WPI-UT 0142	RAILWAY PACKAGE HVAC SYSTEM – SMALL47R OPERATION AND MAINTENANCE MANUAL

Latest revision

Rev.	Date	Revised by	Approved by
00	01.04.2008	S. Anello	A. Fontana

Changes

Rev.	Date	Description
00	01.04.2008	First issue

CONTENTS

1 INTRODUCTION

This manual has the purpose to describe the structure of the railway package HVAC system SMALL47R installed on the driving cabs of the DMU trains ATR220 and contains all the technical information for the operation and maintenance staff.

1.1 ACRONYMS

HP	High Pressure
HVAC	Heating, Ventilation and Air Conditioning
LP	Low Pressure
T_{AMB}	Internal temperature
T_{DIFF}	Temperature difference
T_{DIFF-}	Temperature difference in order to activate the heating mode
T_{DIFF+}	Temperature difference in order to activate the cooling mode
T_{EST}	External temperature
T_{RIF}	Reference temperature

1.2 SUPPLY

The supply includes the complete package unit, ready for the installation.
The accessory materials supplied are:

- three free electrical connectors.

2 GENERAL INFORMATION

2.1 DESCRIPTION AND LOCATION OF THE SYSTEM

This section describes the structure of the package HVAC system SMALL47R and its installation on the driving cabs of the DMU trains ATR220.

The package HVAC system is located on the roof of each motor car, above the driving cab. The only openings on the roof are the ones for the aeraulic interface.

The compressor is electrical and mounted inside the package HVAC system.

There aren't heaters inside the package HVAC system; the heating is realized by means of water heaters.

The temperature control is obtained by using one environment probe inside the HVAC unit.

2.2 PACKAGE HVAC SYSTEM

2.2.1 PACKAGE HVAC UNIT LAY-OUT

The units are made up of the following main sections:

TBC

2.2.2 ELECTRICAL AND MECHANICAL INTERFACE

Each air-conditioning package unit is provided with 4 appropriate holes to which the belts can be attached, in order to uplift the unit (see the assembly drawing nr. 60ACB7301, sheet 4).

Once the HVAC package unit has been placed in the opportune position on the roof of the driving cab, the frame can be fixed by means of 4 bolts M12x70 with nut vargal M12, such as shown in the drawing nr. 60ACB7301, sheet 2.

No antivibration mounts have to be interposed between the HVAC package unit and the train roof. The vibrations decoupling is made between the compressor and the HVAC frame by using antivibration mounts inside the package unit.

The interface with the air distribution system is granted by the HVAC treated and recirculated air outlets and inlets. An appropriate silicon gasket is put between the HVAC treated and recirculated air outlets and inlets and the openings on the train roof.

The electrical connection with the train system is possible by means of three electrical connectors (MV connector XC1, LV connector XC2 and CAN BUS connector XC3) located on the HVAC frame and accessible by opening the cover. Moreover it's necessary to connect the ground block (see the Fig. 1).

The condensate drainage is possible by means of 2 condensate discharges provided of goose lips (see the assembly drawings nr. 60ACB7338 – 60ACB7339, sheet 1) in case

that there isn't on the train a condensate drainage circuit with an appropriate siphon pipe in order to avoid the entrance of air.

TBC

Fig. 1 Electrical interface

TBC

Fig. 2 Package HVAC unit lay-out

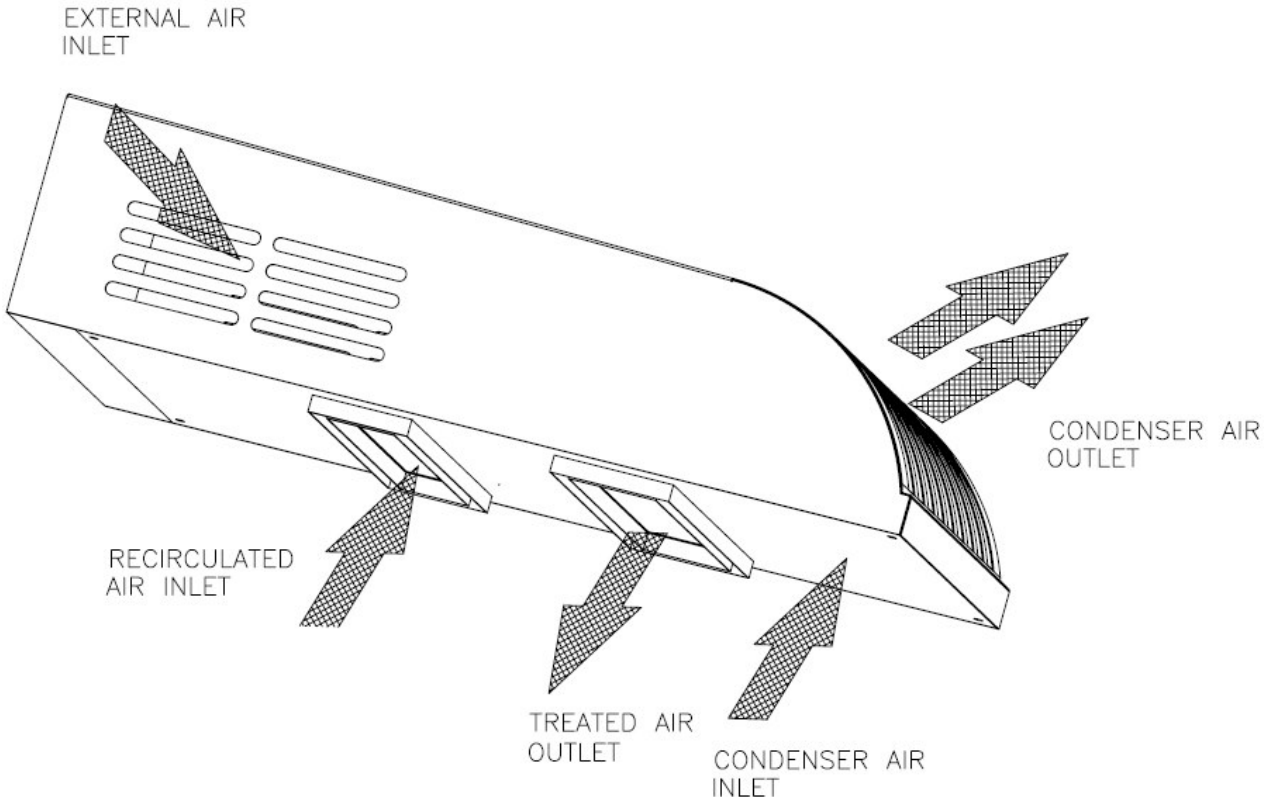


Fig. 3 Air flows (condenser air - recirculated air - fresh air - treated air)

2.2.3 FUNCTIONING CONDITIONS

2.2.3.1 External thermoigrometric conditions

T_{est} min	-20°C
T_{est} max	+40°C
Relative humidity Hr	40%
T_{est} extreme condition	+45°C
Solar radiation	800 W/m^2
Incidence	30°

2.2.3.2 Internal conditions

The internal temperature will be conform to EN 14813 standard, both in summer and in winter conditions.

2.2.3.3 Electrical power supply

Power supply	380Vac±10% / 3ph+N / 50Hz
Auxiliary power supply	24Vdc (from a battery – 18÷36V)

2.2.3.4 Refrigerant

The refrigerant fluid used is R407C. It is a blend of three hydrofluorocarbon (HFC) refrigerants with ODP (ozone depletion potential) = 0.

2.2.4 PERFORMANCES AND TECHNICAL DATA

Cooling capacity 5,5 kW with 40°C and 40% Hr

2.2.4.1 Cooling conditions

Electrical power supply 380V / 3ph+N / 50Hz
Electrical power consumption 4 kW

2.2.5 INDICATIVE DIMENSIONS AND INTERFACE WITH THE COACH

The overall dimensions, as in the assembly drawing nr. 60ACB7301, sheet 1, are:

length: 1350 mm
height: 390 mm
width: 800 mm
weight: 125 kg

2.3 COMMANDS AND OPERATING MODES

The command of the air conditioning system is possible from the driving cab using the monitor on the instrument panel. The command and control signals reach the electronic control board of the HVAC through a CAN BUS protocol.

The user can switch on and off the system, choosing a functioning mode (air-conditioning or ventilation) and setting a temperature value (± 1°C or ± 2°C relative to the set-point temperature; see paragraph 3.3.2.1 for further details).

Also the alarm signals from the HVAC system are transferred onto CAN BUS and are displayed on the monitor.

The ON-OFF command, necessary for the functioning of the HVAC, can also come from a selector located inside the driving cab (if installed). This selector can be used only in the case the CAN BUS doesn't work. In fact the system, after 5 minutes it doesn't receive a life signal on CAN BUS, switches on the manual commands.

When the *air-conditioning* mode is selected, the system automatically chooses the ventilation or cooling functions depending on the temperature difference between the set-point temperature and the internal one.

If the *ventilation* mode is selected the system is forced to function in ventilation only with the fans at a fixed speed.

In the *heating* mode the system functions in ventilation. It cannot use the cooling function.

2.4 ALARMS

This section contains a list of the alarms that can be sent on the CAN BUS and displayed on the monitor.

2.4.1 DRIVING CAB

ALARM CODE	TYPE OF ALARM	ACTION
1		
2	NO VOLTAGE / WRONG PHASE SEQUENCE	The system is switched off.
3		
4	AIR DIFFERENTIAL PRESSURE SWITCH ALARM	Cooling and heating completely stopped.
5	AIR TREATMENT FAN CIRCUIT BREAKER ALARM	Cooling, heating and ventilation completely stopped
6		
7	COMPRESSOR CIRCUIT BREAKER ALARM	The system is switched off in cooling mode.
8		
9	CONDENSER FANS CIRCUIT BREAKER ALARM	The system is switched off in cooling mode.
10		
11		
12		
13	HIGH PRESSURE SWITCH ALARM	The system is switched off in cooling mode.
14	LOW PRESSURE SWITCH ALARM	The system is switched off in cooling mode.
15	REPEATED HIGH PRESSURE ALARM	The system is switched off in cooling mode.
16		
17	REPEATED LOW PRESSURE ALARM	The system is switched off in cooling mode.
18		
19		
20	REPEATED TREATED AIR LOW TEMPERATURE ALARM	Cooling completely stopped.
21		

ALARM CODE	TYPE OF ALARM	ACTION
22		
23	EXTERNAL TEMPERATURE PROBE OUT OF RANGE	Regulation possible with the medium set-point temperature value.
24	ENVIRONMENT TEMPERATURE PROBE OUT OF RANGE	Cooling and heating completely stopped – only ventilation functioning.
25		
26		
27	TREATED AIR TEMPERATURE PROBE OUT OF RANGE	Probe non considered in the algorithms.
28	LOW PRESSURE TRANSDUCER OUT OF RANGE	Transducer non considered in the algorithms.
29	HIGH PRESSURE TRANSDUCER OUT OF RANGE	Transducer non considered in the algorithms.
30		
31		

2.5 AERAULIC CIRCUIT

2.5.1 FRESH AIR INLET

TBC

2.5.2 AIR FLOWS MIXING

TBC

3 FUNCTIONAL DESCRIPTION

3.1 COOLING CIRCUIT

The cooling circuits of the SMALL47R unit is described in the drawing RMB8173.

3.1.1 REFRIGERATION CYCLE DESCRIPTION

The refrigeration cycle uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere.

All such systems have four components: a compressor, a condenser, an expansion valve and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a *saturated vapour* and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapour is then in the thermodynamic state known as a *superheated vapour* and it is at temperature and pressure at which it can be condensed. That hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with air flowing across. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by the air.

The condensed liquid refrigerant, in the thermodynamic state known as a *saturated liquid*, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The auto-refrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapour refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated.

The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the *cold refrigerant liquid and vapour mixture*. That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the air used in the condenser.

To complete the refrigeration cycle, the refrigerant vapour from the evaporator is again a *saturated vapour* and is routed back into the compressor.

NOTE

Saturated vapours and saturated liquids are vapours and liquids at their saturation temperature and saturation pressure. A superheated vapour is at a temperature higher than the saturation temperature corresponding to its pressure.

3.2 HVAC COMPOSITION AND MAIN COMPONENTS

This section describes the functioning of all the main (mechanical or electrical) parts of the HVAC system.

3.2.1 STRUCTURE

TBC

3.2.2 MOTOCONDENSING AREA

TBC

3.2.3 AIR TREATMENT AREA

TBC

3.2.4 FRIGORIFIC CIRCUIT

TBC

3.2.5 ELECTICAL PANEL AND WIRING

TBC

3.2.6 SAFETY DEVICES

The compressor is protected by two pressure switches, a low pressure one and a high pressure one. The pressure is also controlled by means of transducers, for both low and high pressure.

A differential pressure switch invested by the treated air is provided in order to detect the ventilation loss. This pressure switch detects a pressure difference between two points and verifies, consequently, the presence of ventilation.

For the electrical protection there are magnetothermic circuit breakers for the compressor and the fans (installed inside the vehicle electrical panel).

3.2.6.1 Safety devices intervention thresholds

The intervention thresholds of the safety devices are:

- a differential air pressure switch 0,5 mbar,
- a low pressure switches 2 bar (reset 0,5 bar),
- a high pressure switches 29 bar (reset 25 bar).

3.3 HVAC SYSTEM FUNCTIONING

3.3.1 ELECTRONIC BOARD INPUTS AND OUTPUTS

In this paragraph all the electronic board input and output signals are listed. All input signals, both digital and analogical, are filtered.

3.3.1.1 Digital inputs

POSITION	NORMAL CONDITION	DESCRIPTION	ACTION
ID1 (J5)	NO	LP pressure switch opened (SPBP).	The compressor is stopped. The condenser fans goes on functioning. After N interventions: alarm signal.
ID2 (J5)	NO	HP pressure switch opened (SPAP).	The compressor is stopped. The condenser fans goes on functioning. After N interventions: alarm signal.
ID3 (J5)	NC	Configuration (ID1), together with ID2 and ID3.	Cabin 1: ID1=1, ID2=0, ID3=0; Compartment 1: ID1=0, ID2=1, ID3=0; Compartment 2: ID1=1, ID2=1, ID3=0; Compartment 3: ID1=0, ID2=1, ID3=0; Cabin 2: ID1=1, ID2=0, ID3=0;
ID4 (J5)	NC	Configuration (ID2), together with ID1 and ID3.	Cabin 1: ID1=1, ID2=0, ID3=0; Compartment 1: ID1=0, ID2=1, ID3=0; Compartment 2: ID1=1, ID2=1, ID3=0; Compartment 3: ID1=0, ID2=1, ID3=0; Cabin 2: ID1=1, ID2=0, ID3=0;
ID5 (J5)	NC	Configuration (ID3), together with ID1 and ID2.	Cabin 1: ID1=1, ID2=0, ID3=0; Compartment 1: ID1=0, ID2=1, ID3=0; Compartment 2: ID1=1, ID2=1, ID3=0; Compartment 3: ID1=0, ID2=1, ID3=0; Cabin 2: ID1=1, ID2=0, ID3=0;
ID6 (J5)	NO	Compressor circuit breaker opened (QM1)	Alarm signal. The compressor is stopped. The condenser fans goes on functioning.
ID7 (J5)	NO	Condenser fans circuit breaker opened (QM2).	Alarm signal. The compressor is stopped.
ID8 (J5)	NO	Air treatment fan circuit breaker opened (QM4).	Alarm signal. The unit is stopped.
ID9 (J7)	NC	Differential pressure switch signal (SPDS).	Alarm signal. The unit is stopped.

POSITION	NORMAL CONDITION	DESCRIPTION	ACTION
ID10 (J7)	NC	Reverse phase relay signal (KPF).	The absence of this signal activates the alarm signal and the functioning is not possible.
ID11 (J7)	NO	Set-point + 2°C (SB1/+2)	Set-point curve change.
ID12 (J7)	NO	Set-point + 1°C (SB1/+1)	Set-point curve change.
ID13 (J8)	NO	Set-point - 1°C (SB1/-1)	Set-point curve change.
ID14 (J8)	NO	Command selection (SB2/1), together with SB1/2.	OFF: SB2/1=0, SB1/2=0; Ventilation: SB2/1=1, SB1/2=0; Air conditioning: SB2/1=0, SB1/2=1; Heating: SB2/1=1, SB1/2=1. Used when CAN BUS doesn't work: after 5 minutes the electronic board doesn't receive a life signal on CAN BUS, it switches on the manual commands.
ID15 (J19)	NO	Command selection (SB1/2), together with SB2/1.	OFF: SB2/1=0, SB1/2=0; Ventilation: SB2/1=1, SB1/2=0; Air conditioning: SB2/1=0, SB1/2=1; Heating: SB2/1=1, SB1/2=1. Used when CAN BUS doesn't work: after 5 minutes the electronic board doesn't receive a life signal on CAN BUS, it switches on the manual commands.
ID16 (J19)	NO	Set-point - 2°C (SB1/-2)	Set-point curve change.

NO = normally open, NC = normally closed

3.3.1.2 Analogical inputs

POSITION	NORMAL CONDITION	DESCRIPTION
B6 (J6)	Low pressure transducer circuit 1 (BPBP1).	It measures the suction pressure on the compressor.
B7 (J6)	High pressure transducer circuit 1 (BPAP1).	It measures the discharge pressure on the compressor.
B1 (J2)	Treated air temperature probe (STC).	It measures the treated air temperature.
B2 (J2)	External temperature probe (STE).	It measures the external air temperature.
B3 (J2)	Internal – recirculated temperature probe (STA).	It measures the internal air temperature near the recirculated air inlet.

3.3.1.3 Digital outputs

POSITION	NORMAL CONDITION	DESCRIPTION	ACTION
NO2 (J12)	NO	Crankcase heater command (K7).	Compressor crankcase heater insertion.
NO3 (J12)	NO	Hot gas solenoid valve command (YVHG).	Hot gas solenoid valve opening command.
NO7 (J14)	NO	Compressor command (KM1).	Compressor insertion.
NO9 (J15)	NO	Condenser fan 1 command (KM2).	Condenser fan 1 insertion.
NO10 (J15)	NO	Condenser fan 2 command (KM3).	Condenser fan 2 insertion.
NO14 (J21)	NO	System OK signal (H1).	Normal functioning green lamp switched on (if connected).
NC14 (J21)	NO	General alarm signal (H2).	Alarm red lamp switched on (if connected).

3.3.1.4 Analogical outputs

POSITION	NORMAL CONDITION	DESCRIPTION
Y1 (J4)	Air treatment fan (EVTA).	Air treatment fan speed setting.

3.3.2 THERMOREGULATION

When the system is switched on in the *air-conditioning* mode, the software evaluates the temperature required for the internal environment. In order to obtain this value, the software:

- reads the external temperature value,
- reads the internal temperature value (value from the internal probe STA),
- reads the value selected from the user (set-point, set-point + 2°C, set-point - 2°C),
- evaluates the reference temperature (see paragraph 3.3.2.1),
- evaluates the difference between the reference temperature and the internal one (see paragraph 3.3.2.2),
- activates the cooling, heating or ventilation function on the basis of the difference above.

The cooling phase is activated is the internal temperature is 0,5°C above the reference temperature, the heating phase if it is 0,5°C under the reference temperature.

3.3.2.1 Evaluation of the reference temperature

The set-point temperature has, in function of the external temperature, the progress shown in Fig. 4. The curve is completely defined by four parameters:

- minimum internal temperature,
- maximum internal temperature,
- minimum external temperature regulated,
- maximum external temperature regulated.

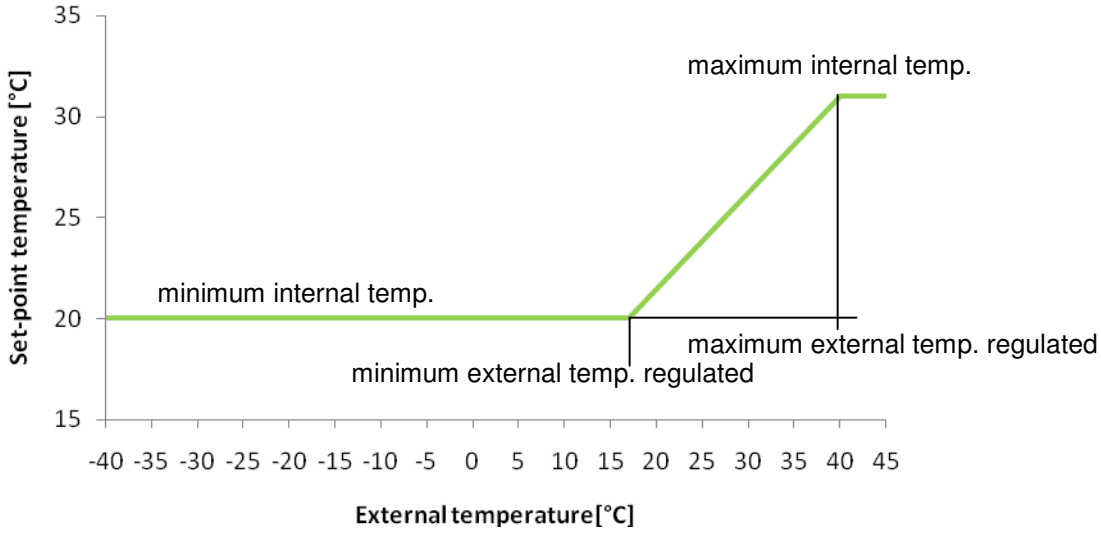


Fig. 4 Set-point temperature versus external temperature

The user can select other curve progresses using the monitor in the driving cab; Fig. 5 shows two of the other possible settings.

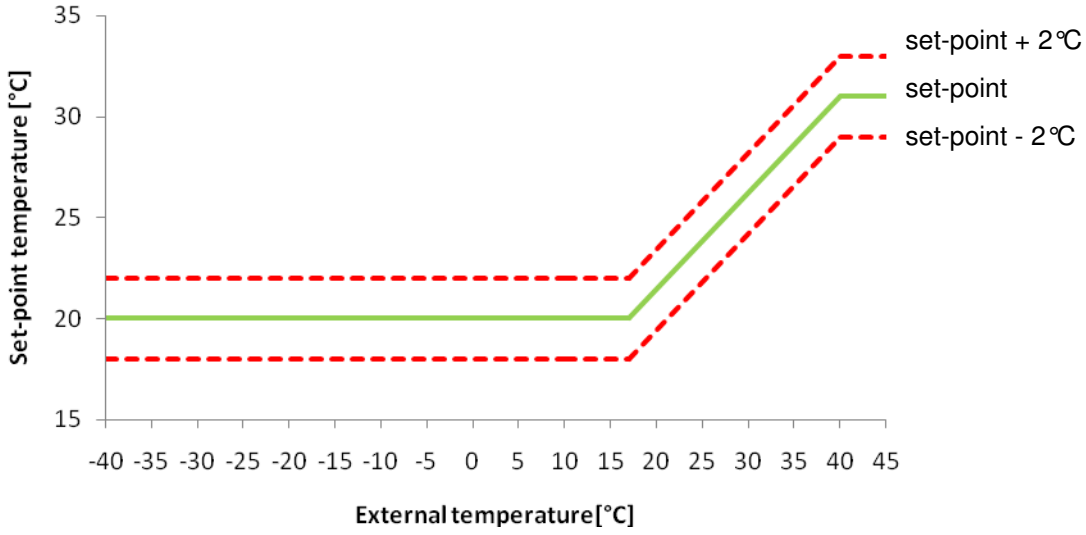


Fig. 5 Possible settings selected from the user

So, once the set-point temperature curve has been defined, the reference temperature is evaluated in base of:

- external temperature,
- settings from the user (set-point, set-point +1°C, set-point +2°C, set-point -1°C, set-point - 2°C).

3.3.2.2 Evaluation of the temperature difference

The temperature difference has to be evaluated depending on:

- reference temperature (evaluated as shown in the paragraph 3.3.2.1),
- internal temperature.

The difference between the internal temperature and the reference (T_{DIFF}) is evaluated with the following formula:

$$T_{DIFF} = T_{AMB} - T_{RIF} .$$

3.3.3 FUNCTIONING MODE SETTING

When the system is switched on in the *air-conditioning* mode, the functioning mode is defined in function of the difference from the reference temperature, as defined in Fig. 6.

When $T_{DIFF} > T_{DIFF+}$ the cooling mode is activated, otherwise the ventilation mode. In the transition from one mode to the other an hysteresis band ΔT_{HYST} (toward the inside) is considered.

The system can be described as a finite state machine with the following functioning states:

- ventilation,
- cooling.

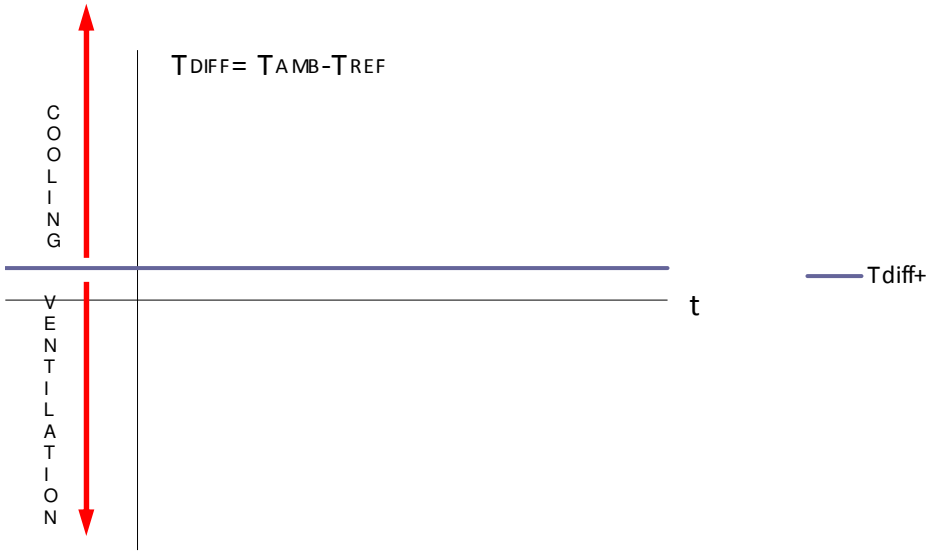


Fig. 6 Determination of the functioning mode in function of the temperature difference from the reference temperature

In this application T_{DIFF+} = 0,5°C, T_{DIFF} and ΔT_{HYST} = 0,5°C.

In the following the different functioning modes are described in details.

3.3.4 VENTILATION

The ventilation is always in function, also in presence of alarm signals.

3.3.4.1 Fan speed regulation

When the *air-conditioning* mode is selected, the ventilation speed changes, depending on the distance from the reference temperature (see paragraph 3.3.2.1), between a maximum and a minimum speed.

The regulation algorithm, in base of the distance from the reference temperature, sends to the fans a 0-10V signals as shown in the Fig. 7.

When the *ventilation* mode is selected, the fan has instead a fixed speed V_{VENT}.

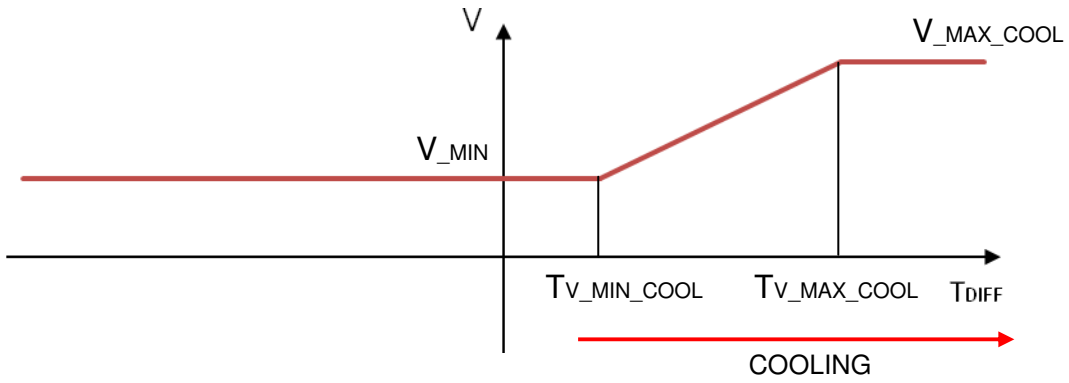


Fig. 7 Fan speed regulation

In this application V_{MAX_COOL} = 10V, V_{MIN} = 5V, $T_{V\_MIN\_COOL}$ = 1°C, $T_{V\_MAX\_COOL}$ = 5°C, V_{VENT} = 5V.

3.3.5 COOLING

In this phase the unit has to implement the following functions:

- compressor insertion/uninsertion,
- air treatment fan speed regulation (as shown in the paragraph 3.3.4.1),
- condenser fans control,
- hot-gas solenoid valve control.

The compressor is activated with an hysteresis regulation depending on the temperature difference from the set-point.

The parameters in the regulation are:

- DIFF_COOL: wideness of the temperature difference band (straddling T_{DIFF+}, as shown in Fig. 8) in which no action is required. If the temperature difference reaches the value T_{DIFF+} + DIFF_COOL, the compressor is started.

The compressor is stopped when the temperature difference reaches a value corresponding to the state transition (T_{DIFF+}).

In this application DIFF_COOL = 1 °C.

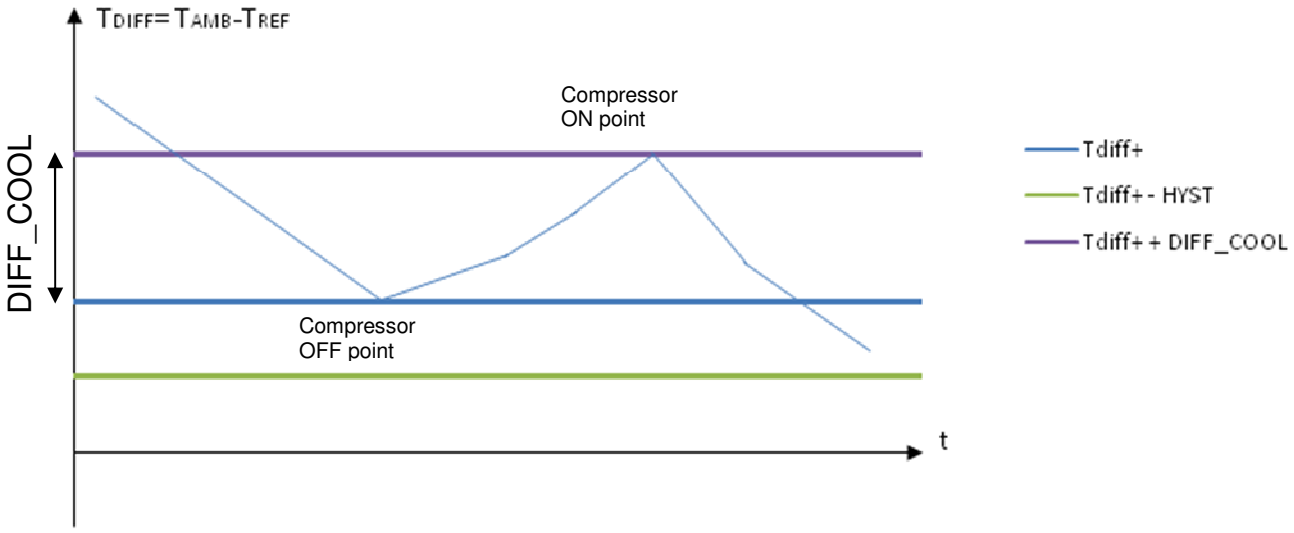


Fig. 8 First compressor regulation

3.3.5.1 Compressor insertion

Every time the compressor is inserted a minimum off time (t_{MIN_OFF}) and a minimum time between following insertions (t_{LAST_ON}) have to be respected, in order to avoid too much strain.

The software remembers the moment of the last insertion and uninsertion and, every time the compressor is required, verifies the correct waiting times are respected.

In this application t_{MIN_OFF} = 1 minute and t_{LAST_ON} = 3 minutes.

3.3.5.2 Compressor uninsertion

Every time the compressor is uninserted a minimum on time (t_{MIN_ON}) has to be respected, in order to avoid too much strain.

The software remembers the moment of the last insertion and, every time the compressor has to be stopped, verifies the correct waiting time is respected.

In this application t_{MIN_ON} = 1 minute.

3.3.5.3 Condenser fans control

The condenser fans are regulated in function of the high pressure in the frigorific circuit.

When the pressure is higher than the value P_{FAN_ON}, the first condenser fan is switched on and when the pressure decreases till $P_{FAN\_ON} - \Delta P_{FAN}$, it is switched off.

When the pressure is higher than the value P_{FAN2_ON}, the other condenser fan is switched on and when the pressure decreases till $P_{FAN2\_ON} - \Delta P_{FAN}$, it is switched off.

In this application P_{FAN_ON} = 15 bar, P_{FAN_ON} = 17 bar and ΔP_{FAN} = 2 bar.

3.3.5.4 Compressor stop for low external temperature

The compressor cannot start if the external temperature is lower than a value T_{EXT_MIN} and, even during the functioning, the compressor is stopped if the external temperature decreases under this limit.

In this application T_{EXT_MIN} = 10 °C.

3.3.5.5 Hot-gas valve control

The hot-gas valve is regulated in function of the high pressure in the frigorific circuit.

When the pressure is higher than the value P_{FAN_ON}, the first condenser fan is switched on and when the pressure decreases till $P_{FAN\_ON} - \Delta P_{FAN}$, it is switched off.

In this application $P_{HOT\_GAS\_ON}$ = 24 bar and ΔP_{HOT_GAS} = 22 bar.

4 INTERFACE WITH THE ELECTRONIC BOARD

It is possible to interface to the electronic board through an external terminal that can be connected directly to the electronic board (connector J10) or to the connector XC4 on the unit electrical panel. The cable to be used is a telephone cable RJ 12.

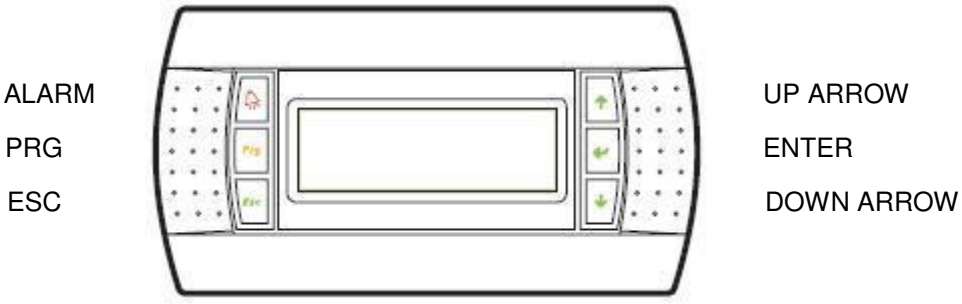


Fig. 9 External terminal

ALARM: used to display some alarms and delete them.

PRG: it is used to enter the list of screens: once you have displayed the list, use the arrow buttons to select the desired loop (branch) and confirm by pressing ENTER.

ESC: it is used to return to the previous branch.

UP: it has two functions, a) scroll to the previous screens in the same branch when the cursor is in the home position (top left corner); b) increase the value of a setting field when the cursor is inside the field; for selection fields, on the other hand, pressing the arrow button displays the previous option.

DOWN: it has two functions, a) scroll to the next screens in the same branch when the cursor is in the home position (top left corner); b) decrease the value of a setting field when the cursor is inside the field; for selection fields, on the other hand, pressing the arrow button displays the next option.

ENTER: used to move the cursor between the home position (in the top left) and the setting or selection fields, or to save the values set for the parameters after the cursor has left the setting fields.

UP + ENTER + DOWN: pressing these buttons together accesses the screen for setting the address of the external terminal.

4.1.1 Setting of the address of the terminal

The address of the terminal can be set in the range between 0 and 32; addresses from 1 to 32 are used by the pLAN protocol, while address 0 identifies the Local terminal protocol, used for point-to-point connections. The default address is 32. The address can only be set after having powered up the terminal via the RJ12 connector. To access configuration mode, press the UP, ENTER and DOWN buttons together for at least 5 seconds; the terminal will display a screen similar to the one shown below, with the cursor flashing in the top left corner.

```
+--------------------+
|Display address     |
|setting..........:32|
|                    |
|I/O Board address:xx|
+--------------------+
```

To change the address of the terminal (“Display address setting”), proceed as follows.

- Press the ENTER button once: the cursor will move to the “Display address setting” field.
- Select the desired value using the UP and DOWN buttons, and confirm by pressing ENTER again.

If the value selected is different from the value previously saved, the following screen will be displayed and the new value will be saved to the permanent memory.

```
+--------------------+
|Display address     |
|changed             |
|                    |
|                    |
+--------------------+
```

NOTE

Set the address field to 0 in order to use the Local terminal protocol. The “I/O Board address” field is no longer shown, as it has no meaning.

4.1.2 List of screens

The user interface of this application is divided into loops (branches) of screens.
All the accessible screens are shown in the following. On the right there is the explanation of the values.

4.1.2.1 Main screen

The main loop of screens on the display shows the temperature and pressure values.
As already explained, the HVAC uses the following transducers:

- temperature:
  - nr. 3 inside each HVAC — recirculated (internal) air temperature probe
    external air temperature probe
    treated air temperature probe
- pressure:
  - nr. 1 inside each HVAC — high pressure transducers
  - nr. 1 inside each HVAC — low pressure transducers

```
main
+--------------------+
| 00:00      00/00/00|          TIME          DATE
|T.Rif.       000.0°C|          REFERENCE TEMPERATURE
|T.ambiente   000.0°C|          INTERNAL TEMPERATURE
|Sistema ON          |          SYSTEM CONDITION
+--------------------+
```

The system condition can be: ON, OFF, OFF DA ALLARME (OFF caused by an alarm), PROCEDURA MANUALE (working with manual settings).
The symbol ⍈ near the system condition means that the control of the unit is from CAN BUS.

```
main_a
+--------------------+
|T.diff.      000.0°C|          DIFFERENCE BETWEEN INTERNAL AND REFERENCE TEMP.
|Set.comp.    000.0°C|          COMPRESSOR SET TEMPERATURE
|T.canale     000.0°C|          TREATED AIR TEMPERATURE
|                    |
+--------------------+
```

```
main_b
+--------------------+
|                    |
|Stato sys           |          SYSTEM STATUS
|Stato reg PCool     |          REGULATION STATUS
|                    |
+--------------------+
```

The system status can be: OFF, CLIMA (air-conditioning), CALDO (heating), VENT (ventilation).

The regulation status can be: COOL (cooling), VENT (ventilation).

```
main_c
+--------------------+
|T.Ambiente   000.0°C|          INTERNAL TEMPERATURE
|T.Esterna    000.0°C|          EXTERNAL TEMPERATURE
|                    |
|                    |
+--------------------+

main_d
+--------------------+
|Alta Prs.   000.0bar|          HIGH PRESSURE
|Bassa Prs.  000.0bar|          LOW PRESSURE
|                    |
|                    |
+--------------------+

m_history
+--------------------+
|       N°0000       |          ALARM NUMBER
|Codice allarme   000|          ALARM CODE
|Ora            00:00|          TIME
|Data        00/00/00|          DATE
+--------------------+
```

In the alarm history 1000 alarm codes can be recorded. In this screen the first one is shown, the ENTER button has to be used in order to enter the list, the UP and DOWN buttons in order to glance through the list. The alarm codes are listed in paragraph **Errore. L'origine riferimento non è stata trovata.**.

```
m_default1
+--------------------+
|Reset storico       |          RESET ALARM HISTORY
|degli allarmi  N    |
|                    |
|                    |
+--------------------+
```

In order to reset the alarm history:

- press the ENTER button,
- use the UP or DOWN button in order to change the value into Y,
- press the ENTER button again.

All the alarms will be deleted.

4.1.2.2 Alarm screens

The alarm screens are shown by pressing the ALARM button.

Only the alarms related to the temperature or pressure transducers or to the expansion board are displayed on this screen. All the other alarms are only registered in the alarms history (see paragraph 4.1.2.1).

```
alarm0
+--------------------+
|                    |
|   NESSUN ALLARME   |        NO ALARMS
|       ATTIVO       |
|                    |
+--------------------+


al_1
+--------------------+
|                AL01|
|   ALLARME SONDA    |        ALARM - TREATED AIR
| TEMPERATURA CANALE |        TEMPERATURE PROBE BROKEN
|ROTTA O NON CONNESSA|        OR NOT CONNECTED
+--------------------+


al_2
+--------------------+
|                AL02|
|   ALLARME SONDA    |        ALARM - EXTERNAL
|TEMPERATURA ESTERNA |        TEMPERATURE PROBE
|ROTTA O NON CONNESSA|        BROKEN OR NOT CONNECTED
+--------------------+


al_3
+--------------------+
|                AL03|
|   ALLARME SONDA    |        ALARM - INTERNAL
|TEMPERATURA AMBIENTE|        TEMPERATURE PROBE
|ROTTA O NON CONNESSA|        BROKEN OR NOT CONNECTED
+--------------------+
```

```
al_4
+--------------------+
|                AL04|
|   ALLARME SONDA    |        ALARM - LOW PRESSURE
| BASSA PRESSIONE    |        TRANSDUCER BROKEN
|ROTTA O NON CONNESSA|        OR NOT CONNECTED
+--------------------+


al_5
+--------------------+
|                AL05|
|   ALLARME SONDA    |        ALARM - HIGH PRESSURE
|  ALTA PRESSIONE    |        TRANSDUCER BROKEN
|ROTTA O NON CONNESSA|        OR NOT CONNECTED
+--------------------+
```

4.1.2.3 Menu screen

This menu is used to access all the other loops of screens. It is shown by pressing the button PRG.

```
menu
+--------------------+
|Utente              |        USER
|Costruttore         |        MANUFACTURER
|Manutenzione        |        MAINTENANCE
|In/Out              |        IN/OUT
+--------------------+

menu1
+--------------------+
|Setpoint            |        SETPOINT
|Versione            |        VERSION
|Orologio            |        CLOCK
|Stato unita'        |        UNIT STATUS
+--------------------+
```

USER loop of screens is not used, MANUFACTURER loop of screens is not accessible, all the other loops of screens are detailed in the following.

4.1.2.4 Maintenance screen

```
manut
+--------------------+
|                    |
|Inserire password   |        INSERT MAINTENANCE
|Manutenzione...0000 |        PASSWORD
|                    |
+--------------------+
```

For the access to the maintenance section a password is required.

In order to insert the password:

- press the ENTER button,
- use the UP or DOWN button in order to change the password value,
- press the ENTER button again.

```
menu_manut
+--------------------+
|Manutenzione        |        MAINTENANCE
|Calibrazione sonde  |        PROBES CALIBRATION
|Password            |        PASSWORD
|                    |
+--------------------+
```

By entering the menu MAINTENANCE there is the possibility to set a value for the outputs of the controller. The unit has to be in the condition OFF in order to use the manual settings. The outputs screens are detailed in the following.

In order to switch on a component:

- press the ENTER button,
- use the UP and DOWN button in order to move on the required output,
- press the ENTER button,
- use the UP or DOWN button in order to change the value into YES (for digital outputs) or to set the required percentage (for analogical 0÷10 V outputs),
- press the ENTER button again.

```
manut2
+--------------------+
|Forzature manuali:  |        MANUAL SETTINGS
|02:Res.Carter    No |        02: CRANKCASE HEATER
|03:Vlv.Gas Caldo No |        03: HOT GAS VALVE
|07:Compressore   No |        07: COMPRESSOR
+--------------------+
```

```
manut4
+--------------------+
|09:V.Cond. 1     No |          09: CONDENSER FAN 1
|10:V.Cond. 2     No |          10: CONDENSER FAN 2
|14:Impianto ON   No |          14: UNIT ON
|01:Vent.TA    000.0%|          01: AIR TREATMENT FAN
+--------------------+
```

4.1.2.5 IN/OUT screen

This section allows to check all the input and output values.

The symbol C signifies presence of the 24V signal, the symbol A signifies no signal. For a detailed description of the digital inputs and outputs, see paragraph 3.3.1.

```
din
+--------------------+
|Ingressi Digitali   |          DIGITAL INPUTS
|01:Prst.Bassa    C  |          01: LOW PRESSURE SWITCH
|02:Prst.Alta     C  |          02: HIGH PRESSURE SWITCH
|03:Config.ID1    C  |          03: ID1 - CONFIGURATION
+--------------------+

din_1
+--------------------+
|04:Config.ID2    C  |          04: ID2 - CONFIGURATION
|05:Config.ID3    C  |          05: ID3 - CONFIGURATION
|06:Termico Comp. C  |          06: COMPRESSOR CIRCUIT BREAKER
|07:Termico V.CondC  |          07: CONDENSER FANS CIRCUIT BREAKER
+--------------------+

din_2
+--------------------+
|08:Termico V.TA  C  |          08: AIR TREATMENT FAN CIRCUIT BREAKER
|09:Prst.Diff.    C  |          09: AIR PRESSURE SWITCH
|10:Presenza MT   C  |          10: MV PRESENCE
|11:Setpoint + 2  C  |          11: SET-POINT TEMPERATURE + 2°C
+--------------------+

din_3
+--------------------+
|12:Setpoint + 1  C  |          12: SET-POINT TEMPERATURE + 1°C
|13:Setpoint - 1  C  |          13: SET-POINT TEMPERATURE - 1°C
|14:Comando SB2/1 C  |          14: SB2/1 COMMAND
|15:Comando SB1/2 C  |          15: SB1/2 COMMAND
+--------------------+

din_4
+--------------------+
|16:Setpoint - 2  C  |          16: SET-POINT TEMPERATURE - 2°C
|17:              X  |          17:
|18:              X  |          18:
|                    |
+--------------------+
```

```
dout
+--------------------+
|Uscite Digitali     |        DIGITAL OUTPUTS
|01:              X  |        01:
|02:Res.Carter    A  |        02: CRANKCASE HEATER
|03:Vlv.Gas Caldo A  |        03: HOT GAS VALVE
+--------------------+

dout_1
+--------------------+
|04:              X  |        04.
|05:              X  |        05:
|06:              X  |        06:
|07:Compressore   A  |        07: COMPRESSOR
+--------------------+

dout_2
+--------------------+
|08:              X  |        08:
|09:V.Cond. 1     A  |        09: CONDENSER FAN 1
|10:V.Cond. 2     A  |        10: CONDENSER FAN 2
|11:              X  |        11:
+--------------------+

dout_3
+--------------------+
|12:              X  |        12:
|13:              X  |        13:
|14:Impianto ON   A  |        14: UNIT ON
|15:              X  |        15:
+--------------------+

dout_4
+--------------------+
|16:              X  |        16:
|17:              X  |        17:
|18:              X  |        18:
|                    |
+--------------------+

aout
+--------------------+
|Uscite Analogiche   |        ANALOGIC OUTPUTS
|01:Vent.TA    000.0%|        01: AIR TREATMENT FAN
|02:                 |        02:
|03:                 |        03:
+--------------------+
```

4.1.2.6 Set point screen

```
setp
+--------------------+
|Setpoint:           |        SETPOINT:
|Compressori  000.0°C|        COMPRESSOR:
|                    |
|                    |
+--------------------+
```

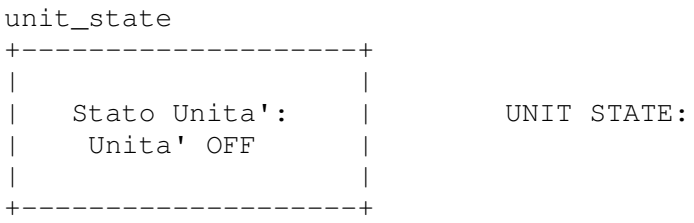
4.1.2.7 Version screen

```
version
+--------------------+
|   WEBASTO S.P.A.   |
|Codice.. CWP3WEBIUD0A|        SOFTWARE CODE:
|Ver.: .   00/00/0000|        SOFTWARE VERSION:
|                    |
+--------------------+

version1
+--------------------+
|                    |
|Bios:   .00 00/00/00|        BIOS:
|Boot:   .00 00/00/00|        BOOT:
|                    |
+--------------------+

version2
+--------------------+
|Scheda pCO          |        PCO ELECTRONIC BOARD
|installata          |        INSTALLED
|Scheda:             |        BOARD:
|                    |
+--------------------+
```

4.1.2.8 Clock screen

```
reg_time
+--------------------+
|Regolazione Orologio|        CLOCK SETTING
|Ora: 00:00          |        TIME:
|Data: 00/00/00      |        DATE:
|                    |
+--------------------+
```

4.1.2.9 State screen



5 PREVENTIVE MAINTENANCE

5.1 PREVENTIVE MAINTENANCE PLANNING

MAINTENANCE TASK FREQUENCY	*OPERATION*
2 months	AIR FILTER CLEANING
6 months	AIR FILTER REPLACEMENT
6 months	HVAC SEASONAL FUNCTIONING CHECK
1 year	CONDENSER CLEANING
1 year	EVAPORATOR CLEANING AND CONDENSATE DISCHARGES CONTROL
1 year	ELECTRICAL PANEL CLEANING AND WIRING CONTROL
1 year	CURRENT ABSORPTION MEASUREMENT
1 year	FILTER DRIER – MOISTURE INDICATORS VISUAL CHECK
1 year	HP AND LP PRESSURE SWITCH FUNCTIONING CHECK
1 year	VIBRATION LIMITERS INSPECTION AND WELDING CONTROL
1 year	COMPRESSOR AND FANS CLEANING AND INSPECTION
5 years	FILTER DRIER REPLACEMENT

5.1.1 AIR FILTER CLEANING

Frequency:

- 2 months.

Materials/tools:

- Standard workshop tools.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Extract the air filter.
4) Examine the filter clogging and, if not excessive, clean with water.
5) Before the remounting the filter has to be perfectly dry.
6) Replace the air filter in case the operation hasn't removed completely the impurities.
7) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.2 AIR FILTER REPLACEMENT

Frequency:

- 6 months.

Materials/tools:

Standard workshop tools.

- Nr. 1 air filter.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Extract the air filter.
4) Replace the air filter.
5) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.3 HVAC SEASONAL FUNCTIONING CHECK

Frequency:

- 6 months.

Materials/tools:

- Standard workshop tools.
- Notebook.
- External terminal.
- Telephone cable RJ 12.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.
- Supply the HVAC through a socket.
- Switch on the air-conditioning unit.

DANGER

During this operation the system has to be supplied so the voltage is present.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Open the electrical panel cover and connect an external terminal to the electronic board (connector J10) using a telephone cable.
4) Verify:

- the coherence between the requests and the functioning mode,
- the excitation of the contactors,
- eventually the intervention of circuit breakers and pressure switches.

5) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.4 CONDENSER CLEANING

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Water low-pressure washer with a specific cleaning agent.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Wash the condenser by using a water low-pressure washer (maximum pressure 10 bar at a 30 cm distance) and a specific cleaning agent. Remove all the dirt in the condenser rows.
4) Wait above 30 minutes.
5) Rinse out whit the water low-pressure washer.
6) Control the welding condition.
7) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.5 EVAPORATOR CLEANING AND CONDENSATE DISCHARGES CONTROL

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Air compressor.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Remove the cover of the air treatment area after removing the 10 M6 screws.
4) Extract the air filter.
5) Clean the evaporator by using an air compressor (maximum pressure 6 bar at a 30 cm distance). Remove all the dirt in the evaporator rows.
6) Accurately clean the condensate drainage basins and the discharge holes.
7) Full with water the condensate drainage basin under the evaporator and check that it correctly empties.
8) Control the welding condition.
9) Remount the air filter.
10) Reposition all the covers and close them using all the bolts and washers previously removed.

5.1.6 ELECTRICAL PANEL CLEANING AND WIRING CONTROL

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Vacuum cleaner.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Open the electrical panel cover after removing the 6 M6 screws.
4) Clean every kind of dirt and debris in the electrical panel by using a vacuum cleaner.
5) Check the wiring fastening and make sure there aren't burn marks or corrosions.
6) Check the electronic board is correctly fixed.
7) Check the contactors are correctly fixed and not damaged.
8) Replace every component eventually damaged.
9) Close the electrical panel cover using all the bolts and washers previously removed.
10) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.7 CURRENT ABSORPTION MEASUREMENT

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Amperometric tester.
- Notebook.
- External terminal.
- Telephone cable RJ 12.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or to ground the electrical line through an appropriate insulating rod.
- Supply the HVAC through a socket.

DANGER

During this operation the system has to be supplied so the voltage is present.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Open the electrical panel cover after removing the 6 M6 screws.
4) Connect the external terminal to the electronic board (connector J10) using a telephone cable RJ 12.
5) Position the amperometric tester on a supply cable, in particular:

- compressor → contactors KM1,
- condenser fans → contactors KM2 and KM3,
- air treatment fan → contactors KM4,

6) After entering the MAINTENANCE menu, start the components and measure their absorption.

ATTENTION

Always switch on the fans before switching on the compressor.

7) Check the absorptions is under the rating values (detailed in the following); if surpassed the component has to be replaced.
8) After leaving the MAINTENANCE menu, disconnect the external terminal.
9) Close the electrical panel cover using all the bolts and washers previously removed.
10) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

Rating values:

- compressor → 4 A,
- condenser fans → 0,4 A,
- air treatment fan → 1,3 A.

5.1.8 FILTER DRIER – MOISTURE INDICATOR VISUAL CHECK

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.

Preliminary operations:

- Switch on the air-conditioning unit and let it works at least 5/10 minutes.
- Switch off the unit.
- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Visually check the moisture indicator.
4) If the indicator is green, the percentage of moisture in the circuit is under the limit and no further actions are required.
5) If the indicator is yellow, the percentage of moisture in the circuit is above the limit and the filter drier has to be replaced.
6) If the indicator is translucent or brown, there is oil in excess in the circuit. The indicator, in this situation, temporarily loses its faculty to change colour but it hasn't to be considered permanently damaged. The fluid circulating is able to remove the excess of oil and to re-establish the standard functioning condition.
7) The air bubbles presence indicates the lack of refrigerant.

NOTE

Before deciding the lack of refrigerant and performing the recharge operation, the bubbles presence has to be steady; some bubbles don't prejudice the functioning.

8) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.9 HP AND LP PRESSURE SWITCHES FUNCTIONING CHECK

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Notebook.
- External terminal.
- Telephone cable RJ 12.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or to ground the electrical line through an appropriate insulating rod.
- Supply the HVAC through a socket.
- Switch on the air-conditioning unit.

DANGER

During this operation the system has to be supplied so the voltage is present.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Open the electrical panel cover after removing the 6 M6 screws.
4) In order to force the intervention of the HP pressure switch, stop the condenser fans or obstruct the condenser air inlets by means of some cardboard.
5) In order to force the intervention of the LP pressure switch, stop the air treatment fan.
6) Connect the external terminal to the electronic board (connector J10) using a telephone cable RJ 12.
7) In the I/O menu, check the intervention of the pressure switches and their re-arming.
8) Disconnect the external terminal and close the electrical panel cover using all the bolts and washers previously removed.
9) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.10 VIBRATION LIMITERS INSPECTION AND WELDING CONTROL

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Visually check if there are refrigerant losses on the vibration limiters welded to the compressor suction and discharge pipes.
4) Control the welding conditions.
5) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.1.11 COMPRESSOR AND FANS CLEANING AND INSPECTION

Frequency:

- 1 year.

Materials/tools:

- Standard workshop tools.
- Air compressor.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover.
3) Clean the compressor area by using an air compressor.
4) Verify the absence of damages or burns on the compressor.
5) Control the welding conditions.
6) Remove the cover of the air treatment area after removing the 10 M6 screws.
7) Clean also the air treatment area by using an air compressor.
8) Close all the covers.

5.1.12 FILTER DRIER REPLACEMENT

Frequency:

- 5 years.

Materials/tools:

- Standard workshop tools.
- Refrigerant recovery system.
- Recovery cylinder.
- Welding torch.
- 4-way manifold gauge set.
- Flexible hoses.
- Nitrogen cylinder.
- Refrigerant recovery system.
- Vacuum pump.
- R407C refrigerant cylinder.
- N° 1 filter drier.

Preliminary operations:

- Take off the power supply.
- Operate only on a railway track without overhead power line or ground the electrical line through an appropriate insulating rod.

Procedure:

1) Accede to the package HVAC system on the roof.
2) Remove the HVAC cover
3) Evacuate the frigorific circuit connecting the access fittings (low pressure access fitting EBP and high pressure access fitting EAP; see drawing nr. RMB8173: cooling circuit) and recover the refrigerant (as detailed in the par. 5.2.3).
4) Deweld the pipes of the filter drier.
5) With a flat-tip screwdriver, loosen the lock clamp on the filter drier.
6) Remove the filter drier.
7) Position the new filter drier in its location.
8) Braze the joints and, in the meantime, circulate in the frigorific circuit a nitrogen flow.
9) Clean the frigorific circuit using nitrogen. At the end, recover the nitrogen using a recovery system.
10) Evacuate the whole circuit (see par. 5.2.1).
11) Charge the refrigerant (see par. 5.2.2).

NOTE

The refrigerant quantity in the SMALL47R HVAC is 1,2 Kg.

12) Reposition the HVAC cover and close it using all the bolts and washers previously removed.

5.2 STANDARD PROCEDURES

All these operations have to be executed by an experienced staff.

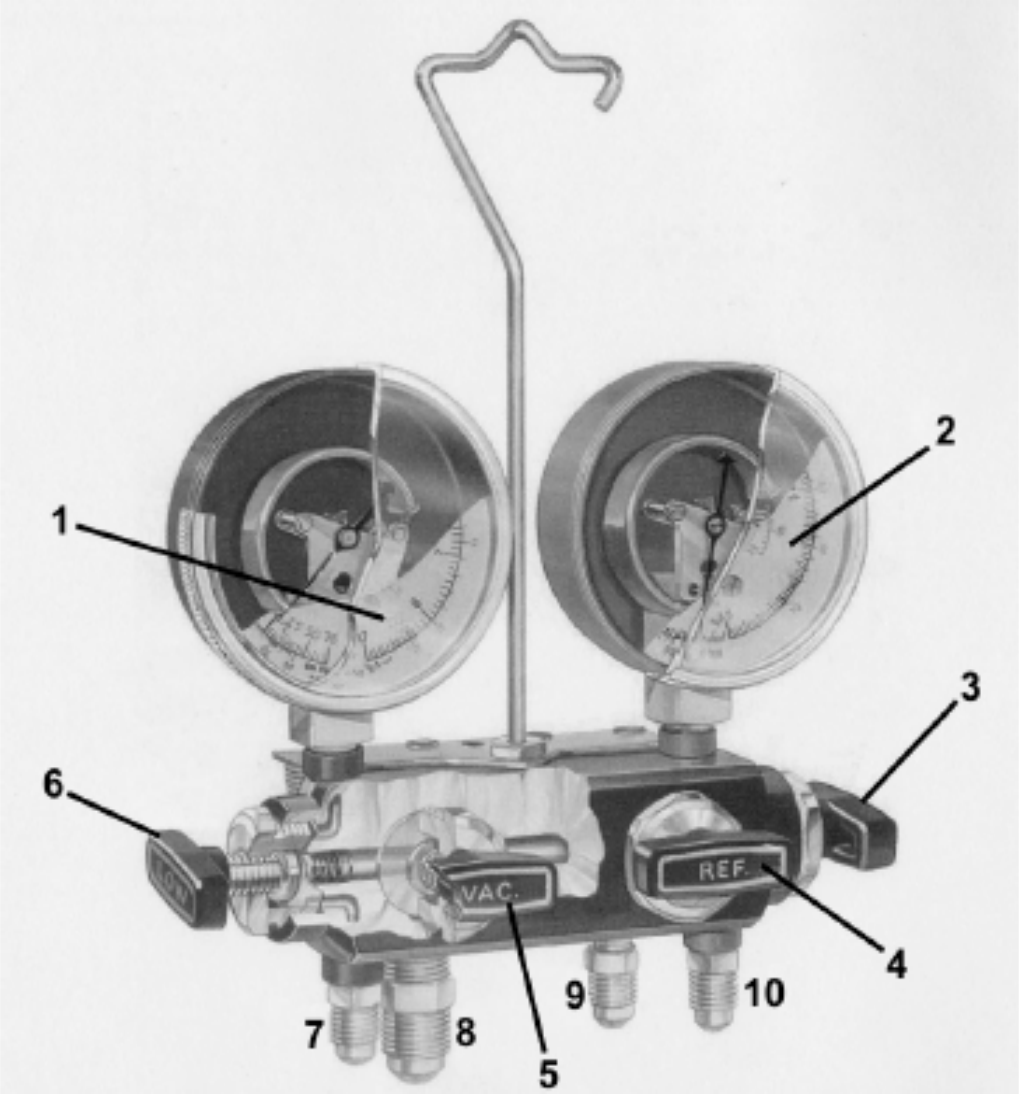
5.2.1 EVACUATION OF THE CIRCUIT

The evacuation procedure is itemized here below.

The required equipments are:

- 4-way manifold gauge set (ref. Fig. 10),
- flexible hoses,
- vacuum pump (ref. Fig. 11),
- nitrogen cylinder.

1) By means of flexible hoses, connect a manifold gauge set (ref. Fig. 10) to the access fittings of the frigorific circuit (the connection 7 has to be connected to the low pressure access fitting EBP and the connection 10 to the high pressure access fitting EAP; see drawing nr. RMB8173: cooling circuit).
2) Connect the vacuum pump (ref. Fig. 11) to the manifold gauge set (connection 8) and, after the opening of the valves 5 and 6, evacuate the circuit till a pressure < 100 Pa (with the pump ON).
3) Measure the vacuum value; if after 15 minutes the pressure is lower than 150 Pa, continue as described in the next point, if it is higher begin again from the beginning after having repaired any leaks.
4) Connect a nitrogen cylinder to the manifold gauge set (connection 9) and open the valve 4. Break the vacuum by slowly introducing into the circuit (by adjusting the cylinder regulator) some nitrogen at a maximum pressure of 1 bar in order to absorb the remaining moisture (with the pump OFF).
5) Carry out the second evacuation at a pressure < 30 Pa (with the pump ON).
6) Carry out a pressure rise test by checking that the vacuum pressure measured after 60 minutes is not greater than the maximum value of 100 Pa. If the test produces negative results, repeat the second evacuation.
7) Proceed with evacuating again to a pressure < 30 Pa.
8) Disconnect all the hoses, except for those connected to the access fittings: close anyway the gauge set valves in order to avoid the entrance of air.



1 **Low pressure gauge**
2 **High pressure gauge**
3 **High pressure valve**
4 **Valve on the connection for the refrigerant supply tank**
5 **Valve on the connection for the vacuum pump**
6 **Low pressure valve**
7 **Connection for the low pressure side of the circuit**
8 **Connection for the vacuum pump**
9 **Connection for the refrigerant supply tank**
10 **Connection for the high pressure side of the circuit**

Fig. 10 Manifold gauge set

5.2.2 REFRIGERANT CHARGE ON THE CIRCUIT

The refrigerant charge operation is very tricky because the compressor uses a polyester oil which is more igroscopic of the mineral oil and a little quantity of air makes it not usable.

The required equipments are:

- 4-way manifold gauge set (ref. Fig. 10),
- flexible hoses,
- vacuum pump (ref. Fig. 11),
- nitrogen cylinder,
- R407C refrigerant cylinder (ref. Fig. 12).

1) With the circuit in a vacuum, connect the connection 9 of the manifold gauge set to a nitrogen cylinder.
2) Open the valves 4 e 6 and break the vacuum with some nitrogen till a pressure of 1,1 bar absolute (so 0,1 bar above the atmospheric pressure). Close the valve 6 and detach the nitrogen cylinder.
3) Connect the connection 9 of the manifold gauge set to a R407C refrigerant cylinder and charge liquid refrigerant (by opening the valves 3 and 6) till the equilibrium of the pressures in the cylinder and in the circuit. The liquid refrigerant can be charged only in the condenser.

ATTENTION

The R407C refrigerant has to be charged only in its liquid state because this refrigerant is a mixture of three different gases and so, charging refrigerant in the vapour phase, there could be the risk of not charging the correct percentages of the three gases.

For the same reason, in a circuit using R407C refrigerant, it is not possible to top up the refrigerant: it is necessary to remove the entire charge and fully re-charge the circuit.

4) In case of a single valve cylinder, the refrigerant can be charged in the liquid state with the cylinder overturned (with the output valve at the bottom). If there is, instead, a two-valves cylinder, there is a bleu valve for the vapour phase charge and a red valve for the liquid phase charge so that it is not necessary to overturn the cylinder (ref. Fig. 12).
5) Close all valves and disconnect the manifold gauge set.

NOTE

The refrigerant quantity charged in the circuit depends on the length of the circuit. In this application consider a quantity of 1,2 Kg.

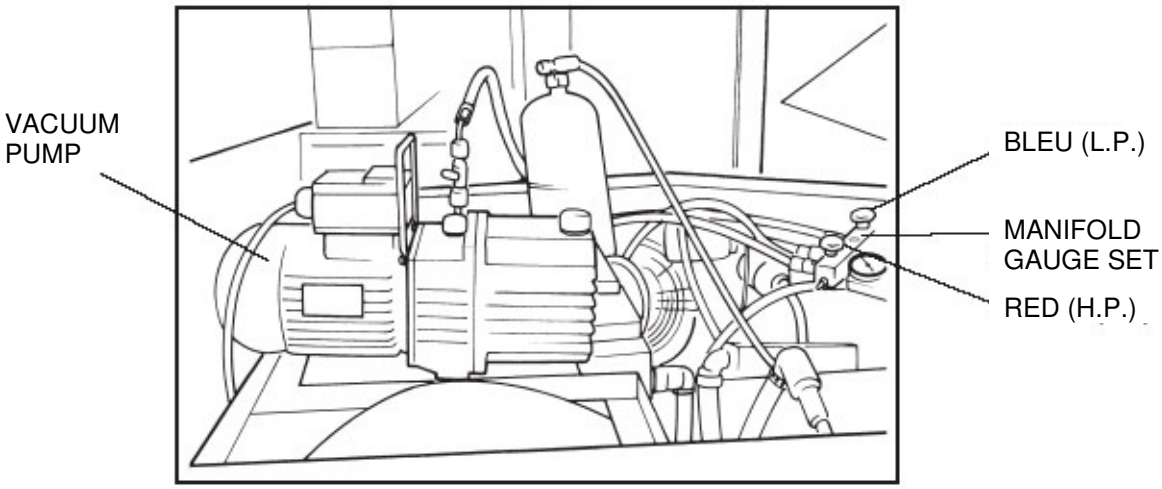
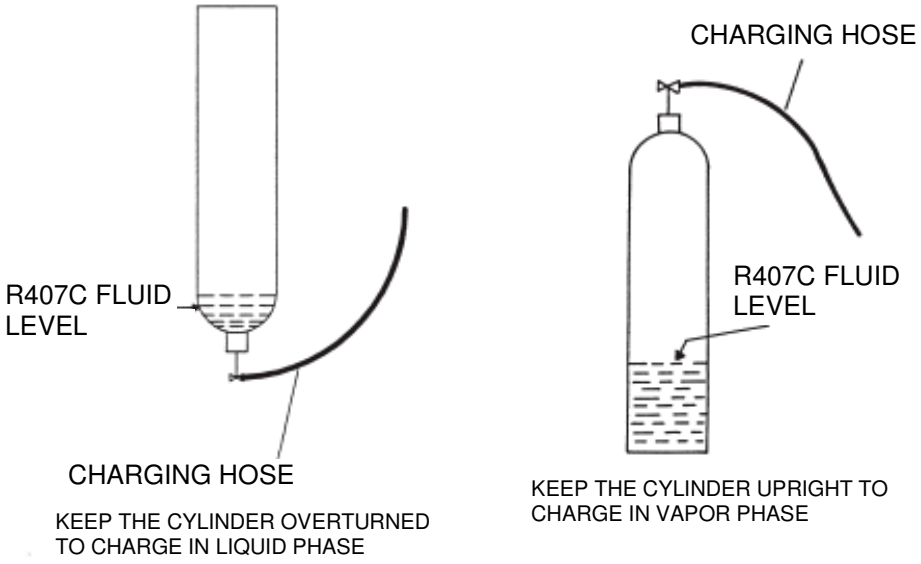
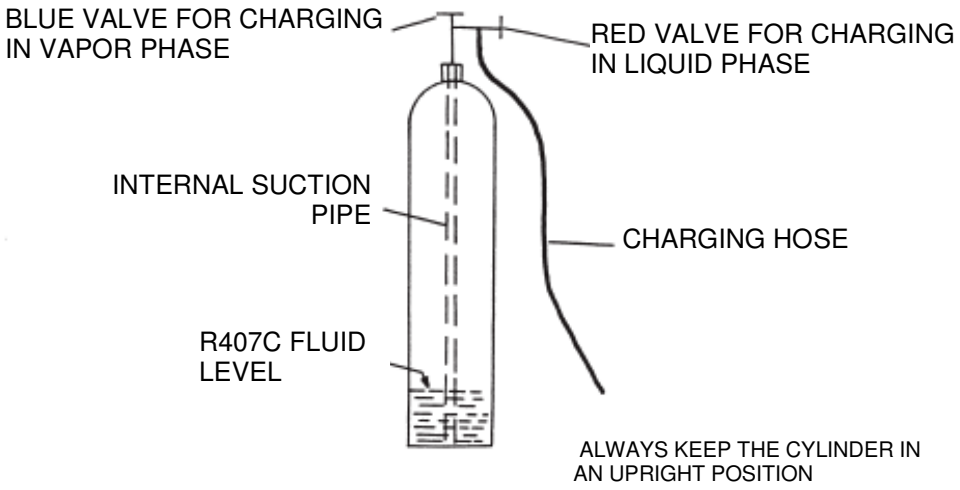


Fig. 11 Vacuum pump



SINGLE VALVE CYLINDER



DOUBLE VALVE CYLINDER

Fig. 12 Refrigerant cylinder

5.2.3 REFRIGERANT RECOVERY

The refrigerant recovery is mandatory for law (Italian law 549/93 dated 20th December 1993, art. 6).

It is necessary to recover the refrigerant in the following conditions:

- if the fluid is contaminate;
- before the dismantling of the unit;
- in every case in which is necessary an intervention on the frigorific circuit.

The required equipments are:

- refrigerant recovery system,
- recovery cylinder.

The recovered fluid, if polluted, has to be delivered to the refrigerant reclaimers for the disposal.

1) Connect the vacuum pump (ref. Fig. 11) to the manifold gauge set (connection 8) and the gas valve (bleu) of the recovery cylinder to the connection 9 and, after the opening of the valves 4 and 5, evacuate the cylinder for about 10 minutes. Close the valves and disconnect the cylinder.
2) By means of flexible hoses, connect the input of the recovery system to the high pressure access fitting of the frigorific circuit (see drawing nr. RMB8173: cooling circuit) and the output of the recovery system to the gas valve (bleu) of the recovery cylinder previously evacuated.
3) Open the valves on the cylinder and on the recovery system.
4) Start the recovery system with the selector set on “liquid”.
5) When the liquid refrigerant recovery is finished, move the selector on “gas”.

ATTENTION

Control the weight of the refrigerant collected on the recovery cylinder; remember that its volume can be filled to the 80% at most.

6) By using the manifold gauge set on the recovery system, check when the pressure on the circuit reaches the value of about -0,3 bar and, at this moment, stop the recovery.
7) Close all the valves on the cylinder and on the recovery system.

5.2.4 REFRIGERANT LEAKS DETECTION

In order to find eventual refrigerant leaks, it is necessary to use a reliable leak detector. The presence of oil on the pipes of the refrigerant system it is the first signal of a leak.

The required equipments are:

- 4-way manifold gauge set (ref. Fig. 10),
- flexible hoses,
- R407C refrigerant cylinder (ref. Fig. 12),
- nitrogen cylinder,
- leak detector (ref. Fig. 13).

In case there has been leaks and the refrigerant has been removed from the system, the procedure is detailed in the following.

1) Control the complete system to verify a possible damage to the components.
2) By means of flexible hoses, connect a manifold gauge set (ref. Fig. 10) to the access fittings of the frigorific circuit (the connection 7 has to be connected to the low pressure access fitting EBP and the connection 10 to the high pressure access fitting EAP; see drawing nr. RMB8173: cooling circuit).
3) Connect the connection 9 of the manifold gauge set to a R407C refrigerant cylinder and open the valves 4 and 6 till the system reaches a pressure of about 345 kPa, 3.45 bar, 50 psig.
4) Verify eventual leaks with a leak detector (ref. Fig. 13) by checking all the joints and connections. If the leaks can't be found but the system lost its charge, pass to the following action.
5) Close the valve 4 and disconnect the refrigerant cylinder.
6) Connect a nitrogen cylinder to the manifold gauge set (connection 9) and open the valve 4. Break the vacuum by slowly introducing in the circuit (using the cylinder regulator) some nitrogen till the pressure of 1380 kPa, 13.80 bar, 200 psig.

ATTENTION

The nitrogen cylinders have to been used in appropriate way.

- *To always hold the protecting cap on the cylinder when it is not used.*
- *To conserve the cylinder in an appropriate area.*
- *Not to expose to an excessive heat or to the direct light of the sun.*
- *Not to bruise or to damage the cylinder and not to let it fall.*

7) Verify eventual leaks with a leak detector by checking all the joints and connections.
8) When necessary, intervene for the repair and check again the system once the repair has been completed.

NOTE

If a leak is found, diminish the pressure in the circuit and then execute the necessary repair.

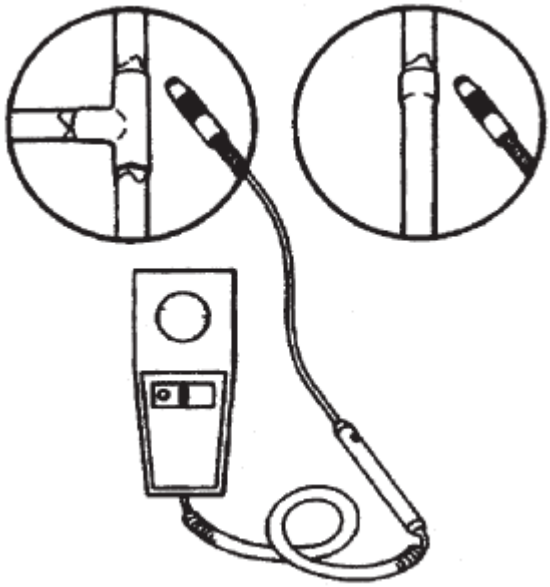


Fig. 13 Leak detector

6 MALFUNCTIONINGS AND BREAKDOWNS DIAGNOSTIC

This paragraph describes the procedures that, in case of a specific symptom, allow the location and the solution of a failure.

6.1 MALFUNCTIONINGS AND BREAKDOWNS DIAGNOSTIC TABLE

SYMPTOM	*CAUSE*	*SOLUTION*
Low refrigerant fluid level, presence of air bubbles on the level indicator of the filter drier.	Refrigerant leak through a damaged welded connection.	To find the leak and to weld the damaged connection.
LP pressure switch opened. ALARM SIGNAL	Refrigerant leak through a damaged welded connection.	To find the leak and to weld the damaged connection.
	Air filter clogging.	To clean or to replace the air filter (see paragraph 5.1.1 and 5.1.2).
	Evaporator clogging.	To clean the evaporator (see paragraph 5.1.5).
	Vibration limiter failure and refrigerant fluid leak.	To replace the vibration limiter if broken.
	Air treatment fan motor failure due to a short circuit in the windings.	To replace the air treatment fan.
	Thermostatic valve input filter partially or completely clogged.	To replace the thermostatic expansion valve.
	Failure to the thermostatic valve bulb.	To replace the thermostatic expansion valve.
HP pressure switch opened. ALARM SIGNAL	Evaporator clogging.	To clean the evaporator (see paragraph 5.1.5).
	Condenser fan motor failure due to a short circuit in the windings.	To replace the condenser fan.
	Burnt-out coil (it isn't energized) in the condenser fan contactor or burnt-out contactor.	To replace the contactor.
	Mechanical failure of the condenser fan circuit breaker.	To replace the circuit breaker.

SYMPTOM	*CAUSE*	*SOLUTION*
High moisture in the refrigerant fluid, level indicator coloured in yellow.	Moisture in the frigorific circuit.	To replace the filter drier (see paragraph 5.1.12).
Differential pressure switch opened. ALARM SIGNAL	Air filter clogging.	To clean or to replace the air filter (see paragraph 5.1.1 and 5.1.2).
	Evaporator clogging.	To clean the evaporator (see paragraph 5.1.5).
	Air treatment fan motor failure due to a short circuit in the windings.	To replace the air treatment fan.
Functioning with a low air flow and no alarm signal.	Air filter clogging.	To clean or to replace the air filter (see paragraph 5.1.1 and 5.1.2).
	Evaporator clogging.	To clean the evaporator (see paragraph 5.1.5).
	Differential pressure switch diaphragm broken.	To replace the differential pressure switch.
Ice on the evaporator or on the pipes.	Moisture in the frigorific circuit.	To replace the filter drier.
	Thermostatic valve input filter partially or completely clogged.	To replace the thermostatic expansion valve.
The compressor doesn't start.	Compressor electrical motor failure due to a short circuit in the windings (insulation breakdown).	To replace the compressor.
	Compressor mechanical failure.	To replace the compressor.
	Burnt-out coil (it isn't energized) in the compressor contactor or burnt-out contactor.	To replace the compressor contactor.
	Mechanical failure of the compressor circuit breaker.	To replace the compressor circuit breaker.
	HP pressure switch contact stuck.	To replace the HP pressure switch.
	LP pressure switch diaphragm broken.	To replace the LP pressure switch.
Noisy functioning and vibrations of a compressor.	Loosening of the compressor anti-vibrations mounts.	To verify the condition of the anti-vibrations mounts and, if needed, to tighten or replace them.

SYMPTOM	*CAUSE*	*SOLUTION*
The air treatment fan doesn't start.	Air treatment fan motor failure due to a short circuit in the windings.	To replace the air treatment fan.
	Burnt-out coil (it isn't energized) in the air treatment fan contactor or burnt-out contactor.	To replace the air treatment fan contactor.
	Mechanical failure of the air treatment fan circuit breaker.	To replace the air treatment fan circuit breaker.
Noisy functioning of the air treatment fan.	Mechanical problems at the bearings of the fan.	To replace the air treatment fan.
A condenser fan doesn't start.	Condenser fan motor failure due to a short circuit in the windings.	To replace the condenser fan.
	Burnt-out coil (it isn't energized) in the condenser fan contactor or burnt-out contactor.	To replace the condenser fan contactor.
	Mechanical failure of the condenser fan circuit breaker.	To replace the condenser fan circuit breaker.
Noisy functioning of a condenser fan.	Mechanical problems at the bearings of the fan.	To replace the condenser fan.
No temperature signal to the electronic board. ALARM SIGNAL	Failure to a temperature probe.	To replace the temperature probe.
Reverse phase relay opened. ALARM SIGNAL	No MV power supply. Wrong phase sequence.	To check the electrical connections.
Compressor circuit breaker opened. ALARM SIGNAL	Compressor current absorption too high.	The circuit breaker has to be rearmed: if there is another opening, the compressor has to be checked.
Condenser fan circuit breaker opened. ALARM SIGNAL	Condenser fan current absorption too high.	The circuit breaker has to be rearmed: if there is another opening, the condenser fan has to be checked.
Air treatment fan circuit breaker opened. ALARM SIGNAL	Air treatment fan current absorption too high.	The circuit breaker has to be rearmed: if there is another opening, the air treatment fan has to be checked.

SYMPTOM	*CAUSE*	*SOLUTION*
Temperature probe disconnected / out of range. ALARM SIGNAL	Temperature probe disconnected. Temperature probe broken.	To verify the connection of the probe. To replace the temperature probe.
Pressure transducer disconnected / out of range. ALARM SIGNAL	Pressure transducer disconnected. Pressure transducer broken.	To verify the connection of the transducer. To replace the transducer.

7 ATTACHEMENTS

- Assembly drawings 60ACB7301B sheet 1, 2, 3, 4, 5
- Electrical wiring diagram RMB7853H
- Cooling circuit RMB8173D