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Application Engineering Europe

ZF24-48K4E TW* COPELAND™ SCROLL COMPRESSORS USING R407A, R407F, R448A, R449A IN LOW-TEMPERATURE APPLICATIONS

1 Introduction

Liquid injection for ZF* Scroll compressors in low-temperature applications is mandatory to keep discharge gas temperatures within safe limits. The previous generation model range ZF24-48K4E TW* was initially designed and qualified for R404A low-temperature applications with liquid injection and capillary tube.

The previous model range ZF24-48K4E TW* is still available from production, but should only be used for servicing. For new refrigerant applications, there will be no further qualification. For all new low-temperature applications with the low GWP alternatives R407A, R407F, R448A or R449A, Emerson has developed a new range of scroll compressors, applicable both for liquid injection or vapour injection. The new model range ZF25, 34, 41, 49K5E TF* will replace the previous model range ZF24, 33, 40, 48K4E TW* for liquid injection. A refrigerant changeover from R404A to R407A, R407F, R448A and R449A for the model range ZF24-48 KVE with vapour injection (EVI) is not possible.

For new systems with R407A, R407F, R448A, R449A, Emerson recommends the use of the new compressor range ZF25-49K5E TFD only.

For users who would like to retrofit existing systems (from R404A to R407A, R407F, R448A or R449A) with the previous range ZF24-48K4E TW*, Emerson has released the following guidelines and recommendations.

2 Replacement, new systems

For all new systems and applications, Emerson recommends to replace the previous compressor generation ZF24-48K4E TW* with the new model family ZF25-49K5E TF*.

Previous model range				New model range			
	Compressor	Ident number TWD	kW*		Compressor	Ident number TFD	kW*
	ZF24K4E	8511622	4.2		ZF25K5E	8852498	4.6
	ZF33K4E	8509636	5.7		ZF34K5E	8613700	5.9
	ZF40K4E	8516207	7.2		ZF41K5E	8613711	7.2
	ZF48K4E	8516616	8.9		ZF49K5E	8613722	8.6

** R448A at -35°C/40°C/15K/0K*

Table 1: Cross reference list, old vs new model range

3 Technical data R407A, R407F, R448A, R449A

Calculated technical data for ZF24-48K4E TW* with R407A, R407F, R448A or R449A are available on request. The calculation is based on the refrigerant data base Refprop and considers experience values from reliability and performance testing.

The operation of compressors with unreleased refrigerants or in non-approved applications does not fall under the standard warranty. The basic requirement for safe and reliable operation is to follow the proper application of the compressor (for example keeping the superheat within the adequate range, no liquid droplets or liquid migration to the compressor, keeping the suction and discharge temperatures within safe limits etc.).

In the case of a potential product deficiency, Emerson reserves the right to investigate the compressor in the plant and to offer a warranty decision on a case-by-case basis. Consequent damages are excluded in any case.

4 Previous generation ZF24-48K4E TW* with liquid injection and capillary tube

Low-temperature applications with the compressor range ZF24-48K4E TW* have been qualified for liquid injection by means of the installation of a capillary tube on the injection port of the compressor. The capillary tube assembly was typically brazed into the injection port of the compressor, as shown in **Figure 1**.

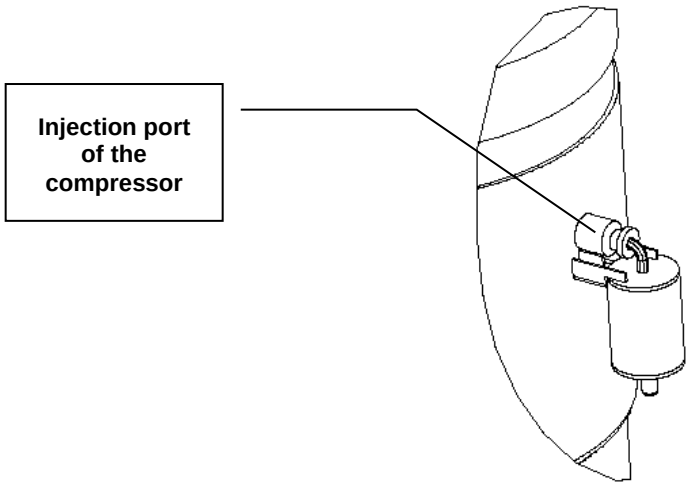

Figure 1: Capillary tube assembly brazed into the injection port of the compressor

The ident number of the capillary tube assembly (length, diameter) was selected according to the compressor model and the refrigerant in use (R404A) - see Emerson spare parts software for reference. A solenoid valve was installed in series with the capillary tube assembly in order to close the injection line during compressor off periods.

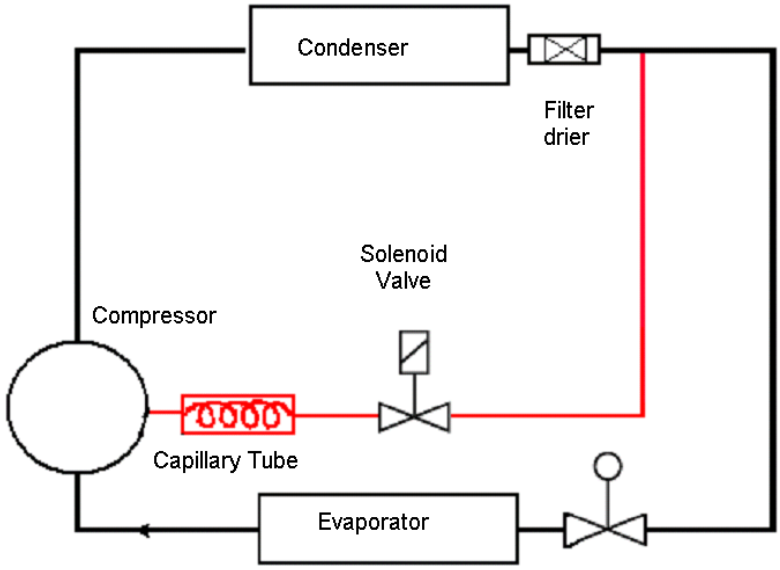

Figure 2: Liquid injection with capillary tube and solenoid valve

All new qualifications for liquid injection, for example with the refrigerants R407A, R407F, R448A, R449A, will be with a DTC valve (Discharge Temperature Control valve) instead of a capillary tube. Therefore, the retrofit of existing R404A systems with ZF24-48K4E TW* will be based on liquid injection and DTC valve.

5 Retrofit applications with ZF24-48K4E and DTC valve

For the retrofit of the previous generation scroll compressor range ZF24-48K4E TW* from R404A to a lower GWP alternative R407A, R407F, R448A or R449A, liquid injection with a DTC valve is required. Therefore, the existing liquid injection with capillary tube and solenoid valve will need to be replaced.

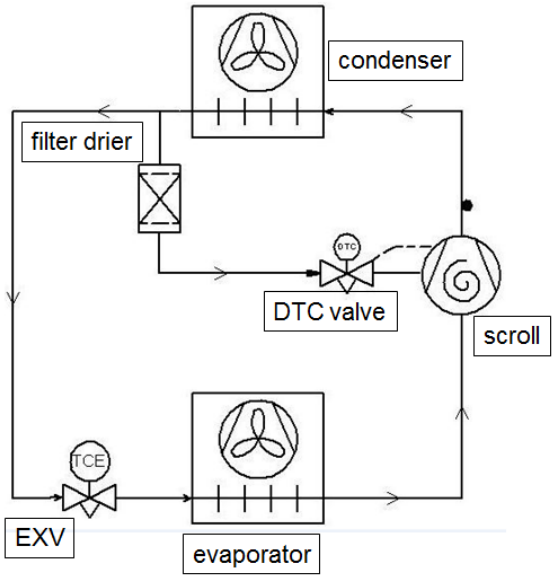

Figure 3: Liquid injection installation with DTC valve

5.1 DTC valve

The following DTC valve has been tested and is suitable for the liquid injection with the previous generation compressor range ZF24-48K4E TW*:

8414390 **Kit liquid injection DTC 120°C – 1"**
including DTC valve, teflon gasket and protection cap

DTC valve connections:

- 3/8" (9.5 mm) braze connection on the liquid inlet of the DTC valve
- 1" – 14 UNS connection, compressor injection port

Recommended tightening torque: 29-34 Nm.

Figure 4: Liquid injection DTC valve 120°C – 1"

5.2 DTC valve installation

For the previous scroll model range ZF24-48K4E TW*, there is generally no hole in the top cap or other connection possibility for the DTC valve bulb installation. For these compressor types, the bulb must be installed on the discharge piping instead. To fix the DTC bulb in place, it is recommended to braze a short copper pipe (for example 5/8" outside diameter, length approximately 40 mm) directly onto the discharge piping as shown in **Figure 5**. The DTC valve bulb (and the copper pipe fixture) must be positioned next to the discharge connection of the compressor (ideally 2-3 centimetres away from the discharge rotalock valve connection).

Figure 5: Short copper pipe brazed on the discharge line to hold the DTC valve bulb

The DTC valve should be connected to the injection port on the side of the compressor. The reference torque is 29-34 Nm for the DTC valve 120°C – 1". It is recommended that the valve be located perpendicular to the compressor orientation, however it will function properly in any orientation. The capillary tube connecting the valve to the bulb should be positioned at least 13 mm away from the side of the scroll to avoid contact during operation.

Compressor types ZF24-48K4E TW* are equipped with a liquid injection port of ¼" (6.5 mm) inner diameter. This injection port was initially not designed to hold a 1" – 14 UNS connection of a DTC valve. For this reason, the connection of the DTC valve to the compressor injection port must be assembled with the help of suitable adapters and fittings:

8026946 Adapter kit 1" rotalock to 1/2" brazing

- copper (reduction) fitting 1/4" to 1/2"
- copper pipe 1/4"

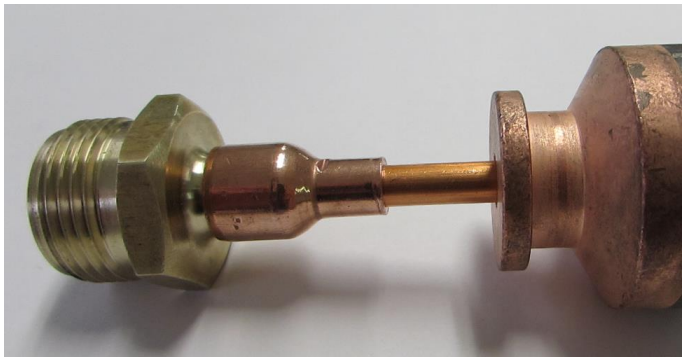

Figure 6: Connection parts to assemble the DTC valve to the ZF24-48K4E injection port

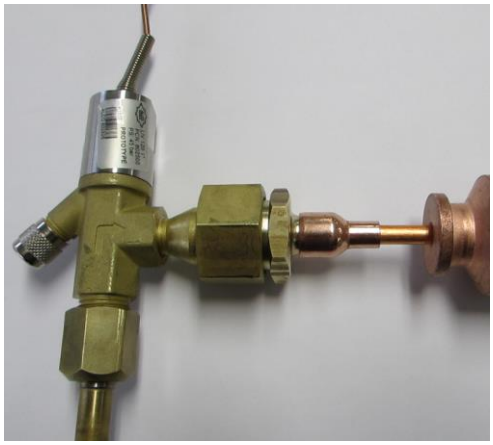

Figure 7: DTC valve connected to the injection port of a ZF24-48K4E TW* scroll compressor

The DTC valves are supplied with a teflon gasket for the injection port connection and an insulating cap which is normally applied to the top of the compressor, but not used here. The teflon gasket is used here for the connection between the DTC valve and the adapter.

NOTE: **It is recommended to check the DTC valve installation individually. Avoid stress on the piping installation due to the relatively small pipe connection diameter of 1/4" and the weight of the DTC valve. If necessary, add an additional clamp or holding to fix the DTC valve.**

To prevent a partial or full blockage at the injection port caused by shavings, foreign bodies, etc, a filter dryer should be installed in the liquid line prior to the DTC valve inlet.

Before starting the compressor, ensure that there is liquid refrigerant in front of the DTC valve inlet. Otherwise the valve could be damaged.

5.3 Discharge temperature protection

Scroll compressor models ZF24-48K4E TW* are equipped with an internal discharge thermistor, which is located in the discharge port of the fixed scroll. This discharge thermistor is wired in series with the other PTC of the motor thermistor. The PTC chain is connected to an electronic motor protection module, which is located in the electrical box of the compressor. This system utilizes the temperature-dependent resistance of the thermistors to read the discharge and winding temperatures. The electronic module processes the resistance values and triggers a control mechanism depending on the thermistor resistance.

Thanks to this internal temperature observation with the thermistor chain, there is no need for extra discharge temperature protection (for example an external discharge temperature thermostat).

6 Retrofit from R404A to R407A, R407F, R448A, or R449A

WARNING
Use only Emerson approved refrigerants and lubricants in the manner prescribed by Emerson. In some circumstances, other refrigerants and lubricants may be dangerous and could cause a fire, explosion or electrical shorting. Contact the Application Engineering department at Emerson for more information.

NOTE: **The difference in thermo-physical properties between R448A and R449A is smaller than 1%. Therefore Emerson will not differentiate between these two refrigerants.**

6.1 Considerations when retrofitting

1. The system capacity and efficiency will be somewhat different with R407A, R407F, R448A and R449A than with R404A/R507. In most multiple compressor racks, there should still be adequate capacity. However, it is strongly recommended that system capacity verification be done using Copeland™ brand products Select software or the refrigerant manufacturer's published comparison factors.

2. When retrofitting an existing refrigeration system, the material compatibility and the condition of the existing seals and gaskets must be taken into account. Heat set, compression set and seal shrinkage can affect the condition of an existing seal or gasket. When the system is put under vacuum, the sealing device can be displaced, creating the potential for leakage.
3. **Caution: R407A, R407F, R448A or R449A should not be mixed with any other refrigerant!**
4. The higher discharge temperatures of R407A, R407F, R448A and R449A, particularly with lower evaporating temperatures, should be evaluated.
5. R407A, R407F, R448A and R449A have other density and mass flow than R404A/R507. It is recommended that pipe sizing be checked to determine that pressure drops and velocities would be acceptable with the new refrigerant. Checking pipe sizing will confirm that capacity and efficient oil return are not being negatively affected.
6. R407A, R407F, R448A and R449A are blend refrigerants. For blend refrigerants, pressure-temperature data will include bubble and dew point data. To determine superheat, the dew temperature column in the temperature/pressure table should be used. To determine subcooling, the bubble temperature column should be used. The average condensing temperature is the mean of the dew and bubble temperatures at the condensing pressure. The average evaporating temperature is the mean of the temperature at the evaporator inlet and the dew temperature at the evaporating pressure.
7. It is essential that blend refrigerants, like R407A, R407F, R448A and R449A be liquid-charged removing only liquid from the filling cylinder. Vapour-charging may shift the refrigerant composition and could result in damage to the system. To prevent compressor damage, it is advocated not to charge liquid into the suction line.

   Due to the different liquid density and weight of R407A, R407F, R448A and R449A, the refrigerant charge can be different from the initial charge of R404A/R507.
8. Unlike pure fluids and azeotropes, blends boil and condense at varying temperatures for a given pressure. The range over which the temperature varies is referred to as temperature glide. R407A, R407F, R448A and R449A have a temperature glide between 3K and 6K.
9. Polyolester lubricant in use with R404A/R507 is suitable for use with R407A, R407F, R448A and R449A. If the lubricant is contaminated or an acid test indicates high levels of acidity, then a lubricant change is required. Approved lubricants for Copeland brand products are Emkarate RL32 3MAF and Mobil Arctic EAL 22CC.
10. Compressor suction and discharge pressures for R407A, R407F, R448A and R449A differ from R404A/R507. It may be necessary to reset the pressure cut-outs to suit the different pressures of the replacement refrigerant. This procedure should be done carefully to avoid exceeding the recommended operating limits of the compressor. Pressure regulators may have to be reset. Contact the manufacturer for correct settings.
11. Systems that use a low-pressure controller to maintain space temperature may need to have the cut-in and cut-out points changed and need adjustment.
12. Due to the differences in temperature glide, capacity and mass flow, a new thermostatic expansion valve for R407A, R407F, R448A and R449A is recommended and superheat must be checked after operation. Consult the TXV manufacturer for correct sizing and superheat settings.
13. Copeland scroll compressors ZF24-48K4E TW* in low-temperature applications with R407A, R407F, R448A or R449A require liquid injection with DTC valve.
14. Filter-driers must be changed at the time of conversion. They should have an equilibrium point of dryness (EPD) of 50 ppm or lower.
    - Solid core driers such as Emerson ADK are compatible with either R404A/R507 or R407A, R407F, R448A, R449A.
    - Compacted bead type driers such as the Emerson FDB series are also compatible.
    - Loose fill-type driers are not recommended and should be replaced with the types referenced above.

6.2 Changeover procedure

Before starting the changeover, at least the following items should be readily available:

- Safety glasses
- Gloves
- Refrigerant service gauges
- Electronic thermometer
- Vacuum pump capable of pulling 0.3 mbar
- Leak detector
- Refrigerant recovery unit including refrigerant cylinder
- Proper container for removed lubricant
- New liquid control device
- Replacement liquid line filter-drier(s)
- DTC valve for liquid injection
- Holding tube 5/8" for DTC bulb
- Adapter and fittings to connect DTC valve 1" – 14 UNS to ¼" (6.5 mm) injection port of the compressor
- New POE lubricant, if needed
- R407A, R407F, R448A, R449A pressure temperature chart
- R407A, R407F, R448A or R449A refrigerant

1. Record baseline data on original system R404A/R507 performance with the system operating under stable conditions. The following should be recorded as a minimum with R404A/R507 still in the system:
   - compressor inlet and outlet pressures and temperatures;
   - outdoor temperature and liquid temperature, preferably near the expansion valve inlet.

   This will enable superheat, subcooling and pressure ratio to be determined and provide the base data for comparison when the system is put back into operation with the R407A, R407F, R448A or R449A.
2. Disconnect electrical power to system.
3. Properly remove the R404A/R507 from the system. The refrigerant charge should be isolated from the system by pumping it down into the receiver enabling the bulk of the charge to be quickly transferred to the recovery cylinder. In all cases the refrigerant must be finally removed from the system using a recovery machine capable of meeting or exceeding the required levels of evacuation. The charge must be collected in a recovery cylinder. Do not vent the refrigerant. Measure and note the amount removed. Knowing the recommended R404A/R507 refrigerant charge size for the system is helpful. In all cases weigh the entire amount of removed refrigerant. This amount can be used as a guide for the internal quantity of the R407A, R407F, R448A or R449A refrigerant to be charged to the system.
4. Replace the liquid line filter-drier with one that is compatible with R407A, R407F, R448A or R449A.
5. If the polyolester oil is contaminated or an acid test indicates high levels of acidity, then a lubricant change is required. If affected, drain the existing lubricant from the compressors, separators and oil reservoirs. Measure the amount (volume) of lubricant removed. Change lubricant filters if present. Recharge the system with polyolester lubricant, use the same amount (volume) as was removed.
6. Change the expansion devices; refer to the valve manufacturer's recommendations.
7. Remove the capillary tube assembly from the liquid injection port of the compressor. If needed install an extra liquid line filter dryer compatible with R407A, R407F, R448A, R449A for the DTC liquid injection line.
8. Braze a 5/8" copper tube on the discharge line close to the discharge connection of the compressor, to hold the bulb of the DTC valve. Install the DTC valve. Connect the 1" – 14 UNS of the DTC valve to the ¼" (6.5 mm) liquid injection port of the compressor by means of appropriate adapter and fittings.
9. Evacuate the system to 0.3 mbar. A vacuum decay test is suggested to ensure that the system is dry and leak free. Use normal service practices to reconnect and evacuate the system. To remove air and other non-condensables, it is recommended to evacuate the system from both sides. Attempting to evacuate a system with the pump connected only to the low side of the system will not adequately remove moisture and non-

condensables such as air. Use a good electronic gauge to measure the vacuum. An accurate reading cannot be made with a refrigeration gauge.

10. Check the system for leaks using normal service practices.
11. Recharge the system with R407A, R407F, R448A or R449A. Remove only liquid from the charging cylinder. First charge should be approximately 85% of the R404A charge by weight. Record the amount of refrigerant charged.
12. Check system operation and operating controls. Start the system and allow conditions to stabilize. The discharge pressure of R407A, R407F, R448A or R449A can be different from R404A and condenser fan and ambient controls may require adjustment.
13. Check the DTC valve for proper functioning. With lower discharge temperatures the DTC valve should close. With discharge temperatures above 110°C the DTC valve should start to open and inject. With the DTC valve working properly, the compressor discharge temperatures should always remain below 125°C.
14. Adjust refrigerant charge.
15. Operate the system. Record the data and compare to the data recorded at step 1. Check TXV and adjust TXV superheat setting if necessary. Make adjustments to other controls as needed.
16. Properly label the components. Tag the compressor with the refrigerant (R407A, R407F, R448A or R449A) and lubricant used.

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