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Application Engineering Europe

## DEMAND COOLING™ FOR COPELAND™ STREAM COMPRESSORS WITH DEMAND COOLING DRIVER (XEV01D)

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## 1 Introduction

Experience has shown that the R407 series of refrigerants and R22 can cause problems in low temperature applications because under some conditions the internal compressor discharge temperature exceeds the safe temperature limit for long term stability of refrigeration oil.

The Demand Cooling™ system uses modern electronics to provide an effective solution to this problem. It is required for low evaporating temperatures with R407A, R407F, R448A, R449A, and all R22 applications with saturated suction temperatures below -20°C (operating envelopes with Demand Cooling are available in Select Software).

## 2 Demand Cooling operation

The Demand Cooling driver uses the signal of a discharge head temperature sensor to monitor discharge gas temperature. If a critical temperature is reached, the driver energizes a long life injection valve which meters a controlled amount of saturated refrigerant into the compressor suction cavity to cool the suction gas.

To minimize the amount of refrigerant that has to be injected, the suction gas cooling process is performed after the gas has passed around and through the motor.

This process controls the discharge temperature to a safe level. If, for some reason, the discharge temperature rises above a pre-set maximum level for 2 seconds, the CoreSense Diagnostics will switch the compressor off for 2 minutes before automatic resetting.

## 3 Components

The Demand Cooling system consists of a temperature sensor, an injection expansion valve, the Demand Cooling driver, the tubing sight glass and filter drier, and mounting brackets.

This system can be delivered as a variation together with the compressor or as a separate kit.

### 3.1 Temperature sensor

The Copeland™ Demand Cooling system uses a Negative Temperature Coefficient (NTC) Thermistor (resistance drops on temperature rise) to give temperature signals to the driver.

The resistance at ambient temperature (25°C) is 86,000 Ohms.

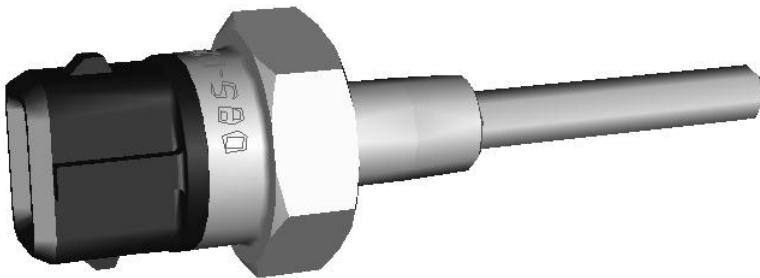


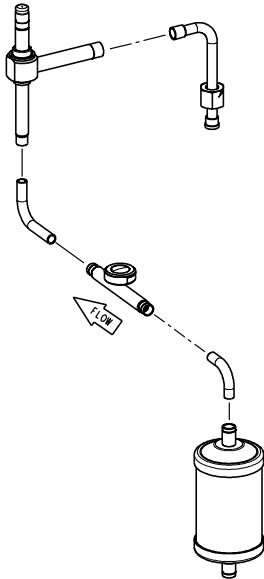
Figure 1: Temperature sensor

### 3.2 Injection valve kit

The injection valve was developed to operate under the usual voltage and ambient conditions plus withstand any vibration that can be expected from being mounted to a compressor.

The injection valve kit comprises of the tubing, filter drier, mounting brackets, solenoid coil with PG9 cable gland. The parts are **NOT pre-assembled** for transport reasons.

#### Injection valve kit for 4M\*



#### Injection valve kit for 6M\*

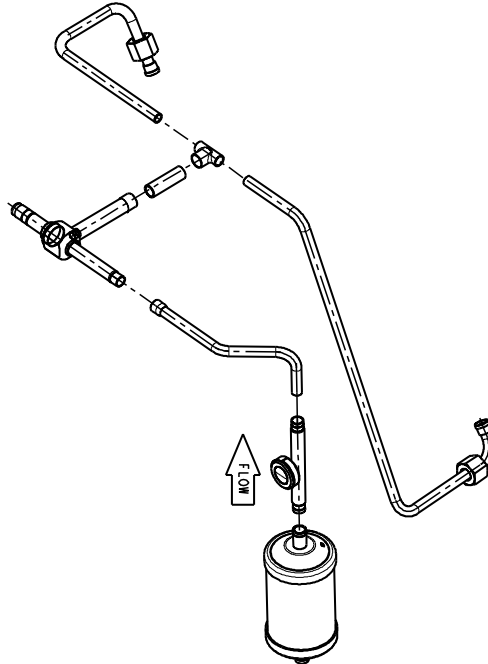


Figure 2: Injection valve kit parts

The parts need to be assembled before installation as shown below.

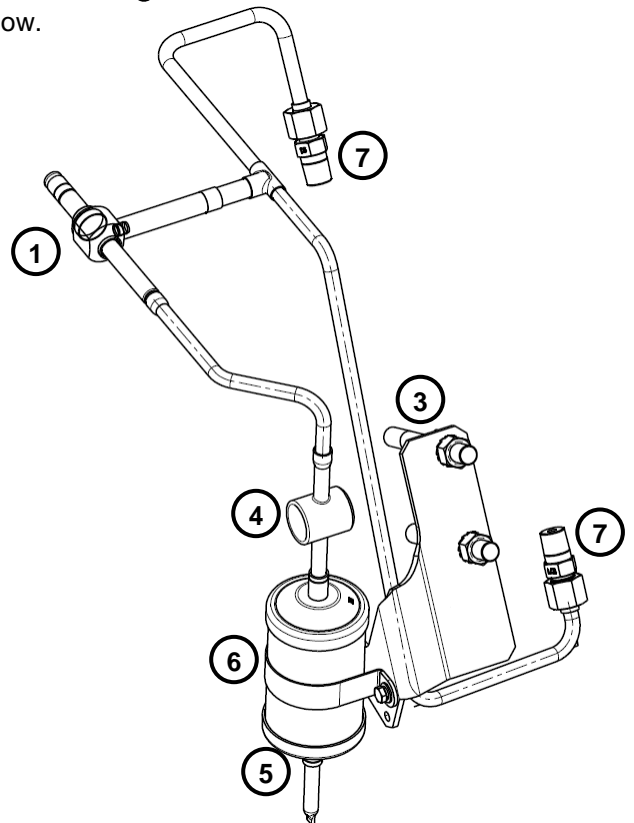
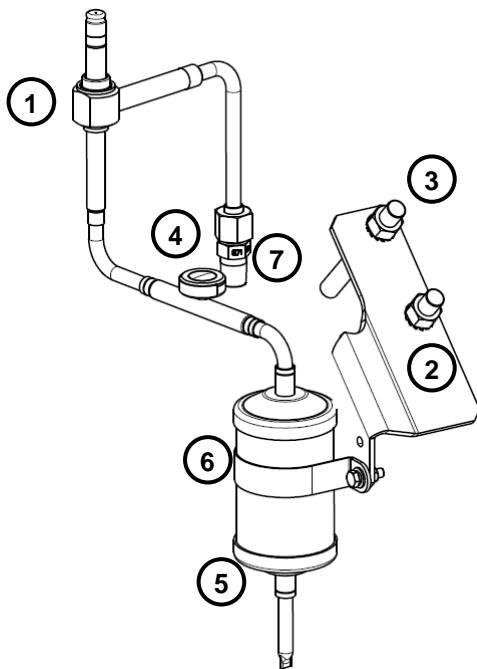


Figure 3: Injection valve kits when assembled

	Designation	4M*	6M*
1	Demand Cooling expansion valve	<b>Alco EX2-100</b>	
2	Mounting bracket to mount the injection valve to the cylinder head		
3	Head studs with washers to fasten mounting bracket to compressor		
4	Sight glass	<b>Alco MIA M10</b>	<b>Alco MIA M10S</b>
5	Filter drier	<b>Alco ADK 1610 MMS</b>	
6	Clamp for Demand Cooling fixing		
7	Male flare union 3/8"-NPT to 3/8"		

### 3.3 Demand Cooling driver (XEV01D)

The XEV01D driver is designed for Demand Cooling applications. It is connected to a temperature sensor (see chapter 3.1).

The driver has a digital output (relay) which is used for alarm indication and a modulating output (TRIAC type). There are also two configurable digital inputs, the first one is free of voltage and the other one is isolated in order to simplify connections with cooling request signal (high voltage input).

The display enables to visualise the temperature value or the output percentage activation.

To complete instrument equipment, a RS485 serial port allows connection of the driver to any modbus network.

The Demand Cooling allows monitoring of the compressor head temperature (measured by a temperature sensor) and acts on a cold gas injection valve (through a TRIAC or a digital output) placed directly in the head, if the measured temperature is higher than a set value.

Modulating is proportional and is based on the values read by the temperature sensor. The lower and upper temperature limits within which the gas injection inside the compressor head must be regulated, are defined by parameters LS and US.

#### 3.3.1 Technical data

- Housing:** ..... Self-extinguishing ABS
- Case:** ..... 4 DIN modules 70x135mm with male and female connectors; depth 60 mm
- Mounting:**..... DIN RAIL mounted in an omega (3) din rail
- Protection:** ..... IP20
- Connections:** ..... Screw terminal block  $\leq 2.5 \text{ mm}^2$  wiring
- Power supply:** ..... 230VAC  $\pm 10\%$
- Power absorption:** Depending on connected valve 20VA max
- Display:** ..... 3.5 digits with icons, red LEDs, height 14.2 mm
- Inputs:** ..... 1 temperature sensor: NTC86k probe: -40 to 180°C
- Digital inputs:** ..... 1 free of voltage  
..... 1 isolated (high voltage)
- TRIAC output:**..... Max 500W at 230VAC
- Data storage:** ..... On the non-volatile memory (EEPROM)
- Operating temp:** .... 0 to 60°C
- Storage temp:**..... -25 to 60°C
- Relative humidity:** . 20 to 85% (no condensing)



### 3.3.2 Driver electrical connections

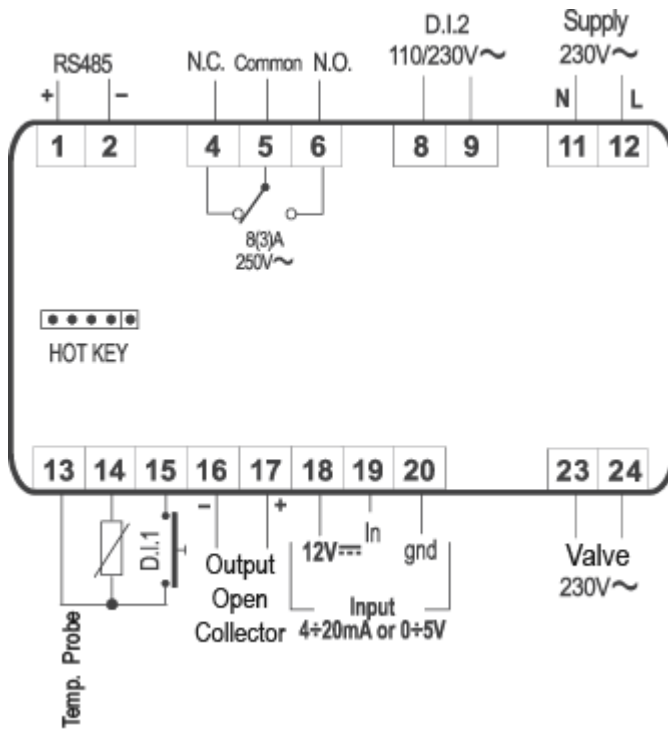


Figure 4

**NOTE:** Connect the injection valve directly to terminals 23 and 24. The XEV01D driver is able to issue the required power supply (by using the same power supply as input terminals 11 and 12).

### 3.3.3 Driver installation

The driver XEV01D has to be installed inside the system control panel/electrical box.

## 4 Demand Cooling application

The Demand Cooling system should be considered as the back-up for a well-designed low temperature refrigeration system.

Normally the Demand Cooling valve only operates during high condensing temperature conditions. The refrigerant injected by the valve cools the compressor to operate safely.

Due to the relatively small amounts of liquid injected, no excessive system pressure fluctuations (normally < 0.15 bar) occur during injection valve cycling.

Compressor capacity and efficiency drops are almost insignificant since the suction gas is cooled by the liquid and becomes denser. This enables the compressor to handle the additional mass flow with a minimal loss of evaporator capacity.

Performance data for Demand Cooling compressors include the effects of injection. They can therefore be used in the conventional manner for compressor and condenser selection.

**NOTE:** Liquid subcooling must be sufficient at the Demand Cooling injection valve to prevent flashing.

### 4.1 Reducing the demand for injected cooling

There are several methods to reduce Demand Cooling operation in order to optimize the energy efficiency.

Suction lines should be well insulated to reduce suction line heat gain. Return gas superheat should be as low as possible but consistent with safe compressor operation.

Evaporator and system control settings should provide the maximum suction pressure consistent with the application in order to have as low a compression ratio as possible.

The condensing temperature should be kept as low as possible to reduce the compression ratio as well as the discharge temperature. Otherwise condensers should be sized using conventional methods.

The exact application range must be taken from Select Software.

**NOTE: A vertical cylinder head fan is always required for usage with R22 only!**

**NOTE: Demand Cooling is not approved for compressors with capacity modulation.**

## 4.2 Demand Cooling operation set points

The Demand Cooling driver controls the liquid injection and also behaves as an alarm.

### 4.2.1 Liquid injection control

- Injection start: Sensor resistance < 2100 Ohms (T > 140°C); Demand Cooling On
- Injection stop: Sensor resistance > 2400 Ohms (T > 130°C); Demand Cooling Off

### 4.2.2 Modulating output for Demand Cooling

If one of the digital inputs is set as **onF**, then the modulation will be enabled only if the related digital input signal is active.

- If temperature is below **LS** (130°C), the valve is always Off.
- If temperature is between **LS** (130°C) and **US** (140°C), the valve will be proportionally modulated (between **0** and **100%**) with cycle time **tdG**.
- If temperature is higher than **US** (140°C), the valve is always On (or at **100%** value).
- If temperature is lower than **LS** (130°C), the valve is always Off (or at **0%** value).

### 4.2.3 High temperature alarm

This process controls the discharge temperature to a safe level.

If the compressor temperature sensor detects a discharge temperature higher than 154°C for 2 seconds, **CoreSense™ Diagnostics** will switch the compressor off until the temperature cools down to an acceptable level. Automatic resetting will occur after 2 minutes.

The CoreSense module will trip by default (either trip or lockout alarm can be selected by user using the PC interface software).

- Trip alarm: Automatic reset after 2 minutes if discharge temp < 130°C.
- Lockout alarm: Manual reset is necessary.

A sensor short circuit (low resistance value) will result in the same tripping.

### 4.2.4 Low temperature alarm

Low temperature can occur if a compressor has been standing in a very cold environment for a long time. To avoid the triggering of an alarm in such a case, a time delay of 2 minutes is installed. The delay allows the discharge temperature to rise to a normal operating level. If the discharge temperature remains too low the module signals an open circuit.

If the temperature sensor P2 measures a value lower than the one set in parameter **ALL** and if this condition persists for longer than the value set in parameter **dLL**:

- General alarm LED and digital output set as alarm (**oAx=ALr**) will be activated.
- If a digital output is set as compressor output (**oA1=CPr**) this will be deactivated.
- Expansion control output will be deactivated.
- Buzzer will be activated (depending on the **bEn** parameter).

Alarm reset is **manual** by means of controller On-Off procedure.

A sensor circuit cut ( $\infty$  infinite resistance value) will result in the same tripping.

**NOTE: In case of improper liquid feed (choked / dirty liquid line filter drier or poor pipe assembly / manufacturing) the EX2 valve will open trying to inject liquid until the CoreSense trips the compressor due to high temperature.**



## 5 Demand Cooling installation

**NOTE: The injection expansion valve and module must be appropriate to voltage and frequency.**

Check that the Demand Cooling kit is complete before installation.

The Demand Cooling kit is delivered with an Installation Manual. The various parts should be installed according to the Installation Manual for proper operation and warranty of the compressor.

### 5.1 Temperature sensor

The Demand Cooling sensor must be installed into the left head looking from oil pump view, both for 4M\* and 6M\* models.

A cable AWG20 (0.5 mm<sup>2</sup>) with 2 wires must be used (not delivered with the kit).

For cables longer than 10 meters, we recommend to use a shielded cable and to ground one end of the shield near the driver (not on the driver).

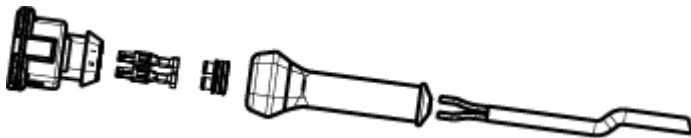


Figure 5: Temperature sensor

### 5.2 Injection valve parts

The injection valve is not pre-assembled: the injection tubing assembly has to be assembled before installation according to Chapter 3.2 and to the Installation Manual delivered together with the Demand Cooling kit.

The white Teflon washer included in the kit can be fitted between the solenoid coil and the blue clip to prevent the coil from moving.



### 5.3 Installation procedure



#### IMPORTANT

Protect valve against excessive heat while brazing (using inert gas).  
Do not swage the inlet tubing on the injection valve itself.

- 1) Before the Demand Cooling system can be installed the compressor has to be depressurized by qualified service personnel and in accordance with local regulations.
- 2) On a brand new compressor the holding charge must be removed.
- 3) Before installing the Demand Cooling kit, braze securely the injection parts (expansion valve filter drier, sight glass, tubing...). Use Solder Fontargen A3005V for brazing copper on copper.
- 4) Remove the plug on the cylinder head (left when looking from the oil pump side) and insert the Discharge temperature sensor. Torque to 19-22 Nm.
- 5) Remove the 2 cylinder head bolts to mount the filter drier bracket with the studs provided. Place the washers and nuts on the studs. Do not fully tighten nuts.
- 6) Remove the 3/8"-NPT plug on the compressor body. Mount male flare union (3/8"-NPT/3/8") instead.
- 7) Connect the female flare fitting to the male flare union mounted to the compressor body. Do not fully tighten.
- 8) Fix the filter drier with the clamp on the bracket.
- 9) Torque the flare fitting of step 6. Torque to 21 Nm with Loctite 192026.
- 10) Torque the stud nuts of the mounting bracket. Torque to 62 Nm.
- 11) Torque the bolts between the filter drier clamp and the bracket. Torque to 10 Nm.
- 12) Braze the liquid line to the inlet tubing of the injection expansion valve (use inert gas when brazing).

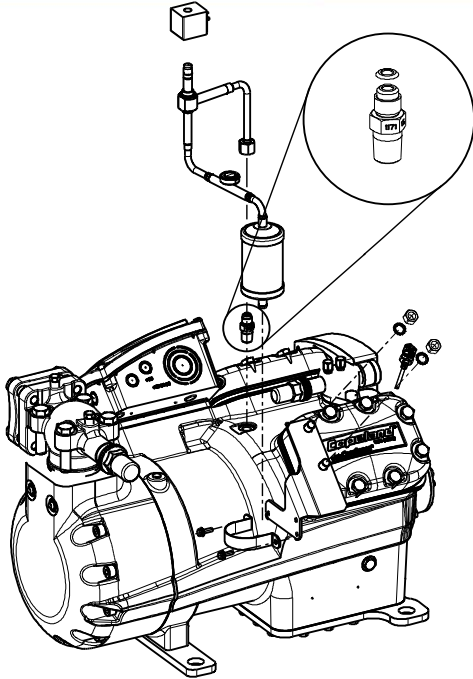


Figure 6: Injection parts on 4M\* compressors

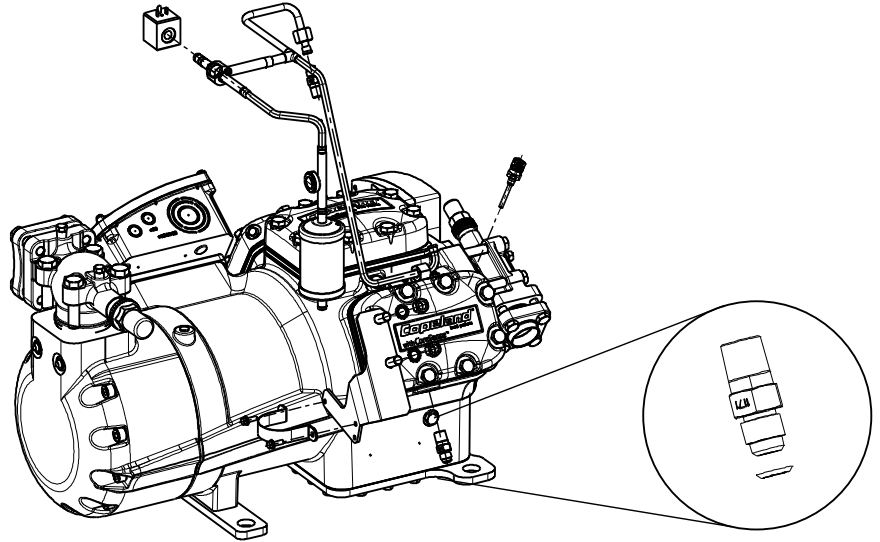
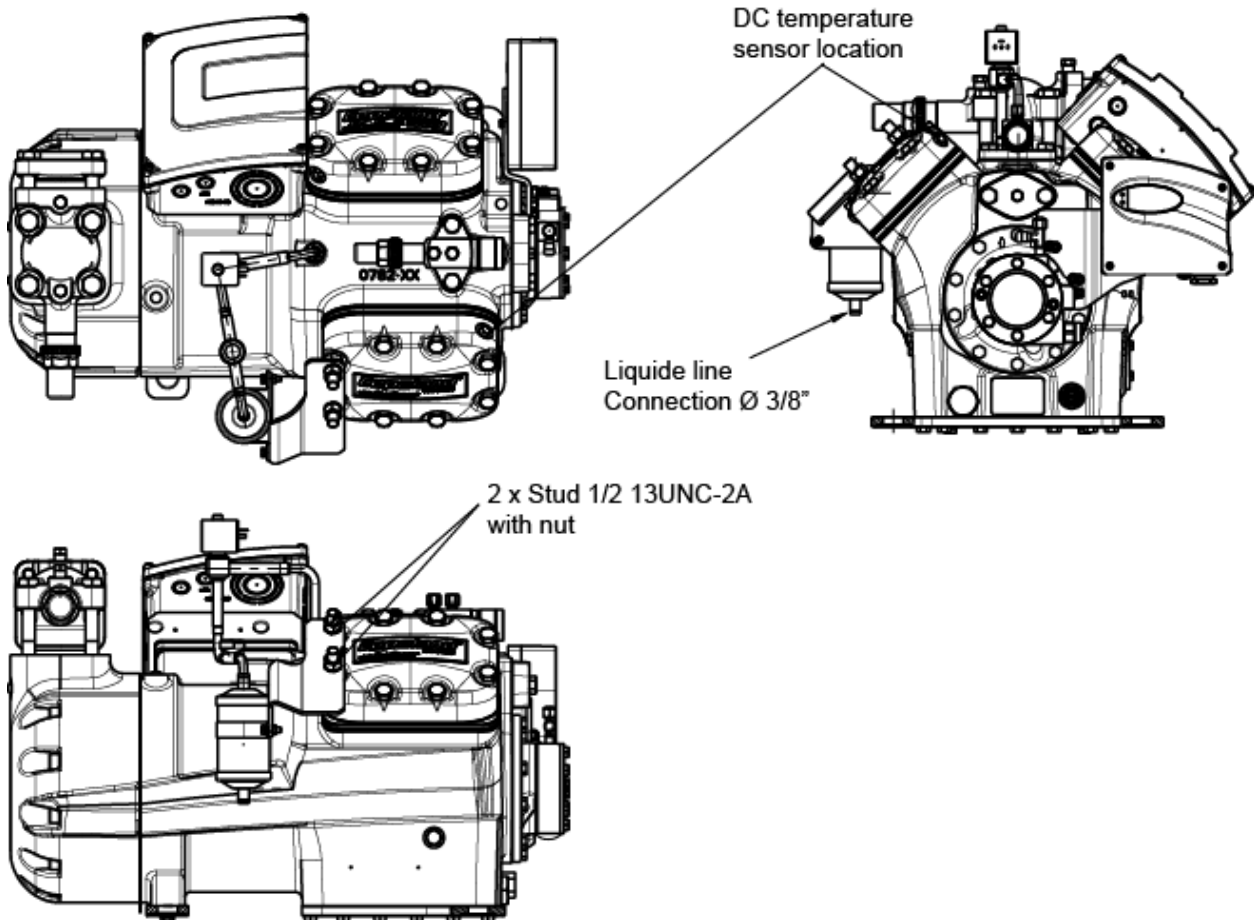


Figure 7: Injection parts on 6M\* compressors

#### 5.4 Installation of Demand Cooling on 4M\* Stream compressors

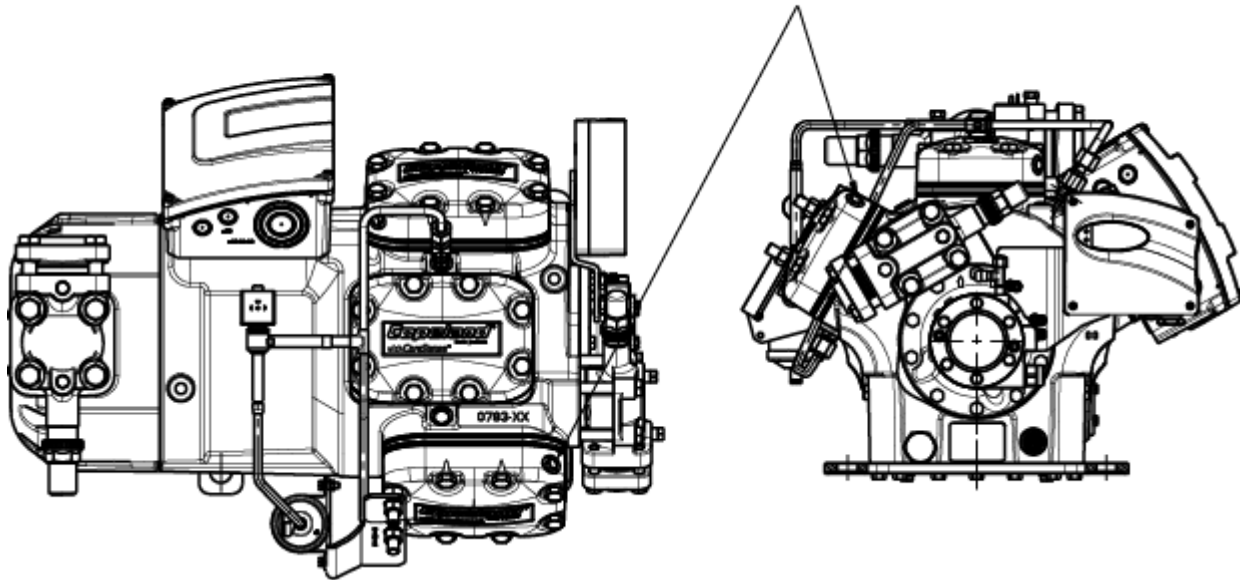


**NOTE:** An additional fan is needed only for application of Demand Cooling with R22.

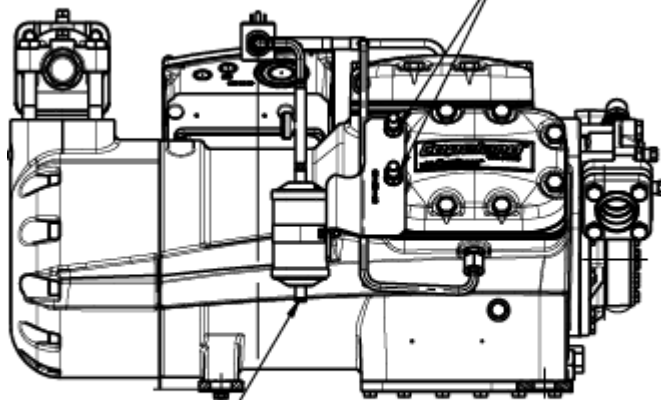


### 5.5 Installation of Demand Cooling on 6M\* Stream compressors

DC temperature sensor Location



2 x Stud 1/2 13UNC-2A  
with nut



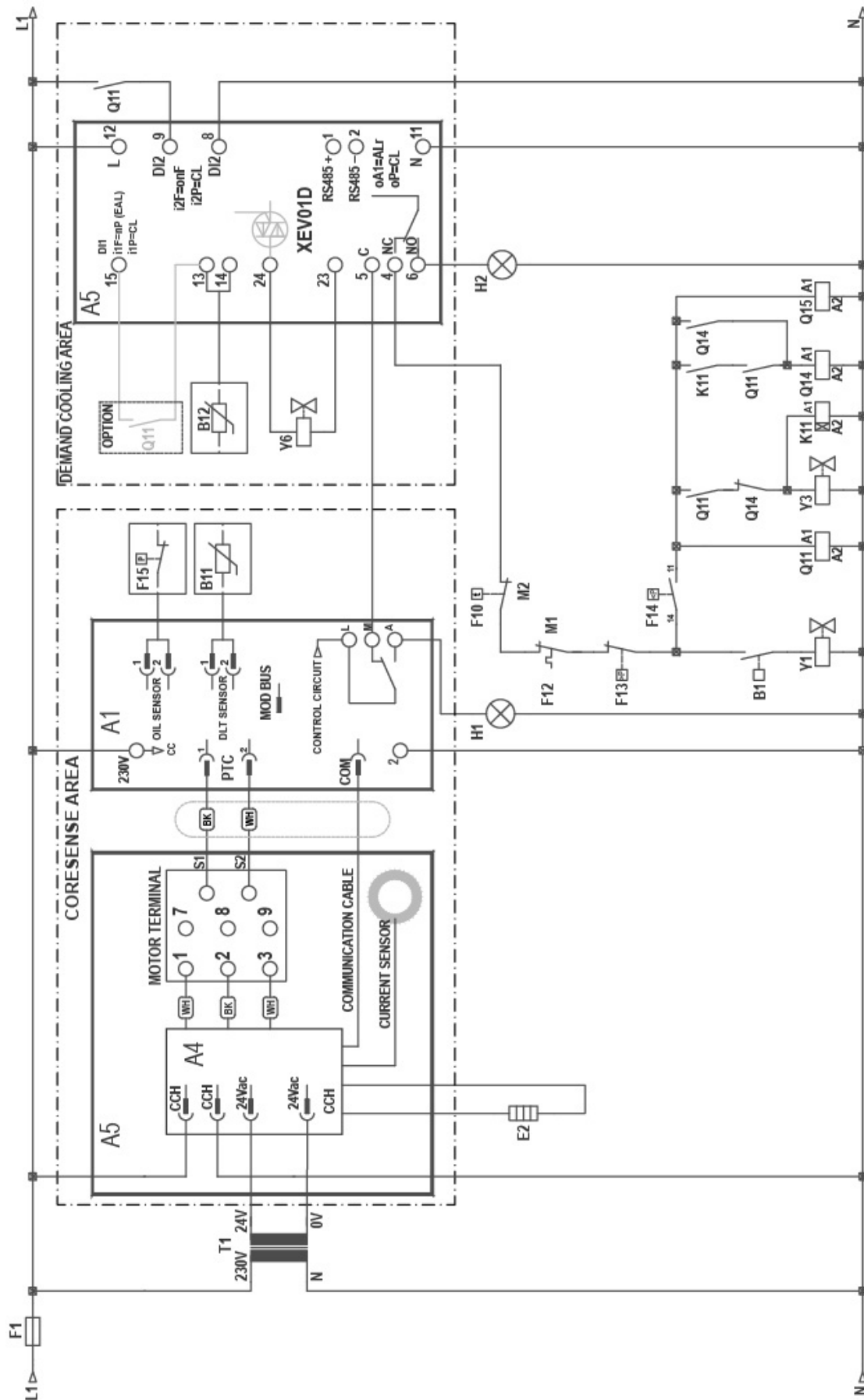
Liquide line  
Connection Ø 3/8"

**NOTE:** An additional fan is needed only for application of Demand Cooling with R22.

### 5.6 Use of inverter

Demand Cooling is not compatible with speed variation/inverter.

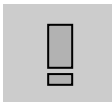
5.7 Demand Cooling wiring diagram



**Wiring diagram Legend**

- |  |   |
|--|---|
| A1..... CoreSense module                           | A4..... Sensor module                         |
| A5..... Compressor terminal box                    | A6..... Demand Cooling Driver / XEV01D        |
| B1..... Room thermostat                            | B11... CoreSense discharge temperature sensor |
| B12... Demand Cooling discharge temperature sensor |   |
| CCH . Crankcase heater                             | E2..... Crankcase heater                      |
| F1..... Fuse for control circuit                   | F10... Fan motor thermal protection           |
| F12... Compressor over-current protection          | F13... High pressure safety switch            |
| F14... Low pressure safety switch                  | F15... Oil pressure sensor                    |
| H1 .... Signal lamp / CoreSense alarm              | H2 .... Signal lamp / Demand Cooling driver   |
| K11... Time relay-delay part winding start         |   |
| M1 .... Compressor motor                           | M2.... Additional fan motor                   |
| N ..... Neutral                                    | Q11 Contactor for first part winding          |
| Q14 .. Contactor for second part winding           | Q15 Contactor for additional fan motor        |
| T1..... Transformer 230/24V; 5VA                   |   |
| Y1..... Solenoid valve liquid line                 | Y3..... Solenoid valve for unloaded start     |
| Y6..... Demand Cooling injection valve             |   |
- WH = White    BK = Black    OG = Orange

**6 Functional checks**



**IMPORTANT**

The compressor must be thoroughly checked for leaks before proceeding to the Demand Cooling functional checks.

**6.1 Checking the NTC Thermistor sensor**

Disconnect the electrical supply and unplug the modular plug from the module case. Measure the resistance of the thermistor with an ohmmeter at the modular plug attached to the sensor cable.

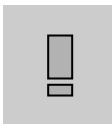
When the temperature sensor is connected to the compressor, resistance can read from more than 100,000 Ohms (very cold compressor) to less than 1600 Ohms (very hot compressor). Readings within these limits usually indicate a satisfactory sensor.

**6.2 Checking the driver**



**WARNING**

Jumpers should be removed with system power Off!  
Never force a compressor to run by bypassing a safety contact!



**IMPORTANT**

The tests should not last longer than is required to verify operation. Do not fail to remove any jumpers added to the module alarm relay, the modular connector and the control circuit when tests have been completed!

There are two driver operational tests. Each of these tests trips the driver alarm relay after a 2-minute delay and switches off the compressor.

### 6.2.1 Test n° 1

This test simulates too low a compressor discharge temperature or an open thermistor sensor connection at the driver, eg, broken wire.

- 1) Disconnect the electrical supply and unplug the temperature sensor modular plug from the module case.
- 2) Restore power to the driver.
- 3) The contact normally closed between 4-5 will switch to 5-6 after 30 sec. and error code P2 will be displayed. The Demand Cooling injection valve (Y6) will be immediately deactivated.

Under actual temperature conditions, ie, when the compressor starts, the 2-minute delay before trip allows the compressor temperature to rise, and the sensor resistance to decrease to a level the driver recognizes as normal.

The temperature sensor was disconnected for this test. Therefore after one minute of operation, the continuous signal to the driver registers that there is an open sensor and trips the driver alarm relay to provide the open sensor protection.

- 4) Remove system power, reconnect the temperature sensor to the driver, reset the alarm relay, then restore system power.

### 6.2.2 Test n° 2



#### **IMPORTANT**

This test should not last longer than is required to verify operation.

This test simulates an excessive compressor discharge temperature or a shorted module sensor connection at the driver terminal.

- 1) Remove system power then disconnect the temperature sensor (B12) from the driver. Connect (jumper) the input terminals of the temperature sensor on the driver (14-13) with a small piece of wire.
- 2) Restore power to the driver.
- 3) The contact normally closed between 4-5 will switch to 5-6 after 30 sec. and error code P2 will be displayed. The Demand Cooling injection valve (Y6) will be deactivated

After one minute of testing the alarm relay will trip indicating a shorted sensor.

- 4) Remove the "short" from the control driver sensor input terminals and restore module power.