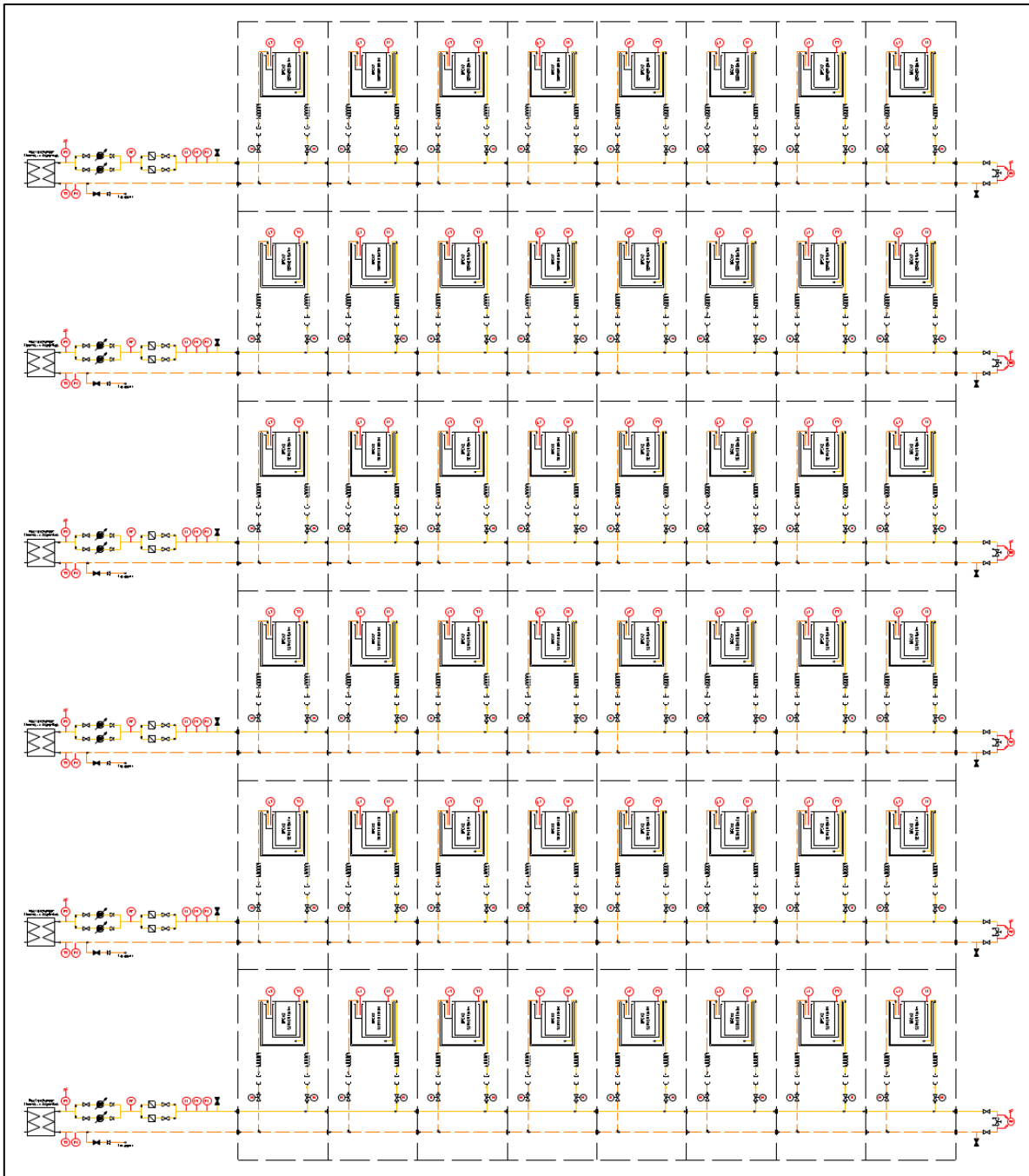
Option 2; max power singular DFCX2

A container filled with a fully occupied DFCX2 (8 baths) needs a total of $353 \times 0.2 = 70.6$ kW to function. This would look like one complete circuit with all the requirements to be a Tier 2 datacenter. This fully occupied DFCX2 will have its own cooling system, connecting to the CDU, which can be seen in the figure below at the left side.



Option 3; overall max power (6 x DFCX2)

A total of six containers filled with fully occupied DFCX2's (8 x 6 baths) needs a total amount of $2118 \times 0.2 = 423.6$ kW of power to function. This would look like six complete circuits with the potential to be a Tier 4 datacenter (when combining six DFCX units with redundant baths and redundant power and cooling systems). What can be seen in the figure below are six maximally occupied independent DFCX2 circuits. In total this consists of 48 server cooling baths. These 8 circuits will have their own cooling system and will not be connected to each other.



These P&ID's/schematics have been delivered by Asperitas. More information on these is provided separately by Asperitas. From the other side (left) of the CDU will be where the design of FWS will be. This will be picked up in the next chapter.

2.3.2 Cooling method (-s)

Immersion cooling is an increasingly popular method for handling the heat produced by high-performance servers. Instead of cooling air around the equipment, the servers are submerged in a special non-conductive liquid, which transfers heat very efficiently. Even though immersion cooling is highly effective inside the rack, the heat still needs to be rejected to the environment or a heat network. This requires external cooling equipment that must operate reliably across a defined outdoor temperature range and at the required thermal load.

Below are the requirements for the coolers. These requirements have been directly taken from the package of requirements.

- Required total net cooling load :
 - At its lowest: 52.65 kW
 - At its highest: 353 kW
- Cooling medium:
 - Water percentage: 60%
 - Glycol percentage: 40%
- Facility water system supply/return temperature (required by Asperisas):
 - 32°C input
 - 42°C output
- Mass flow rate; 8.4 L/s
- Max operating pressure; 1000 kPa
- ASHREA data (n=20)
 - Max dry bulb temperature: 38.9 (°C)
 - Max wet bulb temperature: 26.0 (°C)
 - Min dry bulb temperature: -19.2 (°C)
 - Min wet bulb temperature: -19.5 (°C)

Several cooling technologies can meet these requirements, each with different advantages. These cooling technologies can also be combined. The following cooling technologies are compared in the table below:

Cooling method	Explanation	Efficiency	Water usage	Temperature suitability	Advantages	Disadvantages
Dry Cooler	Air-cooled finned heat exchanger using fans.	High	None	OK (weaker near max temperature)	Low operating cost; simple; no water	Large footprint; less performance in heat waves
Adiabatic Cooler	Dry cooler with optional evaporative pre-cooling.	Very High	Low	Excellent in heat	Great hot-weather performance; efficient	Needs water & pad replacement
Chiller	Mechanical refrigeration cycle using compressors.	Medium	None	Excellent at all temps	Precise control; reliable	High energy use; expensive
Cooling Tower	Evaporative cooling of	High	High	Good (freeze protection needed)	Efficient in warmth;	Water/chemical use; hygiene risks

	recirculated water.				small footprint	
Hybrid: Dry + Adiabatic	Dry most of year; adiabatic during heat peaks.	Very High	Low	Yes	Efficient; strong peak performance	Extra unit adds cost
Hybrid: Dry + Chiller	Dry cooler handles normal load; chiller for peaks.	Very High	Low	Yes	Reliable; covers extremes	Two systems = higher cost
Hybrid all in one cooler; adiabatic dry cooler	Dry cooler with optional adiabatic boost in hot weather.	Very High	Low (only during hot periods)	Excellent in high ambient conditions	Efficient, low water use, strong in heat, simple.	Some pad/nozzle maintenance; heat-wave performance humidity-dependent.
Hybrid all in one cooler; direct adiabatic	Evaporation directly cools supply air; DX/chiller assists when needed.	Very High	Medium	Excellent in dry climates	High efficiency; strong cooling boost	Adds humidity; limited in humid weather
Hybrid all in one cooler; indirect adiabatic	Evaporation cools a separate airstream through a heat exchanger and chiller.	Very High	Medium	Excellent (incl. humid climates)	No added humidity; stable output	Higher cost; more complex

While each individual cooling method has its advantages, a hybrid all in one cooler (adiabatic dry cooler) provides a good balance between efficiency, reliability, and cost. The reasons why this method (in black) is advantageous for the cooling system are described below.

- Excellent fit for high water temperatures (32/42 °C)
 - The system performs very well with high return water, giving you enough temperature difference to reject heat efficiently, even during warmer days.
- Free cooling for most of the year
 - In moderate weather it operates in dry mode, using only fans. This keeps energy use very low most of the time.
- Adiabatic boost ensures full capacity at 38.9 °C ambient
 - When temperatures peak, the adiabatic stage lowers incoming air temperature enough to keep the supply water at 32 °C without requiring a chiller.
- Very low water consumption
 - Water is only used during the hottest periods, making it far more efficient and sustainable than cooling towers or fully evaporative systems.
- No humidity introduced into the IT cooling loop

- The adiabatic section cools outdoor air only.
- Modular, scalable, and simple system design
 - Multiple units can be added to match your 52.65 to 353 kW load range. Each cooler's fans and adiabatic functions work independently, making good for modular CDUs.
- Lower complexity than hybrid indirect systems or chillers
 - No compressors, no secondary heat exchangers, and minimal maintenance. This means higher reliability and easier operation.

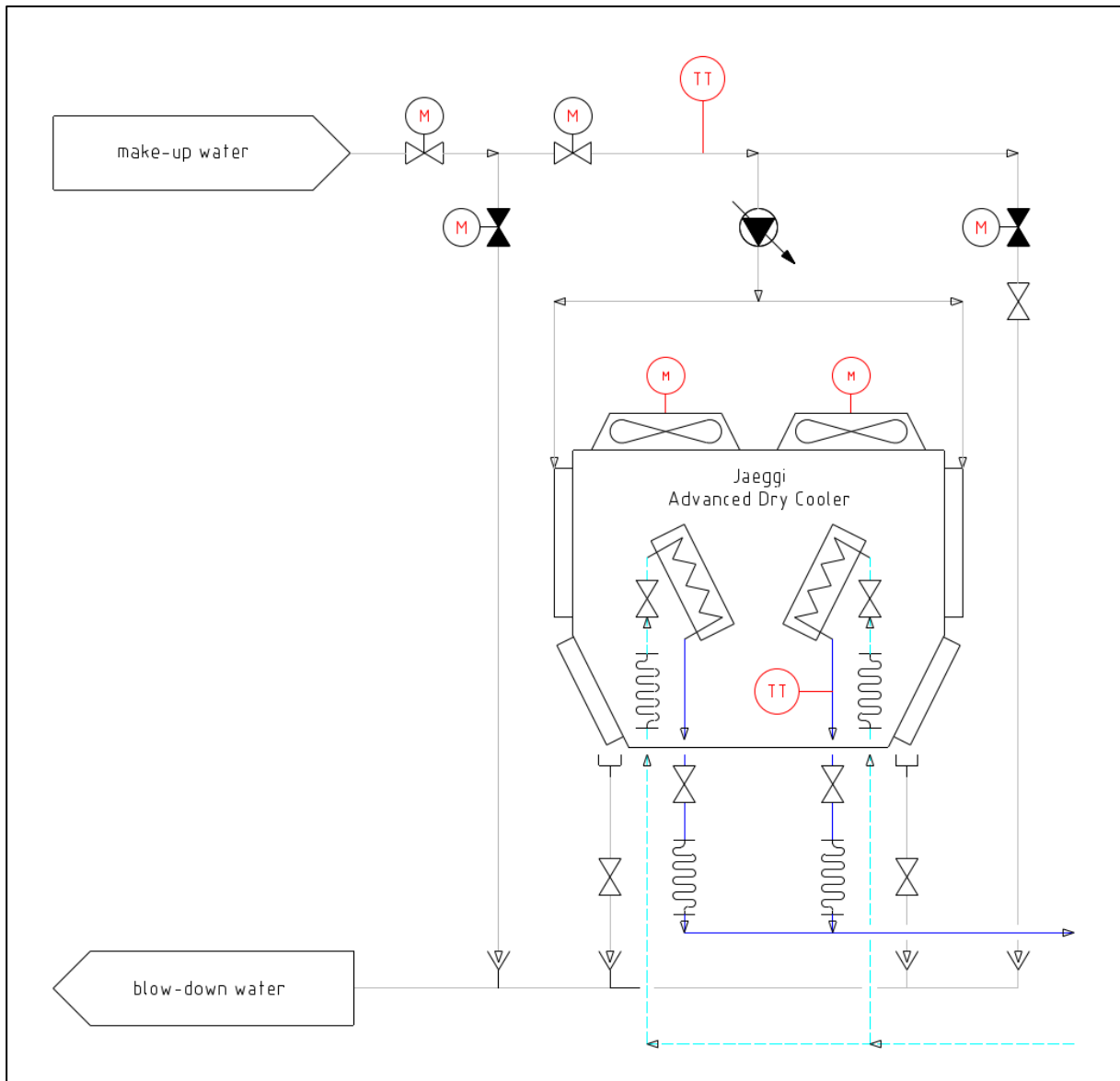
After having decided what kind of cooling machine will cool the facility water, an adiabatic dry cooler can be chosen. This is carried out in collaboration with manufacturers.

Jaeggi are a Swiss hybrid dry cooler manufacturer, with a variety of products for different cooling applications. For our application, we have selected the following adiabatic dry cooler:

Adiabatic Dry Cooler – Jaeggi Hybrid Blue	
Cooling capacity	50 – 2,000 kW
Air flow	166,537 m³/h
Air velocity	2.5 m/s
Total electric power consumption	17.89 kW
Velocity in coil	1.31 m/s
Pressure drop	0.75 bar
Liquid volume flow	33.59 m³/h
Maximum water consumption	2,266.9 kg/h

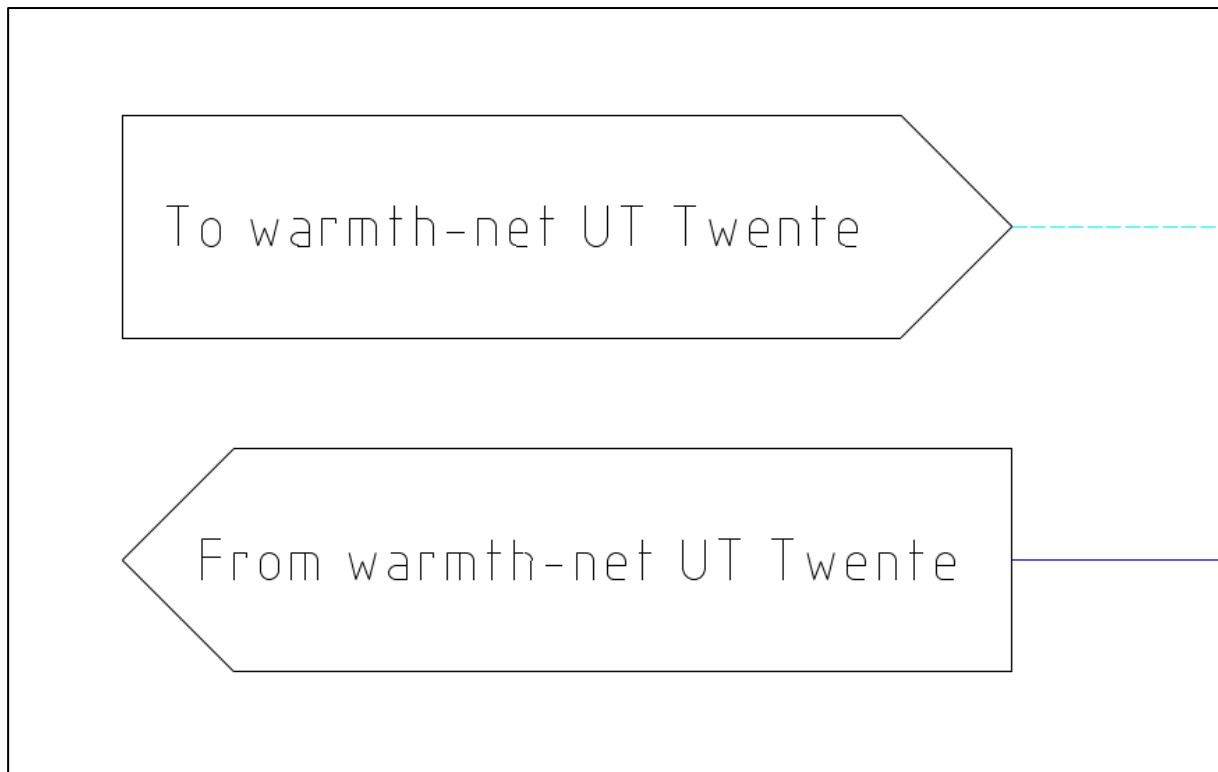
The unit has been selected based on the operating conditions provided. We always try to select an optimal unit, i.e. not oversized, whilst also keeping the cost down as much as possible. Other factors considered are the pressure drop through the coil, power consumption, and noise. Sometimes where there is a low noise requirement, the units need to be oversized to create more surface area for cooling, reducing airflow through the fans to reduce the noise.

A schematic is provided below with some important values and an explanation of the Jaeggi adiabatic dry cooler. Within this schematic (below) the heated facility water (light blue and dashes) is being pulled through a heat exchanger, whereby it comes out as cold facility water (dark blue line), after which it enters the facility water system again, to be pumped towards the Asperitas CDU heat exchanger. When the dry cooler alone is insufficient, a pump-controlled make-up/blow-down water cycle sprays water over the heat exchangers for additional cooling, after which the water is drained and cooled by motorized fans. Because the requirements are a Tier 2 datacenter (with a N+1), in total, a minimum of two adiabatic dry coolers are required in the design. This is because these coolers are seen as capacity components.



After evaluating multiple cooling technologies against the project's requirements, hybrid solutions seem to perform better than single method systems. Among these, the adiabatic dry cooler stands out as the optimal choice, providing a balance of efficiency, reliability, low water usage, and scalability. It creates the possibility for free cooling for most of the year, with adiabatic boosting during peak summer, and maintains a dry IT environment. Its modular design and lower system complexity further enhance operational reliability and ease of maintenance.

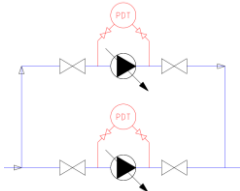
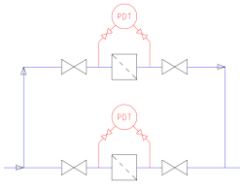
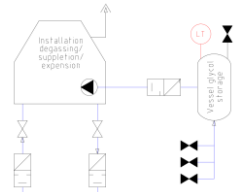
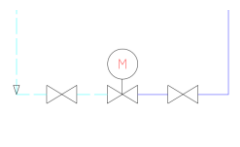
Because of the connection to the warmth-net of UT Twente, which this design needs to incorporate, a connection to them has also been made. This does not include anything else other than a connection, because all these components/systems still need to be designed by UT Twente. This warmth-net will be used as much as would be possible. This will be done, because this where warmth can be re-used while not having to use any power to cool the FWS and bring it back into the TCS (what the adiabatic dry coolers do). For this reason the warmth-net connection will be utilized as much as possible. The required redundancy of a Tier 2 datacenter (N+1) does not influence this connection, because it is not seen as a capacity component, but as a part of the distribution path.



This concludes that in total two adiabatic dry coolers and one warmth-net connection will be included in the design of the facility water cooling loop.

2.3.3 Distribution system

After having decided both on which loads the cooling system should be able to handle and which cooler will be used within the system, the distribution system can be drawn out. The entire distribution system can be found between the servers and the coolers. This distribution system consists of the following components and pipework:

Controlled pumps	Pumps are needed to keep the facility water flowing through the system, so the heat can be exchanged. These pumps are controlled so their flow can be changed, depending on certain sensor data.	
Filters	Regular system filters are needed to keep the facility water clean, protecting the heat exchanger/cooling equipment against debris and maintaining the same viscosity/flow. They will also tell when the system is too polluted, or when the filters need to be changed.	
Valves (motorized and non-motorized)	Valves are needed to open/close certain parts of the system, to open/close drains and to be able to safely isolate certain components from the system.	<i>Within the figures of the other components</i>
Sensors (temperature, pressure, flow)	Sensors are needed to measure certain values, which in this system measure the temperature, pressure and flow. The measurements can be used to make logs of this data, or to control certain valves/pumps.	<i>Within the figures of the other components</i>
Glycol management	Because of the cold environment in the Netherlands, the facility water has a glycol concentration in it to protect against freezing. A glycol management system is therefore necessary to monitor and manage the glycol concentration, as well as de-gassing and pressurizing the system.	
Bypass/mixer warm/cold water	The bypass/mixer for the warm/cold water is needed to mix in warm water into the cold water, when the temperature delivered to the heat exchanger is too cold.	
Piping	To connect all components piping must be added.	<i>Within the figures of the other components</i>

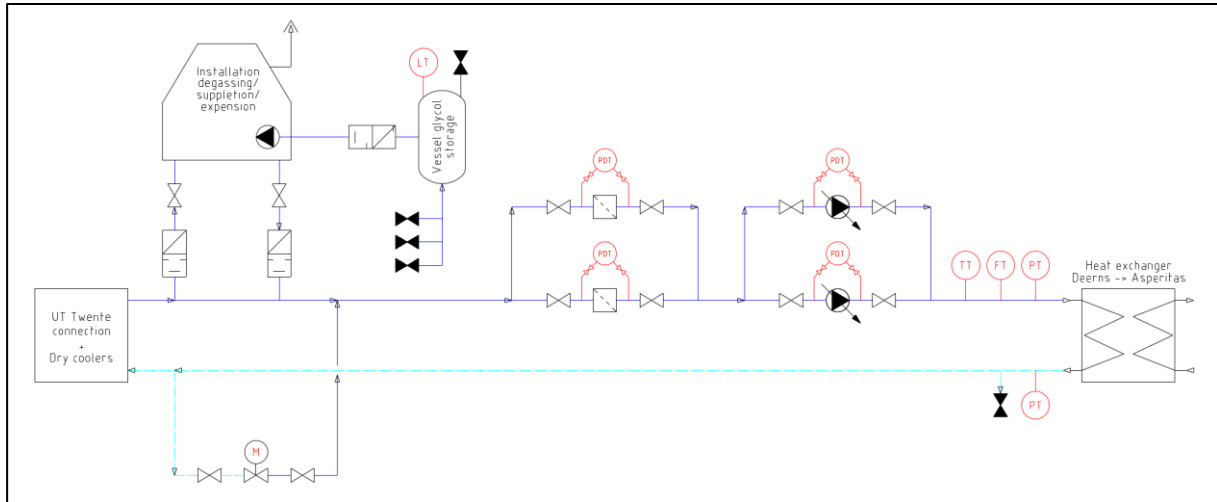
After having concluded which components need to be added to the system, the next step to look at will be redundancy. This will determine how many of these components need to be added to the system. The redundancy which needs to be taken into consideration (described in chapter 5.6) are as follows:

- Every capacity component (on-site power production (e.g., engine generator, fuel cell), UPS modules and energy storage, chillers, heat rejection equipment, pumps, cooling units, and fuel tanks) should have a redundant component; N+1
- The distribution path can be non-redundant; N
- The fuel storage should have twelve hours' worth of on-site fuel; N+12 hours of back-up fuel

With this information the exact number of components can be decided which will be chosen because of the following reasoning:

Controlled pumps	Only a single pump is needed when looking at the pressure difference in the system, but because of the redundancy 2 pumps need to be installed in parallel.
Filters	Only a single regular system filter is needed when looking at how big the system is, but because of the redundancy 2 filters need to be installed in parallel.
Valves (motorized or non-motorized)	Valves need to be installed in all places where these are needed (confinement, draining, maintenance). Valves are crucial in isolating redundant components. Valves don't take redundancy into consideration, because they are not a capacity component, so only the valves needed to run the system at its bare minimum are needed.
Sensors (temperature, pressure, flow)	Sensors need to be installed in all places where these are needed (controlling, logging). Sensors don't take redundancy into consideration, because they are not a capacity component, so only the sensors needed to run the system at its bare minimum are needed.
Glycol management	Only one glycol degasser/supplementer/expender needs to be installed, because it is not a capacity component. The system can still operate with this out of service for maintenance.
Bypass/mixer warm/cold water	Only one bypass/mixer warm/cold water needs to be installed, because it is not a capacity component.
Piping	The piping is not being taken into consideration with the chosen redundancy. This is why only the piping which is needed to run the system is needed.

After having decided how many of the components will be installed in the cooling system a P&ID can be made, including all these components. The P&ID for this part (excluding Asperitas' part, UT Twente's part and the dry coolers) has been drawn out underneath. The full FWS with the dry coolers can be found in the appendix and on the following page.



The cooling distribution system connects the servers to the chosen adiabatic dry coolers and consists of pumps, filters, valves, sensors, glycol management, bypass/mixer for warm/cold water, and piping. Component selection balances operational needs with redundancy requirements: all capacity components (pumps, filters) are installed with N+1 redundancy, while non-capacity components (valves, sensors, glycol systems, piping) are installed in single units as required. This approach ensures reliable operation, maintainability, and proper water quality management. With these decisions made, a complete P&ID has been developed to illustrate the finalized distribution system.

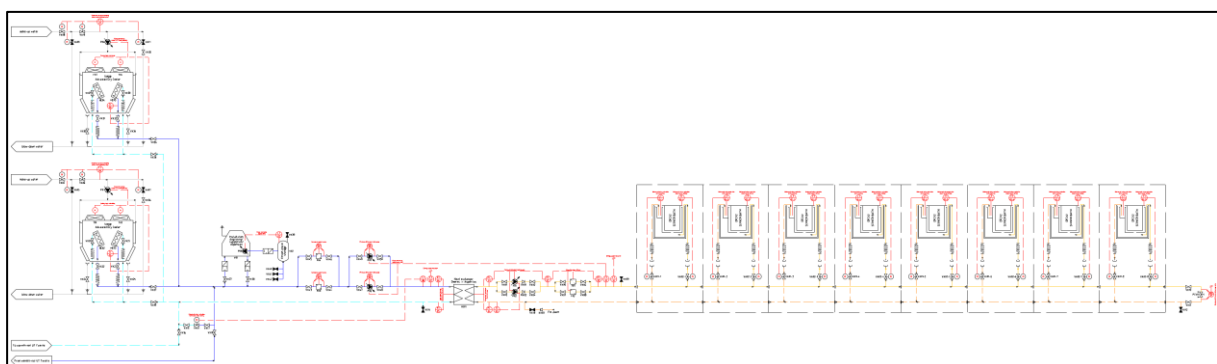
2.3.4 Control Strategy

To let the entire cooling design of the datacenter function properly, whereby all components will need to collaborate perfectly together, the control engineering of the entire system has to be created. Within this chapter, the controlling of the pumps, controlled valves, filters and sensors will be explained. These will be looked at component by component. The control engineering description is qualitative in nature, which means the exact setpoints and control parameters are outside this scope.

All the controlling within the entire cooling design can be found in the attachments under "Control engineering tables". Within these tables the component and in which loop it is located will be put at the top, whereby in the table itself the following things will be explained: component, function, measured variable(s), control variable, control objective, control strategy and system interaction. Beneath; a table can be found for the components of the cooling system. Everything which is in *Italic font* will be explained uniquely to each component.

Component type (component code) – "... loop"	
Component	<i>Identifies the physical device being described, such as a pump, valve, or fan</i>
Function	<i>Describes the role of the component within the overall system</i>
Measured variable(s)	<i>Specifies which sensors provide feedback signals used by the control system</i>
Control variable	<i>Defines which parameter of the component is actively adjusted by the controller</i>
Control objective	<i>States the desired outcome that the control action is intended to achieve</i>
Control strategy	<i>Explains how changes in the measured variables result in adjustments of the control variable</i>
System interaction	<i>Describes how the component operates in coordination with other system elements.</i>

With all the filled tables in the attachments in combination with the P&ID of the final cooling design every component can now be understood and logically coupled. A simple screenshot can be seen below, but for a better P&ID, see "Cooling system design P&ID" in the appendix.



2.3.5 Facility Water System (FWS)

The Facility Water System (FWS) serves as the interface between the building cooling infrastructure and the Technology Cooling System (TCS) of the IT equipment. Material selection for the FWS piping and components is critical to ensure long-term system reliability, corrosion resistance, and compatibility with the treated facility water used in data center environments.

According to the ASHRAE TC 9.9 White Paper: “Water-Cooled Servers – Common Designs, Components, and Processes” (2021) lists materials that are commonly approved for use in both Facility and Technology Cooling Systems. For the FWS, Nitrile Butadiene Rubber (NBR), stainless steel, copper, brass, carbon steel, aluminum and alloys, Polyoxymethylene (POM), Ethylene propylene diene monomer (EPDM), Fluoroelastomer (FKM), Polyamide (PA), Polychloroprene (CR), Polyethylene, Polyoxymethylene (POM), Polytetrafluoroethylene (PTFE), Polypropylene (PP), Polysulfone or polyphenylsulfone (PSU, PPSU), and Silicone are identified as suitable wetted materials. In contrast, carbon steel and aluminium are not recommended due to their sensitivity to corrosion and water quality variations, which can lead to particle contamination, scaling, and reduced reliability over time. Carbon steel requires ongoing corrosion management and is not ideal for modular systems that prioritize low maintenance.

Considering the compact layout typical of small modular edge data centers, polypropylene (PP) represents the most practical and ASHRAE-endorsed material for FWS. PP is explicitly approved for FWS applications in ASHRAE TC 9.9’s Water-Cooled Servers – Common Designs, Components, and Processes (Table 2, 2021), offering a combination of chemical resistance (due to its non-polar nature), low density and therefore very lightweight, mechanical reliability, and installation flexibility. Its low cost and compatibility with fusion-welded joints make it especially suited for prefabricated or modular systems where rapid deployment, clean assembly, and corrosion-free operation are key. Compared with metallic alternatives such as stainless steel or copper, PP provides a cost-effective, lightweight solution with sufficient strength and thermal performance for secondary cooling loops in edge environments. Therefore, PP is recommended as the material of construction for the FWS of this EDC.

2.3.6 Technology Cooling System (TCS)

Based on the ASHRAE TC 9.9 “Common Wetted Materials Found in Water-Cooled Servers” table and the chemical characteristics of S3X, the preferred material of construction for the TCS piping and wetted components is solution-treated and passivated stainless steel (typically 316L). Stainless steel is fully approved for TCS applications in ASHRAE TC 9.9 and provides a chemically inert and mechanically robust solution for hydrocarbon-based dielectric fluids. Because S3X is a low-viscosity synthetic hydrocarbon with extremely low volatility, it does not cause corrosion of stainless steel and does not lead to embrittlement or swelling, making stainless steel the most reliable material for long-term operation and for modular edge data-center designs.

In addition to stainless steel, ASHRAE also approves several polymers in TCS systems that are chemically compatible with S3X, including FEP, PPS, and PSU/PPSU, as well as the elastomer such as EPDM for a seal. These materials exhibit strong resistance to hydrocarbon oils and maintain stability over the typical operating temperature range of S3X. Where polymers are used, PTFE and FEP are preferred due to their excellent inertness and minimal extractables.

Materials not suitable for S3X-based TCS systems include any materials not approved in the ASHRAE TCS column and those known to degrade in hydrocarbon dielectric fluids. These include carbon steel, which is only approved for FWS systems and is susceptible to oxidation in oil-based fluids unless highly treated. Similarly, materials such as PA (polyamide), CR (neoprene), silicone, and PP are not approved for TCS service per ASHRAE TC 9.9 and may exhibit swelling and softening when in

contact with dielectric oils. These materials therefore should not be used in piping systems, seals, or wetted components handling S3X. Using only ASHRAE-approved materials significantly reduces the risk of fluid contamination, elastomer degradation, leakage, and long-term reliability issues in EDC cooling modules.

2.3.7 Reliability and Maintenance Considerations

To ensure reliable operation of the facility water system (FWS) and to support efficient maintenance activities, several mechanical design measures are integrated into the main cooling-water loop. Isolation valves are installed at key locations, such as chiller connections, pump discharge/suction points, strainers, heat exchangers, and major branch take-offs allowing individual components to be serviced or replaced without requiring a complete shutdown of the cooling plant. Drain valves are positioned at system low points to enable full drainage of the water circuit during planned maintenance or emergency interventions, reducing the risk of stagnant water, sediment accumulation, or contamination during handling.

Flow-control valves are used to maintain stable hydronic balance across the distribution network, preventing excessive flow velocities that can contribute to erosion, noise, and premature equipment wear. To protect the piping network from mechanical stresses generated by pumps or external equipment, bellows or flexible connectors are installed at pump inlets/outlets and at equipment interfaces. These components absorb vibration, dampen pump-induced oscillations, and compensate for small misalignments, which helps prevent fatigue failures and prolongs the life of welded and flanged joints. Where movement or thermal expansion is expected, flexible hoses or expansion joints are used, always selected for compatibility with treated facility water and rated for the system's operating pressure and temperature.

Integrating an ammonia-based adsorption/desorption reactor into a facility-water system (FWS) requires attention to material compatibility. Unlike mechanical heat pumps, this system relies on cyclic adsorption and desorption of ammonia, which introduces thermal stresses and pressure fluctuations that can impact reliability. Reactor vessels and piping must be designed for repeated thermal cycling and ammonia exposure, avoiding copper alloys and selecting materials resistant to stress corrosion cracking.

Leak prevention is critical due to ammonia's toxicity; therefore, double piping, redundant sealing, continuous leak detection, and emergency ventilation systems are mandatory. Maintenance should include periodic inspection of adsorbent integrity, valve actuation reliability, and heat exchanger surfaces for fouling or corrosion. Sensor calibration for pressure, temperature, and ammonia concentration is essential to ensure accurate control of adsorption/desorption phases.

Together, these design features enhance the overall reliability of the cooling-water infrastructure, ensure leak-tight operation under varying load conditions, and reduce operational downtime by enabling safe and targeted maintenance on individual components without compromising the integrity of the entire cooling system.

2.4 Ventilation and Air Quality Management

In the case of S3X dielectric fluid applied in immersion cooling tanks, the associated ventilation requirements are relatively minimal due to its low volatility and non-toxic hydrocarbon composition. Continuous high-volume ventilation is not required for fluid safety; standard ASHRAE ventilation rates (e.g., approximately 0.5 ACH) are generally sufficient. Positive pressure should be maintained to prevent dust ingress, and humidity should be controlled between 14% and 60% RH to avoid electrostatic discharge and condensation risks. Filtration should meet F7 or F9 classification for clean

airflow. If the room is unoccupied and no leaks are present, ventilation can be reduced to a minimum level (e.g., 10% of normal rate). In case of S3X spills, cleanup involves absorbent materials such as sand or oil pads; no special vapor extraction is required.

However, should the same space also house an ammonia adsorption/desorption reactor, additional ventilation requirements would apply. Unlike traditional EDC systems, ammonia systems require continuous baseline ventilation to ensure safety. Ammonia is toxic and can accumulate from micro-leaks or residual emissions during adsorption/desorption cycles, even when no personnel are present. Therefore, a minimum ventilation rate, typically at least 0.5 ACH for the entire room, must be maintained at all times. According to IIAR and NEN-EN 378 guidelines, ammonia detection systems should trigger a warning alarm at 25 ppm and activate emergency ventilation at 150 ppm, well below the OSHA IDLH of 300 ppm. Positive pressure and humidity control remain applicable for environmental stability and equipment protection, but ventilation cannot be fully disabled for ammonia systems. A redundant ventilation system is therefore required to ensure continuous operation during a single ventilation failure or during maintenance/replacement. This combined approach ensures compliance with international safety standards and occupational exposure limits while supporting both immersion cooling and ammonia reactor operations in a shared environment.

2.5 Fire Safety and Risk Mitigation

The integration of an ammonia adsorption-desorption reactor within an EDC introduces several fire-safety, leakage, and risk-mitigation considerations that go beyond those of a traditional EDC using only water-based cooling loops. Although ammonia is not a fuel and does not burn, it poses other significant hazards such as primarily toxicity, pressure build-up, and chemical exposure risk, which must be considered in the design. Section 2.5.1, 2.5.2 and 2.5.3 give fire safety and risk mitigation:

2.5.1 Ammonia Hazard Control and Containment

- Dedicated NH_3 detection sensors with redundancy, placed near the reactor, piping joints, and high-risk zones.
- Continuous monitoring with alarm thresholds and automatic notification to BMS.
- Designated ventilation paths that allow safe dispersion of ammonia in case of leakage, ensuring concentrations remain below occupational exposure limits.
- Pressure-relief lines or rupture discs routed to safe outdoor venting points.

2.5.2 Mechanical and Process Safety Barriers

- Use of double-walled piping or sealed enclosures where practical.
- Incorporation of drip trays and corrosion-resistant materials (as ammonia is incompatible with copper and copper alloys).
- Dedicated isolation valves, block valves, and drain points around the ammonia reactor for safe maintenance and emergency intervention.

2.5.3 Fire Suppression and Detection Enhancements

- Water-mist systems may be considered for localised cooling or risk mitigation, but water discharge must comply with municipal regulations for waste water treatment.
- Standard server room gas suppression remains applicable.
- Additional toxic gas alarms integrated into the fire safety control panel.

2.6 Serviceability and Maintenance

IT racks and cooling loops should be designed for efficient serviceability, allowing simple expansion or component replacement during failure or end-of-life scenarios. Clear access paths to immersion tanks,

pumps, and heat exchangers are essential to minimize disruption during maintenance. For systems incorporating an ammonia adsorption/desorption reactor, additional considerations include safe access for adsorbent replacement, valve servicing, and sensor calibration.

Recommended service intervals should follow OEM (Original Equipment Manufacturer) guidelines for both dielectric fluid systems and ammonia reactors, including periodic leak checks, adsorbent integrity inspections, and filter replacements. Operational downtime should be minimized through modular design, quick-disconnect piping, and redundancy in critical components. Maintenance planning must also account for emergency ventilation activation during ammonia-related work and ensure personnel are trained in handling both dielectric fluids and ammonia safely.

3 Assessment of design impact on modular EDCs based on the thermal concept

In this section, the design impact of a modular EDC, based on the thermal concept developed by the University of Twente, will be assessed and compared to that of a traditional heat pump. The parameters considered will include size and energy performance.

Traditional heat pumps operate using electrically driven compressors and synthetic refrigerants, offering high Coefficients of Performance (COP) typically ranging from 2.5 to 4.5. These systems are compact, widely available, and optimized for residential and commercial applications. Their performance is often evaluated using standardized metrics such as COP, EER (Energy Efficiency Ratio), SEER (Seasonal Energy Efficiency Ratio), and HSPF (Heating Seasonal Performance Factor), which reflect their efficiency under various operating conditions.

In contrast, the ammonia-based thermal reactor heat pump utilizes a thermally driven cycle, often powered by waste heat or renewable thermal sources. It employs ammonia in a chemical sorption process. While these systems generally exhibit lower COP values (typically between 0.75 and 1.2) they offer significant advantages in terms of sustainability.

In this project, the Coefficient of Performance (COP) is not used as a primary comparison metric for the ammonia adsorption-desorption reactor, because adsorption-based thermal systems inherently show much lower COP values than conventional heat pumps or vapor-compression cycles. This low COP is not necessarily indicative of poor system performance but is a direct result of the thermodynamic characteristics of adsorption processes.

3.1 Size

The physical footprint of the ammonia adsorption/desorption reactor differs significantly from that of a traditional heat pump due to the nature of the thermal process and the need for reactive material storage.

For the ammonia-based two-salt THT system designed to provide a heat storage capacity of 4 kW for 5 hours, the total footprint is 3.1 m² is expected for the equipment. This is to be verified by UT on further development of their design. Consideration would also be required for ancillary systems such as power, ventilation and controls. Furthermore, all components must be made accessible and replaceable, allowing people and equipment in and out of the space. It is therefore anticipated that room of no less than 6m² will be necessary for this application.

This footprint is considerably larger than that of a traditional heat pump (for the same size equivalent), which typically occupies 1 m² for similar thermal output capacity, due to its compact compressor-based design and absence of large reactive material beds.

3.2 Environmental Impact

Traditional heat pumps use synthetic refrigerants often with high Global Warming Potential (GWP) while ammonia is natural and has zero ODP (Ozone Depletion Potential) and very low GWP. Using ammonia in place of traditional refrigerants will therefore reduce the environmental impact of the system.

3.3 Energy Performance

Exergy analysis is used because it evaluates the quality, not just the quantity, of energy. It provides a fair basis to compare thermal systems with mechanical heat pumps by considering the available work potential of heat at different temperatures. Exergy analysis captures the thermodynamic value of using low-grade heat, quantifies irreversibility in the adsorption cycle, and provides a more accurate representation of the system's performance. For these reasons, exergy-based metrics offer a more reliable comparison for the ammonia adsorption reactor than COP.

Preliminary data is still to be provided in a later stage of the MISD design. However, from research and theoretical calculations, the following comparison between a traditional heat pump and an ammonia adsorption/ desorption reactor can be made.

Table 7: The comparison between a traditional heat pump and an ammonia adsorption/ desorption reactor

Traditional Heat Pump	Ammonia Adsorption/Desorption Reactor
High COP	Low COP, but high exergy efficiency
High exergy input (electricity)	Utilize low-grade cooling-loop waste heat
Best for variable loops and precise control	Provides high temperature lift (90-120°C)
Reduce waste heat, but increase electrical PUE	Minimal electrical consumption
Established, well-known technology. Reliable.	Experimental. Not commercially implemented. Unknown reliability.
Low cost, competitive manufacturing. Available	High cost. Not manufactured or easily available.

3.4 Conclusion

For commercial applications, the traditional heat pump is a safe, established technology for quick implementation. It is however a technology that has been widely available for years with limited scope for improvement. The MISD project provides us with an opportunity to investigate a new technology with significantly reduced electrical consumption.

The ammonia adsorption-desorption reactor is a more sustainable solution when waste heat is available as a free, low-exergy input and when electrical consumption must remain low (such as in EDC or off-grid sites), when the primary purpose is heat upgrading rather than refrigeration, and when slower cycle speeds are acceptable. Even though the thermal COP of such systems is typically lower than that of traditional electrically-driven heat pumps, the exergy efficiency can still be respectable because the reactor makes effective use of energy that would otherwise be discarded.

When evaluated on an exergy basis relative to its input conditions, the ammonia reactor provides a viable and often more sustainable solution for heat upgrading in data-centre applications, particularly in scenarios where minimising electrical demand and maximising the reuse of waste heat are key design goals.

4 Conclusion and Next Steps

With the requirements and scope defined by this report, it is now key to start implementing these into a concept design and performance specification. This design development will be coordinated with partners from all work packages for alignment.

The focus of the development will be;

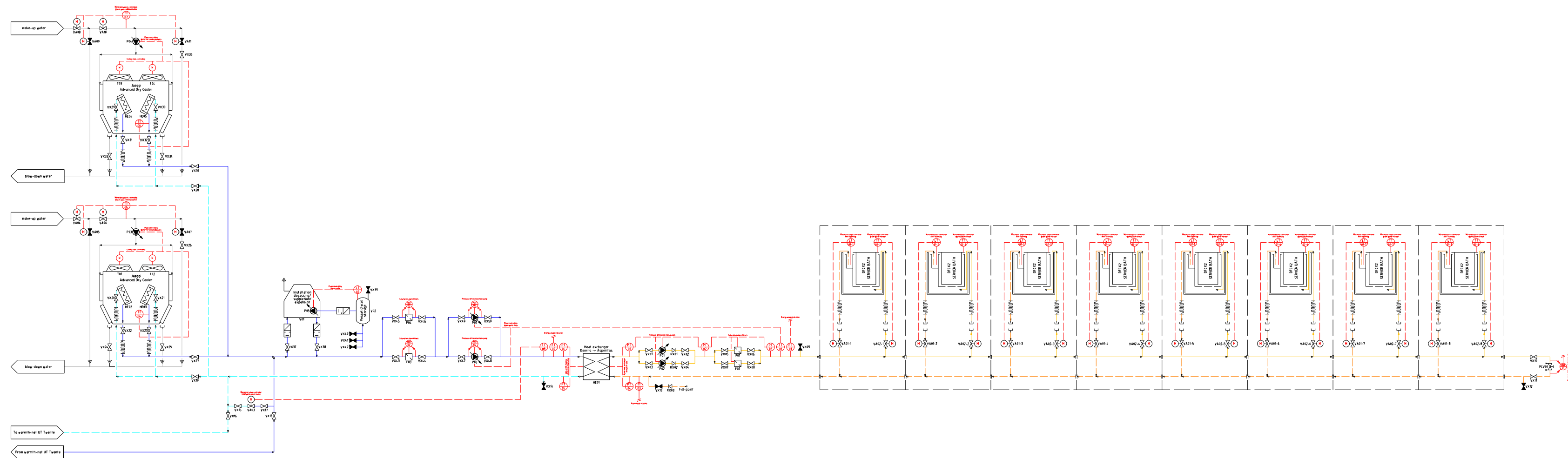
1. Validating the cooling design of the FWS between the TCS (Asperitas) and the heat network (UT – ammonia-based adsorption reactor).
2. Optimising the PUE of the concept design.
3. Develop a control strategy.

In order to implement the UT reactor within the MISD, it is imperative that a risk assessment and safety requirements are investigated thoroughly and implemented into the design.

Annex 1

Cooling system design P&ID

This P&ID consists of the entire cooling system design for the MISD EDGE-datacenter



Annex 2

Control engineering tables

Pressure transmitter (PT01) – Shell S3X loop	
Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	HE01/P01/P02
Control objective	Give a pressure difference over HE01/P01/P02 to see if these components work well/are not faulty
Control strategy	When the pressure difference of this pressure transmitter and of that with PT02/PT04 is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for HE01/P01/P02, in combination with PT02/PT04

Controlled pumps (P01/P02) – Shell S3X loop	
Component	Controlled pump
Function	Pumps the Shell S3X liquid throughout the Shell S3X loop
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	-
Control objective	The controlled pumps should pump the Shell S3X through the system, depending on the information of TT03
Control strategy	When TT03 gives a temperature which is too high, the controlled pumps will pull more cold facility water from the heat exchanger and when this temperature is too low the pump should lower its speed
System interaction	P01/P02 are controlled by TT03 and is monitored by PT01/PT02

Pressure transmitter (PT02) – Shell S3X loop	
Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	P01/P02/F01/F02
Control objective	Give a pressure difference over P01/P02/F01/F02 to see if these components work well/are not faulty
Control strategy	When the pressure difference of this pressure transmitter and of that with PT01/PT03 is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for P01/P02/F01/F02, in combination with PT01/PT03

Filters (F01/F02) - Shell S3X loop	
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Component	Filter
Function	Keeping the Shell S3X loop clean, protecting the heat exchanger/cooling equipment against debris and keeping the water viscosity/flow consistent
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	Partially controlled by PT02/PT03
Control objective	Give a saturation indication of the dirtiness of the filter by calculating a pressure difference over PT02/PT03
Control strategy	When the filter is too dirty (concluded from pressure differential PT/PT03) the filter can be replaced
System interaction	The filter gets feedback from PT02/PT03

Pressure transmitter (PT03) – Shell S3X loop

Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	F01/F02
Control objective	Give a pressure difference over F01/F02 to see if these components work well/are not faulty/are saturated
Control strategy	When the pressure difference of this pressure transmitter and of that with PT02 is lower than expected, the faults/oversaturation in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for F01/F02, in combination with PT02

Temperature transmitter (TT01) – Shell S3X loop

Component	Temperature transmitter
Function	Measuring temperature at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	P06/P07
Control objective	Control the pump speed of P06/P07, to get enough cold water flowing through HE1
Control strategy	When the temperature in the Shell S3X loop before going to the server is not cold enough this temperature can tell this information to P06/P07 to let these pumps pump more cold water over HE1
System interaction	TT01 is directly connected to P06/P07 and indirectly influences HE1

Flow transmitter (FT01) – Shell S3X loop	
Component	Flow transmitter
Function	Measuring flow at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	Logging within system interface
Control objective	Making a logging of how much flow goes through the servers
Control strategy	When the flow is changing this change will be communicated to the users of the servers and will result in data
System interaction	FT01 is not directly connected to any other component and is just there for logging the flow within the Shell S3X loop

Temperature transmitter (TT03) – Shell S3X loop	
Component	Temperature transmitter
Function	Measuring temperature of Shell S3X liquid at highest possible temperature
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	P01/P02
Control objective	Control the pump speed of P01/P02, to get enough cold Shell S3X being pulled from HE1
Control strategy	When the temperature in the Shell S3X loop before going into HE1 is not cold enough this temperature can tell this information to P06/P07 to let these pumps pull more cold Shell S3X through the loop
System interaction	TT03 is directly connected to P01/P02

Pressure transmitter (PT04) – Shell S3X loop	
Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	HE01
Control objective	Give a pressure difference over HE1 to see if this component works well/is not faulty
Control strategy	When the pressure difference of this pressure transmitter and of that with PT01 is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for HE01, in combination with PT01

Controlled Valve (VA01-1 to VA01-8) – Shell S3X loop	
Component	Controlled Valve
Function	Opening/closing warm Shell SX liquid flow return
Measured variable(s)	Shell S3X liquid within pipework loop (by LT01-1 to LT01-8)
Control variable	-
Control objective	Opening/closing the valves in such a way the Shell S3X liquid inside the immersion tank will keep being at the right level and will not run over
Control strategy	When the LT01-1 to LT01-8 measures a level which is too high, the controlled valve can open and when the level indicator measures a level which is too low, the controlled valve can close
System interaction	VA01-1 to VA01-8 are directly couple towards LT01-1 to LT01-8

Level transmitter (LT01-1 to LT01-8) – Shell S3X loop	
Component	Level transmitter
Function	Controlling opening/closing warm Shell SX liquid flow return
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	VA01-1 to VA01-8
Control objective	Measuring the level within the immersion tank, to signal VA01-1 to VA01-8 to open/close, whereby the tank will not run over
Control strategy	When the level indicator measures a level which is too high, the VA01-1 to VA01-8 can open and when the level indicator measures a level which is too low, the VA01-1 to VA01-8 can close
System interaction	LT01-1 to LT01-8 are directly couple towards VA01-1 to VA01-8

Controlled Valve (VA02-1 to VA02-8) – Shell S3X loop	
Component	Controlled Valve
Function	Opening/closing warm Shell SX liquid flow supply
Measured variable(s)	Shell S3X liquid within pipework loop (by TT01-1 tot TT01-8)
Control variable	-
Control objective	Opening/closing the valves in such a way the cooled Shell S3X liquid will enter the temperature with the right temperature
Control strategy	When the TT01-1 to TT01-8 measures a temperature which is too low, the controlled valve can close and when the level indicator measures a temperature which is too high, the controlled valve can open
System interaction	VA02-1 to VA02-8 are directly couple towards TT01-1 to TT01-8

Temperature transmitter (TT02-1 to TT02-8) – Shell S3X loop	
Component	Temperature transmitter
Function	Controlling opening/closing warm Shell SX liquid flow supply
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	VA02-1 to VA02-8
Control objective	Measuring the temperature of the entering liquid towards the immersion tank, to signal VA02-1 to VA02-8 to open/close, whereby the tank will not receive wrong temperatures
Control strategy	When the temperature transmitter measures a level which is too high, VA02-1 to VA02-8 can close and when the level indicator measures a temperature which is too high, VA02-1 to VA02-8 can open
System interaction	TT01-1 to TT01-8 are directly couple towards VA02-1 to VA02-8

Pressure differential transmitter (PDT01) – Shell S3X loop	
Component	Pressure differential transmitter
Function	Measuring pressure differential at its placed location
Measured variable(s)	Shell S3X liquid within pipework loop
Control variable	Logging within system interface
Control objective	Making a logging of what the pressure difference is at the furthest point from the main components in the Shell S3X loop, whereby pressure difference can be changed with PCV01 when needed
Control strategy	When the measured pressure differential is not as intended this will be seen in the system interface, whereby the PCV01 can be changed by hand
System interaction	PDT01 is not directly connected to a component (only indirectly to PCV01) and is mostly there for logging the pressure difference at the furthest point of the Shell S3X loop

Pressure transmitter (PT05) – Facility water loop	
Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Warm facility water within pipework loop
Control variable	HE01
Control objective	Give a pressure difference over HE1 to see if this component works well/is not faulty
Control strategy	When the pressure difference of this pressure transmitter and of that with PT06 is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for HE01, in combination with PT06

Controlled valve (VA03) – Facility water loop	
Component	Pressure transmitter
Function	Opening/closing on command of controller
Measured variable(s)	Coldest water within pipework loop
Control variable	-
Control objective	When TT08 measures a temperature which is too low or too high the controlled valve can mix in warm/cold water into the facility water loop
Control strategy	When the temperature at TT08 is too low or too high, it can control the controlled valve, whereby this will open/close, letting cold/warm water re-enter the system
System interaction	VA03 is directly connected to TT08

Cooling fans (T01/T02/T03/T04) – Facility water loop	
Component	Cooling fan
Function	Cooling the water which is being flown over HE02/HE03/HE04/HE05
Measured variable(s)	Cold water within pipework loop (by TT04/TT06)
Control variable	-
Control objective	Needed to cool the water which flows through the dry cooler water loop, whereby the speed of these cooling fans is controlled by TT04/TT06
Control strategy	When TT04/TT06 measures a temperature which is too high, the cooling fans will blow harder and when the temperature is too low, the cooling fans will blow softer
System interaction	T01/T02/T03/T04 are controlled by TT04/TT06

Controlled pumps (P03/P04) – Dry cooler water loop	
Component	Controlled pump
Function	Pumping water over HE02/HE03/HE04/HE05
Measured variable(s)	Cold water within pipework loop (by TT04/TT06)
Control variable	-
Control objective	Needed to pump water which flows through the dry cooler water loop, whereby the speed of the pumping is controlled by TT04/TT06)
Control strategy	When TT04/TT06 measures a temperature which is too high, the pumps will pump harder and when the temperature is too low, the pumps will pump less hard
System interaction	P03/P04 are controlled by TT04/TT06

Temperature transmitters (TT04/TT06) – Facility water loop	
Component	Temperature transmitter
Function	Measuring and transmitting temperature from outgoing cold facility water to T01/T02/T03/T04/P03/P04
Measured variable(s)	Cold water within pipework loop
Control variable	T01/T02/T03/T04/P03/P04
Control objective	Giving T01/T02/T03/T04 the information to blow more cold air over the dry cooler water loop and giving P03/P04 the information to pump more water within the dry cooler to cool the facility water indirectly
Control strategy	When the temperature measured is too high, T01/T02/T03/T04/P03/P04 will work harder to meet the required cool water temperature
System interaction	T01/T02/T03/T04/P03/P04 are controlled by TT04/TT06

Controlled valves (VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11) – Dry cooler water loop	
Component	Controlled valve
Function	Supplying the dry cooler water loop the right amount of water
Measured variable(s)	Dry cooler water within pipework loop (by TT05/TT07)
Control variable	-
Control objective	Supplying enough cool water to be flown through the dry cooler and enable some valves to drain some water when needed
Control strategy	When TT05/TT07 tell a temperature which is too high the valves can open more and when this temperature is too low the valves should close
System interaction	VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11 are controlled by TT05/TT07

Temperature transmitters (TT05/TT07) – Dry cooler water loop	
Component	Temperature transmitter
Function	Supplying the dry cooler water loop the right amount of water
Measured variable(s)	Measuring and transmitting temperature from outgoing cold facility water to VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11
Control variable	VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11
Control objective	Supplying enough cool water to be flown through the dry cooler and enable some valves to drain some water when needed
Control strategy	When the temperature transmitters tell a temperature which is too high VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11 can open more and when this temperature is too low VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11 should close
System interaction	TT05/TT07 are controlling VA04/VA05/VA06/VA07/VA08/VA09/VA10/VA11

Controlled pump (P05) – Glycol refill	
Component	Controlled pump
Function	Pumping in new glycol to refill the glycol within the facility water system
Measured variable(s)	Glycol within refill tank (by LT02)
Control variable	-
Control objective	Re-supplying more glycol for the facility water system when needed
Control strategy	When LT02 measures a level of glycol which is too low the controlled pump can pump such an amount of glycol, so that the percentage of glycol will return to which it should be
System interaction	P05 is controlled by LT02

Level transmitter (LT02) – Glycol refill	
Component	Temperature transmitter
Function	Measuring and transmitting the level within the glycol tank to refill the system with the right amount of glycol
Measured variable(s)	Glycol within refill tank
Control variable	P05
Control objective	Re-supplying more glycol for the facility water system when needed
Control strategy	When the level transmitter measures a level of glycol which is too low the P05 can pump such an amount of glycol, so that the percentage of glycol will return to which it should be
System interaction	LT02 is controlling P05

Filters (F03/F04) – Facility water loop	
Component	Filter
Function	Keeping the facility water clean, protecting the heat exchanger/cooling equipment against debris and keeping the water viscosity/flow consistent
Measured variable(s)	Cold water within pipework loop
Control variable	Partially controlled by PDT02/PDT03
Control objective	Give a saturation indication of the dirtiness of the filter by using the pressure difference calculated by PDT02/PDT03
Control strategy	When the filter is too dirty (concluded from PDT02/PDT03) the filter can be replaced
System interaction	The filter gets feedback from PDT02/PDT03

Pressure differential transmitters (PDT02/PDT03) – Facility water loop	
Component	Pressure differential transmitter
Function	Measures the pressure difference over F03/F04
Measured variable(s)	Cold water within pipework loop around F03/F04
Control variable	F03/F04
Control objective	Give a pressure difference over F03/F04 to see if these components work well/are not faulty
Control strategy	When the pressure difference of this pressure differential transmitter is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure differential transmitter provides feedback for F03/F04

Controlled pumps (P06/P07) – Facility water loop	
Component	Controlled pump
Function	Keeping the water flowing through the facility water loop
Measured variable(s)	Cold water within pipework loop
Control variable	-
Control objective	The controlled pumps should pump the facility water through the system, depending on the information of TT01
Control strategy	When TT01 gives a temperature which is too high, the controlled pumps will pump more cold facility water over the heat exchanger and when this temperature is too low the pump should lower its speed
System interaction	P06/P07 are controlled by TT01

Pressure differential transmitters (PDT04/PDT05) – Facility water loop	
Component	Pressure differential transmitter
Function	Measures the pressure difference over P06/P07
Measured variable(s)	Cold water within pipework loop around P06/P07
Control variable	P06/P07
Control objective	Give a pressure difference over P06/P07 to see if these components work well/are not faulty
Control strategy	When the pressure difference of this pressure differential transmitter is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure differential transmitter provides feedback for P06/P07

Temperature transmitter (TT08) – Facility water loop	
Component	Temperature transmitter
Function	Measuring temperature at its placed location
Measured variable(s)	Coldest water within pipework loop
Control variable	VA03
Control objective	Controlling VA03, when measured temperature at the temperature transmitter is too low, so the controlled valve can mix in warm/cold water
Control strategy	When the temperature at the temperature transmitter is too low or too high, it can control the VA03, whereby this will open/close, letting cold/warm water re-enter the system
System interaction	TT08 is directly connected to VA03

Flow transmitter (FT02) – Facility water loop	
Component	Flow transmitter
Function	Measuring flow at its placed location
Measured variable(s)	Cold water within pipework loop
Control variable	Logging within system interface
Control objective	Making a logging of how much flow goes through the entire facility water system, whereby the energy usage will be indicated
Control strategy	When the flow changes this change will be communicated towards the system interface
System interaction	FT02 is not directly connected to any other component and is just there for logging the flow within the facility water circuit

Pressure transmitter (PT06) – Facility water loop	
Component	Pressure transmitter
Function	Measures one part of the pressure difference at its placed location
Measured variable(s)	Cold water within pipework loop
Control variable	HE01
Control objective	Give a pressure difference over HE01 to see if this component works well/is not faulty
Control strategy	When the pressure difference of this pressure transmitter and of that with PT05 is lower than expected, the faults in the system can be recognized, whereby maintenance can be consulted
System interaction	This pressure transmitter provides feedback for HE01, in combination with PT05

Annex 3

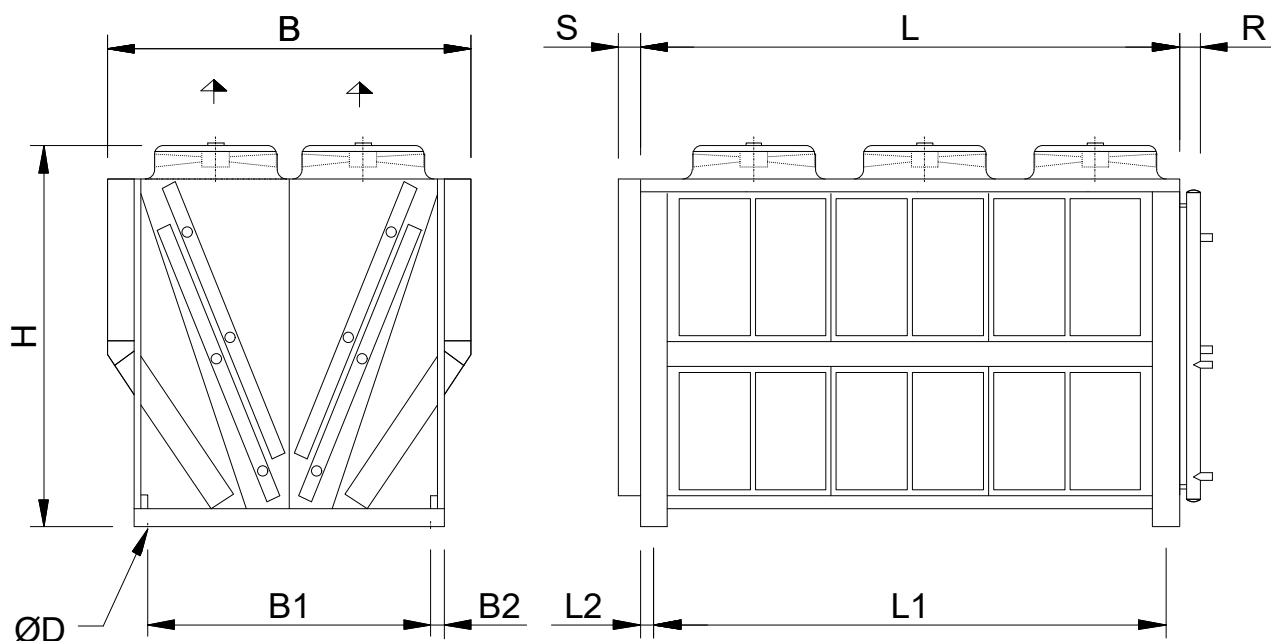
Hybrid dry cooler data sheet

Date:

2025-12-05

Adiabatic dry cooler ADC 2x3/ND9-C1U-3-6P

Capacity:	353.0 kW ⁽¹⁾	Medium:	Ethylene glycol 40 Vol. % ⁽²⁾
Air flow:	166537 m ³ /h	Inlet:	42.0 °C
Air velocity:	2.5 m/s	Outlet:	32.0 °C
Air inlet:	38.9 °C 36 %	Velocity in coil:	1.31 m/s
Height above sea level:	50 m	Pressure drop:	0.75 bar
Changeover point:	27.2 °C	Volume flow:	33.59 m ³ /h
		Mass flow:	35595 kg/h
Fans:	6 Piece(s) 3~400V 50-60Hz	Sound pressure level:	64dB(A) ⁽³⁾⁽⁴⁾
Data per motor (nominal data):		at a distance of:	10.0 m
Speed:	1200 min ⁻¹	Sound power:	96 dB(A) ⁽⁴⁾
Capacity (el.):	3.95 kW	ErP:	Compliant ⁽⁵⁾
Current consumption:	5.10 A ⁽⁶⁾		
Total el. powerconsumption:	17.89 kW	Max. water consumption due to design point:	2266.9 kg/h
Casing:	Galv. Steel, RAL 7035	Tubes:	Copper ⁽⁷⁾
Surface:	1695.7 m ²	Fins:	Aluminium ⁽⁷⁾
Tube volume:	187.3 l	Connections per unit:	
Fin spacing:	2.00 mm	Inlet:	2 x 54 * 2.00 mm
Empty weight:	2492 kg ⁽⁸⁾	Outlet:	2 x 54 * 2.00 mm
Max. operating pressure:	10.0 bar	PED classification:	Art. 4(3) ⁽⁹⁾
		Passes:	6
Dimensions:⁽⁸⁾		Outlet header:	2 x 54 * 2.00 mm
Length:	4139 mm	Inlet header:	2 x 54 * 2.00 mm
Width:	2670 mm	Circuits:	2N
Height:	2850 mm ⁽⁸⁾	Distributions:	2 * 32
No. of legs:	4		



File: EMFIGVD_CD2x3_c_UNI.emf

L	=	3899 mm	B	=	2670 mm	H	=	2850 mm
R	=	220 mm	L1	=	3745 mm	L2	=	77 mm
B1	=	2200 mm	S	=	20 mm	ØD	=	17 mm

Attention: Drawing and dimensions not valid for all accessory options!

Accessories	Piece(s)
Vibration Dampers SMA4.1	4
EC fuse box system ⁽¹²⁾	1
1 x (5209187) Disconnect non fused 32A	
3 x (5209040) Circuit Breaker 3ph, 13A	
1 x (5215597) aicore™ GMOD Fan Module EC/04	
1 x (5209039) Circuit Breaker 1ph+N, 6A	
1 x (5209006.1) GPD Güntner Power Distribution Housing (Plastic) 300x300x132 [mm]	
Temp. sensor with stainless steel pocket	1
Mounting and wiring	1
Lapped flanges DN50 PN10 with brazing neck ⁽¹³⁾	4
like DIN EN 1092-1	
EC fans with combined motor-management aicore™ fusion	1
Ball valve 1/2" for ventilation/drain	4
Repair switch (single-speed), fans wired to front in pairs	3
Evaporative cooling system Custom Data ⁽¹⁴⁾	1

Important remarks / explanatory notes:

- (1) Calculations and capacity tests are based on the following standards: condensers/gas coolers EN 327, evaporators/air coolers EN 328, dry coolers EN 1048.
- (2) Fluid group 2 in accordance with Pressure Equipment Directive 2014/68/EU
- (3) In accordance with the enveloping surface method defined in EN 13487/EN 9614-1; tolerance = +2 dB(A). Applies only for AC fans, AC fans with sine control and EC fans. Noise caused by other control methods, water spraying systems or sound reflexions occurring at the installation site are not taken into account and may result in an increased sound pressure level.
- (4) Based on the nominal data of the fan
- (5) This unit is equipped with fans that meet the efficiency requirements of Directive 2009/125/EC (ErP Directive).
- (6) The current consumption can differ in dependence of the air temperature and of the variations of system voltage according to the VDE guidance.
- (7) When using the unit in aggressive atmospheres, it is imperative to select the materials according to the specific application, see material recommendation brochure in the GPC programme menu "2".
- (8) Dimensions and weights are not valid for all possible options! They may differ for units with accessories or special units (S-...).
- (9) Pipe (DN = 50.0 mm, TSmax = 100 °C, liquid). Final classification in accordance with Pressure Equipment Directive 2014/68/EU when the order is processed.
- (10) Delivery time for standard units ex works, i.e. without transport time. Times for units with customised drawing, special units, special accessories or larger quantities on request.
- (11) Rating of the product in terms of sustainable technologies used. Higher value = better for the environment and/or energy consumption.
- (12) (GSCE06-0510CBL-NNNCNUN-N-TM) Width x Height x Depth: 300 mm x 300 mm x 132 mm, weight: 5 kg, Protect. system IP 54, mounted and wired on inlet side, Operating temperature range: -20.0 °C - 55.0 °C, Power supply: 400 VAC / 5060 Hz / 3-Ph+N+PE, full load amperage (FLA): 30.6 A, Maximum overload protection (MOP): 40.0 A (gL/gG)
- (13) Incl. counter flange (welding neck flange DIN EN 1092-1), screws and gaskets are intended for transport only and must be replaced
- (14) Primary pressure for wetting due to design point: 3.2 bar, wetbulb temperature: 26.0 °C, For internal: 5204793_12 WA 2.5 (Custom Data)

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