SHANGHAI FAIVELEY RAILWAY TECHNOLOGY CO.

AMSTERDAM (Alstom)

1 DESCRIPTION

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SHANGHAI FAIVELEY RAILWAY TECHNOLOGY CO.

Release History

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Revision Table

Revision	Date	Revised Sections, Description, Reason for changes
01	15.10.2010	First issue
02	22.11.2010	Update the software specification
03	24.02.2011	Modify the cab HVAC unit figures according to the modification of mechanical design
04	27.05.2011	Updated according to conf call discussion in March 2011.
05	18.10.2011	Electrical components in CP updated
06	11.11.2011	Electrical components added in CP.
07	16.04.12	1.4.19 power input changed to 170VAC.

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1 DESCRIPTION

One identical HVAC unit saloon is installed in the end of each coach, for supplying comfortable conditioning air to the passenger compartment. In summer, it will working in cooling mode, and in winter in heating mode. Totally there are 6 HVAC Units Saloon in each train. The HVAC units supply conditioned air into a ducting system, which is installed above the ceiling of the compartments. From the ducting the air is evenly distributed, into the passenger saloon, over the entire length of the car via air diffusers, which are integrated in the ceiling of the compartments.

The purpose of the HVAC system is to ensure a pleasant temperature and humidity can be achieved inside the passenger saloon.

The TC car, in addition to equipping one HVAC Unit in the passenger compartment, is also equipped with an HVAC Unit of cab and a Cab aerotherm unit in the cab. The Description of the Cab HVAC will be contained in the section 1.3.

1.1 DESCRIPTION OF SALOON HVAC UNIT

The outline of the Saloon HVAC unit is showed in the following figure 1.1.

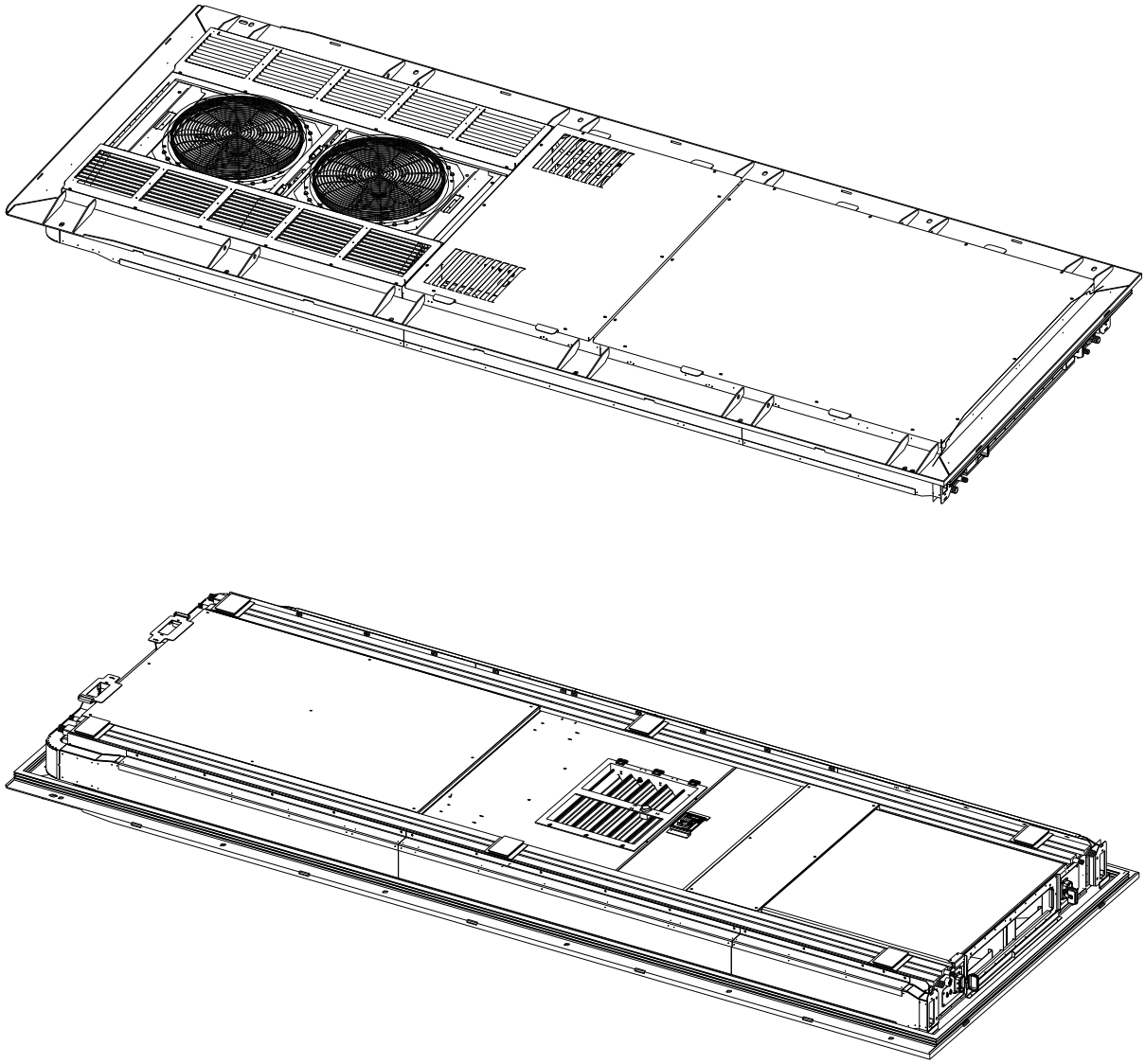


Figure 1.1 Saloon HVAC unit

Fresh air enters the HVAC unit through 2 grilles on the top cover of the unit. The fresh air mixed with the return air from the passenger compartment, which enters the HVAC unit through the air inlet located at the unit's bottom. The mixed air is cooled/heated and then blown into the ducting system of the passenger's saloon.

The HVAC unit contains two refrigeration circuits, each operate independently from the other. The condenser section is designed in such a way that the refrigerant (R-407C) is condensed by means of the ambient air.

Each HVAC unit comprises the following main components;

- 1 housing, material: Aluminium, partly heat and noise insulated
- 2 Condensers made of copper tubes and Al fins
- 2 Condenser fans and motors sets to draw air over the condensers.
- 2 evaporator fans to draw air over the evaporators, radial and 2 speed
- 2 compressors, hermetical scroll type, which are brazed into the refrigerant circuit
- 2 Filter driers
- 2 Sight glasses to inspect refrigerant flow
- 2 High-Pressure switches
- 2 Low-Pressure switches
- 2 Thermal expansion valves controlling refrigerant flow
- 2 Liquid line solenoid valves
- 2 Gas liquid separators
- 1 Electrical heater with safety elements
- 2 Fresh air filters
- 3 Mixed air filters – G3 filter, synthetic material
- 1 Control panel for car to control one HVAC unit
- 2 Fresh air dampers
- 1 Return air damper
- 2 Electrical connectors
- 3 Temperature sensors (1 supply air senor, 1 return air sensor and 1 fresh air sensor)

In cooling mode, the mixed air (mixed by return air from the passenger compartment and fresh air sucked from the ambient), is sucked by the evaporator fans through the evaporator coil where, by means of refrigerant evaporation, heat is transferred from the air, via the evaporator coil, into the refrigerant. The cooled and de-humidified air passes through the evaporator fans and is blown into the ducting to be distributed into the passenger compartment.

Each evaporator section comprises a split evaporator, two thermal expansion valves, two fans, a supply air temperature sensor.

Each car's HVAC units are controlled by a microprocessor unit — FPC08 Controller. The controller acts at all times, by sending the instructions to various components of the HVAC unit, to ensure that the required "set-point" temperature within the car is maintained and the system is operating safely within its design limits. Each microprocessor unit is connected to the TCMS by CAN bus, which is used to provide signals to start & stop the systems, provide fault data and diagnostic information at the train level.

1.1.1 Operational modes of HVAC Unit Saloon

Three kinds of signals can affect the operation mode of HVAC unit. They are:

- Signals from TCMS via CAN
- Signals from hardwired inputs
- Signals from maintenance software MONA

Although the signals from TCMS can affect the operation mode more frequently, the signals from maintenance software and from hardwired inputs have higher priority. See below:

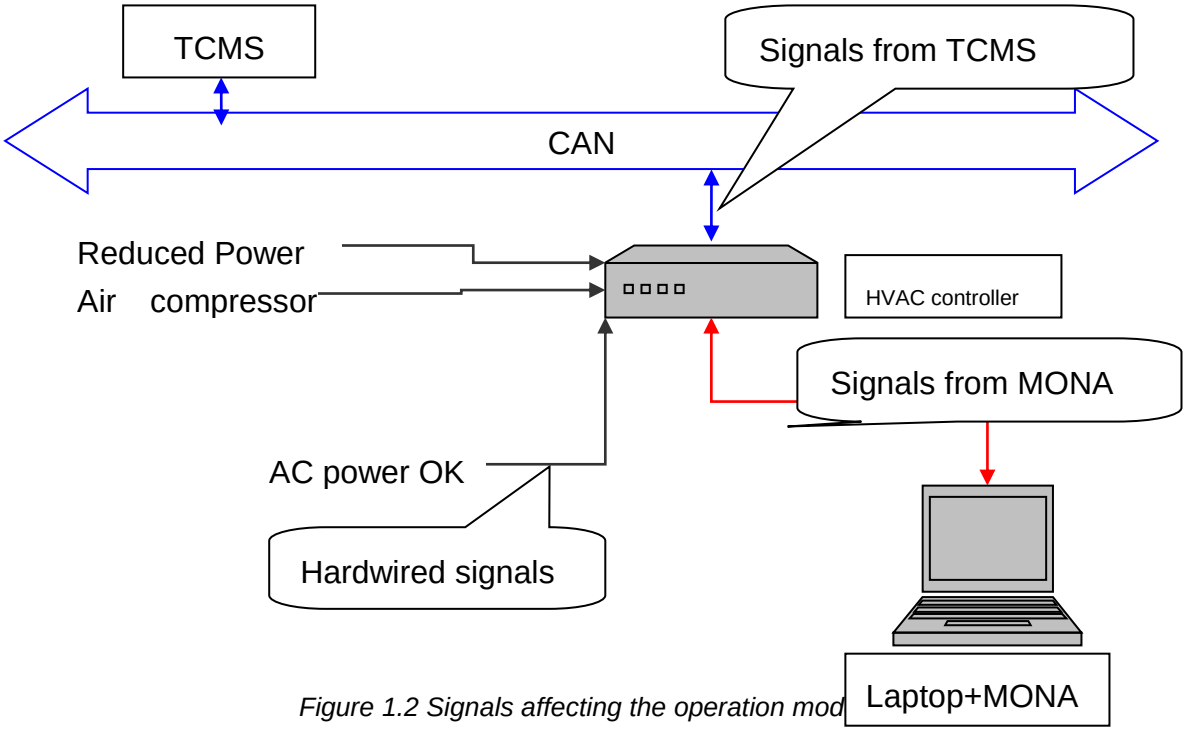


Figure 1.2 Signals affecting the operation mod

The control of the HVAC unit is separated into following modes:

- Self test procedures during startup
- Test mode via Mona
- OFF mode (Hardwired AC power OK signal or signal from TCMS)
- Emergency mode (Signal from TCMS)
- Only ventilation mode
- Slumber mode
- Station mode (Signal from TCMS)
- Automatic mode (Signal from TCMS)

In “Automatic mode”, control of ventilation or cooling or heating is dependent on the temperature set point and temperatures of return air, supply air and fresh air.

Starting sequence of HVAC module is:

- Supply air fans
- Condenser fans
- Compressors

The controller starts relevant modes depending on train bus information, temperature (inside and outside), Furthermore the controller receives feedback from the components and derives the current operation condition. The controller classifies failures and errors are stored in event memory. Operating conditions and error messages will be sent from the digital controller to the train system via train bus.

OFF mode

If the AC power supply for unit is not OK or the TCMS send the “OFF” signal to the HVAC controller, the HVAC will run in Off mode. Only the controller is powered. Ventilation and air conditioning are forbidden. If the OFF mode is active, the TCMS system receives all available signals, such as temperatures.

Automatic mode

In automatic mode, the HVAC unit will be completely controlled by the controller. Cooling, heating and ventilation are allowed. HVAC unit performs according to the defined temperature regulation. The set point of the passenger compartment temperature can be adjusted to the value within ±2K related to the defined temperature regulation via train bus.

According to the calculation of cooling, heating or ventilation requirement, the HVAC controller set the unit in proper sub modes:

- Ventilation
- Half cooling
- Full cooling
- Heating(2 step of heating available)

- Pre-cooling and Pre-heating

According to the calculation of return air and fresh air, there are two cooling modes can be set by controller.

- Half cooling mode: when the calculated value is from 5%...50% of cooling needing, the HVAC unit will run with one compressor;
- Full cooling mode: when the calculated value is over 50% for cool needing, the HVAC unit will run with two compressors;
- During pre-cooling and Pre-heating the fresh air dampers are closed and the units are running with 100% return air until the set point is reached (may limited by a time frame);
- When there is heating needing, the HVAC will turn to “Heating” mode, the compressor will be stopped and heater be started;
- When there isn’t cooling and heating needing, the HVAC will turn to “Ventilation” mode, the HVAC system will stop the compressor, heater, condenser fan, only the supply air fan is running which used to provide fresh air.

The refrigerant circuit is equipped with a hot gas bypass regulator. When the cooling demand is under a level causing the evaporation pressure and temperature to be under a certain unwanted value, the bypass regulator opens allowing hot gas to flow directly into the evaporator and raises evaporation pressure to an acceptable level. The suction (evaporation) pressure is the control-parameter for the bypass regulator.

Station mode

The TCMS sends the information “train speed”. In order to reduce noise, the HVAC unit will go into low speed of ventilation when the train speed is under a limit (fixed today at 5km/h but it will be adjusted during the noise test on the car). The HVAC unit will go into high speed of ventilation when the train speed is higher than a second limit

(not fixed but need to have a hysteresis in order to avoid change too often low / high speed).

The HVAC software sets a maximum running time for low ventilation in station mode. This time must be defined after the climatic tests on the car. For the moment imagine 1 minute but it will be adjusted after the tests. In this mode the cooling capacity will be reduced.

In this mode, the HVAC is running at the compound mode of “Station” and “Automatic”, except that the supply air fans run at low ventilation, other components would act as same as in “Automatic” mode.

Emergency mode

The emergency mode will be activated automatically in case of missing 400V auxiliary power (AI_04_PWR = 10±2°C) and FPC receives ‘authorization ventilation’ signal. Time between absence of 400V and 250V available is around of 20 seconds (time parameter by TCMS).

The fresh air dampers are open and return air dampers are closed. All auxiliary heaters are switched off. Supply air fans are in operation and they will be powered from train. The voltage and frequency of power supply from train is 250Vac 35Hz.

Slumber mode

The objective of this Slumber mode is to maintain a predefined temperature inside the vehicle.

The temperature set point in this mode is 5°C. SFRT will determine the appropriate T° value to insure an internal temperature greater than 5°C. The parameters will be defined during the climatic tests.

The TCMS authorises heating in slumber mode thanks to hardware input “authorization ventilation” of all HVAC saloon and thanks to Can Open signal

"authorization ventilation" of both HVAC cab. The parameters of slumber mode are as same as that of normal mode except that:

- The setting temperature is 5°C (will be checked during the climatic tests on the car)
- There is only return airflow (fresh air dampers are closed)
- Cooling is not allowed

We define the priority of the modes like this.

From highest to lowest priority:

SELFTEST>TEST>OFF>Emergency>Station>Automatic.

In automatic mode, the HVAC unit will be completely controlled by the controller. Cooling, heating and ventilation are allowed.

1.1.2 Auto Mode Control Functions

1.1.2.1 Internal set point temperature creation

If the HVAC runs at automatic mode, the internal set point (goal temperature) is calculated as following:

If Te >= 23°C, then Tic = 22 + 0.25(Te -19)*

If Te < 23°C, then Tic = 23

Notes:

Te is ambient air temperature. Tic is the set point temperature calculated according to EN 14750-1 cat B.

The set point temperature can be adjusted to the value within ±2K related to the defined temperature regulation via CAN bus.

The result is memorized (M_Tic=calculated set point of saloon unit).

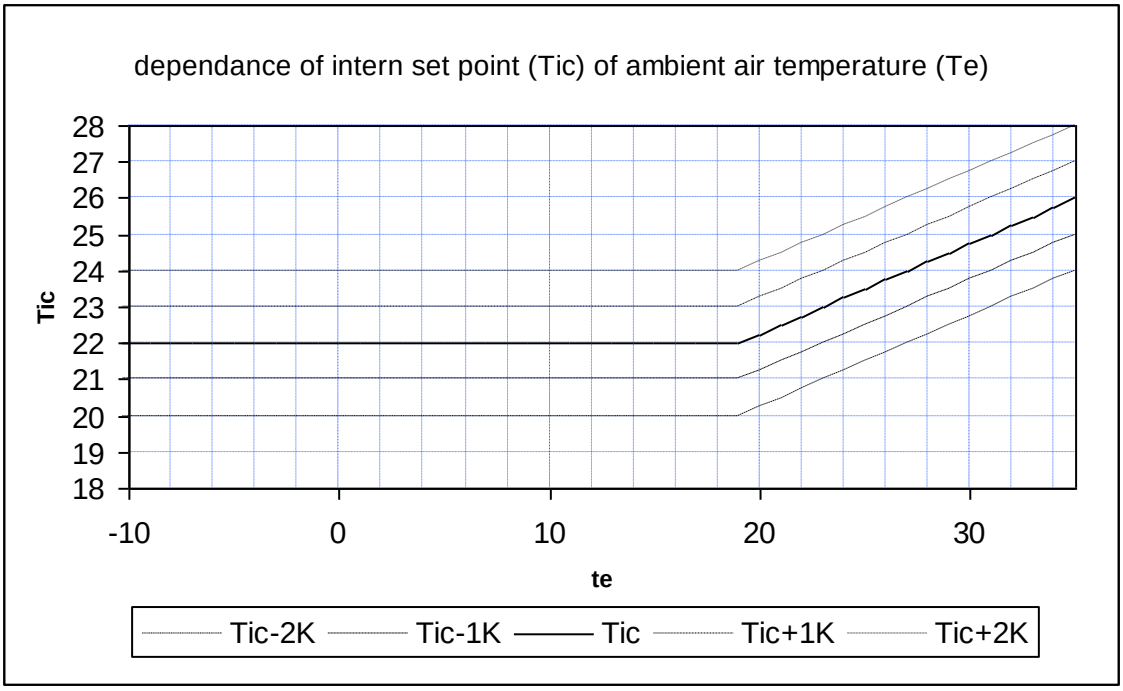


Figure 1.3: Dependance of intern setpoint of ambient air temperature

1.1.2.2 Cooling / Heating and Ventilation Mode

In auto mode the controller will decide the HVAC system should be in what sub mode according to all the digital inputs and analogical inputs information. The HVAC system is completely controlled by FPC. First, the controller calculates Tic (set point temperature), Ti (inside air temperature).

By calculating Ti, Tic, cooling needing, and heating needing, HVAC can work in cooling, heating, or ventilation mode. The purpose is to regulate Ti in range of Tic±1.5°C.

1.2 DESCRIPTION OF COMPONENTS OF HVAC UNIT SALOON

The main components of HVAC unit saloon are shown as Figure 1.4.

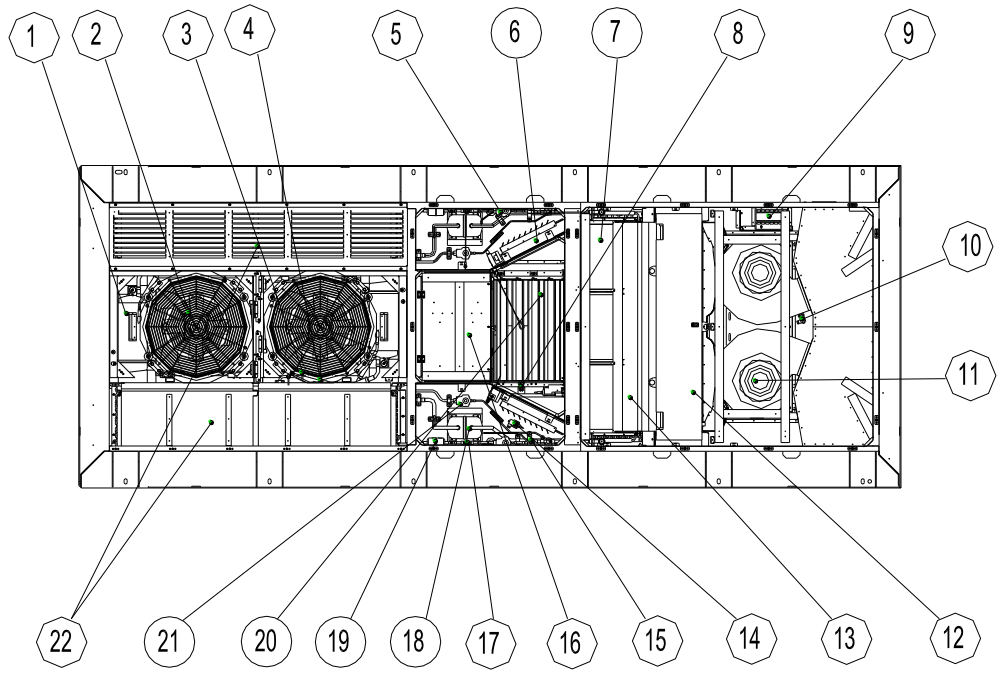


Figure 1.4 Main components of HVAC unit

1 Compressor	*12 Unit heater*
2 Condenser Fan	*13 Evaporator*
3 High Pressure Switch	*14 Fresh air temperature sensor*
4 Low Pressure Switch	*15 Thermal expansion valve*
5 Liquid line solenoid valve	*16 Control panel*
6 Fresh air damper	*17 Sight glass*
7 Mixed air filter	*18 Gas liquid separator*
8 Return air temperature sensor	*19 Filter dryer*
9 Transformer	*20 Return air damper*
10 Supply air temperature sensor	*21 Hot gas bypass solenoid valve*
11 Supply air fan	*22 Condenser*

1.2.1 Compressor

The mounting position of the compressor is shown in Fig 1.4/Pos.1.

The refrigerating output is produced by 2 hermetical scroll compressors in each unit. The scroll compressor is powered directly by the 3-phase auxiliary supply.

Refrigerant vapour returning from the evaporator at low pressure enters the compressor, which compresses it. The refrigerant exits the compressor as a high pressure, high temperature superheated gas via the compressor's discharge valves and flows to the condenser coils.

The compressor used in the refrigerating system is of a hermetical scroll type (G600DL-90DTP). The compressor delivers all the superior benefits of advanced scroll technology.

- Quiet operation.
- Unmatched reliability with 70% fewer moving parts than comparably sized reciprocating compressors
- Greater capacity at handling liquid and debris in the system
- High efficiency performance

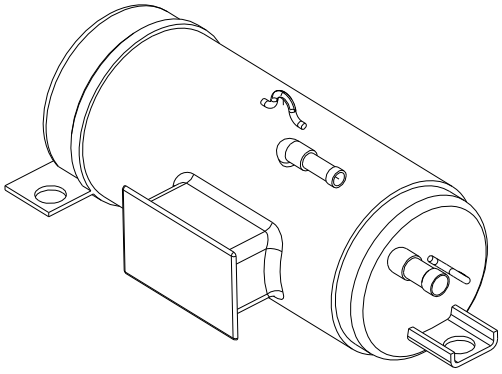


Figure 1.5 Scroll compressor

The compressor is mounted in the compressor-condenser chamber, on the sides of the two condenser fans. Each compressor is equipped with 6 vibration dampers (3

lower dampers, 3 upper dampers) to avoid the transmission of the vibration and reduce the noise.

1.2.2 Condenser

The mounting position of the condenser is shown in Fig 1.4/Pos.22.

Each condenser coil (Refer to figure 1.6) is made of inner screw thread copper tubes and Aluminium fins.

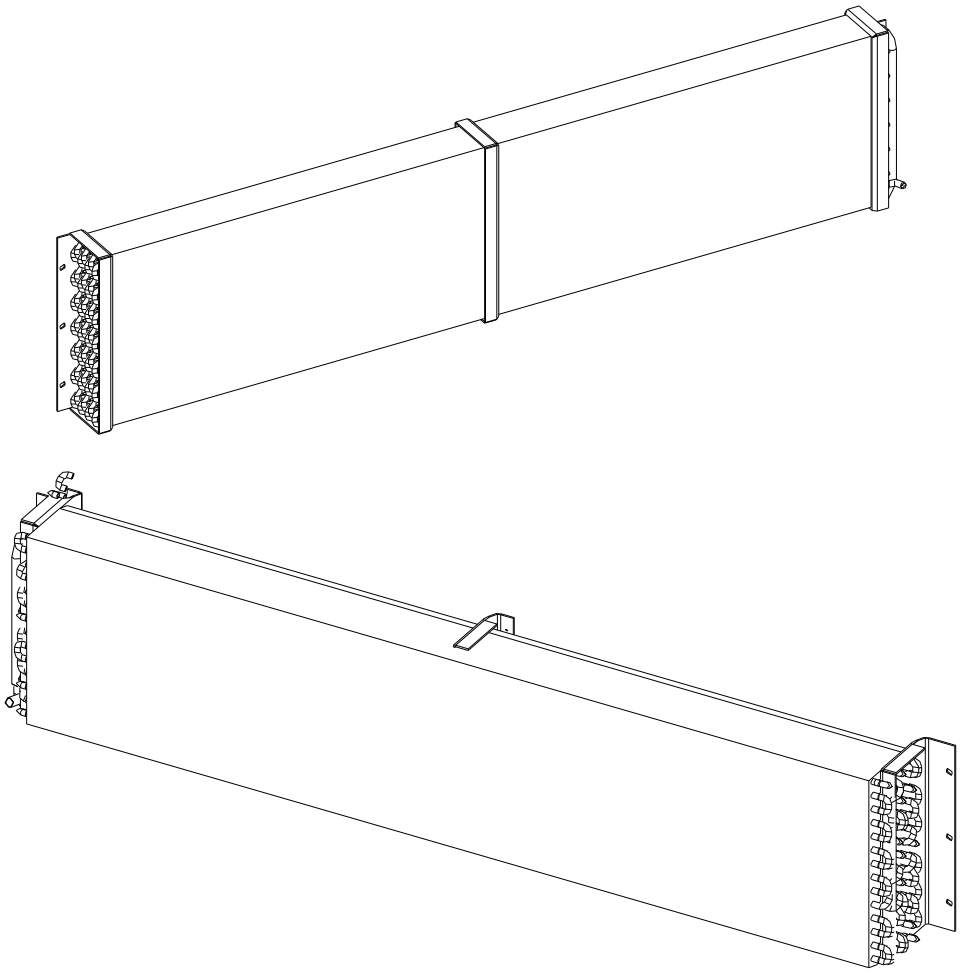


Figure 1.6 Condenser

Two condenser fans draw ambient air through the condenser coils. Each condenser rejects heat to the ambient air from the high temperature refrigerant gas which is

being pumped from the compressor. As the heat is rejected from the coil the refrigerant gas cools and condenses into a liquid refrigerant.

1.2.3 Liquid line solenoid valve

The mounting position of the solenoid valve is shown in Fig 1.4/Pos.5.

Solenoid valve is used in liquid pipe after Sight glass and before the expansion valve. Solenoid valve is used for controlling the open and close of refrigerant flow. The valve is commonly used to replace a manual valve or where remote control is desirable. The valve improves system efficiency and maintain the refrigerant charge in the condenser coil during the off -cycle of the compressor which prevents refrigerant migration when long piping runs are used. If one of the refrigerating circuits could be shut off, solenoid valve can be operated ,one of the two compressors can be switched off, and the half cold mode can be realized.

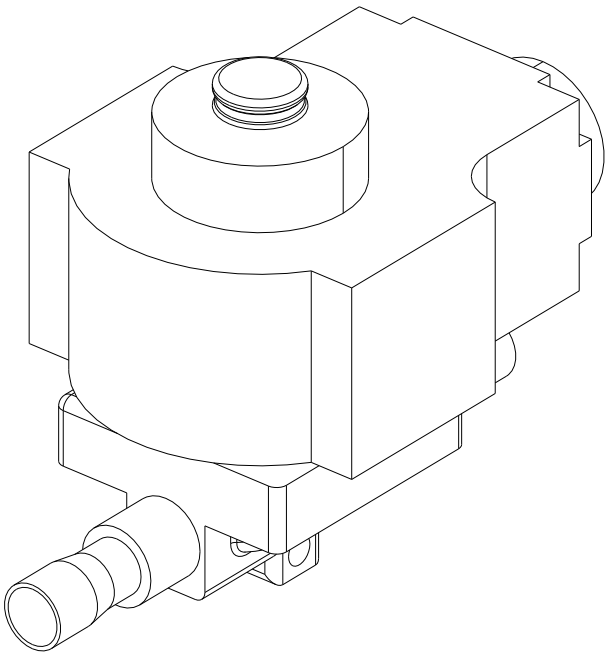


Figure 1.7 Solenoid valve

1.2.4 Filter dryer

The mounting position of the solenoid valve is shown in Fig 1.4/Pos.19.

Filter dryer is mounted on the liquid line after the condenser and before the sight glass.

The filter dryer removes moisture and contaminants from the refrigerant (figure 1.8).

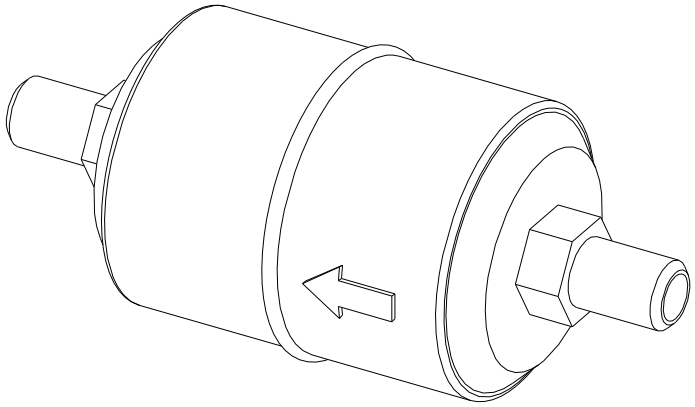


Figure 1.8 filter dryer

1.2.5 Sight glass

The mounting position of the sight glass is shown in Fig 1.4/Pos.17.

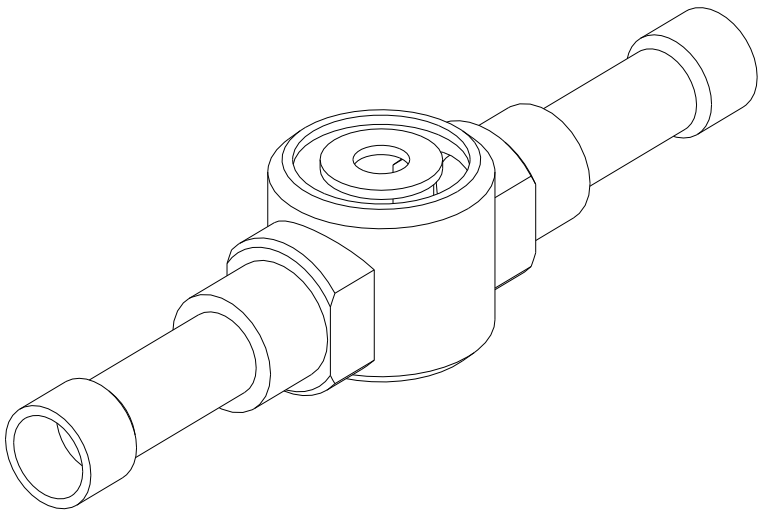


Figure 1.9 Sight glass

The sight glass is used in refrigerating circuit to observe the refrigerant flow and to provide an accurate method of determining the moisture content of a system's refrigerant. Humidity indication is obtained compared to paper indicators.

1.2.6 Thermal expansion valve

The mounting position of the thermal expansion valve is shown in Fig 1.4/Pos.15.

Thermal expansion valve is located after the solenoid valve and close to evaporator. Expansion Valve is used in refrigerating circuit as throttle component. It can open to a certain degree according to the superheat of the outlet of evaporator. Expansion valve is mounted after filter dryer, so the debris in refrigerating circuit is filtered first. Through the expansion valve, the high temperature, high pressure refrigerant liquid changed to low temperature, low pressure refrigerant mixture of gas and liquid.

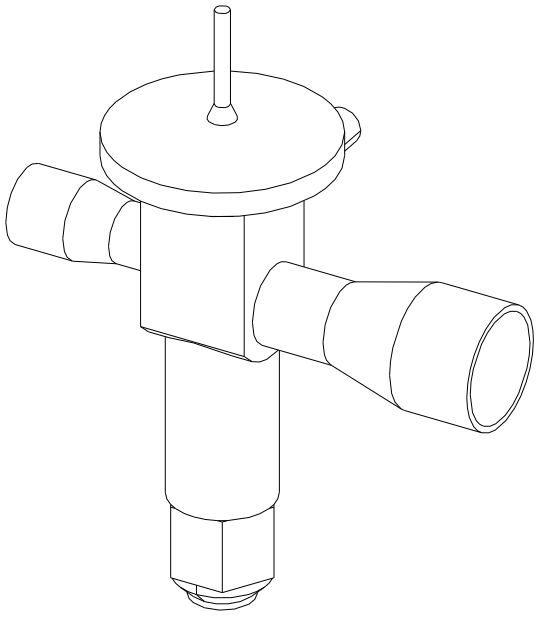


Figure 1.10 Expansion Valve

1.2.7 Evaporator

The mounting position of the evaporator is shown in Fig 1.4/Pos.13.

Each evaporator coil is made of copper tubes and aluminium fins (figure 1.11).

The liquid refrigerant is vaporized in the evaporator coil at a controlled rate and temperature. The low-pressure and low temperature refrigerant in the evaporator coil absorbs heat from the air sucked across the coil by the supply air fan. The air, which is a mixture of the return air and the fresh air passes through the evaporator coils and is cooled and dehumidified, is delivered into the car saloon evenly.

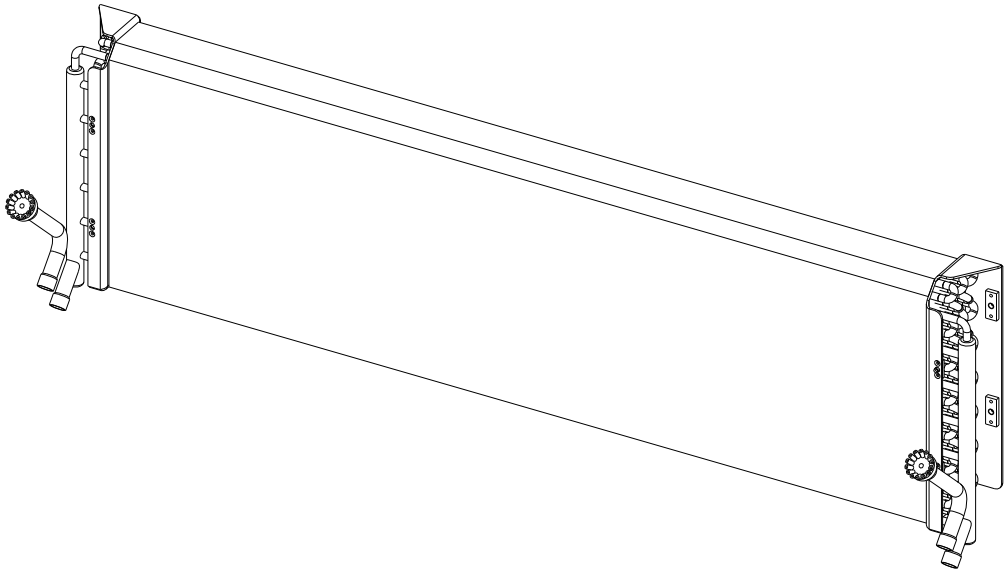


Figure 1.11 Evaporator

1.2.8 Supply air fan

The mounting position of the supply air fan is shown in Fig 1.4/Pos.11.

To meet the air conditioning requirements of the car's saloon and to overcome the pressure losses in the HVAC unit and supply air duct system, each HVAC unit contains two supply air fans. Each fan draws both fresh air from outside, via the fresh air filters, and return air from the saloon into the evaporator chamber. In the evaporator chamber the air two streams mix and then are drawn through the evaporator coil before being sucked into the evaporator fans. Once the air is sucked into the fans it is expelled into the supply air ducting and distributed into the saloon.

Each supply air fan consists of a single 400VAC/155VAC, 3phase, 50Hz motor, a fan impeller and a shell. And the two fans are both fixed to one supporting bracket which is installed to the frame of the HVAC unit.

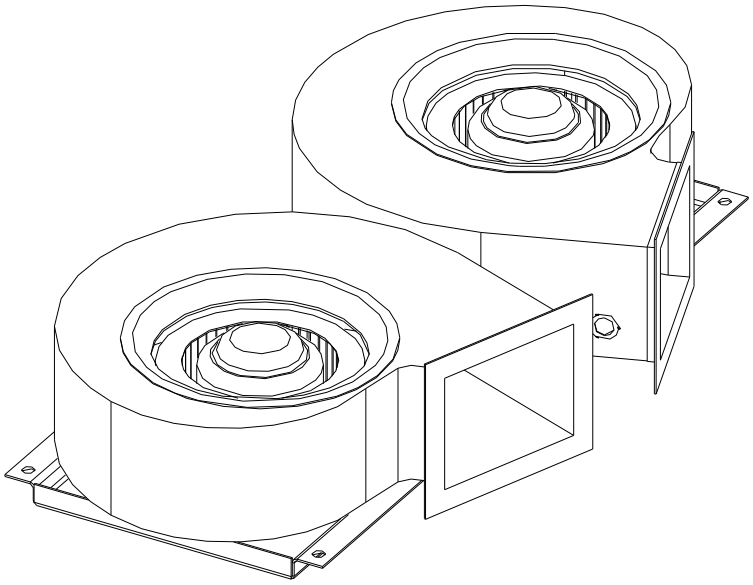


Figure 1.12 Supply air fan

1.2.9 Filter

The fresh air filter is mounted close to the fresh air damper after the fresh air intake. The mixed air filter is mounted close to the evaporator.

The HVAC unit incorporates 3 mixed air filters (figure 1.13) and 2 fresh air filters (figure 1.14) for filtering the air that enters the evaporator coils in order to prevent dust, dirt and other solid particles that could get caught in between the coils fins from entering and obstructing the air circulation causing a reduction of the cooling/heating system efficiency.

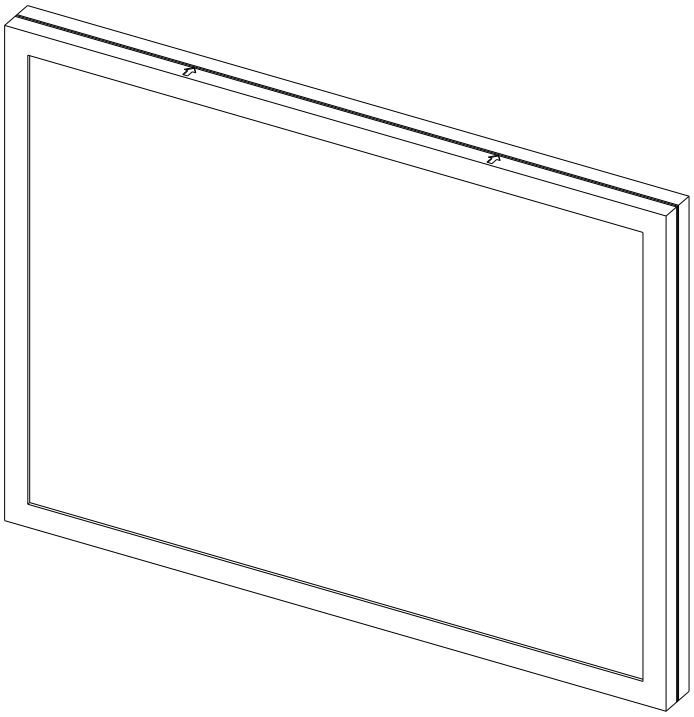


Figure 1.13 mixed air filter (model)

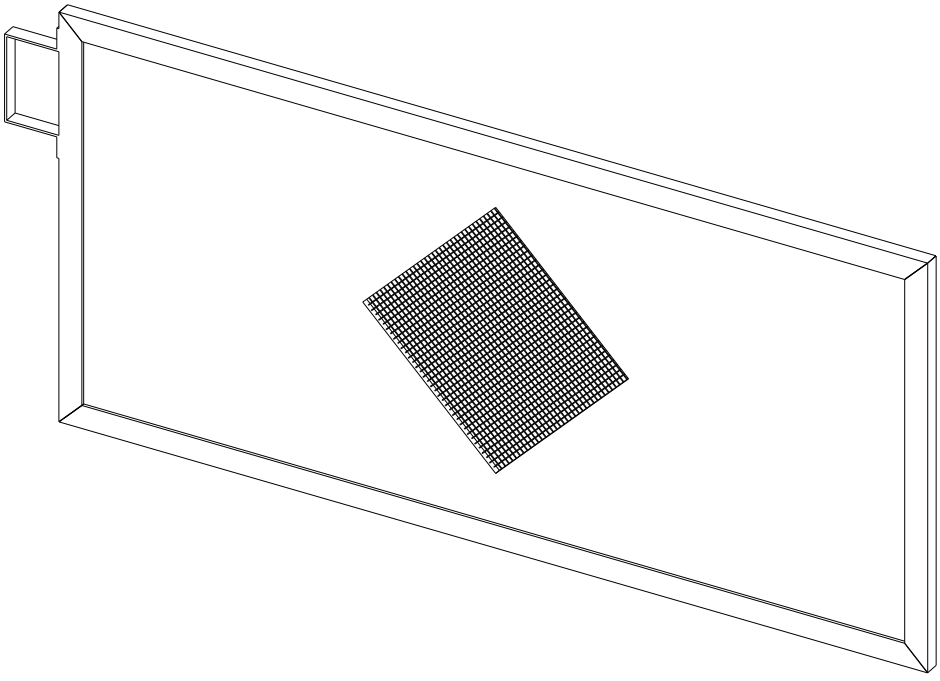


Figure 1.14 Fresh air filter(model)

1.2.10 Fresh air damper and Return air damper

The mounting position of Fresh air damper and return air damper is shown in Fig 1.4/Pos.6. and Fig 1.4/Pos.20.

Return air damper is located in the bottom of the HVAC Unit, near the return air inlet. Fresh air damper is located under the two fresh air intakes. Fresh air damper is used to adjust the fresh air volume to the HVAC unit. Depending on the HVAC mode and the ambient temperature and the return air temperature, the controller will send a signal to the damper actuator in order to adjust the fresh air flap a specific angle. The angle of the damper actuator to the fresh air inlet aperture will determine the amount of fresh air which blows into the HVAC unit. In emergency mode the return air flaps are closed fully.

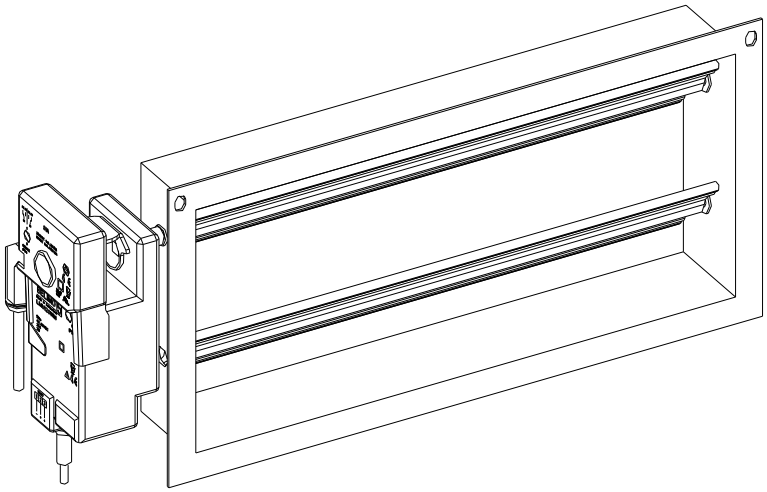


Figure 1.15-1 Fresh air damper

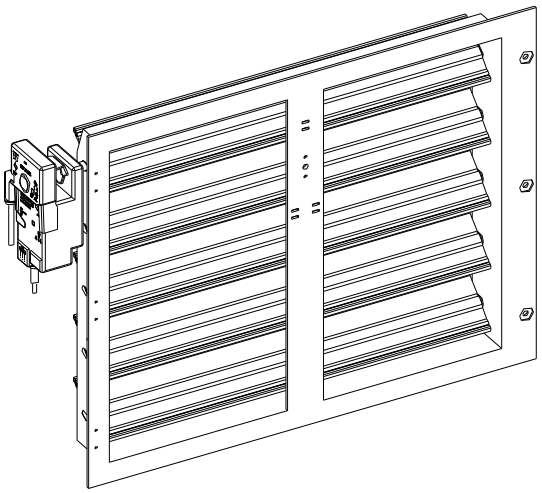


Figure 1.15-2 Return air damper

1.2.11 High pressure switch

The mounting position of the high pressure switch is shown in Fig 1.4/Pos.3.

The HVAC saloon system contains 2 high pressure switches.

The high pressure switch is used for monitoring the high pressure of the system. The high pressure port is connected to the discharge line of compressor. The set value is:

29bar switch off; 24 bar switch on.

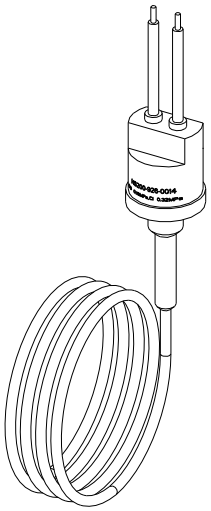


Figure 1.16 High pressure switch

1.2.12 Low pressure switch

The mounting position of the low pressure switch is shown in Fig 1.6/Pos.4.

The HVAC saloon system contains 2 low pressure switches.

The low pressure switch is used for monitoring the low pressure of the system. The low pressure port is connected to the suction line of compressor. The set value is:

1.8 bar switch off; 3.2 bar switch on.

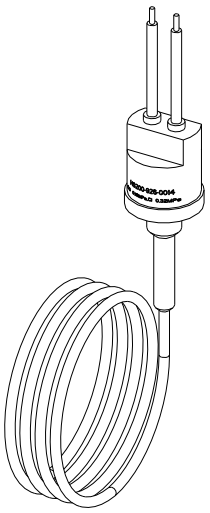


Figure 1.17 Low pressure switch

1.2.13 Gas liquid separator

The mounting position of the gas liquid separator is shown in Fig 1.4/Pos.18.

The gas liquid separator is used to separate the gas and liquid in the refrigeration circuit after the refrigerant leaves the evaporator and before entering the compressor, in order to protect the compressor from liquid slugging.

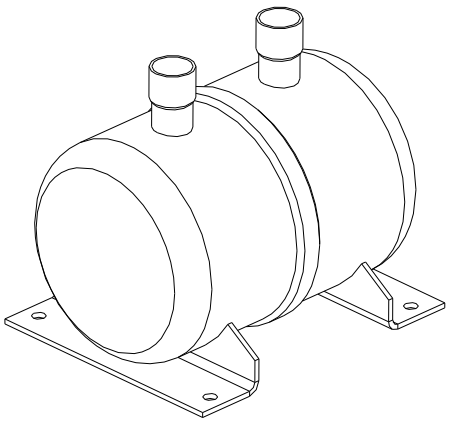


Figure 1.18 Gas liquid separator

1.2.14 Condenser fan

The mounting position of the condenser fan is shown in Fig 1.4/Pos.2.

Condenser fan consists of fan blade, motor and grille.To ensure a high heat transfer in the condenser coil , two axial fans draw “cool” ambient air from the top of the HVAC units and then discharge the now “hot” back to ambient through the condenser coils in the two sides of the HVAC unit.

Each condenser fan contains a 400VAC, 3 phase, 50Hz motor, which supports a 4 bladed axial fan fitted in a precision hub and operating in a close-fitting ring (Figure 1.19).It must be noted that the grille can not be walked on. Fan grille is used to prevent persons from touching the fan blade, protect for items entering the fan.

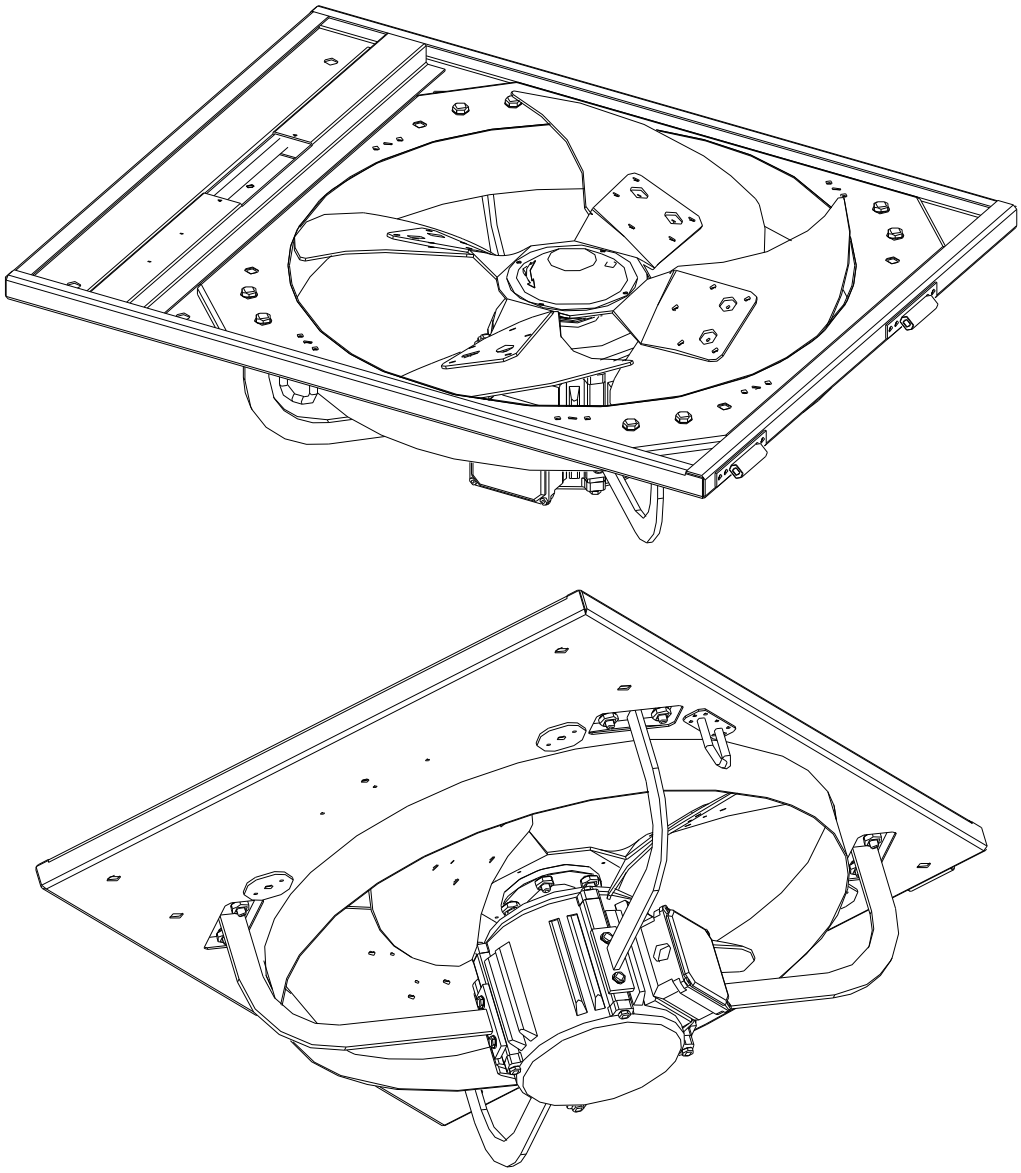


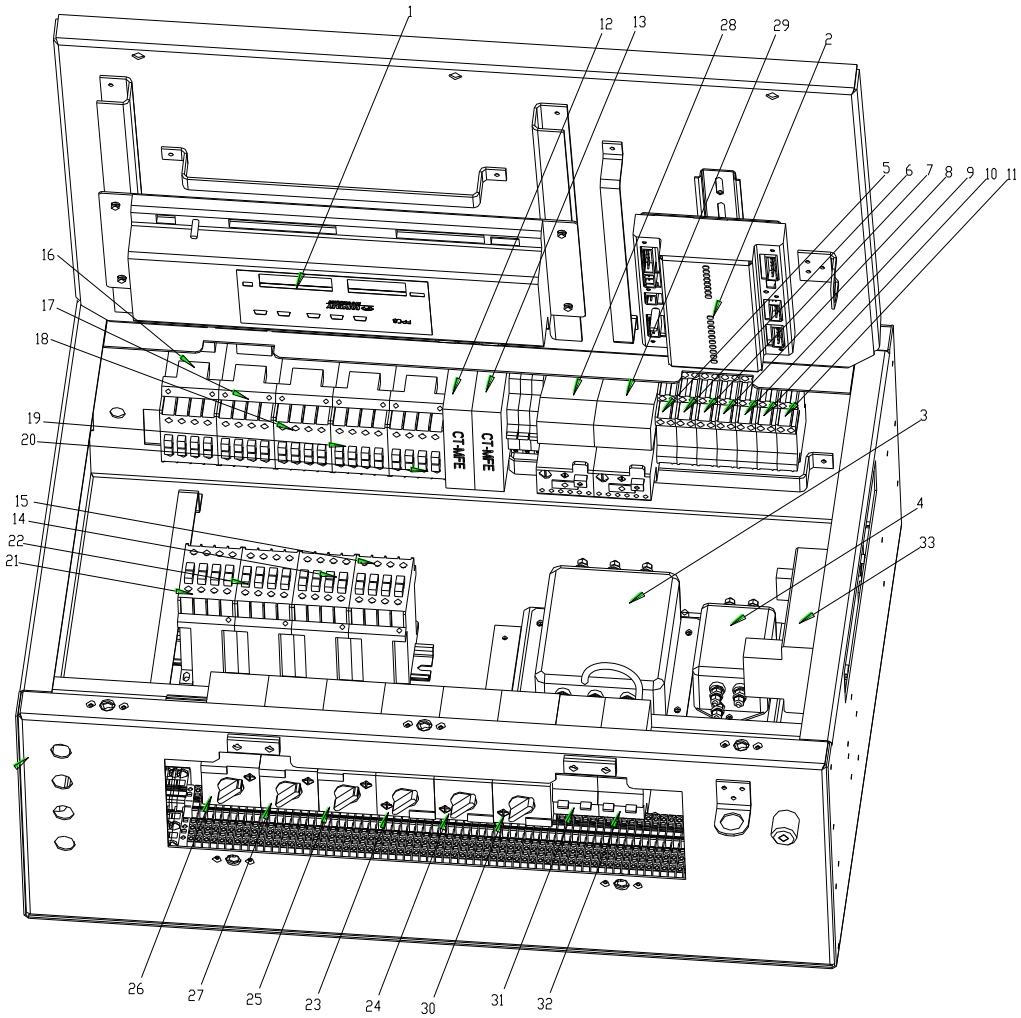
Figure 1.19 Condenser fan

1.2.15 Control panel

The mounting position of the control panel is shown in Fig 1.4/Pos.16.

The Control panel is located in the control panel chamber inside the unit. One control panel is used for one HVAC unit.

The control panel includes one controller and some electrical components for controlling the components of HVAC system, e.g. contactors, circuit beakers and so on.



Diode of Contactor

Diode of

Intermediate relay

No.	Part name	Description	Diode
1	Programmed logical controller	FPC08	No
2	Module for controller	DI08	No
3	EMC filter BTF004	NF1	No
4	EMC filter BTF002	NF2	No
5	Intermediate relay	KA1	With
6		KA2	With
7		KA3	With
8		KA4	With
9		KA5	With
10		KA6	With
11		KA7	With
12	Time relay	KT1	No
13		KT2	No
14	Contactor TAL26-30-10	KM18	With
15		KM19	With
16	Contactor TAL9-30-10	KM13	With
17		KM14	With
18		KM15	With
19		KM16	With

20		KM17	With
21	Contactor TAL16-30-10	KM11	With
22		KM12	With
23	Manual motor starter MS116-2.5(1.6-2.5)	QF3	No
24		QF4	No
25	Manual motor starter MS116-4.0(2.5-4.0)	QF8	No
26	Manual motor starter MS116-16(10-16)	QF1	No
27		QF2	No
28	Thermostat relay FR02	FR1	No
29	Thermostat relay FR01	FR2	No
30	Circuit breaker QF05	QF5	No
31	Circuit breaker QF06	QF6	No
32	Circuit breaker QF07	QF7	No
33	H/L frequency Detector	BTDT-01	NO

Figure 1.20 Control panel

1.2.16 Temperature sensor

The mounting position of the return air temperature sensor is shown in Fig 1.4/Pos.8;

The mounting position of the supply air temperature sensor is shown in Fig 1.4/Pos.10;

The mounting position of the fresh air temperature sensor is shown in Fig 1.4/Pos.14.

A set of temperature sensors are mounted to detect the temperature of the return air /supply air/fresh air. They are located separately in return air inlet, supply air outlet and fresh air inlet. These temperature sensors monitor cooling demand of the saloon. Through them, the FPC controller monitors the various temperatures to select the required mode of operation to give the most suitable comfort conditions for the passengers. (Figure 1.21)

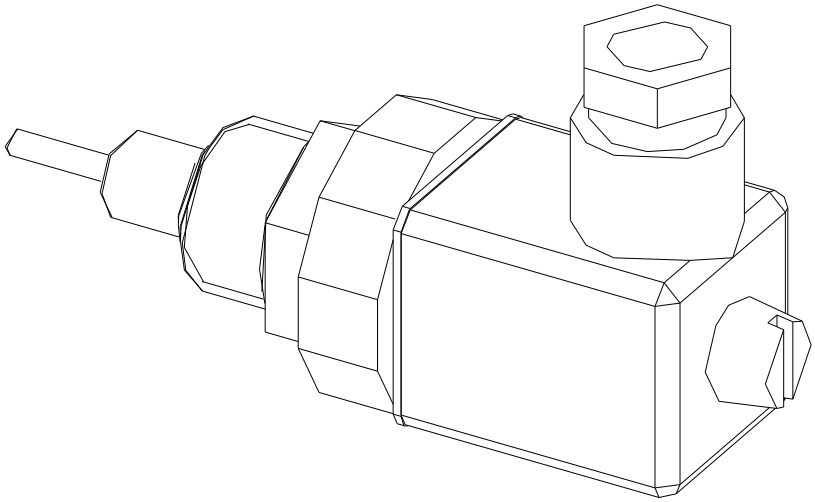


Figure 1.21 Temperature sensor

1.2.17 Controller

All control and regulating functions of the HVAC unit for the individual cars are performed by the software installed in the digital controller FPC 08 in conjunction with the electrical components of the HVAC unit. There is also a DIO8 to expand the inputs and outputs of the FPC08.

The FPC08 is a digital controller with microcomputer control developed by HVAC Faiveley GmbH & Co. It processes and evaluates all control and regulation data, e.g., switching state, temperature, etc. The current operating conditions and required safety precautions are included in the calculations.

There is one digital computer FPC 08 in each unit. The digital computer FPC 08 is the central control and regulating unit for the passenger compartment.
The protection class of the FPC 08 allows it to be held by four screws, it does not need a rack or control cubicle. The digital controller is fitted with push-on terminal strips which act as interface to the peripheral units.

The high requirements, such as high mechanical strain, extended temperature range and widely fluctuating current supply which are common in train operation have been taken into account in the development of the digital controller FPC 08.
The digital controller FPC 08 used in this project operates on 110 V DC. The control and regulating functions are performed by input and output signals of the digital controller.

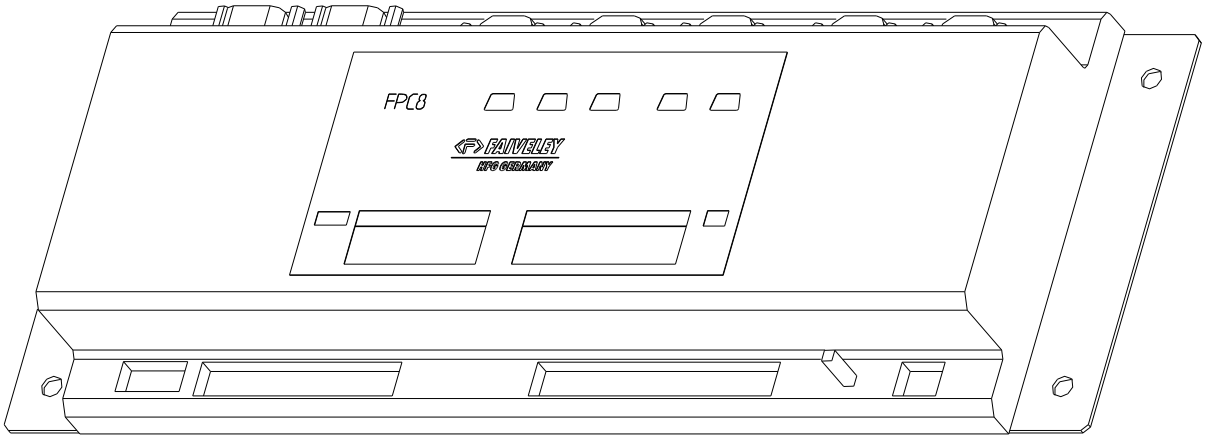


Figure 1.22 Controller FPC08

1.2.18 Transformer

The mounting position of the transformer is shown in Fig 1.4/Pos.9.

The transformer is close to the supply air fans of the HVAC unit. The transformer transform the supply power from 400VAC to 150VAC to power the supply air fans when the supply air fan need to running in low speed.

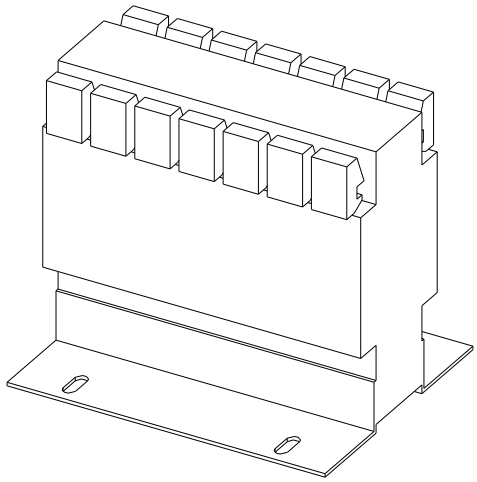


Figure 1.23 Transformer

1.2.19 Unit heater

The mounting position of the unit heater is shown in Fig 1.4/Pos.12.

The unit heater is used to heating the supply air in winter.

It has two steps of heating safety protection. The first step of safety protection is a thermostat act to switch off the heater when the air temperature rise to 70℃, and the second is thermal beaker act to switch off the heater when the air temperature rise to 139℃.

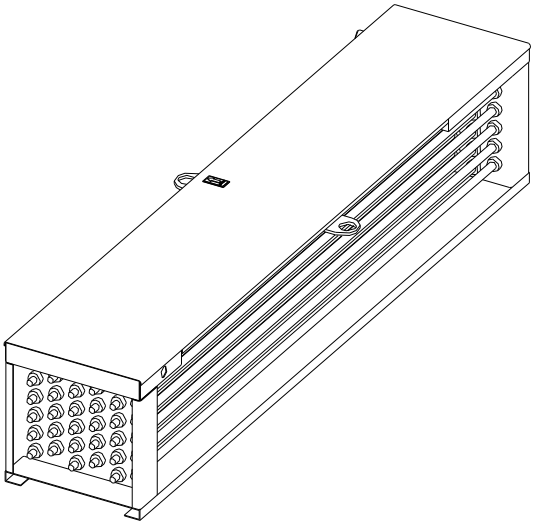


Figure 1.24 Unit heater

1.2.20 Hot gas bypass solenoid valve

The mounting position of the solenoid valve is shown in Fig 1.4/Pos.21.

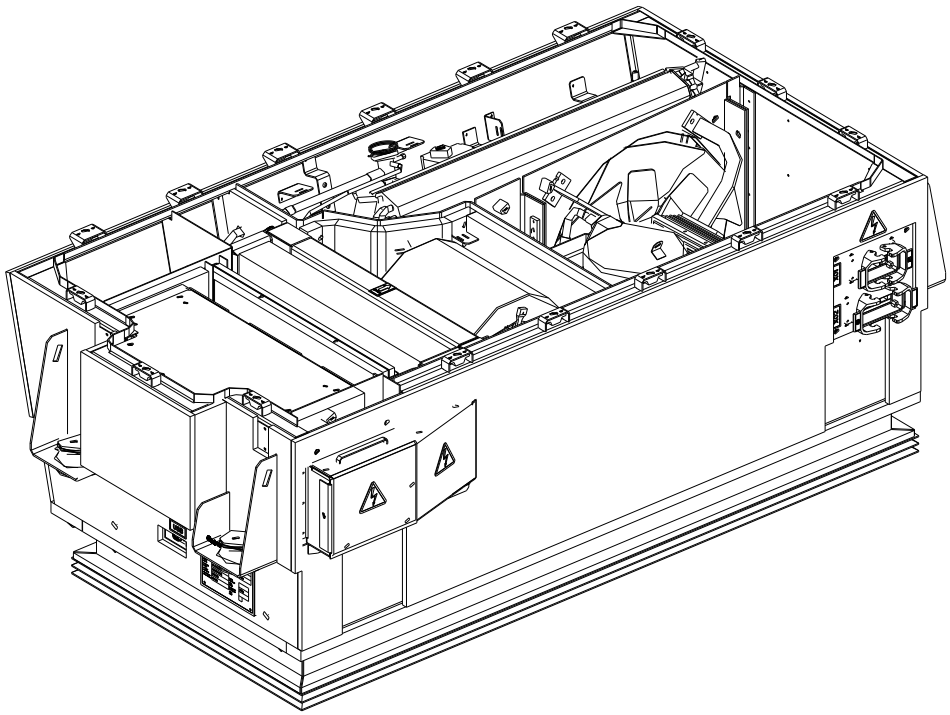
Solenoid valve is used to bypass hot gas to regulate the refrigeration of the compressor, to make the refrigeration performance match the load of the evaporator. (Figure 1.7)

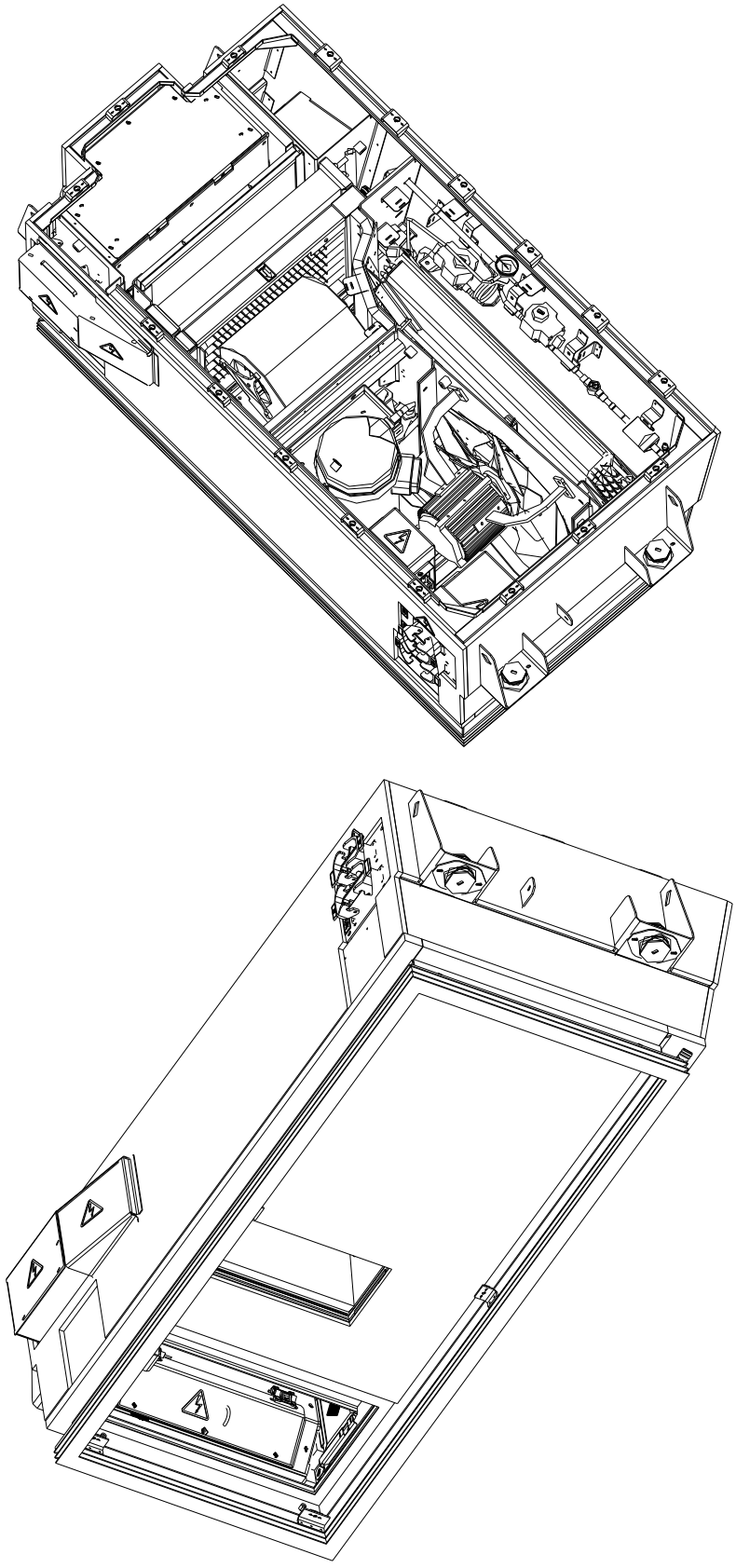
1.3 DESCRIPTION OF CAB HVAC UNIT

1.3.1 Description of Cab HVAC unit

The TC car contains cab, and the cab is equipped with a Cab HVAC unit, the Cooling capacity of the unit is 4.5 kW.There are two cab HVAC units in one train, for supplying comfortable conditioning air to the cabs. In summer, it will working in cooling mode, and in winter in heating mode. The HVAC units supply conditioned air into a ducting system, which is installed above the ceiling of the cab. From the ducting the air is distributed into the cab via adjustable air diffusers, which are integrated in the ceiling of the cab.

The purpose of the HVAC system is to ensure a pleasant temperature and humidity can be achieved inside the cab.





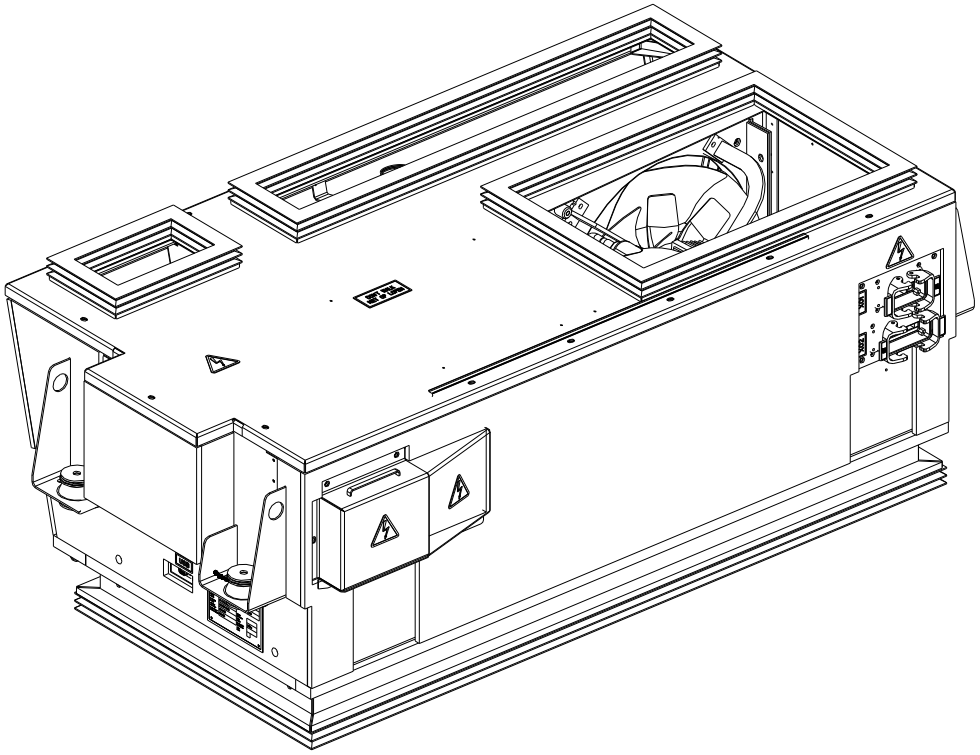


Figure 1.25 Cab HVAC unit

Fresh air enters the HVAC unit through a grille at the top of the unit. Then it is mixed with the return air from the cab, which enters the HVAC unit through the air inlets located under the HVAC unit. The mixed air is cooled and then blown into the ducting system of the cab.

Each HVAC unit comprises the following main components;

- 1 Condenser
- 1 Condenser fan to draw air over the condenser.
- 1 Evaporator used to cool the mixed supply air
- 1 Supply air fan to draw air over the evaporators
- 1 Scroll compressor
- 1 Filter dryer
- 1 Sight glass to inspect refrigerant flow

- 1 High-Pressure switch
- 1 Low-Pressure switch
- 1 Thermostatic expansion value controlling refrigerant flow
- 1 Mixed air filter
- 1 Fresh air filter
- 1 Electrical heater
- 2 Temperature sensors(1 supply air sensor and 1 return air sensor)

In cooling mode, the mixed air (mixed by return air from the cab and fresh air sucked from the ambient), is sucked by the supply air fan through the mixed air filter and the evaporator coil where, by means of refrigerant evaporation, heat is transferred from the air, via the evaporator coil, into the refrigerant. The cooled and de-humidified air passes through the supply air fan and is blown into the cab ducting to be distributed into the cab.

The evaporator section comprises an evaporator, a thermal expansion valves, a fan, a supply air temperature sensor and a mixed air filter.

Each cab's HVAC unit and aerotherm unit are controlled by a microprocessor unit — FPC 08 Controller. The controller acts at all times, by sending the instructions to various components of the HVAC unit, to ensure that the required "set-point" temperature within the cab is maintained and the system is operating safely within its design limits. Each microprocessor unit is connected to the train information system by the CAN bus, which is used to provide signals to start & stop the systems, provide fault data and diagnostic information at the train level.

1.3.2 Operational modes of Cab HVAC system

The selection of operating modes desired is effected via train bus inputs from train system.

Operating modes of HVAC unit are:

- HVAC OFF
- Automatic (Ventilation – Cooling - Heating)
- Emergency mode

Operating modes of aerotherm unit are:

- HVAC OFF
- Automatic (Ventilation - Heating)
- Emergency heating mode

The controller starts relevant modes depending on train bus information, temperature (inside and outside) Furthermore the controller receives feedback from the components and derives the current operation condition. The controller classifies failures and errors are stored in event memory. Operating conditions and error messages will be sent from the digital controller to the train system via train bus.

HVAC off

This mode allow driver to shut down the Cab HVAC and aerotherm unit by 2 switches separately.

Automatic

In automatic mode, the HVAC and aerotherm unit will be completely controlled by the controller. Cooling, heating and ventilation are allowed. HVAC unit performs according to the defined temperature regulation EN14813-1.

If Text > 20°C => TSP = 20 + 0.4 (Text – 20) + Tic

If Text < 20°C => TSP = 20 + Tic

Tic is between -2K and 4K per step of 1K controlled by temperature setting switch.

According to the calculation of cooling, heating or ventilation requirement, the HVAC controller set the unit in proper sub modes:

- Ventilation mode;
- Cooling mode (only HVAC cab unit);
- Heating (In this mode, the system gives the priority to the aerotherm unit. If heating need is more than the aerotherm unit, system will switch on the heater in HVAC cab unit.

Emergency mode

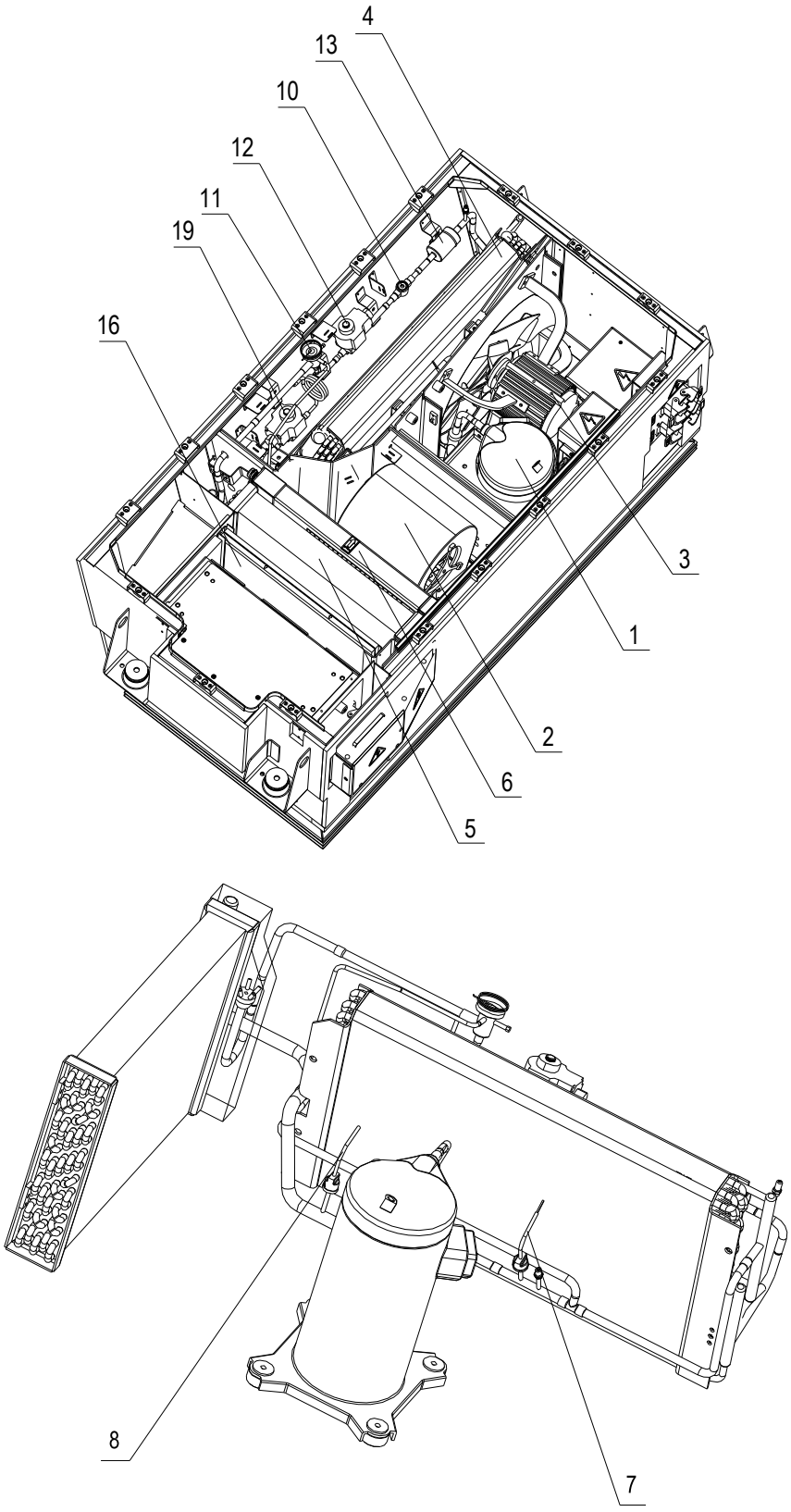
When the unit loose 400Vac (detection by the CP system), the system switches off the heater, the compressor and the condenser fan. The HVAC cab unit will have only ventilation. In emergency mode the power supply is 250VAC 35Hz.

Emergency heating mode

The driver can put the aerotherm switch in position "Emergency heating". Heater of the aerotherm is switch on but the temperature is not regulated. The safety of the heater is assured by the thermostat.

1.4 DESCRIPTION OF COMPONENTS OF CAB HVAC UNIT

The main components of Cab HVAC unit are shown as Figure 1.26.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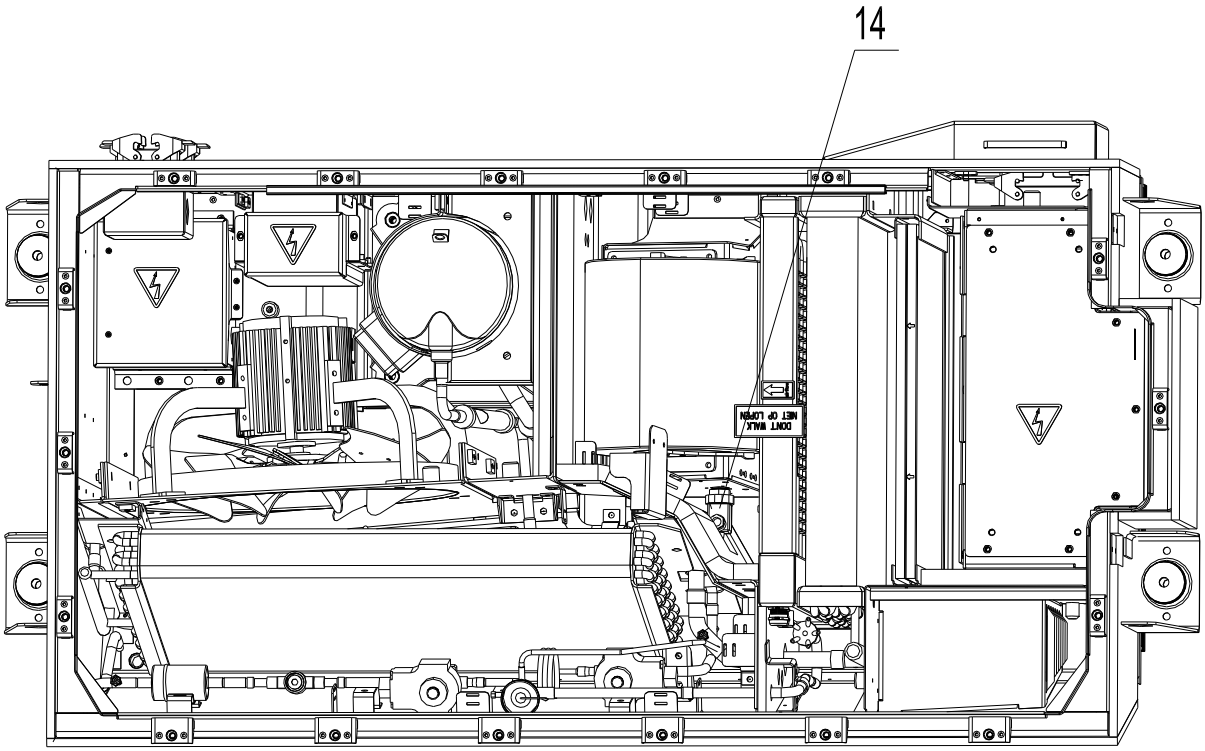
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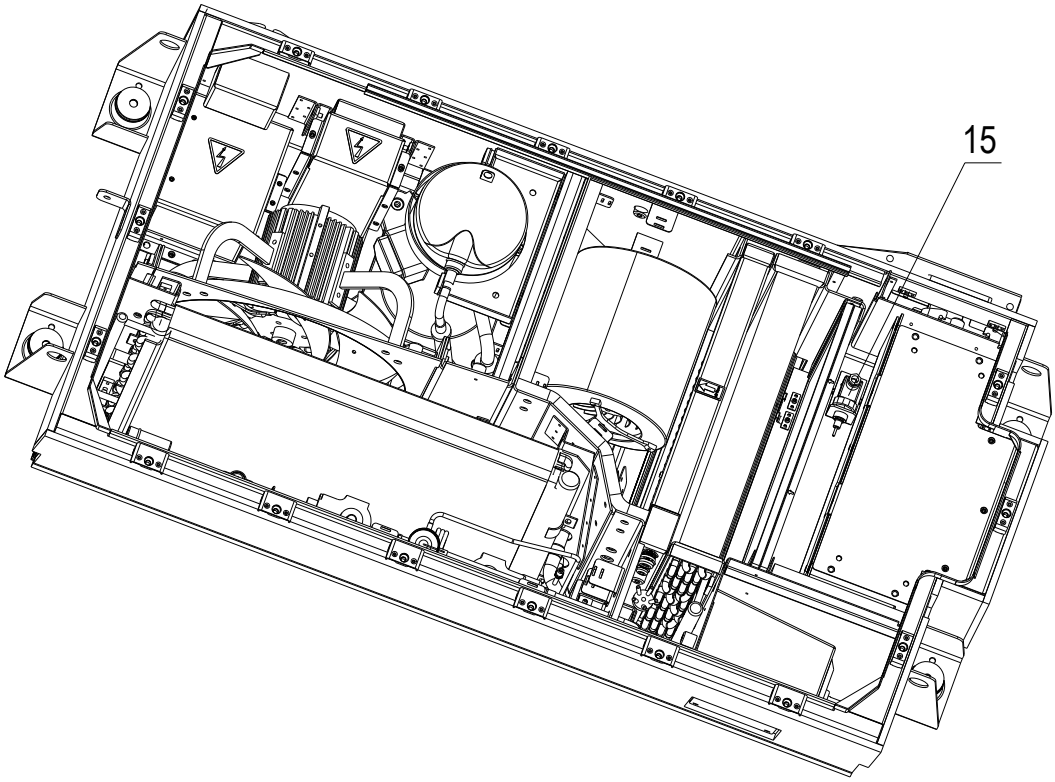
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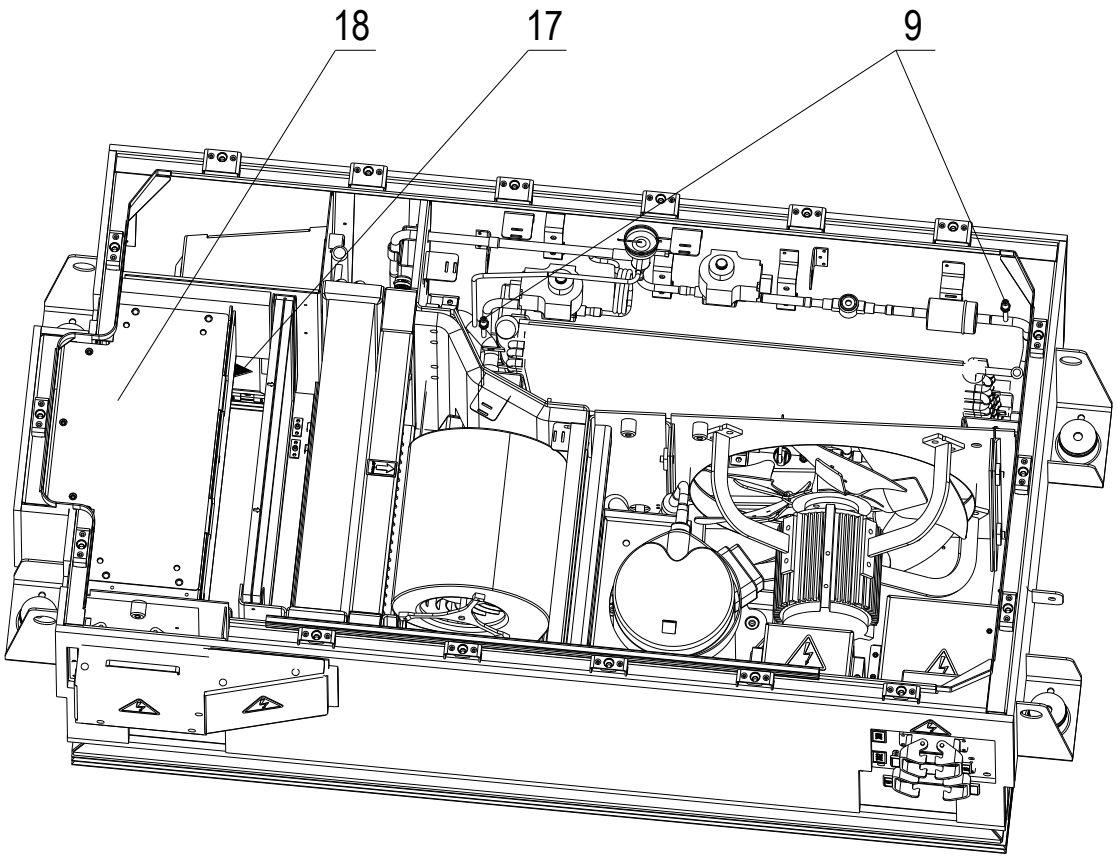


Figure 1.26 Main components of HVAC unit

1 Compressor	*11 Expansion valve*
2 Supply air Fan	*12 Liquid solenoid valve*
3 Condenser fan	*13 Filter dryer*
4 Condenser	*14 Supply air sensor*
5 Evaporator	*15 Return air sensor*
6 Unit heater	*16 Mixed air filter*
7 High pressure switch	*17 Fresh air filter*
8 Low pressure switch	*18 Control panel*
9 Check valve	*19 Hot gas bypass solenoid valve*
10 Sight glass	

1.4.1 Compressor

The mounting position of the compressor is shown in Fig 1.26/Pos.1.

The refrigerating output is produced by a scroll compressor in each unit. The scroll compressor is powered directly by the 3-phase auxiliary supply.

Refrigerant vapour returning from the evaporator at low pressure enters the compressor, which compresses it. The refrigerant exits the compressor as a high pressure, high temperature superheated gas via the compressor's discharge valves and flows to the condenser coils.

The compressor used in the refrigerating system is of a scroll type. The compressor delivers all the superior benefits of advanced scroll technology.

- Quiet operation.
- Unmatched reliability with 70% fewer moving parts than comparably sized reciprocating compressors
- Greater capacity at handling liquid and debris in the system
- High efficiency performance

The compressor includes a thermal protection to protect the motor against failures caused by overheating of the windings, which may be as a result of: lack of gas or excessive starting cycles.

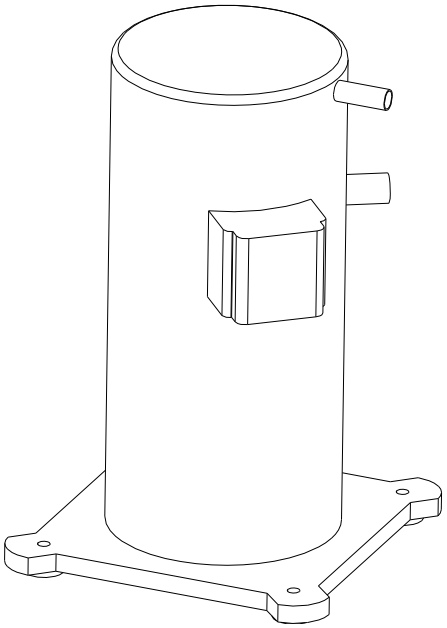


Figure 1.27 Scroll compressor

Each compressor is equipped with 4 vibration dampers to avoid the transmission of the vibration and reduce the noise.

1.4.2 Supply air fan

The mounting position of the supply air fan is shown in Fig 1.26/Pos.2.

To meet the air conditioning requirements of the cab and to overcome the pressure losses in the HVAC unit and supply air duct system, each cab HVAC unit contains 1 supply air fan. Each fan draws both fresh air from outside, via the fresh air filters, and return air from the saloon into the evaporator chamber. In the evaporator chamber the air two streams mix and then are drawn through the evaporator coil before being sucked into the supply air fan. Once the air is sucked into the fans it is expelled into the supply air ducting and distributed into the cab.

Each supply air fan consists of a single 220VAC, 1 phase, 50Hz motor with 1 fan,and a shell.

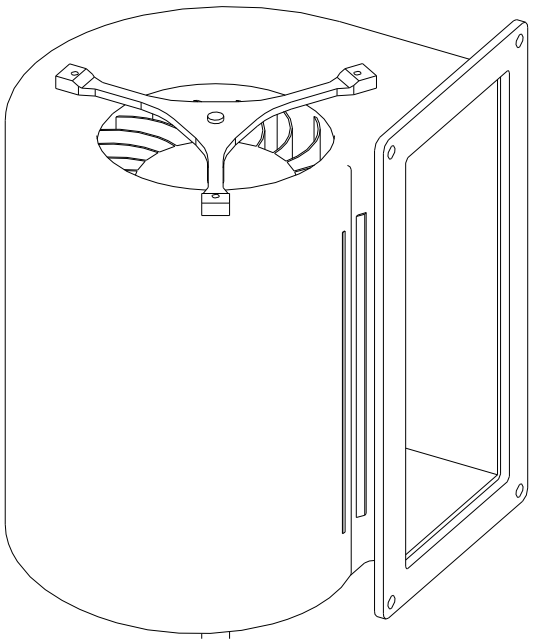


Figure 1.28 Supply air fan

1.4.3 Condenser fan

The mounting position of the condenser fan is shown in Fig 1.26/Pos.3.

Condenser fan consists of fan blade, motor and grille.To ensure a high heat transfer in the condenser coil , a axial fan-motor assemblies draw “cool” ambient air from the sides of the HVAC units through the condenser coils and then discharge the now “hot” back to ambient via the circular grids in the top of the HVAC unit.

Each condenser fan assembly contains a 400VAC, 3 phase, 50Hz motor, which supports a five bladed axial fan fitted in a precision hub and operating in a close-fitting ring (Figure 1.43).It must be noted that the grille can not be walked on. Grille is used to prevent persons from touching the fan blade, protect for items entering the fan.

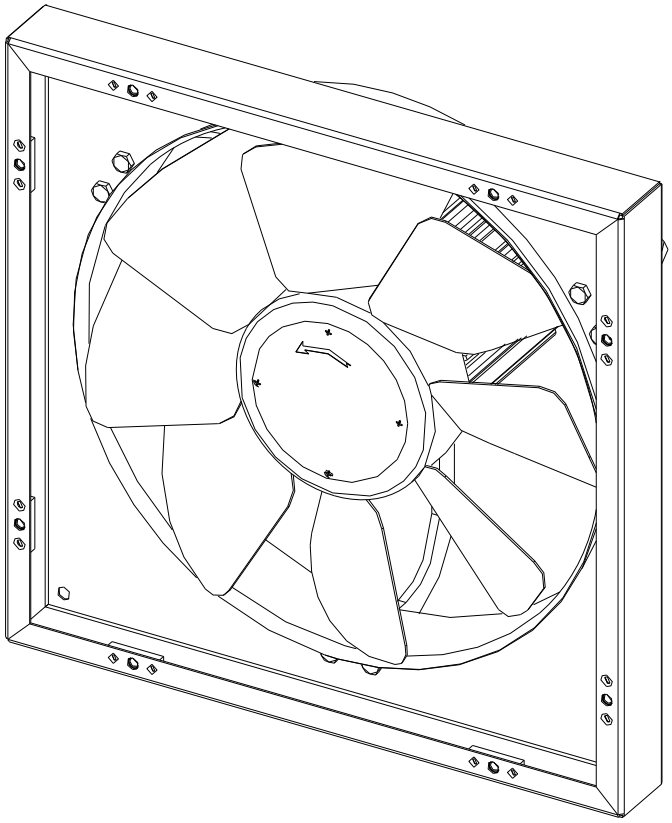


Figure 1.29 Condenser fan

1.4.4 Condenser

The mounting position of the condenser is shown in Fig 1.26/Pos.4.

Each condenser coil (Refer to figure 1.30) is made of inner screw thread copper tubes and Aluminium fins.

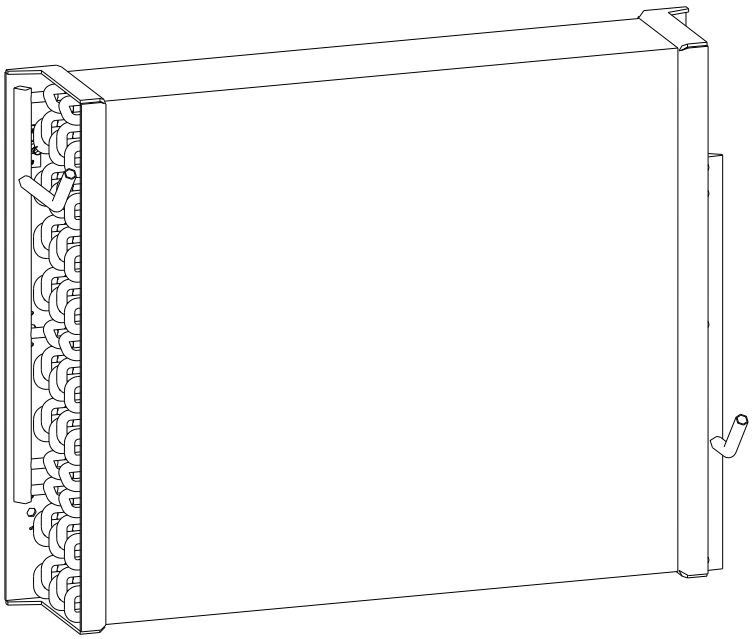


Figure 1.30 Condenser

A condenser fan draw ambient air through the condenser coils. The condenser rejects heat to the ambient air from the high temperature refrigerant gas which is being pumped from the compressor. As the heat is rejected from the coil the refrigerant gas cools and condenses into a liquid refrigerant.

1.4.5 Evaporator

The mounting position of the condenser is shown in Fig 1.26/Pos.5.

Each evaporator coil is made of copper tubes and aluminium fins (figure 1.31).

The liquid refrigerant is vaporized in the evaporator coil at a controlled rate and temperature. The low-pressure and low temperature refrigerant in the evaporator coil absorbs heat from the air sucked across the coil by the supply air fan. The air, which is a mixture of the return air and the fresh air passes through the evaporator coils and is cooled and dehumidified, is delivered into the cab evenly.

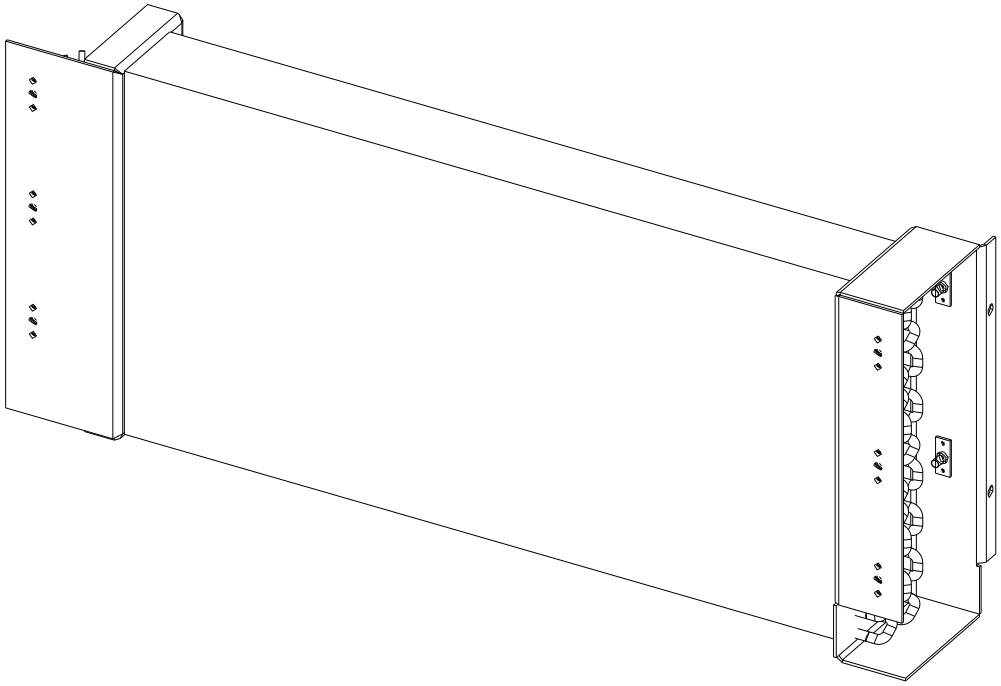


Figure 1.31 Evaporator

1.4.6 Unit heater

The mounting position of the unit heater is shown in Fig 1.26/Pos.6.

The unit heater is used to heating the supply air in winter.

It has two steps of heating safety protection. The first step of safety protection is a thermostat act to switch off the heater when the air temperature rise to 70℃, and the second is thermal beaker act to switch off the heater when the air temperature rise to 139℃.

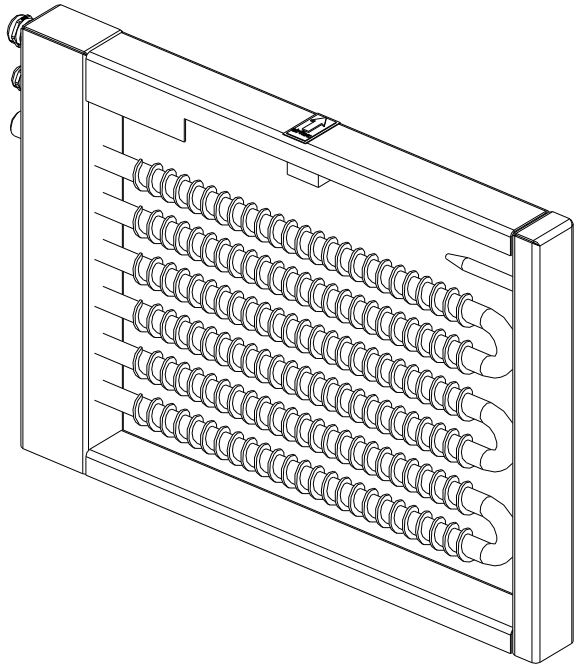


Figure 1.32 Unit heater

1.4.7 High pressure switch

The mounting position of the high pressure switch is shown in Fig 1.26/Pos.7.

The high pressure switch is used for monitoring the high pressure of the system. The high pressure port is connected to the discharge line of compressor. The set value is:

29bar switch off; 24 bar switch on;

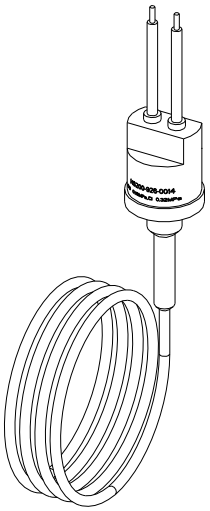


Figure 1.33 High pressure switch

1.4.8 Low pressure switch

The mounting position of the low pressure switch is shown in Fig 1.26/Pos.8.

The low pressure switch is used for monitoring the low pressure of the system. The low pressure port is connected to the suction line of compressor. The set value is:

1.8 bar switch off; 3.2 bar switch on.

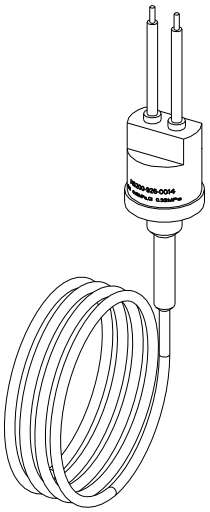


Figure 1.34 Low pressure switch

1.4.9 Schrader valve

The mounting position of the schrader valve is shown in Fig 1.26/Pos.9.

The Schrader valve is used to pump and charge refrigerant to the refrigerant circuit as a maintenance interface.

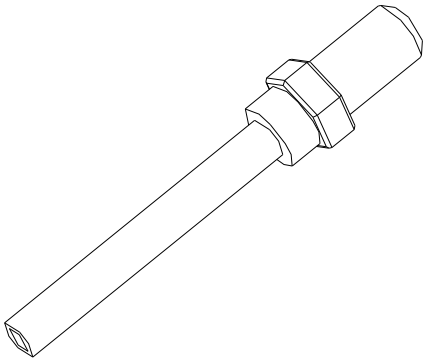


Figure 1.35 Schrader valve

1.4.10 Sight glass

The mounting position of the sight glass is shown in Fig 1.26/Pos.10.

The sight glass is used in refrigerating circuit to observe the refrigerant flow and to provide an accurate method of determining the moisture content of a system's refrigerant. Humidity indication is obtained compared to paper indicators.

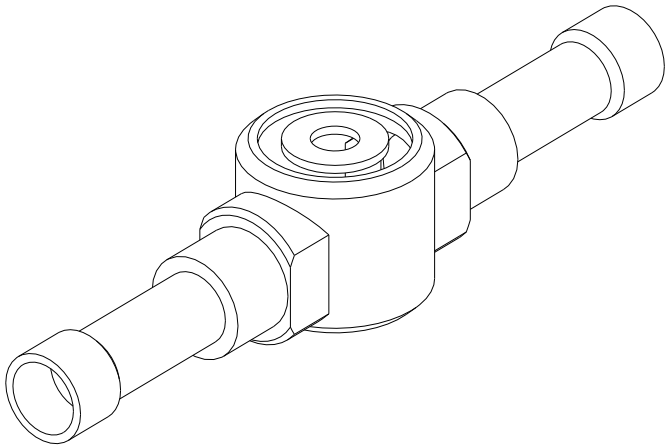


Figure 1.36 Sight glass

1.4.11 Expansion valve

The mounting position of the expansion valve is shown in Fig 1.26/Pos.11.

Expansion Valve is located after the sight glass and close to evaporator. Expansion Valve is used in refrigerating circuit as throttle component. It can open to a certain degree according to the superheat of the outlet of evaporator. Expansion valve is mounted after filter dryer, so the debris in refrigerating circuit is filtered first. Through the expansion valve, the high temperature, high pressure refrigerant liquid changed to low temperature, low pressure refrigerant mixture of gas and liquid.

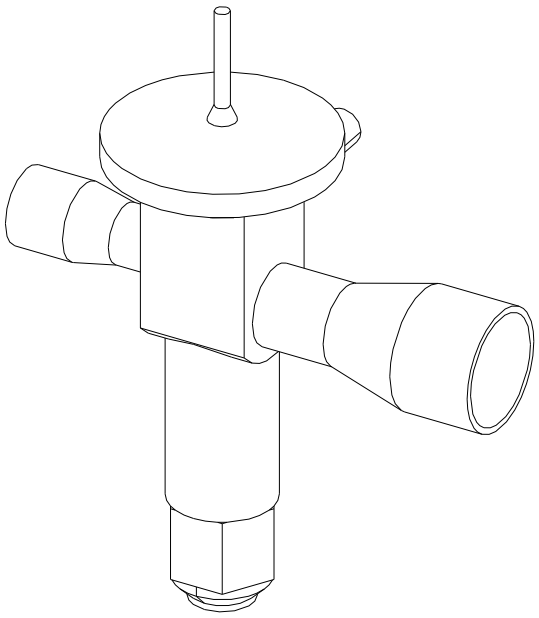


Figure 1.37 Expansion Valve

1.4.12 Liquid line solenoid valve

The mounting position of the solenoid valve is shown in Fig 1.26/Pos.12.

Solenoid valve is used in liquid pipe after Sight glass and before the expansion valve. Solenoid valve is used for controlling the open and close of refrigerant flow. The valve is commonly used to replace a manual valve or where remote control is desirable. The valve improves system efficiency and maintain the refrigerant charge in the condenser coil during the off -cycle of the compressor which prevents refrigerant migration when long piping runs are used.

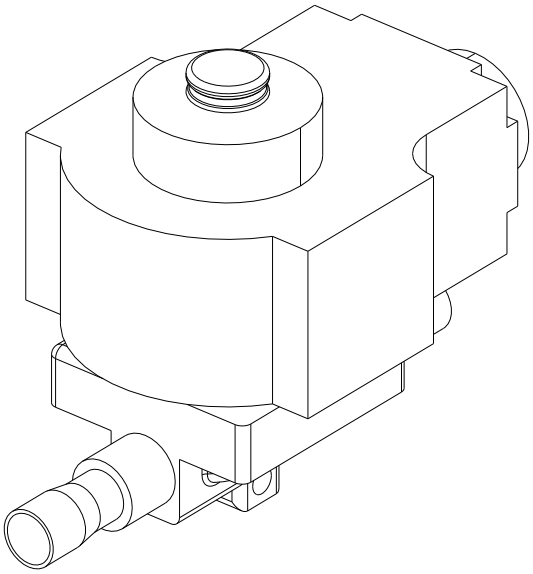


Figure 1.38 Solenoid valve

1.4.13 Filter dryer

The mounting position of the filter dryer is shown in Fig 1.26/Pos.13.

Filter dryer is mounted on the liquid line after the condenser and before the sight glass.

The filter dryer removes moisture and contaminants from the refrigerant (figure 1.39).

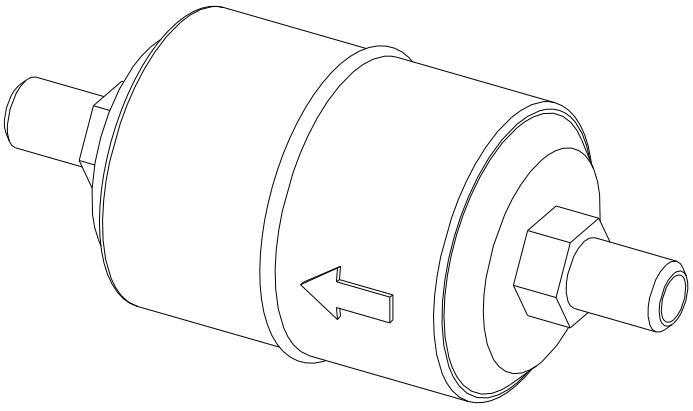


Figure 1.39 Filter dryer

1.4.14 Hot gas bypass solenoid valve

The mounting position of the solenoid valve is shown in Fig 1.26/Pos.19.

Solenoid valve is used to bypass hot gas to regulate the refrigeration of the compressor, to make the refrigeration performance match the load of the evaporator. (Figure 1.38)

1.4.15 Temperature sensor

The mounting position of the temperature sensor is shown in Fig 1.26/Pos.14,15.

A set of temperature sensors are mounted to detect the temperature of the return air and the supply air. They are located in the cab unit. The supply air temperature sensor (Fig 1.26/Pos.14) is located besides the supply air fan, we have to remove the maintenance cover when uninstall and install it. The return air temperature sensor (Fig 1.26/Pos.15) is located in the return air chamber, it is easy to uninstall and install it from the return air opening.

These temperature sensors monitor cooling demand of the cab. Through them, the FPC monitors the various temperatures to select the required mode of operation to give the most suitable comfort conditions for the driver. (Figure 1.40)

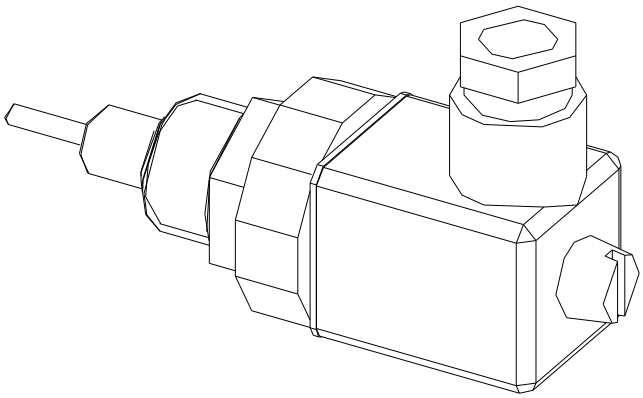


Figure 1.40 Temperature sensor

1.4.16 Filter

The mounting position of the filter is shown in Fig 1.26/Pos.16,17.

The mixed air filter is located close to the evaporator in the evaporator chamber(Fig 1.26/Pos.16), and the fresh air filter is mounted in the evaporator chamber close to the fresh air intake(Fig 1.26/Pos.17).

The HVAC unit incorporates 1 mixed air filter (figure 1.41) and 1 fresh air filter (figure 1.42) for filtering the air that enters the evaporator coils in order to prevent dust, dirt and other solid particles that could get caught in between the coils fins from entering and obstructing the air circulation causing a reduction of the cooling/heating system efficiency.

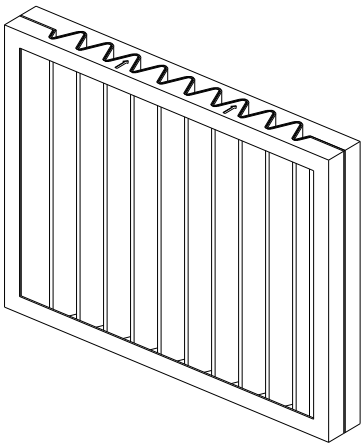


Figure 1.41 Mixed air filter(model)

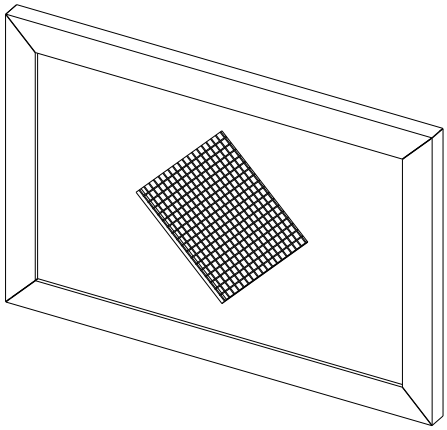
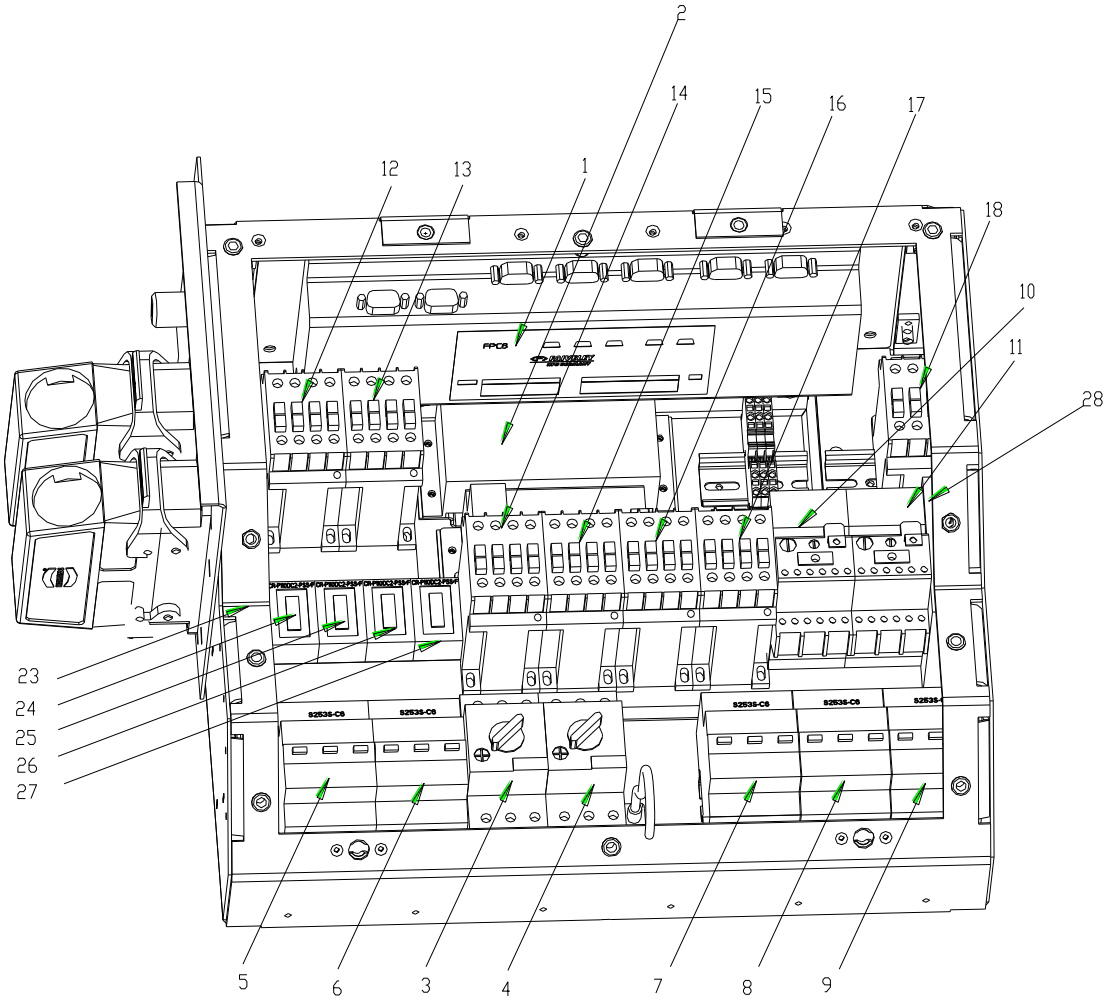


Figure 1.42 Fresh air filter(model)

1.4.17 Control panel

The mounting position of the control panel is shown in Fig 1.26/Pos.18.

The control panel is used to control the operating of the HVAC cab Unit, it located inside the HVAC unit.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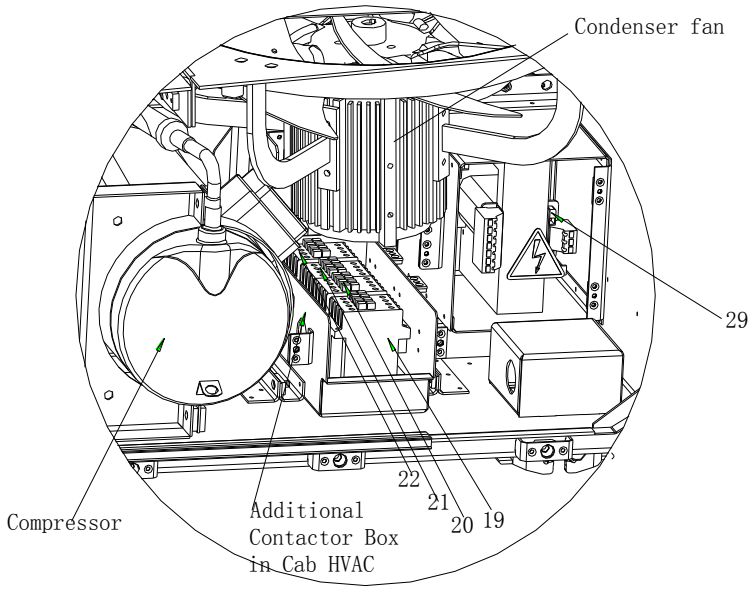

Condenser fan
29
22
21
20
19
Compressor
Additional
Contactor Box
in Cab HVAC

Diode of Contactor

Diode of Intermediate relay

No.	Part name	Description	Diode
1	Programmed logical controller	FPC08	No
2	Frequency detector	BTDT-01	No
3	Manual motor starter	QF1	No
4	Manual motor starter	QF2	No
5	Circuit breaker	QF3	No
6	Circuit breaker	QF4	No
7	Circuit breaker	QF5	No
8	Circuit breaker	QF6	No
9	Circuit breaker	QF7	No
10	Thermostat relay	FR1	No
11		FR2	No
12	Contactor	KM1	With
13		KM2	With

14		KM3	With
15		KM4	With
16		KM5	With
17		KM6	With
18		KM9	With
19		KM7	With
20		KM8	With
21		KM10	With
22		KM11	With
23	Intermediate relay	KA1	With
24		KA2	With
25		KA3	With
26		KA4	With
27		KA5	With
28	Time relay	KT1	No
29	Single phase transformer	MEHT-800-400/ 80-230	No

Figure 1.43 Control panel

1.4.18 Controller

Please refer to chapter 1.2.17.

1.4.19 Single-phase transformer of cab HVAC unit

The outline of the single-phase transformer of cab HVAC unit can see figure 1.44. It is used to transform power supply of 3~400VAC-50Hz to power of 170VAC, 1 phase, 50Hz ,then power the supply air fan. The single-phase transformer is located inside the cab HVAC unit, see figure 1.43 position 29.

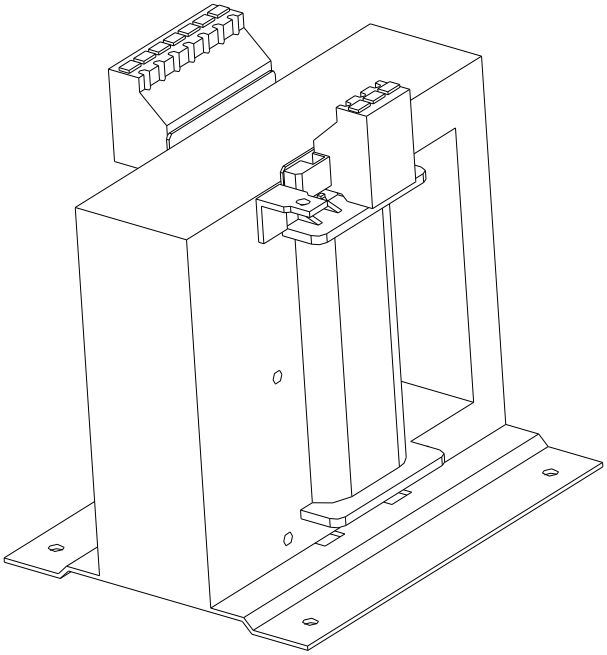


Figure 1.44 single-phase transformer of cab HVAC unit

1.5 DESCRIPTIONS CIRCUIT DIAGRAMS OF HVAC SYSTEM

1.5.1 Detailed description of circuit diagram of saloon HVAC unit

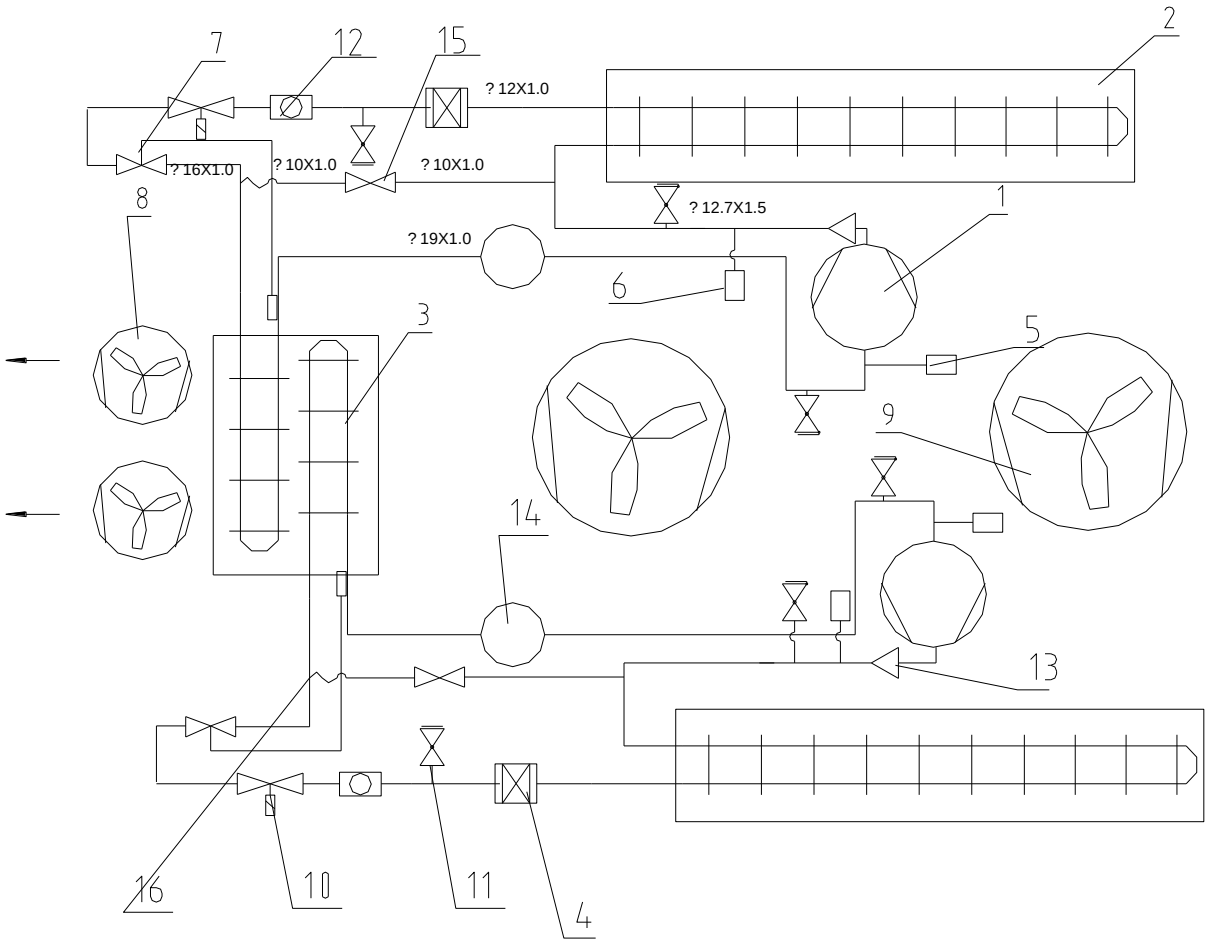


Figure 1.45 Refrigeration circuit of Saloon HVAC unit

No.	Components	Qty	No.	Components	Qty
1	Compressor	2	9	Condenser Fan	2
2	Condenser	2	10	Liquid Solenoid Valve	2
3	Evaporator	1	11	Charging valve	4
4	Filter Dryer	2	12	Sight Glass	2
5	Low Pressure Switch	2	13	Check valve	2
6	High Pressure Switch	2	14	Gas liquid separator	2
7	Expansion Valve	2	15	Hot gas bypass valve	2
8	Supply Air Fan	2	16	Hot gas bypass capillary tube	2

The compressors are designed for parallel service with the an evaporator in the unit. The compressor compresses the refrigerant gas until the saturation temperature of the latter is higher than the outdoor temperature. This causes the gas to condense on the inner wall of the condenser.

To allow this process to occur continuously the so-called heat of condensation must be carried off. The heat is transported by means of finned tube coils, via two powerful fans suck in outside air. The outside air takes up the condensation heat and warms up. The warm outside air is directly blown upwards by the fans through a contact-protection grate.

Two condenser fan motors are provided and they work independently.

When all refrigerant has turned liquid in the condenser it will be slightly undercooled (3 K below saturation temperature). This prevents evaporation before reaching the evaporator which would mean a loss of refrigeration power from the air-conditioning process. Undercooling is possible because the refrigerant circuit contains sufficient

refrigerant so that the bottom of the condenser contains liquid refrigerant in the tube. In the liquid line a refrigerant sight glass is fitted. Upstream of the refrigerant sight glass a generously dimensioned filter dryer is installed, which protects the components inside the refrigerant circuit from soiling and corrosion.

Downstream of refrigerant sight glass there is a solenoid valve each, which is closed when the compressor does not work.

After the liquid refrigerant has passed the solenoid valve, the liquid refrigerant flows into an expansion valve and then is divided between the evaporator working in parallel.

Each thermal expansion valve supplies evaporator with a quantity of liquid refrigerant which can evaporate and slightly overheat (appr. 10 K above saturation temperature) under the given thermal conditions.

Evaporation becomes possible because the thermal expansion valve reduces the refrigerant pressure to a level at which the saturation temperature for this pressure is below the outdoor temperature at the evaporator. To maintain the evaporation process, the so-called evaporation heat is needed, which is supplied by the air flowing past the abundantly finned heat exchanger, which causes the air to cool down.

After evaporate in evaporator, the refrigerant gas come back to compressor via suction line.

This closes the circuit.

1.5.2 Detailed description of circuit diagram of cab HVAC unit

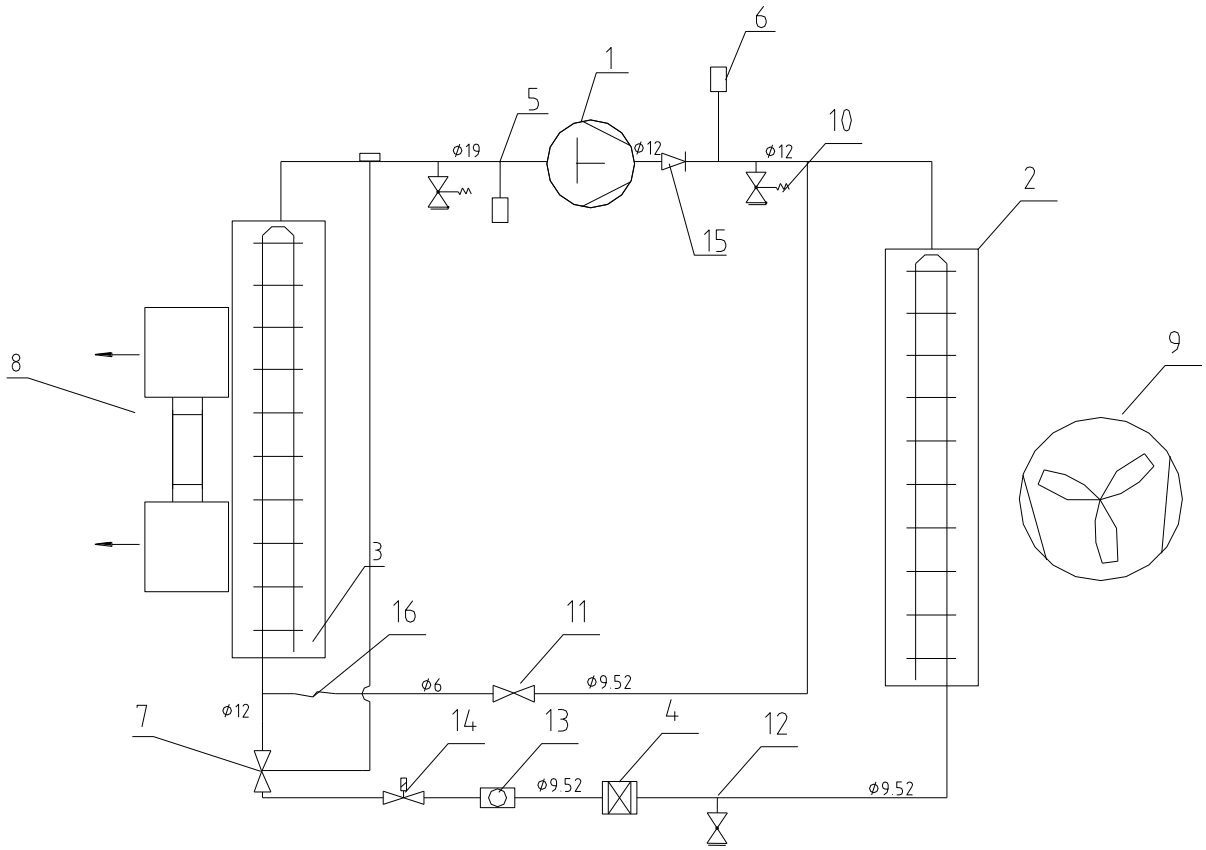


Figure 1.46 Refrigeration circuit of Cab HVAC unit

No.	Components	Qty	No.	Components	Qty
1	Compressor	1	9	Condenser Fan	1
2	Condenser	1	10	Scrader Valve	2
3	Evaporator	1	11	Bypass Solenoid Valve	1
4	Filter Drier	1	12	Charging Valve	1
5	Low Pressure Switch	1	13	Sight Glass	1
6	High Pressure Switch	1	14	Liquid solenoid valve	1
7	Expansion Valve	1	15	Check valve	1
8	Supply Air Fan	1			

The compressor compresses the refrigerant gas until the saturation temperature of the latter is higher than the outdoor temperature. This causes the gas to condense on the inner wall of the condenser.

To allow this process to occur continuously the so-called heat of condensation must be carried off. The heat is transported by means of finned tube coils, via a powerful fan suck in outside air. The outside air takes up the condensation heat and warms up. The warm outside air is directly blown upwards by the fans through a contact-protection grate.

When all refrigerant has turned liquid in the condenser it will be slightly undercooled (3 K below saturation temperature). This prevents evaporation before reaching the evaporator which would mean a loss of refrigeration power from the air-conditioning process. Under cooling is possible because the refrigerant circuit contains sufficient refrigerant so that the bottom of the condenser contains liquid refrigerant in the tube. In the liquid line a refrigerant sight glass is fitted. Upstream of the refrigerant sight

glass a generously dimensioned filter dryer is installed, which protects the components inside the refrigerant circuit from soiling and corrosion.

Downstream of refrigerant sight glass there is a solenoid valve each, which is closed when the compressor does not work.

After the liquid refrigerant has passed the solenoid valve, the liquid refrigerant flows into an expansion valve and then is divided between the two evaporators working in parallel.

Each thermal expansion valve supplies the evaporator with a quantity of liquid refrigerant which can evaporate and slightly overheat (appr. 10 K above saturation temperature) under the given thermal conditions.

Evaporation becomes possible because the thermal expansion valve reduces the refrigerant pressure to a level at which the saturation temperature for this pressure is below the outdoor temperature at the evaporator. To maintain the evaporation process, the so-called evaporation heat is needed, which is supplied by the air flowing past the abundantly finned heat exchanger, which causes the air to cool down.

After evaporate in evaporator, the refrigerant gas come back to compressor via suction line.

This closes the circuit.

1.6 CAB AEROTHERM UNIT

1.6.1 Instruction

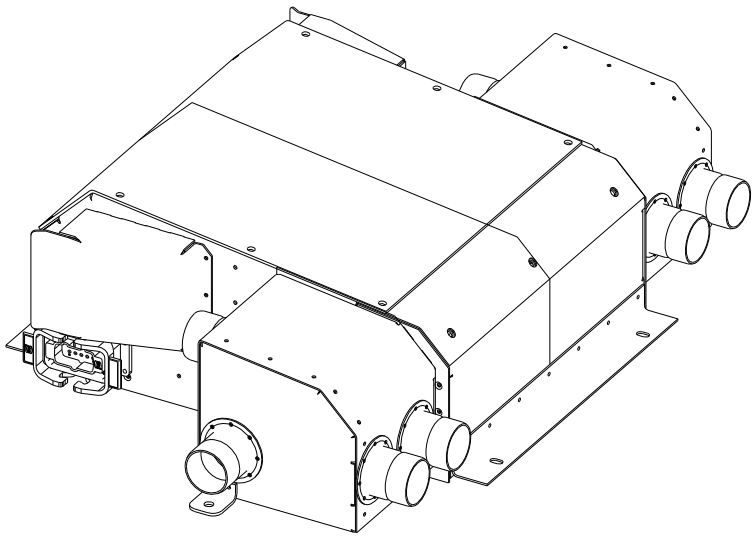
Each cab will be equipped with one compact aerotherm unit, which is located under the driver's desk. The aerotherm unit consists of supply air fan and one electrical heater with safety elements.

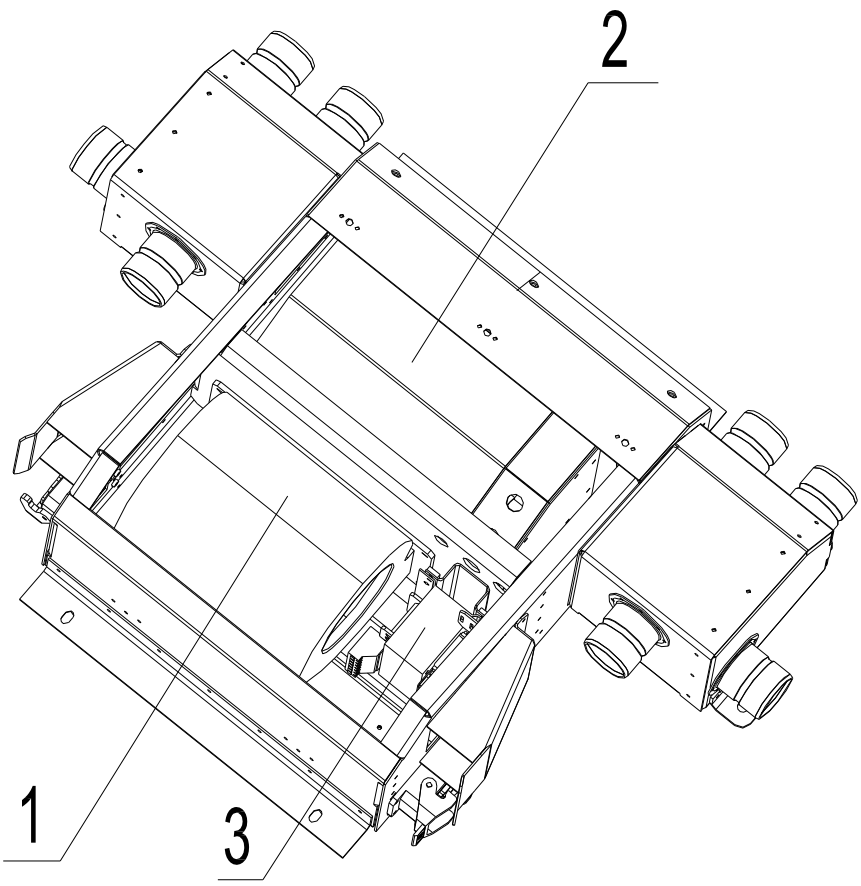
The control system calculates the need of the cab (heating, ventilation, cooling). If the need is heating the system gives the priority to the aerotherm. If the need is more than the aerotherm can give in this case the system uses also the heater inside the unit.

It is also used in emergency heating mode: When the driver put the switch on this mode the heater is switched ON independently from the regulation. It is especially the case when there is a failure of the electronic card. In this mode the internal temperature is not regulated. Please see 1.3.2.

1.6.2 Description

The outline of the cab aerotherm unit can see figure 1.47.It is used to compensate the quantity of heat of cab.





1.Supply air fan 2. Heater 3. single-pahse transformer

Figure 1.47 Aerothern unit

1.6.3 Supply air fan of cab aerotherm unit

The outline of the supply air fan of cab aerotherm unit can see figure 1.48.It is used to supply heat air to cab. The supply air fan is located inside the cab aerotherm unit,see figure 1.47 position 1.

Each supply air fan consists of a single 220VAC, 1 phase, 50Hz motor with 1 fan, and a shell.

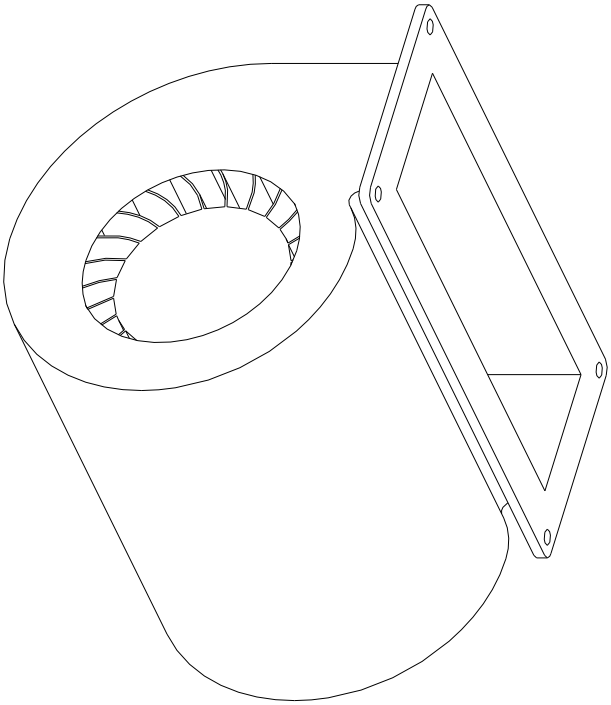


Figure 1.48 Supply air fan of cab aerothern unit

1.6.4 Heater of of cab aerotherm unit

The outline of the heater of cab aerotherm unit can see figure 1.49. It is used to heat the air. The heater is located inside the cab aerotherm unit, see figure 1.47 position 2. The power supply of the heater is 3~400VAC-50Hz,and its Heating capacity is 2.5KW. It is also have two heating protection devices: thermostat and thermal breaker, please refer to 1.2.19.

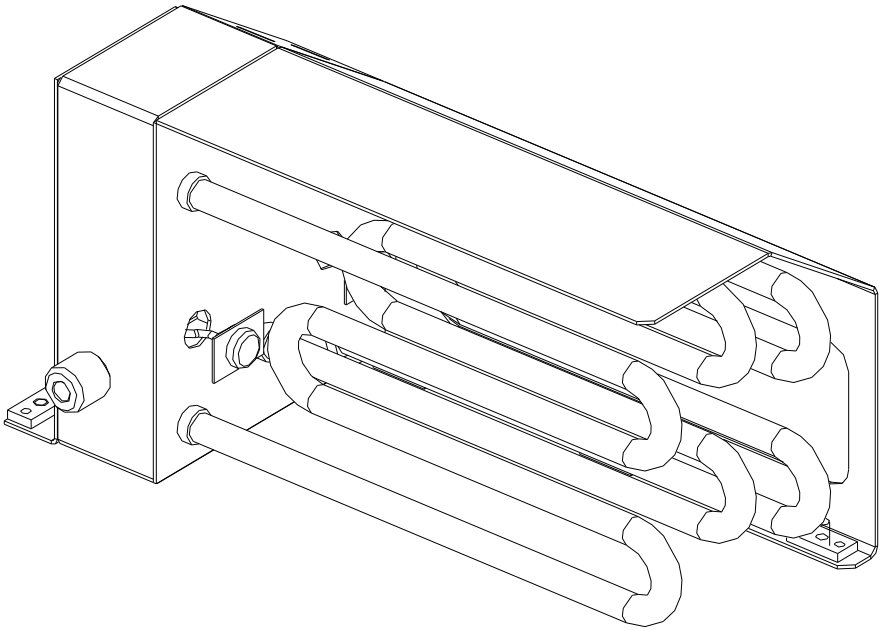


Figure 1.49 Heater of cab aerothern unit

1.6.5 Single-phase transformer of cab aerotherm unit

The outline of the single-phase transformer of cab aerotherm unit can see figure 1.50. It is used to transform power supply of 3~400VAC-50Hz to power of 220VAC, 1 phase, 50Hz ,then power the supply air fan. The single-phase transformer is located inside the cab aerotherm unit, see figure 1.47 position 3.

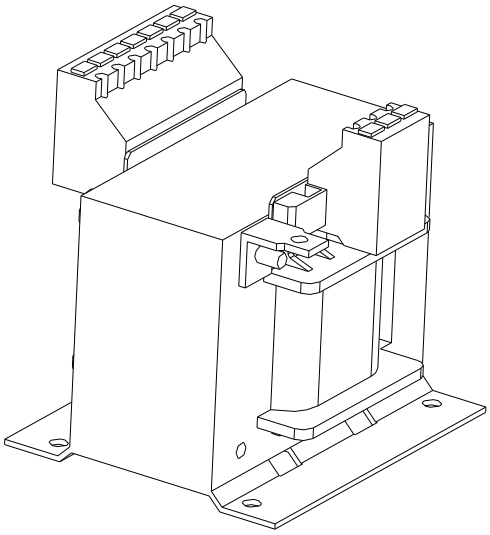


Figure 1.509 single-phase transformer of cab aerothern unit