

Copeland Scroll™

Application Guidelines

Scroll Compressors for Refrigeration

ZS09KAE, ZS11KAE & ZS13KAE



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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

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

1.2 Safety statements

- Refrigeration 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.

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 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 all vertical single Copeland Scroll compressors for refrigeration applications from ZS09KAE to ZS13KAE.

Compressor	Cooling capacity kW					Motor
	R404A	R407A	R407F	R448A, R449A	R134a	
ZS09KAE	2.12	2.03	2.13	1.96	1.32	PFJ/TFD
ZS11KAE	2.55	2.43	2.55	2.35	1.58	PFJ/TFD
ZS13KAE	2.90	2.76	2.89	2.68	1.79	PFJ/TFD

Table 1: Compressor capacity at EN 12900 medium temperature conditions

EN 12900 Conditions for medium temperature:

Evaporating temperature-10°C

Suction gas return temperature20°C

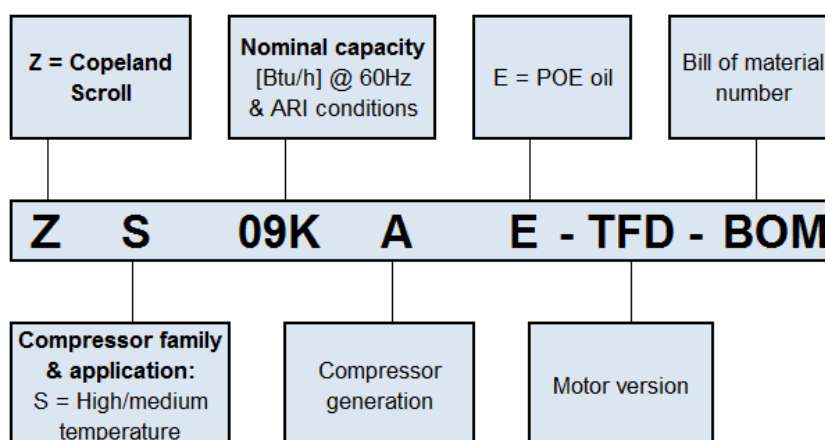
Condensing temperature 45°C

Liquid sub-cooling 0K

These 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 compressors:



2.3 Application range

2.3.1 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, R407F, R448A, R449A and R407C) is 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 available at www.emersonclimate.eu.

Compressor	ZS09KAE to ZS13KAE
Qualified refrigerants	R404A, R407A, R407F, R448A, R449A, R134a
Copeland brand products standard oil	Emkarate RL 32 3MAF
Servicing oils	Emkarate RL 32 3MAF, Mobil EAL Arctic 22 CC

Table 2: Qualified refrigerants and oils

2.3.2 Application limits



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.

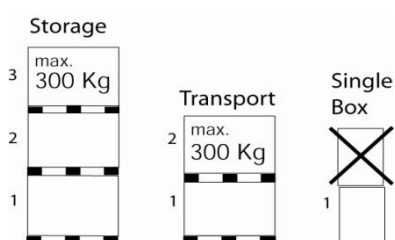


Figure 1: Transport and storage

3.1.2 Positioning and securing



IMPORTANT

Handling damage! Compressor malfunction! Only use the lifting eyes whenever the compressor requires positioning. Using discharge or suction connections for lifting may cause damage or leaks.

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

ZS*KAE compressors can be delivered with 3 or 4 feet, 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.

Mounting parts: ZS09KAE to ZS13KAE - Soft mountings

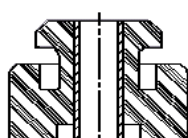


Figure 2: Mounting parts

3.2 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.

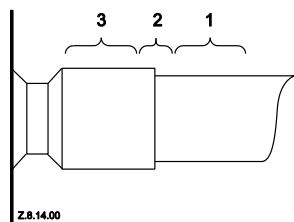


Figure 3: Suction tube brazing

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 3** and 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 to flow into it.

3.3 Suction 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 all compressors ZS*KAE depending on compressor size and compressor flood-back results.

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

3.4 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.

3.5 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 will work quite well. Locate the muffler at minimum 15 to maximum 45 cm from the compressor for the most effective operation. The further the muffler is placed from the compressor within these ranges, the more effective. Choose a muffler with a length of 10 to 15 cm.

3.6 Suction line noise and vibration

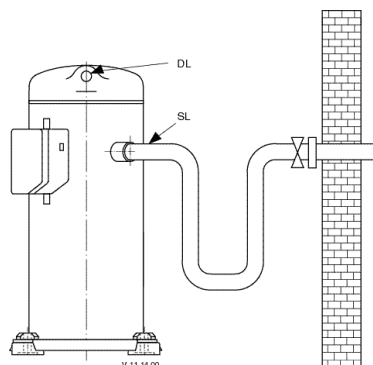


Figure 4: Suction tube design

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 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.

Copeland Scroll™

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:

For the ZS09KAE to ZS13KAE PF* range of compressors the following circuit diagrams can be used:

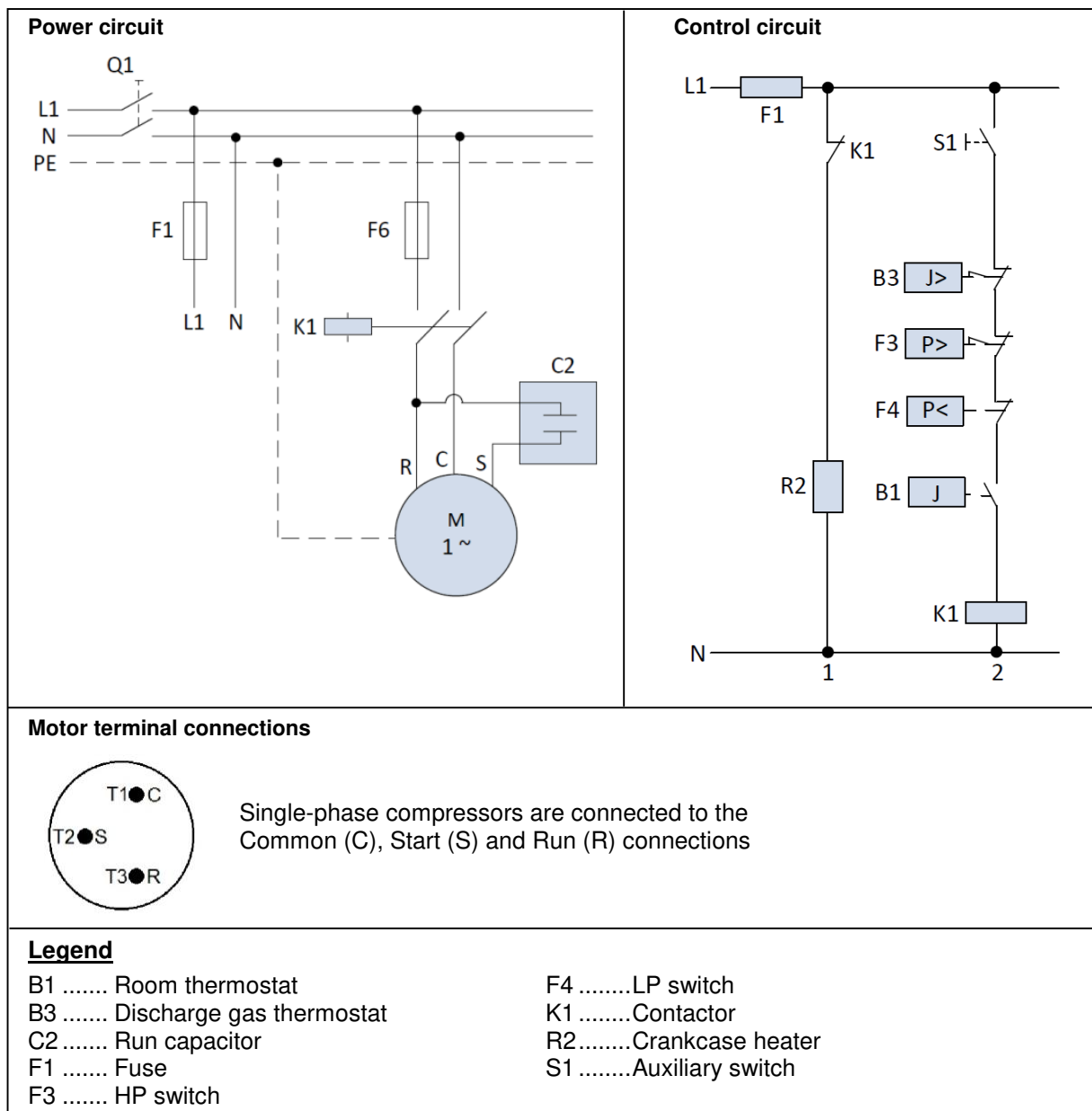


Figure 5: Wiring diagram for single-phase compressors

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

For the ZS09KAE to ZS13KAE TF* range of compressors the following circuit diagrams can be used:

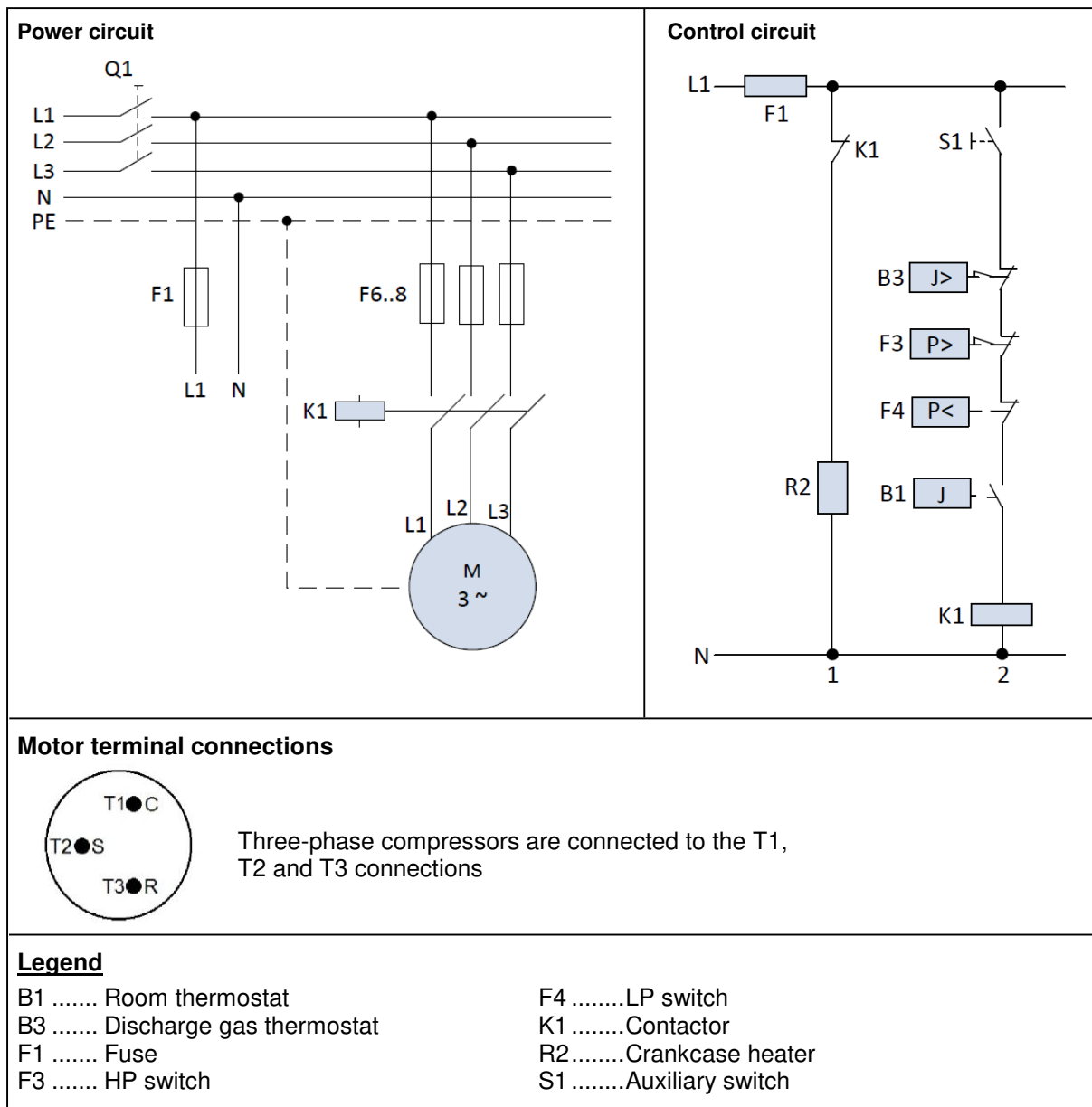


Figure 6: Wiring diagram for three-phase compressors

4.2.1 Terminal box

The protection class of the terminal box is IP21 for all ZS*KAE compressors BOM 524 version, 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 particular 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 **Figure 7** below.



Figure 7: Correct electrical installation with cable glands for IP21 T-box (models ZS09KAE to ZS13KAE)

4.2.2 Moulded plug connection

All ZS*KAE compressors can also be delivered with electrical pin connections ready for moulded plug connection as an option. Version 618 is compliant with all CE and safety regulations and its protection class is IP66. Several conductor cable lengths are available.



Figure 8: Circle fence with motor terminals



Figure 9: Moulded plug IP66

4.2.3 Motor windings

The protection class of the terminal box is IP21 for all ZS*KAE compressors with BOM 524.

All ZS*KAE compressor models can also be delivered with electrical pin connections ready for moulded plug connection, providing an IP66 protection class.

4.2.4 Protection devices

Independently from the internal motor protection, fuses must be installed before the compressor. The 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 must be used to prevent refrigerant migrating into the shell during standstill periods. Due to 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 3.6 kg.

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.

4.3 Pressure safety controls

4.3.1 High-pressure control

The cut-out setting for the high-pressure control shall be determined according to regional standards, usually EN 378, part 2 in Europe.

The maximum pressure value for the individual compressor type, PS high side, is printed on the nameplate of the compressor.

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

4.3.2 Low-pressure control

The minimum cut-out setting shall be determined according to the refrigerant and to the allowed operation envelope. Please refer to technical data in Select software available at www.emersonclimate.eu.

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

4.3.3 Internal pressure relief valve

There is an internal pressure relief valve on all ZS*KAE refrigeration Scroll compressors. The relief valve opens at a differential pressure of 28 bar \pm 3 bar between high- and low-pressure sides.

A high-pressure cut-out may be required according to national regulations and is strongly recommended due to the capabilities of pumping to high pressures once the discharge is obstructed.

The IPR valve is a safety device, not an HP switch. It is not designed for repeated operation and there is no guarantee that it will reset correctly if it does have repeated operation.

4.4 Discharge temperature protection

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

An external thermostat is not included in the standard delivery. It is mandatory and must be ordered separately from the compressor.

The maximum discharge gas temperature is 130°C for all ZS*KAE compressors. These compressors have both an internal Thermodisc and an external discharge line thermostat. The external discharge line thermostat must be installed for all ZS*KAE compressor types.

The Thermodisc is a temperature-sensitive snap disc device located at the muffler plate port. It is designed to open and route hot discharge gas back to the motor protector that will trip and stop the compressor. The internal thermodisc opens at 146°C \pm 4K and closes at 91°C \pm 7K.

The discharge line thermostat must be mounted on the discharge pipe 120 mm from the compressor shell. To avoid any impact of the ambient on the tripping temperature the sensor must be insulated.

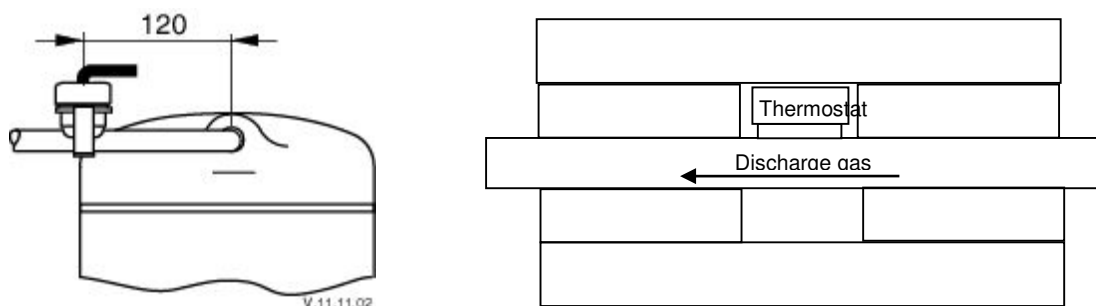


Figure 10: Example of installation of an external discharge line thermostat

Thorough system tests will ensure positive compressor protection and will avoid nuisance tripping within the envelope.

4.5 Motor protection

Conventional inherent internal line break motor protection is provided for the complete range of ZS*KAE compressors.

4.6 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 System evacuation

Before the installation is put into commission, it has to be evacuated with a vacuum pump. Proper evacuation reduces residual moisture to 50 ppm. During the initial procedure, suction and discharge shutoff valves on the compressor remain closed. The installation of adequately sized access valves at the furthest point from the compressor in the suction and liquid lines is advisable. Pressure must be measured using a vacuum pressure (Torr) gauge on the access valves and not on the vacuum pump; this serves to avoid incorrect measurements resulting from the pressure gradient along the connecting lines to the pump.

Evacuating the system only on the suction side of a Scroll compressor can occasionally result in a temporary no start condition for the compressor. The reason for this is that the floating seal could axially seal with the scroll set, with the higher pressure on the floating seal. Consequently, until the pressures equalise, the floating seal and scroll set can be held tightly together. The installation should be evacuated down to 0.3 mbar / 0.22 Torr.

Subsequently, the factory holding charge of dry air in the compressor is released to the ambient. The shut-off valves are opened and the installation, including the compressor, are once more evacuated as described after the system has been recharged with dry nitrogen. Highest demands are placed on the leak proof design of the installation and on leak testing methods (please refer to EN 378).

5.4 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
- Check 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

5.5 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 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 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.

5.6 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 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.

5.7 Rotation direction

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 to L1, L2 and L3. 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 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.

5.8 Starting sound

During the very brief start-up, a clicking sound is audible, resulting from initial contacting of the spirals and is normal. No start assist devices are required for single-phase compressors, even if a system uses non-bleed expansion valves. Due to the design of the Copeland Scroll, 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. Moreover, if low voltage conditions exist at start up, protector trips could result.

5.9 Deep vacuum operation



CAUTION

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

The Scroll compressor can be used to pump down refrigerant in a unit as long as the pressures remain within the operating envelope. Low suction pressures will result in overheating of the scrolls and permanent damage to the compressor drive bearing. Scroll compressors incorporate internal low vacuum protection; the floating seal unloads when the pressure ratio exceeds approximately 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 Pump-down cycle

A pump-down cycle to control refrigerant migration may have to be used when the compressor is located outside without any housing so that cold air blowing over the compressor makes the crankcase heater ineffective.

If a pump-down cycle is used, a separate external check valve must be added. The scroll discharge check valve is designed to stop extended reverse rotation and prevent high-pressure gas from leaking rapidly into the low side after shut-off. The check valve will in some cases leak more than reciprocating compressor discharge reeds normally used with pump-down, causing the scroll compressor to recycle more frequently. Repeated short-cycling of this nature can result in a low oil situation and consequent damage to the compressor. The hysteresis of the low-pressure control differential has to be reviewed since a relatively large volume of gas will re-expand from the high side of the compressor into the low side after shutdown.

For pressure control setting, never set the low-pressure limiter to shut off outside of the operating envelope. To prevent the compressor from running into problems during such faults as loss of charge or partial blockage, the low pressure limiter shall not be set lower than the minimum suction pressure allowed by the operating envelope.

5.12 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. 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.

5.13 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.

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.

6 Maintenance & repair

6.1 Exchanging the refrigerant

Qualified refrigerants and oils are given in section 2.3.1.

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 re-torqued 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.

The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerants R404A / R407A / R407F / R448A / R449A / 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 11**). 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.

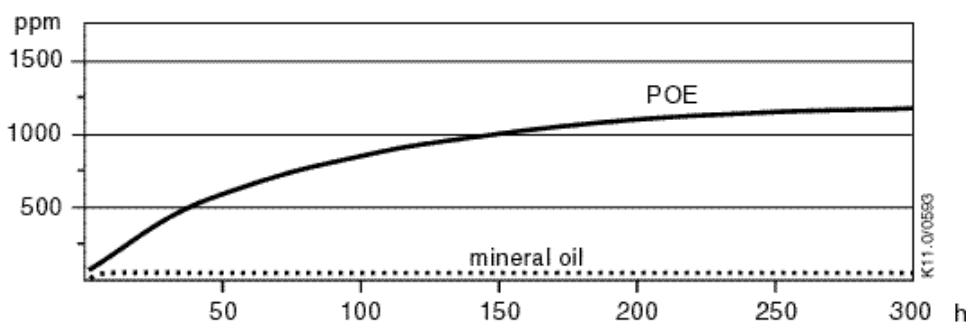


Figure 11: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25°C and 50% relative humidity (h=hours)

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 indicates. 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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