

Copeland Scroll™

Digital

Application Guidelines

Digital Scroll™ Compressors for Refrigeration

ZBD21K* to ZBD114K*
ZFD13KVE to ZFD25KVE
ZFD41K5E



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About these guidelines

The purpose of these application guidelines is to provide guidance in the application of Copeland Scroll™ compressors in users' systems. They are intended to answer the questions raised while designing, assembling and operating a system with these products.

Besides the support they provide, the instructions listed herein are also critical for the proper and safe functioning of the compressors. Emerson Climate Technologies will not guarantee the performance and reliability of the product if it is misused in regard of these guidelines.

These application guidelines cover stationary applications only. For mobile applications, contact Application Engineering as other considerations may apply.

1 Safety instructions

Copeland Scroll compressors are manufactured according to the latest European and US Safety Standards. Particular emphasis has been placed on the user's safety.

These compressors are intended for installation in systems according to the Machinery Directive MD 2006/42/EC and to the Pressure Equipment Directive PED 97/23/EC. They may be put to service only if they have been installed in these systems according to instructions and conform to the corresponding provisions of legislation. For relevant standards please refer to Manufacturers Declaration, available at www.emersonclimate.eu.

These instructions should be retained throughout the lifetime of the compressor.

You are strongly advised to follow these safety instructions.

1.1 Icon explanation

 <p>WARNING This icon indicates instructions to avoid personal injury and material damage.</p>	 <p>CAUTION This icon indicates instructions to avoid property damage and possible personal injury.</p>
 <p>High voltage This icon indicates operations with a danger of electric shock.</p>	 <p>IMPORTANT This icon indicates instructions to avoid malfunction of the compressor.</p>
 <p>Danger of burning or frostbite This icon indicates operations with a danger of burning or frostbite.</p>	<p>NOTE This word indicates a recommendation for easier operation.</p>
 <p>Explosion hazard This icon indicates operations with a danger of explosion.</p>	

1.2 Safety statements

- Refrigerant compressors must be employed only for their intended use.
- Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission and maintain this equipment.
- Electrical connections must be made by qualified electrical personnel.
- All valid standards for connecting electrical and refrigeration equipment must be observed.
- The national legislation and regulations regarding personnel protection must be observed.



Use personal safety equipment. Safety goggles, gloves, protective clothing, safety boots and hard hats should be worn where necessary.

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1.3 General instructions



WARNING

System breakdown! Personal injuries! Never install a system in the field and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.

System breakdown! Personal injuries! Only approved refrigerants and refrigeration oils must be used.



WARNING

High shell temperature! Burning! Do not touch the compressor until it has cooled down. Ensure that other materials in the area of the compressor do not get in touch with it. Lock and mark accessible sections.



CAUTION

Overheating! Bearing damage! Do not operate compressors without refrigerant charge or without being connected to the system.



CAUTION

Contact with POE! Material damage! POE lubricant must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used at all times. POE must not come into contact with any surface or material that it might damage, including without limitation, certain polymers, eg, PVC/CPVC and polycarbonate.



IMPORTANT

Transit damage! Compressor malfunction! Use original packaging. Avoid collisions and tilting.

2 Product description

2.1 Common information about Copeland Scroll Digital™ compressors

The Scroll compressor has been under development at Emerson Climate Technologies since 1979. It is the most efficient and durable compressor Emerson Climate Technologies has ever developed for air conditioning and refrigeration.

These application guidelines deal with Copeland Scroll™ Digital compressors for refrigeration ZBD21K* to ZBD114K*, ZFD13KVE to ZFD25KVE and ZFD41K5E. These compressors include a wide range of capacities, electrical options and features.

Compressor	Cooling capacity kW							Motor
	R404A	R407A	R407F	R448A R449A	R134a	R450A	R513A*	
ZBD21KCE	5.09	4.88	4.67		3.14	2.67	3.00	PFJ/TFD
ZBD29KCE	6.83	6.35	6.77		3.97			TFD
ZBD30KCE	6.98	6.78	6.84	6.67	4.25	3.63	4.09	TFD
ZBD38KCE	8.59	8.46	8.37	8.33	5.29	4.48	5.04	TFD
ZBD45KCE	10.25	9.39	10.00	9.76	6.04	5.38	6.03	TFD
ZBD57KCE	13.22	12.86	12.84		7.63			TFD
ZBD58KCE	13.45	12.00	12.84					TFD
ZBD76KCE	17.85	15.95	17.24		10.20			TFD
ZBD76K5E	18.38	17.08	18.40					TFD
ZBD114K5E	26.19	24.10	24.09					TFD

Table 1: Cooling capacity for medium temperature compressors @ EN 12900 Medium temp

Compressor	COP							Motor
	R404A	R407A	R407F	R448A R449A	R134a	R450A	R513A*	
ZBD21KCE	2.23	2.28	2.01		2.15	2.24	2.14	PFJ/TFD
ZBD29KCE	2.20	2.14	2.09		2.07			TFD
ZBD30KCE	2.22	2.16	2.22	2.15	2.21	2.24	2.12	TFD
ZBD38KCE	2.23	2.20	2.22	2.15	2.23	2.25	2.14	TFD
ZBD45KCE	2.24	2.17	2.23	2.22	2.20	2.27	2.14	TFD
ZBD57KCE	2.26	2.17	2.17	2.36	1.99			TFD
ZBD58KCE	2.12	2.02	2.08					TFD
ZBD76KCE	2.16	2.08	2.16	2.18	2.08			TFD
ZBD76K5E	2.14	2.11	2.19					TFD
ZBD114K5E	2.07	2.08	2.08					TFD

Table 2: Coefficient of performance (COP) for medium temperature compressors @ EN 12900 Medium temp

Compressor	R404A		R407A		R407F		R448A, R449A		Motor
	kW	COP	kW	COP	kW	COP	kW	COP	
ZFD13KVE	3.96	1.35	3.15	1.16	3.31	1.16	3.27	1.45	TFD
ZFD18KVE	5.91	1.49	4.92	1.44	4.92	1.29	4.83	1.43	TFD
ZFD25KVE	7.68	1.62	6.12	1.43	6.43	1.43	6.16	1.58	TFD
ZFD41K5E	8.56	1.35	7.32	1.18	7.32	1.18			TFD
ZFD41K5E EVI	12.46	1.58	10.02	1.55	10.02	1.55			TFD

Table 3: Cooling capacity in kW and COP for low temperature compressors @ EN 12900 Low temp

EN 12900 Conditions for medium temperature:

Evaporating temperature-10°C Suction gas temperature20°C
 Condensing temperature 45°C Liquid sub-cooling 0K

* Except for R513A: Suction superheat = 10K

EN 12900 Conditions for low temperature:

Evaporating temperature-35°C Suction gas temperature20°C
 Condensing temperature 40°C Liquid sub-cooling 0K

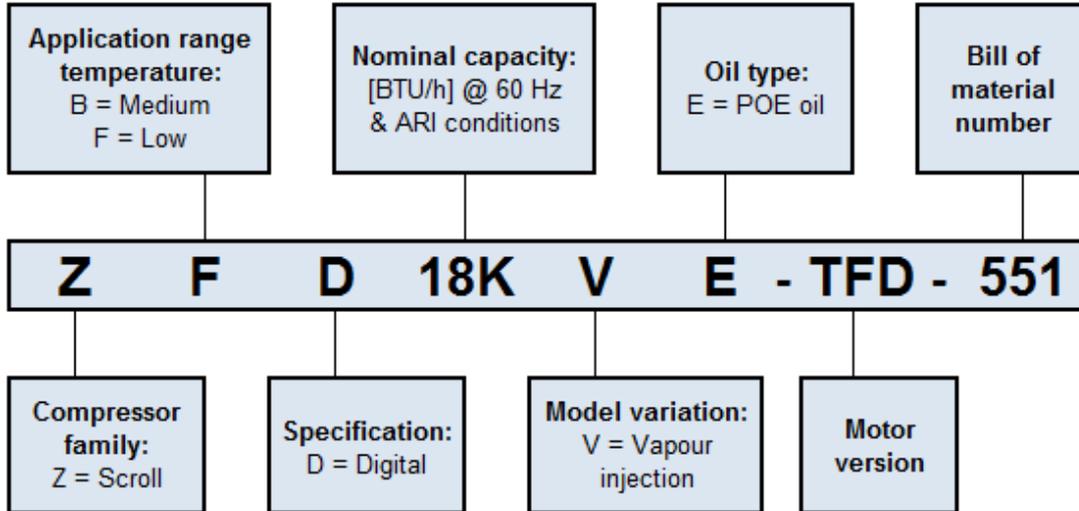
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Copeland Scroll Digital compressors have one Scroll compression set driven by a single or three-phase induction motor. The Scroll set is mounted at the upper end of the rotor shaft of the motor. The rotor shaft axis is in the vertical plane.

2.2 Nomenclature

The model designation contains the following technical information about the compressor:



2.3 Dimensions

	A mm	B mm	C mm	D mm	E mm
ZBD21KCE	432.4	414.3	363.6	261.6	218.9
ZBD29KCE	463.2	445.2	394.3	291.3	249.7

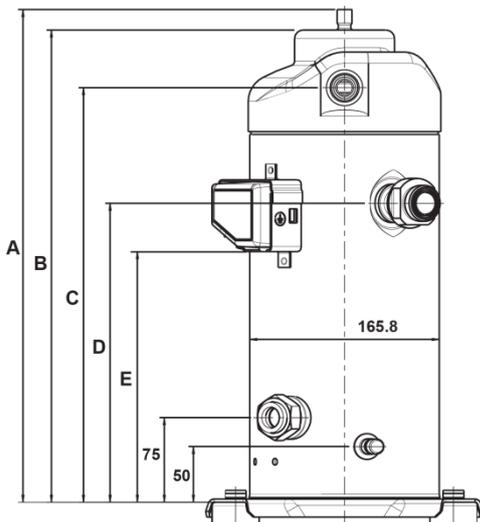


Figure 1: Dimensions ZBD21KCE & ZBD29KCE

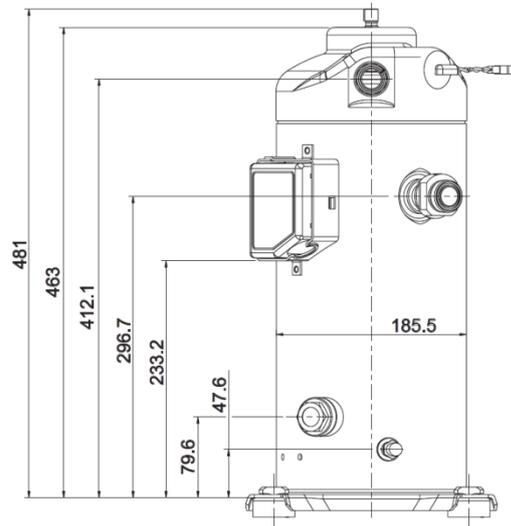


Figure 2: Dimensions ZBD30K* to ZBD57K* & ZFD13KVE to ZFD25KVE

	A mm	B mm	C mm	D mm	E mm	H mm
ZBD58KCE	476.3	444.3	211.7	93.6	201.5	74.3
ZBD76KCE	533.2	501.2	253	122.1	242.8	92.3
ZBD76K5E	533.6	501.8	253.7	277.3	245.7	93
ZBD114K5E	881.5	519.5	271.3	295	263.3	93

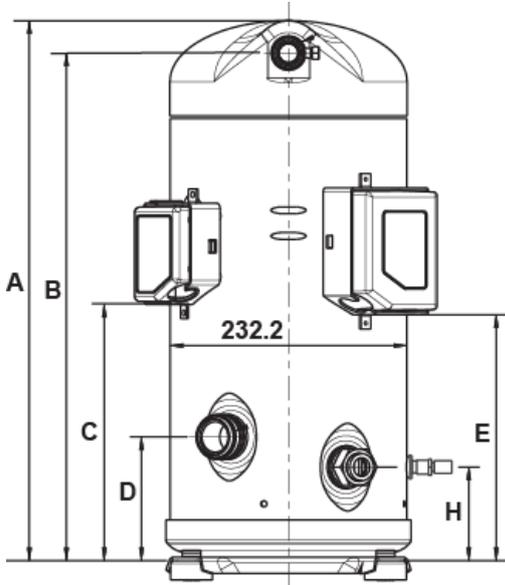


Figure 3: Dimensions ZBD58KCE & ZBD76KCE

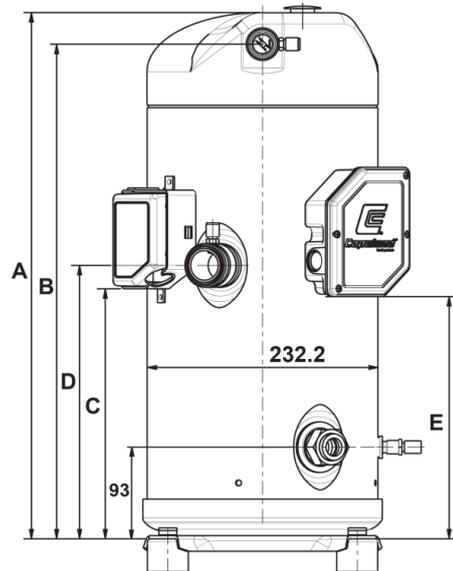


Figure 4: Dimensions ZBD76K5E & ZBD114K5E

2.4 Application range

2.4.1 Qualified refrigerants and oils



WARNING

Use of R450A and R513A refrigerants! Risk of compressor damage!

Refrigerant migration of R450A or R513A into the compressor crankcase could cause low oil viscosity, which could lead to compressor damage. When using R450A or R513A it is critical to meet the following requirements:

- maintain adequate superheat settings with a minimum superheat of 8-10K;
- no liquid refrigerant migration into the compressor at any time, especially during standstill, during or after defrost, or after reverse mode for example in heat pumps;
- pumpdown is recommended;
- the use of a crankcase heater is mandatory;
- retrofit to R450A and R513A is only allowed for compressors which are approved for these refrigerants.



IMPORTANT

It is essential that the glide of refrigerant blends (primarily R407A and R407F) be carefully considered when adjusting pressure and superheat controls.

Oil recharge values can be taken from Copeland Scroll compressors brochures or Copeland™ brand products Select software at www.emersonclimate.eu.

Compressor	ZBD21K* to ZBD114K*	ZFD13KVE to ZFD25KVE, ZFD41K5E
Qualified refrigerants	R404A, R407A, R407F, R448A, R449A, R450A, R134a, R513A, R507; R22 for ZBD30K* & ZBD45K* only	R404A, R407A, R407F, R448A, R449A, R507
Copeland brand products standard oil	Emkarate RL 32 3MAF	
Servicing oils	Emkarate RL 32 3MAF / Mobil EAL Arctic 22 CC	

Table 4: Qualified refrigerants and oils

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2.4.2 Application limits and operating envelopes



CAUTION

Inadequate lubrication! Compressor breakdown! The superheat at the compressor suction inlet must always be sufficient to ensure that no refrigerant droplets enter the compressor. For a typical evaporator-expansion valve configuration a minimum stable superheat of at least 5K is required.

Application envelopes for the various refrigerants can be found in Select software, available at www.emersonclimate.eu.

3 Installation



WARNING

High pressure! Injury to skin and eyes possible! Be careful when opening connections on a pressurized item.

3.1 Compressor handling

3.1.1 Transport and storage



WARNING

Risk of collapse! Personal injuries! Move compressors only with appropriate mechanical or handling equipment according to weight. Keep in the upright position. Stack pallets on top of each other when not exceeding 300 kg. Do not stack single boxes on top of each other. Keep the packaging dry at all times.

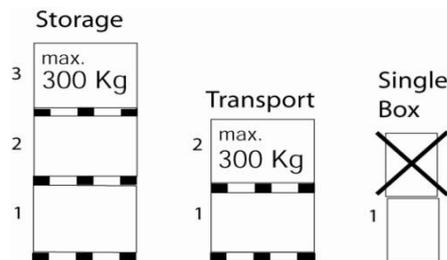


Figure 5

3.1.2 Positioning and securing



IMPORTANT

Handling damage! Compressor malfunction! Only use the lifting eyes whenever the compressor requires positioning. If the compressor has two lifting tabs, both must be used for lifting. Using discharge or suction connections for lifting may cause damage or leaks.

For models ZBD58K* to ZBD114K* and ZFD41K5E, because oil might spill out of the suction connection located low on the shell, the suction connection plug must be left in place until the compressor is set into the unit. If possible, the compressor should be kept vertical during handling. The discharge connection plug should be removed first before pulling the suction connection plug to allow the dry air pressure inside the compressor to escape. Pulling the plugs in this sequence prevents oil mist from coating the suction tube making brazing difficult. The copper-coated steel suction tube should be cleaned before brazing. No object, eg, a swaging tool should be inserted deeper than 51 mm into the suction tube or it might damage the suction screen and motor.

3.1.3 Installation location

Ensure the compressors are installed on a solid level base.

3.1.4 Mounting parts

Four vibration absorber grommets are supplied with each compressor. They dampen the start-up surge of the compressor and minimise sound and vibration transmission to the compressor base during operation. The metal sleeve inside is a guide designed to hold the grommet in place. It is not designed as a load-bearing member, and application of excessive torque to the bolts can crush the sleeve. Its inner diameter is approximately 8.5 mm to fit, eg, an M8 screw. The mounting torque should be 13 ± 1 Nm. It is critically important for the grommet not to be compressed.

If the compressors are mounted in tandem or used in parallel, then the hard mountings (bolt M9 5/16") are recommended. The mounting torque should be 27 ± 1 Nm. It is possible to deliver these hard mounting parts as a kit, or on request to deliver the compressor with these parts instead of the rubber grommets.

Mounting parts ZBD21K* to ZBD114K* & ZFD13K* to ZFD41K* - Soft mountings

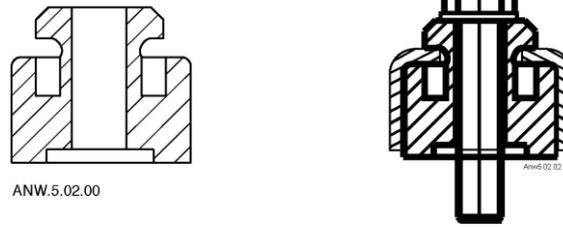


Figure 6

3.2 Solenoid valves for models ZBD21K* to ZBD57K* and ZFD13KVE to ZFD25KVE



IMPORTANT

The external solenoid valve is a critical component for proper function of this compressor. **Only** the Copeland brand solenoid valve supplied as a requested accessory must be used.

Care must be taken during the brazing process that no solid parts can enter the control piston compartment or the solenoid valve tubing. To prevent solid parts from entering the control valve seat, the solenoid valve kit contains a filter screen, which has to be placed into the horizontal tube of the valve before brazing the tube connections as shown in **Figure 7** below.

The solenoid valve has to be fitted in such a way that the sleeve with the stem inside – which supports the solenoid coil – is fixed and aligned in the upright position.

3.2.1 Securing the filter screen in position



The filter screen should be placed into the small tube running at 90° to the solenoid valve stem. A narrow washer fixed on the filter screen will sit on the end of the tube preventing it from falling inside (see photos). The tube running from the top centre of the compressor down to the previous tube needs to be swaged at the solenoid valve end so that it covers the filter screen/tube and is then brazed into position.

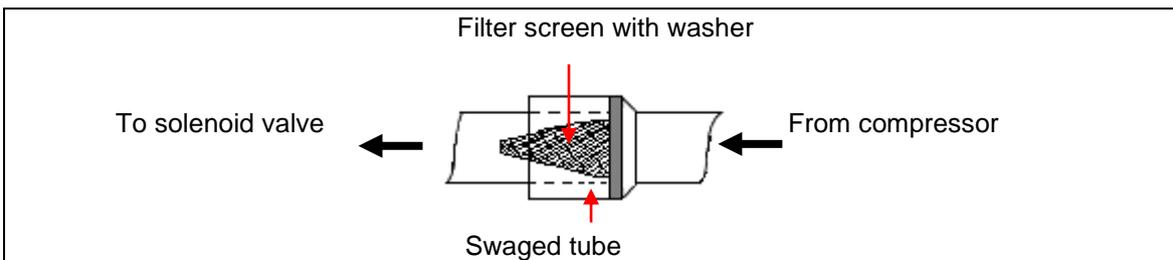


Figure 7

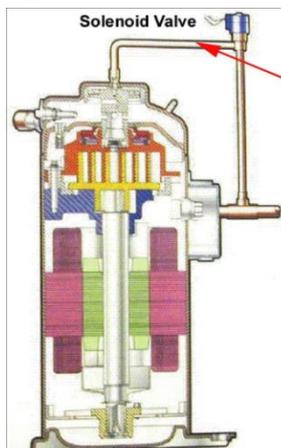


Figure 8: Position of external solenoid valve

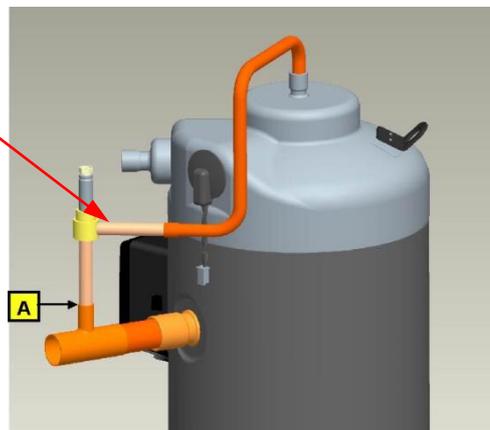


Figure 9: Recommended piping

3.2.2 Solenoid valve installation – General recommendations

- The solenoid must be mounted vertically, within $\pm 15^\circ$ of vertical. Horizontal mounting is not permitted.
- If a suction rotalock fitting is used, the threaded shipping plug in the rotalock fitting must be removed prior to brazing in the vertical solenoid line.
- The valve operation is directional. See **Figures 10 & 11** below for inlet and outlet locations.
- Do not restrict the line size coming from or leaving the solenoid. Use 3/8" soft drawn copper.

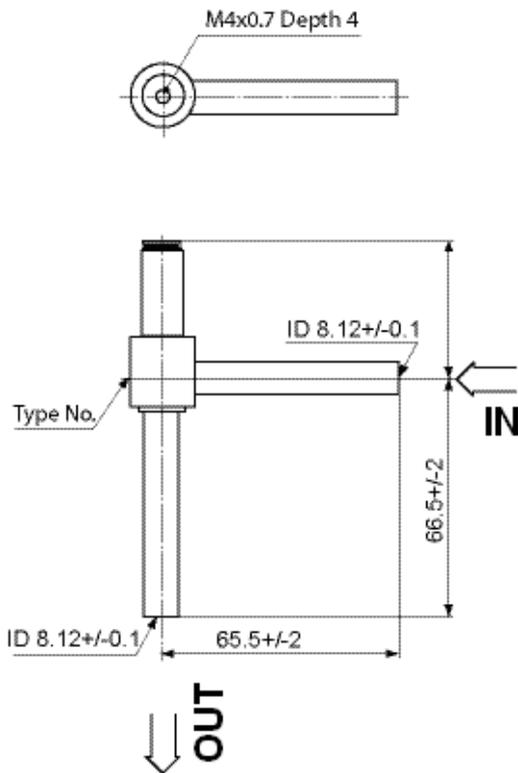


Figure 10: Control valve without coil

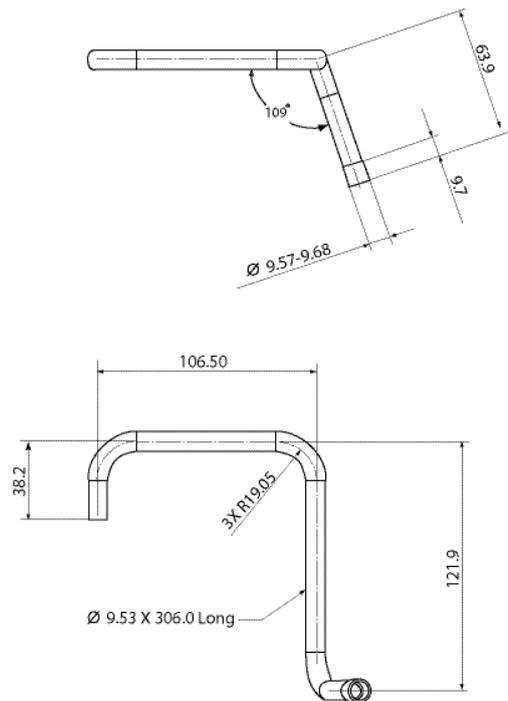
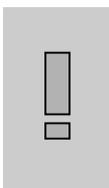


Figure 11: Control valve pipe connection

3.2.3 Solenoid valve installation – Tubing recommendations



IMPORTANT

This tube has been tested and qualified at 50 and 60 Hz operation for running stresses and resonance in a single compressor lab environment. However, in some compressor applications such as racks and transport applications, the OEM is strongly advised to re-confirm the acceptability of the tube when the compressor is subject to additional vibration inputs.

The tube from the solenoid to the suction, marked “A” (see **Figure 9**), should be as short as possible (less than 7.5 cm). Dimensions for a typical tube going from the top of the compressor are shown in **Figures 10 & 11**.

3.3 Copeland Scroll Digital compressors ZFD13KVE to ZFD25KVE and ZFD41K5E with vapour injection / wet vapour injection

The following injection systems can be used:

Compressor family	Liquid injection	Vapour injection	Wet vapour injection (vapour + liquid injection)
ZFD13KVE to ZFD25KVE		X	X
ZFD41K5E	X	X	X

Table 5

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Copeland Scroll compressors ZFD13KVE to ZFD25KVE are vapour injection only. Liquid injection alone is not possible. For compressor model ZFD41K5E both liquid injection and vapour injection are possible.

Dedicated discharge temperature thermostats (DLT) shall be used for R407A, R407F, R448A and R449A applications and can also be used for R404A. The R407A/R407F/R448A/R449A dedicated discharge thermostat has a cut-out setting of $130^{\circ}\text{C} \pm 4\text{K}$ with closing at $101^{\circ}\text{C} \pm 8\text{K}$. It should be installed approximately 120 mm from the discharge valve outlet.

3.3.1 Vapour injection (EVI = Economized Vapour Injection)

Compressor models ZFD13KVE to ZFD25KVE and ZFD41K5E can be used with R404A, R407A, R407F, R448A and R449A refrigerants and vapour injection.

These compressors are equipped with a vapour injection connection for economizer operation. Economizing can be achieved by using a subcooling circuit similar to the circuit shown in **Figure 12**. This increases the refrigeration capacity and the system efficiency.

The line diagram shows a system configuration for the economizer cycle. A heat exchanger is used to provide additional subcooling to the refrigerant before it enters the evaporator. This subcooling process provides the increased capacity gain measured in the system.

The evaporated refrigerant through the heat exchanger (economizer) is injected into the compressors and provides additional cooling at higher compression ratios.

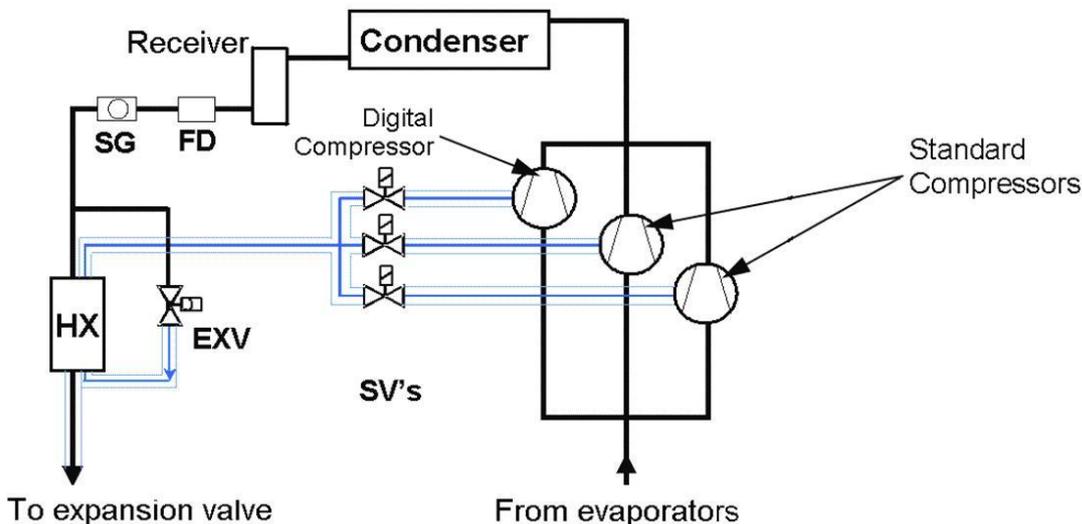


Figure 12: Vapour injection line diagram

The application envelopes for the use of R407A and R407F refrigerants with vapour injection are significantly limited, because of possible high discharge temperatures. Special attention should be paid to the maximum suction gas temperature / superheat values.

NOTE: For further information on vapour injection see Technical Information C7.19.2 "ZF* Refrigeration Copeland Scroll™ Compressors Using R407A and R407F in Low Temperature Applications".

3.3.2 Wet vapour injection (vapour injection + liquid injection)

Compressor models ZFD13KVE to ZFD25KVE and ZFD41K5E can be used with R407A and R407F refrigerants and wet vapour injection.

The operating envelopes for R407A and R407F low temperature applications can be enlarged thanks to the use of wet vapour injection, ie, a combination of vapour injection and liquid injection (DTC valve) (see Select software at www.emersonclimate.eu).

The wet vapour injection cycle showing the main components is shown in **Figure 13** next page:

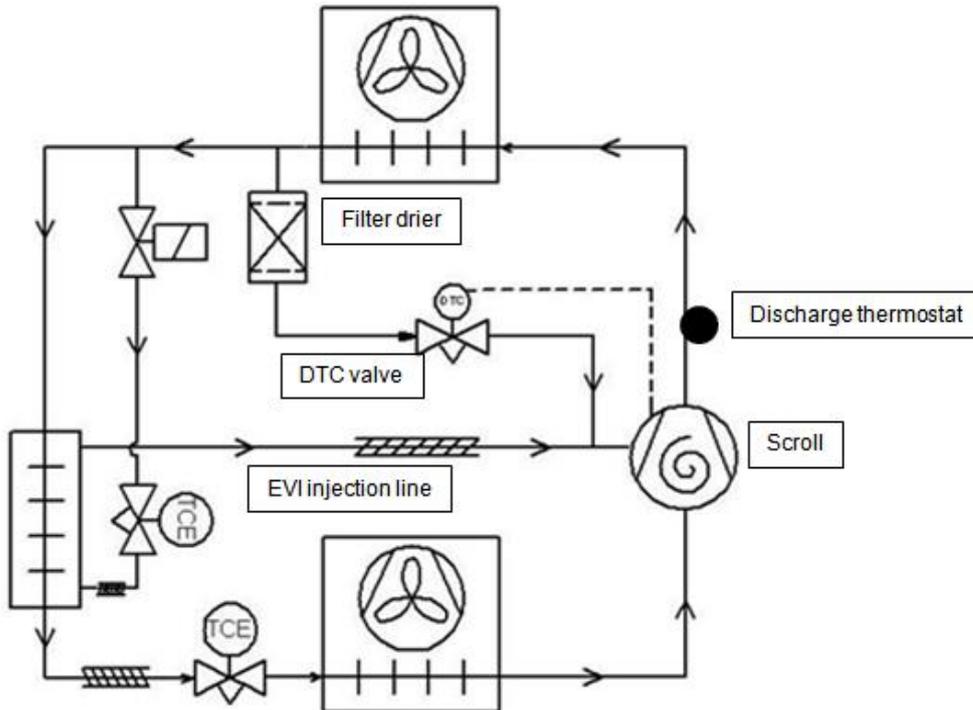


Figure 13: Wet vapour injection cycle for R407A & R407F low temperature applications

NOTE: For Digital compressors ZFD13KVE and ZFD25KVE, the DTC valve bulb must replace the existing NTC sensor located at the side of the compressor top cap. The previous NTC sensor has to be removed and the controller, eg, ALCO EC3-D*, has to be modified (disable discharge sensor input). A new thermostat must be installed on the discharge line. **DO NOT** use the previous solution NTC sensor + controller as a discharge temperature protection since its rating is not suitable for R407A and R407F.

3.4 Discharge check valve

There is no discharge check valve at the discharge port of Copeland Scroll Digital compressors ZBD21K* to ZBD57K* and ZFD13KVE to ZFD25KVE since the high-side pressure is needed to support the operation of the unloader mechanism.

To avoid by-passing during the unloading process back to suction, a dynamic discharge valve is fitted internally on the discharge port of the fixed scroll. This discharge valve cannot be used with recycling pump down because it is not leak-proof during the off period.

Models ZBD58K* to ZBD114K* work with an internal unloader mechanism and are equipped with a check valve in the discharge fitting that will prevent backward flow of gas through the scroll when the compressor shuts off.

3.5 Brazing procedure

IMPORTANT

Blockage! Compressor breakdown! Maintain a flow of oxygen-free nitrogen through the system at very low pressure during brazing. Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to form, the copper oxide material can later be swept through the system and block screens such as those protecting capillary tubes, thermal expansion valves, and accumulator oil return holes.

Contamination or moisture! Bearing failure! Do not remove the plugs until the compressor is set into the unit. This minimises any entry of contaminants and moisture.

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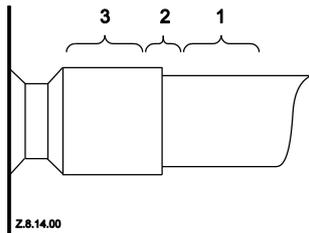


Figure 14: Suction tube brazing areas

Copeland Scroll compressors have copper-plated steel suction and discharge tubes. These tubes are far more robust and less prone to leaks than copper tubes. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

Refer to **Figure 14** and the procedure below for the brazing of the suction and discharge lines to a scroll compressor.

- The copper-coated steel tubes on scroll compressors can be brazed in approximately the same manner as any copper tube.
- Recommended brazing materials: any silfos material is recommended, preferably with a minimum of 5% silver. However, 0% silver is acceptable.
- Be sure tube fitting inner diameter and tube outer diameter are clean prior to assembly.
- Using a double-tipped torch, apply heat in area 1.
- As the tube approaches brazing temperature, move the torch flame to area 2.
- Heat area 2 until braze temperature is attained, moving the torch up and down and rotating around the tube as necessary to heat the tube evenly. Add braze material to the joint while moving the torch around the joint to flow braze material around the circumference.
- After the braze material flows around the joint, move the torch to heat area 3. This will draw the braze material down into the joint. The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

To disconnect:

- Heat joint areas 2 and 3 slowly and uniformly until the braze material softens and the tube can be pulled out of the fitting.

To reconnect:

- Recommended brazing materials: Silfos with minimum 5% silver or silver braze used on other compressors. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

NOTE: Since the discharge stub contains a check valve, care must be taken not to overheat it to prevent brazing material from flowing into it.

3.6 Shut-off valves and adaptors



CAUTION

Leaking system! System breakdown! It is strongly recommended to periodically re-torque all pipe and fixing connections to the original setting after the system has been put into operation.

Copeland Scroll compressor models ZBD58K* to ZBD114K* and ZFD41K5E are delivered with a discharge check valve fitted inside the discharge port and rubber plugs fitted to the suction and discharge port as standard. There are options to fit either Rotalock valves or Rotalock adaptors, or just make brazing connections.

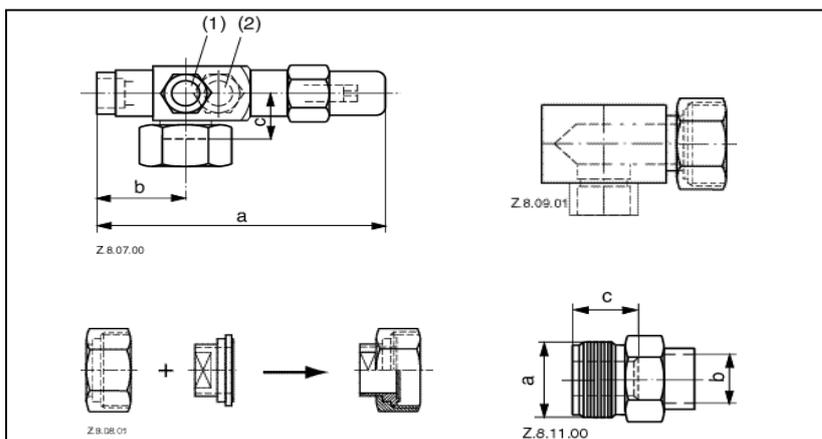


Figure 15

Braze connections can be converted to Rotalock by means of adaptors. Rotalock shut-off valves are available for the suction as well as discharge side. Using either straight or angled adaptors provides a way to convert a Rotalock into a brazing connection.

Refer to **Table 6** for proper tightening torques:

	Torque [Nm]
Rotalock 3/4" – 16UNF	40-50
Rotalock 1" – 14UNS	70-80
Rotalock 1 1/4" – 12UNF	110-135
Rotalock 1 3/4" – 12 UNF	135-160

Table 6

NOTE: More information about adaptors and shut-off valves can be found in the "Spare parts list".

3.7 Oil separator

During any operating cycle of Copeland Scroll Digital compressors, there is a loaded state during which the compressor operates at full capacity. The velocity of gas during this loaded state is sufficient to return oil back to the compressor. Laboratory tests have established that there is no problem in oil return, even when the length of interconnecting pipe used is 100 metres and the vertical elevation is 30 metres. Based on such performance, we do not strictly recommend the use of an oil separator.

3.8 Accumulators



CAUTION

Inadequate lubrication! Bearing destruction! Minimise liquid refrigerant returning to the compressor. Too much refrigerant dilutes the oil. Liquid refrigerant can wash the oil off the bearings leading to overheating and bearing failure. For R450A and R513A refrigerants Emerson Climate Technologies recommends to use suction accumulators, unless it has been qualified that an accumulator is not needed – see below.

Irrespective of system charge, oil dilution may occur if large amounts of liquid refrigerant repeatedly flood back to the compressor during:

- normal off cycles;
- defrost;
- varying loads.

In such a case an accumulator must be used to reduce flood-back to a safe level that the compressor can handle. The use of accumulators is dependent on the application. If an accumulator must be used, the oil-return orifice should be from 1 to 1.4 mm in diameter for models ZBD21K* to ZBD57K* and ZFD13KVE to ZFD25KVE and 2.0 mm for models ZBD58K* to ZBD114K* and ZFD41K5E, depending on compressor size and compressor flood-back results.

The size of the accumulator depends upon the operating range of the system and the amount of subcooling and subsequent head pressure allowed by the refrigerant control.

3.9 Screens



CAUTION

Screen blocking! Compressor breakdown! Use screens with at least 0.6 mm openings.

The use of screens finer than 30 x 30 mesh (0.6 mm openings) anywhere in the system should be avoided with these compressors. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes, or accumulators can become temporarily or permanently plugged with normal system debris and block the flow of either oil or refrigerant to the compressor. Such blockage can result in compressor failure.

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3.10 Mufflers

External mufflers, normally applied to piston compressors in the past, may not be required for Copeland Scroll compressors.

Individual system tests should be performed to verify acceptability of sound performance. If adequate attenuation is not achieved, use a muffler with a larger cross-sectional area to inlet area ratio. A ratio of 20:1 to 30:1 is recommended.

A hollow shell muffler such as the Alco APD-1 will work quite well. Locate the muffler at minimum 15 cm to maximum 45 cm from the compressor for the most effective operation. The farther the muffler is placed from the compressor within these ranges, the more effective. Choose a muffler with a length of 10 to 15 cm.

3.11 Suction line noise and vibration

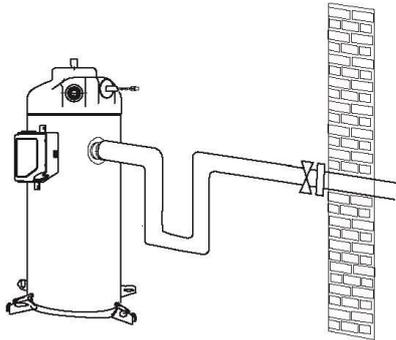


Figure 16: Suction tube design

Copeland Scroll compressors inherently have low sound and vibration characteristics. However in some respects the sound and vibration characteristics differ from reciprocating compressors and in rare instances could result in unexpected sound generation. One difference is that the vibration characteristic of the scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally-suspended compressor. These frequencies, which are present in all compressors, may result in a low-level "beat" frequency that can be detected as noise coming along the suction line into the building under some conditions. Elimination of the beat can be achieved by attenuating either of the contributing frequencies. This is easily done by using one of the common combinations of recommended design

configurations. The scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the line to prevent vibration transmission into any lines attached to the unit. In a split system, the most important goal is to ensure minimal vibration in all directions at the service valve to avoid transmitting vibrations to the structure to which the lines are fastened.

A second difference of the Copeland Scroll compressor is that under some conditions the normal rotational starting motion of the compressor can transmit an "impact" noise along the suction line. This may be particularly pronounced in three-phase models due to their inherently higher starting torque. This phenomenon, like the one described previously, also results from the lack of internal suspension and can be easily avoided by using standard suction line isolation techniques as described below. The sound phenomena described above are not usually associated with reversible air conditioning / heat pump systems because of the isolation and attenuation provided by the reversing valve and tubing bends.

Recommended configuration

- Tubing configuration:small shock loop
- Service valve: "angled valve" fastened to unit / wall
- Suction muffler:not required

Alternative configuration

- Tubing configuration:small shock loop
- Service valve: "straight through" valve fastened to unit / wall
- Suction muffler:may be required (acts as dampening mass)

4 Electrical connection

4.1 General recommendations

The compressor terminal box has a wiring diagram on the inside of its cover. Before connecting the compressor, ensure the supply voltage, the phases and the frequency match the nameplate data.

4.2 Electrical installation

Single-phase (PF*) compressors:

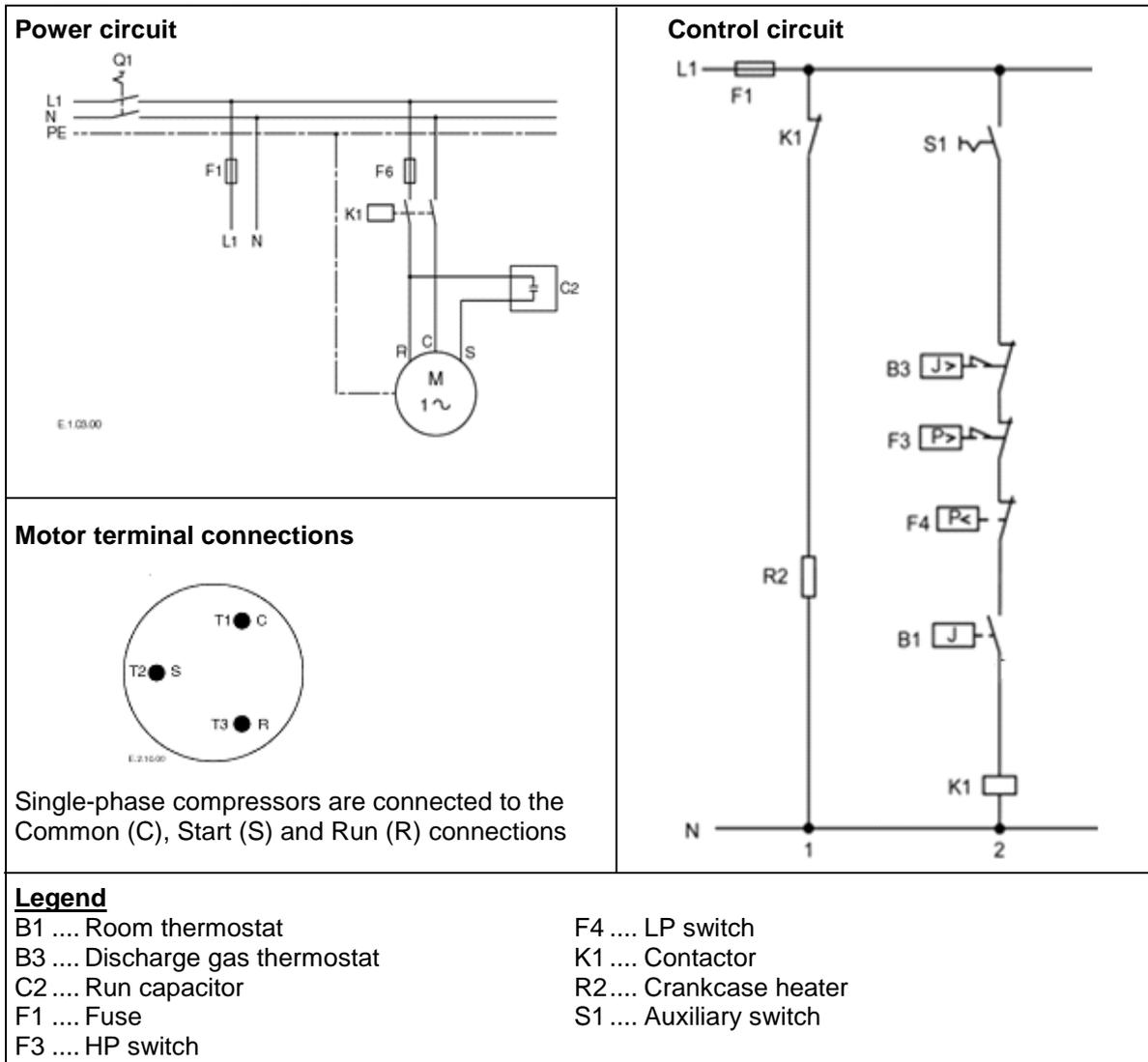


Figure 17

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Three-phase compressors (TF*) with internal motor protection:

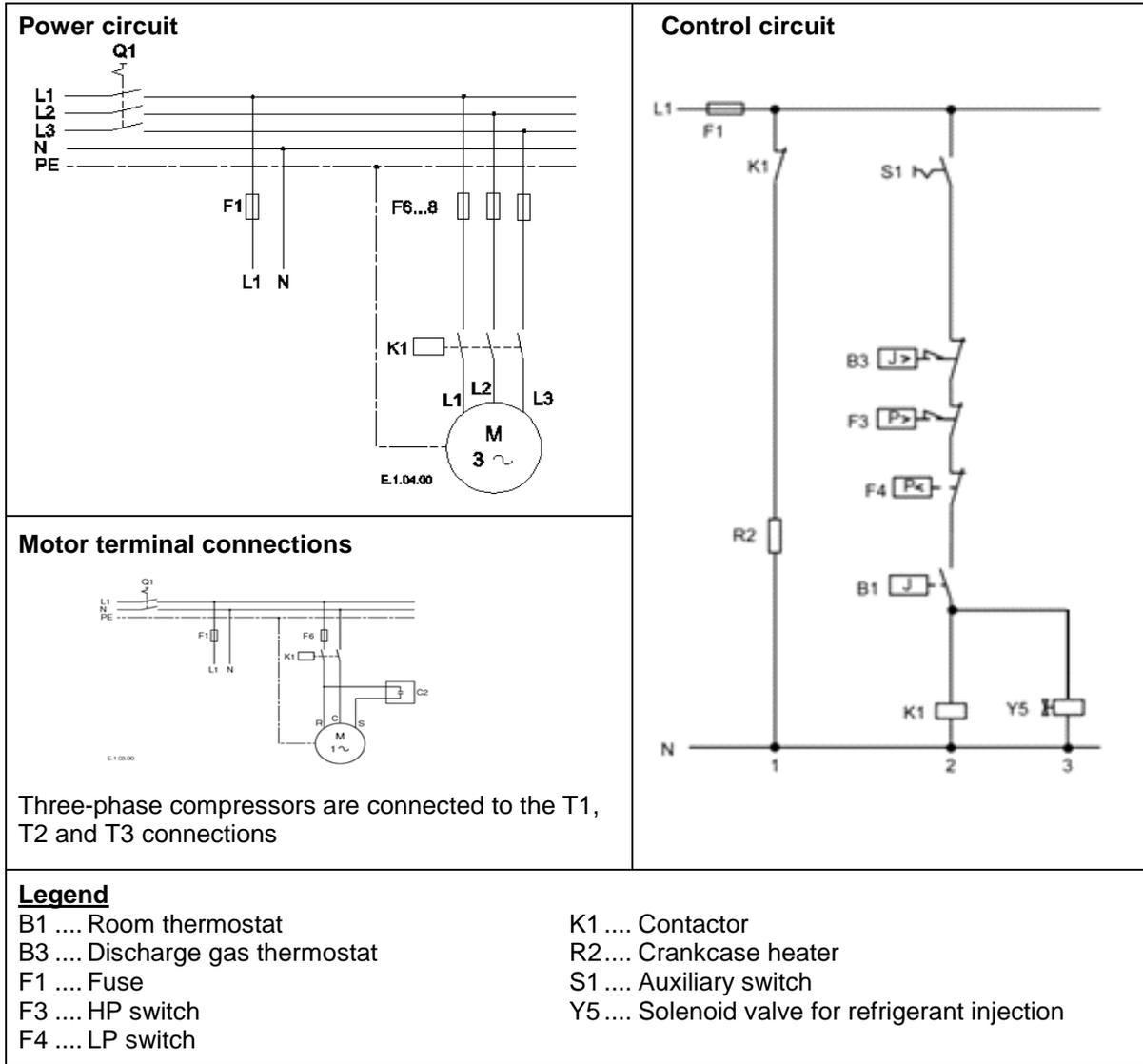


Figure 18

4.2.1 Terminal box

The standard terminal box is IP21 for all models with internal motor protection (TF*/PF*), enclosure class according to IEC 60034-5.

Cable glands have an influence on the protection class of the terminal box. It is strongly recommended to use appropriate cable glands in order to reach the rated protection class. We advise installers/service providers to pay attention to this aspect every time they install or replace a Copeland Scroll compressor and to use cable glands according to EN 50262 or any other relevant standard of application in their country/region. Examples of correct electrical installations are shown in **Figures 19 & 20** below.

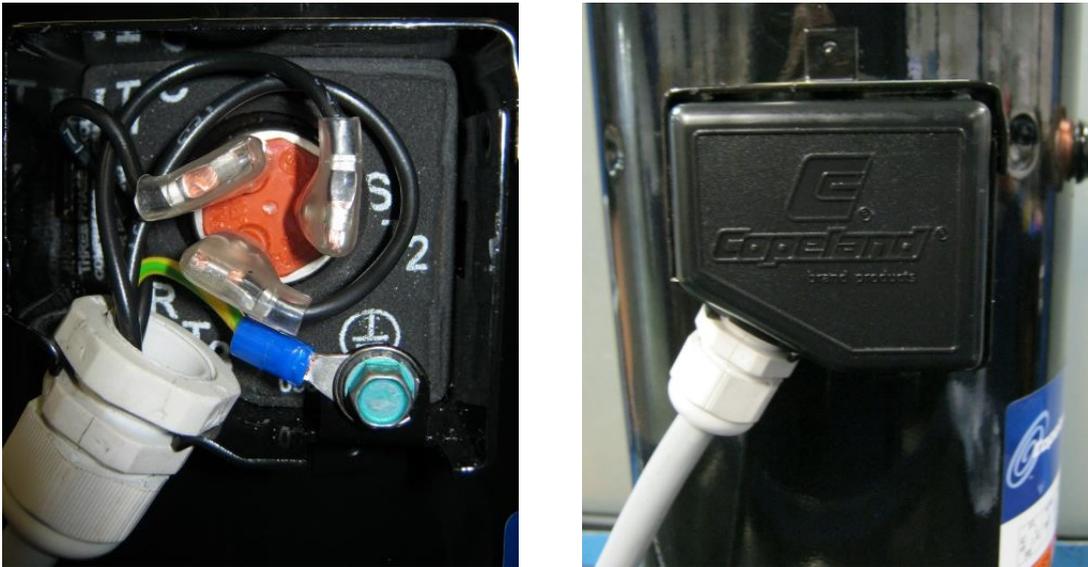


Figure 19: Correct electrical installation with cable glands for IP21 T-box (compressors ZBD21K* & ZBD29K*)



Figure 20: Correct electrical installation with cable glands for IP21 T-box (compressors ZBD30K* to ZBD114K*, ZFD13KVE to ZFD25KVE & ZFD41K5E)

4.2.2 Motor winding

Compressor model ZBD21K* is available in single-phase (PF*). The ZBD and ZFD models are offered with three-phase (TF*) induction motors. Single-phase motors need a run capacitor while all three-phase motors are connected in star.

The motor insulation material is class "B" for compressor models covered in these guidelines. This is according to VDE 0530, IEC 34-18-1 or DIN 57530.

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4.2.3 Motor protection

For compressor models ZBD21K* to ZBD114K*, ZFD13KVE to ZFD25KVE and ZFD41K5E, conventional inherent internal line break motor protection is provided.

4.2.4 Protection devices

Independently from the internal motor protection, fuses must be installed before the compressor. Selection of fuses has to be carried out according to VDE 0635, DIN 57635, IEC 269-1 or EN 60-269-1.

4.2.5 Crankcase heaters



IMPORTANT

Oil dilution! Bearing malfunction! Turn the crankcase heater on 12 hours before starting the compressor.

A crankcase heater is used to prevent refrigerant migrating into the shell during standstill periods. Due to the Copeland scroll's inherent ability to handle liquid refrigerant in flooded conditions a crankcase heater is not required when the system charge does not exceed the charge limits shown in **Table 7**.

Compressor	Refrigerant charge limit
ZBD21K* & ZBD29K*	3.6 kg
ZBD30K* to ZBD57K* ZFD13KVE to ZFD25KVE	4.5 kg
ZBD58K* to ZBD114K* & ZFD41K5E	7.5 kg

Table 7

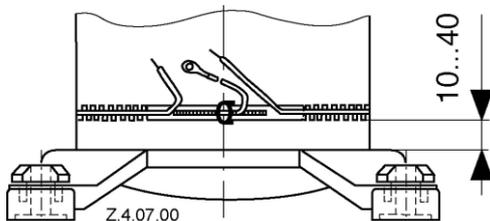


Figure 21: Crankcase heater location

If a crankcase heater is fitted it is recommended that the heater be turned on for a **minimum of 12 hours** prior to starting the compressor. This will prevent oil dilution and bearing stress on initial start-up. The crankcase heater must remain energised during compressor off cycles.

The crankcase heater must be mounted below the oil Schraeder valve located on the bottom shell (see **Figure 21**).

The crankcase heater should be wired in such a way that it is turned on whenever the compressor is switched off.

4.3 Pressure safety controls

4.3.1 IPR valve (Internal Pressure Relief valve)

The internal pressure relief valves for models ZBD21K* to ZBD57K* and ZFD13KVE to ZFD25KVE are located between the high and low sides of the compressor. They are designed to open when the discharge-to-suction differential pressure exceeds 26-31 bar. When the valve opens, hot discharge gas is routed back into the area of the motor protector to cause a trip. During developmental blocked fan testing, it is sometimes noted that the valve opens, but the compressor does not shut off while the discharge pressure continues to climb. This condition is normally caused by flood back and may be corrected by using a more restrictive expansion device or reducing the refrigerant charge.

Compressors ZBD58K* to ZBD114K* and ZFD41K5E do not have internal pressure relief valves. To ensure safe operation, a high-pressure control must be used in all applications with these compressors. This pressure control will act independently from the digital controller.

4.3.2 High-pressure control

A high-pressure control with a maximum cut-out setting of 28 bar(g) is required.

The high-pressure control should have a manual reset feature for the highest level of system protection.

4.3.3 Low-pressure control



IMPORTANT

Loss of system charge! Bearing malfunction! A low-pressure control is highly recommended for loss of charge protection. Do not bridge or by-pass the low-pressure limiter.

Even though these compressors require a discharge temperature sensor, loss of system charge etc. will result in overheating and recycling of the motor protector. Prolonged operation in this manner could result in oil pump-out and eventual bearing failure.

A minimum cut-out setting of 0.3 bar(g) is required for the ZFD compressors using R404A. For ZBD compressors, the low-pressure cut-out should be set as high as possible. The normal minimum is 2.6 bar(g).

The low-pressure limiter should have a manual reset feature for the highest level of system protection.

4.4 Discharge temperature protection

Internal discharge temperatures can reach unacceptable values under some extreme operating conditions (such as operation outside the approved application limits, improper control operation or loss of refrigerant injection charge). This could cause compressor damage.

Discharge gas temperature protection is required for any application with Copeland brand compressors in order to guarantee positive compressor protection. This protection must not be used as an operating envelope controller but as a safety device.

Compressors ZBD21K* & ZBD29K*: These compressors have no internal temperature protection. Therefore they are supplied with a discharge temperature thermostat.

Compressors ZBD30K* to ZBD57K* and ZFD13KVE to ZFD25KVE: These compressors are equipped with a discharge temperature sensor (NTC thermistor) that is embedded in the top cap of the compressor. The output of the NTC thermistor is used in the protection module of the digital Scroll controller. The resistance curve for the NTC thermistor is provided in **Table 8** hereunder.

Temperature (°C)	Resistance (kOhm)	Temperature (°C)	Resistance (kOhm)
-40	2889.60	75	12.73
-35	2087.22	80	10.79
-30	1522.20	85	9.20
-25	1121.44	90	7.87
-20	834.72	95	6.77
-15	627.28	100	5.85
-10	475.74	105	5.09
-5	363.99	110	4.45
0	280.82	115	3.87
5	218.41	120	3.35
10	171.17	125	2.92
15	135.14	130	2.58
20	107.44	135	2.28
25	86.00	140	2.02
30	69.28	145	1.80
35	56.16	150	1.59
40	45.81	155	1.39
45	37.58	160	1.25
50	30.99	165	1.12
55	25.68	170	1.01
60	21.40	175	0.92
65	17.91	180	0.83
70	15.07		

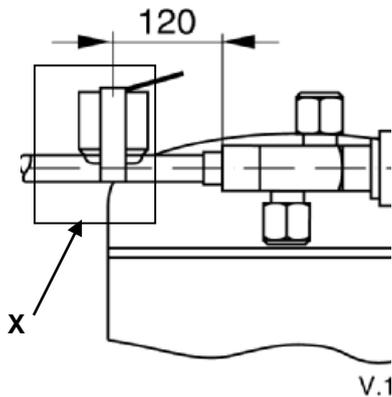
Table 8: Digital Scroll thermistor temperature / resistance values

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Compressors ZBD58K* to ZBD114K* and ZFD41K5E: These models have no internal temperature protection and therefore require an external thermostat or a discharge temperature sensor (NTC thermistor) mounted as close as possible to the discharge fitting in order for the digital Scroll controller to operate properly. For best response the sensor should be insulated.

Compressors ZFD13KVE to ZFD25KVE: For low temperature applications with **R404A**, these compressors could be used with the NTC thermistor, connected to the digital Scroll controller. For low temperature applications with **R407A, R407F, R448A and R449A** the DTC valve bulb (for the wet vapour injection system) must replace the existing NTC sensor located at the side of the compressor top cap. Since there is no more connection possibility for the NTC sensor bulb, the previous NTC sensor has to be removed and the controller, eg, ALCO EC3-D*, has to be modified (disable discharge sensor input). A new discharge gas thermostat must be installed on the discharge line. **DO NOT** use the previous solution NTC sensor + controller as a discharge temperature protection since its rating is not suitable for R407A, R407F, R448A and R449A.



The R404A, R407A, R407F, R448A and R449A dedicated discharge thermostat has a cut-out setting of $130^{\circ}\text{C} \pm 4\text{K}$ with closing at $101^{\circ}\text{C} \pm 8\text{K}$. The thermostat should be installed approximately 120 mm from the discharge valve outlet (see **Figure 22**). It must be insulated in order to avoid improper functioning due to false readings (see "X" in **Figure 22**).

Figure 22: Discharge temperature protection recommended position

4.5 High potential testing



WARNING

Conductor cables! Electrical shock! Shut off power supply before high-potential testing.



CAUTION

Internal arcing! Motor destruction! Do not carry out high-voltage or insulation tests if the compressor housing is under vacuum.

Emerson Climate Technologies subjects all Scroll compressors to a high-voltage test after final assembly. Each motor phase winding is tested, according to EN 0530 or VDE 0530 part 1, at a differential voltage of 1000V plus twice the nominal voltage. Since high-voltage tests lead to premature ageing of the winding insulation further additional tests of that nature are not recommended.

If it has to be done for any reason, a lower voltage must be used. Disconnect all electronic devices, eg, motor protection module, fan speed control, etc prior to testing.

5 Starting up & operation



WARNING

Diesel effect! Compressor destruction! The mixture of air and oil at high temperature can lead to an explosion. Avoid operating with air.



IMPORTANT

Oil dilution! Bearing malfunction! Turn the crankcase heater on 12 hours before starting the compressor.

5.1 Strength pressure test

The compressor has been strength-tested in the factory. It is not necessary for the customer to strength- or leak-test the compressor again although the compressor will normally be exposed to the testing made as part of system testing.

5.2 Tightness/pressure test



WARNING

High pressure! Personal injuries! Consider personal safety requirements and refer to test pressures prior to test.



WARNING

System explosion! Personal injuries! DO NOT USE other industrial gases.



CAUTION

System contamination! Bearing malfunction! Use only dry nitrogen or dried air for pressure testing.

If using dry air do not include the compressor in the pressure test – isolate it first. Never add refrigerant to the test gas (as leak indicator).

5.3 Preliminary checks – Pre-starting

Discuss details of the installation with the installer. If possible, obtain drawings, wiring diagrams, etc.

It is ideal to use a check-list but always check the following:

- Visual check of the electrics, wiring, fuses etc.
- Visual check of the plant for leaks, loose fittings such as TXV bulbs etc.
- Compressor oil level
- Calibration of HP & LP switches and any pressure actuated valves
- Setting and operation of all safety features and protection devices
- All valves in the correct running position
- Pressure and compound gauges fitted
- Correctly charged with refrigerant
- Compressor electrical isolator location & position

5.4 Charging procedure



CAUTION

Low suction pressure operation! Compressor damage! Do not operate with a restricted suction. Do not operate with the low-pressure cut-out bridged. Do not operate compressor without enough system charge to maintain at least 0.3 bar suction pressure. Allowing pressure to drop below 0.3 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage.

The system should be liquid-charged through the liquid-receiver shut-off valve or through a valve in the liquid line. The use of a filter drier in the charging line is highly recommended. Because R404A is a blend and scrolls have discharge check valves, systems should be liquid-charged on both the high and low sides simultaneously to ensure a positive refrigerant pressure is present in

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the compressor before it runs. The majority of the charge should be placed in the high side of the system to prevent bearing washout during first-time start on the assembly line.

5.5 Initial start-up



CAUTION

Oil dilution! Bearing malfunction! It is important to ensure that new compressors are not subjected to liquid abuse. Turn the crankcase heater on 12 hours before starting the compressor.



CAUTION

High discharge pressure operation! Compressor damage! Do not use the compressor to test opening set point of high-pressure cut-out. Bearings are susceptible to damage before they have had several hours of normal running in.

Liquid and high pressure loads could be detrimental to new bearings. It is therefore important to ensure that new compressors are not subjected to liquid abuse and high-pressure run tests. It is not good practice to use the compressor to test the high-pressure switch function on the production line. Switch function can be tested with nitrogen prior to installation and wiring can be checked by disconnecting the high-pressure switch during the run test.

5.6 Rotation direction

Copeland Scroll compressors, like several other types of compressors, will only compress in one rotational direction. Three-phase compressors will rotate in either direction depending upon phasing of the power. Since there is a 50-50 chance of connecting power in such a way as to cause rotation in the reverse direction, **it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction is achieved when the system is installed and operated.**

Observing that suction pressure drops and discharge pressure rises when the compressor is energized allows verification of proper rotation direction. There is no negative impact on durability caused by operating three-phase Copeland Scroll compressors in the reversed direction for a short period of time (under one hour) but oil may be lost. Oil loss can be prevented during reverse rotation if the tubing is routed at least 15 cm above the compressor. After several minutes of operation in reverse, the compressor's protection system will trip due to high motor temperature. The operator will notice a lack of cooling. However, if allowed to repeatedly restart and run in reverse without correcting the situation, the compressor will be permanently damaged.

All three-phase scroll compressors are identically wired internally. Therefore, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the identified compressor terminals will ensure proper rotation direction.

5.7 Pressure fluctuations

During the normal operation of the Digital Scroll compressor, there is a fluctuation in the suction and the discharge pressures. This fluctuation will be in the range of 2 to 3.5 bar. During the unloaded state, discharge pressure will start to drop and suction pressure will start to rise. This is normal. This pressure fluctuation has no effect on the reliability of any system components.

NOTE: Models ZBD21K* to ZBD57K* require a minimum 3.5 bar differential between the suction pressure and the discharge pressure to unload properly.

5.8 Starting sound

During the very brief start-up, a clicking sound is audible, resulting from initial contacting of the spirals and is normal. Due to the design of the Copeland Scroll compressors, the internal compression components always start unloaded even if system pressures are not balanced. In addition, since internal compressor pressures are always balanced at start-up, low-voltage starting characteristics are excellent for Copeland Scroll compressors.

5.9 Deep vacuum operation



CAUTION

Vacuum operation! Compressor damage! Scroll compressors should never be used to evacuate a refrigeration or air-conditioning system.



CAUTION

Vacuum operation! Bearing damage! Vacuum operation causes damage to the drive bearing of the scrolls. Copeland Scroll compressors are able to pull vacuum very quickly and this should be avoided.

The scroll compressor can be used to pump down refrigerant in a unit as long as the pressures remain within the operating envelope. Prolonged operation at low suction pressures will result in overheating of the scrolls and permanent damage to the compressor drive bearing. ZBD scrolls incorporate internal low vacuum protection; the floating seal unloads when the pressure ratio exceeds approximately 10:1 (ZF>20:1).

5.10 Shell temperature

The top shell and discharge line can briefly but repeatedly reach temperatures above 177°C if the compressor cycles on its internal protection devices. This only happens under rare circumstances and can be caused by the failure of system components such as the condenser or evaporator fan or loss of charge and depends upon the type of expansion control. Care must be taken to ensure that wiring or other materials that could be damaged by these temperatures do not come in contact with the shell.

5.11 Minimum run time

Emerson Climate Technologies recommends a maximum of 10 starts per hour. There is no minimum off time because scroll compressors start unloaded even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after start-up. To establish the minimum run time obtain a sample compressor equipped with a sight tube (available from Emerson Climate Technologies) and install it in a system with the longest connecting lines that are approved for the system. The minimum on time becomes the time required for oil lost during compressor start-up to return to the compressor sump and restore a minimal oil level that will ensure oil pick-up through the crankshaft. Cycling the compressor for a shorter period than this, for instance to maintain very tight temperature control, will result in progressive loss of oil and damage to the compressor.

5.12 Sound characteristics

For the Copeland Scroll Digital compressor the sound spectrum of the loaded state and that of the unloaded state are quite different. The unloaded sound power is normally 2 dB(A) higher than the loaded sound power. If sound variability is an issue, we recommend the use of a sound cover.

5.13 Shut-off sound

Scroll compressors incorporate a device that minimizes reverse rotation. The residual momentary reversal of the scrolls at shut off will cause a clicking sound, but it is entirely normal and has no effect on compressor durability.

5.14 Frequency

There is no general release of standard Copeland Scroll compressors for use with variable speed AC drives. There are numerous issues that must be considered when applying Scroll compressors with variable speed, including system design, inverter selection, and operating envelopes at various conditions. Only frequencies from 50 Hz to 60 Hz are acceptable. Operation outside this frequency range is possible but should not be done without specific Application Engineering review. The voltage must vary proportionally to the frequency.

If the inverter can only deliver a maximum voltage of 400V, the amps will increase when the speed is above 50 Hz, and this may give rise to nuisance tripping if operation is near the maximum power limit and/or compressor discharge temperature limit.

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5.15 Oil level

The oil level should be maintained at mid-point of the sight glass. If an oil regulator is used the level should be set within the top half of the sight glass.

5.16 Digital system control

Due to the pulsing characteristic of Copeland Scroll Digital compressors superheat control needs to be performed by qualified solutions in order to ensure the stability, reliability and good performance of the system.

NOTE: For further information about these solutions see Technical Information C7.8.3 "Refrigeration – Controlling Digital Scroll".

5.17 Power factor

During the loaded state, when the Copeland Scroll Digital compressor operates at full capacity, the power factor is almost the same as with a standard scroll. However, when the scrolls are unloaded, the power factor is lower.

6 Maintenance & repair

6.1 Exchanging the refrigerant

Qualified refrigerants and oils are given in section 2.4.1.

It is not necessary to replace the refrigerant with new unless contamination due to an error such as topping up the system with an incorrect refrigerant is suspected. To verify correct refrigerant composition, a sample can be taken for chemical analysis. A check can be made during shut down by comparing the refrigerant temperature and pressure using precision measurements at a location in the system where liquid and vapour phases are present and when the temperatures have stabilised.

In the event that the refrigerant needs replacing, the charge should be recovered using a suitable recovery unit.

6.2 Rotalock valves

Rotalock valves should be periodically retorqued to ensure that leak tightness is maintained.

6.3 Replacing a compressor



CAUTION

Inadequate lubrication! Bearing destruction! Exchange the accumulator after replacing a compressor with a burned out motor. The accumulator oil return orifice or screen may be plugged with debris or may become plugged. This will result in starvation of oil to the new compressor and a second failure.

6.3.1 Compressor replacement

In the case of a motor burnout, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through the use of suction and liquid line filter driers. A 100% activated alumina suction line filter drier is recommended but must be removed after 72 hours. **It is highly recommended that the suction accumulator be replaced if the system contains one.** This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure. When a single compressor or tandem is exchanged in the field, it is possible that a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage.

6.3.2 Start-up of a new or replacement compressor

Rapid charging only on the suction side of a scroll-equipped system or condensing unit can occasionally result in a temporary no start condition for the compressor. The reason for this is that, if the flanks of the compressor happen to be in a sealed position, rapid pressurisation of the low side without opposing high-side pressure can cause the scrolls to seal axially. As a result, until the pressures eventually equalise, the scrolls can be held tightly together preventing rotation. The best way to avoid this situation is to charge on both the high and low sides simultaneously at a rate which does not result in axial loading of the scrolls.

A minimum suction pressure of 1.75 bar must be maintained during charging. Allowing pressure to drop below 0.3 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage. Never install a system in the field and leave it unattended when it has no charge, a holding charge, or with the service valves closed without securely electrically locking out the system. This will prevent unauthorised personnel from accidentally operating the system and potentially ruining the compressor by operating with no refrigerant flow. **Do not start the compressor while the system is in a deep vacuum.** Internal arcing may occur when a scroll compressor is started in a vacuum causing burnout of the internal lead connections.

6.4 Lubrication and oil removal



CAUTION

Chemical reaction! Compressor destruction! Do not mix up ester oils with mineral oil and/or alkyl benzene when used with chlorine-free (HFC) refrigerants.

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The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerants R404A, R407A, R407F, R448A, R449A, R450A, R513A and R134a is a polyolester (POE) lubricant Emkarate RL 32 3MAF. In the field the oil level could be topped up with Mobil EAL Arctic 22 CC if 3MAF is not available. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1 litre less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (see **Figure 23**). Only brief exposure to ambient air is needed for POE to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since POE holds moisture more readily than mineral oil it is more difficult to remove it through the use of vacuum. Compressors supplied by Emerson Climate Technologies contain oil with low moisture content, and it may rise during the system assembling process. Therefore, it is recommended that a properly sized filter drier is installed in all POE systems. This will maintain the moisture level in the oil to less than 50 ppm. If oil is charged into a system, it is recommended to use POE with a moisture content no higher than 50 ppm.

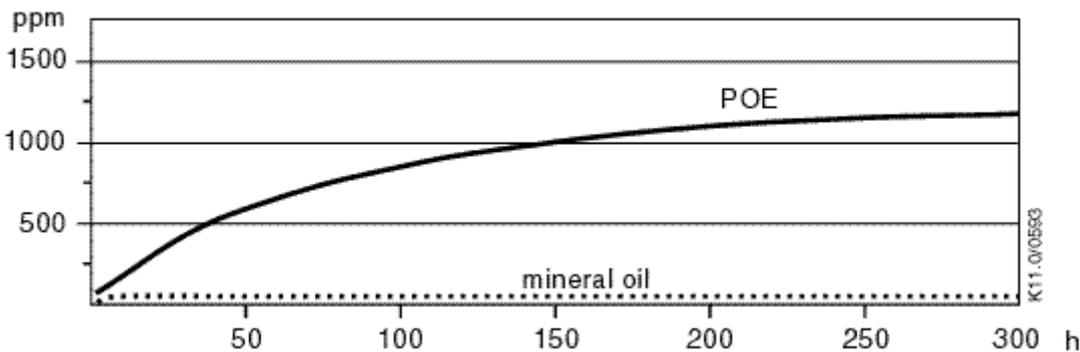


Figure 23: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25°C and 50% relative humidity (h=hours)

If the moisture content of the oil in a refrigeration system reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 0.3 mbar or lower. If there is uncertainty as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the HFC refrigerants and lubricants; however, the moisture indicator will just show the moisture content of the refrigerant. The actual moisture level of POE would be higher than the sight glass specifies. This is due to the high hygroscopicity of the POE oil. To determine the actual moisture content of the lubricant, samples have to be taken from the system and analysed.

6.5 Oil additives

Although Emerson Climate Technologies cannot comment on any specific product, from our own testing and past experience, we do not recommend the use of any additives to reduce compressor bearing losses or for any other purpose. Furthermore, the long term chemical stability of any additive in the presence of refrigerant, low and high temperatures, and materials commonly found in refrigeration systems is complex and difficult to evaluate without rigorously controlled chemical laboratory testing. The use of additives without adequate testing may result in malfunction or premature failure of components in the system and, in specific cases, in voiding the warranty on the component.

6.6 Unbrazing system components



WARNING

Explosive flame! Burning! Oil-refrigerant mixtures are highly flammable. Remove all refrigerant before opening the system. Avoid working with an unshielded flame in a refrigerant charged system.

Before opening up a system it is important to remove all refrigerant from both the high and low sides of the system. If the refrigerant charge is removed from a scroll-equipped unit from the high side only, it is possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized. If a brazing torch is then applied to the low side while the low side shell and suction line contain pressure,

the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and low sides with manifold gauges before unbrazing. Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required, the compressor should be cut out of system rather than unbrazed.

7 Dismantling & disposal



Removing oil and refrigerant:
Do not disperse in the environment.
Use the correct equipment and method of removal.
Dispose of oil and refrigerant properly.
Dispose of compressor properly.

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