

PROJECT: AVANTE 2200 CORVETTE  
SHIPYARD: NAVANTIA  
SYSTEM: HVAC



**PROJECT:** AVANTE 2200 CORVETTE  
PROJECT 569-C

**SHIPYARD:**



**SYSTEM:** HVAC

## CHILLED WATER UNITS

REF.: D-MO5462-016

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## 1 FUNCIONAL DESCRIPTION

### 1.1 Object

The purpose of this document is to define the control philosophy for the chilled water plants, describing the conditions and modes of operation of the system. It includes the description of control points, running sequence, modes of operation, etc.

### 1.2 General Description of the Chilled Water Plants

On board of the ship there will be installed three (3) chilled water plants for the HVAC system. These plants are identified with TAGs as following indicated:

EQUIPMENT	TAG
Chiller water unit No 1	CWP-CHW00001
Chiller water unit No 2	CWP-CHW00002
Chiller water unit No 3	CWP-CHW00003

This functional description explains the operation of one chilled water plant but it applies for the other plants due they all have the same operational features.

Each chilled water plant is assembled as a compact unit and consists of two (2) independent refrigerant gas circuits of 50% of total plant capacity which integrate the following main components:

COMPONENT	TYPE	MODEL	QTY
Compressor	Semi-hermetic screw.	BITZER CSW 8573-90Y	2
Condenser	Sea water cooled condenser with double circuit of refrigerant.	TEMOJECT Taylor made	1
Evaporator	Double circuit of refrigerant.	BITZER DH2-403 / STD	1
Exp. Valve	Electronic Expansion Valve with electronic controllers (one per circuit).	CAREL	2
Control Panel	(It includes electronic devices for protection and devices for local and remote control and monitoring of the chiller water unit).	-	1
Refrigerant	R- 134A	-	-

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There are other main components installed outside of the base frame of each chilled water plant controlled by control panel, such as:

COMPONENT	QTY
Water pump for chilled water circuit	1
Three way valve for chilled water circuit	1
Sea water pump for condensing circuit	1
Three way valve for sea water	1

#### NOTE

*The compressors are equipped with frequency inverters (FI's) (one per compressor), which allow a soft start of the compressors and modulate their cooling capacity. These FI's are located into electrical panels in the skid of the chilled water unit and they are wiring with its respective compressor.*

*The FIs of both compressors in each chilled water plant will be controlled by the PLC located in the main control panel of respective chilled water plant.*

### 1.2.1 Water condensing system

The condenser of each chilled water plant exchanges heat between the refrigerant gas and the sea water. To do it, the control system starts-up the sea water pump before to active the compression system of the chilled water unit.

The TAGs to identify these sea water pumps in the system are:

COMPONENT	TAG
Sea water pump for Chiller water unit: CWP-CHW00001	PMP-ASW00005
Sea water pump for Chiller water unit: CWP-CHW00002	PMP-ASW00006
Sea water pump for Chiller water unit: CWP-CHW00003	PMP-ASW00007

The condensing system is equipped also with a motorized three way valve to regulate the seawater flow to the condenser. The TAGs of these valves are:

COMPONENT	TAG
Three-way valve for Chiller water unit: CWP-CHW00001	THV-ASWS0149
Three-way valve for Chiller water unit: CWP-CHW00002	THV-ASWS0150
Three-way valve for Chiller water unit: CWP-CHW00003	THV-ASWS0151

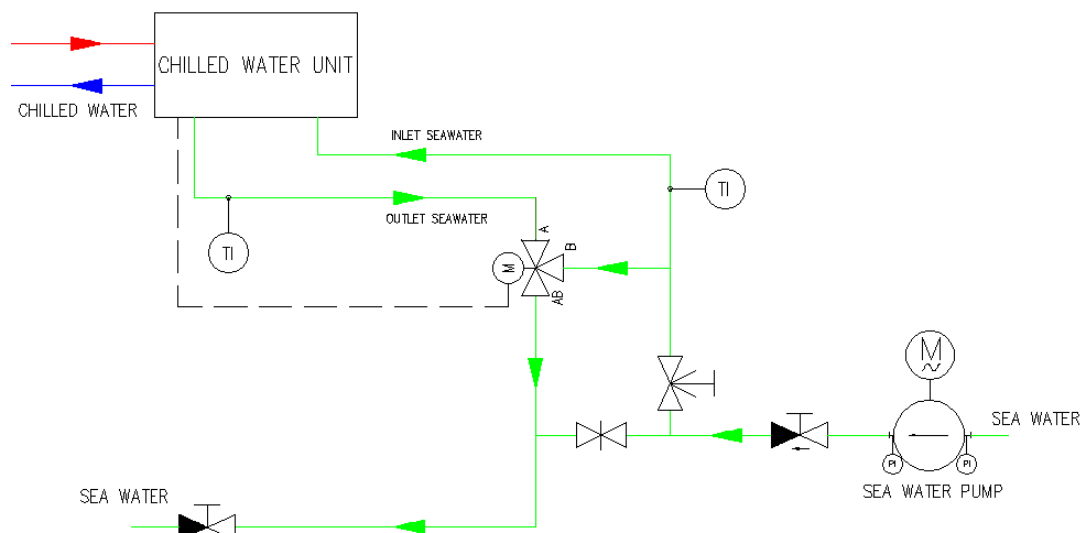
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The modulation (open / close position) of this valve is made by the control panel based on the temperature value of the seawater at the condenser outlet (the temperature setpoint to regulate this valve is editable).

Sea water temperature sensors (for condenser water inlet and outlet) are located in the own chilled water unit and factory wired.

The modulation of the three-way valve will get started once a compressor is running, otherwise it will positioned in way that that all seawater flow goes to the condenser, i.e, non-bypass position.



*Fig 1 Generic Seawater Circuit Scheme*

### 1.2.2 Chilled water circuit

In this document are considered only the components of the chilled water circuit that are controlled by the panel of the chilled water plant.

The control panel starts-up the chilled water pump before to active the compression system of the chilled water unit. The TAGs to identify these pumps in the systems are:

COMPONENT	TAG
Chilled water pump for Chiller water unit: CWP-CHW00001	PMP-CHW00001
Chilled water pump for Chiller water unit: CWP-CHW00002	PMP-CHW00002
Chilled water pump for Chiller water unit: CWP-CHW00003	PMP-CHW00003

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However, the operation of the compressor is conditioned also by the action of others devices installed in the chilled water circuit, for example:

- Anti-freeze protection by PLC, according to supply water temperature sensor in the chilled water circuit.
- Water flow switch.

The identification TAGs of these devices are:

COMPONENT	TAG
Supply water temperature sensor/ chiller unit CWP-CHW00001	TTR – CHWS0615
Supply water temperature sensor/ chiller unit CWP-CHW00002	TTR – CHWS0634
Supply water temperature sensor/ chiller unit CWP-CHW00003	TTR – CHWS0653
Return water temperature sensor/ chiller unit CWP-CHW00001	TTR – CHWS0616
Return water temperature sensor/ chiller unit CWP-CHW00002	TTR – CHWS0635
Return water temperature sensor/ chiller unit CWP-CHW00003	TTR – CHWS0654
Water flow switch in chiller unit CWP-CHW00001	FLS – CHWS0618
Water flow switch in chiller unit CWP-CHW00002	FLS – CHWS0637
Water flow switch in chiller unit CWP-CHW00003	FLS – CHWS0656

These sensors are field installed and must be field wired

Thus, a condition to activate the compressors is the confirmation of chilled water flow. For this, the system first checks that the anti-freeze protection is not tripped, then when the chilled water pump is started up the system allows a time to stabilize the water flow (editable delay time, default 60sec), after which time the system monitors the status of the water flow switch and the anti-freeze protection to confirm that there is a water flow.

In the event that the flow switch indicates a lack of water flow, the control system will confirm that this signal is permanent for at least 15 seconds (editable) before activating the alarm and stopping the compressors or preventing their starting-up.

Other component installed in the chilled water circuit and controlled by the panel is a three-way valve. The TAG of these valves for each chilled water plant is:

COMPONENT	TAG
Three-way valve in chilled water circuit / unit CWP-CHW00001	MTV-CHWS0620
Three-way valve in chilled water circuit / unit CWP-CHW00002	MTV-CHWS0639
Three-way valve in chilled water circuit / unit CWP-CHW00003	MTV-CHWS0658

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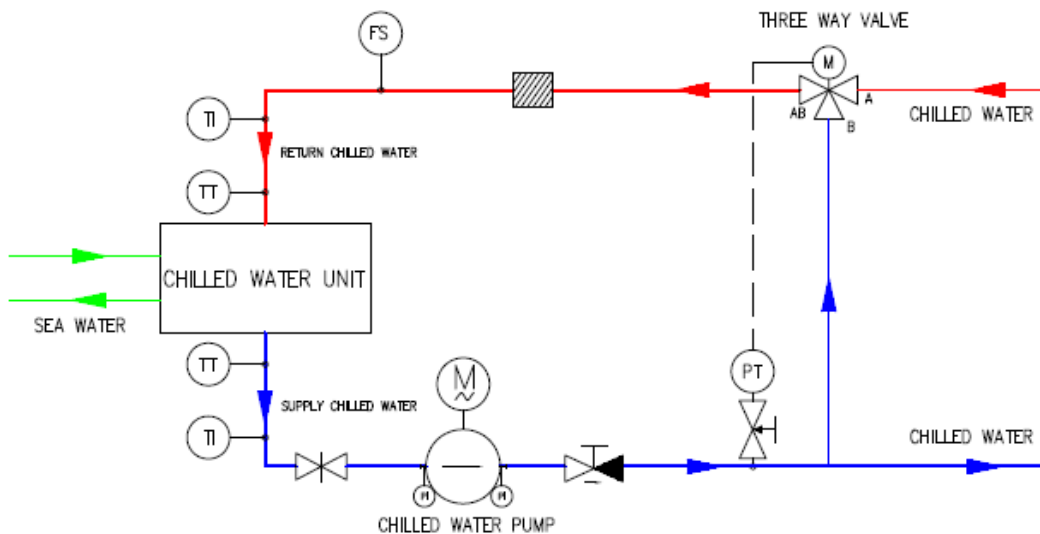


This valve allows control the pressure in the water pipe, for this purpose, the system monitors the pressure value of the water circuit through a pressure transmitter installed in the water pipeline. The TAG of these sensors for each chilled water plant is:

COMPONENT	TAG
Pressure transmitter in water pipe/ chiller unit: CWP-CHW00001	PTT – CHWS0677
Pressure transmitter in water pipe/ chiller unit: CWP-CHW00002	PTT – CHWS0678
Pressure transmitter in water pipe/ chiller unit: CWP-CHW00003	PTT – CHWS0679

In the event that the pressure value increases above the set point (editable), the valve will perform a by-pass for the return of water to the chiller.

The modulation of this valve will start once the system confirms the water flow; otherwise it will remain in the non-bypass position.



*Fig 2 Generic Chilled Circuit Scheme*

### 1.2.3 Refrigeration Circuit

As indicated above, each refrigeration circuit is equipped with a semi-hermetic compressor which is wiring with frequency regulator (Frequency Inverter control – FI control) to perform a soft start of the engine and to modulate its refrigeration capacity.



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For the electrical protection of each compressor, elements for protection by short circuit and overload are available in the main control panel.

Additionally for the protection of each compressor the following mechanical protections are contemplated:

- Oil level switch.
- Temperature monitoring.
- Chiller water flow (indicated in the section 1.2.2 of this document).
- High pressure switch (manual reset).
- Low pressure switch (manual reset).

A brief description of these protections is indicated below:

Oil level switch	<p>A sensor monitors the oil lubrication level of each compressor, this</p> <p>This sensor is incorporation into the safety chain of the compressor, so if the oil level is detected for a continuous time longer than the delay time of the protection, the compressor is stopped by the control system.</p> <p>The fault must be reset from the HMI.</p>
Temperature monitoring	<p>Through a protection device incorporated into the safety chain of the compressor, the compressor is stopped (protected) if present temperature for <i>Motor</i>, <i>Discharge gas</i> or <i>Oil</i> is exceeded.</p> <p>This device locks out if set point is exceeded for three times within two hours.</p>
High and Low Pressure cut-out	<p>These functions stops the compressor if the discharge pressure gets too high or the suction pressure gets too low. In case these elements trip, they must be rested manually.</p>

The control system (PLC) also performs protection functions to the cooling system based on the pressure and temperature readings of sensors installed in the plant:

- Protection due high pressure (Manual reset in HMI).
- Protection due low pressure (Manual reset in HMI).
- Control of the number of starts per hour.
- Anti-freeze protection (indicated in the section 1.2.2 of this document)

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The protections of the control system that are redundant to the mechanical protections mentioned above, are regulated to activate in the first instance while the mechanical elements act as a backup in the event of a failure of the control system.

Another protection for the chilled water plant is the "Refrigerant Leak detector". This protection generates a warning signal in case at least a sensor is detecting a refrigerant gas leak (R-134), but it does not stop or avoid the operation of any equipment. The user according to his criteria must decide the maintenance actions.

The chiller unit panel also controls the liquid solenoid valve of each refrigerant circuit. The opening of these valves is interlocked with:

- Confirmation signal of chilled water flow.
- Confirmation that timing for stabilization of chilled water flow has been completed.
- Confirmation signal that security compressor devices are not tripped.
- Start-up compressor signal activated.
- Temperature value of return chilled water or supply chilled water (according to user selection) is above set point value.

For the case of the electronic expansion valve of each refrigerant circuit, there is an electronic controller into the control panel to regulate the valves status. To enable/activate the operation of these devices the PLC sends a signal simultaneously to the signal to open the liquid solenoid valve, i.e, both kind of valves have the same conditionals or interlocks to operate. The operation parameters of the expansion valve should be entered in its controller devices.

The refrigerant injection will start at least 10 seconds (editable) before the compressor start-up sequence beginning.

### *1.2.3.1 Compressor control.*

#### *1.2.3.1.1 Activation.*

The start signal comes from the PLC located in the main control panel to the FIs, which it is validated when:

- The user enables the compressor operation: In automatic mode or in manual mode (only for local operation)
- Compressor mechanical protections are not tripped (High pressure pressostat, low pressure pressostat, chilled water flow, etc).

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- Compressor securities from the PLC are not active (High pressure, low pressure, oil temperature, motor temperature, anti-freeze protection, oil level, chilled water flow stabilized, etc).
- The interlocking conditions between the compressor and the sea water and cold water pumps are met (Pumps must be running to allow compressor to start).

#### NOTE

*The enable order for the compressor is always made by the user either manually or automatically, but its activation (putting in service) and its capacity control is executed by the control system.*

So, the compressor starts when

- A start signal is activated by control panel.
- The return or supply chilled water temperature (according to user selection) is higher than set point (set point editable in HMI).
- The start-to-start time interval has elapsed

#### NOTE

*The user can decide which parameter activates the liquid solenoid valves and the expansion valve controllers either by: Return chilled water temperature set point or by Supply chilled water temperature set point, and **this same parameter will control the compressors starting**.*

*A differential of temperature (editable in HMI) avoids that the liquid solenoid valves of both compressors close at the same time when the chilled water temperature setpoint is reached. So, the system closes (de-energizes) the liquid solenoid valve of a first compressor when the chilled water temperature setpoint is reached and it will close (de-energize) the second solenoid valve if the water temperature downs 1°C (editable in HMI) regarding with to the setpoint.*

*Always that compressor is not running the liquid refrigerant injection solenoid valve to the evaporator must be in close position.*

In case that at least one of the following protections trip, the compressor will stop in immediately (freewheel), and it will require an intervention by user to solve the failure and generate the compressor activation signal again:

- Local or Remote emergency stop.
- High pressure switch (KP5) or high pressure protection from PLC.
- Low pressure switch (KP1) or low pressure protection from PLC.
- Electric protection of the Compressor or Water pumps.

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- High oil compressor or motor temperature.

However, the activation of the following protections, securities or alarms causes a controlled shutdown of the compressor:

- Antifreeze protection.
- Flow switch.
- Temperature or pressure Sensor failure.
- Low oil level.

Finally, the following protections and alarms do not stop the operation of the compressor or water pumps:

- Refrigerant leakage alarm.
- System controlled in Remote mode and any equipment in manual mode.

#### 1.2.3.1.2 Modulation and Control

The Frequency Inverter control (FI control) varies the speed of the compressor motor according to the set point defined by user in the HMI.

The parameter used by control system to modulate the compressor cooling capacity is the same that user selected to enable the compressor starting and the activation of liquid solenoid valve and the expansion valve: Return chilled water temperature or Supply chilled water temperature.

However the "maker" user (see section 1.3.1 of this document) can select a third control way to regulate the compressor cooling capacity: The suction pressure of the refrigerant circuit. Nevertheless, ***the activation will continue depending on the selected parameter: Return chilled water temperature or supply chilled water temperature.***

#### NOTE

*The minimum frequency at which each compressor could run is 25Hz to ensure proper lubrication of the engine.*

As indicated above, each compressor will use its own frequency inverter to perform a soft start and regulate its cooling capacity, for this purpose it also uses the solenoid valves (CR) installed in it as indicated below:

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Status	CR1	CR2	CR3	CR4
Compressor Stopped	--	--	--	--
Startup to 25Hz (Ramp time 3 sec)	--	--	<b>Solenoid valve energized</b>	--
From 25hz to Setpoint	--	--	--	<b>Solenoid valve intermittent (10 ON / 10 s OFF)</b>
Setpoint	--	--	--	<b>Solenoid valve intermittent (10 ON / 10 s OFF)</b>
From (Setpoint – differential) to 25hz	--	--	--	<b>Solenoid valve intermittent (10 ON / 10 s OFF)</b>
25 hz to Stop (Ramp time 3 sec)	--	--	<b>Solenoid valve energized</b>	--

-- : Solenoid valve de-energized

This means:

- Start ramp:** Ramp time 3 sec. In this period the frequency inverter will drive the motor from 0hz up to 25 hz. During this time, the solenoid valve CR3 is the only one energized (permanently).
- From 25 hz, the engine speed will vary to allow the compressor to reach the appropriate refrigeration capacity to bring the temperature of the chilled water to the defined setpoint value. While this is happening, the CR3 solenoid valve is de-energized and only the CR4 solenoid valve is energized but intermittently (10 sec intervals).
- Once the setpoint of the chilled water has been reached, the frequency inverter keeps the motor speed constant. The CR4 solenoid valve continues to energize intermittently (10 sec interval).
- If the water temperature falls below the setpoint minus its differential, the control system reduces the speed of the compressor up to 25hz to effect a controlled stop, then the control executes a stop ramp. The CR4 solenoid valve continues to energize intermittently (intervals of 10 sec), the other solenoid valves remain de-energized.
- Stop ramp:** Ramp time 3 sec. In this period the frequency inverter will drive the motor from 25hz up to 0 hz. During this time, the solenoid valve CR3 is permanently energized again and the solenoid valve CR4 is de-energized.

Once the compressor stops, the control system timed to prevent an immediate restart of that compressor.

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In the event that the setpoint leads to the compressor having a speed below 25 Hz, the compressor will not reduce its speed and it runs at 25 Hz.

#### 1.2.3.1.3 Operation

When both compressors are available to operate, e.g, when the user execute a "general start" locally or remotely, the control system will make a balance of the working hours of the two compressors of each water chiller plant, and it will start-up the compressor with fewer hours of work accumulated since its last maintenance, while the other compressor remains in standby.

Under normal conditions, the second compressor will start only when the following conditions are met:

- The first compressor is at 100% of its nominal capacity.
- The set point of the chilled water is not reached.
- A delay time (editable) elapses for the activation of the second compressor.

#### NOTE

*In the event that a compressor fails (a mechanical or electrical protection of the compressor trips), the chilled water unit shuts off completely in a controlled way and an alarm advice is sent to IPMS.*

If the first compressor is 100% of its refrigeration capacity and the second compressor is activated, it will remain at 100% capacity while the second compressor modulates its capacity according with the parameter selected (return chilled water temperature, supply chilled water temperature or suction pressure of the refrigerant circuit)

At the moment both compressors are at 100% of their refrigeration capacity and the system demands less cooling capacity, the control system will reduce the refrigeration capacity of the compressor with more hours of accumulated work, keeping the other compressor at 100% until the first one stops.

In case that user decides to control the compressors manually (this is only possible locally through the HMI); the control system will put in service (start-up ) and will regulate the cooling capacity of the compressor enabled by the user , keeping the other compressor shutting out, even if this compressor is at its maximum capacity and the water temperature set point cannot be reached.

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In case the user enables both compressors, the control system will apply a working hour's regulation of these engines, similar as a general start.

### 1.2.4 Control System.

Each water unit is controlled and monitoring through individual control panels, these panels are equipped with a PLC and a touch screen (HMI) for the operator-machine interaction.

#### NOTE

*The status of the equipment of a chiller water unit is **only** controlled and visualized from its **own control panel** or from the **remote system**, i.e., there is no interface between the chiller units*

The control panel for each chilled water plant will be fed from two sources through a manual bus transfer switch (MBT) included in the panel.

The MBT switch will be able to open under full load conditions. The change will be performed manually. The system will be equipped with an indication lamp to show the MBT position. MBT switch will be "three positions type"

- Electrical source No 1
- Disconnected.
- Electrical source No 2

#### NOTE

*The control system of the electric power sources No 1 or 2 (depending on the position of the selector determined by the user), must respond to an authorization signal issued by the control panel of the chilled water plant, which will allow the equipment to start.*

The control panel is equipped also with a button to activate a general and immediate stop of the equipment of system in emergency case. In order to start the equipment again, emergency stop order shouldn't be active, and a new start order from control system should be sent. An automatic restart when emergency stop order is deactivated can't be possible.

A similar action can be executed in remote mode: Remote Emergency Stop. It must be done through a hardwire signal potential-free continuous, open in case of "Emergency stop".



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### NOTE

*Whether an emergency stop is activated or the control panel is without power, the PLC and the display (HMI) will not be turned off or disconnected. For this the PLC and the HMI will be equipped with a UPS (autonomy time at least 60min) that allows detect the failure and notify the event to the remote system.*

From the touch screen (HMI) installed in the control panel, the user can:

- Monitor the temperature value of the chilled water in the inlet and outlet of the evaporator.
- Monitor the pressure value of the chilled water pipe at the discharge of the water pump to control the three way valve.
- Monitor the temperature value of the seawater in the inlet and outlet of the condenser.
- Monitor the suction and discharge pressure reading of each compressor.
- Monitor the suction and discharge temperature of each compressor according to pressure values (Indirect reading).
- Monitor the oil temperature of each compressor.
- Monitor the status of each engine of the chiller water unit (compressors, water pumps, three-way valves, and solenoid valves).
- Monitor working hours of each engine of the chiller water unit: compressors and water pumps.
- Monitor the refrigeration capacity of each compressor.
- Records of alarms (Timestamp, alarm code and text, status: set or clear)
- Records of events (Timestamp, compressors and water pumps start / stop commands; parameter changes; set or clear of alarms).
- Perform the manual start / stop of the water pumps.
- Define the position of the three-way valves (manual control).
- Enable start up / stop of the compressors.
- Carry out the general start / stop of the chiller water unit

The control system sends and receives information to remote system; these signals are described in the documents: D-MO5462-091 -- IDD CHILLER WATER PLANT CWP-CH00001, D-MO5462-092 -- IDD CHILLER WATER PLANT CWP-CH00002, D-MO5462-093 -- IDD CHILLER WATER PLANT CWP-CH00003, for each chiller water plant respectively.



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## 1.3 Basic Philosophy of Operation.

### 1.3.1 System's Users

For the operator-machine interaction through the HMI screen located in the control panel of the chilled water plant, the following user levels are identified:

Level	Scope
<b>Visualization</b>	It does not require entry password and can check the status of the system entering in the different menu screens.  This user cannot activate any order to the system.
<b>Technical</b>	Requires login password.  Interact with the system through the different screens of the control system and activate the start / stop sequence of the system in "Auto" mode and perform "manual" starting of the water pumps.
<b>Advanced</b>	Requires login password.  It includes functions of the "Technical" level and the possibility to modify operating parameters of the equipment and control modes.  This user can disable the start authorization requirement to the control system of the power source No 1 or 2 and directly activate the start of the chilled water plant.  This user can disable the interlock between the compressors and the seawater pump. This option allows operate the compressors with the water pump associates to the fire system control on board.
<b>Maker</b>	Requires login password.

In case the user "Technical" or "Advanced" remains three minutes without interacting with the screen, his session will be closed automatically and the "visualization" level will be activated.

### 1.3.2 System Operation

Each chiller water unit can be controlled / monitored in a Remote or Local mode.

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- Local control is performed from the control panel through the touch screen (HMI) installed on it.
- The remote control is done from IPMS on board.

To choose one of these control modes, the user has a selector switch located in the main control panel. So, in case of select the local control mode none order sent from remote mode alters equipment status, except a remote emergency stop.

The user will enable the start-up or shutdown of the chiller water plant equipment; however the control will be executed by the PLC.

Therefore, to enable the system, the user has the following options

- Automatic Start / Stop
- Manual Start / Stop

#### **NOTE**

*Regardless of the mode of operation, there are interlocks between the equipment that the control system manages to avoid a wrong operation of the system, for example, the compressors cannot enable to operate if the water pumps have not started up previously.*

### **1.3.2.1 Local Control**

The operation modes of the chiller water unit are explained below considering that the system is operated locally:

#### **1.3.2.1.1 Automatic Mode.**

To execute an automatic start of the equipment, the user must press on the HMI screen of the **"AUTO START"** button.

Once the **"AUTO START"** button has been pressed, the starting sequence described in section 1.3.4 of this document will start.

To stop the operation of all equipment in the chiller water unit in a controlled manner, the user must press the **"AUTO STOP"** button on the HMI screen. By pressing this button, the system will stop all the equipment of the chiller water unit according to the sequence indicated in section 1.3.5 of this document.

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#### NOTE

*It is recommended to operate the chiller water unit in this control mode due it allows a balance of working hours of the compressors and the startup sequence is carried out respecting the interlocking between the equipment and the appropriate timings to protect the system.*

Once the start sequence is finished, the user can select the manual mode for each equipment, but the change of state will depend of the interlocks between the equipment.

Therefore, the pumps cannot stop while at least a compressor is enabling to run, but the compressor can be stopped while the pumps are running.

The three way valves can be regulated in manual mode without consider any interlock, however, once the valve has been graduated manually the control system does not consider the value of the temperature (in the case of seawater) or pressure (in the case of chilled water) to adjust the position of the respective valve.

#### 1.3.2.1.2 Manual Mode.

This operation mode of the equipment is mainly considered to perform tests of operation of the equipment once performed maintenance, however the user can operate the equipment under this modality once assimilated the concepts of interlock between equipment.

From this function the user can perform the following operations:

- Starting up the condensation pump without activate the complete system.
- Starting up the chilled water pump without activate the complete system.
- Enable the start-up of each compressor. The control system only allows this function will be performed if the condensation and chilled water pumps have been started.

#### NOTE

*The user does NOT start the compressor up directly. This signal corresponds to the "enable signal by user" described in the section 1.2.3.1.1 to generate the "start signal" required to the control system can activate the start sequence of the compressor.*

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#### **NOTE**

*The opening of the liquid solenoid valve and the expansion valve is always executed by the control system and the user does not have incidence in this action.*

In the event that the user has started up an equipment in manual mode without previously starting the system in automatic mode (section 3.2.1.1), and decides to active the auto mode to this equipment, the equipment will stop.

However, if this is the case for both water pumps (seawater and chilled water) while a compressor is enable to startup or it is running, the control system will not allow change the operation mode of any water pump until the compressor has been stopped by user. In this case, the system will display a warning message: "interlock with compressor".

Likewise, if the system has not been started in auto mode previously and the water pumps (seawater and chilled water) are started up in manual mode by user, the three-way valves of the respective systems must be operated on manual mode, that is, they will remain constantly in the "no bypass" position until the user modifies their position.

Finally, the user has available a button in the touch screen that allows him to change the manual operation mode to automatic mode: "Restore auto mode".

Regarding the configurations of segregated / non segregated (sequential) operations, these configurations are not stated in the chilled water units.

Segregation valves between zone 1 and zone 2 allow the operation in segregated mode (both valves in close position). For each of these valves a local operation panel (LOP) is available. In this panel "open" and "close" push buttons, and "Local / Stop / Remote" switch are available (these operations are not available in the local control panel, CTP, associated). This operation will not be developed from the chilled water units.

In segregated mode the chilled water unit located in zone 2 must be set in operation. Only one chilled water unit can be used for forward zone

#### **1.3.2.2 Remote Control**

The user can monitor the status of equipment (running, stop or alarm) and the performance of the chiller water unit through of the reading data (temperature and pressure data) in remote mode and he can also control remotely the chiller water unit.

For this case, the user has the following commands:

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- General start command.
- General stop command.
- Restore to auto mode.

This is equivalent to the automatic mode of local control.

In case some equipment is started up in manual mode (locally) and then the user turns the selector switch to "remote mode" a warning advice is display: "some equipment in manual mode". This warning advice will be also sent to IPMS.

The system must remain in the situation that is found when changing the position of the control selector (local or remote), that means, no equipment must be stopped or activated by the action of changing the location of the control; however a warning signal must be activated in case any equipment is controlled manually. The user must to stop the system, restore it to auto mode and start it again to ensure the complete control of the system in remote mode.

#### NOTE

*The compressor shut-off will always be carried out in a controlled manner (independently if it is done manually or automatically by reaching the set point), performing a deceleration ramp (time editable from HMI) until the minimum speed value (25 Hz) and then braking through another deceleration ramp called "Ramp Time at Low Speed" (3 sec)*

*That does not apply in the cases of emergency stop (local or remote) or stop due to compressor failure, in which case the compressor will immediately stop (freewheel).*

Regarding the configurations of segregated / non segregated (sequential) operations, these configurations are not stated in the chilled water units. They must be stated in the IPMS:

\*Segregated: segregation remote controlled valves between main fire zones are kept closed and each main fire zone is supplied by the Chilled Water plants located in their own fire zone. In this configuration, for the fire zone FWD supplied by two chilled water plants, one of them will be configured as main plant and the other ones as stand-by. In case that the main plant reaches it 100% capacity the secondary chiller unit cannot be started.

\*Non segregated (Sequential): segregation remote controlled valves between main fire zones are kept opened and all chilled water plants are available to serve to all ship's

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consumers. In order to get these configurations, each chilled water plant will be designed to be configured as main or secondary, and will send a "CHILLER WATER UNIT REACHING FULL CAPACITY" signal to IPMS for managing the remote starting commands to secondary plants depending on the system configuration. This signal will be generated when the capacity of the unit stays over 90% during 15 minutes or longer.

Additionally a "COOLING CAPACITY VALUE" signal will be provided from each chilled water plant. Recommendation is to stop one chilled water unit when the addition of the capacity of both plants in operation remains under 90% during 15 minutes or longer.

In this case one zone (aft or forward) will be set as primary. For forward zone its main plant will be started, and the second plant will remain stopped as stand-by.





IPMS operator may select which plant will be configured as main and which one as secondary for both available configurations.

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### 1.3.3 Identification of equipment states

To facilitate the identification of equipment status, the following colour code is used in the HMI control screen (*In "HVAC HMI USER INTERFACE" is indicated all status of system equipment*), for example:

COLOUR	MEANING	EXAMPLE
RED	Equipment with a fault	
GREEN	Equipment is running or solenoid valve energized	
GREY	Equipment is shut off (In case of compressors: Equipment is not enabled).	
BLUE	Equipment in Standby (Equipment enabled to operate but it is not running)	

### 1.3.4 Stop Condition

When the system is stopped by the stop command, the equipment have the following status:

- Chilled water pump shut off (colour: grey )
- Sea water pump shut off (colour: grey )
- Compressors shut off (colour: grey )
- Liquid solenoid valves closed (colour: grey )
- Three way valves in non-bypass position (colour: grey )

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### 1.3.5 Starting Sequence

#### NOTE

*The user must perform the following checks before starting the water chiller unit:*

- *Check the opening of the valves of the condensation water pipe and chilled water recirculation.*
- *Check that the chilled water pipe is properly purged.*
- *Check the opening of the valves of the refrigerant gas circuit of the chilled water plant.*
- *Visual inspection to refrigerant gas circuit and rule out possible refrigerant / oil gas leaks.*
- *Check the power supply voltage level in the control panel.*

A general description to start up the chiller water unit is indicated below.

- A. Check none alarm is active. Press the ALARMS button on the HMI. If any fault is detected the user shall proceed to its identification, correction and clear it as the case may be.
- B. Verify that none of the equipment is "stopped" in Manual mode.
- C. Enabling the start sequence of the HVAC system: Press the "AUTO START" button on the HMI.
- D. The control system of the chilled water plant confirms the start authorization given by the control system of the electric power source No 1 and 2 and executes the following steps:
  - D- 1 Check three way valve position in sea water pipe (non-bypass: allow all water flow to the condenser)
  - D -2 Start up the condensation pump
  - D -3 Check the three-way valve in chilled water pipe (non-bypass: allow all water flow to consumers)
  - D -4 10 sec. delay with respect to seawater pump startup, Start up the chilled water pump
  - D -5 Set three way valves in chilled water pipe according to set point.



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- D -6 Confirm chilled flow is stable
- D -7 If chilled water temperature value is higher than set point, start command is activated to compressor with less working hours.
- D -8 Send opening signal to liquid solenoid valve and enable signal to expansion valve controller associated to compressor with less working hours.
- D -9 Start command.

### 1.3.6 Shutdown sequence

A general description to shut down the chiller water unit is indicated below

- A. Enable the stop sequence of the HVAC system: Press the "AUTO STOP" button on the HMI.

The following steps are executed by the control system:

- A- 1 Stop the compressors in a controlled manner, reducing refrigeration capacity.
- A -2 30 seconds later that both compressor are stopped, the control system will stop the chilled water pump
- A -3 30 seconds later that chilled water stops, the control system will stop the seawater pump

## 1.4 Signal List

### 1.4.1 Interchange Signals with IPMS

Please see documents:

- D-MO5462-091 – IDD CHILLER WATER PLANT CWP-CH00001.
- D-MO5462-092 – IDD CHILLER WATER PLANT CWP-CH00002
- D-MO5462-093 – IDD CHILLER WATER PLANT CWP-CH00003

### 1.4.2 Alarm List display in HMI

Code	Type	Description
GN – 001	Alarm	Chiller Water Unit General Failure Alarm
GN – 002	Alarm	Chiller Water Unit Power Supply Failure Alarm
GN – 003	Alarm	Antifreeze protection tripped
GN – 004	Alarm	Low chilled water flow
GN – 005	Alarm	High pressure – chilled water pipe

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GN – 006	Alarm	Local Emergency Stop activated
GN – 007	Alarm	Remote Emergency Stop activated
GN – 008	Alarm	Start authorization request to power source 1 denied
GN – 009	Alarm	Start authorization request to power source 2 denied
GN – 010	Warning	Start authorization request to power source 1 disable
GN – 011	Warning	Start authorization request to power source 2 disable
GN – 012	Warning	Refrigeration gas leakage alarm
GN – 013	Warning	Parameter changes
GN – 014	Warning	Any equipment in manual mode
GN - 015	Warning	Interlock between compressors and seawater pump disable
COMP1 – 001	Alarm	Compressor No 1 – Failure Indication
COMP1 – 002	Alarm	Compressor No 1 – High pressure switch KP5 tripped
COMP1 – 003	Alarm	Compressor No 1 – High pressure analogue protection tripped
COMP1 – 004	Alarm	Compressor No 1 – Low pressure switch KP1 tripped
COMP1 – 005	Alarm	Compressor No 1 – Low pressure analogue protection tripped
COMP1 – 006	Alarm	Compressor No 1 – Low oil level
COMP1 – 007	Alarm	Compressor No 1 – High oil temperature
COMP1 – 008	Alarm	Compressor No 1 - Motor overheat protection tripped
COMP1 – 009	Alarm	Compressor No 1 – Electrical protection tripped
COMP1 – 010	Warning	Compressor No 1 – Start-to-start interval active
COMP1 – 011	Warning	Compressor No 1 – Refrig. Capacity reduced due high power
COMP1 – 012	Warning	Compressor No 1 – Refrig. Capacity reduced due high pressure
COMP1 – 013	Warning	Compressor No 1 – Refrig. Capacity reduced due low power
COMP2 – 001	Alarm	Compressor No 2 – Failure Indication
COMP2 – 002	Alarm	Compressor No 2 – High pressure switch KP5 tripped
COMP2 – 003	Alarm	Compressor No 2 – High pressure analogue protection tripped
COMP2 – 004	Alarm	Compressor No 2 – Low pressure switch KP1 tripped
COMP2 – 005	Alarm	Compressor No 2 – Low pressure analogue protection tripped
COMP2 – 006	Alarm	Compressor No 2 – Low oil level
COMP2 – 007	Alarm	Compressor No 2 – High oil temperature
COMP2 – 008	Alarm	Compressor No 2 - Motor overheat protection tripped
COMP2 – 009	Alarm	Compressor No 2 – Electrical protection tripped
COMP2 – 010	Warning	Compressor No 2 – Start-to-start interval active
COMP1 – 011	Warning	Compressor No 2 – Refrig. Capacity reduced due high power
COMP1 – 012	Warning	Compressor No 2 – Refrig. Capacity reduced due high pressure
COMP1 – 013	Warning	Compressor No 2 – Refrig. Capacity reduced due low power
CWP – 001	Alarm	Chiller water pump – Thermal magnetic motor protection tripped
CWP – 002	Alarm	Chiller water pump – Electrical contactor failure
CWP – 003	Warning	Chiller water pump – Interlock with compressor
SWP - 001	Alarm	Seawater pump - Thermal magnetic motor protection tripped
SWP - 002	Alarm	Seawater pump – Electrical contactor failure
SWP - 003	Warning	Seawater pump – Interlock with compressor
INSTR - 001	Alarm	Temp. transm. – Chilled water inlet failure

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INSTR - 002	Alarm	Temp. transm. – Chilled water outlet failure
INSTR - 003	Alarm	Temp. transm. – Seawater inlet failure
INSTR - 004	Alarm	Temp. transm. – Seawater outlet failure
INSTR - 005	Alarm	Pressure transm – Chilled water pipe failure
INSTR - 006	Alarm	Pressure transm – Compressor No 1 Suction failure
INSTR - 007	Alarm	Pressure transm – Compressor No 1 Discharge failure
INSTR - 008	Alarm	Pressure transm – Compressor No 2 Suction failure
INSTR - 009	Alarm	Pressure transm – Compressor No 2 Discharge failure

### 1.4.3 Signal / Status display in HMI.

Description	Type
Compressor No 1 – Running	Indication
Compressor No 1 – Stopped	Indication
Compressor No 1 – Alarm	Indication
Compressor No 1 – Enable	Indication
Compressor No 2 – Running	Indication
Compressor No 2 – Stopped	Indication
Compressor No 2 – Alarm	Indication
Compressor No 2 – Enable	Indication
Chilled water pump – Running	Indication
Chilled water pump - Stopped	Indication
Chilled water pump – Alarm	Indication
Seawater pump – Running	Indication
Seawater pump - Stopped	Indication
Seawater pump – Alarm	Indication
Liquid Solenoid Valve No 1 – Open (Energized)	Indication
Liquid Solenoid Valve No 1 – Closed (Not Energized)	Indication
Liquid Solenoid Valve No 2 – Open (Energized)	Indication
Liquid Solenoid Valve No 2 – Closed (Not Energized)	Indication
Three way valve seawater – Non by-pass	Indication
Three way valve seawater – Modulating	Indication
Three way valve seawater – Total by-pass	Indication
Three way valve seawater - % opening	Monitoring
Three way valve chilled water – Non by-pass	Indication
Three way valve chilled water – Modulating	Indication
Three way valve chilled water – Total by-pass	Indication
Three way valve chilled water - % opening	Monitoring
Inlet Chilled water temperature – Temp. value	Monitoring
Inlet Chilled water temperature – Probe failure	Indication

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Outlet Chilled water temperature – Temp. value	Monitoring
Outlet Chilled water temperature – Probe failure	Indication
Inlet Seawater temperature – Temp. value	Monitoring
Inlet Seawater temperature – Probe failure	Indication
Outlet Seawater temperature – Temp. value	Monitoring
Outlet Seawater temperature – Probe failure	Indication
Suction Pressure Compressor No 1 – Pressure value	Monitoring
Suction Pressure Compressor No 1 – Probe failure	Indication
Suction Pressure Compressor No 1 – Low pressure Alarm	Indication
Discharge Pressure Compressor No 1 – Pressure value	Monitoring
Discharge Pressure Compressor No 1 – Probe failure	Indication
Discharge Pressure Compressor No 1 – High pressure Alarm	Indication
Oil lubricant Temperature Compressor No 1	Indication
Suction Pressure Compressor No 2 – Pressure value	Monitoring
Suction Pressure Compressor No 2 – Probe failure	Indication
Suction Pressure Compressor No 2 – Low pressure Alarm	Indication
Discharge Pressure Compressor No 2 – Pressure value	Monitoring
Discharge Pressure Compressor No 2 – Probe failure	Indication
Discharge Pressure Compressor No 2 – High pressure Alarm	Indication
Oil lubricant Temperature Compressor No 2	Indication
Chilled Water Pipe – Pressure Value	Monitoring
Chilled Water Pipe – Probe failure	Indication
Compressor No 1 – Total working hours	Indication
Compressor No 1 – Working hours since last maintenance	Indication
Compressor No 2 – Total working hours	Indication
Compressor No 2 – Working hours since last maintenance	Indication
Chilled water pump – Total working hours	Indication
Chilled water pump – Working hours since last maintenance	Indication
Seawater pump – Total working hours	Indication
Seawater pump – Working hours since last maintenance	Indication
User Level activated	Indication

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## 2 MAINTENANCE

The unit is a high-quality and reliable unit. However, to guarantee the permanent functioning and performance of the unit, regular maintenance and inspection by technical experts is necessary.

### NOTE

*Maintenance must only be performed by trained technical personnel in observance of this operation manual and the regulations in force.*

### WARNING



- High voltage installed
- Risk of electric accident!
- Before performing any work on the unit, ensure that it is powered down. Ensure that the unit is secured against being switched back on at an appropriate point of the on-site power supply.



- High voltage installed
- Risk of electric accident!
- Power the unit down before undertaking any work that involves the unscrewing of covers. Ensure that the unit is secured against being switched back on at an appropriate point of the on-site power supply.

### NOTE

*The warranty will be invalidated by damage which is attributable to the non-performance of regular essential inspections.*

***Maintenance tasks may only be performed by suitable trained personnel. Maintenance on the electrical components of the chilled water unit should be executed by an electrical service engineer.***

***Maintenance to the refrigerant section of the chilled water unit should be executed by authorized refrigerant personnel.***

***It is absolutely forbidden to remove all the protections of the moving parts of the unit***

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***The causes of repeated shutdowns deriving from triggering of safety devices must be investigated and corrected. Re-starting the unit after simply resetting the alarm can seriously damage the equipment.***

***A correct refrigerant and oil charge is essential for optimal operation of the machine and for environmental protection. Any oil and refrigerant recovery must conform to legislation in force.***

***The required skill level for maintenance tasks of the chilled water units is level 1.***

***Skill level 1 means that the maintenance engineer has a technical education level and is familiar with the unit. Work to the electrical components of the chilled water unit must be performed by an electrical maintenance engineer. Work to the refrigerant section of the chilled water unit must be performed by a refrigerant certified maintenance engineer.***

***Frizonia requires users to have a complete check on the unit and on the state of the pressurised refrigeration circuit carried out after ten years of use. In addition, Frizonia recommends that all users analyse compressor vibrations annually and make routine inspections to check on possible refrigerant leaks. These checks ascertain that the refrigeration circuit is intact and safe and must be carried out according to local and/or European laws by personnel holding the qualifications required by such laws.***

## **2.1 Compressor maintenance**

The analysis of vibrations is a good method for verifying the mechanical conditions of the compressor.

Verification of vibration readings immediately after start-up and periodically on an annual basis is recommended. The compressor load must be similar to the previous measurement's load to ensure measurement reliability.

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## **2.2 Lubrication**

The units do not require a routine procedure for lubrication of components.

Compressor oil is of the synthetic type and is highly hygroscopic. It is therefore advised to limit its exposure to the atmosphere during storage and filling. It is recommended that the oil be exposed to the atmosphere for no more than 10 minutes.

The compressor oil filter is located under the oil separator (delivery side). Its replacement is advised when its pressure drop exceeds 2.0 bar. The pressure drop across the oil filter is the difference between the compressor discharge pressure and the oil pressure. Both these pressures can be monitored through the microprocessor for both compressors.

## **2.3 Routine maintenance**

Annually      Weekly      Monthly







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Replacement of the cartridges is advised when the pressure drop across the filter reaches 50 kPa with the compressor under full load.

The cartridges must also be replaced when the humidity indicator in the liquid sight glass changes colour and shows excessive humidity, or when the periodic oil test reveals the presence of acidity (TAN is too high).



- *Interruption of the water flow during the filter replacement process.*
- *Evaporator freeze.*
- *Ensure proper water flow through the evaporator during the entire servicing period.*

#### **NOTE**

*To protect the environment, do not release removed refrigerant into the atmosphere. Always use a recovery and storage device.*

## **2.5 Refrigerant charge**

The units ship with a full refrigerant charge, but in some cases it might be necessary to replenish the machine in the field.

***The units have been designed to operate with R134a refrigerant. DO NOT USE refrigerants other than R134a.***

***The addition or removal of refrigerant gas must be carried out in compliance with the laws and regulations in force.***

***When refrigerant gas is added to or removed from the system, ensure proper water flow through the evaporator for the entire charge/discharge time. Interrupting the water flow during this procedure would cause the evaporator to freeze with consequent breakage of its internal piping. Damage caused by freezing makes the warranty void.***

***Removal of the refrigerant and replenishing operations must be performed by technicians who are qualified to use the appropriate materials for this unit. Unsuitable maintenance can result in uncontrolled losses in pressure and fluid. Do not disperse the refrigerant and lubricating oil in the environment. Always be equipped with a suitable recovery system. Always verify the causes of a loss of refrigerant. Repair the system if necessary then recharge it.***

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The machine can be replenished under any stable load condition (preferably between 70 and 100%) and under any ambient temperature condition (preferably above 20°C). The machine should be kept running for at least 5 minutes to allow the condensation pressure to stabilize.

The subcooling value is about 3-4°C.

Once the subcooling section has been completely filled, additional refrigerant will not increase system efficiency. However, a small additional quantity of refrigerant (1,2 kg) makes the system slightly less sensitive.

Note: Subcooling varies and requires a few minutes to re-stabilise. However, subcooling should not come below 2°C under any condition. Also, the subcooling value can change slightly as the water temperature and the suction superheating vary. As the suction superheating value decreases, there is a corresponding decrease in subcooling.

One of the two following scenarios can arise in a machine without refrigerant:

1. If the refrigerant level is slightly low, flow of bubbles can be seen through the liquid sight glass. Replenish the circuit as described in the replenishment procedure.
2. If the gas level in the machine is moderately low, the corresponding circuit could have some low-pressure stops. Replenish the corresponding circuit as described in the replenishment procedure.

### **2.5.1 Refrigerant charge procedure**

1) If the machine has lost refrigerant, it is necessary to first establish the causes before carrying out any replenishment operation. The leak must be found and repaired. Oil stains are a good indicator, as they can appear in the vicinity of a leak. However, this is not necessarily always a good search criterion. Searching with soap and water can be a good method for medium to large leaks, while an electronic leak detector is required to find small leaks.

2) Add refrigerant to the system through the service valve on the suction pipe or through the Schrader valve located on the evaporator inlet pipe.

3) The refrigerant can be added under any load condition between 25 and 100% of the system capacity.

Suction superheating must be between 4 and 6°C.

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4) Add enough refrigerant to fill the liquid sight glass entirely, so that no flow of bubbles can be seen anymore. Add an extra 2 , 3 kg of refrigerant as a reserve, to fill the subcooler if the compressor is operating at 50 – 100% load.

5) Check the subcooling value by reading the liquid pressure and the liquid temperature near the expansion valve. The subcooling value must be between 3 and 5°C. The subcooling value will be lower at 75, 100% load and higher at 50% load.

6) Overcharging the system will cause a rise in the compressor's discharge pressure.

## **2.6 Standard checks**

The unit comes factory-equipped with all the sensors listed below. Periodically check that their measurements are correct by means of reference instruments (manometers, thermometers); correct the wrong readings as necessary using the microprocessor keypad. Well-calibrated sensors ensure better efficiency for the machine and a longer lifetime.

Note: Refer to the microprocessor use and maintenance manual for a complete description of applications, settings and adjustments.

All sensors are preassembled and connected to the microprocessor. The descriptions of each sensor are listed below:

**Outlet water temperature sensor** – This sensor is located on the evaporator outlet water connection and is used by the microprocessor to control the machine load depending on the system's thermal load. It also helps control the evaporator's antifreeze protection.

**Inlet water temperature sensor** – This sensor is located on the evaporator inlet water connection and is used for monitoring the return water temperature.

**Compressor discharge pressure transducer** – This is installed on the compressor and allows to monitor the discharge pressure and to control the fan. Should the condensation pressure increase, the microprocessor will control the compressor load in order to allow it to function even if the compressor flow gas must be reduced. It also contributes to the oil control logic.

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**Low-pressure transducer** – This is installed on every compressor and allows to monitor the compressor suction pressure along with low pressure alarms. It contributes to complementing the oil control logic.

### **3 MAINTENANCE DATA RECORDS**

#### **3.1 General**

For adequate maintenance management a log-book should be maintained. A log-book comprises:

- All inspections.
- All executed repairs and replacements of components.
- All executed revisions of the refrigeration installation.
- Particular events like:
  - Deviations from the normal management/operation.
  - Dangerous situations.
  - Refrigerant leakage.

#### **3.2 Periodical inspections**

Records of periodical inspections could contain:

- What periodical inspections should be carried out?
- The executor who should carry out these inspections.
- The time interval between which the inspections should be carried out.
- Persons who should be informed about these inspections.

#### **3.3 Repair and maintenance**

Repairs should only be carried out by skilled personnel and after permission of the management. Repairs and maintenance should be carried out by more than one person, unless the installation is gas free.

Each repair and case of maintenance should be recorded in the log-book.

#### **3.4 Replacement of components and revision of installation**

Revisions and replacement of components of the refrigerating installation should be recorded in the log- book.

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### **3.5 Particular events**

Faults, accidents, deviations of normal management and other particular events should be recorded in the log-book