CH50 - CH480

Service Book **KHA13950 - ENGLISH**

Aquatech

AQUATECH adopts a policy of on-going development.

With the exception of information required by law, the general information (or diagrams) featured in this document may depict models and/or versions different to the one you have purchased.
This will in no way alter the validity or applicability of the information provided.

ENGLISH

This manual is completed with the wiring diagram. The wiring diagram is included in the CD-Rom.
The paper version of the manual must obligatorily contain also the wiring diagram.

Non original instructions obtained by translating the original manual written in Italian

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	Refers to procedures or practices that, if not performed correctly, *will cause* serious damage to health, injury or death.
	Refers to procedures or practices that, if not performed correctly, *may cause* serious damage to health, injury or death.
	Refers to procedures or practices that, if not performed correctly, *may cause* damage to the product.
	Danger: electric discharge.
	Danger: hot surface.
	Protective footwear must be worn.
	Protective gloves must be worn.
	Head protection must be worn.
	Face guard must be used.
	Respiratory protection must be used.

Tab.1

1. GENERAL INFORMATION

The machines described in this manual will hereinafter be called “WATER CHILLER” or simply “CHILLER”.
This manual is for the personnel assigned to installing, using and servicing the chiller.
These chillers have been designed to cool a flow of liquid.
In most applications the liquid to cool is water; for this reason the word “WATER” will hereinafter be used even if the liquid to cool is not water (for instance, a mixture of water and ethylene glycol).
The liquid to cool must be compatible with the materials used: this analysis must always be made prior to purchasing or installing the chiller (see “WATER SPECIFICATIONS SHEET” on page 33).
When interfacing with other processing machines, keep strictly to the instructions given by the manufacturers of the other machines.

2. SAFETY

2.1. GENERAL INFORMATION

This machine has been designed to be safe for its designated use provided it has been installed, commissioned and serviced following the instructions given in this manual.
Therefore it must be studied by anyone wishing to install, use or service the system.
The machine contains electric components that operate at line voltage and also moving parts such as the fan and/or pump.
Therefore it must normally be cut off from the electricity supply before being opened.
Any maintenance work that requires access to the system must be performed by skilled or suitably trained personnel who are fully aware of the necessary precautions.
When handling or servicing the machine and auxiliary equipment, personnel must work in safety and observe the instructions concerning safety and health at the place of installation.
Many accidents that occur when operating and servicing the machinery are the result of failing to observe basic safety precautions or rules.
Accidents can often be avoided by recognizing a situation that is potentially hazardous.
The user has to make sure that all personnel concerned with operating and servicing the machine and auxiliary equipment have **read and understood** all the warnings, precautions, prohibitions and notes given in this manual and on the machine.
Improper use or maintenance of the machine and auxiliary equipment can be hazardous and cause even fatal accidents.
Never operate the machine or auxiliary equipment until the instructions on starting and operation have clearly been read and understood by the personnel involved.
Never perform any maintenance work or repairs until the instructions given in this manual have clearly been understood by the personnel involved.
It is not possible to foresee all the possible circumstances that may be a potential hazard for people. The notes on safety in this manual are therefore not exhaustive.
If the user employs operating procedures, instruments or work methods that are not specifically recommended, he must make sure that the machine and auxiliary equipment do not get damaged or made unsafe, and that there are no risks for people and property.
The water chillers made by AQUATECH must not be installed in potentially explosive atmospheres (they are not explosion proof).

2.2. GENERAL PRECAUTIONS

2.2.1. Liquids to cool

The liquids to cool must be compatible with the materials used (see “WATER SPECIFICATIONS SHEET” on page 33). They may, for instance, be **water or mixtures of water and ethylene glycol**.
Never use distilled or demineralized water as it is incompatible with the construction materials of the chiller.
It is recommended to add anti-corrosive chemical additives to the water that are compatible with the materials used and work with pH between 7 and 8.
In the case of glycol mixtures, too, it is extremely important to use appropriate chemical additives (contact the glycol supplier) to protect the materials of the chiller from any corrosive action caused by the chemical deterioration to which glycol is subject.
Using these chemical additives **is necessary** when the chiller belongs to **a hydraulic circuit that is open to the atmosphere in at least one point**: in this case, the constant supply of oxygen will feed any corrosive reactions inside the chiller.
The liquids to cool must be not flammable. If the liquids to cool contain hazardous substances (such as, for instance, ethylene glycol), any liquid spilling out of an area of leakage must be collected as it can damage the environment.
In addition, when the chiller will no longer be used, it will be necessary to dispose of the hazardous liquids by consigning them to specialized firms authorized to treat them.

2.2.2. Precautions for lifting and transport

The machine must be handled by expert personnel in accordance with binding safety and health regulations.
Check the state of the machine after removing the packing. If you have any doubts, do not use the machine and contact the AQUATECH Technical Service Department.
The packaging must be disposed of in accordance with binding waste disposal regulations.
Avoid all hazardous situations when using a hoist to lift heavy items.
When a load is lifted off the ground, it is necessary to keep away from the area beneath and around it.
Keep the lifting speed and acceleration within safe limits and never leave a load hanging from a hoist any longer than necessary.
Handling chillers with lift forks must be done **in accordance with the enclosed diagrams and figures.**

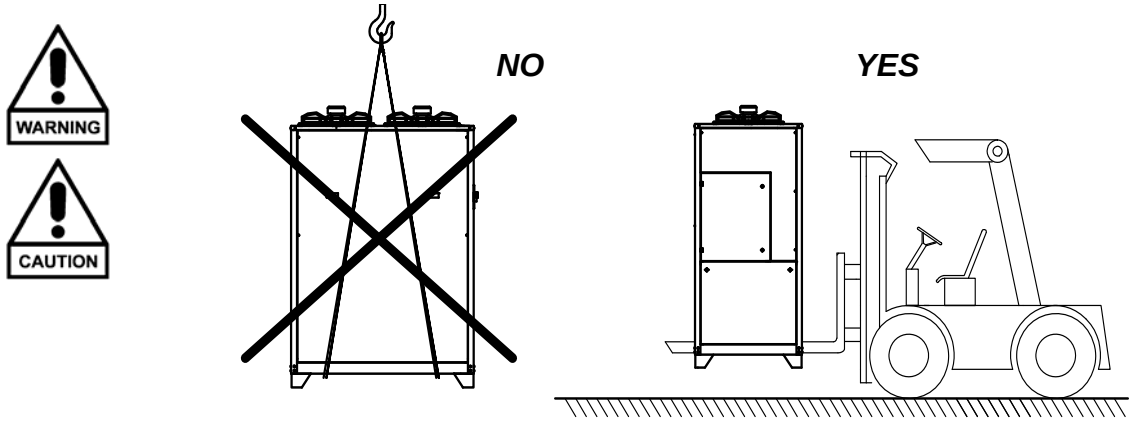


Fig. 1

2.2.3. Precautions to be observed during installation

The machine must be installed by expert personnel in accordance with binding safety and health regulations.
For the connection to the electricity supply, check that the voltage and frequency stated on the machine data plate correspond to those of the electricity mains and check that the mains circuit is suitably scaled for the machine maximum power (Tab. 2 page 9).

2.2.4. Precautions during operation

Machine operation must be followed by skilled personnel directed by a qualified supervisor.
All the water pipes must be painted or clearly marked in accordance with local safety regulations at the place of installation.
Do not remove or tamper with the safety devices, guards or insulating materials installed on the machine or auxiliary equipment.
All the electrical connections must conform to the regulations at the place of installation.
The machine and auxiliary equipment must be earthed and protected against short-circuits, overloads and insulation failures (residual current switch).
When the main switch is turned off the voltage in the electric circuit reaches fatal levels; therefore, if it is necessary to work on the electric circuit, the greatest precautions must be taken.
Never open the panels closing off the electrical equipment while it is live unless this is necessary for testing, measurements or settings that are anyhow to be made by skilled personnel equipped for the purpose.
This work should be performed solely by qualified personnel with suitable equipment and wearing protection against dangers of an electrical nature.

2.2.5. Precautions for maintenance and repair work

Maintenance, overhauling and repairing the machine must be performed by **skilled personnel directed by a qualified supervisor.**
Tab. 13 page 29 for the machine's scheduled maintenance.
When it is necessary to discharge waste materials, make sure no water courses are polluted and no materials are burnt that may pollute the air.
Use solely appropriate storage methods that are environment friendly.
If spare parts are needed, use genuine parts only.
Keep a written report of all the work done on the machine and auxiliary equipment; use the attached sheet for this purpose.
The frequency and nature of the work required in a certain period may reveal abnormal operating conditions that should be corrected.
Use solely the refrigerant gas specified on the machine's data plate; never substitute or mix gases as they are not alternatives.
Make sure that all the instructions concerning operation and maintenance are closely followed and that the entire unit with all its accessories and safety devices is serviced in good working order.
The accuracy of the temperature and pressure gauges has to be checked regularly. They need to be replaced when the acceptable tolerances are exceeded.
Always keep the machine clean. Protect the components and exposed openings by covering them for example with clean rags during maintenance work and repairs.
Never weld or perform any other operations that generate heat near a system containing oil or flammable liquids.
Systems that may contain oil or flammable liquids must be completely drained off and cleaned, for example with steam, before performing these operations. Never weld on, or anyhow modify, a container that can be pressurized.
To prevent an increase in working pressure and temperature, check and clean the heat exchange surfaces (e.g., the condenser fins) regularly. Set down a suitable frequency for cleaning each unit. Tab. 13 page 29 for the machine's scheduled maintenance.
Avoid damaging the safety valves and other pressure limiting devices.
Avoid obstructing these parts with paint, oil or accumulated dirt.
Precautions need to be taken when welding or performing repair work generating heat, flames or sparks. The components nearby need to be protected with non-flammable material and if the work needs to be done near parts of the lubrication system or near components that may contain oil or flammable liquids, the system must first be bled.

Never use a source of light such as a naked flame to inspect parts of a machine.
Before dismantling machine parts, make sure all the movable and heavy parts have been secured.
When repairs have been completed, make sure no tools, loose parts or rags have been left inside the machine.
Check the direction of rotation of the motors when starting the machine for the first time after work on the electrical connections or on the supply disconnecting device.
All the guards have to be re-installed after maintenance or repair work.
Never use flammable liquids to clean components when the machine is running. If non-flammable hydrocarbons containing chlorine are used for cleaning, all the safety precautions must be taken against the toxic fumes that may be given off.
Before removing any panels or any part of the unit, perform the following operations.

- Cut off the machine from the main electricity supply from above the supply cable.
- Lock the disconnecting switch in the “OFF” position with a padlock.
- Put a sign up on the disconnecting switch warning “WORK IN PROGRESS - DO NOT POWER UP”.

Do not turn on the electricity supply switch or try to start the machine if there is a warning sign attached.
The manufacturer cannot be considered liable for any damage to people or property caused by the failure to observe the above-mentioned safety regulations. These rules supplement but do not replace the binding industrial accident prevention regulations in the country where the machine is installed.
The chillers are charged with R407c or R22. Refer to the identification plate on the back panel of the machine.
To clean a heavily contaminated chiller circuit, for instance after the burning of the compressor, it is necessary for the work to be done by an expert chiller technician.
Cylinders containing refrigerant gases must be used and stored in accordance with the recommendations of the manufacturers of these cylinders and with the binding safety laws and regulations at the place of installation.
The machine can arrive at its destination packed in palletizable cardboard packing, crates, cages, wooden pallets and protective plastic sheets. Keep the packing materials to protect the machine if it has to be moved again in the future; in any case, dispose of such materials observing the binding provisions in the place of installation.

2.3. SAFETY DEVICES

The water chillers are equipped with the following safety devices:

- **SP2,** high pressure switch, which have been adjusted to 2600 kPa *(26 bar)*; **it is forbidden** to modify the setting value.
- **QM1 - QM2 - QM6,** motor circuit breakers which have been adjusted according to the maximum current rating of each protected motor: **it is forbidden** to modify the setting value.
- **QM3,** Compressor circuit breakers, which have been adjusted according to the maximum current rating shown in the electric drawing: **it is forbidden** to modify the setting value.

3. TECHNICAL DATA

MAIN TECHNICAL DATA		CH50		CH90	
Power supply voltage	V	400	460	400	460
Power supply frequency	Hz	50	60	50	60
Place of installation		indoor			
Cooling capacity (*)	kW	6.6		10.2	
Total power installed (standard pump) (**)		4.1	4.6	4.9	5.7
Total power installed (uprated pump) (**)		6.8	6.3	7.8	7.4
Maximum noise level	dBA	≤80			
Type of refrigerant		**R407C**			
Type of compressor fluid		Mobil EAL ARCTIC 22CC			

MAIN TECHNICAL DATA		CH180		CH280		
Power supply voltage	V	400	460	400	380	460
Power supply frequency	Hz	50	60	50	60	
Place of installation		indoor				
Cooling capacity (*)	kW	22		38		
Total power installed (standard pump) (**)		8.3	8.8	13.3	14.4	
Total power installed (uprated pump) (**)		9.6	10.5	15.6	17.4	
Maximum noise level	dBA	≤80				
Type of refrigerant		**R407C**				
Type of compressor fluid		Mobil EAL ARCTIC 22CC				

MAIN TECHNICAL DATA		CH380			CH480		
Power supply voltage	V	400	380	460	400	380	460
Power supply frequency	Hz	50	60		50	60	
Place of installation		indoor					
Cooling capacity (*)	kW	47.4			57		
Total power installed (standard pump) (**)		16.4	17.1	17.5	20.2	20.1	20.6
Total power installed (uprated pump) (**)		18.7	20.1	20.5	21.9	22.9	23.3
Maximum noise level	dBA	≤80					
Type of refrigerant		**R407C**					
Type of compressor fluid		Mobil EAL ARCTIC 22CC					

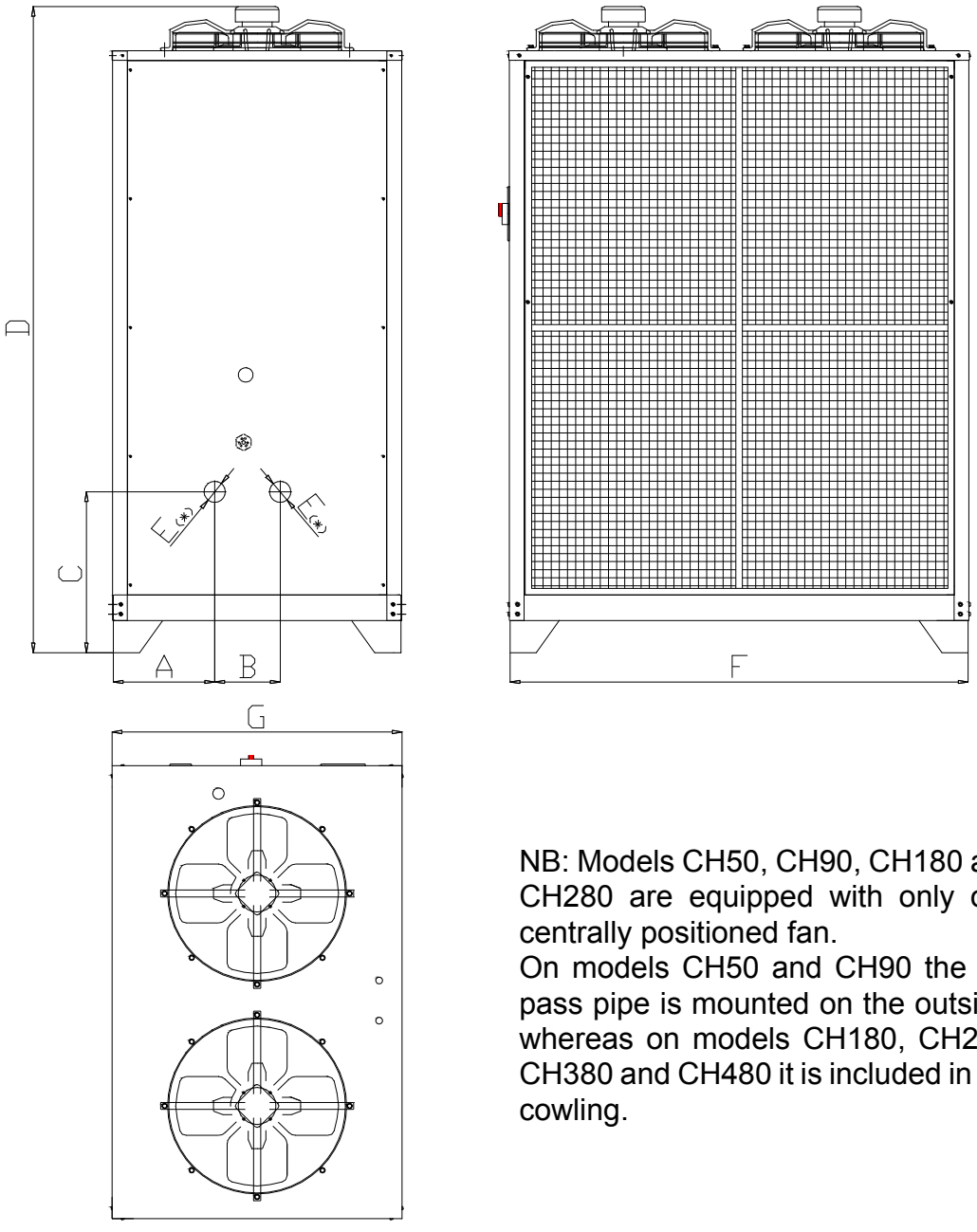
WORK ENVIRONMENT			
Ambient temperature	°C *(°F)*	version for indoor installation (standard)	7 ÷ 40 *(44.6 ÷ 104)*
		version for outdoor application with fan speed regulation (special)	7 ÷ 45 *(44.6 ÷ 113)*
Maximum altitude	m	1500	
Transport and storage temperature	°C *(°F)*	-10 ÷ 50 *(14 ÷ 122)*	
Design pressure PS top side	kPa *(barg)*	2800 *(28)*	
Design pressure PS bottom side		2260 *(22.6)*	

Tab.2

(*) Measured in the following conditions: Ambient temperature = 25°C *(77°F)*; Temperature of the water entering the chiller = 15°C *(59°F)*;
Altitude 0 m; Refrigerated liquid: water without additives.
(**) See wiring diagram.

4. GENERAL DESCRIPTION OF THE MACHINE

4.1. TECHNICAL SPACES, WEIGHTS



NB: Models CH50, CH90, CH180 and CH280 are equipped with only one centrally positioned fan.
On models CH50 and CH90 the by-pass pipe is mounted on the outside, whereas on models CH180, CH280, CH380 and CH480 it is included in the cowling.

	A	B	C	D	E	F	G	WEIGHTS (kg)
CH50-CH90	391 mm	150 mm	441 mm	1500 mm	G 3/4"	1007 mm	677 mm	230-240
CH180-CH280	310 mm	200 mm	500 mm	1670 mm	G 1"	1220 mm	886 mm	295-370
CH380-CH480	310 mm	200 mm	500 mm	2010 mm	G 1"1/4	1409 mm	886 mm	460-500

Tab.3

4.2. OPERATION

4.2.1. Hydraulic circuit

The liquid to cool coming from the services enters the circulation pump and is sent through the evaporator, where it is refrigerated thanks to the action of the refrigerant gas that evaporates; from the evaporator it passes through the accumulation tank to be sent back to the services (see tables of spare parts).

Motor pump (M1)

Centrifugal with impeller in stainless steel (standard or uprated version).

Inertial accumulation tank

In hot-galvanized iron with anti-condensation insulation, together with a fixed setting safety valve, bleed valve at the highest point and drain tap.

System charging assembly (4)

A pressure reduction unit keeps the pre-charging pressure at a value of 50 kPa *(0.5 bar)*. It is equipped with an integrated pressure gauge and tap to shut off the water supply.

Differential pressure switch (SF1)

This detects a pressure drop within the evaporator by detecting the flow of water. A low water flow rate causes the machine to stop with an alarm.

Anti-freeze protection (BT2)

A probe detects the water temperature immediately at the evaporator outlet. The control panel constantly checks this temperature does not drop under the anti-freeze Set Point. If this happens, the anti-freeze alarm triggers and the compressor is stopped. On standard machines the anti-freeze Set Point is set to 4°C *(39.2°F)*.

Manual by-pass (10)

Between the machine inlet and outlet there is a manual by-pass in order to adjust the flow rate of refrigerated fluid to the service.
The sequence to set the by-pass correctly is described below.
NOTE: This sequence should be performed with the system fully charged and the pre-charging pressure stabilized (50 kPa - *0.5 barg*).
1. Shut the register of the by-pass completely by turning it fully clockwise.
2. Check that the services are open and they therefore mirror the conditions of normal operation.
3. Set the AQUATECH Chiller working as described in the user manual.
4. Check the working pressure shown on the pressure gauge near the register and directly connected with the piping coming out of the AQUATECH Chiller.
5. If the pressure shown is too high, open the by-pass with the register and turn it anticlockwise to reach the required pressure.

NOTE: If completely shutting the by-pass trips alarm E41, set the register of the by-pass until the alarm tripping is prevented.

4.2.2. Chiller circuit

The refrigerant in a gaseous state on leaving the compressor reaches high pressure and temperature in the pipes of the condenser where condensation takes place via ambient air blown by the fans. Downstream from the condenser, the liquid refrigerant passes through the dewatering filter, the refrigerant gauge and the thermostatic expansion valve, that supplies the evaporator according to the load. On leaving the evaporator, the gaseous refrigerant is sucked in by the compressor (see tables of spare parts).

Compressor (M3)

The compressors are the airtight scroll type. The motors have an internal protection against electric and heat overloads: in addition, they are protected externally by a specific magnetothermal motor cut-out in the electric panel. After any work on the internal thermal protection, normal operation is automatically restored when the temperature of the windings falls under the set safety level in a time that may vary from a few minutes to a few hours.
Lubrication is ensured by a specific integrated pump: oil suction takes place via the casing and it is distributed on the bushings and internal parts subject to sliding.
The oil level in the casing is visible through a sight glass; the sight glass must be half-covered by the oil contained in the casing.
Each compressor has an electric heating element that heats the casing to prevent the refrigerant gas condensing during stoppages and mixing in high percentages with the oil in the casing. The electric heating element must be powered at least 2-3 hours before starting up the machine.
All the compressors are mounted on special rubber mounts to limit the transmission of vibration to the chiller structure.

Condenser (C)

The air-cooled condenser is made up of several rows of mechanically expanded copper tubing with aluminium fins.
The large surface area of exchange ensures proper sub-cooling and therefore the right supply to the thermostatic valve.
The volume of the coils ensures a partial storage of the machine's refrigerant during maintenance.

Filter (17)

This is located on the liquid line and eliminates any debris and moisture from the circuit, preventing acid residues from forming that would damage the compressor.

Liquid and moisture gauge (18)

This is located on the liquid line and signals a sufficient refrigerant charge when the flow of fluid crossing it is clear and constant. If the flow is turbulent with gas bubbles, the machine charge is insufficient. The chiller circuit must be completely free of moisture, whose level is signalled by the colour taken on by the ring-shaped sensitive element inserted in the gauge.

Solenoid valve (YV1)

Positioned on the liquid line, it prevents refrigerant migrating towards the compressor casing during downtime.

Thermostatic expansion valve (13)

This is mounted right before the evaporator. A sensitive bulb at the evaporator outlet is connected via a capillary tube to the valve body and, opposing the action of the equalization tube, it acts according to the overheating detected, increasing or decreasing the amount of refrigerant entering the evaporator.
The valve is set for gas overheating of 5-7°C *(41-44.6°F)* to prevent the compressor from being able to draw in liquid.

Evaporator (E)

The evaporator has brazed plates insulated with an elastomer mattress that protects the exchanger from condensation.

High-pressure switch (SP2)

This is located on the compressor delivery line.
It stops the compressor when the condensation pressure exceeds the setting.
Once it has tripped, the pressure switch must be reset manually pressing the reset button located on the switch itself.

Low pressure switch (SP3)

This is located on the suction line. It stops the compressor when the suction pressure reaches the setting. The compressor can restart when the pressure has increased by the amount of the differential.

Fan control pressure switch (SP1)

This is located on the compressor delivery line.
It controls the operation of the fan(s) according to the condensation pressure. This component is not fitted on the versions for outdoor application where the fans are powered through a speed governor according to the condensation pressure.

4.3. CONTROL PANEL

On the control panel of the machine there is:
QS1: Main switch. This is the point to which the machine's power cables are connected. It can be used to turn off the power under normal conditions or in an emergency.
ST1: Control panel. This device guarantees that the water temperature is maintained at the set level and checks the operation of the chiller managing any alarm situations.
HP: High-pressure switch. Checks the gas delivery pressure of the compressor (high-pressure). The reading must be taken on the scale which refers to the gas with which the machine has been charged.
LP: Low pressure switch. Checks the gas suction pressure of the compressor (low-pressure). The reading must be taken on the scale which refers to the gas with which the machine has been charged.

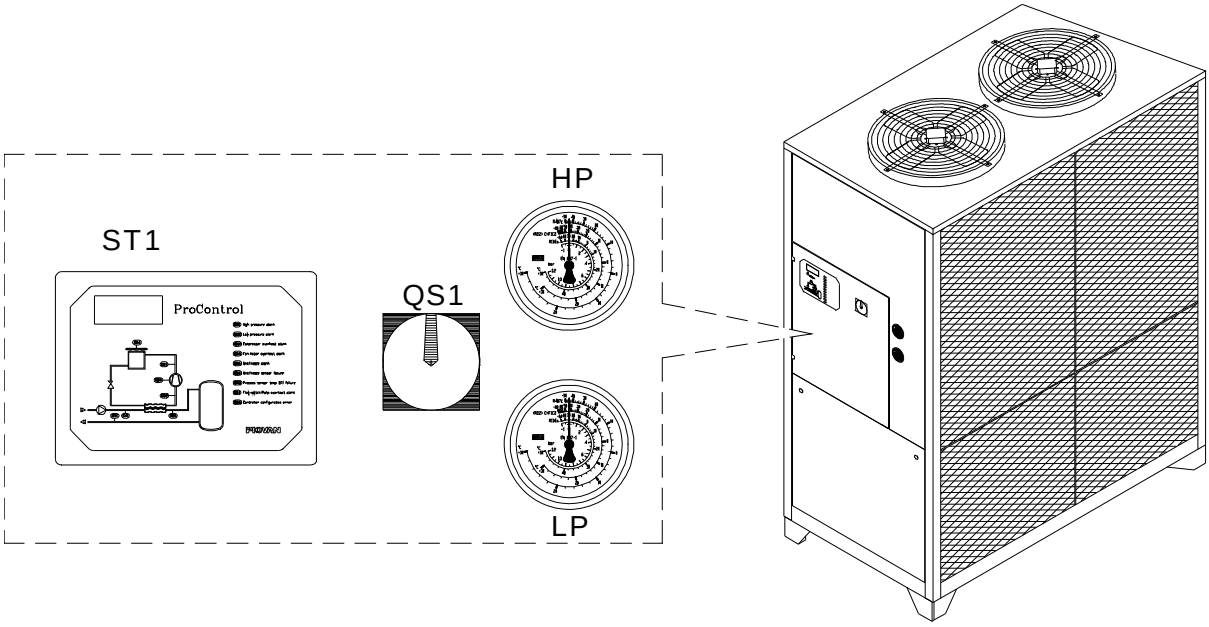


Fig. 2

5. DUCTING FOR HOT AIR LEAVING FANS

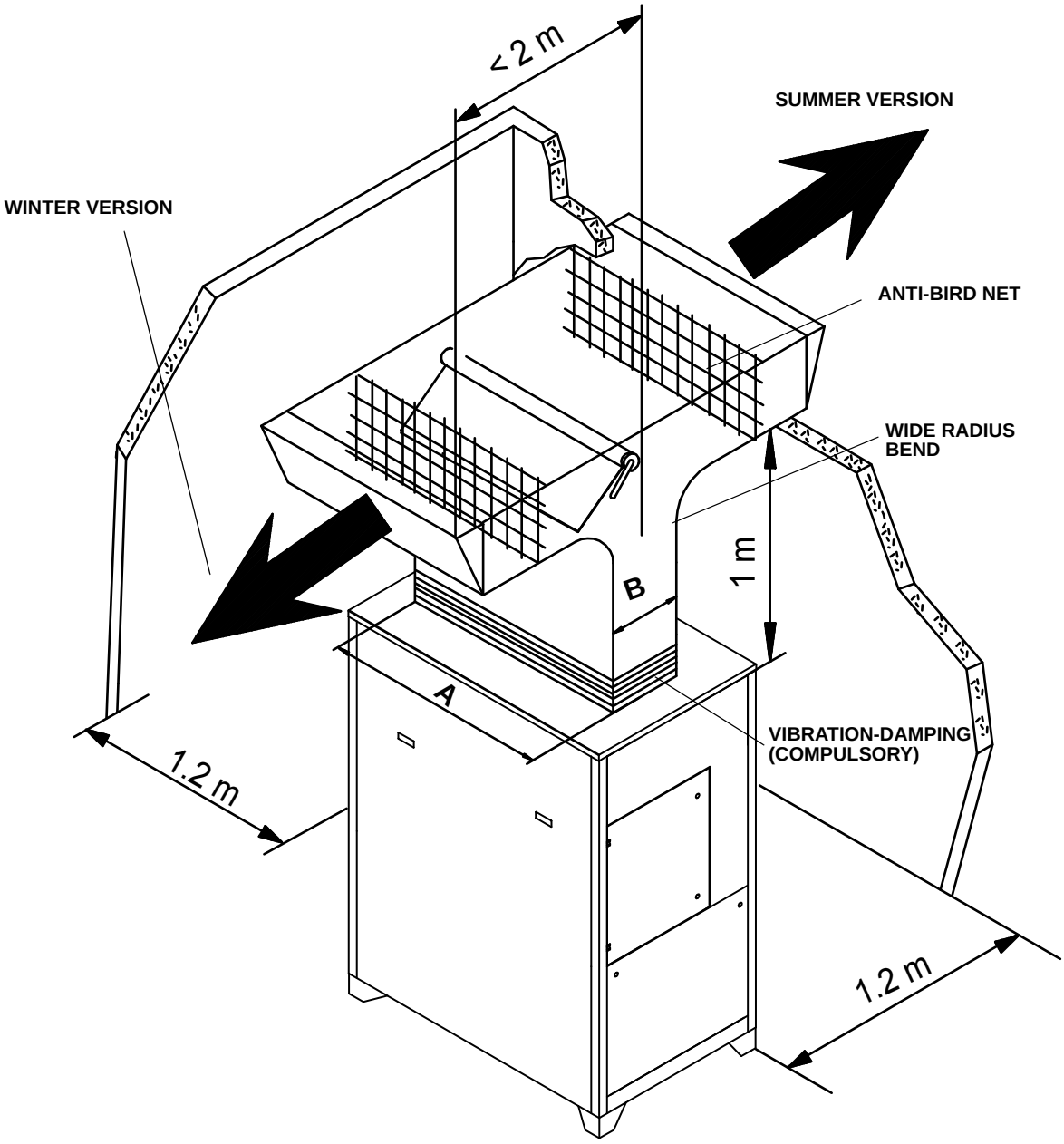


Fig. 3

N.B. The drawing of the ducting represents one example of application.

	A	B
CH50-90	600 mm	600 mm
CH180-280	800 mm	800 mm
CH380-480	1300 mm	750 mm

The chillers in the CH series are equipped with axial fans that cause a certain airflow to circulate through the condenser coils. The passage of cool air into the condensers is necessary to condense the hot refrigerant contained within them under high pressure.
For the same ambient air inlet temperature, the condensation temperature is a function of the quantity of air flowing through the condenser coils. When the airflow decreases, the condensation temperature increases until it reaches the conditions for tripping the high-pressure switch (SP2) and diminishing the cooling capacity of the chiller.
A chiller in which the airflow through the condenser coils diminishes, would therefore have performances and functioning limitations lower than those of a machine with design airflow.
Although the use of axial fans does not originate for the installation of ducting for hot air leaving them, this can be carried out provided that:

- a reduction in the cooling capacity of the machine is accepted, with the ambient temperature and the water temperature on leaving the chiller being equal;
- a reduction in the maximum working ambient temperature of the machine is accepted;
- the instructions given below are complied with.

In the installation of a chiller in the CH **series, a maximum reduction in the airflow through the condenser coils of 20% of the nominal airflow is permitted, provided that a reduction in cooling capacity and a reduction in maximum working ambient temperature is accepted.** The reduction in the airflow causes a smaller pressure drop in the condenser coil and an increase in the head of the fan. The result of the difference between these two is the useful head for the hot air ducting.

A 20% reduction in the airflow leads to an average reduction in cooling capacity of 4% and to an average reduction in maximum working ambient temperature of 5°C *(41°F)*. These values are anyhow approximate and can be subject to considerable increases if further impediments to the correct passage of air through the condenser coils (walls too close, lack of sufficient ventilation in the room, dirty filters, …) exist.

In the following table the design flow rates for each model of CH chiller and the available head for the hot air ducting are given considering a reduction in flow of 20%.

Chiller model	No. of fans	Nominal flow rate per fan [m ^{3}/h]	Flow rate reduced by 20% per fan [m ^{3}/h]	Available pressure drop [Pa]
CH50	1	6100	4880	76
CH90	1	5600	4480	75
CH180	1	7800	6240	29
CH280	1	8300	6640	35
CH380	2	2 X 7500	2 X 6000	67
CH480	2	2 X 7200	2 X 5760	71

Tab.4

In indicating the flow rates of air, a single fan is considered; all the following considerations refer to a single fan, the number of ducts in machines with two fans will have to be doubled.
For calculating the pressure drop in the air distribution ducts, the following data have been assumed:
• Air density of 1.204 kg/m³. This value is really a function of the air temperature and the height above sea level, but can be considered valid for a broad work field.
• Galvanized expulsion ducts (maximum roughness ε = 0.09 mm) and joints about every 1.2 m.
In calculating air-pressure drop of the duct, both the distributed pressure drop (the duct itself) and the concentrated pressure drop (bends, expulsion outlets, shutters, …) will have to be considered.

With regard to the **distributed pressure drop**, refer to Fig. 6 - pag. 18, where the air-pressure drop values are given in Pa/m according to the airflow in l/s and the diameter of the duct in mm and to Fig. 7 - pag. 18, where the equivalent diameters for the rectangular section ducts are given.
When choosing the duct diameter always stay within the grey zone.
As regards the **concentrated pressure drop**, the bends, the expulsion outlets and the various shutters can be traced back to a certain number of equivalent lengths of round duct. Consider the values given in table no. 5.

Components typology	Equivalent length
90° bend with ratio of 1:1 between radius of curvature and diameter.	17 m
90° bend with ratio of 2:1 between radius of curvature and diameter.	10 m

Tab.5

For other components, refer to the manufacturer's instructions.

One last consideration must be made about the height of the duct outlet compared to the level of the fan (h). In fact, an additional “pressure drop” must be considered, of:

$\Delta P = 1.204 \times 9.8 \times h = 11.8 \times h$ [Pa]

5.1. EXAMPLES OF SIZING EXPULSION DUCTS

Example of calculation “A”
A CH480 has to be ducted to expel hot air from the condensers at a height of 1 metre above the level of the fans.
In tabella 4 - pag. 15 it says that the nominal flow of the machine fans is 7200 m³/h (third column).
On the chillers in the CH series, a maximum reduction in the airflow of 20% is permitted. The airflow to be allowed for will therefore be 5760 m³/h per fan (penultimate column).
With this flow, the head of the fan available for the ducting is 71 Pa *(0.71 mbar)* (last column).
Suppose one wants to duct the air with a section of 500 x 500 mm square duct to a height of 1 m above the level of the fans, and one then wants to bring the duct into a horizontal position with a bend to then expel the hot air (Fig. 3 page 14). One therefore wants to know the maximum length of the horizontal section of the duct.
In the diagram of Fig. 7 - pag. 18, it says that a duct with a 500 x 500 mm cross-section is equivalent to a round duct of 550 mm.

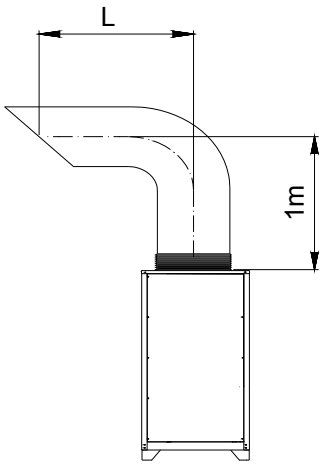


Fig. 4

In the diagram of Fig. 6 - pag. 18, with an airflow of 5760 m³/h, equivalent to 5760 x 1000 / 3600 = 1600 l/s, the following values can be read:
• Distributed pressure drop = 1.2 Pa/m;
• Air speed 7.5 m/s (needed for calculating the concentrated pressure drop in some ducting component catalogues).

The bend (considering a radius/diameter ratio of 1), will lose the equivalent of 17 m of duct, that is 17 x 1.2 = 20.4 Pa *(0.204 mbar).*
To take the air to a height of 1 m, 1 x 11.8 Pa *(0.118 mbar)* = 11.8 Pa *(0.118 mbar)* will be necessary and the vertical metre of duct loses 1 x 1.2 = 1.2 Pa *(0.012 mbar)*.
As a final loss, the drop in air-pressure on leaving the duct must be considered (called loss due to sharp outflow), equal to 1 x (0.612 v ^{2}) = 35 Pa *(0.35 mbar)*, where v indicates the air speed in the duct (7.5 m/s).

Considering, then, that the available head with a reduction in the nominal flow of 20% is 71 Pa *(0.71 mbar)*, the maximum length of the horizontal section will be:

Maximum duct length = $\frac{71 - 1,2 - 20,4 - 11,8 - 35}{1,2}$ = 2.2 m

This obviously does not take into account other components that might be installed such as shutters, expulsion grilles or other things that might lead to a large reduction in the maximum length.

Example of calculation "B"
If we wanted to expel the air with a vertical duct, we should allow for:
Air-pressure drop at bend = 17 x 1.2 = 20.4 Pa *(0.204 mbar)*
Air-pressure drop due to outflow = 35 Pa *(0.35 mbar)*
Therefore we have:
1.2 x L = 71 - 20.4 - 11.8 x L - 35 where L is the maximum duct length.

That is L = $\frac{71 - 20,4 - 35}{11,8 + 1,2} = 1,2m$

This obviously does not take into account other components that might be installed such as shutters, expulsion grilles or other things.
Attention is paid to how having to expel air upwards is much more important than having to make horizontal sections of duct.
As a general rule, when sizing ducting for these machines, as far as possible try to use ducts with a large cross-section and with as few bends and narrowings or supplementary components as possible. Special attention must also be paid to the wind direction that could slow down, or even reverse, the airflow.

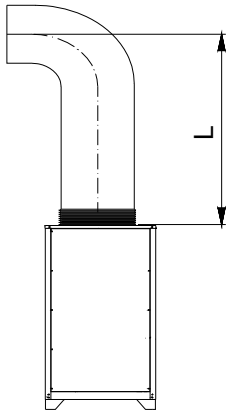


Fig. 5

Fig. 6

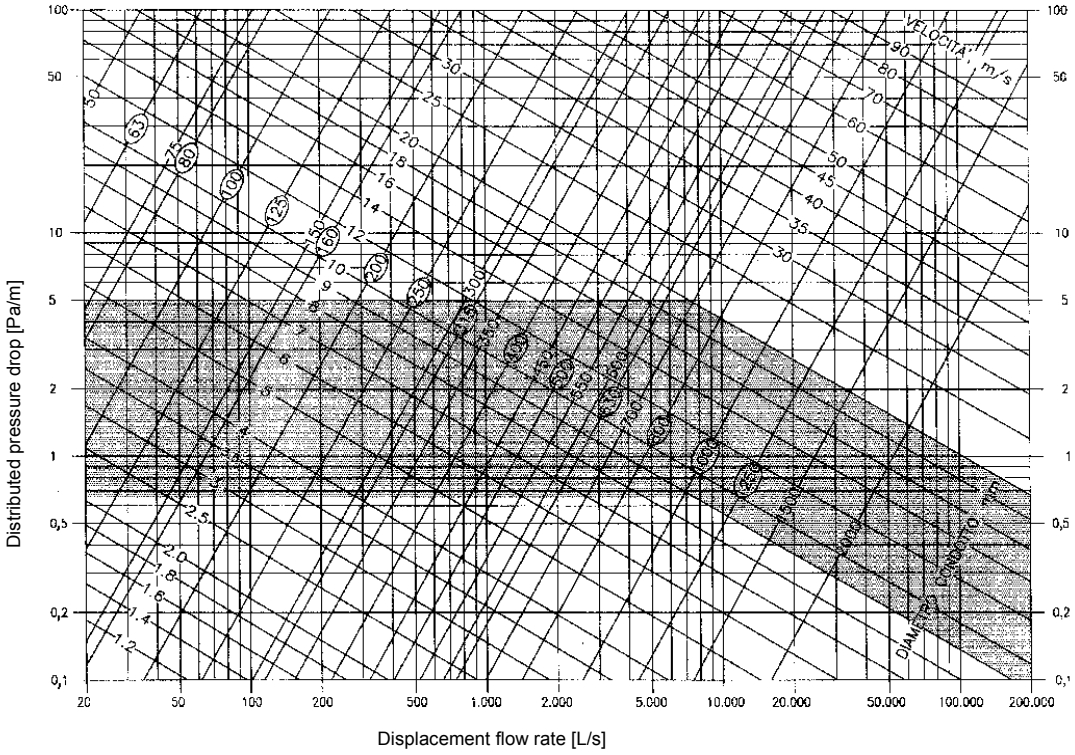


Fig. 7

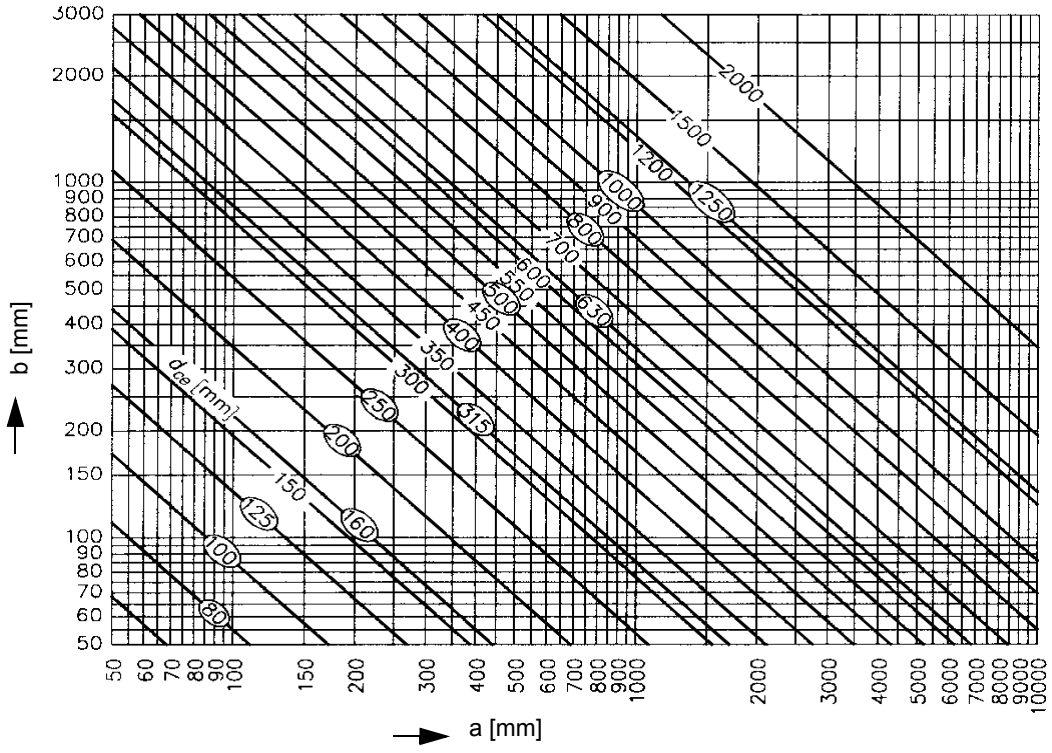
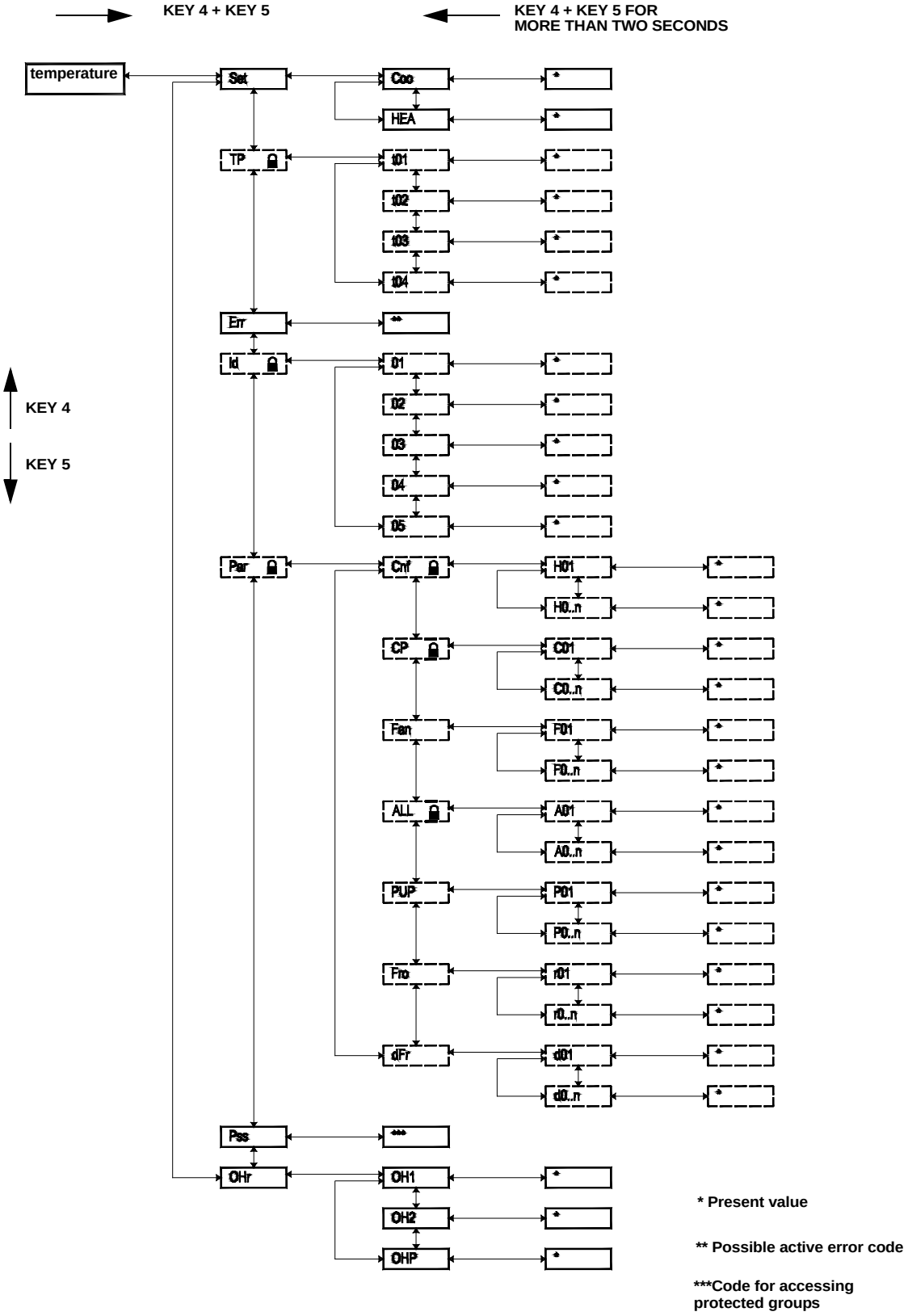


Fig. 8



6. INSTALLATION

6.1. REQUISITES OF THE ROOM - POSITIONING

There must be sufficient free space around the perimeter of the machine to guarantee easy access to all the parts that need servicing and to the service and control members.

Machines with air condensing must observe the minimum distances around the perimeter in order to guarantee proper ventilation of the condensing coils.

The stated maximum ambient temperatures take into account the correct installation of the machine. Incorrect installation inevitably leads to a reduction in this value.

Installation must be carried out by specialized personnel.

Never install the machines in harsh environments, in small rooms or rooms with poor ventilation and the risk of re-circulating condensation air. The chiller can only be installed in the open if it is in the version for outdoor application (special) and must be protected from atmospheric agents by a special canopy. In any case observe the instructions regarding positioning given in the Par. “REQUISITES OF THE ROOM - POSITIONING” on page 20.

Position the machine on a flat surface. If installing on an elevated surface, make sure it is adequately structured and scaled to bear the weight of the machine and big enough to accommodate it.

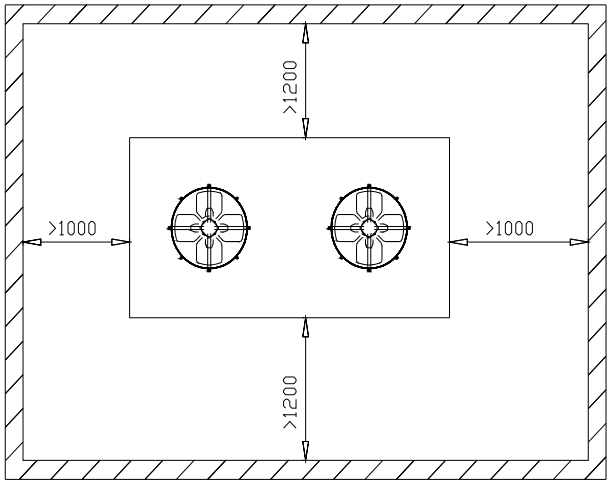


Fig. 9

Observe the minimum distances for positioning (Fig. 9 page 20), to guarantee easy access to all the parts that need servicing and to the service and control members.

Machines with air condensing must observe the minimum distances around the perimeter in order to guarantee proper ventilation of the condensing coils.

Do not obstruct the flow of cooling air of the condenser. Position the chiller so that the air expelled from the fans cannot recirculate into the suction filters.

Make certain that the chiller is not assailed by the hot air coming from the cooling systems of other machines. The flow of hot air leaving the fans must absolutely not meet any obstacles that might impede the diffusion of hot air into the environment.

A minimum height of 3 metres between the fan outlet and any obstacle is permitted.

If more than one unit is installed, the minimum distance between the refrigerating units must be no less than 2 metres, to prevent interference in the working of the fans of each machine.

An installation that does not take into account the recommended technical spaces will cause the machine to function poorly and will result in a considerable reduction in the refrigerating power delivered, an increase in consumption and a substantial reduction in maximum working temperature.

If necessary, duct that air outlet of the fan(s) complying with the maximum lengths and cross-sections given in Chap. “DUCTING FOR HOT AIR LEAVING FANS” on page 14; provide suitable aeration for the reintegration of the expelled air.

If installed in a closed place the room must be well ventilated. In some cases it might be necessary to install fans or extractors in the room to limit its temperature.
The ambient air must be clean and contain no flammable gases or solvents. The minimum and maximum working temperature are specified in the Chap. “TECHNICAL DATA” on page 9.

6.2. REFRIGERATED WATER DISTRIBUTION NETWORK

6.2.1. Head of the pump on the machine and head at the service

Due to a drop in pressure in the refrigerated water distribution circuit, the head at the service will be lower than that stated in the pump characteristics.
For this reason, when installing the chillers, it is necessary to size the pipes of the hydraulic system correctly.
Incorrect sizing can significantly decrease the performance of the pump installed on the machine, in terms of both head at the point of use and rate of flow.
For this reason the instructions in this manual must be strictly followed or a designer must be used to size the plant correctly.
AQUATECH shall not be held responsible for a decrease in chiller performance or for any trouble deriving from poor installation.

6.2.2. Ratio between pipe lengths and diameters

The following table gives the diameters of the hydraulic pipes according to the distances they travel (out + return) with the following:

- Use of trade pipes made of steel;
- Thermal conveying fluid = water without any additives (see water specifications paragraph);
- Straight pipes (no bends, valves, filters or other components that might cause a drop in pressure).

By using the following diameters, the drop in pressure of the refrigerated water distribution line is limited to 50 kPa *(0.5 bar)*.

Cchiller model	Nominal flow rate [m^3/h]	Length of piping (out + return)						
		L=10 m	L=20 m	L=30 m	L=40 m	L=60 m	L=80 m	L=100 m
CH50	1.7	1/2”	3/4”	1”	1”	1”	1”	1” 1/4
CH90	3.0	3/4”	1”	1”	1” 1/4	1” 1/4	1” 1/4	1” 1/4
CH180	6.0	1”	1” 1/4	1” 1/4	1” 1/2	1” 1/2	2”	2”
CH280	9.3	1” 1/4	1” 1/4	1” 1/2	2”	2”	2”	2” 1/2
CH380	12.7	1” 1/4	2”	2”	2”	2” 1/2	2” 1/2	2” 1/2
CH480	16.0	2”	2”	2”	2” 1/2	2” 1/2	2” 1/2	2” 1/2
--	23.3	2”	2” 1/2	2” 1/2	2” 1/2	2” 1/2	3”	3”
--	30.0	2”	2” 1/2	2” 1/2	2” 1/2	3”	3”	4”

Tab.6

If any bends or elbows are included in the piping, besides the pressure drop of 50 kPa *(0.5 bar)*, consider also the following additional values for each component installed.

If the hydraulic circuit is charged with a solution of water and ethylene glycol, increase the losses according to the following corrective factors:

Overall length of piping [m]	Elbow [kPa *(bar)*]	Bend [kPa *(bar)*]
10	12 *(0.12)*	9 *(0.09)*
20	5 (0.05)	4 *(0.04)*
30	4 *(0.04)*	3 *(0.03)*
40	3 *(0.03)*	2 *(0.02)*
60	2 *(0.02)*	2 *(0.02)*
80	2 *(0.02)*	1 *(0.01)*
100	1 *(0.01)*	1 *(0.01)*

Tab.7

% Ethylene glycol in the water	Increase in load loss
0	0%
5	4%
10	8%
15	12%
20	17%
25	21%
30	25%
35	29%
40	33%
45	37%
50	41%

Tab.8

Example of calculation:

It is necessary to install a chiller model CH380 to cool the water in a mould at a distance of 10 metres, using a 20% solution of ethylene glycol for the fluid and having to insert 4 bends and 6 elbows in the hydraulic piping. See Tab. 6 page 21, at model CH380 and the column for 20 metres (10 out and 10 back), you find that the diameter to use for the pipes is 2". With this diameter, just the pipes will lose 50 kPa *(0.5 bar).*

In Tab. 7 page 22, it is possible to obtain the losses of the bends and elbows. Overall, these components will therefore lose 4 x 4 + 6 x 5 = 46 kPa *(0.46 bar)*

Using a solution of water and ethylene glycol, the drop in pressure in the circuit must be increased by 17%, so we have:

Total pressure drop = (5 + 46) x 1.17 = 112 kPa *(1.12 bar)*

This value has to be subtracted from the head of the pump. The result will be the head at the service.

6.2.3. Hydraulic circuit pre-charging

The automatic charging valve is factory set to a pressure of 50 kPa *(0.5 barg).*
This value permits correctly charging the system in the event of water loss due for instance to changing a mould in the hydraulic circuit.

6.3. MACHINE CONNECTIONS TO THE REFRIGERATED LIQUID DISTRIBUTION NETWORK

Connect the chiller to the water pipes and to the water supply (or to an appropriate charging assembly).
Provide:

• two taps (one on the inlet and one on the outlet) to cut off the machine in the event of maintenance without having to drain the water from the service circuit.

• automatic breather valves at all the highest points of the water circuit.

• expansion tank (not needed in the case of an open circuit on pump suction).

To calculate the minimum volume of the expansion tank needed for a certain installation, it is possible to use the following calculation.

The volume of the expansion tank V in litres is given by the formula:

$$V_{tot} = 2 \cdot V_t \cdot (P_{tmin} - P_{tmax})$$

where:

V_{tot} = Total circuit volume in litres.

P_{tmin} = Specific weight at the minimum temperature the water can reach in the course of a year in °C (also with the system at a standstill).

P_{tmax} = Specific weight at the maximum temperature the water can reach in the course of a year in °C (also with the system at a standstill).

Example of calculation:

V_{tot} = 200

Percentage in volume of ethylene glycol = 30%

tmin = 5°C *(41°F)* from the table P_{tmin}= (1.045+1.041)/2 = 1.043

tmax = 40°C (*104°F*) from the table P_{tmax} = 1.0282

V = 2 · 200 · (1.043 - 1.0282) = 5.92 litres

Table of specific weights P

% Glycol	-20°C *(-4°F)*	-10°C *(14°F)*	0°C *(32°F)*	10°C *(50°F)*	20°C *(68°F)*	30°C *(86°F)*	40°C *(104°F)*
0%	1.0036	1.0024	1.0008	0.9988	0.9964	0.9936	0.9905
10%	1.0195	1.0177	1.0155	1.0130	1.0101	1.0067	1.0030
20%	1.0353	1.0330	1.0303	1.0272	1.0237	1.0199	1.0156
30%	1.0511	1.0483	1.0450	1.0414	1.0374	1.0330	1.0282
40%	1.0669	1.0635	1.0669	1.0635	1.0598	1.0556	1.0408

Tab.9

6.4. ELECTRICAL CONNECTIONS

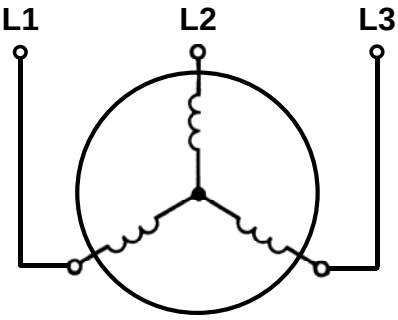
Check that the supply voltage and frequency conform to those of the machine's data plate and that they are within the tolerances stated in Tab. 2 page 9.
Make sure the electrical installation conforms to the binding laws and regulations at the place of installation.
The power cable must be sized for the electrical characteristics of the chiller.
For connection to the electric mains, protection with a rating of at least IP2X or IPXXB must be guaranteed and devices that meet the following indications must be installed:

1. protection against overcurrent of the power cable;
2. short-circuiting current limited to a peak of 15 kA in correspondence with its rated breaking capacity if the short- circuiting current envisaged at the point of installation is effectively greater than 10 kA;
3. protection against indirect contacts on the machine (short-circuiting between live and the equipotential protection circuit) automatically cutting off supply according to the requirements of the IEC 364 - HD 384 - CEI 64-8 standard. For this purpose, use an RCD (normally with a rated residual current of 0.03 A).
4. protection against a lack of phase in the case of three-phase power supply.

For the sizing of the protection circuit, refer to the data given in the Chap. “TECHNICAL DATA” on page 9 and possibly in the attached wiring diagram.
Before making the electrical connections to the supply mains, it is necessary to make the following checks:

- the integrity of the electric components, which must show no sign of wear or burning;
- the maximum unbalance between phases has to be less than 3%. Higher unbalance nullifies machine warranty.

To calculate the unbalance, follow the example given (consider a three-phase power supply voltage of 400 V):
the voltages between the three-phase connecting points have been measured with a voltmeter;
voltage L1 - L2 = 393 V;
voltage L2 - L3 = 401 V;
voltage L1 - L3 = 403 V;
mean voltage = $\frac{393 + 401 + 403}{3}$ = 399 V;
the maximum voltage difference between the phases is 399 - 393 = 6 V;



the unbalance between the phases is $\frac{6}{399} \cdot 100$ = 1,5% and is acceptable because it is under 3%.

WARNING!

Supply values that fail to come within the guidelines in Tab. 2 page 9 nullify machine warranty.

Use an electric cable of cross-section suited to the total machine power. See Tab. 2 page 9 or attached wiring diagram.

Connect the power cable, through the cable clamp provided, to the terminals of the main switch (QS1), following the wiring diagram.
THE MACHINE SHOULD BE CONNECTED TO AN EFFICIENT EARTH SOCKET.

6.5. FILLING WITH WATER

- Connect the water from the water supply to connection (5) (see Fig. 10 page 25);
- open the tap (6) and the ball valve (2);
- if necessary, use the pressure reduction unit (4) to set the charging pressure to 50 kPa *(0.5 bar)*, already adjusted at the manifacture factory, measured on the pressure gauge (7). The machine is supplied with a pressure reduction unit already set to 50 kPa *(0.5 bar)*;
- wait for water to come out of the ball valve (2) with a constant flow. **It is important to prevent air pockets from being left in the tank**;
- shut off the ball valve (2) and open (only for CH180, CH280, CH380 and CH480) the (2a).
- when charging is complete, shut off tap (6);
- if required by current regulations in the country of installation, it may be necessary to install suitable equipment (hydraulic disconnectors) to prevent polluting the water supply mains with the water of the refrigerator's hydraulic circuit.

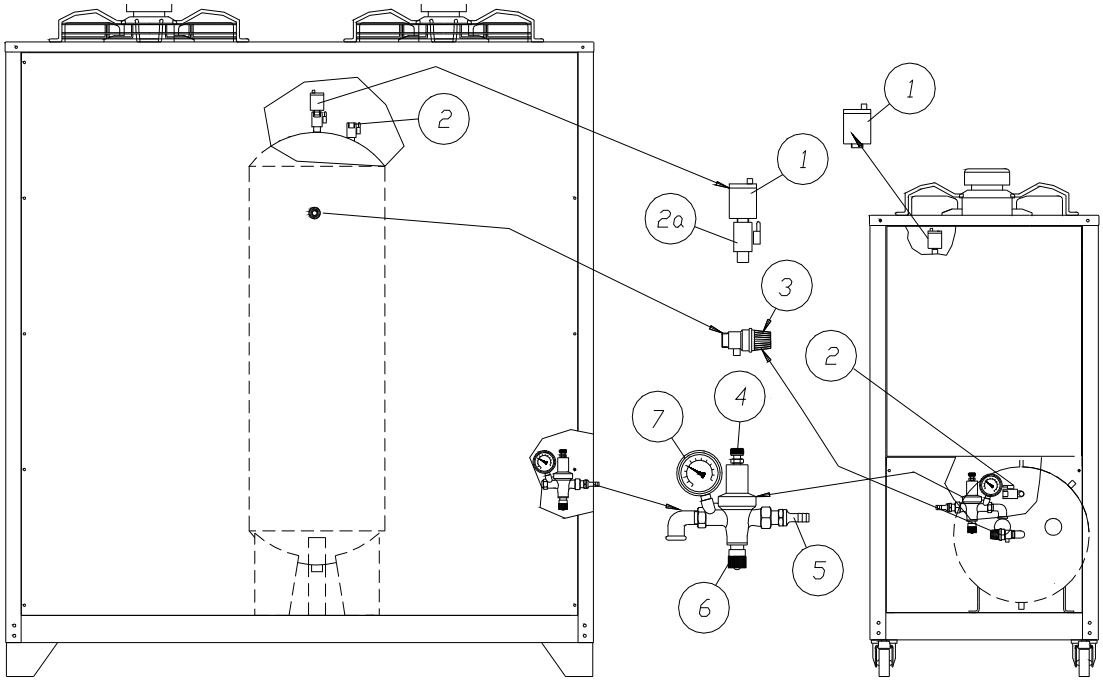


Fig. 10

6.6. BLEEDING AIR FROM HYDRAULIC CIRCUIT (SERVICES)

Correct chiller operation requires the air in the hydraulic circuit to be efficiently eliminated. To achieve this, it is necessary to fit the following components on the line connecting the chiller with the services:

- automatic air breather valves to be fitted at the highest points of the system;
- manual air breather valves to be fitted at the highest points of the system.

Air breather valves are needed for the hydraulic lines on the floor, too, not necessarily to be fitted at the highest points of the system.

For systems supplying a high number of service machines that, in their turn, involve frequent mould changing and therefore air entering the circuit, it is wise to fit an accumulation tank and air bleed on the return pipe from the services to the chiller.

6.7. ANTI-FREEZE PROTECTION

Even if the minimum ambient working temperature is higher than 0°C *(32°F)*, during the cold season the chiller might be in a place where the temperature is below 0°C *(32°F)*. In these cases, if the chiller is not drained, it is necessary to add an anti-freeze fluid to prevent ice forming (ethylene glycol or another fluid compatible with the materials used) in the following percentages:

Min. ambient temp. [°C*(°F)*]	Ethylene glycol [% in volume]
<10 *(50)*	10
-5 *(23)*	15
-10 *(14)*	20
-15 *(5)*	30
-20 *(-4)*	35

Tab.10

Minimum water outlet temperature [°C*(°F)*]	Ethylene glycol [% in volume]
<5 *(41)*	10
0 *(32)*	15
-5 *(23)*	20
-10 *(14)*	30
-15 *(5)*	35
-20 *(-4)*	40

Tab.11

Depending on the refrigerated water outlet temperature, to prevent ice forming, it is necessary to add anti-freeze (ethylene glycol) in the following percentages:
Depending on the percentage of glycol added to the water system, the cooling capacity will decrease as shown in the following table:

Loss of cooling capacity [%]	Ethylene glycol [% in volume]
1.0	10
1.5	15
2.0	20
3.0	30
3.5	35
4.0	40

Tab.12

For the increase in drop in pressure of the system after adding anti-freeze, refer to Par. “MACHINE CONNECTIONS TO THE REFRIGERATED LIQUID DISTRIBUTION NETWORK” on page 23.

7. START-UP

7.1. PRELIMINARY CHECKS

Before going ahead and starting up the chiller, make sure all the personnel have read and understood the Chap. “SAFETY” on page 5 in this manual.

Check that the shut-off valves on the water system are open.

Fully open the by-pass gate installed between the delivery and return pipes of the chiller.

Open the water charging tap underneath the pressure reduction unit.

Open the side inspection panel (on the side opposite the condensation air suction filter) and check that the tank is completely full of water and that the air has been properly bled.

If the hydraulic circuit is the closed type, check an expansion tank of suitable capacity has been installed.

Check (with the water pressure gauges) that the pressure in the water circuit is approximately 50-100 kPa *(0.5-1 bar)* to make sure that during operation the pump does not lower the pressure in parts of the circuit (risk of cavitation), causing air to get in (preventing both manual and automatic breather systems from working) and any hoses to implode (which would prevent the regular flow of water).

Check that the ambient temperature is in the limits stated on the machine data plate.

Check that the main switch is turned to “OFF”.

Check that the supply voltage is correct.

Use the supply line protection device to power up the machine.

Turn the machine's main switch to the “ON” position; the control panel will begin to display the actual temperature of the water leaving the chiller.

Wait for the oil to warm up in the compressor casing for about 2-3 hours. In normal use, leaving the equipment live even in production downtime, when starting up afterwards it will not be necessary to wait for the oil to heat since the casing heating element stays on even if the chiller is not working.

Press the ON/OFF button on the control panel; **the pump starts immediately.**

Check the pump turns in the right direction. If necessary, after having cut off the power, swap over two phases on the chiller power supply line. CAUTION! Do not reverse the direction of rotation of solely the pump.

With the pump running, check that the pressure difference between the reading on the delivery pressure gauge (located on the rear panel) and the reading on the return pressure gauge (located on the pressure reduction unit of the filler assembly inside the machine) is greater than the available head at maximum pump delivery (see Chap. “TECHNICAL DATA” on page 9). If this difference is less, it means that the water flow rate is greater than the maximum permissible amount. **So as not to damage the pump, it is necessary to increase the pressure drop in the hydraulic circuit, e.g. by partly shutting a pump delivery tap.**

When starting up the first time, if the ambient temperature is high and the temperature of the water in the hydraulic circuit is much higher than its working temperature **(e.g. 25-30°C *(77-86°F)*)** it means the chiller starts overloaded with the protection devices **possibly tripping. To reduce this overload, you can progressively close a chiller outlet valve to decrease the flow of water crossing through it.** As the temperature of the water in the hydraulic circuit reaches its working temperature, open the valve.

The machine is now ready to work.

If the thermal load is lower than that produced by the chiller, the water temperature drops until it reaches the Set Point value and the compressor stops: the water pump continues running.

8. SWITCHING OFF THE CHILLER

WARNING!

In the event of an emergency, turn the main switch QS1 onto 0 (OFF). Use this procedure only in case of need and not as a routine procedure.

To stop the chiller press the ON/OFF key.

It is advisable to keep the machine powered [QS1 in position 1 “ON”) to avoid having to wait for the oil in the compressor casing to warm up, or, if the machine is intended to be left inactive for a long time, turn switch QS1 to position 0 “OFF” to cut off the power.

9. SERVICING THE CHILLER

9.1. GENERAL INFORMATION

WARNING!

Carefully read Chap. “SAFETY” on page 5 before carrying out the following operations.

All maintenance work (unless indicated otherwise) must be performed with the machine switched off and disconnected from the electric power supply line.

To access the components inside the machine, use the following diagram (Fig. 11 page 28):

From **side A** it is possible to access: connections to the water supply.

From **side B** it is possible to access: condenser.

From **side C** it is possible to access: electric panel.

From **side D** it is possible to access: chiller and hydraulic circuit.

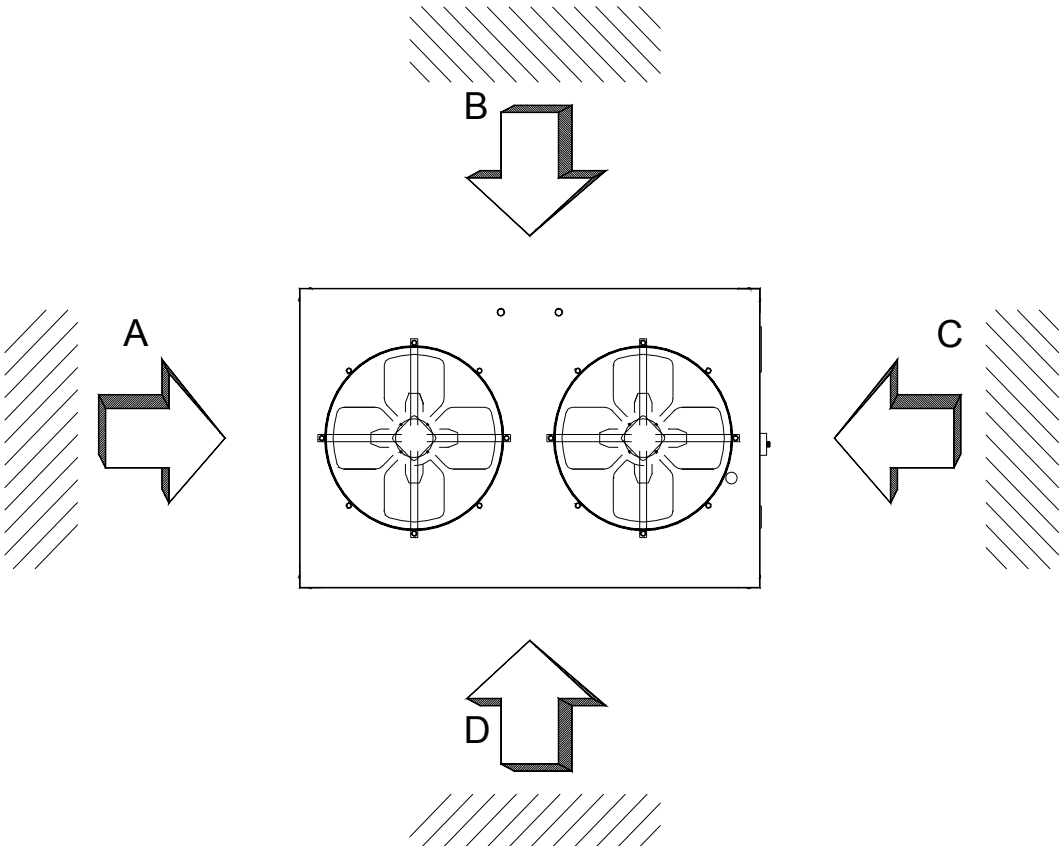


Fig. 11

9.2. SCHEDULED MAINTENANCE

Every week	**Cleaning air filters**: take out the filters, clean with an extractor and, if necessary, wash them. **Checking the inside for water leakage and condensation**: take off the closing panels; tighten the fittings if necessary and restore the insulation. **Cleaning water filter cartridge (optional)**: thoroughly wash under running water with a soft brush and, if necessary, replace it.
Every month	**Checking and cleaning the condenser**: take out the filter and, if necessary, clean the condenser using an extractor. Protect the internal components with a sheet. **Electrical check**: check and clean the electric panel with the main switch QS1 in the OFF position. Check the tightness of the clamps, check the state of wear of the contacts of the contactors and replace them if necessary. On the version for outdoor application also clean the panel aeration filters. **Mechanical check**: thoroughly clean the inside of the machine and check the tightness of the bolts fixing the various components. **Oil level**: with the machine stationary for over half an hour, check the level through the sight glass located on the compressor; if this has fallen under a third of the sight glass, call the AQUATECH technical assistance service. The type of fluid to use is stated in Chap. “TECHNICAL DATA” on page 9. Never mix different oils. **General check**: Search for any leakage with a specific leak finder, taking the end of the probe close up to all the fittings and welds.

Tab.13

The frequency of performing scheduled maintenance indicated here is not absolute.
The correct times depend on the hours of use of the materials processed; they must be defined by means of repeated initial tests.

9.3. UNSCHEDULED MAINTENANCE

Repairing the chiller circuit

Any repairs to the chiller circuit that may become necessary have to be performed solely by skilled chiller technicians.
If repairs have been made, it is necessary to carry out the following operations.
• Leak test;
• Forced vacuum and circuit drying;
• Charge with refrigerant.

Leak test
Charge the circuit with anhydrous nitrogen from a cylinder fitted with a reduction unit to reach a pressure of approximately 1500 kPa *(15 bar)*.
Any leaks will have to be identified with a bubble-type leak detector; any bubbles and/or foam indicate the location of leaks; in which case, before repairing, drain the circuit again.

Forced vacuum and circuit drying
To obtain a forced vacuum in the chiller circuit it is necessary to have a specific pump with a high vacuum level capable of reaching at least 0.01 kPa *(0.1 mbar)* absolute.
If a specific pump were not available or when a circuit has stayed open for a long time, it is strongly recommended to follow the triple evacuation method.
This method is also indicated if there is any moisture in the circuit.
The vacuum pump should be connected to the filler sockets.
Evacuate the circuit to an absolute pressure of at least 3.5 kPa *(35 mbar)*; afterwards break the vacuum with anhydrous nitrogen.
Repeat the operation of the above point.
Repeat the operation of the above point for a third time, trying in this case to reach the greatest vacuum possible.
With this procedure it is possible to remove up to 99% of pollutants easily.

Refrigerant charge

Connect the refrigerant gas cylinder to the charging socket on the liquid line letting a little gas come out of the pipe to eliminate the air it contains.

Turn over the cylinder and charge it with liquid until 100% of the total charge has been introduced. Afterwards, check the sub-cooling value that has to be between 7°C *(44°F)* and 10°C *(50°F)*.

10. PUTTING THE MACHINE OUT OF SERVICE

When the machine has reached the end of its life cycle, it must be disconnected from the electrical supply line and disinstalled from its working position.

The machine must be disposed of in full compliance with the waste disposal laws in the country where it is installed.

IMPORTANT! After removing the machine from its work station, affix a permanent notice to it with the message: "MACHINE FOR DISMANTLING, DO NOT USE".

11. SPARE PARTS

The following data must be given when ordering spare parts.

1. All the data on the identification plate affixed to the machine.
2. The description of the part required.
3. The quantity required.
4. The exact destination address and means of dispatch required.

AQUATECH accepts no responsibility for mistaken consignments resulting from inaccurate or incomplete information.

The components which are not referred to in the machine maintenance procedures described, can be replaced only by the AQUATECH Technical Assistance Service.

12. ACCESSORIES

The entire range of CH chillers can be integrated with a set of optional extras making it possible to keep it working correctly. These chillers may come to work in anomalous conditions (process water with considerable debris, electric mains not very stable, etc.) that could undermine its working properly.

12.1. FILTERS

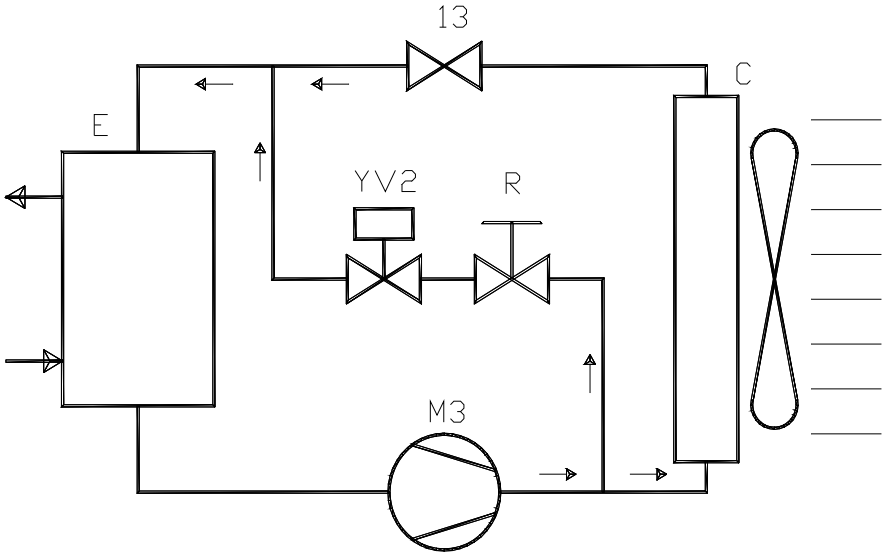
The water chillers in the CH series can be fitted out with filters for the inlet water. This accessory, (supplied loose) is helpful when the process water contains debris that, should it reach the chiller, could impair its operation. A cartridge filter is proposed with the following characteristics:

Chiller	IN-OUT connections	Filterable flow rate	Filtration grade
CH50-90	3/4" G	9.6 m3/h	60 μm
CH180-280	1" G	9.6 m3/h	60 μm
CH380-480	1"1/2 G	20 m3/h	60 μm

12.2. HOT GAS INJECTION BY-PASS VALVE

The purpose of the gas injection solenoid is to reduce the cooling capacity of the chiller when the temperature of the process fluid is near the Set Point. In this way a reduction in the frequency with which the compressor switches ON and OFF is obtained and as a result also in the resulting fluctuations in the fluid leaving the compressor due to the minimum starting and stopping times set by the control panel (which are indispensable for preventing damage to the electrical motor); a similar result is obtained increasing the accumulation capacity in the hydraulic circuit.

The reduction in refrigerating power is obtained by reducing the quantity of gas that is rolled through the expansion valve, diverting part of the gas from the compressor outlet directly into the evaporator. The compressor outlet and evaporator inlet are physically connected by a by-pass valve that may be open or shut by a (hot gas injection) solenoid valve controlled by the control panel. The calibration tap R is factory set to allow the chiller to work with the by-pass open up to a thermal load of not less than 30% of the maximum load the chiller can handle with the by-pass closed. See the the following diagram.



The following diagram gives the solenoid valve's operation when varying the temperature of the process fluid with respect to the Set Point.

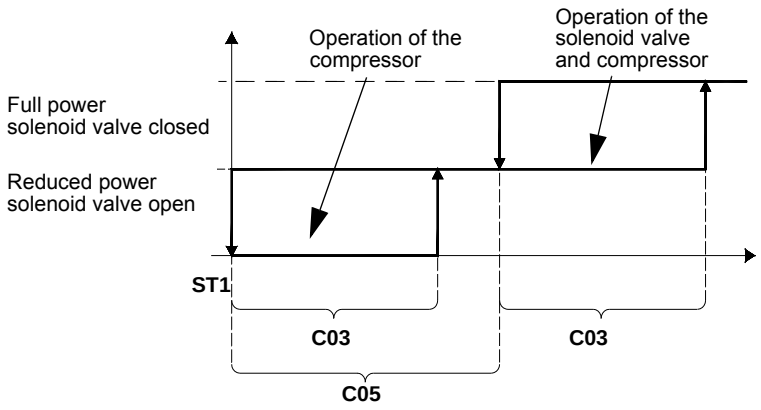


Fig. 12

12.3. CHECKING PHASE SEQUENCE AND VOLTAGE

The construction of scroll-type compressors requires keeping a strict direction of rotation. If the compressor is made to work for a long time in the opposite direction of rotation, besides not compressing the refrigerating gas, it can get severely damaged. To avoid this danger, it is possible to install a phase sequence control in the electric panel that will prevent the chiller starting if there is the wrong phase sequence. This control acts directly on the remote ON/OFF input of the control panel, so if the sequence is wrong then “E00” is shown on the display and the HL0 lamp on the front of the panel comes on.

If the alarm trips, it is necessary to cut off power to the machine with the main isolating switch and the switch upline from the chiller and then swap over two of the three wires coming into the isolating switch.

Once the system has been started up the phase sequence control stays active and checks for the line voltage lowering and/or one of the three phases failing (this is again to prevent damage to the electric motors). So, if during normal operation the chiller switches off, the control panel shows “E00”, and the signal lamp HL0 (situated on the door of the panel) lights, it will be necessary to cut off power to the machine and check for any trouble with the electricity distribution line.

APPENDIX A. WATER SPECIFICATIONS SHEET

AQUATECH refrigerating systems need the process and cooling (condenser) fluid to be water with the following characteristics :

Characteristic	Value (ppm or mg/l)
Suspended substances	almost absent (1)
Silica (SiO_2)	< 60
Alkalinity (HCO_3^-)	100 – 500
Sulphates (SO_4^{2-})	< 100
Electr. conductivity	10 - 800 microS/cm
pH	7.5 – 9 (7.5 – 8.0 in the presence of Aluminium)
Ammonia (NH_3)	absent
Chlorides (Cl^-)	< 50
Free Chlorine (Cl_2)	absent
Hydrogen Sulfide (H_2S)	absent
Free carbon dioxide (aggressive) (CO_2)	< 2
Total Hardness	< 5 °dH (8.9 °dF)
Nitrate (NO_3^-)	< 40
Iron (Fe) (2)	< 0.1
Aluminium (Al)	< 0.1
Manganese (Mn) (2)	< 0.05
Copper (Cu^{++})	< 0.1
Oils and fatty substances (if used)	absent
Ethylene/Propylene glycol antifreeze (if used)	> 20%

(1) With plate heat exchangers the filtering capacity must be at least 0.5 mm (35 mesh), with tube-nest heat exchangers at least 1 mm.

(2) Fe^{3+} and Mn^{4+} absent.

Evaluate carefully, analysing the characteristics of water used for the filling of the circuit, if an appropriate water treatment is required.

Periodic analysis of the content of the circuit is necessary and the results have to be compared with the previous requirements.

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