**LOS ANGELES COUNTY**

**METROPOLITAN TRANSPORTATION AUTHORITY**

**LIGHT RAIL VEHICLE**

# P2550

**RUNNING MAINTENANCE AND SERVICE MANUAL**

**VOLUME M-01**
**PART I**
**THEORY OF OPERATION**
**SECTION 05 - HVAC**

# SECTION 05

## HEATING, VENTILATION & AIR CONDITIONING

## PART I

## THEORY OF OPERATION

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# SECTION 05

## HEATING, VENTILATION & AIR CONDITIONING

### 05-I-01 INTRODUCTION

This Section of the Running Maintenance and Service Manual is divided into three Parts:

- Part I: Theory of Operation
- Part II: Troubleshooting
- Part III: Maintenance

Each Paragraph is numbered accordingly, to avoid that paragraphs of the same Section, pertaining to a different Part, have the same number.

Part I - Theory of Operation

Part I gives a thorough overlook of the System structure and operation, by means of descriptions, figures, photos, schematics, block diagrams and flow charts, together with references to other documents or Sections when needed.

Part II - Troubleshooting

It gives the Maintenance Technicians a path to troubleshoot the System in every condition by means of the available tools:

- The PTU, equipped with the specific SW program
- The IDU
- The Fault Isolation Table

The Part III - Maintenance consists of:

- Preventive Maintenance
- Corrective Maintenance
- Consumable Materials
- Test Equipment , Tools & Special Tools

## 05-I-01.a LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

The Abbreviations, Acronyms and Symbols commonly used throughout this manual are given below with their related meaning.

| Abbreviation | Meaning |
|---|---|
| AB | AnsaldoBreda |
| APS | Auxiliary Power Supply |
| BHP | Pressure Switch, High Pressure |
| BLP | Pressure Switch, Low Pressure |
| BMP | Pressure Switch, Modulation Pressure |
| BRAS | Return Air Sensor |
| C/L | Centerline |
| CB | Circuit Breaker |
| CCH | Communication Control Head |
| CCU | Climate Control Unit |
| CM | Coast Motoring |
| DVE | Discharge Vibration Eliminator |
| EXP | Expansion Valve |
| FD | Filter Drier |
| GTW | Gateway |
| HV | High Voltage |
| HVAC | Heating, Ventilation & Air Conditioning |
| HW | Hardware |
| IDU | Integrated Diagnostic Unit |
| IP | Ingress Protection Rating |
| KO | Out of Service |
| LED | Light Emitting Diode |
| LH | Left Hand Side |
| LRV | Light Rail Vehicle |
| LV | Low Voltage |
| LVDS | Low Voltage Distribution System |
| LVPS | Low Voltage Power Supply |
| MV | Medium Voltage |
| MVB | Multifunction Vehicle Bus |
| OK | Working |
| PTU | Portable Test Unit |
| RH | Right Hand Side |
| SB | Service Brake |
| SCEB | Slide Controlled Emergency Brake |

| Abbreviation | Meaning |
| --- | --- |
| SRV | Safety Relief Valve |
| SVE | Suction Vibration Eliminator |
| SW | Software |
| SWT | Switch, A/C Unit AUTO-OFF-TEST |
| TBS | To Be Supplied |
| TCMS | Train Communication System |
| TCN | Train Communication Network |
| TWC | Train-to-Wayside Communication |
| WTB | Wired Train Bus |
| YLL | Solenoid Valve, Liquid Line |

## 05-I-01.b LIST OF DEFINITIONS

The Definitions commonly used throughout this manual are given below with their related meaning.

| Definition | Meaning |
|---|---|
| // | Parallel |
| 'A' body section | The section of an articulated vehicle containing the pantograph |
| 'B' body section | The section of an articulated vehicle not containing the pantograph |
| AW0 | Empty car operating weight |
| AW1 | Full seated load plus AW0 |
| AW2 | Standees at 4 persons per square meter plus AW1 |
| AW3 | Standees at 6 persons per square meter plus AW1 |
| AW4 | Standees at 8 persons per square meter plus AW1 |
| Front door | The door close to the Operator's Cab |
| Rear door | The door close to the Articulation Section |

## 05-I-01.c LIST OF MEASUREMENT UNITS AND SYMBOLS

The Measurement Units commonly used throughout this manual are given below with their related meaning.

| Definition | Meaning |
|---|---|
| Ω | Ohm |
| °C | Celsius degree |
| °F | Fahrenheit degree |
| A | Ampere |
| ac | Alternate Current |
| dB | Decibel |
| dc | Direct Current |
| ft | Foot |
| gal | Gallon |
| Hz | Hertz |
| in | Inch |
| kg | Kilogram - approx 2.205 pounds |
| km | Kilometer - approx 0.621 miles |
| kN | Kilo-Newton - approx 224.809 pounds force |
| kVA | Kilo Volt Ampere |
| lb | Pound |
| lb-ft | Pound force |
| lps | Liters per Second |
| m | Meter - approx 3.28 feet |
| mH | Milli Henry |
| mm | Millimeter - approx 0.0394 inches |
| ms | Milli second |
| Pa | Pascal |
| psig | Pounds per square inch |
| rms | Root Mean Square Voltage |
| rpm | Revolution per Minute |
| V | Voltage |
| Vin | Input Voltage |
| W | Watt |

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# 05-I-02 THEORY OF OPERATION

## 05-I-02.01 General Description of the System

The HVAC consists of two independent and identical systems, one per Vehicle Body Section.

Each HVAC System is made up of a Climate Control Unit (CCU) connected to the Air Distribution System which delivers the treated air in the Passenger compartment and in the Operator Cab.

The Climate Control Unit (CCU), supplied by Thermo King Corporation for the P2550 Light Rail Vehicle, is an automatically controlled, self-contained, hermetically sealed roof-mount unit.

Each CCU contains two compliant scroll compressors operating in two independent refrigerant circuits.

The cooling is accomplished by pulling return air from the car interior into a chamber where it mixes with fresh air ducted in from the end of the unit.

The mixed air then passes through the evaporator coil, where it is cooled, dehumidified, then warmed in the heaters (if needed) before it enters the fans.

The fans pressurize the cooled air and discharge it out the bottom of the unit into the vehicle air distribution ducts (refer to paragraph 05-I-02.03).

The refrigerant system is hermetically sealed.

Major components such as the evaporator blower assembly, return air filters and the condenser fan assemblies are arranged for easy access and service from the rooftop level.

Both hinged and removable access covers and grilles are used to provide complete service access to all unit components requiring service or maintenance.

The microprocessor controller and electrical control system components are located in the control box that is accessible from the return air plenum. The controller is removable through the return air plenum.

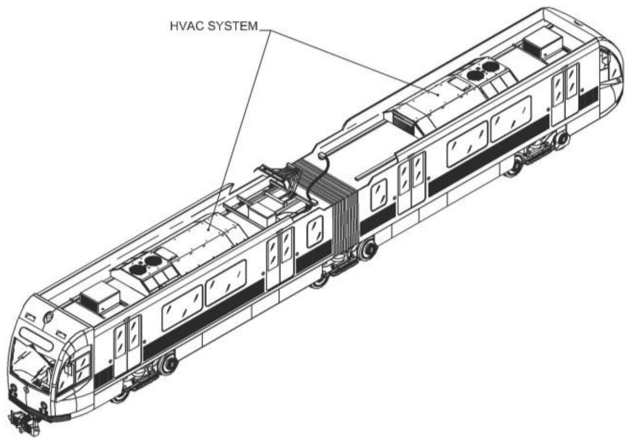



**Figure 05-I-02.1 HVAC Location**

### i. System-Vehicle Relationship

The interconnections of the HVAC System with the other vehicle systems are very limited.

The HVAC system is interconnected with:

- The LVDS (through the Relay Logic, refer to Section 10). The LV Signals are listed in Table 05-I-02.5
- The IDUs through the MVB bus (refer to Section 18). The MVB Signals are listed in Table 05-I-02.6 through Table 05-I-02.13)
- The TCU, through the MVB bus, to acquire the Propulsion System Status

Figure 05-I-02.2 describes the HVAC System - Vehicle Relationship.

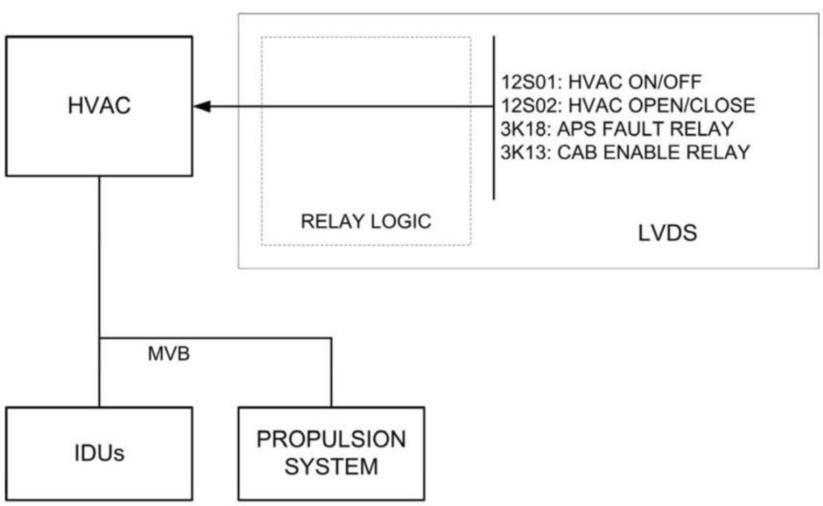



**Figure 05-I-02.2 System - Vehicle Relationship**

The Operator can manage the HVAC System directly from the Active Cab through:

- The HVAC ON/OFF Switch (12S01) Relay Logic (LVDS)
  (refer to Figure 05 -I-02.3)
- The HVAC Dampers Open/Close Switch (12S02) Relay Logic (LVDS) (refer to Figure 05-I-02.4)
- The IDU - HVAC System Status Screen: (Refer to Section 18)

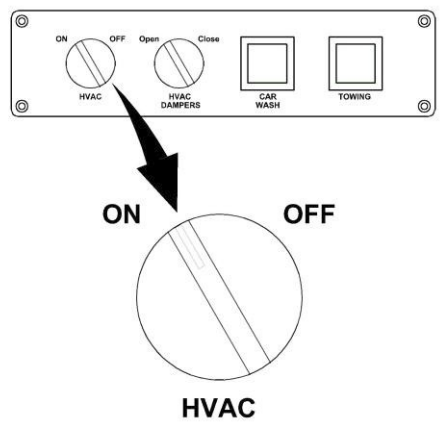



**Figure 05-I-02.3 12S01: HVAC ON/OFF Switch**

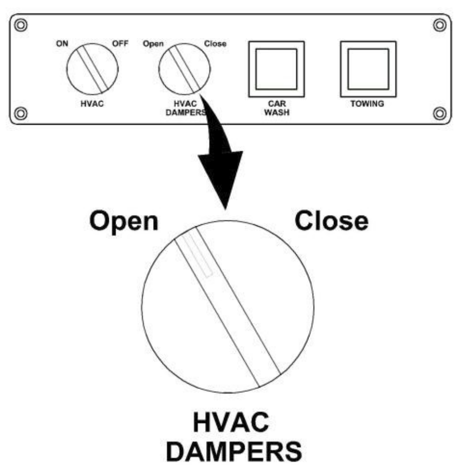



**Figure 05-I-02.4 12S02: HVAC Dampers Open/Close Switch**

Independently from the Operator request, the Relay Logic shuts down the HVAC System if the APS is out of service (the 3K18 Relay is de-energized) and if the vehicle is in Car Wash Mode.

[redacted]

[redacted]

## ii. System-Equipment Relationship

[redacted]

### iii. CCU Performances and Characteristics

**A/C System Specifications:**

| | |
|---|---|
| Compressor Model No.: | ZR61KCE-TF5, Hermetic Scroll |
| Refrigerant: | R-407C |
| Refrigerant Charge: | 26.5 lb |
| System Compressor Oil Capacity: | |
| Replacement Compressor Charge (each): | 1.69 liter (57 oz.) |
| Additional Refrigeration System Charge: | 1.2 liter (41 oz..) |
| Total Charge: | 4.6 liter (175 oz.) |
| Compressor Oil Type: | Polyol Ester Based Type (required)<br>TK Part No. 203-433 |
| High Pressure Cutout Switch: | Open 450 +/- 10 psig<br>Close 315 +/- 15 psig |
| Modulation Pressure Switch: | Open 390 +/- 12 psig<br>Close 315 +/- 12 psig |
| Low Pressure Cutout Switch: | Open 5 to 17 in. Hg vacuum<br>Close 1 to 7 psig |
| High Pressure Relief Valve: | Relief Pressure 550 to 700 psig |
| Liquid Line Solenoid Valve: | Type TK P/N 306-1807<br>Voltage 24 Vdc |
| Compressor Overload Set point: | 24 A |
| Condenser Overload Set point: | 4 A |
| Evaporator Overload Set point: | 13 A |
| Interface Control Voltage: | 37.5 Vdc, 6A |
| Power Supply: | 208 Vac, 60 Hz, 3 phases |

**WARNING:** **WHEN THE COMPRESSOR IS REMOVED FROM THE UNIT, OIL LEVEL SHOULD BE NOTED OR THE OIL REMOVED FROM THE COMPRESSOR SHOULD BE MEASURED SO THAT THE SAME AMOUNT OF OIL CAN BE MAINTAINED IN THE REPLACEMENT COMPRESSOR.**

**WARNING:** **DO NOT USE OR ADD STANDARD SYNTHETIC OR MINERAL OIL TO THE REFRIGERATION SYSTEM. IF ESTER BASED OIL IS CONTAMINATED WITH MOISTURE OR WITH STANDARD OILS, DISPOSE OF IT PROPERLY - DO NOT USE IT!**

### Electrical System

Circuit Breakers:

| | |
|---|---|
| Controller Circuit (QSUP): | 6 A |
| Compressor #1 (QCOM1): | 24 (20 -25) A |
| Compressor #2 (QCOM2): | 24 (20 -25) A |
| Condenser Fan Motor #1 (QCFM): | 4 (2.2 - 5) A |
| Condenser Fan Motor #2 (QCFM): | 4 (2.2 - 5) A |
| Evaporator Fan Motor #1(QEFM): | 13 (11 - 16) A |
| Heater #1 (QHTR1): | 25 A |
| Heater #2 (QHTR2): | 25 A |

Thermal Overload Current Setting:

| | |
|---|---|
| Compressor#1: | Overload Set point 24 A |
| Compressor#2: | Overload Set point 24 A |
| Condenser Fan Motor #1: | Overload Set point 4 A |
| Condenser Fan Motor #2: | Overload Set point 4 A |
| Evaporator Fan Motor #2: | Overload Set point 13 A |
| Heater #1: | Overload Set point 25 A |
| Heater #2: | Overload Set point 25 A |

Compressor Motor:

| | |
|---|---|
| Type: | 208V, 60 Hz, 3 Phases |
| Number: | 2 |
| Kilowatts (60 Hz): | 6.3 kW |
| Horsepower (60 Hz): | 8.5 hp |
| RPM (60 Hz): | 3,450 rpm |
| Full. Load Amps (60 Hz): | 20.7 A |
| Locked Rotor Amps (50 Hz): | 128 A |

Condenser Fan Motors:

| | |
|---|---|
| Type: | 208V, 60 Hz, 3 Phases |
| Number: | 2 |
| Kilowatts (60 Hz): | 0.75 kW each |
| Horsepower (60 Hz): | 1 hp each |
| RPM (60 Hz): | 1,725 rpm |
| Full Load Amps (60 Hz): | 4 A |
| Locked Rotor Amps (60 Hz) : | 26 A |

| | |
|---|---|
| Evaporator Blower Motor: | |
| Type: | 208V, 60 Hz, 3 Phases |
| Number: | 1 |
| Kilowatts (60 Hz): | 2.98 kW |
| Horsepower (60 Hz): | 4.0 hp |
| RPM (60 Hz): | 1,725 rpm |
| Full Load Amps (60 Hz) | 12.8 A |
| Locked Rotor Amps (60 Hz): | 103.5 A |
| Heaters (Low Heat) Stage1: | 9 kW |
| Heaters (Full Heat) Stage2: | 18 kW |
| Thermal Overheat Protection Thermostat: | 1-stage Open 194°F<br>2-stage Open 284°F |

**Physical Specifications**

| | |
|---|---|
| LRV 8T Base Unit (net weight): | 1,270 lb |
| Component Weight: | |
| Compressor: | 90 lb |
| Condenser Fan Motor: | 37 lb |
| Evaporator Blower Motor: | 66 lb |

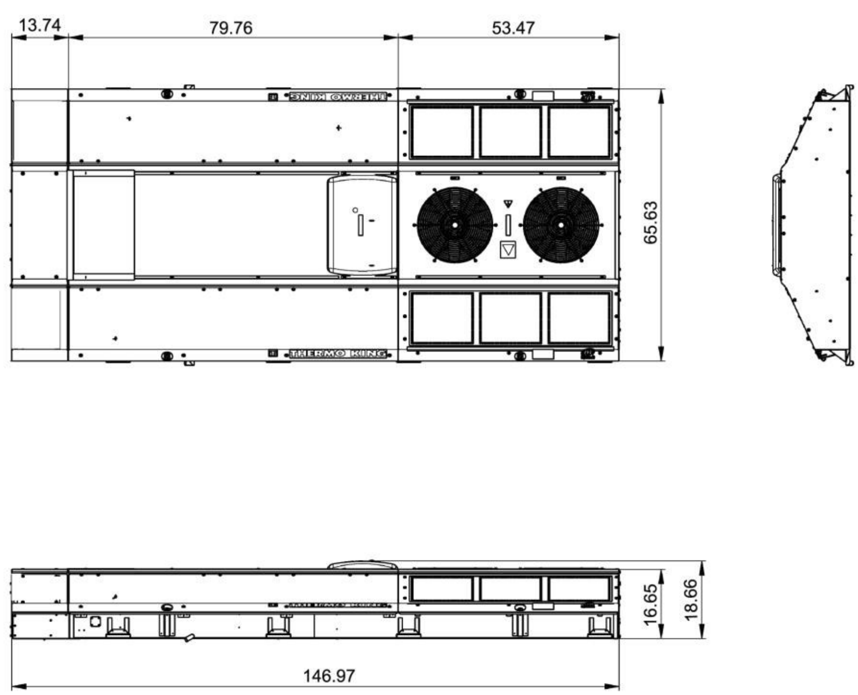



**Figure 05-I-02.8 CCU Dimensions**

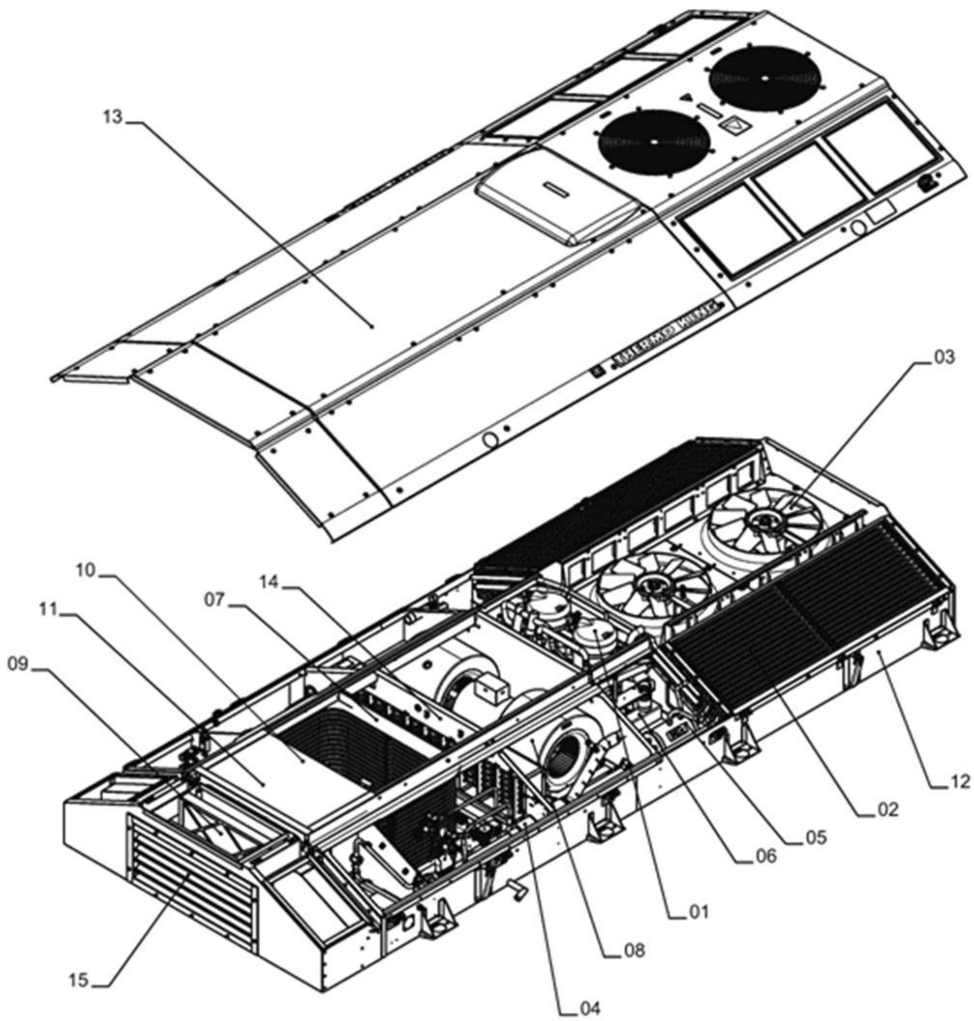
### 05-I-02.02 Climate Control Unit (CCU)

The Climate Control Unit manages the air temperature automatically (through the HVAC electronic equipment).

Nevertheless, the operator can choose to turn the system ON or OFF or to force the “Ventilation Only” Mode.

The main HVAC components are (Refer to Figure 05-I-02.9):

1. Scroll Compressors (2)
2. Condenser Coils (2)
3. Condenser Fans and Motors (2)
4. Dehydrator
5. Liquid Receiver Tank
6. Vibration Eliminators (2)
7. Evaporator Coil Assembly and Solenoid Valves
8. Evaporator Blower Assembly
9. Air Filters
10. Control Box
11. Microprocessor Controller
12. Structural Frame
13. Covers and Grilles
14. Heater Assembly
15. Water Eliminator with Fresh Air Damper




| | |
|---|---|
| 01. SCROLL COMPRESSOR (2) | 09. AIR FILTERS |
| 02. CONDENSER COILS (2) | 10. CONTROL BOX |
| 03. CONDENSER FAN MOTORS (2) | 11. MICROPROCESSOR CONTROLLER |
| 04. DEHYDRATOR | 12. STRUCTURAL FRAME |
| 05. LIQUID RECEIVER TANK | 13. COVERS AND GRILLES |
| 06. VIBRATION ELIMINATOR (2) | 14. HEATHER ASSEMBLY |
| 07. EVAPORATOR COIL | 15. WATER ELIMINATOR |
| 08. EVAPORATOR BLOWER | |

**Figure 05-I-02.9 HVAC Components**

## 05-I-02.02.01 CCU Components

### 05-I-02.02.01.01 Scroll Compressors

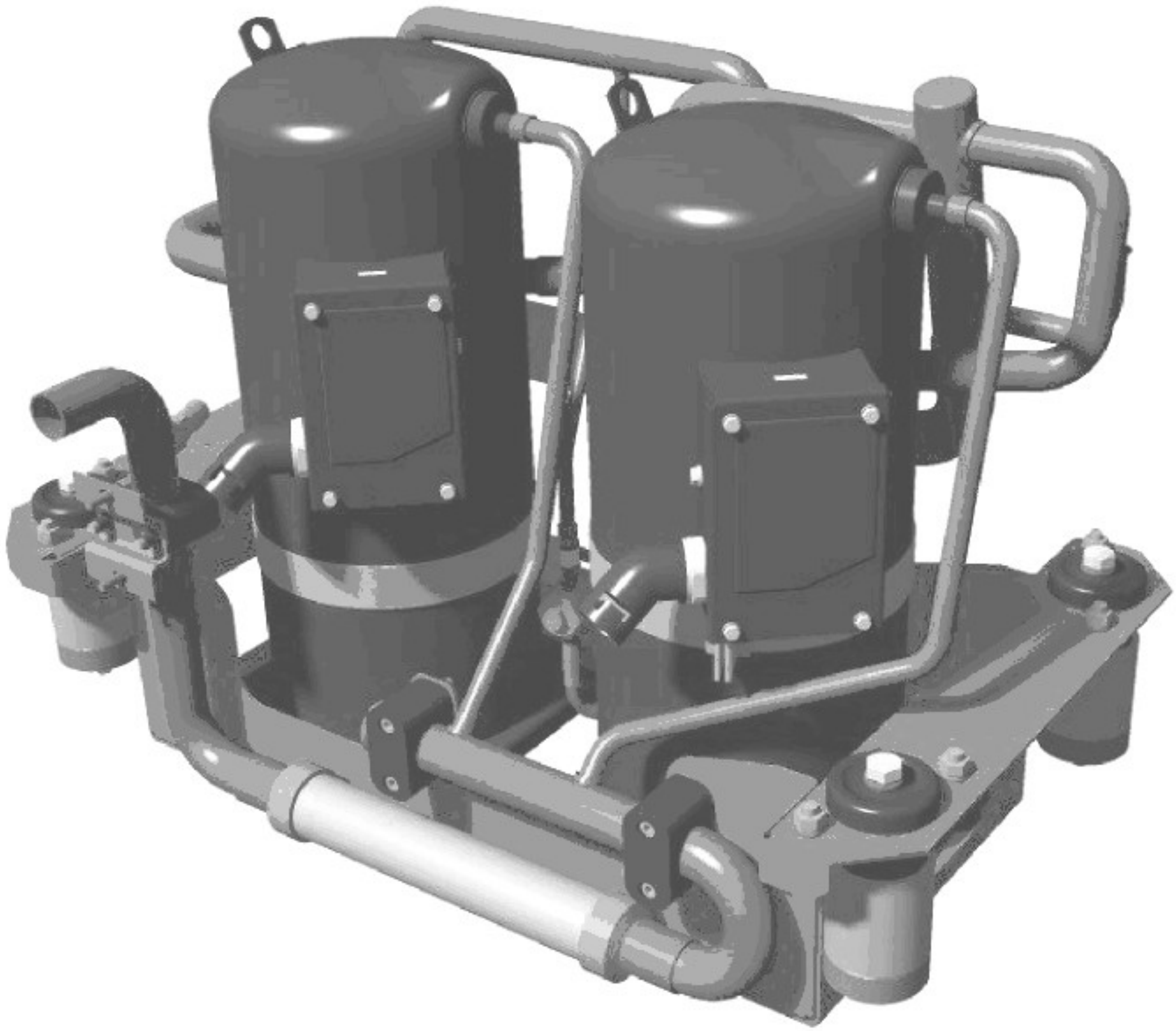


**Figure 05-I-02.10 Scroll Compressors**

Each HVAC unit is equipped with two fully hermetic Copeland Scroll compressors.

The compressors are mounted in the condenser end of the unit adjacent to the condenser coil.

Resilient mounts and a one-piece mounting base provide easy removal of both compressor assemblies.

Each compressor includes an electrical junction box and an internal motor. The external check valves are located in the discharge lines of both compressors.

## 05-I-02.02.01.02 Condenser Coils

**Figure 05-I-02.11 Condenser Coils**

Each HVAC unit contains two aluminum wavy fin, copper tube condenser coil assemblies that mount adjacent to the condenser fans and motors.

Pressurized refrigerant gas (R-407C) is discharged by the compressors into the condenser coils for the condensing phase of the refrigeration cycle.

Air is drawn through the coils by two propeller type fans.

Refrigerant gas condenses in the condenser coils, returning the refrigerant to the liquid state.

Condenser coils also include a sub cooler circuit that lowers the temperature of the liquid refrigerant before it enters the expansion valves of the evaporator coil.

### 05-I-02.02.01.03 Condenser Fans and Motors

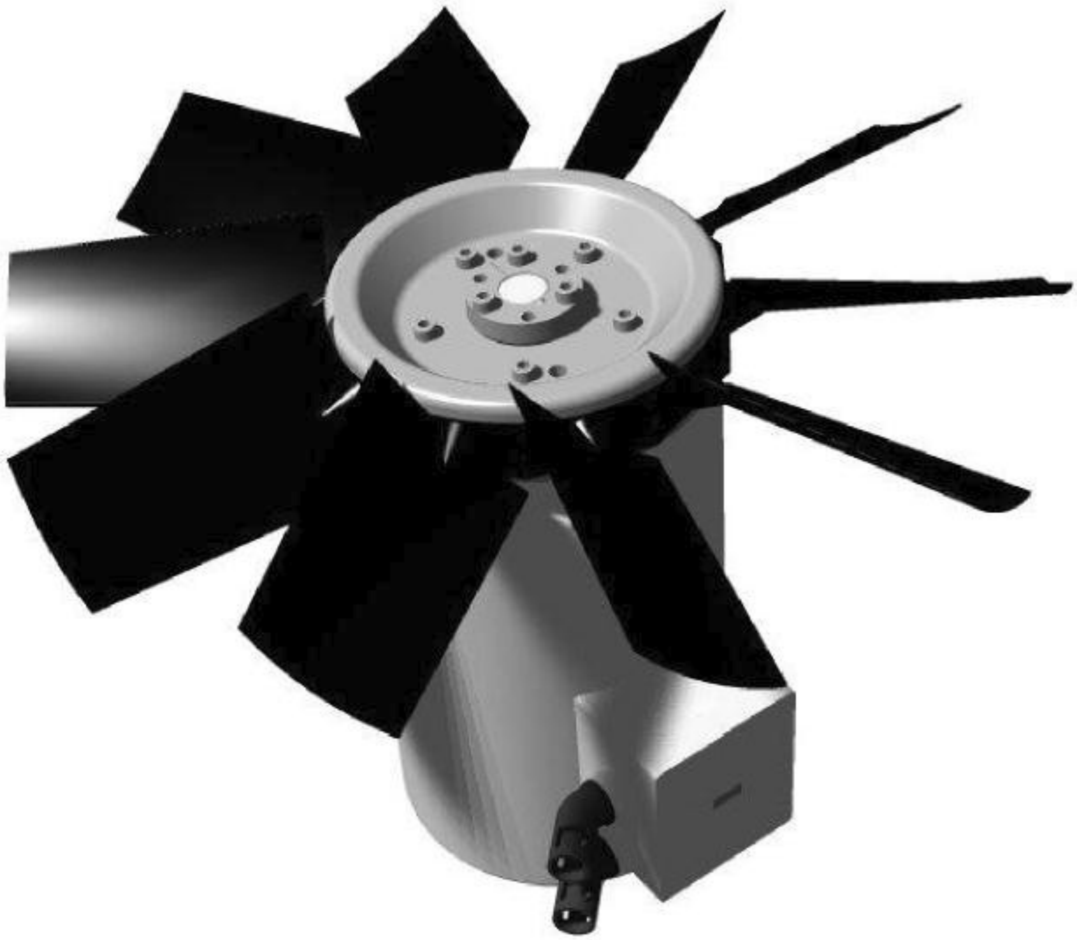


**Figure 05-I-02.12 Condenser Fans and Motors**

Each HVAC unit contains two condenser fan and motor assemblies.

Located between the condenser coils, the fans are designed to pull fresh air through the condenser coils.

Two grilles mounted on the side condenser covers prevent debris from being drawn into the condenser coils.

A stainless steel split-lock bushing mounts the fan blade onto the motor shaft.

Each fan blade is centered in an inlet ring that mounts onto the fan cover assembly. Two condenser fan outlet grilles mounted on the center condenser cover prevent objects from contacting the fan blades.

The condenser fan motors feature permanently sealed ball bearings, over temperature protection, protection against tropical conditions (fungus and humidity), and an individual junction box.

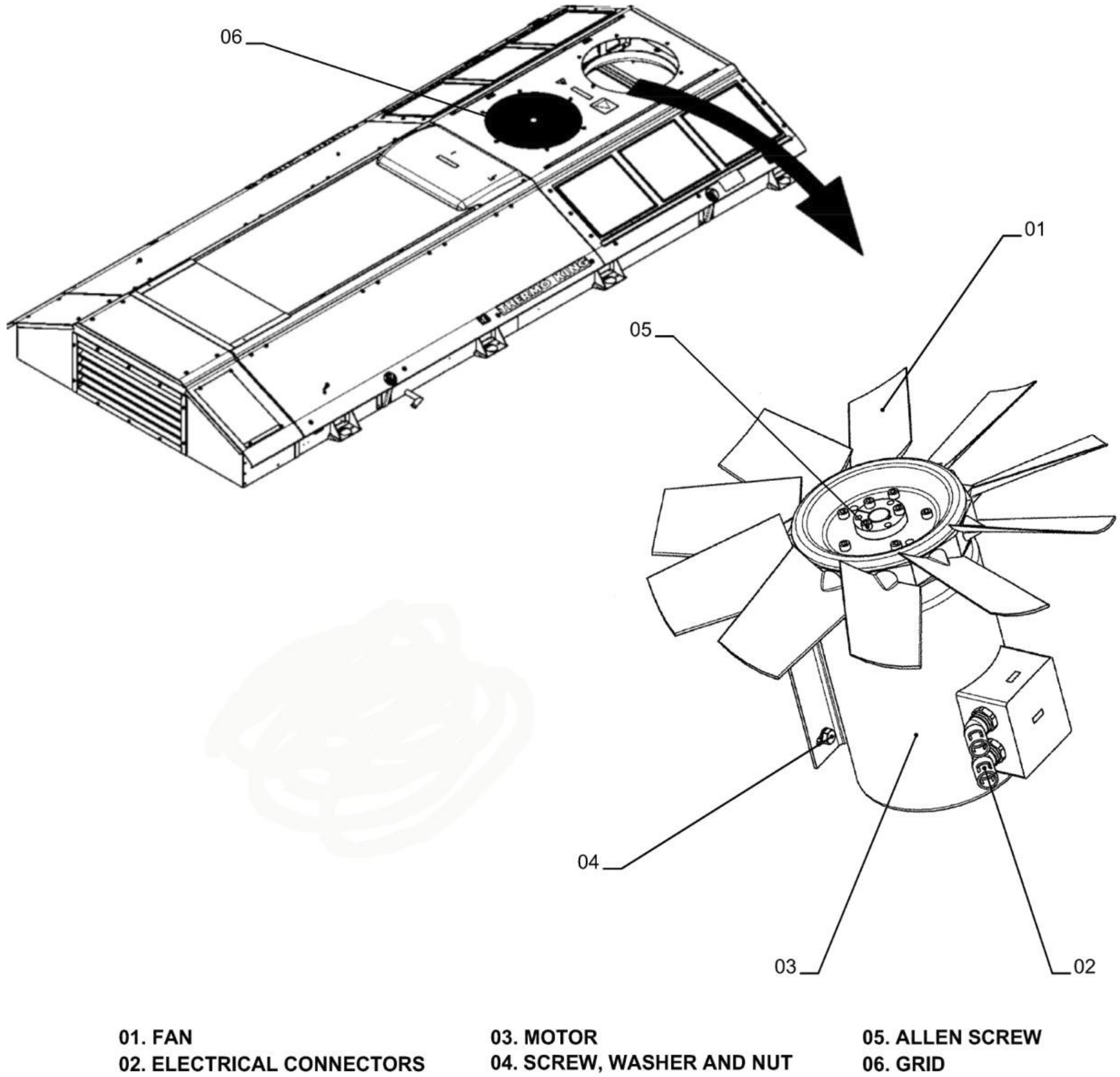



**Figure 05-I-02.13 Condenser Fan Motor Components**

### 05-I-02.02.01.04 Dehydrator (filter-drier)

Two dehydrators (filter-driers) are a cartridge type unit located next to the evaporator coil.

The dehydrators remove any particles or debris in the refrigerant and retain any moisture present in the refrigeration system.

## 05-I-02.02.01.05 Liquid Receiver Tank

The liquid receiver tank mounts in the compressor compartment. The receiver tank is connected between the condenser coil outlet lines and the condenser coil sub cooler circuit inlet lines. The receiver tank stores reserve refrigerant that is needed to support variable system demands.

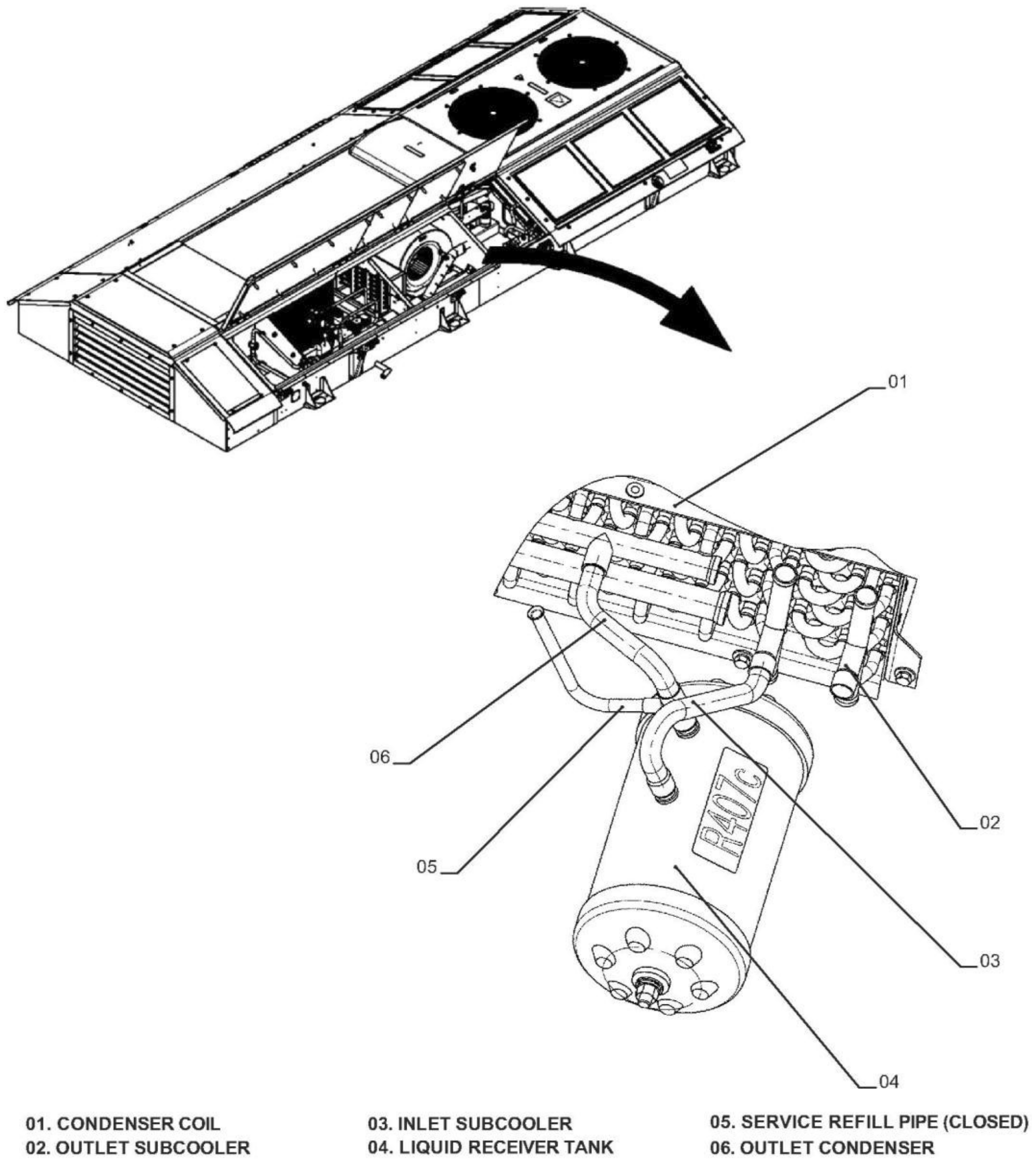



**Figure 05-I-02.14 Liquid Receiver Tank Components**

### 05-I-02.02.01.06 Vibration Eliminators

The suction line and discharge line contain in-line vibration eliminators.

Constructed of stainless steel reinforced flexible hose, the vibration eliminators remove the vibration and noise that are normally produced by the major mechanical devices and transmitted along refrigerant lines to more sensitive components.

### 05-I-02.02.01.07 Evaporator Coil Assembly and Solenoid Valve

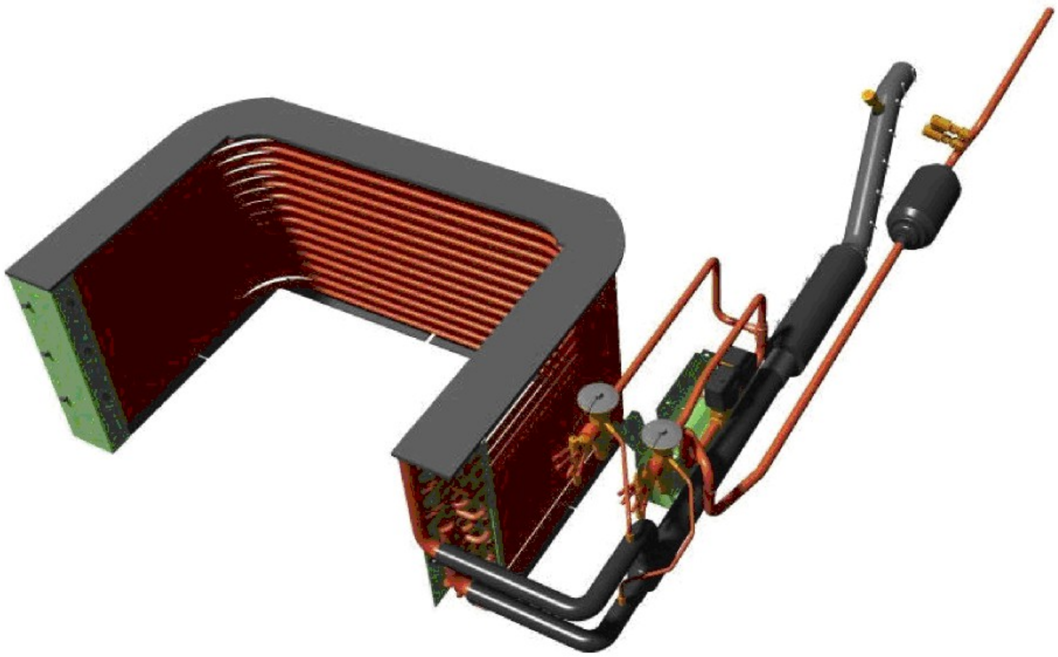


**Figure 05-I-02.15 Evaporator Coil Assembly**

The HVAC unit contains an aluminum, wavy fin, copper tube evaporator coil assembly that mounts above the return air opening in the evaporator section.

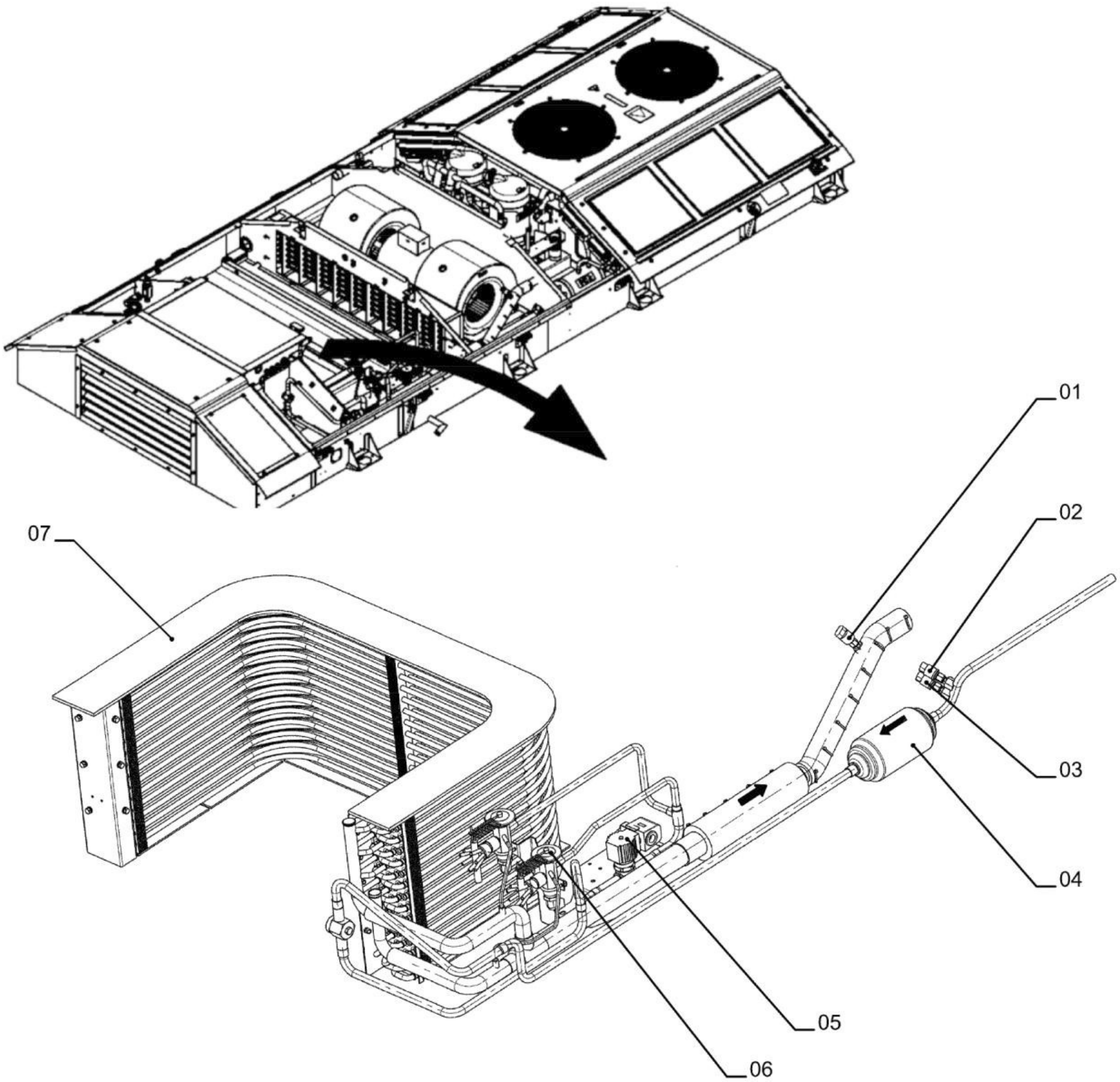
The liquid solenoid valve closes to isolate the refrigerant charge in the receiver tank and condenser coils during system shutdown and reopens prior to system startup.

Liquid refrigerant flows from the sub cooler circuits to the evaporator coil expansion valves. Airflow going to the evaporator blowers passes through the evaporator coils creating an evaporation process (liquid returns to a vapor state), thereby the cooling and dehumidifying the vehicle air.

Then, if needed, the dehumidified air is warmed by passing through the heater coils.

This airflow is then discharged back into the vehicle supply air ducts. An insulated drain pan mounts underneath the evaporator coils to catch any water condensation from the evaporator coils.

Drain lines allow the water to flow from the unit.




01. PRESSURE SWITCH (BLP)
02. PRESSURE SWITCH (BHP)
03. PRESSURE SWITCH (BMP)
04. FILTER DRIER
05. SOLENOID VALVE
06. EXPANSION VALVE
07. EVAPORATION COIL

**Figure 05-I-02.16 Evaporator Coil Components**

## 05-I-02.02.01.08 Evaporator Blower Assembly

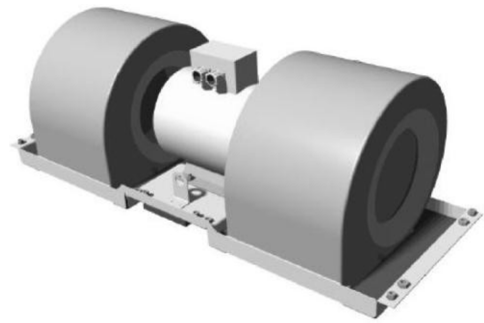


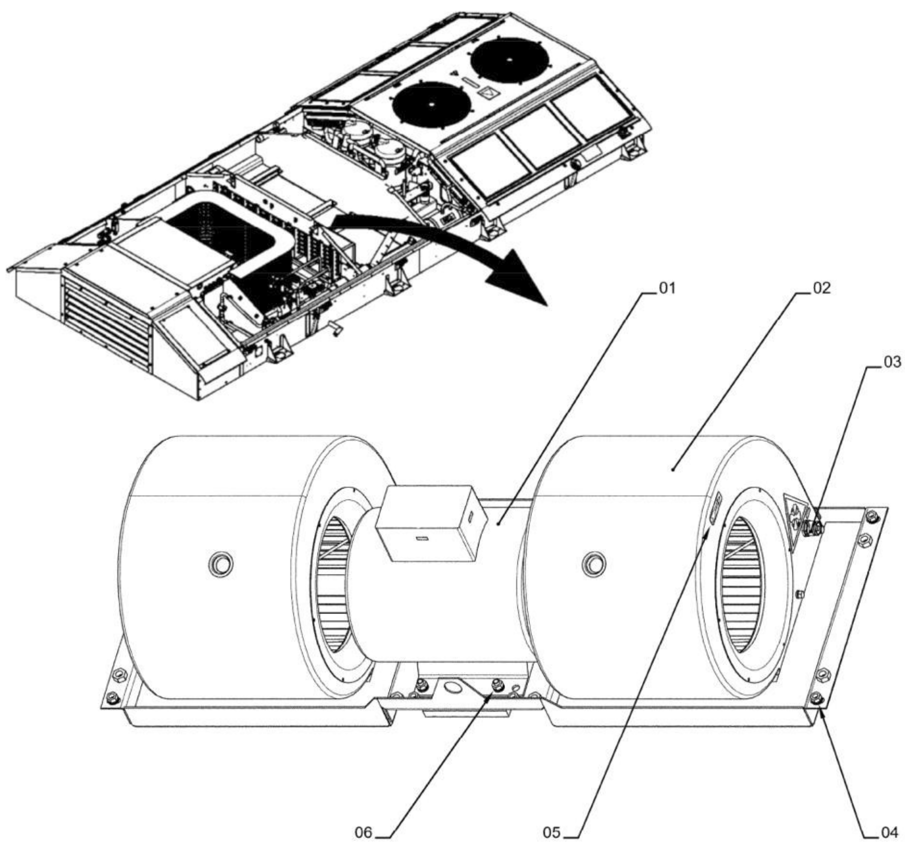
**Figure 05-I-02.17 Evaporator Blower Assembly**

The evaporator blower assembly consists of two blowers with an integrated electric motor that discharges air into the vehicle supply air ducts.

The blower assembly is located in the evaporator section.

The evaporator blower motor has permanently sealed ball bearings, over temperature protection, protection against tropical conditions (fungus and humidity) and a junction box.

Rotation arrows designating fan rotation are located on the blower housings.




01. MOTOR
02. BLOWER
03. TEMPERATURE SENSOR
04. EVAP. BLOWER CONN. NUT
05. ROTATION DIRECTION SIGN
06. MOTOR CONNECTION NUT

**Figure 05-I-02.18 Evaporator Blower Components**

### 05-I-02.02.01.09 Air Filters

Each HVAC unit is equipped with disposable air filters that remove dust and dirt:

- Fresh Air Filter
- Return Air Filter

The Fresh Air Filter element is located inside the Intake grid (faces the Articulation section) and can be accessed from the rooftop only.

The Return Air Filter element is located inside the Return Air grid and can be accessed from the vehicle interior, from the Return Air Plenum, through the HVAC access panel in the Passenger Compartment.

### 05-I-02.02.01.10 Control Box

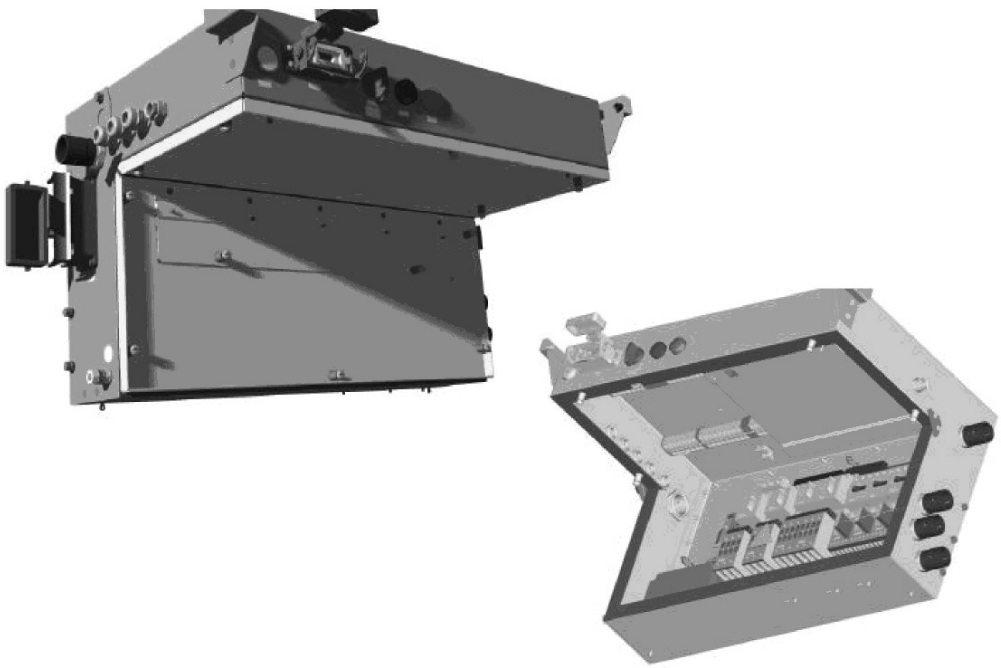


**Figure 05-I-02.19 Control Box**

The LRV Control Box is located in the return air plenum and contains all electrical controls including the current transformer, relays, contactors and circuit breakers, as well as the controller.

The unit switch, a 3-position switch (OFF, AUTO, TEST) that controls the overall operation of the LRV unit is also contained in the control box.

When maintenance tasks are being performed, place the switch in the OFF position. During normal system operation, the test switch remains in the AUTO position.

When the unit switch is placed in the TEST position (unit switch moved from AUTO or OFF to TEST position), the controller performs an automatic check of system control.

The RESET button resets the controller. See the Service software User Manual for more information.

A green light indicates that the control voltage is functioning correctly and that the unit switch SWT is in the AUTO position.

A red light indicates a fault. Flashing red means warning. Continuous red means alarm. Use the Service software for fault identification. See also the Microprocessor Controller paragraph in this manual for more information (page 32).

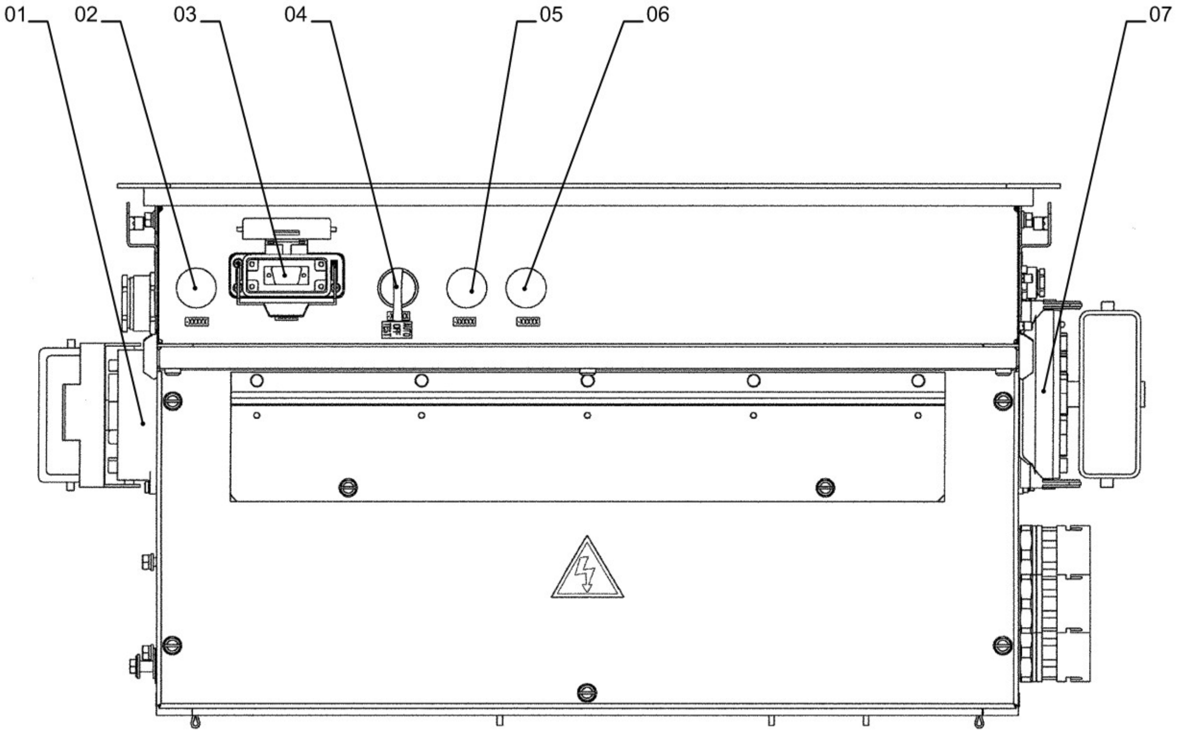
a ) High Voltage Components

- Contactor, Condenser Fan Motor #1 (KCFM1)
- Contactor, Condenser Fan Motor #2 (KCFM2)
- Contactor, Compressor Motor #1 (KCOM1)
- Contactor, Compressor Motor #2 (KCOM2)
- Contactor, Evaporator Fan Motor (KEFM)
- Contactor, Heater # 1 (KHTR1)
- Contactor, Heater #2 (KHTR2)
- Circuit Breaker, Condenser Fan Motor #1 (QCFM1)
- Circuit Breaker, Condenser Fan Motor #2 (QCFM2)
- Circuit Breaker, Compressor Motor #1 (QCOM1)
- Circuit Breaker, Compressor Motor #2 (QCOM2)
- Circuit Breaker, Evaporator Fan Motor (QEFM)
- Circuit Breaker, Heater #1 (QHTR1)
- Circuit Breaker, Heater #2 (QHTR2)
- Power Line Connector (X12)

b ) Low voltage components include:

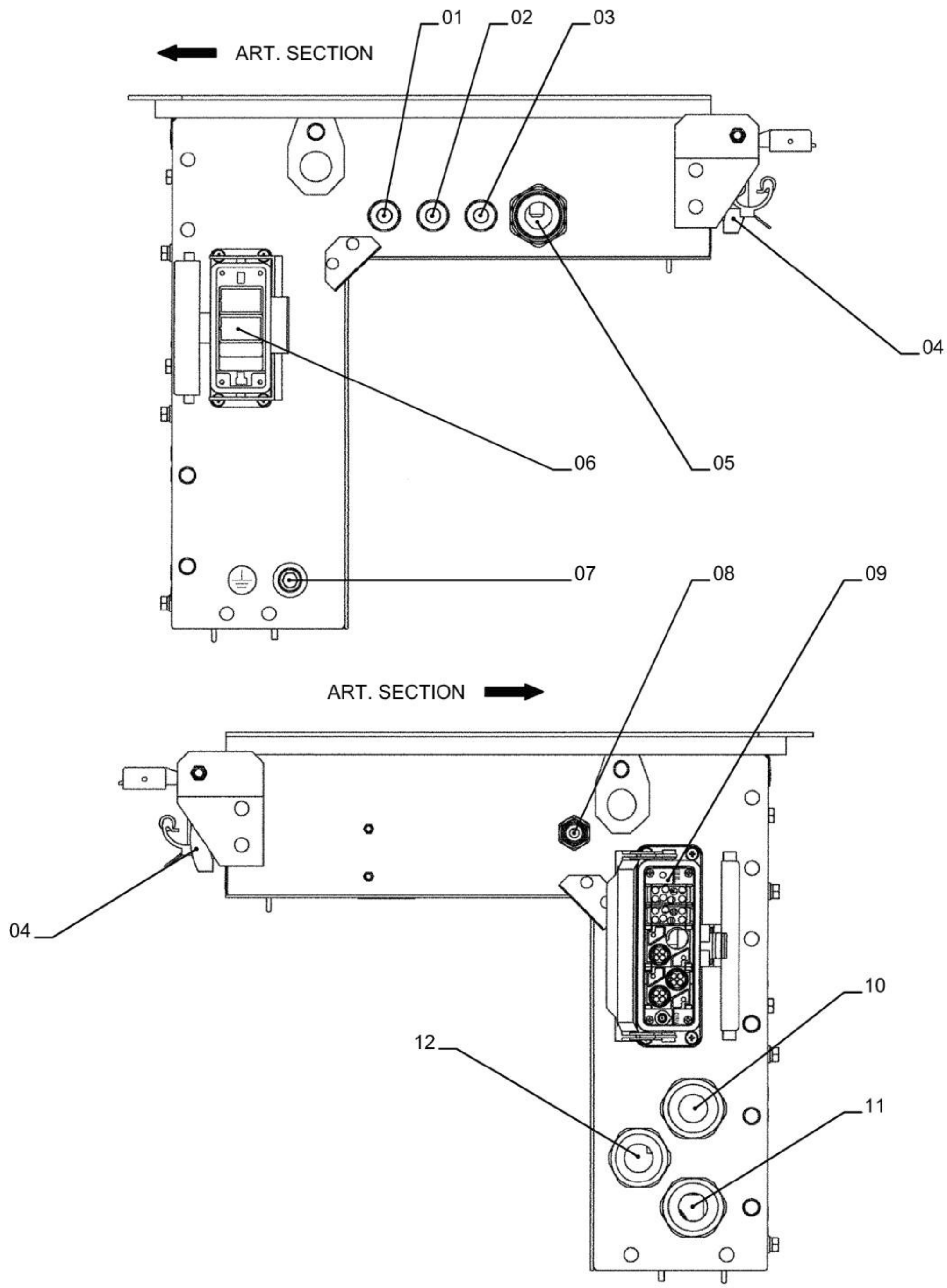
- Microprocessor Controller (D1)
- Circuit Breaker, Controller Circuit (QSUP)
- Switch, A/C Unit AUTO-OFF-TEST (SWT)
- Current Transformer, Condenser Fan Motor (TCFM)
- Current Transformer, Compressor Motors (TCOM)
- Current Transformer, Evaporator Fan Motor (TEFM)
- Control Circuit Connector (X11)
- Liquid Line Solenoid Valve (YLL)

Refer to paragraph 05-I-01.01.01 for Control Box Functional Schematic.



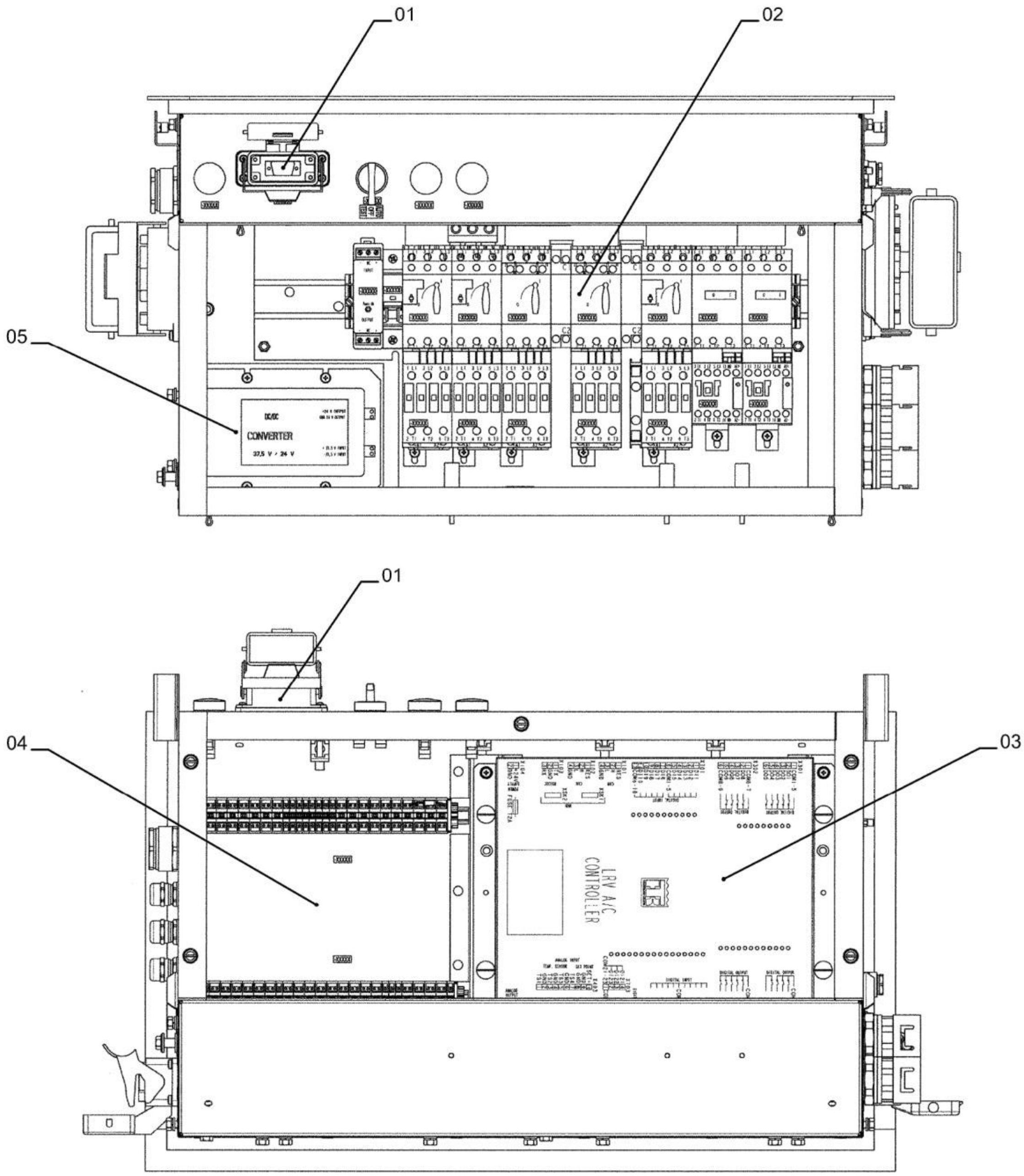

01. POWER AC CONNECTOR
02. SIGNAL LED (GREEN)
03. COMMUNICATION CONNECTOR
04. SWITCH - AUTO/OFF/TEST
05. SIGNAL LED (RED)
06. SIGNAL LED (YELLOW)
07. MULFUNCTION CONNECTOR

**Figure 05-I-02.20 Control Box Front View**




01. RETURN AIR TEMP. SENSOR
02. DISCHARGE AIR TEMP. SENSOR
03. FRESH AIR TEMP. SENSOR
04. COMMUNICATION CONNECTOR
05. LOW VOLT. CONTROL OUTLET
06. POWER AC CONNECTOR
07. GROUND
08. LIMIT SWITCH
09. MULTIFUNTION CONNECTOR
10. FANS VOLTAGE
11. COMPRESSOR VOLTAGE
12. HEATERS VOLTAGE

**Figure 05-I-02.21 Control Box Side View**




01. C0MMUNICATION CONNECTOR 02. CONTROL PANEL 03. CONTROLLER
04. TERMINAL BLOCK 05. CONVERTER

**Figure 05-I-02.22 Control Box Internal View**

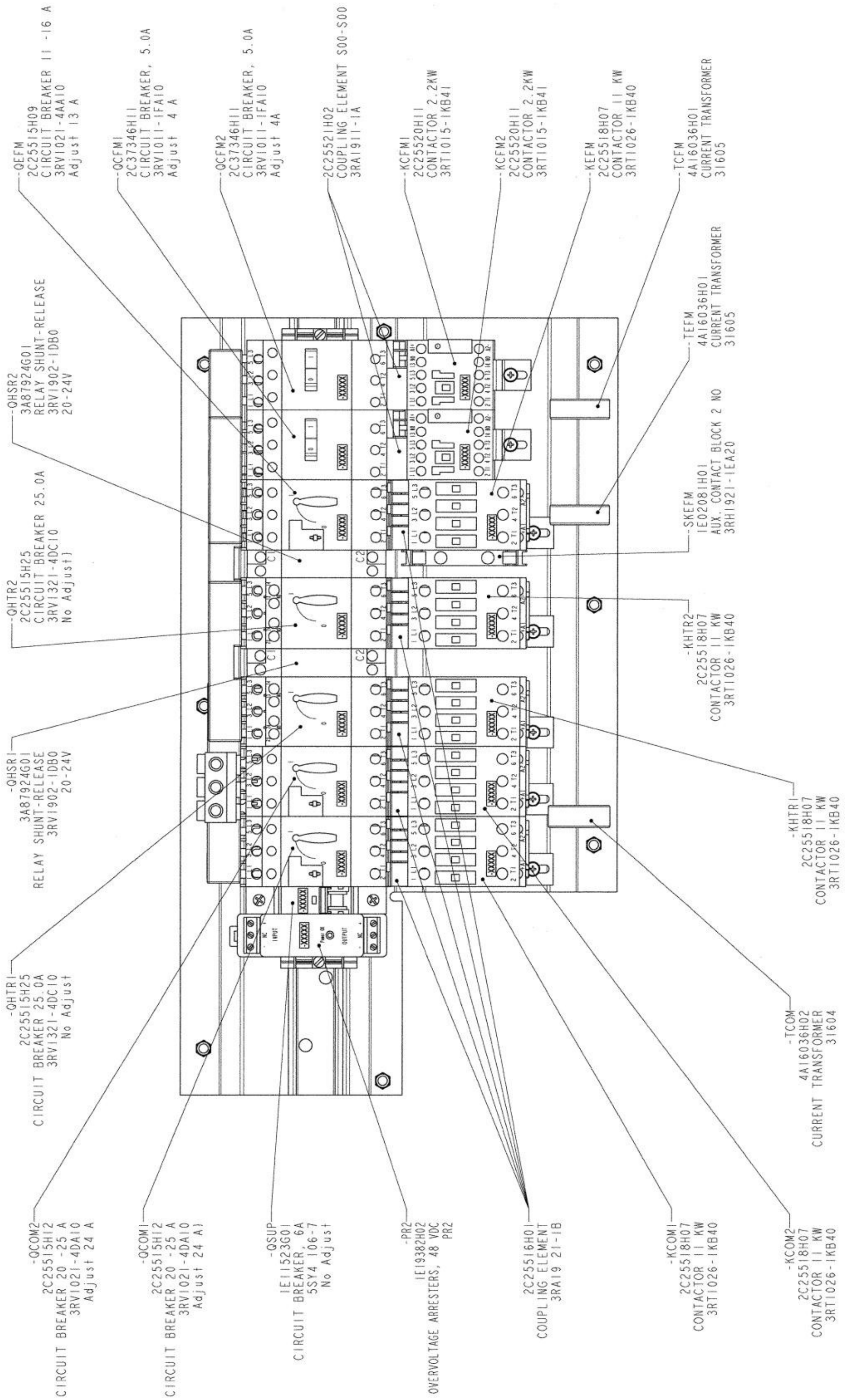


**Figure 05-I-02.23 Control Panel**

**Table 05-I-02.1 Control Panel Components**

| Acronym | Description | Voltage |
|---|---|---|
| KCFM1 | Contactor, Condenser Fan Motor 1 | 208 V High |
| KCFM2 | Contactor, Condenser Fan Motor #2 | 208 V High |
| KCOM1 | Contactor, Compressor Motor #1 | 208 V High |
| KCOM2 | Contactor, Compressor Motor #2 | 208 V High |
| KEFM | Contactor, Evaporator Fan Motor | 208 V High |
| KHTR1 | Contactor, Heater # 1 | 208 V High |
| KHTR2 | Contactor, Heater #2 | 208 V High |
| QCFM1 | It is a 5 amp circuit breaker which protects the Power Supply Circuit. Of Condenser Fan motor #1 | 208 V High |
| QCFM2 | It is a 5 amp circuit breaker which protects the Power Supply Circuit. Of Condenser Fan motor #2 | 208 V High |
| QCOM1 | 25 amp circuit breaker Protects compressor #1 | 208 V High |
| QCOM2 | 25 amp circuit breaker Protects compressor #2 | 208 V High |
| QEFM | 16 amp circuit breakers Protects the Evaporator Fan Motor | 208 V High |
| QHTR1 | 25 amp circuit breaker Protects the Power Supply Circuit of Heater #1 | 208 V High |
| QHTR2 | 25 amp circuit breaker Protects the Power Supply Circuit of Heater #2 | 208 V High |
| QSUP | 6 amp circuit breaker Protects the Control Power Supply Circuit | Low |
| TCFM | Current Transformer, Compressor Motors | Low |
| TCOM | Current Transformer, Condenser Fan Motor | Low |
| TEFM | Current Transformer, Evaporator Fan Motor | Low |
| QHSR1 | Relay Shunt Release | Low |
| QHSR2 | Relay Shunt Release | Low |
| PR2 | Over-voltage Arrester | High |
| SKEFM | Auxiliary Contact Block | |

### c ) Microprocessor Controller

Each unit is controlled by a Microprocessor located in an enclosure mounted in the return air plenum of the unit.

The microprocessor provides system component control, fault indication and system diagnostics to simplify system service and maintenance.

A portable microcomputer operating Service software (refer to Section 5 - Part II) allows technicians to download diagnostic information from the LRV unit controller via a RS232 serial port both in the evaporator return air section of the unit and in the car. Service software allows the technician to observe unit operating status, observe faults, manually initiate any unit operating mode, observe sensor temperatures, initiate an LRV system cooling check and initiate a controller self-diagnostic check. You can also modify system temperature control algorithms and temperature set-points through a password protected menu using Service software.

The microprocessor operates the unit to maintain interior conditions. The microprocessor controller operates the LRV unit in the following modes of operation:

- Full Cool
- Partial Cool
- Reheat Mode
- Ventilation
- Heating 1
- Heating 2

Microprocessor Inputs:

- Return Air Sensor (BRAS)
- Duct Air Sensor (BDAS)
- Fresh Air Sensor (BFAS)
- Pressure Switch, Modulation Pressure (BMP)
- Fault Signal, Evaporator Fan Motor Overload (FS1)
- Fault Signal, Compressor Motor #1 Overload (FS2)
- Fault Signal, High Pressure (FS3)
- Fault Signal, Low Pressure (FS4)
- Fault Signal, Compressor Motor #2 Overload (FS5)
- Fault Signal, Condenser Fan Motor #1 Overload (FS6)
- Fault Signal, Condenser Fan Motor #2 Overload (FS7)
- Fault Signal, Evaporator Contactor is switched off (FS8)
- Fault Signal, Heater #1 (FS9)
- Fault Signal, Heater #2 (FS10)
- Fault Signal, Back Up Protection Heater #1&#2 (FS11)
- Fault Signal, Condenser Fan Motor #1 Thermal Overload (FS12)
- Fault Signal, Condenser Fan Motor #2 Thermal Overload (FS13)
- Fault Signal, Evaporator Fan Motor Thermal Overload (FS14)
- Inverter AC okay Signal (ACOK)

Microprocessor Output:

- Solenoid Valve, Liquid Line (YLL)

## 05-I-02.02.01.11 Structural Frame, Covers and Grilles

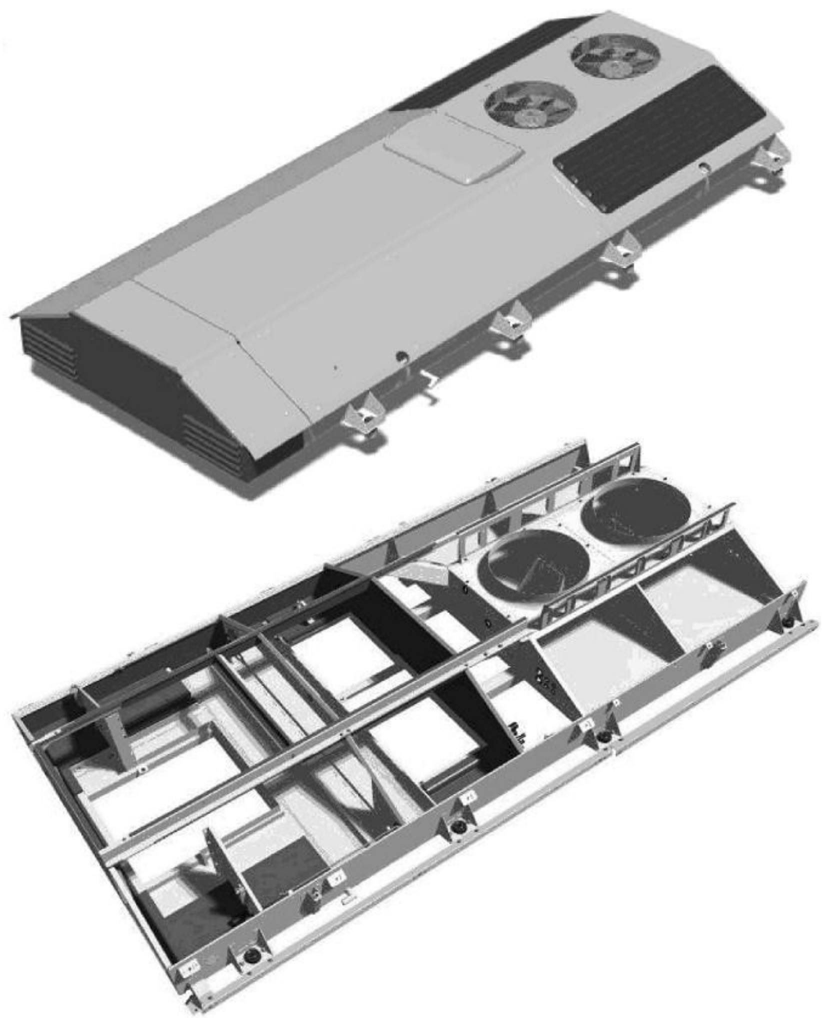


**Figure 05-I-02.24 Frame and Cover**

The CCU structural frame is manufactured from stainless steel. Outer covers and panels are formed from aluminum.

Two hinged evaporator side covers provide primary access to the evaporator coil, expansion valves, evaporator blower assembly, refrigerant piping and solenoid valve, dehydrator, receiver tank and compressor assembly.

A compressor cover provides top access to the compressor assembly.

Two removable side condenser covers provide access to the condenser coils. Removable condenser fan grilles and a removable center condenser cover provide access to the condenser fan motor and fan blade assemblies.

The return air grille, accessed from the car interior, provides access to the air filters. Access to the control box that contains the circuit breaker and contactor panel as well as the microprocessor controller is also provided through the return air grille. A RS232 communications port is accessible through the return air plenum.

### 05-I-02.02.01.12 Heaters

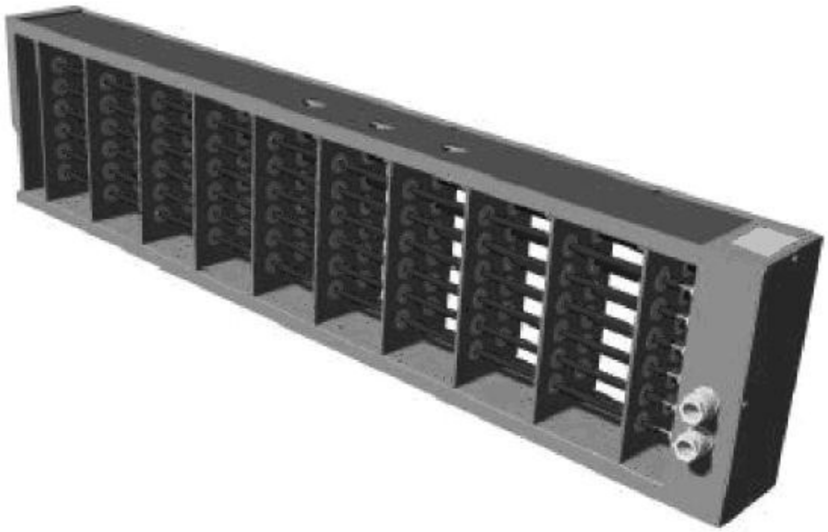


**Figure 05-I-02.25 Heater**

The CCU contains one (1) 2 stage 18 kW heater. The heater is wire wound with two (2) temperature limit switches.

The Heater is provided with water barrier

### 05-I-02.02.01.13 Water Eliminator with Fresh Air Damper

The fresh air damper is directly controlled via HW signals.

The purpose of the Air Dampers is to close off outside air from being sucked into the passenger compartment during a fire in a tunnel.

The default position of damper is open. Water Eliminator secures fresh air input against the water drops in case of rain.

### 05-I-02.02.01.14 Unit Decals

Serial number decals, refrigerant type decals and warning decals appear on all Thermo King equipment. These decals provide information that may be needed to service or repair the unit. Service technicians should especially read and follow the instructions on all warning decals.

Serial Number Locations:

- Electric Motors: Nameplate attached to the motor housing
- Compressor: Nameplate attached to the compressor housing
- CCU: the First nameplate is on the unit frame outside under the right evaporator cover (near by fresh air openings). The Second nameplate is on the unit frame outside on the evaporator wall - right bottom corner

### 05-I-02.02.02 CCU Functional Description

#### 05-I-02.02.02.01 Basic A/C System Theory of Operation

The components of the A/C unit are all connected in a closed, hermetically sealed system to form a refrigerant loop that responds to the commands of the microprocessor controller.

The refrigerant system circulates R-407C refrigerant (refer to NOTE in the next page) between the evaporator and the condenser coil to provide the necessary pressures. (Refer to Figure 05-I-02.26)

The evaporator blower circulates heat-laden air across the evaporator coil. The heat is absorbed by the refrigerant (a low pressure, low temperature liquid) in the coil as it evaporates.

As the refrigerant evaporates, a low pressure, high temperature, heat-laden vapor is formed. In this manner, heat is transferred from the air to the refrigerant. The conditioned air is forced into the ductwork for distribution throughout the rail car. Although the air is now conditioned and cools, the refrigerant needs to release the heat it gained from the evaporator.

Compressor suctions continuously draw the heat-laden vapor from the evaporator. As the refrigerant vapor is compressed, it increases its pressure and temperature, changing it to high-pressure, high temperature vapor.

This elevates the vapor temperature and pressure to facilitate heat transfer to the ambient air and establish a higher condensing temperature.

As the high-temperature vapor travels through the condenser coil, the heat from the refrigerant is dispersed into the cooling fins, and is removed by the ambient air circulated by the condenser fan.

As the heat is removed, the vapor condenses back into a liquid.

Thus, the heat absorbed by the refrigerant from the evaporator, is transferred to the condenser and given off to ambient air.

The high temperature liquid is maintained under high pressure in the receiver, where it is stored until needed.

The receiver serves as a reservoir for the variable demands of liquid refrigerant from the system.

Liquid refrigerant then flows from the receiver tank through the sub cooler circuit in the bottom of the condenser coil.

The refrigerant continues to give off heat to the cooler ambient air circulating across the fins of the sub cooling circuit, lowering, the liquid temperature below saturation/condensing temperature.

This additional cooling ensures that the high pressure liquid remains in its liquid state until it reaches the thermal expansion valve(s).

From the sub cooler circuit of the condenser coil, liquid refrigerant flows through the filter-drier (dehydrator), where impurities, solids, and moisture are removed.

The filter-drier consists of a filter and a desiccant (molecular sieve) that traps and holds water molecules.

From the filter-drier, the high temperature, high, pressure liquid flows through the liquid line solenoid valve to the expansion valves.

The expansion valves control the flow of the liquid refrigerant entering the evaporator coil, where it again absorbs heat from the car interior air circulated over the evaporator coil by the evaporator blower.

The low pressure, low temperature liquid refrigerant absorbs heat, causing a change of state from liquid to vapor (evaporates).

A heat laden, low pressure, low temperature gas then repeats the cycle as it is drawn back to the compressors.

When Partial Cool is required, the controller energizes the liquid line solenoid valve, one compressor and one condenser fan motor, circulating refrigerant through the evaporator coil.

The evaporator blower starts first and runs at all modes.

When Full Cool is required, the controller also energizes the second compressor and the second condenser fan motor.

**NOTE:** The R-407C is a mixture of HFC-32, HFC-125 and HFC-134a, not harmful for the ozone layer. The R-407C mixture is fit for applications in air conditioning systems and is a good alternative to R-22 in small air conditioning systems. Since it is similar to R-22, it can be used as conversion fluid in air conditioning systems which make use of R-22.

**Table 05-I-02.2 Temperature/Pressure Table**

| Temperature (°C) | Pressure (liquid) (kPa) | Pressure (vapor) (kPa) |
|---|---|---|
| -20 | 281 | 215 |
| -15 | 339 | 264 |
| -10 | 405 | 320 |
| -5 | 481 | 386 |
| 0 | 568 | 461 |
| 5 | 666 | 547 |
| 10 | 776 | 645 |
| 15 | 899 | 755 |
| 20 | 1,036 | 880 |
| 25 | 1,188 | 1019 |
| 30 | 1,256 | 1175 |
| 35 | 1,541 | 1348 |
| 40 | 1,745 | 1539 |
| 45 | 1,967 | 1751 |

[redacted]

## 05-I-02.02.02.02 CCU Controls

a ) A/C Unit Auto-OFF-Test Switch

- AUTO position. Unit will operate in one mode depending on the controller set-point temperature and the rail car air temperature (Full Cool, Partial Cool, Reheat, Ventilation, Heating 1, and Heating 2)
- OFF position. The unit will not operate
- TEST position. When the unit switch is placed in the TEST position (unit switch moved from AUTO or OFF position to TEST position), the controller performs an automatic check of the system controls

b ) Microprocessor Controller

A microprocessor controls all unit functions to maintain the rail car at the proper temperature.

The controller also monitors and records system faults.

Service software operates on a Laptop Computer which is used to download information, program unit functions and perform diagnostic tests of the A/C system.

c ) Modulation Pressure (BMP) Switch

When the condenser head pressure rises above 2691±83 kPa, 26.91±0.83 bar, 390±12 psig, the modulation pressure switch opens, signaling the controller to stop one compressor. Both condenser fans continue to run.

Stopping one compressor and reducing the discharge pressure on the running compressor reduces the compressor current draw to protect against unit shut down due to high current draw in high ambient.

The unit continues cooling Modulation Cool until the modulation pressure switch closes.

The modulation pressure switch closes when the condenser head pressure decreases to 2174 ± 83 kPa, 21.74 ± 0.83 bar, 315 ± 12 psig. If the return air temperature requires Full Cool operation, the controller starts compressor 2, placing the unit in Full Cool mode.

## 05-I-02.02.02.03 CCU Protection Devices

a ) Circuit Breakers

A number of circuit breakers located in the control box protect unit circuits and components.

- A 25 amp circuit breaker (QCOM1) protects the compressor #1 208 V power supply circuit.
- A 25 amp circuit breaker (QCOM2) protects the compressor #2 208 V power supply circuit.

- A 5 amp circuit breaker (QCFM1) protects the condenser fan motor #1 208 V power supply circuit
- A 5 amp circuit breaker (QCFM2) protects the condenser fan motor #2 208 V power supply circuit
- A 25 amp circuit breaker (QHTR1) protects the heater #1 power supply circuit
- A 25 amp circuit breaker (QHTR2) protects the heater #2 power supply
- A 6 amp circuit breaker (QSUP) protects the control power supply circuit
- A 16 amp circuit breakers (QEFM) protects the evaporator fan motor 208 V power supply circuits

b ) High Pressure (SWHP) Switch

The refrigerant high pressure opens and sends a fault signal to the controller if the compressor discharge pressure rises above 3105 ± 69 kPa, 31.05 ± 0.69 bar, 450 ± 10 psig.

The controller immediately stops the compressors and condenser fans. However, after 2 minutes, the controller attempts a cooling system restart.

If high pressure recurs 3 times in 30 minutes, the controller locks out cooling operation and operates the unit on ventilation only.

The high pressure switch resets (closes) when the pressure drops back to 2174 ± 104 kPa, 21.74 ± 1.04 bar, 315 ± 15 psig.

After the high pressure switch closes, the controller restarts the cooling system.

The cooling system operates until high discharge pressure recurs.

If high pressure cutout recurs 3 times in 30 minutes, the controller locks out cooling operation (unit operates on ventilation only).

The controller must be reset before cooling system will restart.

c ) Low Pressure (BLP) Switch

The refrigerant low pressure opens and sends a fault signal to the controller if the compressor suction pressure drops below - 17 to -57 kPa, -0. 17 to -0.57 bar, 5 to 17 in. Hg vacuum.

The controller immediately stops the compressors and condenser fans. However, after 2 minutes, the controller attempts a cooling system restart.

If low pressure cutout recurs 3 times in 30 minutes, the controller locks out cooling operation and operates the unit on ventilation only.

The low pressure switch resets (closes) when the pressure drops back to 7 to 48 kPa, 0.07 to 0.48 bar, I to 7 psig.

After the low pressure switch closes, the controller restarts the cooling system.

The cooling system operates until low refrigerant pressure recurs.

If low pressure cutout recurs 3 times in 30 minutes, the controller locks out cooling operation. The controller must be reset before cooling system will restart.

d ) Safety Relief Valve (SRV)

A safety (high pressure) relief valve is installed in the compressor discharge line to avoid excessive pressure build-up within the refrigeration system from extraordinary and unforeseen circumstances.

The valve is a spring- loaded piston that lifts when refrigerant pressure exceeds 3795 to 4830 kPa, 37.95 to 48.30 bar, 550 to 700 psig.

e ) Thermal Overload Relay Protection

The compressors, condenser fan motors and evaporator fan motor are protected by external thermal overload relays, which are combined with circuit breakers.

f ) Current Transformers

Three current transformers measure component current draw of the compressor motors, condenser fan motors and the evaporator fan motor.

Component current draw is then monitored by the controller so component operation can be interrupted (via control circuits) in the event of low airflow or current overload conditions.

g ) Heat Limiter

The heaters are protected by heat limiter against the overheating.

h ) Overvoltage Arrester

The overvoltage arrester protects the control circuit against overvoltage.

### 05-I-02.02.02.04 Starting the A/C System

A/C system operation is fully automatic.

The A/C systems starts when the ON/OFF switch located in the active cab is turned on.

The controller operates the system on Full Cool, Partial Cool, Reheat or Heating based on the set-point temperature, return air temperature and fresh (outside) air temperature.

The set-point temperature is given automatically by controller in relation with outside temperature.

1. Turn rail car power supply ON. Turn the ON/OFF switch on.
2. When the ON/OFF switch is in the ON position, the controller checks if the inverter generated the ACOK (24 Vdc) signal.
3. When the unit switch is in the TEST position, the controller initiates the Unit Self Test mode. In the Unit Self Test mode, the controller operates the unit in Full Cool for 5 minutes and then in Full Heat for 5 minutes. Position of the ON/OFF switch is not significant in this case.
4. To start the unit, turn the unit switch to the AUTO position. The controller initiates the unit startup in the required operating mode.
5. In both cases, the unit starts sequentially as follows:

Depending on the control voltage (24 Vdc) and ACOK input, the controller energizes the evaporator blower contactor after a delay of0. 1 to 4.0 seconds.

- The controller energizes condenser fan motor I contactor (KCFM1)
- The controller then energizes compressor motor 1 contactor (KCOM1) after another delay of 1 second
- The controller energizes the liquid line solenoid valve (YLL) after another delay of 4 seconds

On each successive switch between cooling modes, the controller alternates the initial startup of the condenser fan motor between condenser fan motor 1 and Condenser fan motor 2.

**NOTE:** The controller also alternates the startup of the compressor between compressor 1 and compressor 2. This is done to balance the service duty (hours of operation) equally between both condenser fan motors and both compressors.

- The controller energizes condenser fan motor 2 (KCFM2) contactor after a delay of 1 second. The controller then energizes compressor motor 2 contactor (KCOM2) after another delay of 1 second.

If an alarm condition prevents unit startup, the remote Fault Light will flash.

See "Alarm Codes, Descriptions and Correct Actions” in this manual. Correct the problem before trying to restart the A/C system.

**WARNING:** **SOME UNIT MALFUNCTIONS WILL CAUSE AN ALARM AND UNIT SHUTDOWN CONDITION. WHEN THE CONTROLLER IS RESET, THE UNIT WILL START AUTOMATICALLY.**

**NOTE:** A permanent record of the alarm codes remains stored in the controller memory for retrieval via Service software.

a ) Normal Operating Modes

With the A/C system energized and operating with the unit switch in the AUTO position, the return air sensor, fresh air sensor and set-point temperature determine the unit mode of operation. (refer to Figure 05-I-02.27).

[redacted]

### b ) Full Cool

During the Full Cool Mode the controller energizes the following:

- Evaporator Fan Motors Contactor (KEFM)
- Condenser Fan Motor Contactors (KCFM1&2)
- Liquid Line Solenoid Valve (YLL)
- Compressor Motor Contactors (KCOM1&2)

On increasing rail car temperature, the unit shifts from Partial Cool to Full Cool when the return air temperature increases to 4 K (7.2°F)[1] above the set-point temperature.

On decreasing rail car temperature, the unit shifts from Full Cool to Partial Cool when the return air temperature decreases to 2 K (3.6°F)[2] above the set-point temperature.

### c ) Partial Cool

During the Partial Cool mode the controller will energize the following:

- Evaporator Fan Motor Contactor (KEFM)
- Condenser Fan Motor Contactors (KCFM1)
- Liquid Line Solenoid Valve (YLL)
- Compressor Motor Contactors (KCOM1)

The unit shifts from Reheat to the Partial Cool mode when the return air temperature increases to 2 K (3.6°F) above the set-point temperature.

The unit then remains in Partial Cool as long as the return air temperature remains between 1 K (1.8°F)[3] above set-point and 4 K (7.2°F) above the set-point temperature.

**NOTE:** On each successive switch from Full Cool to Partial Cool, the controller alternates the initial startup of the condenser fan motor between condenser fan motor 1 and condenser fan motor 2.

The controller also alternates the startup of the compressor between compressor 1 and compressor 2. This is done to balance the service duty (hours of operation) equally between both condenser fan motors and both compressors.

---

[1] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[2] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[3] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

The controller also places the unit in Modulation Cool whenever the unit is operating in Full Cool and the modulation pressure switch opens (refrigerant discharge pressure rises to 2691 ± 83 kPa, 26.91 ± 0.83 bar, 390 ± 12 psig).

**NOTE:** The modulation pressure switch protects against unit shutdown due to current overload in high ambient operating conditions. (Modulation Cool Mode is not normal operating mode.

During this mode, in addition to the components, which are energized in the Partial Cool Mode, the second condenser fan motor is energized too).

d ) Reheat

The purpose of reheating is to dehumidify. During the reheat mode the controller will energize the following:

- Evaporator Fan Motor Contactor (KEFM)
- Condenser Fan Motor Contactor (KCFM1)
- Liquid Line Solenoid Valve (YLL)
- Compressor Motor Contactor (KCOM1)
- Stage 1 Heat Contactor (KHTR1)

The unit switches from Ventilation Mode to the Reheat Mode when the return air temperature increases by 1 K (1.8°F )[4] above set-point temperature.

The unit remains in the Reheat Mode as long as the return air temp remains between 1.5 K (2.7°F )[5] below set-point and 2 K (3.6°F )[6] above set-point temperature.

The units shifts from Reheat Mode to Ventilation Mode, when return air temp decreases to 1.5 K (2.7°F )[7] below its set-point temperature.

[4] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[5] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[6] This default value is a parameter that, can be modified using communication software. Refer to Section 05 - Part II.

[7] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

e ) Ventilation

During ventilation the controller will energize the following:

- Evaporator Fan Motor Contactor (KEFM)

The unit switches from Ventilation Mode to the Reheat Mode when the return air temperature increases by 1 K (1.8°F )[8] above set-point temperature.

The unit remains in the Ventilation mode as long as the return air temp remains between 2.5 K (4.5°F )[9] below set-point and 1 K (1.8°F )[10] above set-point.

The units shifts from Ventilation Mode to Heat Stage 1 Mode, when return air temp decreases to 2.5 K (4.5°F )[11] below its set-point temperature.

f ) Heat, Stage 1

During Heat Stage 1, one heater (in the LRV unit) is energized in addition to the blower motor.

The unit shifts from Ventilation Mode to Heat Stage 1 when return air temperature decreases by 2.5 K (4.5°F)[12] below set-point.

The unit remains in Heat Stage 1 as long as the return air temp remains between 2.5 K (4.5°F ) [13] below set-point and 0.5 K (0.9°F )[14] below set-point.

The unit shifts from Heat Stage 1 to Heat Stage 2 when return air temperature decreases by 5 K (7.5°F)[15] below set-point.

During Heat Stage 1 the controller energizes the following:

- Evaporator Fan Motor Contactor (KEFM)
- Stage 1 Heat Contactor (KHTR1)

[8] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[9] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[10] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[11] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[12] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[13] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[14] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[15] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

g ) Heat, Stage 2

During Heat Stage 2, both heaters in LRV unit are energized in addition to Evaporator blower motor.

The unit shifts from Heat Stage 2 to Heat Stage 1, when return air temperature increases by 2 K (3.6°F)[16] below set-point.

The unit shifts from Heat Stage 1 to Heat Stage 2, when return air temperature decreases by 5 K (7.5°F)[17] below set-point.

The unit remains in Heat Stage 2 as long as the return air temperature remains 2 K (3.6°F )[18] below set-point.

During heat stage 2 the controller will energize the following:

- Evaporator Fan Motor Contactor (KEFM)
- Stage 1 Heat Contactor (KHTR1)
- Stage 2 Heat Contactor (KHTR2)

h ) Fresh Air Dampers

The fresh air dampers are directly controlled via hard-wired signals
(refer to Table 05-I-02.5). The default position of the dampers is OPEN.

The Fresh Air Dampers are to be closed by the train operator should there be fire or smoke in the vicinity.

[16] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[17] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

[18] This default value is a parameter that can be modified using communication software. Refer to Section 05 - Part II.

### 05-I-02.02.02.05 Microprocessor Controller

The controller is a programmable Microprocessor that regulates all unit functions to maintain the rail car at the proper temperature and humidity.

The Microprocessor Controller is equipped with an MVB module for exchanging data with the Vehicle Logic.

TCU MoV (Master of Vehicle) / Slave detection:

At a certain time only one of the two TCUs can be the Master Of Vehicle (refer to Section 07). The TCU that is currently Master Of Vehicle must be detected by reading the datasets number (105 for TCU_A and 106 for TCU_B) and considering the status of the MoV bit (position 2.0 of dataset TRAINCMD_A (0) or TRAINCMD_B (0); refer to Table 05-I-02.3, Table 05-I-02.4 and Section 18).

If TCU_A is detected to be MoV, the slave units (TCUs, ECUs and HVACs) must read and use the information from the MoV listed in the following dataset:

**Table 05-I-02.3 Input Dataset (from MoV TCU_A)**

| Port Number | Group Name | Source | Description |
|---|---|---|---|
| 510 | TCU_A_INFO | TCU_A | Time reference, vehicle ID etc. |
| 105 | TRAINCMD_A (0) | TCU_A | Commands from Local TCU_A |

If TCU_B is detected to be Master Of Vehicle, the slave units (TCUs, ECUs and HVACs) must read and use the information from the MoV in the following dataset:

**Table 05-I-02.4 Input Dataset (from MoV TCU_B)**

| Port Number | Group Name | Source | Description |
|---|---|---|---|
| 610 | TCU_A_INFO | TCU_B | Time reference, vehicle ID etc. |
| 106 | TRAINCMD_B (0) | TCU_B | Commands from Local TCU_B |

The Microprocessor Controller generates Warning Signals and Alarm Signals for remote monitoring.

The Fault light flashes ON and OFF continuously when a Warning signal occurs. Warning signals indicate that a corrective action should be taken before the problem becomes severe.

In this condition the unit continues to operate, however, some unit functions may be inhibited.

The Fault light stays ON when an Alarm Signal occurs. Alarm signals indicate that a problem exists that affects the cooling system performance.

On some alarms, the compressors and condenser fans are stopped to prevent damage to unit components while the unit continues to operate in ventilation mode.

Usually alarms must be corrected and the Microprocessor Controller reset before the A/C system can be set back to normal operation. See Section 5 - Part II on "Alarm Codes, Descriptions and Corrective Actions" for information about the specific actions the Microprocessor Controller takes in response to each alarm code.

Fault codes are recorded in the Microprocessor Controller memory to ease unit diagnosis and troubleshooting procedures.

Fault codes are available both via MVB and RS232 port.

Two HVAC units are supplied by one Inverter. Due to inrush current, the units cannot start at the same time.

The units communicate via MVB. When one unit starts, it generates a DOUSI signal. Based on the DOUSI signal, a DISE signal (Digital Input Second Unit) is generated for the second unit. In this way, the second unit can start when DISE signal is in logical 1 only.

A serial communication port is provided for downloading system performance data, monitoring system operation and performing system test and diagnostic routines using a Laptop (PTU) with Service software (Refer to Section 05 - Part II.)

Return air, duct air and fresh (outside) air sensors are field replaceable.

- Internal diagnostic capability: The unit has an internal self-checking and diagnostic capability upon initial startup and in the background.
- Data recording capability: The microprocessor controller records all sensor temperatures, system faults and six hourmeter counters. Recorded data can be downloaded (or erased) from the controller memory using Service software.
- Sequential component start-up control: A sequence start of the required loads occurs during initial start-up of the controller and when a control mode shift requires the compressor to start.
- Hourmeters: The Microprocessor Controller is equipped with six built-in hourmeters, accessible by means of the Service software. Separate hourmeter counters record the operation hours of the controller, the condenser fan motor #1, the condenser fan motor #2, compressor #1, compressor #2 and the evaporator blower motor.
- Flash memory: A flash program memory in the controller allows the application software to be updated without replacing the controller. Application software can be updated in the field using a Laptop (PTU) with Service software.

### a ) Communications between HVAC and Vehicle Logic

Each CCU is connected with the Vehicle Logic through:

- HVAC Low Voltage Wired Lines: High/Low signals transferred through dedicated wired lines. The vehicle Relay Logic and the LVDS in general (Refer to Section 10) manage these signals.

- MVB Bus: through this bus the HVAC System communicates its status to the other Vehicle Systems and receives commands. (Refer to Section 18).

The Microprocessor Controller receives the HVAC LV signals.

With the MVB communication working properly, the unit remains in OFF mode (switched off), until it receives the start command via MVB. If the MVB communication is not working properly and HVAC ON/OFF and HVAC SHUT DOWN signals are in logical 1, then the unit starts with a 3 seconds delay HVAC_SD..

If MVB is not working, the unit controllers make sure that the motors (Compressor motors, evaporator and condenser fan motors) of the two car units (supplied by one inverter) do not start simultaneously.

In this case, the motors of unit A can start only if the number of seconds in the real time clock is between 0 and 15. While the motors of unit B can start only if the number of seconds in the real time clock is between 30 and 45.

Heaters can start without any time delay.

The CCU (and the Microprocessor Controller as a consequence) is equipped with one connector for interfacing the Vehicle Logic: Connector X11, used for both HVAC LV Wired Lines and MVB signals (refer to the figures in paragraph 05-I-01.01.01).

- HVAC LV Wired Lines

Table 05-I-02.5 lists the hard-wired signals carried via connector X11:

**Table 05-I-02.5 List of HVAC LV Wired Signals**

| Signal | TK Designation | Remark |
|---|---|---|
| + 24 Vdc | - | Control Voltage Supply |
| HVAC SHUT DOWN | DIACOK1 | Hard-wired shut down: if this signals drops to logical 0, unit stops |
| 0 V | - | Control Voltage Supply (Return) |
| HVAC ON/OFF | DICF0 | Hard-wired signal ON/OFF |
| A-UNIT | DIAOM | Signal for Unit A designation: if in logical 1 Unit A is designed |
| FAD_IN<br>FAD_OUT | FAD_IN<br>FAD_OUT | Control of Fresh air dampers: FAD_IN put through FAD_OUT damper close. FAD_IN open FAD_OUT damper open |
| Digital input HSP | DIHSP | Signals reserved for TK use |
| Digital input MSP | SIMSP | |
| Digital input LSP | SILSP | |
| External Switch Common | ESC | |
| Digital Output for TK use | DOLFLS1 | |

- MVB Bus

The Tables of this paragraph list all relevant parameters available in the HVAC controller that can be transmitted via MVB. Not all of the following signals are actually used by other vehicle systems. For the signal actually used refer to Section 18.

**Table 05-I-02.6 Digital Inputs of the HVAC Controller**

| Bit Number | Symbol | Description | Remarks |
|---|---|---|---|
| 0 | DIMPS | Modulation Pressure Switch | DIMPS = 1 → O.K. |
| 1 | DIEFOL | Evaporator Fan Overload Relay | DIEFOL = 1 → OK |
| 2 | DIC1OL | Compressor #1 Overload Relay | DIC1OL = 1 → OK |
| 3 | DIHPCO | High Pressure Cut Out Switch | DIHPCO = 1 → OK |
| 4 | DILPCO | Low Pressure Cut Out Switch | DILPCO = 1 → OK |
| 5 | DIC2OL | Compressor #2 Overload Relay | DIC2OL = 1 → OK |
| 6 | DICF1OL | Condenser Fan #1 Overload Relay | DICF1OL = 1 → OK |
| 7 | DICF2OL | Condenser Fan #2 Overload Relay | DICF2OL = 1 → OK |
| 8 | DICF0 | L_HVAC Shut down | DICF0 = 1 → unit runs<br>DICF0 = 0 → unit stops |
| 9 | DIH1TS | Heater #1 Temperature Switch or Heater #1 Circuit breaker trip | DIH1TS = 1 → OK |
| 10 | DIAUTO | SWT “AUTO” Position | DIAUTO = 1 → automatic mode |
| 11 | DICV | Control Voltage Supply and Dead Man Switch | DICV = 1 → control voltage OK and dead man switch closed |
| 12 | DITEST | SWT “TEST” Position | DITEST = 1 ® testing mode |
| 13 | DIACOK1 | HVAC ON/OFF | DIACOK1 = 1 → Supply Voltage is OK |
| 14 | DIH2TS | Heater #2 Temperature Switch or Heater #2 Circuit breaker trip | DIH2TS = 1 → OK |
| 15 | DIACOK2 | | N/A |
| 16 | DISE | Motor Start Enable | DISE = 1 |
| 17 | DILSP | Reserved TK Use | N/A |
| 18 | DIMSP | Reserved TK Use | N/A |
| 19 | DIHSP | Reserved TK Use | N/A |
| 20 | DIHSR | Heaters Circuit Breaker Shunt Release | DIHSR = 0 → OK<br>DIHSR = 1 → shunt release |
| 21 | DIHC | Evaporator Contactor Interlocking Signal | DIHC = 1 → if contactor is turned on DIHC = 0 ⇒ if contactor is opened |

### Table 05-I-02.6 Digital Inputs of the HVAC Controller

| Bit Number | Symbol | Description | Remarks |
|---|---|---|---|
| 22 | DIAOM | Priority Status Bit | DIAOM = 0 → B unit - lower priority<br>DIAOM = 1 → A unit higher priority |
| 23 | DICF1TS | Condenser Fan Motor #1 Temperature Switch | DICF1TS = 1 → OK |
| 24 | DICF2TS | Condenser Fan Motor #2 Temperature Switch | DICF2TS = 1 → OK |
| 25 | DIEFTS | Evaporator Fan Motor Temperature Switch | DIEFTS = 1 → OK |

### Table 05-I-02.7 Digital Outputs of the HVAC Controller

| Bit Number | Symbol | Description | Remarks |
|---|---|---|---|
| 0 | DOCF1 | Condenser Fan Motor #1 ON/OFF Switch | DO1 |
| 1 | DOCF2 | Condenser Fan Motor #2 ON/OFF Switch | DO2 |
| 2 | DOEF | Evaporator Fan Motor ON/OFF Switch | DO3 |
| 3 | DOFLS1 | Unit Fault - ERROR | DO4 |
| 4 | DOFLS2 | Unit Fault - WARNING | DO5 |
| 5 | DOC1 | Compressor #1 ON/OFF Switch | DO6 |
| 6 | DOC2 | Compressor #2 ON/OFF Switch | DO7 |
| 7 | DOEH1 | External Heater #1 ON/OFF Switch | DO8 |
| 8 | DOEH2 | External Heater #2 ON/OFF Switch | DO9 |
| 9 | DOYML | Digital Output | DO10 (Not Used) |
| 10 | DOYLL | Liquid Line Solenoid ON/OFF Switch | DO11 |
| 11 | DO12 | Digital Output | DO12 (Not Used) |
| 12 | DO12 | Digital Output | DO13 (Not Used) |
| 13 | DOH1 | Internal Heater #1 ON/OFF Switch | DO14 |
| 14 | DOH2 | Internal Heater #2 ON/OFF Switch | DO15 |
| 15 | DOUSI | Unit Start Inhibition | DO16 |
| 16 | DO17 | Digital Output | DO17 (Not Used) |
| 17 | DO18 | Digital Output | DO18 (Not Used) |

**Table 05-I-02.8 Analog Inputs of the HVAC Controller**

| Symbol | Description | Remarks | Sing. Name + Type |
|---|---|---|---|
| AIEFC | Evaporator Fan Motor Current | Analog input | EFC (Integer16) |
| AICFC | Condenser Fan Motors Current | Analog input | CFC (Integer16) |
| AICC | Compressor Motors Current | Analog input | CC (Integer16) |
| AIRAT | Return Air Temperature | Analog input | ReturnAirTemp (Integer16) |
| | Return Air Temperature Valid | N/A | ReturnAirTempValid (Bit) |
| AIDAT | Duct Air Temperature | Analog input | DuctAirTemp (Integer16) |
| | Duct Air Temperature Valid | N/A | DuctAirTempValid(Bit) |
| AIFAT | Fresh Air Temperature | Analog input | FreshAirTemp (Integer16) |
| | Fresh Air Temperature Valid | N/A | FreshAirTempValid(Bit) |
| AISP | Set Point | Analog input | Set-point(Integer16) |
| | Set-pointValid | N/A | Set-pointValid(Bit) |
| AITS | Spare Temperature Sensor | Analog input | SPI(Integer16) |
| AIRH | Relative Humidity | Analog input | RelHum(Integer16) |
| | Rel Hum Valid | N/A | RelHumValid(Bit) |
| AIDC2 | Spare DC Current Input | Analog input | CI2(Integer16) |

**Table 05-I-02.9 Internal Parameters of the HVAC Controller**

| Symbol | Description | Remarks | Sing. Name + Type |
|---|---|---|---|
| WHU | Working hours of the A/C unit | Time resolution 1 minute | WHU(Integer16) |
| WHEF | Working hours of the evaporator fan (#1 and #2) | Time resolution 1 minute | WHEF(Integer16) |
| WHCF1 | Working hours of the condenser fan #1 | Time resolution 1 minute | WHCF1(Integer16) |
| WHCF2 | Working hours of the condenser fan #2 | Time resolution 1 minute | WHCF2(Integer16) |
| WHC1 | Working hours of the Compressor #1 | Time resolution 1 minute | WHC1(Integer16) |
| WHC2 | Working hours of the Compressor #2 | Time resolution 1 minute | WHC2(Integer16) |
| WHIEH1 | Working hours of the Internal Electric Heater #1 | Time resolution 1 Minute | WHIEH(Integer16) |
| WHIEH2 | Working hours of the Internal Electric Heater #2 | Time resolution 1 minute | WHIEH(Integer16) |

## Table 05-I-02.9 Internal Parameters of the HVAC Controller

| Symbol | Description | Remarks | Sing. Name + Type |
|---|---|---|---|
| WHEEH1 | Working hours of the External Electric Heater #1 | Time resolution 1 minute | WHEEH1(Integer16) |
| WHEEH2 | Working hours of the External Electric Heater #2 | Time resolution 1 minute | WHEEH2(Integer16) |
| AWM | Actual working mode | Actual Mode | AworkMode(ENUM4) |
| RWM | Required working mode | Required Mode | RworkMode(ENUM4) |
| UnitId | Unit Identification | Identification Number | UnitId(ENUM4) |
| AS | Actual Status | Actual Unit Status | ActualStatus(Integer16) |
| DICFO | Control voltage | DICFO = 1 = OK | ActualStatus Bit0 |
| DIACOK1 | Power 1 OK | DIAOK1 = 1 = OK | ActualStatus Bit1 |
| DIACOK2 | Power 2 OK | DIAOK2 = 1 = OK | ActualStatus Bit2 |
| DIAOM | Priority status bit | DIAOM = 1 = Unit A (master),<br>DIAOM = 0 = Unit B | ActualStatus Bit3 |
| DOUSI | Unit start inhibition | DOUSI = 1 = Unit star | ActualStatus Bit4 |
| Modulation | Modulation pressure Switch | Modulation = 1 = Activ | ActualStatus Bit7 |
| HumidCtrl | Humidity control | HumcontrolExist = 1 = Activ | ActualStatus Bit8 |
| AlarmExist | Alarm state | AlarmExist = 1 = Activ | ActualStatus Bit9 |
| WarnExist | Warning state | WarnExist = 1 = Activ | ActualStatus Bit10 |
| Emergency | Emergency state | Emergency = 1 =Activ | ActualStatus Bit11 |

## Table 05-I-02.10 SW and NSDB versions sent to TCU

| Description | Remarks | Sing. Name + Type |
|---|---|---|
| NSDB Release Number | NSDB Release Number | NSDBVersion Rel (Integer16) |
| NSDB Patch Number | NSDB Patch Number | NSDBVersion Pat (Integer16) |
| NSDB Release Number | NSDB Release Number | NSDBVersion Rel (Integer16) |
| NSDB Patch Number | NSDB Patch Number | NSDBVersion Pat (Integer16) |

**Table 05-I-02.11 Error Signals sent to HVAC and TCU**

| Description | Remarks | Sing. Name + Type |
|---|---|---|
| Critical Faults | CriticalFault = 1 = some critical faults<br>CriticalFault = 0 = without critical faults | CriticalFault(Bit) |
| Minor Faults | MinorFault = 1 = some minor faults<br>MinorFault = 0 = without minor faults | MinorFault(Bit) |
| Maintanance Request | MaintananceRequest = 1 = some maintanance request<br>MaintananceRequest = 0 = without maintanance requests | MaintananceReq(Bit) |

**Table 05-I-02.12 Error Signals sent to TCU via MVB**

| Description | Remarks | Sing. Name + Type |
|---|---|---|
| **Critical Error Bits** | | CritErrBits(Bitset32) |
| Alarm Code 10 | 1 = Activ,0 = NonActiv | LowPressCO Bit0 (Bit) |
| Alarm Code 11 | 1 = Activ,0 = NonActiv | HighPressCO Bit1 (Bit) |
| Alarm Code 140 | 1 = Activ,0 = NonActiv | TempReadFault Bit2 (Bit) |
| Alarm Code 350 | 1 = Activ,0 = NonActiv | BothWyeTrip Bit3 (Bit) |
| Alarm Code 405 | 1 = Activ,0 = NonActiv | EFOLR Bit4 (Bit) |
| Alarm Code 406 | 1 = Activ,0 = NonActiv | EFTherm Bit5 (Bit) |
| Alarm Code 415 | 1 = Activ,0 = NonActiv | HeatShunt Bit6 (Bit) |
| Alarm Code 420 | 1 = Activ,0 = NonActiv | ContainerOpen Bit7 (Bit) |
| Alarm Code 416 | 1 = Activ,0 = NonActiv | EFContactOpen Bit8 (Bit) |
| **Minor Error Bits** | | MinorErrBits(Bitset32) |
| Alarm Code 5 | 1 = Activ,0 = NonActiv | CalConstErr Bit0 (Bit) |
| Alarm Code 6 | 1 = Activ,0 = NonActiv | GlgDataErr Bit1 (Bit) |
| Alarm Code 7 | 1 = Activ,0 = NonActiv | DataArchErr Bit2 (Bit) |
| Alarm Code 101 | 1 = Activ,0 = NonActiv | RASensFail Bit3 (Bit) |
| Alarm Code 102 | 1 = Activ,0 = NonActiv | FASensFail Bit4 (Bit) |
| Alarm Code 103 | 1 = Activ,0 = NonActiv | DASensFail Bit5 (Bit) |
| Alarm Code 105 | 1 = Activ,0 = NonActiv | HumidSensFail Bit6 (Bit) |
| Alarm Code 403 | 1 = Activ,0 = NonActiv | C1WyeTrip Bit7 (Bit) |
| Alarm Code 404 | 1 = Activ,0 = NonActiv | C2WyeTrip Bit8 (Bit) |
| Alarm Code 408 | 1 = Activ,0 = NonActiv | CF1Therm Bit9 (Bit) |
| Alarm Code 410 | 1 = Activ,0 = NonActiv | CF2Therm Bit10 (Bit) |

### Table 05-I-02.12 Error Signals sent to TCU via MVB

| Description | Remarks | Sing. Name + Type |
|---|---|---|
| Alarm Code 401 | 1 = Activ,0 = NonActiv | C1OLR Bit 11 (Bit) |
| Alarm Code 402 | 1 = Activ,0 = NonActiv | C2OLR Bit 12 (Bit) |
| Alarm Code 407 | 1 = Activ,0 = NonActiv | CF1OLR Bit13 (Bit) |
| Alarm Code 409 | 1 = Activ,0 = NonActiv | CF2OLR Bit14 (Bit) |
| Alarm Code 411 | 1 = Activ,0 = NonActiv | Heat1Fault Bit15(Bit) |
| Alarm Code 413 | 1 = Activ,0 = NonActiv | Heat2Fault Bit16(Bit) |
| Alarm Code 30 | 1 = Activ,0 = NonActiv | HighDucTemp Bit17(Bit) |
| Alarm Code 24 | 1 = Activ,0 = NonActiv | LowFATemp Bit18(Bit) |
| Alarm Code 25 | 1 = Activ,0 = NonActiv | HighRelHumid Bit19(Bit) |
| Alarm Code 150 | 1 = Activ,0 = NonActiv | HighHumidSensBit20 (Bit) |
| Alarm Code 151 | 1 = Activ,0 = NonActiv | LowHumidSensBit 21(Bit) |
| Alarm Code 20 | 1 = Activ,0 = NonActiv | GenCoolFault Bit22 (Bit) |
| Alarm Code 21 | 1 = Activ,0 = NonActiv | HotVehFault Bit23 (Bit) |
| Alarm Code 22 | 1 = Activ,0 = NonActiv | InvalidDigSP Bit24 (Bit) |
| Alarm Code 23 | 1 = Activ,0 = NonActiv | InvalidAnSP Bit25(Bit) |
| **Maintenance Error Bits** | | MaintenErrBits(Bitset32) |
| Alarm Code 1 | 1 = Activ,0 = NonActiv | InitRS232ErrBit0 (Bit) |
| Alarm Code 2 | 1 = Activ,0 = NonActiv | BatLow Bit1(Bit) |
| Alarm Code 110 | 1 = Activ,0 = NonActiv | RASensShort Bit2(Bit) |
| Alarm Code 111 | 1 = Activ,0 = NonActiv | RASensOpen Bit3(Bit) |
| Alarm Code 120 | 1 = Activ,0 = NonActiv | FASensShort Bit4(Bit) |
| Alarm Code 121 | 1 = Activ,0 = NonActiv | FASensOpen Bit5(Bit) |
| Alarm Code 130 | 1 = Activ,0 = NonActiv | DASensShort Bit6(Bit) |
| Alarm Code 131 | 1 = Activ,0 = NonActiv | DASensOpen Bit7(Bit) |
| Alarm Code 300 | 1 = Activ,0 = NonActiv | BothCOverC Bit8(Bit) |
| Alarm Code 301 | 1 = Activ,0 = NonActiv | C1OverC Bit9(Bit) |
| Alarm Code 302 | 1 = Activ,0 = NonActiv | C2OverC Bit10(Bit) |
| Alarm Code 303 | 1 = Activ,0 = NonActiv | BothCFOverC Bit11(Bit) |
| Alarm Code 3 | 1 = Activ,0 = NonActiv | CF1UnderC Bit12(Bit) |
| Alarm Code 3 | 1 = Activ,0 = NonActiv | CF2UnderC Bit13(Bit) |
| Alarm Code 306 | 1 = Activ,0 = NonActiv | EFOverC Bit14(Bit) |
| Alarm Code 307 | 1 = Activ,0 = NonActiv | EFUnderCBit15(Bit) |
| Alarm Code 308 | 1 = Activ,0 = NonActiv | FilterFault Bit16 (Bit) |
| Alarm Code 309 | 1 = Activ,0 = NonActiv | BothCFUnderC Bit17(Bit) |
| Alarm Code 310 | 1 = Activ,0 = NonActiv | CF1OverC Bit18 (Bit) |
| Alarm Code 311 | 1 = Activ,0 = NonActiv | CF2OverC Bit 19(Bit) |

**Table 05-I-02.13 Digital Commands sent via MVB**

| Description | Remarks | Sing. Name + Type |
|---|---|---|
| Bit0 | VentilationOn = 1 . → Ventilation mode<br>VentilationOn = 0 and HVACOn = 0 →. HVAC OFF | VentilationOn(Bit) |
| Bit1 | HVACOn = 1 . HVAC control VentilationOn = 0 and HVACOn = 0 →. HVAC OFF | HVACOn(Bit) |
| LoadShed | LoadShed = 1 LoadShedModeActiv<br>LoadShed = 0 LoadShed ModeDeactiv | LoadShed(Bit) |

b ) HVAC Sensors - Microprocessor Controller Inputs

System inputs are used to monitor system performance and determine operating modes.

**Analog Inputs**

- Return Air Sensor (BRAS)
- Duct Air Sensor (BDAS)
- Fresh (Outside) Air Sensor (BFAS)
- Current Signal, Compressor Motors (TCOM)
- Current Signal, Evaporator Fan Motor (TEFM)
- Current Signal, Condenser Fan Motors (TCFM)

**Digital Inputs**

- Pressure Switch, Modulation (BMP)
- Fault Signal, Evaporator Fan Motor Overload (FS1)
- Fault Signal, Compressor Motor #1 Overload (FS2)
- Fault Signal, High Pressure (FS3)
- Fault Signal, Low Pressure (FS4)
- Fault Signal, Compressor Motor #2 Overload (FS5)
- Fault Signal, Condenser Fan Motor #1 Overload (FS6)
- Fault Signal, Condenser Fan Motor #2 Overload (FS7)
- Fault Signal, Evaporator Contactor Switched Off (FS8)
- Fault Signal, Heater #1 (FS9)
- Fault Signal, Heater #2 (FS10)
- Fault Signal, Back up Protection Heater #1 and #2 (FS11)
- Fault Signal, Condenser Fan Motor #1 Thermal Overload (FS12)
- Fault Signal, Condenser Fan Motor #2 Thermal Overload (FS13)
- Fault Signal, Evaporator Blower Motor Thermal Overload (FS14)

### c ) Microprocessor Controller Outputs

System outputs are used to control system component operation.

- Fault Light Signal (FLS1)
- Solenoid Valve, Liquid Line (YLL)
- Contactor, Condenser Fan Motor #1 (KCFM1)
- Contactor, Condenser Fan Motor #2 (KCFM2)
- Contactor, Compressor Motor #l (KCOM1)
- Contactor, Compressor Motor #2 (KCOM2)
- Contactor, Evaporator Fan Motor (KEFM)
- Contactor, Heater #1 (KHTR1)
- Contactor, Heater #2 (KHTR2)

### d ) General Theory Of Operation

The microprocessor controller uses advanced solid-state integrated circuits to monitor and control all unit functions.

The controller monitors inputs from:

- Return air sensor
- Duct air sensor
- Fresh (outside) air sensor
- Current transformer circuits(3) for compressor motors, condenser fan motors and evaporator blower motor

Output signals from the controller automatically regulate all unit functions including:

- Compressor operation
- Condenser fan operation
- Evaporator blower motor operation
- Liquid line solenoid valve
- Fault light
- Two Stage Heater

### e ) Unit Start-up

A sequence start of the required loads occurs during initial start-up of the controller.

If cooling is required, the unit operates in the Full Cool or Partial Cool as required by the return air sensor, set-point temperature and control algorithm.

- When the unit AUTO-OFF-TEST switch is turned to AUTO, the controller polls the control voltage (24 Vdc) and ACOK inputs. If either input is ON (High), the controller energizes the evaporator fans' contactors after a delay of 0.1 to 4.0 seconds.

- If the controller calls for cooling, the controller energizes the condenser fan motor 1 contactor and the liquid line solenoid valve after a 1 second delay.
- The controller then energizes compressor motor 1 contactor after another 1 second delay, placing the unit in Partial Cool.

**NOTE:** On each successive switch from low heat mode to a reheat mode, the controller alternates the initial startup of the condenser fan motor between condenser fan motor 1 and condenser fan motor 2. The controller also alternates the startup of the compressor between compressor 1 and compressor 2.

This is done to balance the service duty (hours of operation) equally between both condenser fan motors and both compressors.

- If the return air temperature requires Full Cool operation, the controller energizes the condenser fan motor 2 contactor, Compressor 2 combination after a 1 second delay, setting the unit in Full Cool.

f ) Continuous Temperature Control Operation

After initial unit start-up, the controller regulates the compressors, condenser fan motors, and liquid line solenoid valve based on the set point temperature and the return air sensor temperature. The controller operates the unit on (see Figure 05-I-02.27):

- Full Cool mode
- Partial Cool mode
- Reheat mode
- Ventilation mode
- Heat Stage 1 mode
- Heat Stage 2 mode

**NOTE:** The controller also places the unit in Modulation Cool mode whenever the unit is operating in Full Cool and the modulation pressure switch opens (refrigerant discharge pressure rises to 390 ± 12 psig).

The modulation pressure switch protects against unit shutdown due to current overload in high ambient operating conditions.

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