MOUNTAIR

DATA CENTER

Cooling and refrigeration units

High-level cold generation

- Maximum free cooling thanks to high cold-water temperatures
- High COP values thanks to low recooling temperatures
- Minimum refrigerating machine running time thanks to use-dependent load removal
- Safety through n+1 redundancy

Contents

Introduction

Which factors influence the efficiency of a data center?

A data center is assessed on the basis of its PUE value. The PUE value shows how much energy is necessary in order to ensure the operation of the data center. Aside from the actual data computers that consume pure electrical energy, HVAC installations are required in order to provide the energy to cool the computers. And devices are required for the actual computer cooling. There are various approaches to this energy conversion. There are direct systems, where the computers are cooled via an internal cooling circuit; cold water flows directly through the computers. Other models have a double-floor system – the cold air is blow into the data center area via double-floors, heated by the computers if needed and removed and cooled down by an exhaust air system.

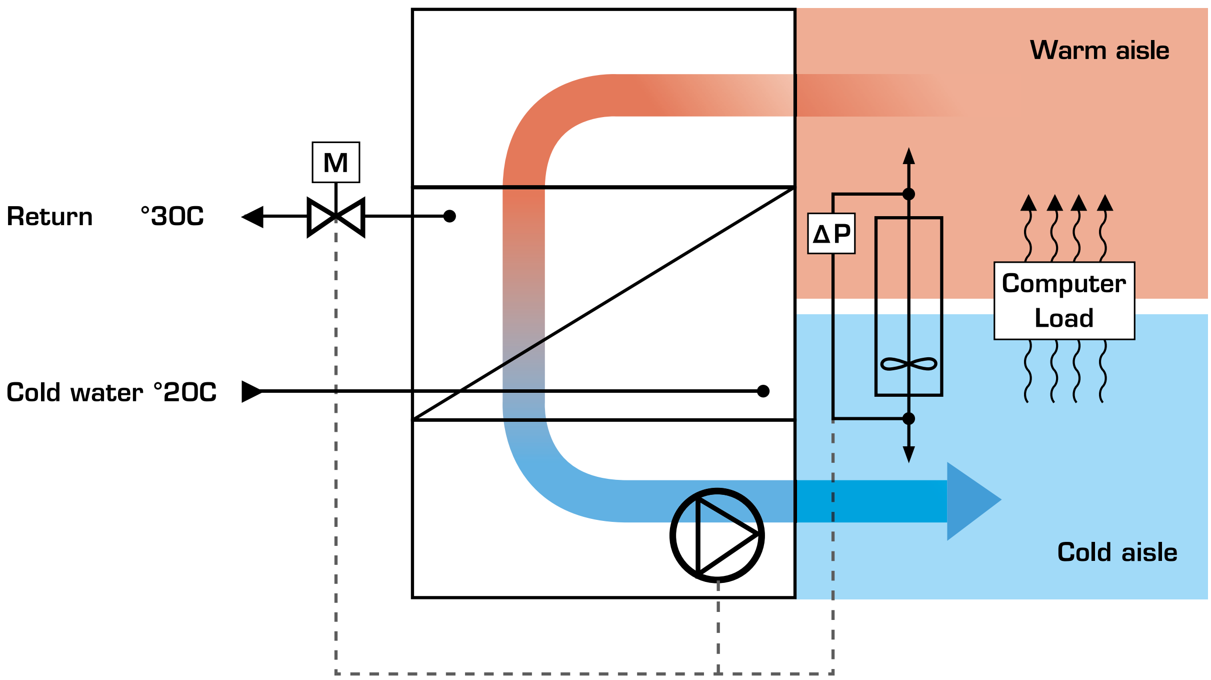
To choose the right system, peripheral questions must also be answered. Is the access to the data center area permitted in the case of a disturbance/maintenance, or can the devices only be serviced in a zone outside of the data center area? Furthermore, the required degree of security must be determined. Is redundancy necessary? Yes, it usually is. The computers installed are usually system-relevant and may not fail in any circumstances. This is why tier 3 is often used; n+1 redundancy. This means that a system part can fail within a system, but the remaining system parts are able to provide the necessary performance. For a 100 kW cage, 100 kW cooling power must therefore always be available. n+1 means that at least 2 cooling units must be installed. If the number of independent system parts increases, the performance to be provided individually is reduced. However, this also means that the number of units increases. Thus, 1+1, 2+1 or even 3+1 systems can be designed. The question of which constellation makes sense is also determined through geometrical, spatial facts. In addition, the costs must be taken into account. For a 100 kW cage and a 5+1 design, each system part only has to provide 20 kW of power, but on the other side it means that 6 independent systems have to be installed; including independent controlling and integration. The tier 3 rule is applied for all data center-relevant systems. Two electrical networks are thus also necessary, as well as 2 separate hydraulic networks (cold water supply).

In a data center, on the one side the heat must be removed from the data center area, and on the other the cold energy must be provided. A primary side (data center heat) and a secondary side (cold generation) can thus be defined. For both system parts, in some circumstances the tier 3 rule is also applied, i.e. n+1 redundancy.

Primary side heat removal

Removing the data center heat

The computers installed in a data center mainly generate heat alongside the computing power. This heat must be removed. The installed computers thereby have an important role to play. Internal temperature monitoring systems let the computer-internal cooling system run according as needed. In the case of air cooling, the computer circuit board is equipped with a temperature sensor that constantly monitors the surface temperature of the circuit board. If the temperature increases, the fans are started. As a consequence of this, only the amount quantity of cold air that is needed by the computers should be introduced into the data center area. This is ensured if the same pressure is present on both sides of the computer, therefore if there is no differential pressure. This is a task for the regulation of the cold air volumes.
The data center surface are also divided into different zones. Is only one tenant present or are there various independent tenants who share the data center? The rack rows are very standardised nowadays. A computer has a defined width and a variable height, depending on its power. This forms a rack row. One possibility is the creation of a warm and a cold aisle for the spatial separation of the rack rows. In the cold aisle, the necessary cold air is blown in and provided for the computer cooling. In the warm aisle, the use-dependent warmed air is sucked out via the cooling module and cooled back down to the input temperature. The time of day and the business activities influence the power requirements. Sophisticated controlling makes it possible for the circulating air cooling units to only require that which is actually necessary at any given point in time. For this purpose, Mountair has developed so-called "Cooling wall modules" that are adjusted to the spatial and power-dependent conditions – design and construction are different in every project. Below you will see an example of a cooling wall and system description with a 2+1 redundancy design and a cooling power of 100 kW per rack row.



Cooling wall modules

System description

A cooling wall module has a nominal performance of e.g. 100 kW and is separated into (three) zones. If a zone fails due to a defect, the two remaining zones are able to provide the required 100kW of cooling power.

A cooling wall module is assigned to a server row. The servers are all installed on the same side. Cold air is sucked in from behind (cold aisle) and the air heated by the servers is blown out (warm aisle) in front (user side). The servers convey the air required for the cooling from the cold aisle to the warm aisle with their own computer fans.

The cooling wall module is tasked with sucking out the heated air from the warm aisle, cooling it down and blowing it back into the cold aisle. The cooling wall works as a Circulating Air Unit (CAU).

The cold water required for the cooling (20°C) is provided redundantly. There are two water networks (A+B). In normal operation mode, each zone provides 33.3kW of cooling power, in emergency operation mode a zone can provide up to 50 kW of cooling power. Each zone is equipped with its own fan. In normal operation mode, a fan conveys 10 000 m^3/h. In emergency operation mode, a fan conveys 15 000 m^3/h per zone.

The CAU cooling wall module is designed as a deflector module. The heated air (34°C) is sucked into the module via a filter wall and cooled down by a water-air heat exchanger (24°C), in order to then be conveyed back into the cold aisle. The warmed water (30 °C) is cooled back down to the required 20°C through cold and refrigerant units.

The CAU cooling wall modules are operated so that they work as well as possible. This means that only as much air is conveyed as necessary. The air should heat up as much as is permissible in the server computers. The air volumes required for this are optimised. If the delta-T decreases, the fans are cut back. The delta-T should ideally be as close as possible to the 10 K value.

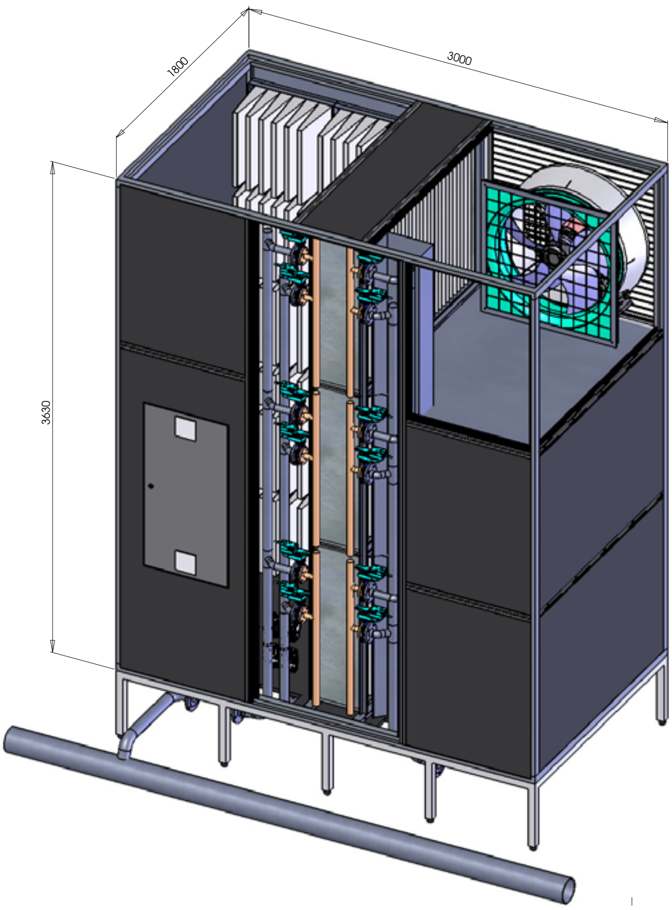
Technical data (example) Cooling wall module 100 kW

Height	3630 mm
Width	1220 mm
Length	1800 mm

Circulating air	
Flow volume	30 000 m³/h
Nominal performance	100 kW

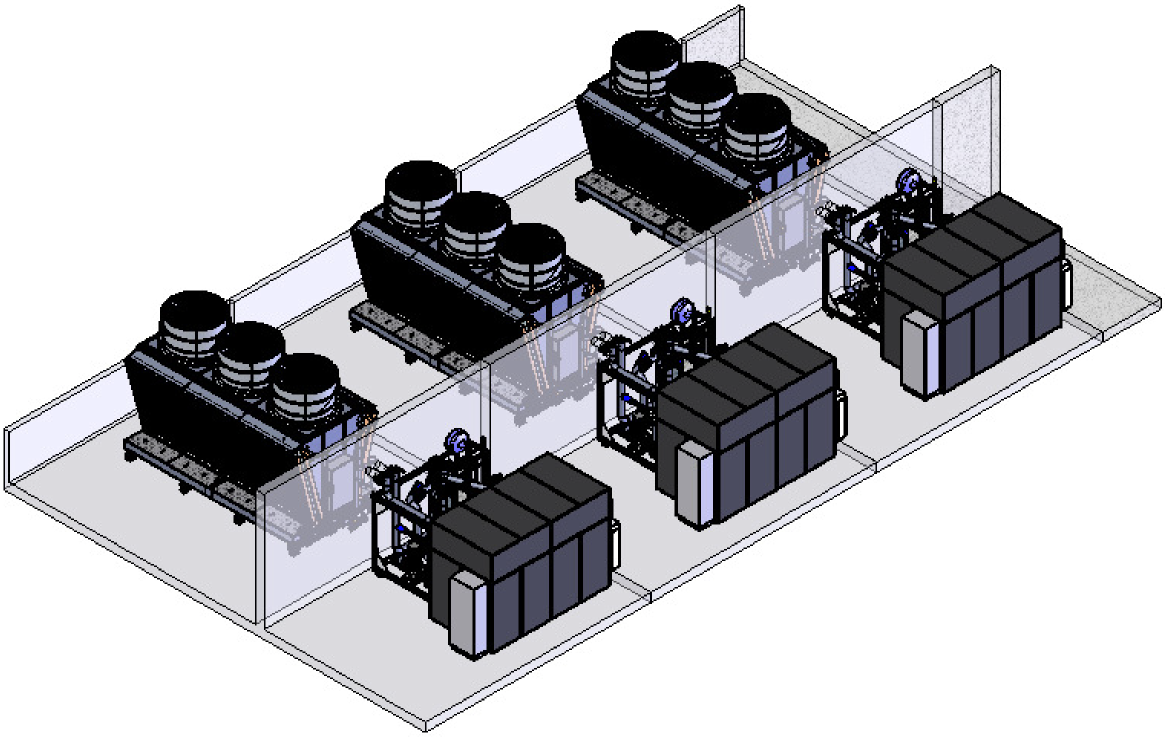
Air cooler (3 pc. = n+1)	
Air entry	34 °C
Air exit	24 °C
Cooling power	33.3 kW / 50 kW
Flow temperature	20 °C
Return temperature	30 °C
Pressure loss	10 kPa
Number of pipe rows	8 RR
WT tube material	Cu
Fin material	AL

Fan (3 pc. = n+1)	
Flow volume	10 000 m³/h
Nominal operating power	700 Watt
Current	1.0 A



Cooling wall module, redundant development

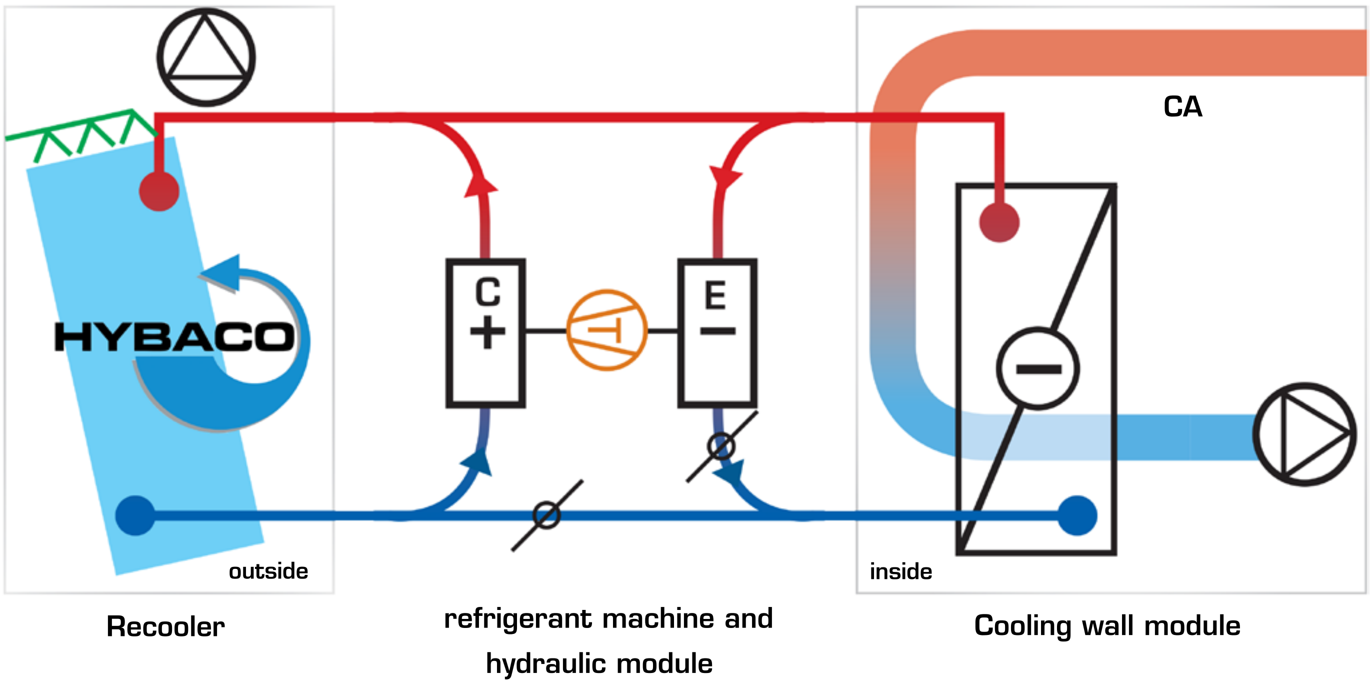
Secondary side cold generation



Preparing the cold energy for data center cooling

Regardless of how the computers in the data center area are cooled, cold energy must be provided for it. We speak of cold water that is often used in the CAU cooling wall module heat exchangers. Even in case of direct computer cooling with cold water pipes within the computer, cold energy in the form of cold water is necessary.
Data center computers require very cold conditions in order to be able to run efficiently. As already described, the computers have an internal temperature regulation. A data center computer works at best in the 20–40°C range. This fact means that relatively high cold-water temperatures are sufficient. It is therefore not necessary to provide 6°C CPW. Additionally, this brings further disadvantages such as condensation.

Fundamentally, the following applies: the smaller the lift, the more efficiently a cooling system can be run. The smaller the lift, the higher the cold-water temperature (regardless of the load removal on the secondary side of the refrigerant machine). The cold-water temperatures must therefore be chosen so that the heat exchangers are not too high (higher pressure loss = constant energy consumption), but however also so that the cooling energy can be efficiently prepared. It is therefore possible to work with 18–20°C cold water flow temperatures, in order to simultaneously cool the data center air from 34°C down to 24°C.
The choice of a high cold-water temperature has the advantage of being able to work with the maximum possible free cooling and of reducing the refrigerating machine operating times.



System definition Cold generation

Cold water is required for the computer cooling. Refrigerating machines are used in order to provide this. On their primary side, the cold energy is provided, while on the secondary side the condensation exhaust heat is removed. This is performed by recooling systems. Between the consumer/CPW reservoir and the cold generation, there are several pumps and valves in order to ensure the provision.

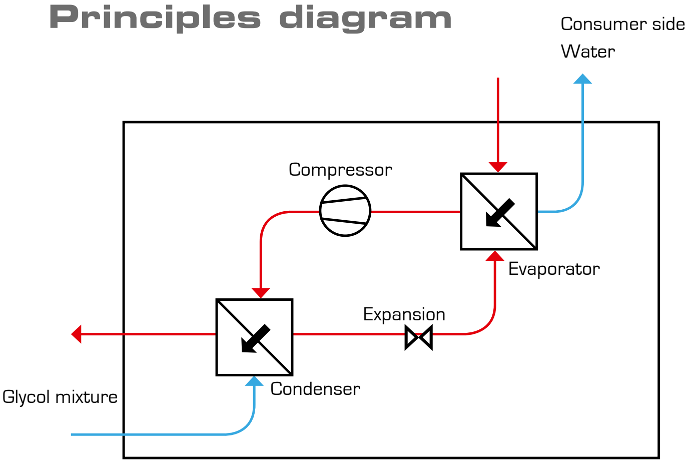
For the case of data center applications, Mountair has designed a hydraulic module that, along with the medium conveyance, also controls and optimises the free-cooling cold and constantly couples it in the cold-water circuit. This therefore means 3 units: refrigerating machines for cold water generation, recoolers to remove the condensation heat (in summer) and the provision of free-cooling cold energy as well as the so-called hydraulic module, which is superordinate to both systems (refrigerating machines, recoolers) and takes over the regulation of such a cold generation unit.

Refrigerating machines with machine housing

System description

Refrigerating machines work with the thermo-dynamic circuit process and thus use the evaporation/vaporization/condensation phase transition to deploy their effect. The "gain" is taken by the system on the cold side, with the evaporator. Coolant is atomized in the heat exchanger and takes on thermal energy. Heat is thus removed from the primary circuit and thus cools it down (water). The coolant is then condensed ("pumped" on a thermally higher level, arrives in the condenser, where it gives off the energy "outside" in a heat exchanger (recooler to outside). The circuit process closes off with the expansion of the now liquid coolant before it returns again to the evaporator.

Principles diagram



Refrigerating machine efficiency

For refrigerating machines (and heat pumps), we do not speak of an efficiency level, instead of a COP. An efficiency level cannot be higher than 1, for CM/HP the use of the system is significantly higher. This because it is not primary energy that is compared de-facto, instead thermal use versus primary energy used. The thermal gain (for ex.: 620 kW cooling power) is opposed to the electrical power used (for ex.: 80 kW). This gives a coefficient of performance (COP) of 7.75.

A refrigerating machine therefore works more efficiently when it does not have to provide as much lift. This means: the closer the evaporation and condensation temperatures, the more efficiently the refrigerating machine can work. Alongside high cold-water temperatures, equally low recooling temperatures are the key to a high COP → use of hybrid recoolers.

Choice of coolant

Many coolants are now forbidden/limited in use (see Kältefibel literature). In the data center area, the powers range from several hundred kilowatts to a few megawatts. Even fewer coolants are appropriate for this. The GWP (global warming potential) is another factor of a coolant. This should of course be as low as possible. Natural coolants are very good on this front (for ex.: ammonia). Currently, the coolant HFO is very popular. It is a further development of the now disused coolant R134a. It has a good GWP and its use is well-known.
The final decision for the choice of coolant is however also influenced by factors such as procurement costs, construction sizes, required security precautions (pistons, screws, turbocore, scroll). Some are little appropriate, depending on the performance class – in any case, an evaluation with the given framework conditions of a project is recommended.

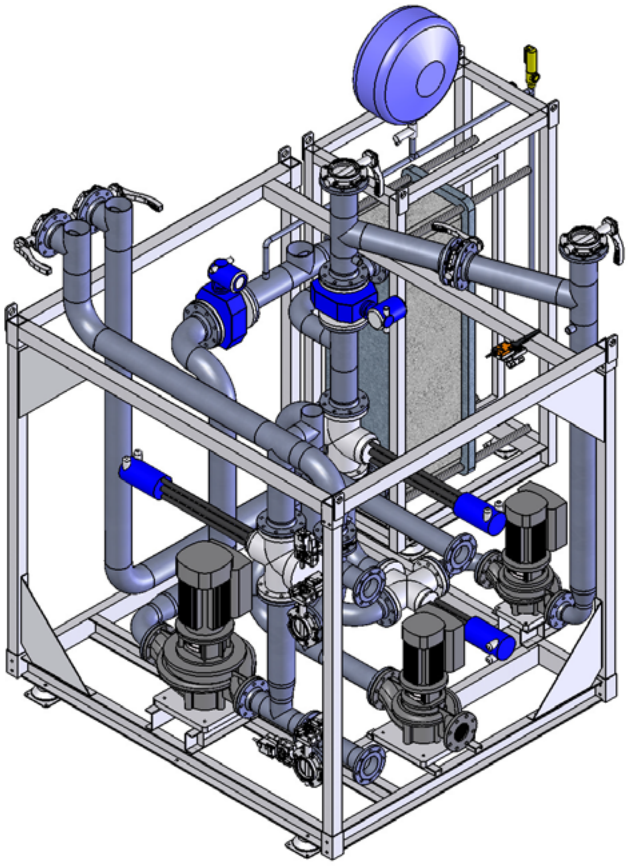
Hydraulic module

System description

Hydraulic module for the constant coupling of free cooling and mechanical cooling with PHE system separation. Recooling range with 30 % glycol. Recooler for simultaneous generation of free cooling and removal of the condensation exhaust heat from the refrigerating machine. Hydraulic bypass of the condenser in the pure free cooling area, hydraulic bypass of the plate exchanger in the pure refrigerating machine operations.

External admission flow of the hydraulic station with load-dependent, variable/fixed water mass flows. The consumer pump speed is controllable. The nominal mass flow is set via an inductive through-flow meter.

The hydraulic station is equipped with a regulation valve to generate cold water with constant flow. The free cooling mode is run in the first sequence. In the second sequence, a partial mass flow is conveyed via the refrigerating machine. The proportion of mechanical cooling is minimised through the coordination of the mass flows, by the load-dependent sliding ideal temperature of the generator. The system is divided by a plate heat exchanger. An expansion system with safety fittings and pressure maintenance is installed for the external recooling medium.



The hydraulics are regulated and controlled via an electrical control cabinet with a process device with a bus interface and commissioning. The electrical control cabinet serves as "master" for the generator group. The refrigerating machines and the hybrid recooler are connected via Modbus TCP. The communication with the BMS is conducted via OPC.

Technical data (example)

Cooling power	Qo	620 kW
Recooling power	Qr	750 kW
Primary circuit	Medium	Water
Temperature	Tvl / Trl	29/19 °C
Mass flow	ṁ	53.4 m³/h
Secondary circuit	Medium	Water-30% Glycol
Temperature	Tvl / Trl	35/27 °C
Mass flow	ṁ	86.1 m³/h

Consumer pump P1	**Grundfos with FC**
Type	TPE 80–150
Water	53.4 m³/h
Pressure increase	100 kPa
Nominal motor power	3.0 KW
Connection	3 × 400 V
Nominal current	6.2 Amp
BUS interface	

Secondary pump P2	**Grundfos with FC**
Type	TPE 100–110
Water	89 m³/h
Pressure increase	60 kPa
Motor power	3.0 KW
Connection	3 × 400 V
Nominal current	6.2 Amp
BUS interface	

Recooling pump P3	**Grundfos with FC**
Type	TPE 100–170
Water-30%Glycol	86.1 m³/h
Pressure increase	110 kPa
Nominal motor power	5.5 KW
Connection	3 × 400 V
Nominal current	11.0 Amp
BUS interface	

Plate exchanger 620 kW		**Inox PN10**
Medium A		Water
Entry / Exit		29 / 19 °C
Water volume		53.4 m³/h
Pressure loss		20 kPa
Connections		100 DN
Medium B		Water- 30% Glycol
Entry / Exit		17 / 27 °C
Through-flow volume		56.8 m³/h
Pressure loss		20 kPa
Pressure loss calculation		40 kPa
Mass flow for calculation		92.2 m³/h
Connections		100 DN
Dimensions	L	1040 mm
	W	480 mm
	H	1720 mm
Weight		750 kg
Insulation	Armaflex	40 mm

Control valve V1	
With rapid-response actuator with limit switch	HORA
Type	BR316GF – MC400
Water	53.4 m³/h
DN	100

CM valve V2 (switch valve)	
With rapid-response actuator with limit switch	HORA
Type	BR316GF – MC400
Water	89 m³/h
DN	125

Bypass valve V3	
With rapid-response actuator with limit switch	HORA
Type	BR216GF – MC400
Water	–30% Glycol 86.1 m³/h
DN	125

Glycol through-flow measurement	
Measurement method	magnetic-inductive
Type	Promag 10W1Z
DN	125
Auxiliary energy	230 V
Output	4-20 mA

Water through-flow measurement	
Measurement method	magnetic-inductive
Type	Promag 10W1H
DN	100
Auxiliary energy	230 V
Output	4–20 mA

Cantonal hospital of Münsterlingen

Hybaco® hybrid recooler

System description

Mountair Hybaco® recoolers come in two forms, the V form and the H form. V-form recoolers are usually installed on roofs, H-form recoolers usually in ventilation stations where the air is supplied and removed via ducts. The task of recoolers is to cool down a medium (water or water-glycol mixture). The medium flows through the recooler and is thereby cooled down to the desired temperature with the help of air and water. Hybaco® hybrid recoolers represent a closed system, in which the water required for the heat exchanger wetting is collected in tanks and then used for wetting.

Alongside heat exchangers for medium cooling and fans for air conveyance, the system must include the following parts/components:

- Frequency converter for the fan (if no EC drive)
- Circulation pump for wetting
- Frequency converter for the circulation pump
- Motor-controlled flaps to spatially separate the wetting
- Ultrasound level measurement in the tank
- Conductivity measurement to monitor the water quality
- Water filter
- Outdoor air sensor (temperature, humidity)
- Immersion temperature sensor for the medium circuit (flow/return)
- Pressure sensor (flow pressure, pump discharge pressure, pressure after filter)

Dampening solution quality

Hybrid recoolers require water to extract heat (vaporization energy). The circulating water that is surrendered at the air-water heat exchangers can be of various different qualities (from osmosis to tap water).

Fundamentally:

1) The better the water quality (osmosis), the less purging and maintenance.
2) The better the water quality, the more expensive it is to provide.

It is therefore a matter of choosing what the minimum water quality should be. Mountair hybrid recoolers (Hybaco®) require at least fully softened water (0°fH).

A question that any operator can ask and answer themselves concerns the groundwater/tap water available on site.

Two extremes

1) Jura. The water is very hard here, has a high salt content (measured in water hardness – for ex.: 45°fH).
2) Proximity to a lake. This usually means that relatively good water is available (no rocks – for ex.: 10°fH).

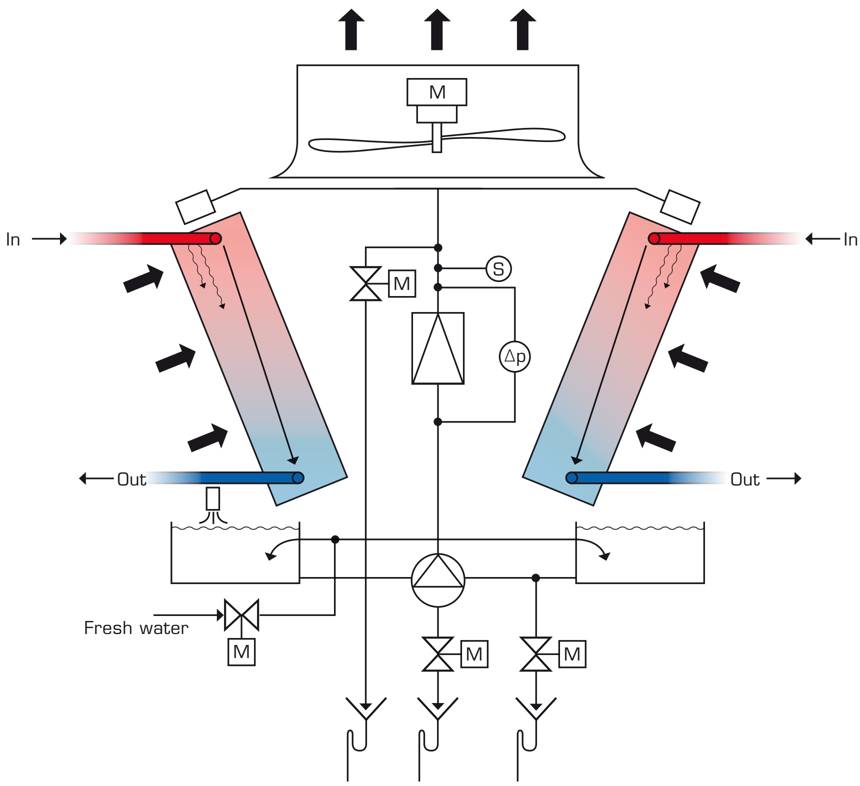
The softer the water the better. In Jura, osmosis systems should therefore absolutely be installed, whereas fully softened water can be used in Münsterlingen.

V form

The Hybaco® V form corresponds to the well-known recooler construction form for outside installation. The two tilting heat exchangers that make a 'V' shape form a compact unit. For this reason, the V form allows high performance with a small installation surface.
With the patented Hybaco® wetting system, the fin heat exchangers are evenly dampened, and the air is humidified.

Principles diagram

- Heat exchangers in V arrangement
- Quiet-running axial fans
- Highly efficient EC drive motors
- Hybaco® wetting system
- Water tanks
- Circulation pump (1 pc/RC)
- Water level measurement
- Conductivity measurement
- Water filter system
- Fresh water and emptying valves



Components

Heat exchangers

Hydrophile AlMg3 fins and galvanised copper pipes have the best properties with regard to heat exchange, alongside excellent corrosion-resistance, which leads to the best performances.
Properties overview:

- Fin material: AlMg3
- Pipe material: galvanised Cu
- Frame material: V2A – AlMg3
- Connection flanges

Pump

Hybaco® recoolers work with only one circulation pump. Mountair uses chrome-steel normalised block pumps.

Fans

For the high acoustic requirements, Mountair counts on continuity and uses quiet-running axial fans of the company Howden. These achieve high air volumes, excellent acoustic qualities and an outstanding efficiency.
Properties overview:

- Material: GRP
- Direct drive
- Excellent acoustical properties
- High efficiency

EC motors

Hybaco® recoolers are equipped with EC motors. These achieve a very high degree of efficiency (equivalent to the class IE4) and can be very efficiently used especially in the partial load range.
Properties overview:

- Latest EC technology
- Highly efficient (equivalent class IE4)
- No external frequency inverter required

Hybaco® recooler design example

Refrigerating machine operation

Recooling performance		750 kW
Recooling performance	Medium	Water-30% Glycol
Temperatures	Tvl/Trl	35/27°C
Mass flow	ṁ	86.1m³/h
Medium pressure loss	dp	37.5 kPa
Outdoor air temperature		34°C
Outdoor air humidity		40% r.H.
Wet bulb temperature		23°C
Hybrid operation (87%)		150 000 m³/h
Air exit temperature		28.1 °C
Air exit humidity		90 % r.H.
Evaporation volume		1.57 m³/h
Total water consumption*		2.1 m³/h
Dry operation (87%)		160 000 m³/h
Dry switchover point		18 °C
Air exit temperature		32.3 °C

Free cooling operation

Cooling performance		620 kW
Temperatures	Tvl/Trl	27/17°C
Mass flow	ṁ	57.0 m³/h
Medium pressure loss	dp	20 kPa
Outdoor air temperature		20°C
Outdoor air humidity		53 % r.H.
Wet bulb temperature		14.1°C
Hybrid operation (100%)		180 000 m/h
Air exit temperature		19.4 °C
Air exit humidity		86 % r.H.
Evaporation volume		0.94 m³/h
Total water consumption*		1.25 m³/h
Dry operation (100%)		186 000 m³/h
Dry switchover point		12 °C
Air exit temperature		22.2 °C

Fans

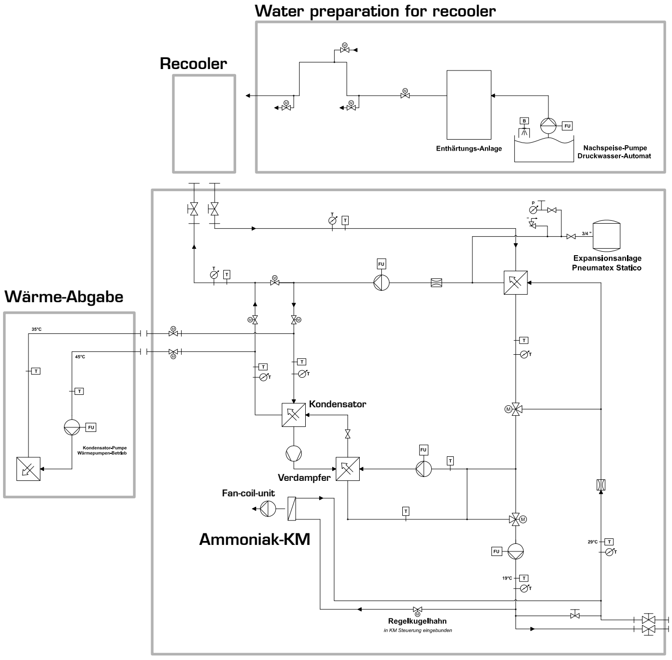
Number of fans per RC	3 piece
Fan speed (100%)	445 rpm
Power consumption (per fan)	3.4 kW
Sound power level individual fan (100%)	74.2 dB(A)
Total recooler Sound power level	79 dB(A)

* dependent on the wetting water quality (osmosis, rainwater, fully softened)

Controlling and connection

Component coordination

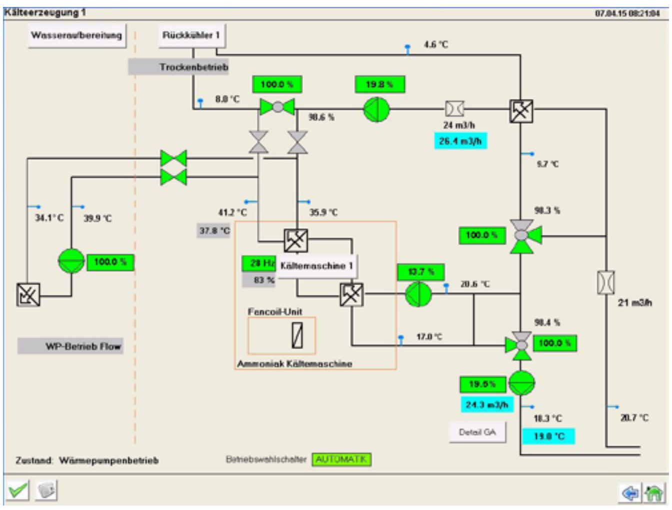
The interaction between the consumer (cooling wall module), the recooler and mechanical cooling is decisive and a very important factor in order to achieve the calculated efficiency values. The Mountain hydraulic module with integrated intelligence (master) controls this function. The master units are superordinate to the refrigerating machines and the recooler and communicate directly with the control system. This unit contains a pump module that is interposed between the refrigerating machines and the recooler. A plate exchanger serves as system separator between the consumer network (water) and the recooler (water-glycol). Thanks to the patented hydraulic circuit, a constant coupling of the free cooling part in the consumer network is possible. This operation mode (mixed operation) is very important, with over 2000 hours of operation per year.
In the so-called mixed operation, corresponding valves are connected, the recooler runs with full loads and the lacking cooling energy is mechanically coupled into the consumer network via the refrigerating machine if necessary. If the refrigerating machines are running in the partial load range, pre-cooling is performed by the recooler. If the temperatures rise anew, the free cooling part is steadily reduced, until the point where the refrigerating machines provide all the power.

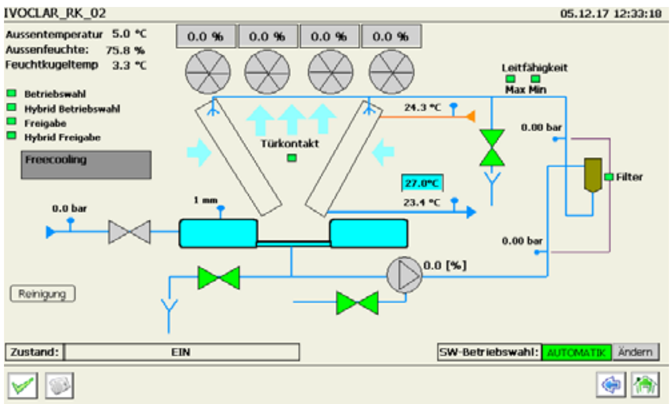


In this extreme operation case (design basis case), the cold generation must perform at 100%. The system is decoupled and functions as a classic chiller.

Controlling and connection

Thanks to the intelligent hydraulic master module, all these operation modes can be run fully automatically. The exterior temperature and humidity, as well as the effective cold requirements of the server rows are therefore decisive for the choice of operation mode. The load discharge is optimised thanks to the high cold-water temperatures of 19/29°C. The connection of the Mountair system to the BMS is performed via bus.
The master units are fundamentally independent from the building automation. Only the consumer mass flow is transferred from the BMS to the Mountair master. This allows a use-dependent cold generation/storage charging and an ideal load distribution between the (three) cold generation modules. If the BMS fails, the masters fully regulate themselves. The principle applied is: "emergency start" (instead of emergency stop).
All Mountair systems are equipped with visualisation and touch screen panels. The current ideal and actual values can be consulted at all times and are recorded for system optimisation purposes.





Mountair AG
Lufttechnischer Apparatebau
Sonnenwiesenstrasse 11
8280 Kreuzlingen

T +41 71 686 64 64
F +41 71 686 64 76

Mountair AG, Basel
Florenzstrasse 9
4142 Münchenstein

T +41 61 841 09 74
F +41 61 841 09 75

Mountair AG, Suisse Romande
Route de Saint Julien, 275
1258 Perly

T +41 (0)79 104 90 38

info@mountair.com
www.mountair.com

2020-09 | cinziadesign.ch