EMICON

AIR CONDITIONING AND INDUSTRIAL APPLICATION

R A C

AIR COOLED WATER CHILLERS WITH TURBOCOR COMPRESSORS (OIL FREE)

USE AND MAINTENANCE MANUAL

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1. INTRODUCTION

1.1. FOREWORD

The present handbook, originally written in Italian, was completed in accordance with the European legislation. It contains all the necessary information for carrying out without any risk transportation, installation, start-up, operation, setting, maintenance and dismantling of the unit.

All people authorized to operate with the unit, in particular, all technicians assigned to the unit maintenance, must know all information and instructions contained in this handbook and all its attachments.

In the event of non-compliance with the instructions contained in this manual regarding the installation, start-up, operation, setting, maintenance and dismantling of the unit, it could be unsafe for people, could damage objects and environment.

Should you have any doubt on the correct under standing of these instructions, please contact the Manufacturer in order to get further clarifications.

The unit has to be installed, handled, subjected to maintenance, repaired and dismantling in compliance with local technical standards.

1.2. Safety marks

The following safety marks are used in this manual to draw attention to all useful information in order to avoid any dangerous situations which could be unsafe and harmful for people, could damage equipment and environment or besides breaking the unit.

It means operation not allowed, because it could compromise the functionality of the unit.

It means a warning about important information for correct unit utilization.

It means a danger to people, things or environment.

It means an electrical danger or risk to people, things or environment.

1.3. Referring standards

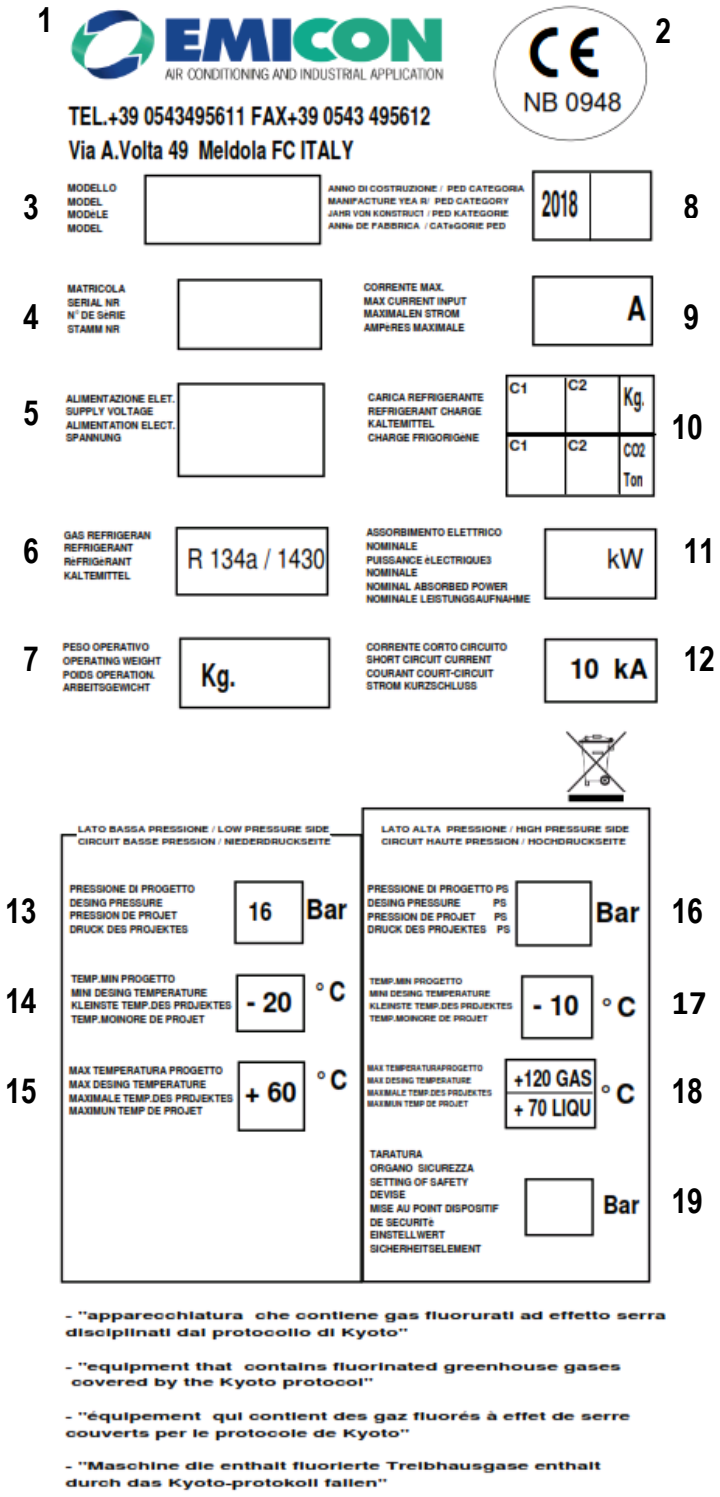
The unit of this handbook is designed and manufactured, unless the order has a different agreement, in compliance with the relevant European Directives and in particular, they meet the "Essential Safety Requirements" as set out in the following directives:

- 97/23/CE (PED),
- 2004/108/CE (Electromagnetic Compatibility),
- 2006/42/CE (Machinery Directive),
- 2006/95/CE (Low Voltage Directive).

As a matter of fact, the unit is certified by the Manufacturer and provided together with the CE Declaration of Conformity which is attached to the chapter n°8 of the present Manual and on the Identification tag of each unit.

1.4. Identification tag

The data for the identification of the unit are marked on a permanent tag attached inside the unit, close to the electrical panel. As shown in Figure 1.1, the identification tag contains the information unit in conformity with the European regulations.



1	Manufacturer's name and address
2	CE mark and the Notified Organization identification number which released the PED certification
3	Model
4	Serial number
5	Supply voltage
6	Refrigerant
7	Operating weight
8	Manufacture year / PED category
9	Max current input
10	Refrigerant charge
11	Nominal absorbed power
12	Short circuit current
13	Design pressure
14	Min. design temperature
15	Max design temperature
16	Design pressure
17	Min. design temperature
18	Max. deign temperature
19	Setting of safety device

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1.5. Warranty

The manufacturer warrants the Unit according to what stated on his general sales terms or according to what else explicitly agreed.

This manual provide detailed information on the proper receiving, handling, rigging, site installation requirements and maintenance of the equipment. All requirements must to be followed to ensure that your RAC (air cooled water chillers with turbocor compressors) will perform properly. Failure to follow these instructions can significantly impact the chiller's performance and reliability. The Manufacturer Warranty is void in case the guidance of this manual has not been carefully respected.

The manufacturer refuses all responsibility for any damage to people, animals, things or environment, caused by incorrect installation, maintenance or setting or misuse of the machine. It is considered as "misuse" of the machine any use not explicitly allowed in this manual.

On the first start-up, it is necessary duly fill in the relevant report attached to this manual and send a copy to Emicon A.C. (Customer Service), in order to make the warranty valid.

1.6. Readers of the Manual

This manual and all its attachments are supplied with the described unit.

The Manual must be kept by the machine's owner or by the person in charge to care for the machine, in a proper place. To this end, a plastic bag where to store the manual has been placed inside of the electric panel board of the machine, so that it can be always easily accessible for consultation and at the same time, it can be preserved in a good state.

All people authorized to operate with the unit, in particular, all technicians assigned to the maintenance and to charge the chiller with liquid refrigerant, must know all information and instructions contained in this manual.

In case the manual is lost or deteriorated, a new copy must be requested directly to the manufacturer.

1.7. Personnel requirements

Every work necessary on the unit, and especially on the refrigerant circuit, must to be to carried out from qualified and trained personnel. During such jobs workpeople must use the Personal Protective Equipment (PPE) and to be trained to use the refrigerant gas conforming to the norms in force for safety subject during the work, in regard to the place and the time where the job is done.

Maintenance and repair works require personnel with specific skills (as welders, electricians, programmer, etc), must to be run under supervisor.

The technician will work on the unit must to know:

- The directives, rules in accordance with the local current legislation concerning refrigeration gas;
- How to manage the refrigerant gas and Personal Protective Equipment necessary;
- Rules on safety and protection of the environment.

To keep these skills, the personnel have to take regularly refresher training.

1.8. Dangerous areas

In the unit can be dangerous areas such as:

- Components subject to electric voltage,
- Mechanism in movement,
- Overheated surfaces,
- Sharp edge,
- Components contain liquid at high pressure.

The unit is closed by case panel, in this way the unit is not accessible from outside in order to keep the personnel safe from these parts. . Only qualified and trained personnel can remove the covering panels.

The dangerous areas are adequately indicated with marks if they don't have any protection device.

1.9. Preventing electrostatic discharge when working with with electrical components on the DTC compressor

1.9.1. Purpose

Notify customers and technicians of the requirements to use correct procedures to prevent Electrostatic Discharge (ESD) when working with electrical components on the DTC compressor. This ensures that customers are aware of possible damage to static sensitive PCBs and devices if the procedures are not followed.

1.9.2. Handling electrostatic sensitive devices

Active electronic components are susceptible to damage when exposed to static electrical charges. Voltages as high as 1000 VAC may be encountered under some circumstances. Damage to these components may lead to outright failure or reduction in service life. Since the presence of static charges is not always evident, it is essential that service personnel follow static control procedures at all times when handling sensitive electronic components.

This section outlines static control precautions that must be followed when providing service support in the field. Preferably, service support personnel should create a safe, static-free environment.

Service personnel must use a commercially available service kit for handling static-sensitive devices. The kit typically includes:

- Ground cord Assembly
- Alligator clip
- Grounding wrist strap

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- Wrist strap tester

If a safe, static control environment cannot be created for a specific reason, the operator will ensure that ESDS items and personnel are at the same electrical potential as the equipment before touching the module and will not carry the module without its electrostatic discharge (ESD) protective bag.

The electronic modules should only be removed from the ESD protective bag at the last moment, just before installation when the operator is ready to do the replacement. The operator should avoid touching any components or connectors on the module and should hold the module by its edge or enclosure, as applicable. To start follow these procedures.

1.9.3. Electrical isolation of the compressor

This equipment contains hazardous voltages that can cause serious injury or death. Only qualified and trained personnel should work on DTC compressors.

Always wear appropriately rated safety equipment when working around equipment and/or components energized with high voltage. Faulty components can explode and cause serious injury or death.

Before replacing the spare part, you must isolate the compressor power by completing the following steps:

1) Turn off the mains input power to the compressor;
2) Secure/lock-out/tag-out the mains disconnect to ensure no accidental or unauthorized re-application of the mains input power can occur.

Removing the mains input cover will expose you to a high voltage hazard of up to 640VAC. Ensure the mains input power is turned off and locked out before removing it.

Do not allow the mains input or top covers to touch any components during their removal.

In particular, be careful with the CE type covers because they are coated on the outside for the purpose of being conductive. The painted covers only apply to TT300P and TT300C.

3) Remove the Mains Input cover. See Figure 1.

Figure 1 Mains Input Cover

The mains input fast-acting fuses are installed in the power panel for all compressor models except the TT300.

4) Using an appropriately rated multimeter (set for AC voltage measurements) and leads, on the line side of the mains input fast-acting fuses, place the red (+) multimeter lead on the phase 1 mains input terminal and the black (-) multimeter lead on the compressor main housing and record the result. The measured value should be 0.0VAC. If the measured voltage is not the expected value, determine the source of the voltage and turn it off, otherwise proceed with the next step.

5) Repeat step 4 for the remaining phases.

6) Remove the top cover.

TENSIONE ELETTRICA PERICOLOSA

Removing the top cover will expose you to a high voltage hazard of up to 1000VDC, wait at least 15 minutes to allow the DC capacitors to discharge and ensure there is no mains input voltage present before removing it.

1.9.4. ESD Protection / Grounding Instructions

All parts that are susceptible to damage by Electrostatic Discharge (ESD) will be marked using the following label. Please follow the instructions below to ensure safety and to protect the parts from ESD damage.

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1) Using an appropriately rated multimeter (set for DC voltage measurements) and leads, place the red (+) multimeter lead on the positive (+) SCR DC bus bar and the black (-) multimeter lead on the negative (-) SCR DC bus bar and record the result. The measured value should be below 5VDC. If the measured value does not correspond to the expected DC bus voltage, then wait at least 5 minutes and repeat this step until 5VDC or less is measured.

2) Clip the ESD strap ground clip to the compressor ground post. See blue arrow in Figure 2.

3) If you need to remove the Soft-Start, clip the ESD strap ground clip to the Mains Plate. See green arrow in Figure 2.

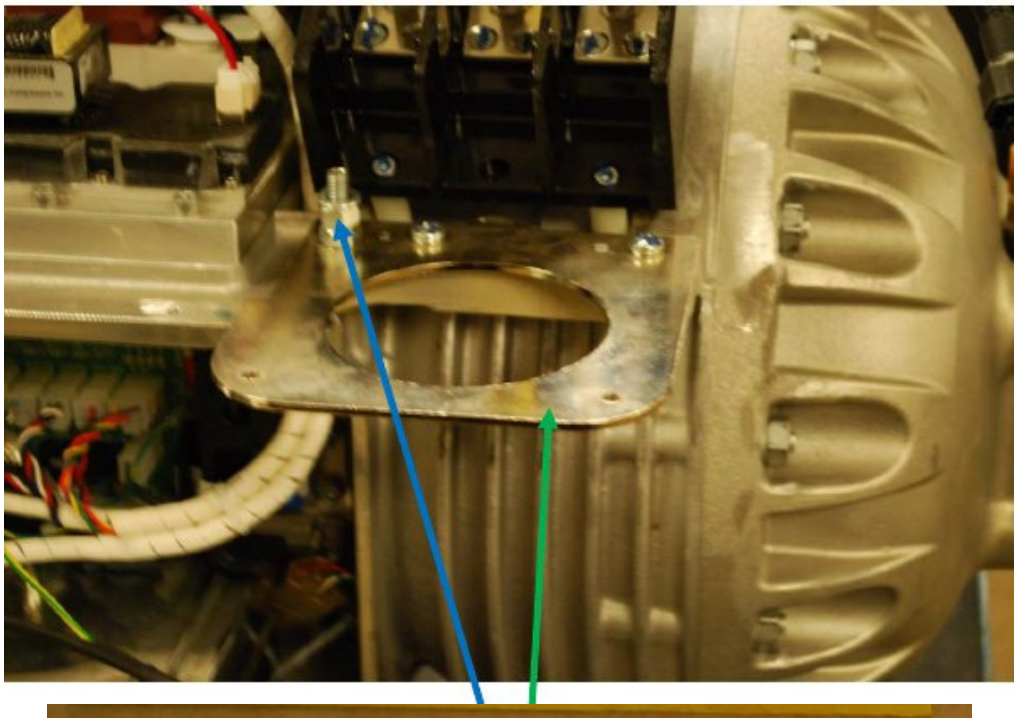

Figure 2 Mains Plate, round

4) If you only need to remove the Service Side cover, clip the ESD strap ground to the cover screw hole that is part of the compressor housing. See yellow arrows in Figure 3.

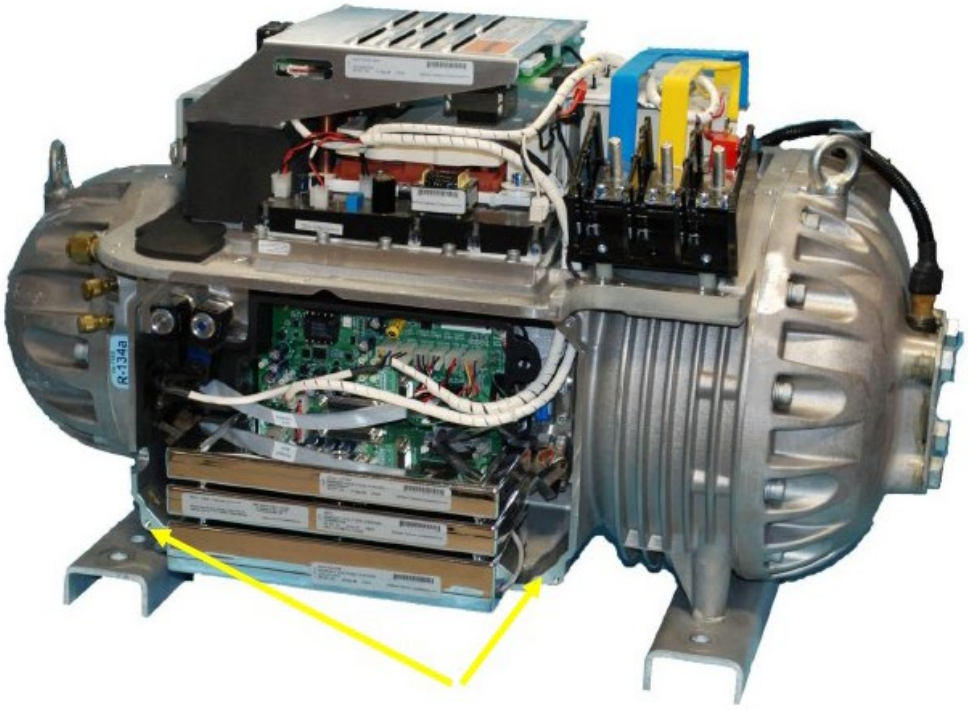

Figure 3: Compressor Grounding Points

1.10. Use

The unit is a monobloc water chiller with air condenser. The purpose of the unit starts with the evaporator, which contains the liquid refrigerant. The refrigerant radiates out cold to the surrounding tubes that are filled with water. The water is chilled and pumped through the circuit, absorbing heat from whatever items the chiller is meant to cool. When the water has finally reached a high enough temperature, it radiates the heat back at the refrigerant in the evaporator, causing it to turn into vapour. The vapour passes through the pipe into the compressor, which compresses the vapour putting it under high pressure and heat. This superheated vaporized refrigerant is then pumped through the condenser by axial fans. The vapour gives off its heat into the surrounding air and then condenses back into a liquid. The liquid flows back into the evaporator to repeat the chilling process.

1.11. Service rating

The unit can work regularly and realiably even in out-of-specification operational conditions. In this case, however, the machine's performance may be remarkably different from normal, since this depends heavily on working conditions. In particular, the unit's refrigerating capacity may be lower and its current draw may be higher than specified.

However, operating limits must be abided by during unit operation, as indicated in table 1.1.

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If you want to operate with the cooled fluid at the outlet of the evaporator at a different temperature than nominal, it is necessary to set the right value for the set point on the microprocessor. Also, if the temperature is lower than design temperature, anti-freeze alarm settings must also be modified (to a value at least 4° higher than the freezing point of the fluid to be cooled).

The tension and frequency of the feeder must fall within the intervals indicated in table 1.2

Table 1.1: Operational working limits

Parameter	Limit value
Minimum temperature of condensation air (without condensation pressure regulator – as an option)	20°C
Minimum temperature of condensation air (with condensation pressure regulator – as an option)	-15°C
Maximum temperature of condensation air	43°C
Minimum temperature of cooled water at the outlet of the evaporator (without adding brine)	4°C
Minimum temperature of cooled fluid at the outlet of the evaporator (with added brine)	2°C
Maximum temperature of cooled fluid at the inlet of the evaporator (during unit operation)	25°C
Maximum temperature of cooled fluid at the inlet of the evaporator (at unit start)	35°C
Minimum transfer rate of cooled fluid in the evaporator	0.9 x nominal rate
Peak transfer rate of cooled fluid in the evaporator	1.1 x nominal rate

Table 1.2: Allowed characteristics for power supply

ELECTRICAL MAGNITUDE	OPERATING RANGE
Power supply voltage (Nominal 400 V – 3ph)	395 - 410 V – 3ph
Power frequency (Nominal 50 Hz)	±5% of nominal value

If the power supply voltage or frequency do not fall within the specified interval, the compressors turn off automatically.

It is forbidden to exceed the limits set out in this paragraph while the unit is in operation without the manufacturer's prior explicit authorisation.

1.12. Prohibited use

The device must not be used

- for purposes different from the ones indicated in paragraph 1.9;
- in atmospheres exposed to the risk of fires or explosions;
- in environments with aggressive atmospheres towards copper, aluminium, and carbon- or stainless steel;
- indoors, in environments not properly ventilated or below ground level (see also chap. 3);
- to cool aggressive fluids towards copper and carbon steel;
- in operating conditions different from nominal ones specified by the manufacturer and explicitly agreed upon by contract.

Please contact the manufacturer for clarifications on the use of the cooler

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2. Description

2.1. Identification tag

The following figure there are the interpreting key for the initials used to mark the air cooled water chillers with turbocor compressors.

R	A	C	60	2	.U	.Ka
1	*2*	*3*	*4*	*5*	*6*	*7*

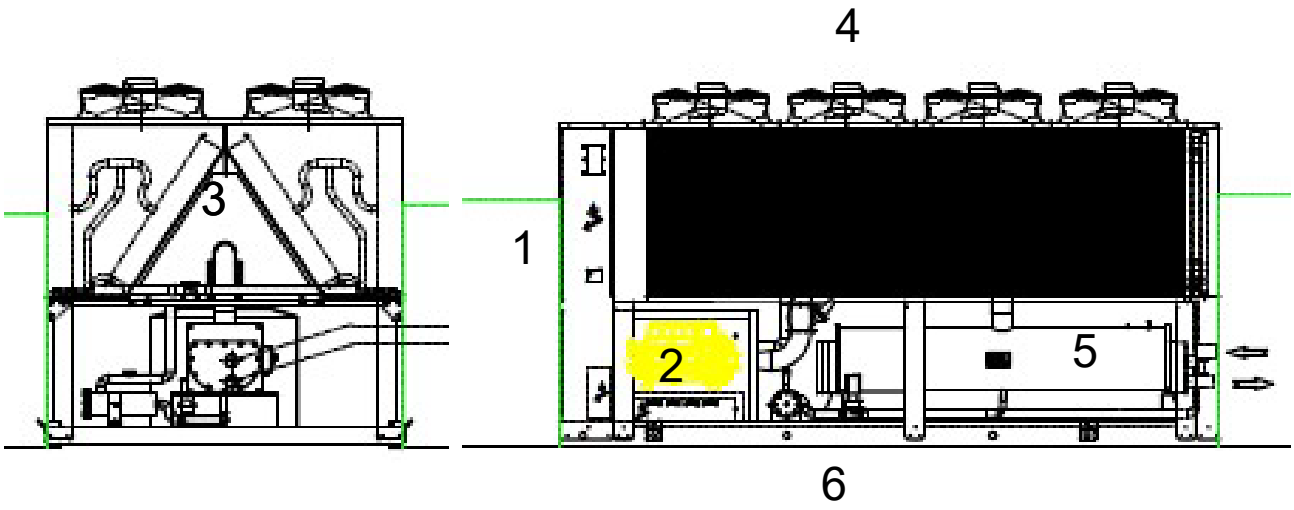
1	R	*Type of unit*	R = Chiller
2	A	*Condenser type*	A = Air
3	C	*Type of compressors*	C = Centrifugals
4	60	*Nominal capacity of chiller*	
5	2	*Number of compressors*	
6	.U	*Sound level*	_ = Standard S = Silenced U = Ultra-silenced X = Extra-silenced
7	.Ka	*Refrigerant type*	Ka = R134a

2.2. Main components

This unit is equipped with one or more two-stage centrifugal compressors, fitted with semi-hermetic design, with integrated control, variable frequency drive. The compressor is provided with radial and axial magnetic bearings to levitate the shaft, thereby eliminating metal-to-metal contact, and thus eliminating friction and the need for oil.

In the next paragraph will show the main characteristic components. The figure 2.1 shows the main parts of the unit.

Figure 2.1: Main components



1	Electrical board	**4**	Condensation axial fans
2	Centrifugal compressors	**5**	Flooded evaporators
3	Condenser with finned coil	**6**	Supporting frame

2.2.1. Structural frame

The modular carpentry of the unit is in galvanized carbon steel profiles and painted with epoxy powder primer of colour RAL 7035.

The structural frame parts are mounted in the way to be a solid chassis, to carry the unit components and to sustain the stress during the handling and unit operation.

All the parts in the unit are easily accessible, to facilitate and to make secure the unit during the operation and maintenance.

2.2.2. Compressors

The compressors fitted in the unit utilize a two-stage, variable-speed, centrifugal compressor design requiring no oil for lubrication.

Compressor is constructed with cast aluminium casing and high-strength thermoplastic electronics enclosures.

The two-stage centrifugal impellers consist of cast and machined aluminium. The motor rotor and impeller assembly shall be the only major moving parts.

The motor is compatible with high-speed variable-frequency operation that affords high-speed efficiency, compactness and soft start capability.

Compressors is designed for use with HFC-134a.

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The compressor is provided with radial and axial magnetic bearings to levitate the shaft, thereby eliminating metal-to-metal contact, and thus eliminating friction and the need for oil.

The magnetic bearing system consists of front, rear, and axial bearings. Both the front and the rear bearings are to levitate the shaft at radial and longitudinal directions. Each bearing position shall be sensed by position sensors to provide real-time repositioning of the rotor shaft, controlled by onboard digital electronics.

The compressor is provided with a direct-drive, high-efficiency, permanent-magnet synchronous motor powered by pulse-width-modulating (PWM) voltage supply.

The compressor has a Variable Frequency Drive (VFD) for linear capacity modulation, high part-load efficiency and reduced in-rush starting current. Signals from the compressor controller determines the inverter output frequency, voltage and phase, thereby regulating the motor speed. In case of power failure, the compressor is capable of allowing for a normal de-levitation and shutdown.

Compressor speed is reduced as condensing temperature and/or heat load reduces, optimizing energy performance through the entire range from 100 percent to 30 percent or below, depending on the pressure ratio, of full-load capacity of each compressor given Air Conditioning and Refrigeration Institute (ARI) unloading conditions. Capacity modulates infinitely as motor speed is varied across the range.

Inlet Guide Vanes (IGVs) is built-in to further trim the compressor capacity in conjunction with the variable-speed control to optimize compressor performance at low loads.

The motor cooling is determined by liquid refrigerant which is channelled, at full condenser pressure, from the main liquid line (after the drier filter) to the compressor to cool the electronics, mechanical components.

In case of power failure, the compressor shall be capable of allowing for a normal de-levitation and shutdown.

The compressor includes a microprocessor controller capable of controlling magnetic bearings and speed control. The controller is capable of providing monitoring, including commissioning assistance, energy outputs, operation trends, and fault codes via a ModBus interface.

2.2.3. Evaporator

Flooded shell and tube evaporator with shell in carbon steel operating with refrigerant in shell and water in the copper pipes. This solution allows working with an extremely low temperature superheating gas refrigerant value; consequently it allows to contain the difference between the temperature of the evaporator outlet water and the temperature of evaporation. The combination of these factors improves the heat exchange and as consequently the energy efficiency of the unit.

2.2.4. Evaporator's liquid level

The temperature that is sensed by the Electronic Expansion Valve thermal bulb is the superheat temperature of the refrigerant at the outlet of the evaporator. This is the temperature increase of the refrigerant above the saturation temperature corresponding to the existing evaporator pressures. When the superheat gas temperatures are too low, they suggest to adjust the liquid flow by the Electronic Expansion Valve.

An electronic refrigerant gas level transducer measures the refrigerant into the evaporator, it transfers the date to the unit microprocessor which controls the opening or closing of the Electronic Expansion Valve.

2.2.5. Condenser coil

The air heat exchanger is manufactured with copper tubes and aluminium fins; which are adequately spaced to decrease the thermal contact resistance and having the best heat exchange efficiency.

2.2.6. Axial fans

The axial fans with external rotor, at low rpms, generate the air capacity to the condenser coil. The electric motor fit for the purpose tot o run at variable rotation speed, which allows for controlling condensation by adjusting the speed rotation with voltage steps.

The axial fan with airfoil blades in aluminium alloy is expressly thought and manufactured to maximize the efficiency and to reduce the sound level.

The axial fans are furnished with safety grille.

2.2.7. Cooling circuit

The main components of the refrigerant circuit, above all that mentioned, are:

- Compressor discharge check valve,
- dryer filter,
- sight glass,
- solenoid valve,
- electronic thermostatic valve,
- high pressure safety valve,
- low pressure safety valve,
- compressor discharge shut-off valve
- compressor suction shut-off valve
- liquid line shut-off valve,
- High and low pressure guages,
- high and low pressure switches,
- evaporator temperature probes (inlet and outlet).

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2.2.8. Electric board

The unit electric board is built inside a metallic box, meeting the European current legislation. The electric board is IP 54 and it's manufactured to ensure protection for external installation..

The main panel is fitted with a main switch interlocked door. It's completed with:

- contactors,
- thermal and amperometric protectors,
- transformers,
- conductors,
- auxiliary low voltage circuit,
- terminal block,
- electronic card.

2.2.9. Controller

The complete management of the chiller control system is controlled by the electronic microprocessor, Turbocor Compound Capacity Chiller.

The Turbocor Compound Capacity Chiller is dedicated to Chiller systems with one or more Danfoss Turbocor compressors and it allows the management of chiller cooling: Air/Water, Water/Water, one or more refrigerant circuits and totally up to 4 Danfoss Turbocor compressors.

The main microprocessor's functions are as follows:

- chilled inlet or outlet water temperature regulation;
- proportional/integral regulation;
- anti freeze control;
- Danfoss Turbocor compressor management;
- pre-emptive handling of low evaporator or high discharge pressure;
- twin pumps control;
- alarms management;
- setpoint management:
- second setpoint;
- remote setpoint;
- setpoint compensation;
- liquid level control;
- Fan control (step or variable speed);
- Auto/Manual control modes;
- historical alarm list.

The main screen of the Turbocor Compound Capacity Chiller has a LCD display surrounded by soft keys. See the paragraph 7.4

2.2.10. Manufacturer test

The machine is subjected to thorough test and inspection before to leave the factor.

The cooling circuit is tested by pressure tester to confirm that it is without leaks and has the ability to hold the pressure specified by the Manufacturer's Quality System.

The unit is charged with refrigerant R134A only when the test and inspection give a positive result.

2.3. Centrifugal compressor

The purpose of this paragraph is to identify the parts of the compressor and to provide fundamental knowledge that describe the controller and the energy and signal flow.

2.3.1. Power supply

Turbocor compressors are designed to operate with a power supply that is within a strict tolerance for the values of nominally rated voltage and frequency.

Nameplate AC Voltage	Acceptable Voltage Range
400V (50Hz)	390 - 410 VAC

Nameplate frequency	Acceptable Voltage Range
50Hz	47 - 53 Hz

Even if the compressor is not running the input terminal can be under voltage

The use of wrong values of nominal voltage and / or frequency outside the permitted range can cause malfunctions and / or faults and implies the expiry of the warranty terms offered by Emicon AC. In particular, this applies in any case where is used a nominal voltage of 400 V AC with 380 V AC power supplies.

The AC line power is routed to the Silicon-Controlled Rectifiers (SCR) to convert the AC voltage into DC voltage. The DC bus voltage output from the SCR is about 1.35 times that of the input signal (a bus is a

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common electrical connection between multiple electrical devices). The DC bus has a voltage of 460-900 VDC, depending on the value of the AC input voltage. The DC voltage output from the SCR is then fed into the Soft-Start Board for voltage monitoring.

DC capacitors at the SCR output serve as energy storage and filter out the voltage ripple to provide a smooth DC voltage.

The DC capacitors provide the IGBT(Insulated Gate Bipolar Transistor) Inverter with 460-900VDC. The IGBT Inverter converts the DC link voltage into an adjustable frequency and adjustable amplitude, 3-phase simulated AC voltage.

Using both the AC input voltage source and the DC voltage output from the SCRs, the Soft-Start Board generates the in-rush current control signal and outputs pulses of 0-12VDC (with respect to the positive DC bus) to the SCR. This system together with speed variable operation limits the in-rush current at compressor power-up.

2.3.2. Motor drive system

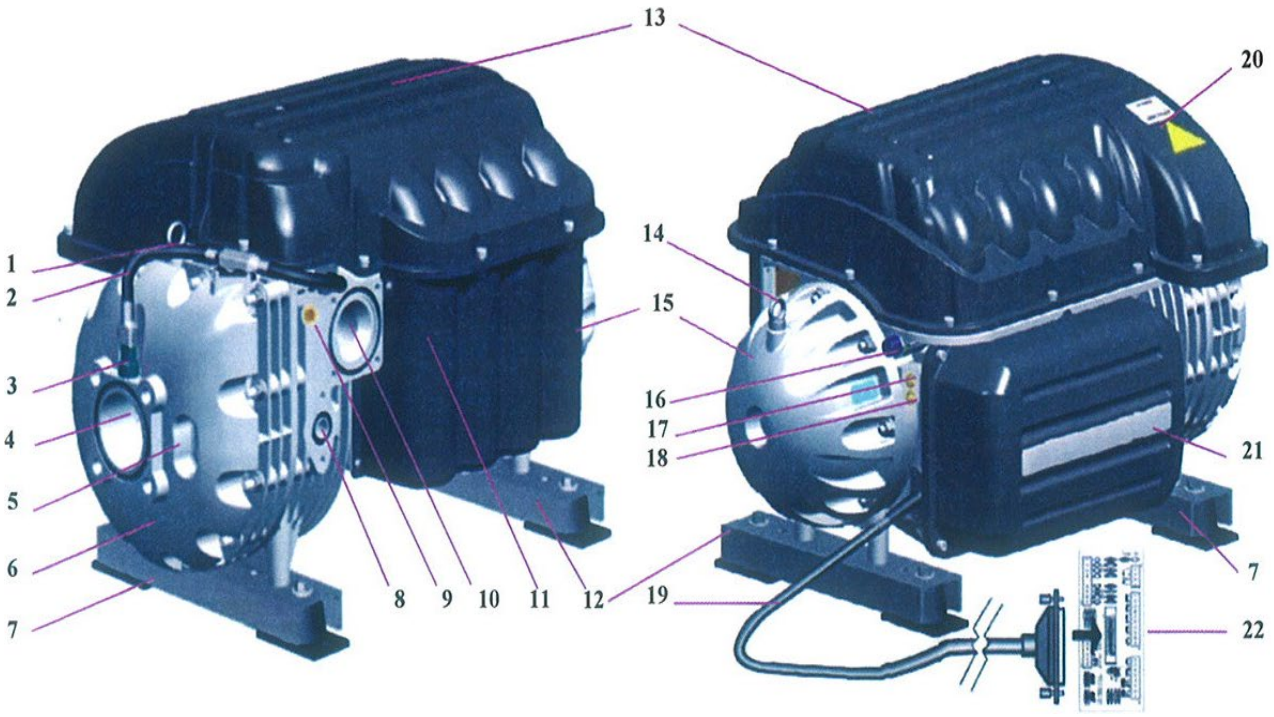
Normally, AC power to the compressor remains on, even when the compressor is in the off state. The compressor motor requires a variable-frequency three-phase source for variable speed operation. The AC line voltage is converted into a DC voltage by a half-controlled, full-wave rectifier. DC link capacitors at the rectifier output serve as energy storage and filter out the voltage ripple to provide a smooth DC voltage. The Insulated-Gate-Bipolar Transistor (IGBT) is an inverter that converts the DC link voltage into an adjustable three-phase AC voltage. Pulse-Width Modulation (PWM) signals from the Bearing-Motor-Compressor Controller control the inverter output frequency and voltage. By modulating the on and off times of the inverter power switches, three-phase variable sinusoidal waveforms are obtained.

If the power should fail while the compressor is running, the motor switches into generator mode thereby sustaining the capacitor charge. The rotor can then spin down safely in a controlled sequence preventing damage to components.

The soft-start controller limits inrush current by progressively increasing the conduction angle of the silicon-controlled rectifiers (SCRs). This technique is used at compressor start-up while the DC link capacitors are charging up.

The soft-start function and the variable-speed drive combined, limit the inrush current at start-up.

Figure 2.2: Compressor component identification



No.	Component	No.	Component
1	Lift anchor (front)	**12**	Rear support base
2	Cable harness (sensor)	**13**	Top access cover
3	Suction pressure/temperature sensor	**14**	Lift anchor (rear)
4	Inlet guide vanes (IGV) suction port	**15**	End bell
5	IGV Position indicator	**16**	Motor–cooling connection
6	IGV housing	**17**	Motor–cooling (TT300) and Power electron ics cooling (TT400) Access port #1
7	Front support base	**18**	Motor-cooling Access port#2 (TT400 only)
8	Economizer port	**19**	Compressor I/O board cable
9	Optional pressure regulating port	**20**	Mains input access cover
10	Discharge port	**21**	Service-side access cover
11	Capacitor side access cover	**22**	Compressor I/O board

Figure 2.2: Compressor component location

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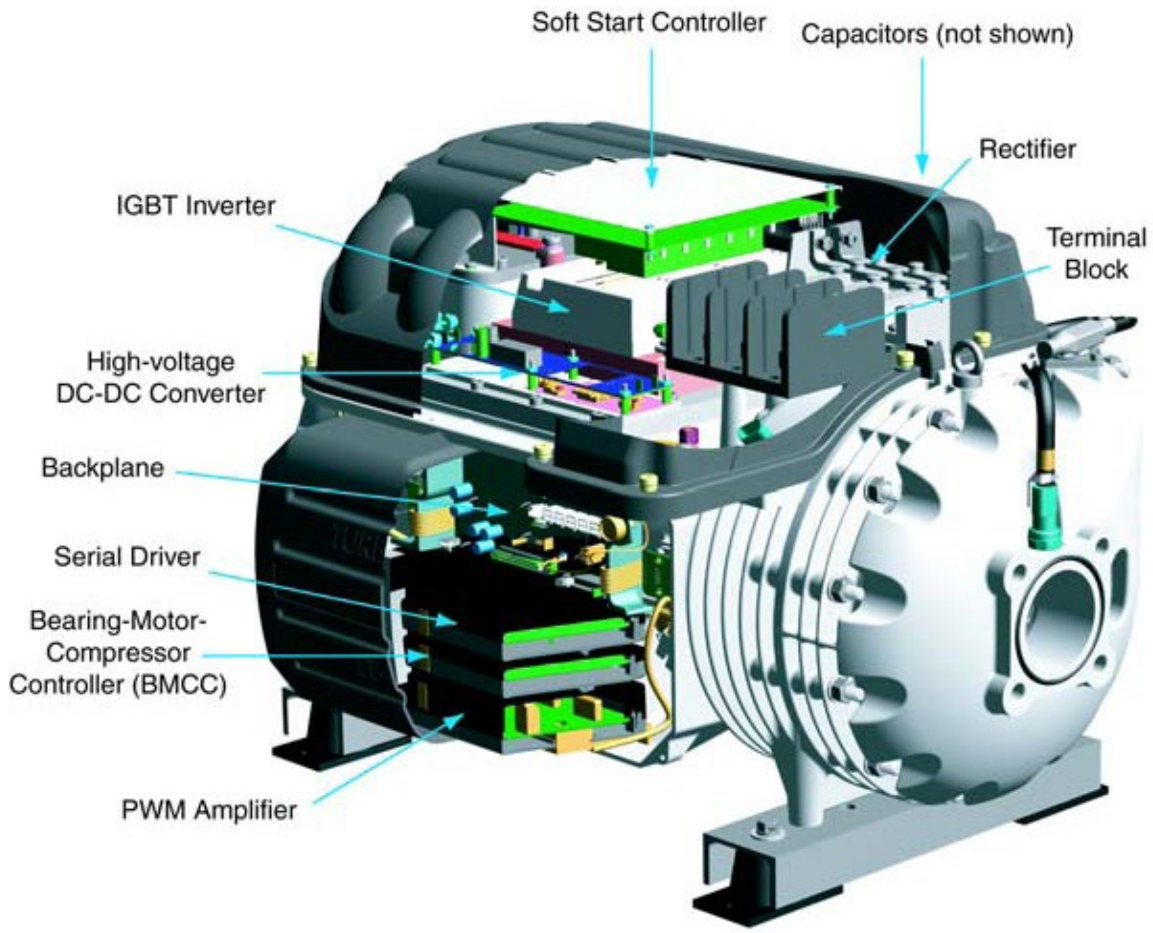

The Backplane is powered by +24VDC (with respect to 0V) from the High Voltage DC-DC Converter, which also provides the Backplane with High Voltage + (+250VDC with respect to High Voltage-) for the Bearing PWM Amplifier. The Backplane connects the onboard plug-in modules with the power electronics, expansion valves, IGV stepper motor, motor-cooling solenoids, rotor-position sensors, and pressure/temperature sensors. It is a means to transfer control, sensor, and error information between the BMCC and other Compressor components.

The Backplane also serves as the source of power to the parts connected to it. Enfact it provides +15VDC and +24VDC to the Serial Driver. The Serial Driver, in turn, uses +15VDC to control the external expansion valves and the IGV stepper motors. The +24VDC is used by the Serial Driver to control the motor-cooling solenoids.

The Backplane powers the BMCC with +5VDC, +15VDC and -15VDC. The BMCC uses the power source to process current, sensor, and error information.

The Backplane provides the Bearing PWM Amplifier with +5VDC, along with +17VDC and HV+ (both with respect to HV-). The PWM Amplifier uses the energy to supply current to the radial and axial magnetic bearing coils as commanded by the BMCC. In return, the PWM Amplifier passes feedback from the current sensor for the bearing coils and a spare temperature sensor for the heatsink.

The Backplane sends +24VDC and gating signals to the IGBT as per the BMCC. In return, the IGBT Inverter sends current, temperature, error, and DC bus voltage information to the BMCC via the Backplane. With the input gating signals, the IGBT Inverter controls the motor at a variable frequency of 0-750Hz.

2.3.3. Compressor controller

Over current The hardware and software for the compressor controller and the bearing/motor controller physically reside in the Bearing-Motor-Compressor Controller (BMCC) module.

The compressor controller is continuously updated with critical data from external sensors that indicate the compressor's operating status. Under program control, the compressor controller can respond to changing conditions and requirements to ensure optimum system performance.

One of the compressor controller's primary functions is to control the compressor's motor speed and IGV position in order to satisfy load requirements and to avoid surge and choke conditions. However, the majority of capacity control can be achieved via motor speed.

The compressor controller monitors over 60 parameters, including:

- Gas pressure and temperature monitoring
- Line voltage monitoring and phase failure detection
- Motor temperature
- Line currents
- External interlock

One of the compressor controller's primary functions is to control the compressor's motor speed and IGV position in order to satisfy load requirements and to avoid surge and choke conditions. However, the majority of capacity control can be achieved via motor speed.

The magnetic bearing system physically supports a rotating shaft while enabling non-contact between the shaft and surrounding stationary surfaces.

A digital bearing controller and motor controller provide the PWM command signals to the bearing amplifier and IGBT inverter, respectively.

The bearing controller also collects shaft position inputs from sensors and uses the feedback to calculate and maintain the desired shaft position.

The compressor controller responds to abnormal conditions by monitoring:

- Surge RPM
- Choke RPM
- Power failure/phase unbalance
- Low/high ambient temperature
- High discharge pressure
- Low suction pressure
- Stop/start short cycle
- Motor cooling circuit failure (over temperature)
- Refrigerant loss
- Power supply

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The Compressor I/O Board allows the user to control the Compressor and allows the Compressor to return status and sensor information to the user.

2.4. Unit Technical data

The main technical of the units are shown in the attachments.

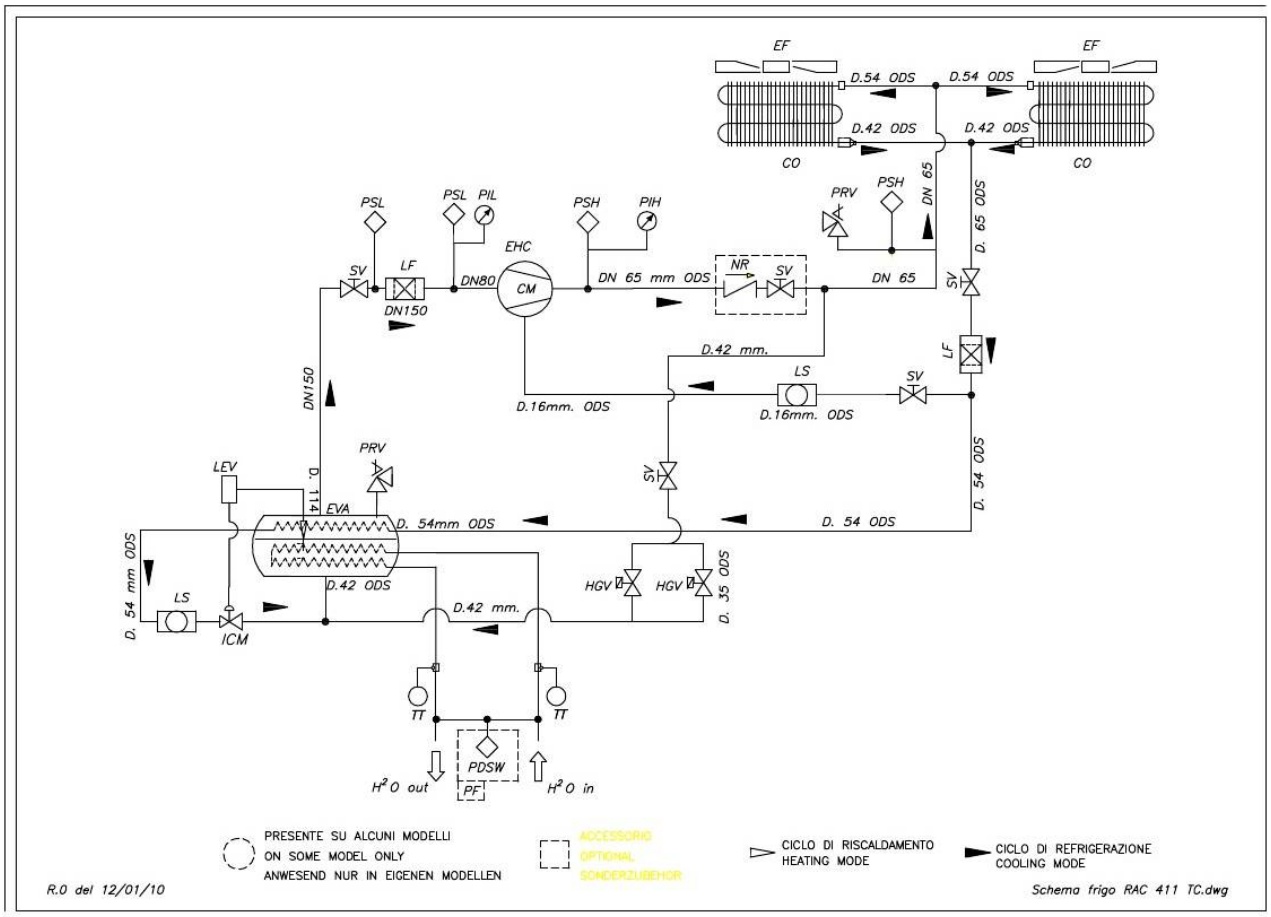
2.5. Cooling circuit

The figure 2.3 shown a typical cooling circuit of the unit.

Cooling circuit keys

CM	Centrifugal compressor	**PIH**	High pressure gauge
CO	Condenser with finned coil	**PIL**	Low pressure gauge
EF	Condensation axial fans	**PRV**	Safety valve
EV	Solenoid valve	**PSH**	High pressure switch for refrigerant gas
FSR	Fan speed regulator	**PSL**	Low pressure switch
HR	Heat recovery	**PT**	Pressure transducer
LF	Dehydrating filter	**SFF**	Heat exchanger
LLT	Refrigerant gas level transducer	**SV**	Shut-off valve
LS	Sight glass	**TT**	Temperature probe
NR	Non-Return valve	**VP**	Flooded evaporator
PDSW	Differential pressure switch	**VT**	Electronic expansion valve

Figure 2.3: Typical Cooling circuit of the unit



2.6. Wiring diagram

The wiring diagram is stored into the plastic bag placed inside of the electric panel board of the machine.

2.7. Dimensional drawings

The dimensional drawings are stored into the plastic bag placed inside of the electric panel board of the machine.

2.8. Main accessories

BT: Electronic device for the continuous voltage control of the condensing pressure through the variation of the axial fan rotation speed for low temperature operation (-15° C).

CF: Insulation of compressors by a cabinet coated with soundproofing material.

ECO: Economizer: to increase the chiller Energy efficiency, growing the liquid sub-cooling in the thermal expansion valve inlet, tank to a refrigerant quantity took immediately after the filter and put in the 2 compressor stage inlet.

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GP: Metal protection grille (dismountable) to protect the condenser coil and the cooling circuit.

IH: Connect RS485 serial interface to external supervision systems (the furniture does not include the supervision system and software controller – contact the Manufacturer to verify which communication protocols are available.

PA: Bell shaped vibration supports for insulating the unit, made of base and bell in galvanized steel and natural rubber mixture.

PF: Safety water flow switch installed between the evaporator inlet and outlet. It switch off the unit in case of lack of water flow rate through the evaporator.

PM: Spring type vibration dampers, with damping factor above 90.

PQ: Allowing to display unit parameters by Remote display terminal.

P1: Circulation pump group with standard head composed of expansion vessel, safety valve, hydrometer, pump inlet valve, pump outlet valve and air vent.

P1H: Circulation pump group with high head composed of expansion vessel, safety valve, hydrometer, pump inlet valve, pump outlet valve and air vent.

P2: N°2 circulation pump group installed in parallel composed of expansion vessel, safety valve, hydrometer, pump inlet valve, pump outlet valve and air vent. The pumps run one by one. Automatic switch in case of failure of the working pump. Double pumps runs in master/ slave mode, they invert their status at every stop. In this way the balance the working hours. The pumps are furnished of discharge shut-off valve and check valve.

RM: Condensing coil with pre-painted fins, it is obtained by superficial treatment of the condensing coils with epoxy coating.

RR: Copper/copper condensing coil, it is a special execution of the condensing coils with copper pipe and fins.

VB: The evaporator is insulated externally with thermal insulation and anti condensation cladding, which has 19 mm thick instead 9 mm on the standard model.

RAC series are available in various versions with different pressure sound.

2.9. Refrigerant

The unit is designed to work with gas R134A. It contains no chlorine and it is considered ozone-safe and environment friendly.

The refrigerant Safety data sheet is shown on Chapter 7.

3. Installation

The unit installation must comply with local existing laws and regulations.

In the European Community the unit can be descrive as indirect closed system in compliance of the EN 378-1 (par. 4.1.3, 4.4.2.1 and fig. 2.a). The type of refrigerant and the charge of refrigerant on each circuit are written on the identification tag.

For several installations, follow the charge limit imposed in EN 378-1, att. C. And if the group A1 refrigerant is used follow the EN 378-1, par. 4.2(in the case people are near the system.

In the intention to place the unit into room (not in a engine room) or below floor level, make sure of verify the restrictions published in EN 378-1, tab. C.

The unit must to be placed in a way that in the event of a leakage, the gas realised it can not to go in renew air intake, inlets or in close buildings, which could be a lee shore for people.

The unit owner, which contain at least 300 kg of gas, should install leak detection systems (see EN 378-4, att. D, par. D.5). The leak detector system must be tested once every 12 months to ensure proper functionality.

3.1. Identification

The uniti s identified by the identification tag. This is explained in in detail in section 1.4.

The correct unit identification by means of the serial number is essential for the execution of any operation to carry out on the unit. The serial number must be always advised whenever submitting a request of Manufacturer technical service support.

3.2. Reception and inspection

It's very important to check(by visual inspection) the packing integrity immediatly upon delivery. In case the packing is found damaged, it is necessary to accept the goods with reservation and indicate on the consignment note the state of the received goods and let the driver countersign it.

Any claim concerning the delivered material must be sent to the manufacturer by fax, by e-mail or by registered letter within 8 days from the receiving data.

3.3. Handling

The handling of the unit must be carried out by expert personell, equipped with appropriate equipment in relation to the weight and the dimensions of the machine. During the handling operation, the machine must be always kept upright(basament parallel to the ground).

The weight of some models could be unbalanced, it's necessary check the unit stability before starting to handle it.

For any unit handling, please follow the instructions shown in figure 3.1 , considering it as indicative.

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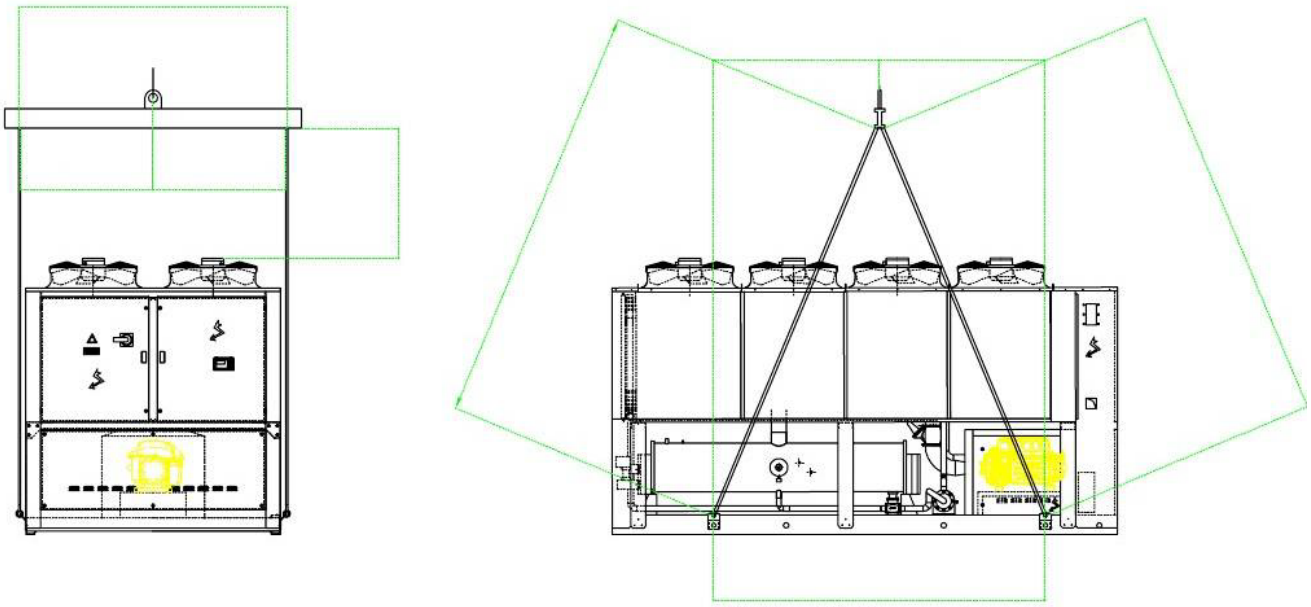
In the case the machine is moved by means of a crane, it is important to avoid that cables and belts that may exert a too high tractive effort on the packing that might damage it.

Before to start handling and placing the unit, the overall dimension of the unit, packaging included, the weight unit must be

Figura 3.1: Lifting drawing



The angle formed from the cables or belts, it must not be greater than 30°.

The lifting equipment, cables, belts have to be in compliance with the laws and local directives.

3.4. Placing

The Client(owner of the unit) is responsible for expenses of installation, and he must supervise the execution operations. The execution of a correct installation presupposes that a plan has been drawn up by an expert and that is carried out by skilled trained technicians.

The area used to install the unit, there must be no aggressive substance or not compatible with copper, carbon steel, aluminum and other materials which are used in its construction. It's necessary to carry out chemical analysis in case of doubts and to send the result to the Manufacturer, in order to develop of common agreements on necessary measures.

The installation must be carried out in compliance with laws and local regulations.

Before placing the unit, the following points must be checked:

- The floor where the machine is positioned can bear the total unit weight under normal operation;
- Enough room must be left around the unit to follow the routine and the special maintenance, such as compressors and heat exchangers replacement, as shown in figure 3.2;
- Connections for electric and hydraulic circuits must be done.

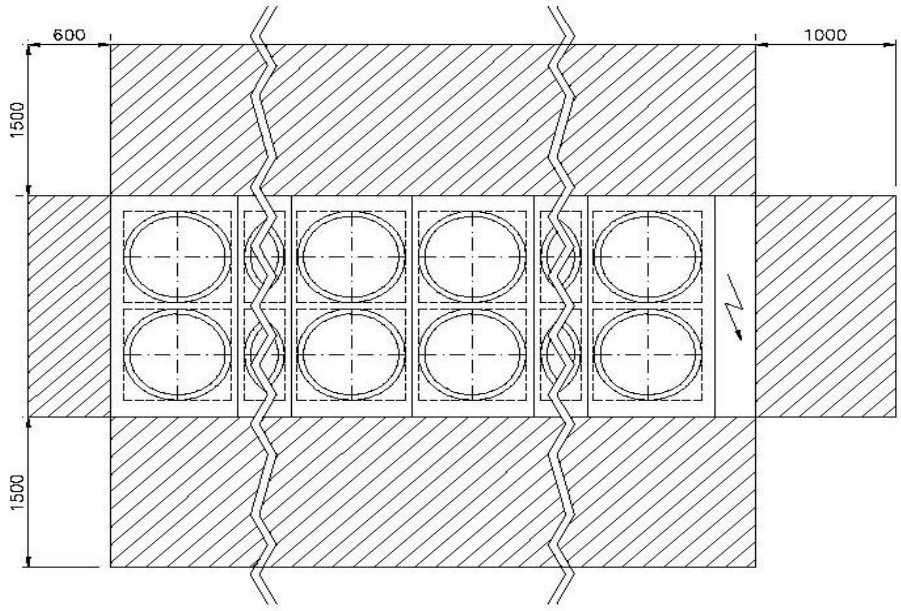
The space left around the unit help to avoid the condensation air circulation, which can cause high pressure alarm and the consequently unit disruption.

The unit is designed and manufactured for outdoor installation. In the case the unit is placed undercover, the cover must to be at least 2 meters above the fans.

The unit basament must to be ground plane with a accetable tollerance of 5° in lenght and witdh way.

The unit doesn't need any special basament, since it can be simply laid down on the chosen surface, just placing rubber gaskets or spring-type vibration dampers(option) underneath.

Figure 3.2: Service area



It is recommended to verify the congruence between the tecnical data of the Manual's unit and the project data.

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3.5. Hydraulic Circuit

The unit is designed to be connected to a closed circuit-system in which a heat transfer fluid.

The fluid must no contain aggressive substance or not compatible with copper, carbon steel, aluminum and other materials which are used in its construction. It's necessary to carry out chemical analysis in case of doubts and to send the result to the Manufacturer, in order to develop of common agreements on necessary measures.

Only qualified draftsman can designe the hydralic connection and only expert refrigeration technicians appointed by the Client(Unit's Owner) are allowed to perfom the hydraulic connections and in conformity with local regulations.

The diameter of the hydraulic connections are shown in the dimensional drawing attached at the Manual.

The following general instruction must be respected:

- Perform the piping path in such a way so as to limit as much as possible the pressure drop in the system.
- Pipes must be adequately supported by brackets and arranged so as to allow an easy installation and inspection.
- The materials used for the realisation of the system must have a nominal pressure not lower than PN6.
- During the pipes installation, all necessary measures to prevent dirt and solid particles from entering the tubes must be taken.
- The water circulating pump must be able to deliver the appropriate water flow capacity with the necessary available pressure to overcome the system pressure drop in any operating conditions.
- The functioning pressure of the hydraulic circuit must be between 1,5 and 3,5 bar. Therefore they have to be fitted with one or more diaphragm pressure vessels.

It is essential to inform the Manufacturer in the event that hydraulic circuit is designed to function with pressure lower than 1,5 bar (opened systems) or higher than 3,5 bar, in order to develop of common agreements on necessary measures.

- The system must to be protected by a safety valve and a pressure no higher than 6 bar.
- Place the air discharge valves in the appropriate points of the hydraulic system..
- The hydraulic system outfitted of connection for its emptiyng.
- The hydraulic system must be outfitted with connection so to fill water in, and if applicable of anti-freeze mixture.
- Washing the hydraulic circuit once the pipes are placed by appropriate substances. So avoiding dirt and solid particles remain in the tubes and to cause any damage.

3.5.1. Hydraulic circuit connections

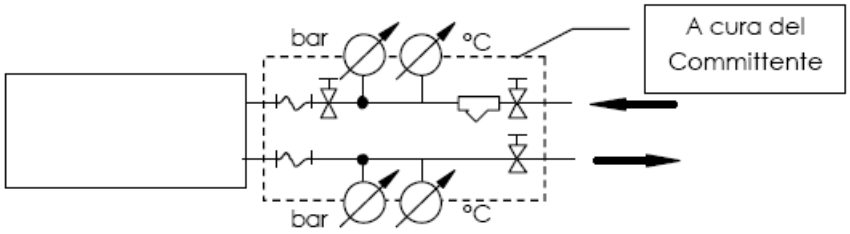
Only expert refrigeration technicians appointed are allowed to perfom the hydraulic connections to the unit and in conformity with local regulations.

It is important the chilled liquid flows in the correct direction into the evaporator. So the pipes must be joined following the indication given on the connections point of the unit.

For the connection of pipes and evaporator, it is advisable to follo the instruction as shown in the diagram in figure 3.3.

- Employ anti-vibration pipe fittings to avoid any vibration transmission and to allow the thermal expansion.
- **To prevent the entrance as dirt and solid particles must be installed on the water inlet a filter with grid not larger than 2 mm and with appropriate diameter to limit the pressure drop in the system. Install shut-off valves on the inlet and outlet of the filter to will ease the cleanness operations.**

Figure 3.3: Piping connection diagram



- Install shut-off valves on the inlet and outlet in case of special maintenance operations.
- The installation of temperature probes and pressure guages on the inlet and outlet of the unit to will ease to verify the correct unit operation.
- The cooled water system must be thermally insulated with closed-cells material having adequate features of heat insulation and steam tightness for the operating conditions.
- The unit must be connected to the hydraulic system by using the appropriate areas as indicated in the dimensional drawing attacheched to the Manual.
- Once the pipes are placed and the unit installed, the system must be leak tested to detect any possible leak to be repaired before the starting up of the system.

Do not exceed 6 bar during the leak test!

After the leak test with water is performed, if low ambient temperatures (close or below 0°C). or a long break before the sturtup are likely, it is recommended to drain the circuit or to fill it with a appropriate anti-freeze mixture quantity.

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If the unit is not equipe with a differential pressure switch (option), it is advisable to install a flow switch on the hydraulic circuit, stopping the unit in case of insufficient evaporator water flow. Such a device shall be connected to the foreseen terminal inside the electrical board(see attached wiring diagram).

The unit compressor can start only if the pumps for the water evaporator circulation are already operating. It can be obetained by, for example, electrical interblock (as shown on the wiring diagram attached to the Manual).

3.5.2. Hydraulic circuit filling

Once the hydrualic circuit, the unit connection are performed, the leak test with water is performed , it is necessary to fill the circuit as descrive here below:

a) Opem all the air discharge valves on the circuit.
b) Connect the circuit to a water supply system, possibly in a permanent way, by means of an automatic fill group provided with a manometer and a non-return valve.
c) If the circuit works with an anti-freeze mixture, fill the circuit with an appropriate quantity of a pure anti-freeze fluid according to a system siza and to the anti-freeze concentration to get.
d) Start fill the system with water by the fill group.
e) Check all the air discharge valves present in the system and shut them when the water starts to go out.
f) Once all valves are closed, go on filling the system with water until the pressure between 1,5 and 3,5 bar is reached.
g) Stop the water charge and start the circulating pumps so that any presence of air can be gathered in the top points where air discharge valves are present.
h) After two operating hours, stop the pumps and discharge the air by means of the air discharge valves laid on the system.
i) Charge water to bring pressure back to its original value.
j) Repeat the points from g) to j) until no air goes out from the air discharge valves.

3.5.3. Use of anti-freeze mixtures

It is necessary to introduce to the hydraulic system anti-freeze mixtures in the event the cooled water temperature drop down 4°C during the operation, or drop close to 0°C during the shut down. The freezing point of the anti-freeze mixture must to be lower than the minimum temperature expected.

Anti-freeze mixtures are harmful if ingested and can cause irritation if on contact with skin and sensitive mocous membranes. Therefore, it is recommended to wear protection glasses and gauntlets and to avoid the contact with the mouth; follow the instructions indicated on the container or in the corresponding directions.

To use aggressive anti-freeze mixtures or not compatible with copper, carbon steel, aluminum and other materials which are used in its construction, it is forbidden.

The temperatures shown in the table 3.1 are approximate.

Sometimes suppliers dilute the product and therefore it is necessary to follow the dilution percentage recommended by the anti-freeze liquid manufacturer.

Table 3.1: Ethylene glicol mixture temperature freezing

	Percentage of Ethylene glycol							
	5%	***10%***	***15%***	***20%***	***25%***	***30%***	***35%***	***40%***
Volume-volume percentage (l/l)	***4,4%***	***8,9%***	***13,6%***	***18,1%***	***22,9%***	***27,7***	***32,6***	***37,5***
Freezing temperature (°C)	***-1,4***	***-3,2***	***-5,4***	***-7,8***	***-10,7***	***-14,1***	***-17,9***	***-22,3***

If the anti-freeze mixture contains a lower ethylene glicol percentage than below recommended, there could be risks of freezing, of hydraulic system or evaporator breakage. While a higher percentage can reduce the unit performance.

The liquid in the hydraulic circuit must to be test periodically and however at the beginning of the cold season. The anti-freeze mixture manufacturer indicates when replace the liquid. Anyway Change the anti-freeze solution every two years.

It is strickly prohibited to pollute the environment with the anti-freeze mixture.

3.6. Electric connections

Only qualified and trained technicians must perform any operation on the machine in compliance with local technical standards.

Before starting the electric connection, it is advisable to check the wiring diagram contained in the unit electric panel.

Make sure the power tension and frequency match the same data as specified on the unit identification tag and on the wiring diagram contained in the unit electric panel.

The electrical system of the unit must to be projected by qualified draftsman and only expert electrical technicians appointed by the Client(Unit's Owner) are allowed to perfom the electrical connections and in conformity with local regulations.

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Protect the power supply cable by means of an automatic switch of appropriate size and features and in compliance with local technical standards.

The electrical system must to be perfomed in the way that lighting, ventilation, alarms and safety systems still work even if switching off the power unit.

Connect the phases and the neutral to the terminals of the main switch and the earth wire to its corresponding terminal.

For the cross section of the power supply cable, the size of the automatic switch and the characteristics of the electric components, check the wiring diagram attached to the present manual.

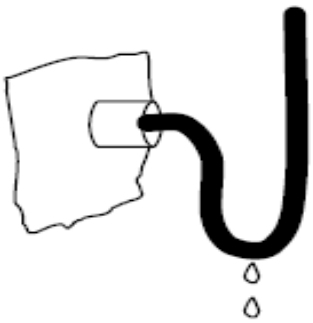
3.6.1. Power supply connection

The unit can be powered with 4-pole cable (3 poles + earth), if the power supply tension is 400V/3ph/50Hz without neutral. On demand, it is possible to supply units with arrangements for special power supply tension(check the identification tag and the wiring diagram).

The power cable input is shown in the attached dimensional scheme attached at the manual. The power cable input must to be protected in compliance with local technical standards.

If the power cable comes from the top to the input point, perform a bend on the cable as shown on the figure 3.4

Figure 3.4: Power cable comes from the top



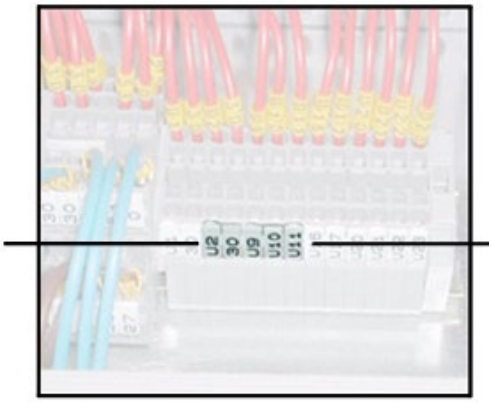
Before to operate on the electrical system, Check the electric circuits have not been damaged during transportation. Check all terminals screws are tight and the wire insulation status are in a good conditions.

The power cable conductors must be connected to the free terminals upstream the main disconnecting switch, while the grounding conductor must be connected to the appropriate terminal PE or to the ground bar.

3.6.2. User's terminal board connection

There is a terminal board with corresponding to the unit electric board. The terminal to unit, refer to the wiring diagram attached at the

Figura 3.5: Sample of connection



User's terminal board

digital and analogic signals operating condition into the board setting can change from unit information described on the manual.

(1)

(2)

If the water circulating pump is not controlled by the unit microprocessor, it is recommended to connect an auxiliary contact of its contactor to the remote ON/OFF terminals present in the electrical panel (see attached wiring diagram), so that the unit can start only when the pump is working.

(1)	Digital input (free contact)	U2-30	ON/OFF remote: • Open = unit OFF • Close = unit ON
(2)	Digital output (free contact)	U9-U10	Generic alarm: contact usually opened (Chiuso = allarme)
	Digital contact (free contact)	U10-U11	Generic alarm: contact usually closed (Open = alarm)

3.6.3. Phases sequence in the power supply line

The rotation direction of all electric motors installed on the unit (compressors, fans, pumps) are checked and harmonized during the operational test performed by the manufacturer (at the exception of units supplied with arrangements for special power supply tension).

When connecting the unit to the power supply, it is necessary to check that the phases are connected in the correct sequence. On this purpose, make sure that all electric motors rotation is right.

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For pumps and fans, refer to the information indicated on the component itself. Nel caso dei compressori, se la sequenza delle fasi non è corretta, il programma di gestione integrato fornirà una specifica segnalazione di allarme sul microprocessore di controllo.

In case of three-phase power supply, when connecting the unit to the power supply, If the rotation of any component is wrong, two out of three phases must be inverted in the terminals of the main switch (do not unplug the neutral).

To avoid connections faults, must no disconnect other conductors pertinent to the main switch, in addition to the other used in the operation.

If some components go on rotating in the wrong direction, check the conductors sequence of each 3-phase component and correct it, if needed.

3.7. Safety valve

The output connections of the external safety valves installed on the unit are equipped with a threaded end, so they can be connected to the drain pipe if any and if the installation design and the local regulations in force allow it.

If allowed, the valves must be piped individually in metal piping, to an area where the discharged coolant cannot damage people or things.

The coolant coming out of safety valves is a high pressure, high temperature gas which is discharged at supersonic speeds. Its flow may damage things and people if it hits them directly.

Opening safety valves comes with a noise whose intensity may impair the hearing capabilities of surrounding people.

The pipings' diameter must be no less than the safety valves' draining pipe's; coolant leaks in the line must be as small as possible and in any case should not provoke a reduction in the discharge rate of the valves.

The pipings' output must be shaped so to prevent rain water, snow, ice, and dirt, from accumulating and obstructing the pipeline.

Discharge from the valves must occur at a suitable distance from other equipment or sparking sources; the discharged coolant must not accidentally end up in buildings.

In any case, any pipes on the safety valves discharge must be manufactured according to laws and regulations in force.

4. Operation

Before its commissioning, it is necessary that operational staff is instructed, also by means of this Manual, on the unit's manufacture, handling, operation, and maintenance, on safety measures and regulations to abide by, any personal protective equipment to be arranged, properties and indications on how to to handle the coolant in use.

As for installations inside the European Union, personal protective equipment must satisfy the EN 378-3 standard, ann. A requirements.

4.1. Documentation

The Owner of the unit must apply for the relevant authorisations and prepare the documentation for the installation and operation of the unit provided by the applicable laws and local regulations. In particular, he/she must obtain and provide the necessary documentation to confirm that the installation was carried out as per the specifications, and as provided by laws and local regulations in force.

All the necessary information to handle the system and keep it safe and reliable, must be visible in its whereabouts, according to local regulations in force. In the case of installations on the European Union's territory, information required by EN 378-2, par. 6.4.3.3 and 6.4.3.4 must be provided.

Also, if the machine (with a refrigerant charge heavier than 3 kg) is installed on the territory of the European Union, a Unit Register (henceforth called *Register*) must be set up and kept up to date, as provided by EN 378-4, par. 4.3. This document must contain the following information on the unit:

a) the details of all maintenance and repair works;
b) the quantity and type (new, used, or recycled) of coolant charged and the quantity of coolant extracted on each occasion;
c) analysis of the used coolant, whose results, where available, must be kept in the register;
d) the origin of the used coolant;
e) modifications to and replacements of system components;
f) the results of all pre-planned inspections;
g) records of all sgnificant periods of non-operation.

The register must be kept by the owner in a way that one updated copy may be consulted by personnel during maintenance and inspections of the unit.

4.2. Initial survey

Before starting-up, the unit must undergo a visual inspection by a technician with suitable expertise, including the following checks:

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a) identification of any possible damage sustained during transport, stocking or handling;
b) checking installation against the hydraulic and wiring diagrams;
c) checking of safety devices provided and their documentation;
d) checking of certificates, data plates, and, in general, of mandatory documentation;
e) checking that accessibile pipings cannot cause any accidental harm to the public;
f) checking that power supply is adequate to the charge;
g) checking that the valves' and the shut-off cocks are in the right position and condition;
h) checking that the fastening supports and devices are adequate;
i) checking the quality of welding, brazing and other junctions;
j) checking that protection against mechanical damage, heat and moving machinery is adequate;
k) checking that the main components are clear for inspection, maintenance and repair;
l) checking for heat and steam insulation and its condition;
m) checking the condition of heat exchange surfaces of condensing coils

The technician who carries out these checks must document them as provided by local regulations in force.

Before starting the unit, when first starting up or after a long pause, it is necessary to check cables and connections, as well as protective conductor connections. If any fault is detected, the unit may not be started.

Before starting the unit you must check that the following conditions are met:

- the cooler must be placed on a frame which can hold it steadily;
- the earthing connections must be laid out correctly and connected to an efficient system;
- the power supply line must be protected by an automatic switch with suitable size and characteristics;
- next to the unit's input port there must be a mechanical filter with suitable size and characteristics.

Periodically, it is necessary to check that the filter is clean, to prevent an excessive head loss from reducing the flow rate of the fluid to cool.

- The hydraulic system must be filled correctly and any air must be completely eliminated.

During unit operation, the hydraulic system pressure must fall within 1.5 and 3.5 bar.

- Hydraulic connections must be correctly set up and must be leak-free;
- the fluid to be cooled must circulate freely and in the proper direction, through the evaporator;
- the flow rate of the circulating fluid to cool must match the designed flow rate;
- the taps on the compressor and along the cooling line must be in open or closed mode, as laid down for operation;
- if necessary, the hydraulic line must contain a brine mixture in the required concentration;
- the value of adjustment temperature and of the anti-freeze warning on the microprocessor must be set correctly.

4.3. First startup

The first startup of the unit must be carried out by an expert refrigeration technician authorized by the Manufacturer.

4.3.1. Switching on

Before the first machine start or before starting it after a long break, it is necessary to check that the parameter settings on the microprocessor match the required operating conditions.

To switch the device on, you must turn the master switch to the ON position, to supply the unit with power.

Then, it is necessary to push the ON/OFF button on the microprocessor keyboard, and switch to ON.

If the ON/OFF remote switch is shut, any circulation pump controlled by the microprocessor shall be switched on immediately.

After a certain time lag, whose extent may be set on the microprocessor, the fans shall start and, subsequently, the compressors, according to the necessary cooling effect to meet the cooling requirement.

Once the machine reaches a steady-state operation, the technician carrying out the first startup shall verify the unit's operating parameters and check that:

a) the safety high pressure switches work, are installed and are correctly calibrated;
b) the calibration pressure is indicated on the external safety valves and that its value is as required;
c) there are no coolant leaks.

The verified data must be recorded on the First Startup Form attached to the Manual.

A copy of the First Startup Form with all the applicable boxes filled in, must be transmitted to the Manufacturer, in order to start the device warranty.

During first startup operations, the technician must check that safety features (high- and low-pressure switches, water differential pressure switch, frost protection thermostat, etc.) and adjustments (regulator thermostat, condensation pressure adjustment, etc.) work properly.

4.3.2. Switching off

To stop the unit, it is necessary to push the ON/OFF button on the microprocessor keyboard, and switch to OFF.

If the machine is expected to stay in this mode for more than 24 hours, the master switch must be turned to the OFF position in order to cut the power supply.

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Any anomalies detected during unit operation must be fixed as soon as possible, in order not to have them at the following switch-on.

4.3.3. Winter break

If, during equipment stop, room temperature approaches or drops under 0° C, it will be necessary to run some brine in the hydraulic line with a freezing point sufficiently lower than the required minimum temperature, according to instructions in par. 3.5.3.

If you do not want to or cannot run brine in the line, it is possible to prevent water from freezing by installing heating wires, which can be activated by a thermostat measuring water or air temperature. In this case, naturally, water must continue to circulate and, therefore, the pump must keep operating (if the pump is controlled by the unit, the latter must be powered electrically).

Finally, in some cases, in order to prevent dangers associated with freezing it is preferable to empty the water from the hydraulic line completely during breaks in the operation of the machine. In this case, before filling the system again as described in par. 3.5.2, it will be necessary to clean it (see par. 3.5).

4.4. Microprocessor setting

In order to change microprocessor settings, instructions laid out in the documentation attached to the Manual must be followed.

Changes to microprocessor settings may be carried out exclusively by qualified technicians and, anyways, after prior authorisation from the Manufacturer. Inputting incorrect values may allow unit operation in out-of-specification conditions and, consequently, damage the machine and the whole system.

5. MAINTENANCE

The Owner must make sure that the unit undergoes proper maintenance, as indicated in the Manual and as provided by local laws and regulations in force.

Equipment maintenance must be carried out by qualified and trained personnel, equipped with personal protective equipment, as provided by local laws and regulations in force.

In general, anyone handling the coolant must be equipped, at least, with protective spectacles and gloves.

Machine maintenance must be carried out in a way that

a) the risk of accidents for people and of damage to things is minimal
b) no damage is caused to system components
c) the system's operation and readiness are not compromised
d) any coolant leaks are identified and fixed
e) power consumption is minimal.

Maintenance operations which do not require working on or adjusting the cooling line, and which do not require specific knowledge of cooling (for instance, cleaning of the condensation coil fins), may be carried out by qualified personnel appointed by the Owner.

During maintenance operations, only said authorised personnel may stand close to the unit.

During maintenance operations, it is necessary to check the conditions of labels and warnings on the system and its components; unreadable writing must be replaced.

The unit may not be changed in any way, nor may any of its parts be replaced without prior explicit authorisation by the Manufacturer.

Before carrying out any kind of work on the machine, it is necessary to cut the power supply to the electric panel, by turning the master switch to the OFF position.

Inside the unit there can be areas with high voltage. Works requiring access to such areas may be carried out only by qualified and trained personnel, authorised as provided by local laws and regulations in force.

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Component surfaces on the compressor's discharge and on the liquid coolant line may reach high temperatures and touching them may cause burning.

On board the unit there are sharp parts and cutting edges which, if accidentally hit, may cause cuts or scratches.

Works on the compressor must be carried out by trained personnel, following the appropriate procedures described in the Compressor Maintenance Manual circulated by the Manufacturer to its authorised customer care centres.

The compressor covers shield the components exposed to high voltages in AC (380 ÷ 604 V) and DC (600 ÷ 900 V), so it is necessary to be careful when working near electrical circuits.

Before carrying out any kind of work on the compressors, it is necessary to cut the power supply and discharge high voltage capacitors, following the procedure described in the Compressor Manual. 15 minutes must go by before any work starts.

While working on the electronic power lines of the compressors, it is necessary to use the special tool provided to check the system DC, following the procedure described in the Compressor Manual.

Before loosening the diode's and the inverter's mounting screws, it is necessary to collect the coolant in the compressor.

Because of the technology used, compressors generate a static magnetic field (with a peak of about 9 Gauss at a 150 mm distance), which may influence the functioning of medical devices. That is why works on the compressor must not be carried out by people carrying such devices.

In case of doubts on the kind of malfunction detected or on works to be performed to fix it, please contact the Manufacturer.

Smoking is forbidden while performing maintenance operations on the unit.

5.1. Scheduled maintenance

The Owner must make sure that the unit is periodically inspected, also on-site, adequately maintained, according to the type, size, age and use of the system, and to the indications contained in the Manual.

Servicing during the unit's operating lifetime and, in particular, scheduled leak detection, on-site inspections and check-ups of safety equipment, must be carried out as provided by local laws and regulations in force.

If leak detection instruments are installed on the system, they must be inspected at least once a year, to make sure that they work properly.

5.1.1. Leak detection

If no further precautions are required, the unit must undergo a tightness check at least every three months ([1]). If, during the test, the suspicion arises that there may be a coolant leak (for instance, following a reduction in cooling capacity or in the results of overheating or undercooling measurements), it will be necessary to locate it with the appropriate instruments, repair it and carry out another tightness check, as provided by national legislation in force.

The results of the checks and of actions undertaken must be recorded in the Register.

The personnel involved in the detection of coolant leaks must not use open flames or sparking sources.

Coolant leaks must be identified and repaired as soon as possible by authorised personnel, as provided by local laws and regulations in force.

5.1.2. Safety pressure switch check

In the absence of more restrictive local regulations, the safety high pressure switches must be inspected on site at least every twelve months, to check that they are well regulated and work properly, as well as installed according to applicable laws.

5.1.3. Safety valve check

In the absence of more restrictive regulations, external safety valves must be inspected on site at least every twelve months, to check their tightness. If a leak is identified, the valve must be replaced.

Valves must be inspected every five years, to check that they are in working order, that the calibration pressure printed on the valves is readable, that they are installed and have proper characteristics to guarantee the system's safety, as provided by regulations in force.

5.1.4. Check on the fluid to be cooled

The fluid of the coolant/liquid exchanger must be inspected at least every six months, to check its composition and identify the presence of any coolant in it.

([1]) For units installed on the European Union's territory, leakage management must be carried out according to indications laid out in the (CE) Regulation 1516/2007.

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5.1.5. Noise and vibration check

It is necessary to check, at least once a month, that the unit does not make unusual noises, and that pipings do not vibrate abnormally, because this may cause a breakdown.

5.1.6. Scheduled works

Scheduled maintenance works, necessary to keep the machines reliable and in good working order over time, are summarised in Table 5.1, together with their frequency.

Daily and monthly works may be carried out directly by the Owner of the system. All other works must be performed by authorised and trained personnel.

It is forbidden to touch the device while barefooted or with wet or damp body parts.

Any kind of cleaning whatsoever is forbidden before disconnecting the device from power supply by turning the master switch to the OFF position.

Works on the cooling line must be carried out by qualified and trained technicians, as provided by local laws and regulations in force.

The required personal protective equipment must be used at all times when working on the unit. In particular, it is necessary to at least wear protective spectacles, gloves, safety helmet and shoes.

Table 5.1: Scheduled maintenance works

ACTION TO BE PERFORMED	FREQUENCY						
	Daily	Monthly	Every 3 months	Every 6 months	Every year	Every 5 years	As necessary
ELECTRICAL SYSTEM AND ADJUSTMENT							
Check that the unit works properly and that there are no active warnings	X						
Visually inspect the unit		X					
Check noise and vibration level of the unit		X					
Check operation of safety features and of interblocks					X		
Check the unit's performance				X			
Check the current draws of the different parts (compressors, fans, pumps, etc.)			X				
Check the list of saved warnings for the compressors			X				
Check the supply voltage of the unit				X			
Check tightness of cables in their clamps				X			
Check the integrity of the insulating coating of power cables					X		
Check the conditions and functioning of the counters					X		
Check functioning of the microprocessor and of the display			X				
Check microprocessor settings					X		
Dust electrical and electronic components					X		
Check functioning and calibration of probes and transducers					X		
Check functioning of the coolant level sensor in the evaporator			X				
Check calibration of the coolant level sensor in the evaporator					X		

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Table 5.1: Scheduled maintenance works (continued)

ACTION TO BE PERFORMED	FREQUENCY						
	Daily	Monthly	Every 3 months	Every 6 months	Every year	Every 5 years	As necessary
COMPRESSORS							
Visually inspect compressors		X					
Check noise and vibration level of the compressors		X					
Check the supply voltage of the compressors				X			
Check the compressors' electrical connections					X		
Check the conditions of the compressors' power cables and their tightness in the clamps				X			
Check the value of voltages in DC on the compressors' circuit boards				X			
Dust the compressors' circuit boards					X		
Replace the capacitors in DC of the compressors						X	
Check functioning of the IGV valve of the compressors				X			
Inspect, and, if necessary, clean the filter of the compressors' cooling system							X
Replace the buffer battery of the Compressors' BMCC						X	
CONDENSING COILS AND FANS							
Visually inspect condensing coils		X					
Clean finned coils					X		
Check noise and vibration level of the fans		X					
Check the supply voltage of the fans				X			

Table 5.1: Scheduled maintenance works (continued)

ACTION TO BE PERFORMED	FREQUENCY						
	Daily	Monthly	Every 3 months	Every 6 months	Every year	Every 5 years	As necessary
Check the fans' electrical connections					X		
Check functioning and calibration of the fans' speed adjustment system (if any)					X		
EVAPORATOR							
Visually inspect the evaporator		X					
Check the air tightness of the hydraulic line		X					
Check the pressure of the fluid to be cooled in the hydraulic line			X				
Check the conditions and the pressure of the expansion vessel of the hydraulic line (if any)					X		
Check the quality and characteristics of the fluid to be cooled				X			
Clean the evaporator's tubes							X
Take all necessary actions in order to prevent the formation of frosting in the evaporator							X
Check functioning of the differential pressure switch and of the water flow switch on the hydraulic line (if any)					X		
COOLING LINE							
Check functioning of the thermostatic valve			X				
Check for bubbles in the liquid coolant signal			X				
Carry out leak detection on the cooling line			X				
Check calibration and functioning of the safety high pressure switch							

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Table 5.1: Scheduled maintenance works (continued)

ACTION TO BE PERFORMED	FREQUENCY						
	Daily	Monthly	Every 3 months	Every 6 months	Every year	Every 5 years	As necessary
Check tightness of the safety valves					**X**		
Check the conditions of the safety valves						**X**	
Check functioning of the check and solenoid valves				**X**			
Check functioning and tightness of the shut-off cocks					**X**		
Check the temperature difference between input and output of the dehydration filter				**X**			
Check the values of the suction and discharge pressure			**X**				

5.2. Routine maintenance

If the unit reliable functioning is endangered by faults, do not start up the unit before the problem has been solved.

During its operating lifetime, the unit must undergo inspections and examinations according to existing laws and local regulation. As a rule, where no other more severe regulation is required, the installation should comply with the information in table 5.2 (Conf. EN 378-4, ann. D) according to the situations described.

5.2.1. Checking the Unit Operating Parameters

The checks on the operating parameters must be carried out while the unit is working in regular conditions as similar as possible to nominal ratings. Carefully verify that

- the heat load is suitable;
- the flow rate and temperature of the fluid to be cooled comply with the nominal data;
- the temperature of condensation air resembles the nominal data.

If the installation environment does not allow to preserve operating conditions similar to the nominal ones during a suitable period of time, contact the manufacturer to identify which procedures must be carried out.

In order to get reliable results, the required measurements must be carried out using suitable precision instruments subject to periodic metrological controls.

Table 5.2: Inspections and checks

Case	Visual Inspection (par. 4.2, pts a – m)	Pressure Test	Leaks Hunting
A	**X**	**X**	**X**
B	**X**	**X**	**X**
C	**X**		**X**
D			**X**

A. Inspection after an intervention with possible effects on the mechanical strength or after use change or in case the machine has not being working for more than two years. Replace all the components which are not suitable any more. Do not carry out checks at a higher pressure than the one indicated in the project.

B. Inspection after maintenance or significant adjustments to the system or its components. The checks can be restricted to the parts adjusted. Nonetheless, carry out leaks hunting procedures on the whole system when coolant leaks are detected.

C. Inspection after installation in a different position than the original one. Refer to point A when mechanical strength could have been affected by the change.

D. Leaks hunting is required when coolant leaks are suspected. Examine the system to detect possible leaks using direct measurement methods (which allow to detect leaks) or indirect measurement methods (which infer the presence of leaks from the analysis of operating parameters). Carefully examine the parts where leaks could be more probable, such as the junctions.

5.2.2. Checking the refrigerant moisture indicator

The flow and moisture indicator is installed on the liquid coolant line, after the dehydrator filter. It allows to carry out two kinds of checks.

According to the color of the sensitive material in the transparent guide, it is possible to infer whether the moisture in the coolant is within the allowed limits or not. When the moisture is low enough the indicator is usually bright green, while it becomes yellowish as the coolant becomes more and more moist. At any rate, refer to the indications on the sight-glass.

If too much moist is detected in the circuit, you may have to replace the dehydrator filter or the coolant in the circuit when the situation is serious.

If the unit remained inactive for a long period of time, check the moisture indicator after the unit has been working for at least one hour. In this way, the dehydrator filter has the time to extract part of the moisture in the coolant.

Checking the guide it is also possible to see whether the level of coolant in the circuit is suitable or not. As a

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matter of fact, the coolant level is usually considered suitable when no vapor bubbles are visible through the flow indicator after the unit has been working at nominal conditions for at least 10 minutes.

5.2.3. Checking the refrigerant superheat

To measure the coolant superheat at the evaporator outlet, run the unit at nominal conditions for at least 10 minutes and check

- evaporation pressure using a gauge connected to one of the dedicated inlets along the suction line;
- suction temperature using a contact thermometer positioned along the low pressure line, about 20 cm away from the evaporator.

If needed, measure the temperature by partially removing the insulating material covering the suction pipe. It is advisable to place the sensitive element along a horizontal pipe, in a 10 o'clock position on the pipe axis. The contact between the probe and the surface can be improved using the dedicated conductive paste.

The coolant superheat is the difference between the suction temperature (measured using the contact thermometer value) and the saturation temperature (dew point in zeotropic blends, that is to say blends characterized by temperature glide) which conforms to the evaporator pressure measured by the gauge.

The equipment includes a flooded evaporator which can run with a superheat rate close to 1 K.

If the superheat rate is lower than 1 K or higher than 5 K, adjust the thermostat valve parameters (Conf. Microprocessor Manual enclosed) at about 2 ÷ 3 K.

5.2.4. Checking the refrigerant subcooling

To measure the coolant subcooling at the condenser outlet, run the unit at nominal conditions for at least 10 minutes and check

- condensing pressure using a gauge connected to one of the dedicated inlets along the fluid coolant line;
- liquid coolant temperature using a contact thermometer positioned along the coolant line, about 20 cm away from the condensing coils.

The contact between the probe and the surface can be improved using the dedicated conductive paste.

The liquid coolant subcooling is the difference between the saturation temperature (bubble point in zeotropic blends, that is to say blends characterized by temperature glide) which conforms to the condensing pressure

measured by the gauge and the liquid coolant temperature (measured using the contact thermometer value).

If the subcooling rate is lower than 3 K or higher than 10 K, you may have to adjust the quantity of coolant in the circuit at about 5 ÷ 7 K.

5.2.5. Checking the safety devices to avoid electric overcharges

Examine the devices which protect electric charges from overcharges to check their integrity and functionality.

Replace fuses only after the unit has been cleared by turning the master switch to the OFF position.

Do not bypass the unit fuses or replace them with others with higher flow rates.

Fuses can reach very high temperatures which can result into burns if they are not handled with adequate precautions.

When high voltage is involved, use blade type fuses and replace them using the dedicated handle supplied with the machine. Using unsuitable tools may cause damages to the device or the operator.

If adjustable devices are employed (thermal or overload cutouts), verify that the absorption value set does not exceed the rate indicated on the identification plate of the element to protect.

5.2.6. Checking the switches

Switches employed to start up electric charges must be examined to check their integrity, the contacts and the coil.

Also check that the power cables are correctly and firmly fastened to the dedicated clamps.

When needed, remove dirt and debris which may cause the device noisy and treacherous functioning.

5.3. Troubleshooting

The identification of possible functioning troubles is carried out by the unit control microprocessor. Apart from indicating alarm conditions, it also displays the type of troubles underway.

The circuit boards managing the centrifugal compressors communicate with the unit microprocessor through a local network with Modbus protocol. The microprocessor can therefore indicate and describe the troubles underway.

Table 5.3 indicates the most common types of device crashes that can occur, as well as the most probable causes and possible solutions according to each type.

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When an alarm is running, before carrying out any maintenance procedure, it is advisable to check that

- the operating conditions comply with the indications provided or are consistent with the unit operating limits;
- all the power cables of the devices involved are firmly fastened to the dedicated clamps (Conf. the Wiring Diagram enclosed);
- the rates set for the parameters involved comply with the existing operating conditions (Conf. the Microprocessor Manual enclosed).

Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
1. The unit doesn't work	a. The electrical panel is not powered	Check presence of electric tension on the single phases. Check the main switch is closed.(ON)
	b. The auxiliary circuit is not powered	Check the fuses of the auxiliary circuit (see wiring diagram)
	c. The microprocessor does not start the unit	Check the electric connections to the microprocessor Check the temperature set of the chilled liquid
	d. The external impulse to the startup fails	Check the remote ON/OFF contact is closed (see wiring diagram)
2. The cooled water temperature is higher than expected	a. The unit does not work	See trouble 1
	b. The compressor does not work	See trouble 12
	c. The cooling capacity of the compressor is insufficient	The discharge pressure is higher or the pressure suction is lower than estimated. See troubles 8 and 9
	d. The microprocessor does not work properly	See trouble 1.b Check electric connections of the microprocessor Consult the attached microprocessor manual
	e. The control system setting is not correct	Check the parameters setting of the microprocessor Consult the attached microprocessor manual
	f. The thermal load is higher that estimated	Check the thermal load and compare it with the cooling capacity in the operatiing conditions
3. The cooled water temperature is lower	a. The control system setting is not correct	See trouble 2.e
	b. The microprocessor does not work	See trouble 2.d

than expected	properly	
	c. The evaporator water flow is lower than estimated	See trouble 4

Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
4. Cooled water flow is lower than estimated	a. Pressure drop in the hydraulic system iis higher than estimated	Check the pressure drop in the circuit and compare it with the pump hydraulic head (at the nominal flow)
	b. Air presence in the hydraulic system	Discharge air gathered in the top points of the circuit by air discharge valves. If it is necessary, filling the system with water until the pressure between 1,5 and 3,5 bar is reached.
	c. Obstruction presence in the hydraulic system	Check all the shut-off valves are in the hydraulic circuit, must to be in the correct status(open/close) Check the filter are in the system, they must not be clogged.
	d. The circulating pump rotation is wrong	Check the rotation direction of the pump and if it is necessary reversing two of the power supply conductors.
	e. The water circulation pump does not work	Check the power supply connection cables and the pump control circuit.
	f. The pump heat protection is activated	Check the pump heat protection setting. Check presence of electric tension on the single phases of the pump. Check the pump winding electric resistance Check the pump impeller can rotate without resistances and impacts. Return the heat pump protection, checking the rotation direction and the electrical absorption of the pump If all these controls give a positive result.

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Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
5. The condensation air flow is lower than estimated	a. The condensing coils are obstructed by foreign bodies, dust, dirt.	Clean the exchanger coil removing the clogging material, in this way the air can flow. Clean the exchanger coil by compressed air (flow it in the condensation air direction) and using a brush. Make sure to use a brush wich does not damage the exchanger coil. Do not use liquid or other products without Manufacturer authorisation.
	b. There are obstruction to the inlet echanger coil and outlet fan air flow	Make sure the space left around the unit(service area) are respected. Remove the clogging material, if it is possible, which obstruct the air flow
	c. The control system of the fan speed regulator(if it is present) setting is not correct, or it does not work	Make sure the fan speed regulator and the microprocessor is set Check the electrical connections and the pressure transducer operatio(which are connected to the fan speed regulator). Make sure the probe signal is appropriate with the regulator fitted Check the power supply connection cables to the fan speed regulator. and the pump control circuit.
	d. One or more condenser fan does not work	Check the power supply connection cables and the fan control circuit.
	e. Fan heat protection system is activated	Check the setting of the fan heat protection Check of the presence of the fan electric tension on the single phases. Check the fan winding electric resistance Check the fan impeller can rotate without resistances and impacts Return the heat fan protection, checking the rotation direction and the electrical absorption of the fan If all these controls give a positive result.

Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
5. The condensation air flow is lower than estimated	f. The condensation fan rotation direction is not correct	Check the rotation direction of the fan and if it is necessary reversing two of the power supply conductors.
6. High pressure switch is activated	a. The high pressure switch is not set properly	Set the pressure switch with the correct parameter (The value must not be over 90% of the safty high pressure valve setting)
	b. The high pressure switch does not work properly	Replace the pressure switch
	c. The discharge pressure is higher than estimated	See trouble 8
7. Low pressure switch is activated	a. The low pressure switch is not set properly	Set the pressure switch with the correct parameter
	b. The low pressure switch does not work properly	Replace the pressure switch
	c. The suction pressure is lower than estimated	See trouble 9
8. The discharge pressure is higher than estimated	a. The condensation air flow is lower than estimated	See trouble 5
	b. The suction pressure is higher that estimated	See trouble 11
	c. Circuit charged with too much refrigerant	Check the subcooling value of the liquid refrigerant to the condenser outlet If the subcooling value is higher than 7 K, it is necessary tot o proceed with a partially drain cooling system(the refrigerant must to be recovered and not realesed it to the ambient)
	d. Air or other incondensable gas are in the cooling circuit	Drain the cooling system(the refrigerant must to be recovered and not realesed it to the ambient) Execute the vacuum Recharge the cooling system The operations described must to be to carried out from qualified and trained personnel

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Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
8. The discharge pressure is higher than estimated	e. The condensation air temperature is higher than estimated	Make sure the air temperature to the condenser inlet is higher than the max allowed. Make sure the air discharged from the condenser fans it will not channelled to the condenser coil inlet
9. The suction pressure is lower than estimated	a. The chilled liquid flow is lower than estimated	See trouble 4
	b. The discharge pressure is lower than estimated	See trouble 10
	c. Insufficient refrigerant charge	Check the cooling system operation parameters(temperature of evaporation, superheated and subcooling) If a leakage is present, carry out the following operations : Leak detection; Vacuum and dehydratation; Recharge the cooling system The operations described must to be to carried out from qualified and trained personnel
	d. Clogged refrigerant filter	Check the temperature gap between dehydrator filter inlet and outlet. Replace the filter if the temperature gap is higher than 0,3 K
	e. The thermostatic valve does not work properly or is defective	Check the superheated value of the refrigerant to the exchanger coil outlet Check the thermostatic expansion valve set in the microprocessor Check : electric connection, driver functioning, valve level controls. (make sure the transducer signal is proper with the driver and valve istalled) Check electric connections and the thermostatic expansion valve operation

Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
9. The suction pressure is lower than estimated	f. The chilled liquid temperature is lower than estimated	See trouble 3
	g. The thermostatic valve does not work properly or is defective	Check the superheated value to the exchanger outlet Check the thermostatic expansion valve set in the microprocessor Check : electric connection, driver functioning, valve level controls. (make sure the transducer signal is proper with the driver and valve istalled) Check electric connections and the thermostatic expansion valve operation
10. The discharge pressure is lower than estimated	a. The control system of the condensation fan speed regulator(if it is present) setting is not correct, or it does not work	See trouble 5.c
	b. The suction pressure is lower than estimated	See trouble 9
11. The suction pressure is higher than estimated	a. The discharge pressure is higher tha estimated	See trouble 8
	b. The thermal load is higher than estimated	See trouble 2.f
	c. The cooling capacity ofe the compressor is insufficient	See trouble 2.c
12. Probe does not work properly	a. The probe corresponding to the alarm code is disconnected	Check the electrical connection of the probe
	b. The probe corresponding to the alarm code is defective	Check if the probe works Change the probe parameter in the microprocessor; otherwise replace the probe.

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Table 5.3: Troubleshooting

Trouble	Possible cause	Corrective actions
13. The compressor does not work	a. Compressor's protection device is activated	Check the alarm type by microprocessor display Check the compressor's calibration device protections Check the presence of the compressor electric tension on the single phases. If all the verification give a positive result, replace the protection device and the compressor operating parameters.
	b. The compressor contactor does not work	Check the electrical connection of the compressor Make sure the microprocessor operation (see trouble 2.d) Make sure the microprocessor parameters setting are correct(see trouble 2.e) Check proper contacts and contactor clois status and funtioning
	c. The compressor is damaged	Replace the compressor (It must be to carried out from qualified and trained personnel)

5.4. Extraordinary maintenance

Unit maintenance must be carried out by properly qualified and informed personnel with personal protection equipment in accordance with existing local law and regulation.

If brazing or welding is required where coolant flows, the personnel involved must wear the personal protection equipment needed to handle the fluid and a respirator with specific protection filter for possible degradation products.

The refrigeration circuit contains high-pressure coolant. Before carrying out any intervention on the refrigeration circuit, release the pressure completely and carefully.

When needed, comply with the national law and regulation on the transport of coolant fluid.

Do not modify the unit or replace its components without the manufacturer's explicit approval.

The procedures carried out by skilled staff (welders, electricians, programmers, etc.) must be supervised by personnel specialized in the coolant sector.

Welding and brazing must be carried out only by properly certified and qualified personnel in accordance with specific procedures and only after the part of the circuit involved is drained of coolant and fluxed with anhydrous nitrogen.

When brazing and welding, remove the parts that may be damaged by heat or protect them wrapping wet cloths around them.

When disassembling shut-off cocks and valves, replace the gaskets with new sealing components.

If no stricter requirements are indicated, maintenance activities on refrigeration circuit components must be carried out according to the following stages, when applicable:

a) Analyze and assess the intervention risks
b) Give proper instructions to the maintenance team
c) Disconnect and protect the components to be repaired
d) Collect the coolant and create the vacuum
e) Clean the component and flux it with anhydrous hydrogen
f) Give the permission for maintenance
g) Carry out maintenance
h) Test and check the repaired components (pressure test, leak test, function test)
i) Reassemble, create the vacuum and fill with coolant

5.4.1. Opening the cooling circuit

Before working on the refrigeration circuit, take the following precautionary measures:

a) Get the permission to carry out the work, if needed
b) Make sure the working area does not accommodate flammable materials and sources of ignition
c) Make sure suitable protective and fire control equipment is present
d) Make sure the working area is properly ventilated before working on the refrigeration circuit and carrying out welding and brazing
e) Make sure the personnel involved in the procedure is properly trained

For environmental security reasons, when the intervention includes the emptying of the refrigeration circuit, collect the coolant gas using a suitable tool.

When the intervention includes the handling of coolant, make sure ventilation is appropriate and no open flames or other sources of ignition are in the area.

The equipment to collect the coolant must comply with local existing regulation and must be in a good maintenance condition. It is advisable to make sure it can work up to a pressure equal to 0.3 bar absolute.

After performing maintenance on the refrigeration circuit, carry out the following activities:

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a) Leak test
b) Vacuum and dehydration
c) Refrigerant charge

5.4.2. Leak test

To identify possible leaks in the refrigeration circuit, follow these steps:

a) Fill the circuit with gaseous coolant up to a pressure equal to 1 bar gauge
b) Add anhydrous nitrogen using cylinders with reducers up to a pressure equal to 15 bar gauge
c) Look for possible leaks using a leak detector with suitable sensitivity (5 g/year or more) according to the coolant employed. Check with special care the junctions involved in the maintenance activity
d) If a leak is detected, empty the refrigeration circuit, perform maintenance and carry out the leak test once more

Do not use oxygen, hydrogen or other reactive or flammable gases to pressurize the refrigeration circuit. Use only anhydrous nitrogen.

Do not exceed 16 bar gauge in the circuit, especially in the low pressure side.

5.4.3. Vacuum and Dehytration

To get a suitable vacuum degree, use a two stage pump with adequate features (minimum transfer rate 10 m^3/h, minimum vacuum degree 3 Ps absolute).

The vacuum degree is usually considered suitable if the moist in the coolant is lower than 100 ppm when the unit is started up. If this condition is satisfied, the dehydrator filter will be able to maintain the rate lower than 20 ppm during functioning.

The vacuum pump must be connected to the inlets on the circuit high and low pressure side. The vacuum pump discharge material must be channeled to fresh air in a safe area.

Do not use the compressor to create the vacuum.

Do not use a megaohmeter to check the engine or feed the compressor when the vacuum has been created.

To correctly create the vacuum in the refrigeration circuit, check possible leaks and perform the following procedures:

a) Connect the vacuum pump to the refrigeration circuit and wait until pressure gets to 50 Pa absolute. From this moment, keep the pump running for at least 4 hours

The vacuum degree must be verified using the gauges installed along the circuit. Do not use the equipment on the pump.

b) Break the vacuum introducing anhydrous nitrogen in the circuit up to a pressure equal to 1 bar absolute
c) Repeat the vacuum creation procedure described in a)

If the refrigeration circuit remained open just for a short period of time, the procedure described from a) to c) is usually enough to get a suitable vacuum degree.

If the equipment available is not suitable or the circuit remained open for a long period of time, you may have to repeat the procedures in b) and c) and break the vacuum using coolant, rather than nitrogen.

5.4.4. Refrigerant charge

After creating the vacuum, fill the refrigeration circuit with coolant according to the following steps:

a) Connect the coolant container to a 1/4" SAE inlet (7/16" – 20 UNF) along the liquid coolant line
b) Let a small quantity of fluid leak to free the connection pipe from air
c) Open the cylinder valve and let the coolant flow in the refrigeration circuit due to the difference in pressure. Replace the coolant container when it is empty
d) If the pressure inside the circuit reaches the break-even value at room temperature, the coolant will not naturally flow from the container. In this case, connect the container to an inlet between the thermostat valve and the evaporator
e) Eliminate air from the connection pipe as indicated in b)
f) Switch the compressor on, open the container shut-off cock and complete the filling. Replace the container when needed
g) Fill progressively with small coolant quantities and check operating pressure and temperature from time to time to avoid the system overload
h) Complete the filling comparing the quantity of coolant in the circuit with the value on the Data Plate
i) Make sure the quantity of coolant in the circuit is correct by examining the flow indicator and evaluating the liquid subcooling and the suction superheat

Connection piping must be as short as possible and equipped with shut-off cocks to reduce coolant leaks probability.

Do not use a different coolant than the one indicated on the Data Plate.

Use only new or recycled coolants with known composition and suitable features for use in refrigeration

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circuits.

The coolant collected can be employed in the unit if the circuit is found to be free from inert gases or other pollutants.

Before filling with coolant, verify the fluid quality and quantity.

Measure the quantity of coolant in the refrigeration (according to mass or volume). It is advisable to add the coolant when it is liquid.

5.4.5. Coolant handling

Unless otherwise specified in local regulation, handle the coolant according to the following instructions.

Carry out the procedures involving the use of coolant being careful to release in the air the smallest amount of gas as possible.

Fill the refrigeration circuit with coolant only if it has successfully passed the leak test.

Do not connect the coolant container to a system with higher pressure when a back flow is possible.

Disconnected the coolant containers from the system as soon as the fluid transfer is finished.

Do not hit, knock, plunk the coolant containers or expose them to heat sources during the fluid filling procedure. Perform visual inspections to check the containers conditions.

Do not fill the containers with a higher quantity of coolant than the maximum allowed, which must be clearly visible on the container.

Do not store coolants in containers designed for other substances. The material in the container must be clearly indicated on the container itself.

Clearly indicate the coolant quality (new, recycled, reused) on the containers to avoid mixing different kinds of fluid.

Do not connect coolant containers to one another using a collector.

Store the coolant containers in a devoted area away from fire and heat sources and direct solar radiation.

Handle the containers with care to avoid possible mechanical damages. If needed, fasten them to make sure they can't fall.

Close and protect the containers shut-off cocks. Replace the gaskets when needed.

5.4.6. Procedures after maintenance

After each maintenance intervention, perform at least the following procedures:

a) Check all the safety, control and measurement devices to make sure they work correctly
b) Check the leaks along the parts of refrigeration circuit involved
c) Check and adjust the coolant filling
d) Check the safety devices correct functioning
e) Check the presence of coolant in the fluid to be cooled

After each maintenance intervention, check and record the functionality of possible safety systems such as coolant detectors and mechanical ventilation systems.

Replace all the labels on the components of the refrigerating circuit when lost or illegible.

When the maintenance intervention is over, carry out a functional test. If a coolant leak is detected, perform a leak test on the whole system.

Record on the Register the quantity and type of coolant employed.

Verify the unit tightness within one month from the leak repair to make sure the intervention was successful.

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6. Dismantling and Disposal

Before disposing of the unit, drain the refrigeration circuit and collect the coolant gas using a suitable collector in compliance with local regulation.

Coolant collection, reuse, recycling, maintenance, regeneration and disposal must be carried out by certified, qualified, informed and properly equipped personnel in accordance with existing local law and regulation.

Be careful when draining the coolant because its pressure in the refrigeration circuit can be high.

If the coolant fluid is released abruptly, it can produce low-temperature skin burns.

Do not release coolant in the environment.

Used coolant filters can contain residual fluid quantities. Remove any trace of it before disposing of the filter.

Deal with the drained coolant in accordance with EN 378-4 regulation, ann. C.

Dispose of the drained coolant in accordance with EN 378-4 regulation, par. 6.2.

Collect, transport and store the coolant in accordance with EN 378-4 regulation, par. 6.3.

Dispose of the unit in accordance with EN 378-4 regulation, par. 6.5 and with existing national law and regulation.

After draining the coolant, reduce the machine to single components. Dispose of them according to their features in accordance with existing local law and regulation.

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7. T3C Chiller

7.1. Introduction

Name of the SW algorithm: Turbocor Compound Capacity Chiller or in brief: T3C Chiller.

The Turbocor Compound Capacity Chiller is dedicated to Chiller systems with one or more Danfoss Turbocor compressors.

The algorithm allows the management of chiller cooling: Air/Water, Water/Water, 1 refrigerant circuits and totally up to 4 Danfoss Turbocor compressors.

Because of the algorithm capability to manually assign inputs and outputs according to the unit's features to control, it is suitable to be executed in any MCX electronic controller, but I/O requirements normally would demand a MCX15 or MCX20

The main algorithm's functions are as follows:

- chilled inlet or outlet water temperature regulation;
- proportional/integral regulation;
- anti freeze control;
- Danfoss Turbocor compressor management;
- pre-emptive handling of low evaporator or high discharge pressure;
- twin pumps control;
- alarms management;
- setpoint management:
- second setpoint;
- remote setpoint;
- setpoint compensation;
- liquid level control;
- Fan control (step or variable speed);
- Auto/Manual control modes;
- historical alarm list.

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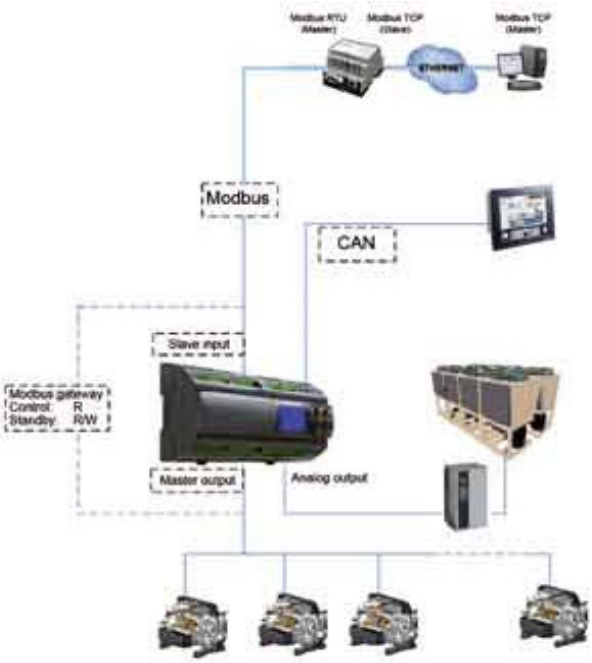
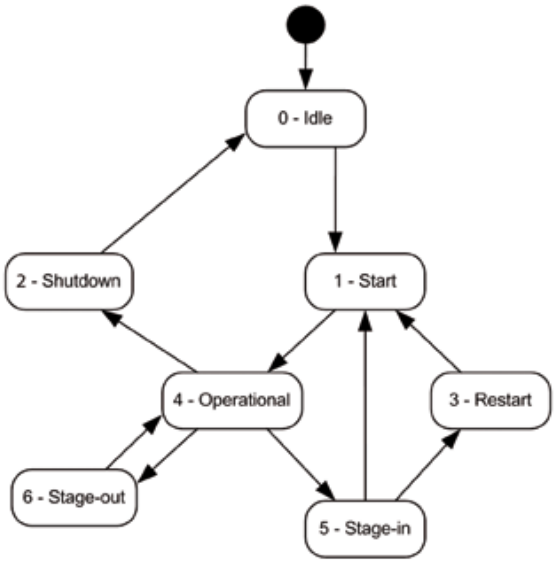


7.2. Compressor control

7.2.1. Chiller states



Idle State:

The chiller is standing idle (zero capacity) but is ready for start of the first compressor.

Start State:

The pressure ratio must be kept low while one or more compressors are in the process of starting. The start state maintains the low pressure ratio until all running compressors have reached sufficient speed to operate without risk of surging. At that point, the state is changed into the operational state.

Operational State:

The chiller is in normal operation.

Stage-in State:

Starting a compressor when other compressors are already running requires some care because the pressure ratio has to be low enough to start a compressor. This is the purpose of the stage-in state. The system is instructed to lower the pressure ratio and the rack controller contributes by instructing all running compressors to reduce their capacity (the retreating and hold states of the individual compressor states below. As soon as the pressure ratio has reached the threshold, the new compressor is instructed to start and the state changes into start state.

Restart State:

It is assumed in the stage-in state that the pressure ratio will come down below the threshold where another compressor can be started. However, it must be assumed that this is not always the case (although should not happen in well designed system unless it is a malfunctioning). In that case all compressors will be stopped and restarted together with one additional compressor. In the restart state, all compressors are signalled to stop. As soon as they have all reached full stop, the controller signals start to all compressors that need to be started and switches into the start state.

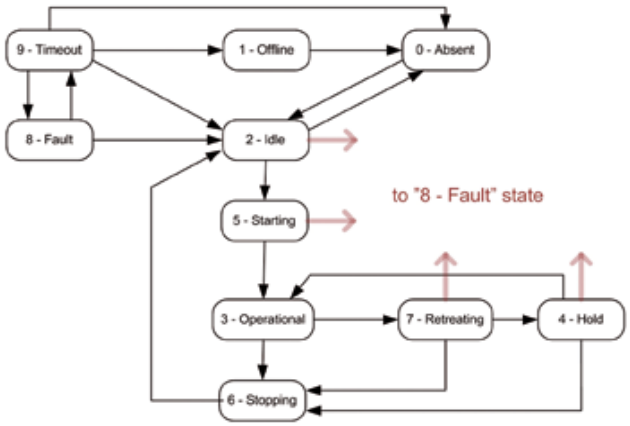
Stage-out State:

In the stage-out state, one compressor is instructed to stop in order to reduce capacity. When it as reached full stop, the state switches automatically back to the operational state.

Shutdown State:

The shutdown state is similar to the stage-out state with the sole exception that in this case the last running compressor is being stopped. The shutdown state therefore switches into the idle stage when this compressor reaches full stop.

7.2.2. Individual compressor states



Absent State:

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A chiller may contain less than the maximum allowed number of compressors. This leaves some of the state machines unused and uninitialized. This is indicated by the absent state.

Offline State:

The offline state indicates that the compressor is not to be started. This can be due to three reasons:

- the operator has taken the compressor offline for maintenance;
- the compressor encountered a fault state which cannot be recovered by thecontroller (the operator needs to recycle the power manually);
- the controller lost its Modbus connection to the compressor.

Idle State:

The compressor is currently idle but it is online and ready for use.

Starting State:

The compressor has received a start signal and is in the process of speeding up. The state automatically switches into the operational state when the compressor reaches sufficient speed to operate normally without risk of surging.

Operational State:

The compressor is in normal operation.

Stopping State:

The compressor has received a stop signal and is in the process of slowing down. The state automatically switches into the idle state when the compressor reaches full stop.

Retreating State:

Compressors cannot be started against a high pressure ratio. Thus it is sometimes necessary to bring the pressure ratio down before another compressor can be started. It is advisable to do this as quickly as possible so that the interruption of the normal operation is reduced to a minimum. This involves the entire chiller (for example utilizing condenser and bypass valves). The compressors that are already running can help by reducing their power as much as possible.

This is implemented as the retreating state: power is reduced as long as the pressure ratio is too high to start another compressor. It automatically switches into the hold state as soon as the threshold is reached.

Hold State:

The compressor keeps running at low power after the retreating state has changed into the hold state. It returns to normal operation after the new compressor has been started (ie. when it has reached its operational state).

Fault State:

The compressor has shut itself down after it detected a fault. The controller attempts to clear the fault, with three possible outcomes:

- The fault is reset and the compressor is made available for normal use again by switching into the idle state.
- After overheating faults (motor or electronics have become too hot), the compressor is given some extra time to cool down by changing into the timeout state. This ensures that the compressor cools down well below its alarm threshold before it can be started again.
- Some faults cannot be reset by the controller, for example when the compressor is damaged. The controller then takes this compressor out of circulation by switching into the offline state.

Timeout State:

The compressor has recovered from an overheat fault. It is given some additional time to cool down before it becomes available.

7.2.3. Alarm handling

The Danfoss Turbocor compressors handle virtually all alarms that directly concern the compressors. System related alarms, such as high condenser pressure, must be handled by the controller. The rack and compressor managers include some features to help avoid such alarms but they do not detect or act directly to alarms.

In case of alarm it may be advisable to stop compressors as quickly as possible. This overrules the normal operation of the two state machines that were described above. There are two possibilities:

- full stop: Stop all compressors;
- partial stop: cut the capacity by at least 30%, and always minimum one compressor.

7.3. Unit configuration

7.3.1. Parameters for unit configuration

The Danfoss Turbocor compressor is controlled by Modbus serial communication. A safe and reliable communication is essential for the control performance.

- Correct terminating of the Modbus communication lines;
- Correct baud rate for MCX slave input (RS485-1);
- Correct baud rate for MCX master and all Danfoss Turbocor compressors (RS485-2);
- Correct address setup for individual Danfoss Turbocor compressors.

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7.4. User Interface

7.4.1. Main screen

7.4.1.1. LCD Display

On the main screen the following data are displayed:

- the main analog inputs measurements or other information
- the alarm or service icon

7.4.1.2. Icons description

Icon	Description
	Evaporator pump has started
	Heater is started
	One or more compressors are running
	Bypass valve is active (and compressor is running)
	Economizer is active (and compressor is running)
	Free cooling is active (and compressor is stopped)
	Indicating compressor start
	Indicating compressor shutdown
	Condenser fans are running
	Condenser fans are forced due to safety, start-up or free cooling
	Condenser pump is running
	LLSV is ON (Liquid Line Solenoid Valve)
	LLSV is ON, liquid level reference is forced

7.4.2. Menu navigation

Pressing the key  when the unit is ON, you go to the menu described in the following table.

MENU NAVIGATION				
Codes on Excel sheet (Main_Menu)			**LCD DISPLAY**	
Menu code (Cod A)	**Sub-menu code (Cod B)**	**Sub-menu code (Cod C)**	**Description**	**Function**
StA			Status	Status of the controller – Read only screens
	SCM		Compressor status	Reading status of compressors
	SCD		Compressor Details	Reading values for each compressor
	SCN		Condenser	Reading values for Condenser
	SBY		Bypass valve	Reading values for Bypass valve
	SEP		Evaporator	Reading values for Evaporator
	SLL		Free cooling	Reading values for Freecooling state
	SLL		Liquid Line	Reading values for Liquid Level
LOG			Login	Defines the access level to menus and parameters. Password is defined with I01, I02 and I03 parameters
PAR			Parameters	Access to menu of parameters. You need to login first.
I/O			Input/Output	Access to input/output menu
	IOd		I/O Display	Display input and output values
ALA			Alarms	Access to alarm menu
	AAL		Active Alarms	List of the active alarms
	AAL		Alarm Log	

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	ALR		Reset Alarms	Alarms manual reset
SER			Service	Access to service information
	INF		Software info	Information on application software
	DEV		Device info	Information on device
SCH			Scheduler	Access to scheduler menu
	SCH		Scheduler	Configuration of scheduler record
	RTC		Set RTC	Set time and date
	DSC		Clear schedule	Reset the schedule list

To navigate inside menus use the and keys . The key allows you to go down to the next level, if present; the key allows you to go up to the previous level, up to the main screen.

To change the value of the selected parameters use the following keys:

- , to enter in changing mode (the value starts to blink),
- and to change value,
- again to confirm changes or for not confirming them.

7.4.2.1. Status

Menu: StA – Status

This is an only display menu. In each sub-menu you have one different part of the machine of which you can see different values concerning that part. So you can have an overview about status of all the parts of the machine. The only sub-menu in which you can surf inside with the buttons is the “Compressor Details” menu.

Sub-menu: SCD – Compressor Details

The screen shows some data on specific compressors. If you press the or buttons, the screen changes to display additional data for that compressor. If you press LEFT or RIGHT, the screen switches to the next/previous compressor.

7.4.2.2. Login

Menu: LOG – Login

To insert the 4 digit password defining the access level to menus and parameters.

The current access level is then shown on the second raw of the main menu screen.

Press  and  to change the value of the selected digit.

Press  to confirm the value and skip to the next digit, if present, or to login.

The LEFT and RIGHT keys, if present, allow you to move the cursor on the desired digit.

Password for the access levels from 1 to 3 are defined with l01 [1000], l02 [2000], l03 [3000] parameters, group1 “GEN

- General”, group2 “PAS – Password”.

Without logging in, you get access level 0.

You can’t see parameters or menu entries belonging to a higher level then yours. What is the level of each parameter

and menu is defined with the configurator.

If the inserted password is not correct you stays inside the login screen. Otherwise you get back to the main menu.

7.4.2.3. Parameters

Menu: PAR - Parameters

Gives access to parameters.

For a description of each parameter menu, see the relevant paragraph below.

7.4.2.4. Input and output display

Menu I/O – Input/Output

Sub-menu: IOd – I/O Display

LCD display

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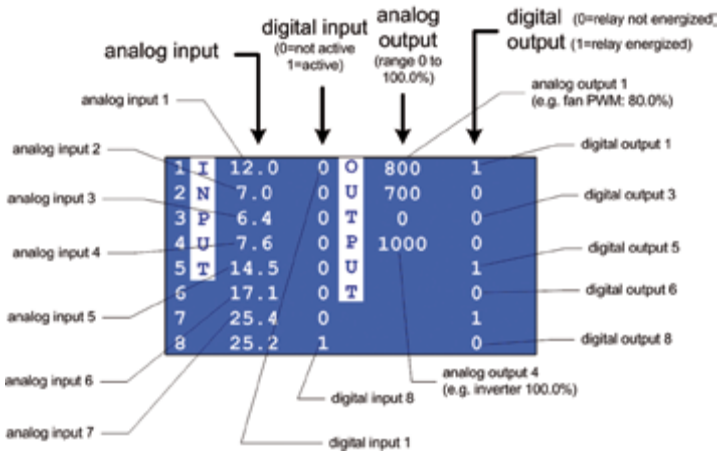
You have access to three screens showing all the input and output values; each screen shows a group of 8 I/O. Use and keys to scroll them. The second and third screen are used with MCX15 and MCX20 only.

Below example shows the first screen.



7.4.2.5. Alarm display and configuration

Menu: ALA – Alarms

Sub-menu: AAL – Alarm Log

The screen displays the alarm log, one entry per screen. It will display the last entry that was viewed or the first entry, if it is the first time you view the screen. If you press the / buttons it will display the next/previous entry. If you press the LEFT button it will display the first entry, if you press RIGHT button it will display the last entry.

The entries are displayed even though they are empty as indicated with bars in the data fields. If an alarm is still active only the "On" time will be filled out, since the "Off" time is obviously not registered until the alarm is off.

Sub-menu: AAL – Active Alarms

Shows you the active alarm screens.

Each screen is dedicated to an alarm.

You can scroll among them using the and keys.

Each alarm is described through:

- alarm description (for LCD display only);
- alarm code;
- time since its activation in the format hours:minutes:seconds (seconds for LCD display only).

Note: you can access to alarm visualization also by pressing the ESC key from the main screen

Sub-menu: ALR – Alarms Reset

Reset of active alarms (for manually resettable alarms only).

Press to reset manually all the active alarms.

Note: alarms reset can be performed also pressing ESC for 3s within the alarm screens.

7.4.2.6. Service

Menu: SER - Service

Access to service menu.

Sub-menu: INF – Software info

Information about device software

Sub-menu: DEV – Device info

Information about device hardware.

7.4.2.7. Scheduler configuration

The purpose of the scheduler setting is to plan a set of actions that has to be taken at certain time and repeated in different weekdays.

Menu: SCH – Scheduler

Access to the scheduler and real time clock settings.

Sub-menu: SCH – Scheduler

Access to configuration of the scheduler. Up to 21 records are managed, and each record consists of 3 fields, a time of day, an action and weekdays.

The time of day can be set in ten minute time steps allowing a total of 144 activation times in a 24 hour period.

Two actions are available, setting cooling enable ON or cooling enable OFF (“CE ON” or “CE OFF”).

The schedule can be enabled for individual weekdays. An enabled weekday will be displayed as an abbreviation of the day (MO for Monday etc.). A disabled weekday will be displayed as “--”.

To set a schedule, use the and keys to select a schedule and press to enter edit mode. Use the and keys to change the selected value and press to confirm and move to the next field or press to abort.

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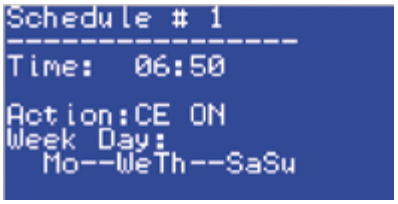
After editing the schedule use the key to exit the scheduler, or and keys to select another schedule.



Sub-menu: RTC – Set RTC

Access to configuration of time and date of the internal real time clock (option)

Use the , , LEFT and RIGHT keys to select the field to be edited (marked with a cursor). Use the key to enter edit mode. Use the and keys to change the value. Press to confirm or to abandon.

Sub-menu: DSC – Clear schedule

Activating this function by pressing key will clear and reset the entire schedule list. The screen will return to the main menu.

7.5. Keyboard

KEYBOARD			
Unit status	**Key**	**Function**	**Description**
Main screen		menu	Access to menus
		Alarms	Admission to the list of active alarms
Menu		Up	Backward scroll of menu

		Down	Forward scroll of menu
		-->	Change to the next menu level, if present, or command execution
		<--	Go back to the previous menu level, if present, or to the main screen
Login		+	Increment the selected digit
		-	Decrement the selected digit
		OK	Confirm the value and skip to the next digit, if present, or execute login.
		<--	Go back to the previous menu level, if present, or to the main screen
Parameters - navigation		Up	Backward scroll of parameters or group of parameters
		Down	Forward scroll of parameters or group of parameters
		-->	Change to the next group of parameters, if present, otherwise enter in parameter programming mode
		<--	Go back to the previous menu level, if present, or to the main screen
Parameters - changes		Prg/OK	• Enter in parameter programming mode • Confirm the change
		+	Increment the parameter value
		-	Decrement the parameter value
		Esc	Exit from programming mode discarding the change
Alarms - list		Up	Backward scroll of the alarm list
		Down	Forward scroll of the alarm list
		<--/Reset	Go back to the main screen. Pressed for 5 seconds, manual reset of all the active alarms
Power ON	 +  5s	Default	Pressed together for 5 seconds at power ON, force reloading the default values of all the parameters

7.6. Alarms

Group1: ALA – Alarms

Group2: CFG – Configuration

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7.6.1. Alarm actions

When an alarm happens generally the following actions are executed.

- Buzzer activation, if present and enabled and if required by the active alarm (see "10.3] Alarms table"). The "buz" parameter sets the buzzer activation time in case of alarm; 0 is always OFF, 1..14 the buzzer is automatically muted after the related value in minutes, 15 is always ON.
- Alarm or warning relay activation (if present) according to what is required by the active alarm (see "10.3] Alarms table"). Through the "rad" parameter you define the relay activation delay. Through "rao" you set the alarm relay status in case of alarms with unit on OFF state. The relay working logic between Normally Close (N.C.) and Normally Open (N.O.) is defined at the physical output configuration phase. If polarity is set to "Open" (as by default) it means that relay is energized in case of alarm.
- Display of the alarm icon and alarm code on, together with the time since its activation.
- Display of the active alarms list and of the related description on the LCD controllers. For a more detailed description of the user interface in case of alarms.

7.6.2. Reset types

Alarms can be of manual, automatic or semi-automatic reset type.

- If they are of manual reset type, they requires an acknowledgement to be reset; the user must press the ESC key for 3 seconds within the alarm screens to reset the alarm, if the alarm condition doesn't occur anymore. Or he can reset it from menu (Menu: ALA – Alarms, Submenu: RAL – alarm Reset);
- If they are of automatic reset type, the alarm is reset as soon as the alarm condition disappear. The display icon stays active till it is manually reset (see the point above).
- There are alarms with automatic reset but that becomes of manual reset type after a configurable amount of activations: they are the so called semi-automatic alarms.

Buzzer is muted pressing any key even if the alarm condition is still present and stays muted till a new alarm occurs.

7.6.3. Alarm table

Each alarm is characterized by:

- enable from configurator or from a parameter, if present;
- code: acronym to identify the alarm and that is showed on the display;
- description to display on a LCD display;
- reset type (-1=automatic, 0=manual, >0=number of occurrences for semi-automatic alarms);
- if semi-automatic alarms, the period for counting alarm occurrences; if during this time the alarm exceeds its maximum number of occurrences, it becomes a manual reset alarm;
- delay from the start-up of the related element and delay in normal functioning;
- if active even when the unit is OFF;
- action on the alarm relay, warning relay and buzzer.

7.6.4. Main alarms description

The reset type is configurable among:

- manual: alarm must be reset manually.
- automatic: alarms are reset automatically if the alarm condition is cleared.
- semi-automatic: the alarm are reset automatically if the alarm condition is cleared. If the alarm becomes active again within the semiautomatic period, the alarm becomes manually resettable.

ALARM TABLE

Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay
A01	Main switch	-1	0	0	0	Yes	On	Off
A02	Refrigerant NOT selected: Select, Restart	0	60	0	0	Yes	On	On
A03	Evaporator flow switch alarm	0	60	10	5	Yes	On	Off
A04	Condenser flow switch alarm	0	60	10	5	Yes	On	Off
A05	Communication fault	0	0	0	0	No	On	Off
A06	Compressor in surge	-1	0	0	0	No	Off	Off
A07	Entering chilled water sensor alarm	-1	0	0	0	Yes	On	Off
A08	Leaving chilled water sensor alarm	-1	0	0	0	Yes	On	Off
A09	Room return air sensor alarm	-1	0	0	0	Yes	On	Off
A10	Entering condenser water sensor alarm	-1	0	0	0	Yes	On	Off
A11	Leaving condenser water sensor alarm	-1	0	0	0	Yes	On	Off
A12	Condenser entering air sensor alarm	-1	0	0	0	Yes	On	Off
A13	Outside air sensor alarm	-1	0	0	0	Yes	On	Off
Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay

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A14	Suction pressure 1 transmitter alarm	-1	0	0	0	Yes	On	Off
A15	Discharge pressure 1 transmitter alarm	-1	0	0	0	Yes	On	Off
A18	LP 1 cutout alarm	-1	0	0	0	Yes	On	Off
A20	HP 1 cutout alarm	-1	0	0	0	Yes	On	Off
A22	Evaporator flow switch alarm	0	60	10	5	Yes	On	Off
A23	Evaporator pump overload	0	60	10	5	Yes	On	Off
A24	Evaporator pump 1 overload	0	60	10	5	Yes	On	Off
A25	Evaporator pump 2 overload	0	60	10	5	Yes	On	Off
A26	Evaporator pump 1 run hours exceeded	0	60	10	5	Yes	On	Off
A27	Evaporator pump 2 run hours exceeded	0	60	10	5	Yes	On	Off
A28	Evaporator pump switched due to fault	0	60	10	5	Yes	On	Off
A29	Chiller general alarm	-1	0	0	0	Yes	On	Off
A30	Low water temp	2	60	10	sa5	Yes	On	Off
A31	Low To (saturated suction temp)	2	60	10	sa5	Yes	On	Off
A32	High discharge pressure	-1	0	10	sa5	Yes	On	Off
A33	High pressure ratio	-1	0	10	sa5	Yes	On	Off
A34	Warning: Low water temp	-1	0	10	sa5	Yes	On	Off
A35	Warning: Low To (saturated suction temp)	-1	0	10	sa5	Yes	On	Off
A36	Warning: High discharge pressure	-1	0	10	sa5	Yes	On	Off
A37	Warning: High pressure ratio	-1	0	10	sa5	Yes	On	Off
A38	Liquid level sensor alarm	-1	0	0	0	No	On	Off
A39	High Liquid Level 1	-1	0	10	70	Yes	Off	On
A40	Low Liquid Level 1	-1	0	10	30	Yes	Off	On
A43	Inverter fan 1 overload alarm	-1	0	10	5	No	On	Off
Code	Alarm description	Reset type	Semi automatic period	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay

			(min)					
A44	Condenser fan 1 overload alarm	-1	0	10	5	No	On	Off
A45	Condenser fan 2 overload alarm	-1	0	10	5	No	On	Off
A46	Condenser fan 3 overload alarm	-1	0	10	5	No	On	Off
A47	Condenser fan 4 overload alarm	-1	0	10	5	No	On	Off
A48	Condenser fan 5 overload alarm	-1	0	10	5	No	On	Off
A49	Condenser fan 6 overload alarm	-1	0	10	5	No	On	Off
A50	Condenser fan 7 overload alarm	-1	0	10	5	No	On	Off
A51	Condenser fan 8 overload alarm	-1	0	10	5	No	On	Off
A52	Free cooling freeze error	-1	0	0	0	No	On	Off
A53	General DI alarm 1	-1	0	0	0	No	On	Off
A54	General DI alarm 2	-1	0	0	0	No	On	Off
A55	General DI alarm 3	-1	0	0	0	No	On	Off
A56	General DI alarm 4	-1	0	0	0	No	On	Off
A57	General DI alarm 5	-1	0	0	0	No	On	Off
A58	General DI alarm 6	-1	0	0	0	No	On	Off
A59	General DI alarm 7	-1	0	0	0	No	On	Off
A60	General DI alarm 8	-1	0	0	0	No	On	Off
A61	General DI alarm 9	-1	0	0	0	No	On	Off
A62	General DI alarm 10	-1	0	0	0	No	On	Off
A63	General AI alarm 1	-1	0	0	0	No	On	Off
A64	General AI alarm 2	-1	0	0	0	No	On	Off
A65	General AI alarm 3	-1	0	0	0	No	On	Off
A66	General AI alarm 4	-1	0	0	0	No	On	Off
A67	General AI alarm 5	-1	0	0	0	No	On	Off
Code	Alarm description	Reset	Semi automatic	Startup	Steady	Activi with	Alarm	Warning

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		type	period (min)	delay (s)	delay (s)	unit OFF	relay	relay
A68	General AI alarm 6	-1	0	0	0	No	On	Off
A69	General AI alarm 7	-1	0	0	0	No	On	Off
A70	General AI alarm 8	-1	0	0	0	No	On	Off
A71	General AI alarm 9	-1	0	0	0	No	On	Off
A72	General AI alarm 10	-1	0	0	0	No	On	Off
A73	Common interlock activated	-1	0	0	0	No	On	Off
A74	Compressor 1 interlock activated	-1	0	0	0	No	On	Off
A75	Compressor 2 interlock activated	-1	0	0	0	No	On	Off
A76	Compressor 3 interlock activated	-1	0	0	0	No	On	Off
A77	Compressor 4 interlock activated	-1	0	0	0	No	On	Off
A78	Evaporator heaters overload	-1	0	0	0	No	On	Off
A79	Evaporator heater 1 overload	-1	0	0	0	No	On	Off
A80	Evaporator heater 2 overload	-1	0	0	0	No	On	Off
A81	Evaporator heater 3 overload	-1	0	0	0	No	On	Off
A82	Evaporator heater 4 overload	-1	0	0	0	No	On	Off
A83	Evap. Condenser water level	-1	0	0	0	No	On	Off
A84	Evap. Condenser heaters	-1	0	0	0	No	On	Off
A85	Adiabatic Pump overload	-1	0	0	0	No	On	Off
aC1	TC1 communication error	-1	0	0	0	No	On	Off
a11	TC1 AC-Inverter temp	-1	0	0	0	Yes	On	Off
a12	TC1 AC-discharge temp	-1	0	0	0	Yes	On	Off
a13	TC1 AC-suction pressure	-1	0	0	0	Yes	On	Off
a14	TC1 AC-discharge pressure	-1	0	0	0	Yes	On	Off
a15	TC1 AC-3 phase current trip	-1	0	0	0	Yes	On	Off

Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay
a16	TC1 AC-shaft cavity temp	-1	0	0	0	Yes	On	Off
a17	TC1 AC-leaving air/water	-1	0	0	0	Yes	On	Off
a18	TC1 AC-total compression ratio fault	-1	0	0	0	Yes	On	Off
a19	TC1 AC-bearing motor fault	-1	0	0	0	Yes	On	Off
a1A	TC1 AC-sensor error	-1	0	0	0	Yes	On	Off
a1B	TC1 AC-SCR fault	-1	0	0	0	Yes	On	Off
a1C	TC1 AC-lock out fault	-1	0	0	0	Yes	On	Off
a1D	TC1 AC-motor thermistor	-1	0	0	0	Yes	On	Off
a1E	TC1 AC-super heat fault	-1	0	0	0	Yes	On	Off
a1F	TC1 ANC-inverter temp	-1	0	0	0	Yes	Off	On
a1G	TC1 ANC-discharge temp	-1	0	0	0	Yes	Off	On
a1H	TC1 ANC-suction pressure	-1	0	0	0	Yes	Off	On
a1I	TC1 ANC-discharge temp	-1	0	0	0	Yes	Off	On
a1J	TC1 ANC-3 phase current trip	-1	0	0	0	Yes	Off	On
a1K	TC1 ANC-shaft cavity temp	-1	0	0	0	Yes	Off	On
a1L	TC1 ANC-leaving water	-1	0	0	0	Yes	Off	On
a1M	TC1 ANC-total compression ratio fault	-1	0	0	0	Yes	Off	On
a1N	TC1 ANC-SCR temp	-1	0	0	0	Yes	Off	On
a1O	TC1 ANC-super heat	-1	0	0	0	Yes	Off	On
aC2	TC2 communication error	-1	0	0	0	No	On	Off
a21	TC2 AC-inverter temp	-1	0	0	0	Yes	On	Off
a22	TC2 AC-discharge temp	-1	0	0	0	Yes	On	Off
a23	TC2 AC-suction pressure	-1	0	0	0	Yes	On	Off
a24	TC2 AC-discharge pressure	-1	0	0	0	Yes	On	Off
a25	TC2 AC-discharge pressure	-1	0	0	0	Yes	On	Off
a26	TC2 AC-shaft cavity temp	-1	0	0	0	Yes	On	Off

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a27	TC2 AC-leaving Air/Water	-1	0	0	0	Yes	On	Off
Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay
a28	TC2 AC-total compression ratio fault	-1	0	0	0	Yes	On	Off
a29	TC2 AC-bearing motor fault	-1	0	0	0	Yes	On	Off
a2A	TC2 AC-sensor error	-1	0	0	0	Yes	On	Off
a2B	TC2 AC-SCR fault	-1	0	0	0	Yes	On	Off
a2C	TC2 AC-look out fault	-1	0	0	0	Yes	On	Off
a2D	TC2 AC-motor thermistor	-1	0	0	0	Yes	On	Off
a2E	TC2 AC-super heat fault	-1	0	0	0	Yes	On	Off
a2F	TC2 ANC-inverter temp	-1	0	0	0	Yes	Off	On
a2G	TC2 ANC-discharge temp	-1	0	0	0	Yes	Off	On
a2H	TC2 ANC-suction pressure	-1	0	0	0	Yes	Off	On
a2I	TC2 ANC-discharge pressure	-1	0	0	0	Yes	Off	On
a2J	TC2 ANC-3 phase current trip	-1	0	0	0	Yes	Off	On
a2K	TC2 ANC-shaft cavity temper	-1	0	0	0	Yes	Off	On
a2L	TC2 ANC-leaving water	-1	0	0	0	Yes	Off	On
a2M	TC2 ANC-total compression ratio fault	-1	0	0	0	Yes	Off	On
a2N	TC2 ANC-SCR temp	-1	0	0	0	Yes	Off	On
a2O	TC2 ANC-super heat	-1	0	0	0	Yes	Off	On
aC3	TC3 communication error	-1	0	0	0	No	On	Off
a31	TC3 AC-inverter temp	-1	0	0	0	Yes	On	Off
a32	TC3 AC-discharge temp	-1	0	0	0	Yes	On	Off
a33	TC3 AC-suction pressure	-1	0	0	0	Yes	On	Off
a34	TC3 AC-discharge pressure	-1	0	0	0	Yes	On	Off
a35	TC3 AC-3 phase current trip	-1	0	0	0	Yes	On	Off
a36	TC3 AC-shaft cavity temp	-1	0	0	0	Yes	On	Off

a37	TC3 AC-leaving Air/Water	-1	0	0	0	Yes	On	Off
Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay
a38	TC3 AC-total compression ratio fault	-1	0	0	0	Yes	On	Off
a39	TC3 AC-bearing motor fault	-1	0	0	0	Yes	On	Off
a3A	TC3 AC-sensor error	-1	0	0	0	Yes	On	Off
a3B	TC3 AC-SCR fault	-1	0	0	0	Yes	On	Off
a3C	TC3 AC-look out fault	-1	0	0	0	Yes	On	Off
a3D	TC3 AC-motor thermistor	-1	0	0	0	Yes	On	Off
a3E	TC3 ANC-super heat	-1	0	0	0	Yes	On	Off
a3F	TC3 ANC-inverter temp	-1	0	0	0	Yes	Off	On
a3G	TC3 ANC-discharge temp	-1	0	0	0	Yes	Off	On
a3H	TC3 ANC-suction pressure	-1	0	0	0	Yes	Off	On
a3I	TC3 ANC-discharge pressure	-1	0	0	0	Yes	Off	On
a3J	TC3 ANC-3 phase current trip	-1	0	0	0	Yes	Off	On
a3K	TC3 ANC-shaft cavity temp	-1	0	0	0	Yes	Off	On
a3L	TC3 ANC-leaving water	-1	0	0	0	Yes	Off	On
a3M	TC3 ANC-total compression ratio fault	-1	0	0	0	Yes	Off	On
a3N	TC3 ANC-SCR temp	-1	0	0	0	Yes	Off	On
a3O	TC3 ANC-super heat	-1	0	0	0	Yes	Off	On
aC4	TC4 communication error	-1	0	0	0	No	On	Off
a41	TC4 AC-inverter temp	-1	0	0	0	Yes	On	Off
a42	TC4 AC-discharge temp	-1	0	0	0	Yes	On	Off
a43	TC4 AC-suction pressure	-1	0	0	0	Yes	On	Off
a44	TC4 AC-discharge pressure	-1	0	0	0	Yes	On	Off
a45	TC4 AC-3 phase current trip	-1	0	0	0	Yes	On	Off
a46	TC4 AC-shaft cavity temp	-1	0	0	0	Yes	On	Off
a47	TC4 AC-leaving Air/Water	-1	0	0	0	Yes	On	Off

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a48	TC4 AC-total compression ratio fault	-1	0	0	0	Yes	On	Off
Code	Alarm description	Reset type	Semi automatic period (min)	Startup delay (s)	Steady delay (s)	Activi with unit OFF	Alarm relay	Warning relay
a49	TC4 AC-bearing motor fault	-1	0	0	0	Yes	On	Off
a4A	TC4 AC-sensor error	-1	0	0	0	Yes	On	Off
a4B	TC4 AC-SCR fault	-1	0	0	0	Yes	On	Off
a4C	TC4 AC-look out fault	-1	0	0	0	Yes	On	Off
a4D	TC4 AC-motor thermistor	-1	0	0	0	Yes	On	Off
a4E	TC4 ANC-super heat	-1	0	0	0	Yes	On	Off
a4F	TC4 ANC-inverter temp	-1	0	0	0	Yes	On	Off
a4G	TC4 ANC-discharge temp	-1	0	0	0	Yes	On	Off
a4H	TC4 ANC-suction pressure	-1	0	0	0	Yes	On	Off
a4I	TC4 ANC-discharge pressure	-1	0	0	0	Yes	On	Off
a4J	TC4 ANC-3 phase current trip	-1	0	0	0	Yes	On	Off
a4K	TC4 ANC-shaft cavity temp	-1	0	0	0	Yes	On	Off
a4L	TC4 ANC-leaving water	-1	0	0	0	Yes	On	Off
a4M	TC4 ANC-total compression ratio fault	-1	0	0	0	Yes	On	Off
a4N	TC4 ANC-SCR temp	-1	0	0	0	Yes	On	Off
a4O	TC4 ANC-super heat	-1	0	0	0	Yes	On	Off

7.7. Parameters

The parameters are divided by groups, depending on the function type.

For each parameters are defined the here below features (these features could be a numeric value or could depend from the value of another parameter which is specified by an acronym).

All the described features can be modified through the configurator.

Code: acronym to identify the parameter. It clearly identifies the parameter and it is showed on the display.

Description: parameter description to display on a LCD display.

K: indicates a not adjustable parameter (constant value equal to the default value); it isn't showed on the display.

Min: minimum value.

Max: maximum value.

Default: factory setting value. To force parameters to get their factory setting values see "u02" Reset parameters default values".

U.M.: indicates the unit of measurement.

Decimals: number of decimal digits.

Visibility requirements: specifies if the parameter visibility is depending on the value of another parameter.

Level: the parameters are organized on 4 levels. Levels from 1 to 3 are linked to a password. It is not allowed the access to parameters when they are on a higher level than the entering level.

- Level 0 is accessible without password
- Level 1 is easily accessible (password "l01"). It contains all the parameters that are not critical for the unit functioning. They are frequently modified.
- Level 2 contains all the parameter that are useful to set the unit (password "l02").
- Level 3 contains all the parameters reserved to the unit manufacturer (password "l03").

Text Values: list of mnemonic values that parameters can assume.

The entering to the parameters visualization and modification mode is possible from menu.

For a complete user interface description, please (see "7.4 User Interface").

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8. Refrigerant safety data sheet

SAFETY DATA SHEET according to Regulation (EC) No. 1907/2006

DuPont™ SUVA® 134a refrigerant

Version 2.5
Revision Date 18.05.2010 Ref.130000000349

This SDS adheres to the standards and regulatory requirements of Great Britain and may not meet the regulatory requirements in other countries.

1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product information

Product name	:	DuPont™ SUVA® 134a refrigerant
Types	:	ASHRAE Refrigerant number designation: R-134a
Use of the Substance/Mixture	:	Refrigerant
Company	:	Du Pont de Nemours (Nederland) B.V. Baanhoekweg 22 NL-3313 LA Dordrecht Netherlands
Telephone	:	+31-78-630.1011
Emergency telephone	:	+44-(0)8456-006.640
E-mail address	:	sds-support@che.dupont.com

2. HAZARDS IDENTIFICATION

Rapid evaporation of the liquid may cause frostbite.
Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing.
May cause cardiac arrhythmia.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical name of the substance : 1,1,1,2-Tetrafluoroethane (R134a)

Chemical Name	CAS-No.	EC-No.	Classification	Concentration [%]
1,1,1,2-Tetrafluoroethane	811-97-2	212-377-0		100

4. FIRST AID MEASURES

General advice	:	Never give anything by mouth to an unconscious person. When symptoms persist or in all cases of doubt seek medical advice.
Inhalation	:	Remove from exposure, lie down. Move to fresh air. Keep patient warm and at rest. Artificial respiration and/or oxygen may be necessary. Consult a physician.
Skin contact	:	Take off all contaminated clothing immediately. Flush area with lukewarm water. Do not use hot water. If frostbite has occurred, call a physician.
Eye contact	:	Hold eyelids apart and flush eyes with plenty of water for at least 15 minutes. Get medical attention.

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Ingestion	:	Is not considered a potential route of exposure.

Notes to physician

Treatment	:	Do not give adrenaline or similar drugs.

5. FIRE-FIGHTING MEASURES

Specific hazards during fire fighting	:	pressure build-up Hazardous thermal decomposition products: Carbon oxides Hydrogen fluoride Carbonyl fluoride
Special protective equipment for fire-fighters	:	In the event of fire, wear self-contained breathing apparatus. Wear neoprene gloves during cleaning up work after a fire.
Further information	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Cool containers / tanks with water spray.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	:	Evacuate personnel to safe areas. Ventilate the area. Refer to protective measures listed in sections 7 and 8.
Environmental precautions	:	Should not be released into the environment.
Methods for cleaning up	:	Evaporates.

7. HANDLING AND STORAGE

Handling

Advice on safe handling	:	Avoid breathing vapours or mist. Avoid contact with skin, eyes and clothing. Provide sufficient air exchange and/or exhaust in work rooms. For personal protection see section 8.
Advice on protection against fire and explosion	:	No special protective measures against fire required.

Storage

Requirements for storage areas and containers	:	Keep container tightly closed in a dry and well-ventilated place. Store in original container. Protect from contamination.
Advice on common storage	:	No materials to be especially mentioned.
Storage temperature	:	< 52 °C

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

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Components with workplace control parameters

Components	CAS-No.	Type Form of exposure	Control parameters	Update	Basis
1,1,1,2-Tetrafluoroethane	811-97-2	TWA	4 240 mg/m3 1 000 ppm	2007	EH40 WEL

Engineering measures

Ensure adequate ventilation, especially in confined areas.

Personal protective equipment

Respiratory protection	:	For rescue and maintenance work in storage tanks use self-contained breathing apparatus. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing.
Hand protection	:	Heat insulating gloves
Eye protection	:	Safety glasses with side-shields Additionally wear a face shield where the possibility exists for face contact due to splashing, spraying or airborne contact with this material.
Hygiene measures	:	Handle in accordance with good industrial hygiene and safety practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Form	:	Liquefied gas,
Colour	:	colourless,
Odour	:	slight, ether-like,
Melting point/range	:	-103 - -101 °C at 1 013 hPa
Boiling point	:	-26,1 °C at 1 013 hPa
Flash point	:	does not flash
Ignition temperature	:	> 743 °C
Upper explosion limit / upper flammability limit	:	, not applicable
Vapour pressure	:	6 661 hPa at 25 °C
Vapour pressure	:	13 190 hPa at 50 °C
Density	:	1,206 g/cm3 at 25 °C, (as liquid)
Density	:	0,0042 g/cm3 at 25 °C (1 013 hPa)

Density	:	0,0053 g/cm3 at -26,1 °C (1 013 hPa)
Water solubility	:	1,5 g/l at 25 °C at 1 013 hPa
Relative vapour density	:	3,6 at 25 °C, (Air = 1.0)

10. STABILITY AND REACTIVITY

Conditions to avoid	:	The product is not flammable in air under ambient conditions of temperature and pressure. When pressurised with air or oxygen, the mixture may become flammable. Certain mixtures of HCFCs or HFCs with chlorine may become flammable or reactive under certain conditions.
Materials to avoid	:	Alkali metals, Alkaline earth metals, Powdered metals, Powdered metal salts
Hazardous decomposition products	:	Carbon oxides, Hydrogen fluoride, Carbonyl fluoride, Fluorocarbons
Hazardous reactions	:	Stable under recommended storage conditions.

11. TOXICOLOGICAL INFORMATION

Acute inhalation toxicity

• 1,1,1,2-Tetrafluoroethane	:	LC50/ 4 h/ rat : > 359 300 ppm
Human experience	:	Excessive exposures may affect human health, as follows:

Inhalation
Severe shortness of breath, narcosis, Irregular cardiac activity

Further information	:	Cardiac sensitisation threshold limit : 312 975 mg/m3 Anaesthetic effects threshold limit : 834 600 mg/m3 Did not show carcinogenic or teratogenic effects in animal experiments.Inhalation of decomposition products in high concentration may cause shortness of breath (lung oedema).Rapid evaporation of the liquid may cause frostbite.

12. ECOLOGICAL INFORMATION

Toxicity to fish

• 1,1,1,2-Tetrafluoroethane	:	LC50 / 96 h/ Oncorhynchus mykiss (rainbow trout) : 450 mg/l

Aquatic toxicity

• 1,1,1,2-Tetrafluoroethane	:	/ EC50/ 48 h/ Daphnia magna (Water flea): 980 mg/l
Ozone depletion potential	:	0
Global warming potential (GWP)	:	1 430

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13. DISPOSAL CONSIDERATIONS

Product	:	Can be used after re-conditioning.
Contaminated packaging	:	Empty pressure vessels should be returned to the supplier.

14. TRANSPORT INFORMATION

ADR

Class:	2
Classification Code:	2A
HI No::	20
UN-Number:	3159
Labelling No.:	2.2
Proper shipping name:	1,1,1,2-Tetrafluoroethane

IATA_C

Class:	2.2
UN-Number:	3159
Labelling No.:	2.2
Proper shipping name:	1,1,1,2-Tetrafluoroethane

IMDG

Class:	2.2
UN-Number:	3159
Labelling No.:	2.2
Proper shipping name:	1,1,1,2-Tetrafluoroethane

15. REGULATORY INFORMATION

Labelling according to EC Directives

Special labelling of certain mixtures	:	Contains fluorinated greenhouse gas covered by the Kyoto Protocol. 1,1,1,2-Tetrafluoroethane

The product does not need to be labelled in accordance with Directive 1999/45/EC, or Annex VI to 67/548/EEC.

16. OTHER INFORMATION

Further information

Before use read DuPont's safety information., For further information contact the local DuPont office or DuPont's nominated distributors., ® DuPont's registered trademark

Significant change from previous version is denoted with a double bar.

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The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The above information relates only to the specific material(s) designated herein and may not be valid for such material(s) used in combination with any other materials or in any process or if the material is altered or processed, unless specified in the text.