APPLICATION GUIDELINES

Copeland scroll compressors for comfort applications

ZR24KRE to ZR190KRE

COPELAND

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About these guidelines

The purpose of these 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. The performance and reliability of the product may be impacted if the product is not used according to these guidelines or is misused.

These application guidelines cover stationary applications only. For mobile applications, please contact the Application Engineering department at Copeland as other considerations may apply.

1 Safety instructions

Copeland scroll compressors are manufactured according to the latest relevant European, UK and US safety standards. Particular emphasis has been placed on the user's safety.

The ZR*KRE compressors are intended for installation in systems in accordance with the following directives and regulations:

Machinery Directive MD 2006/42/EC	Supply of Machinery (Safety) Regulations 2008
Pressure Equipment Directive PED 2014/68/EU	Pressure Equipment (Safety) Regulations 2016
Low Voltage Directive LVD 2014/35/EU	Electrical Equipment (Safety) Regulations 2016

They may be put to service only if they have been installed in systems according to instructions and conform to the corresponding provisions of legislation.

The Material Safety Datasheet (MSDS) of each individual refrigerant shall be considered – please check the document provided by the gas supplier.

These instructions shall 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

- **Refrigerant compressors must be employed only for their intended use. The system has to be labelled according to the applicable standards and legislation.**
- **Only qualified and authorized RACHP (refrigeration, air conditioning and heat pump) 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
Pressurized system! Serious personal injuries and/or system breakdown! Accidental system start before complete set-up must be avoided. Never leave the system unattended without locking it out electrically when it is under vacuum and has no refrigerant charge, when it has a holding charge of nitrogen, or when the compressor service valves are closed.

WARNING
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 come into contact with it. Lock and mark accessible sections.

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

CAUTION
Contact with refrigerant oil! Material damage! Polyolester (POE) lubricants must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used at all times. Refrigerant oil 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 Compressor range

These application guidelines deal with all vertical single Copeland scroll compressors from ZR24KRE to ZR190KRE for air-conditioning applications.

Compressor	Cooling capacity (kW)				Motor
	R450A	R513A	R134a	R407C	
ZR24KRE	3.06	3.54	3,61	5.02	PFJ/TFD
ZR28KRE	3.60	4.17	4.18	5.88	PFJ/TFD
ZR36KRE	4.58	5.21	5.25	7.59	PFJ/TFD
ZR42KRE	5.24	6.20	6.07	8.87	PFJ/TFD
ZR48KRE	6.01	6.91	6.60	10.30	TFD
ZR61KRE	7.62	9.01	8.77	13.00	TFD
ZR69KRE	8.59	10.15	9.76	14.30	PFJ
ZR72KRE	9.08	10.55	10.50	14.75	TFD
ZR81KRE	10.0	11.60	11.80	16.55	TFD
ZR92KRE	11.3	13.50	13.35	18.75	TFD
ZR108KRE	-	15.80	15.70	23.00	TFD
ZR125KRE	-	18.40	18.25	27.00	TFD
ZR144KRE	-	20.80	21.00	30.90	TFD
ZR160KRE	-	22.90	22.70	33.40	TFD
ZR190KRE	-	27.40	27.20	39.30	TFD

Refrigerant dew temperature, evaporating temperature: 5 °C; condensing temperature: 50 °C; suction gas superheat: 10 K; liquid sub-cooling: 0 K; frequency: 50 Hz

Table 1: ZR*KRE model overview for high-temperature applications

2.2 Nomenclature

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

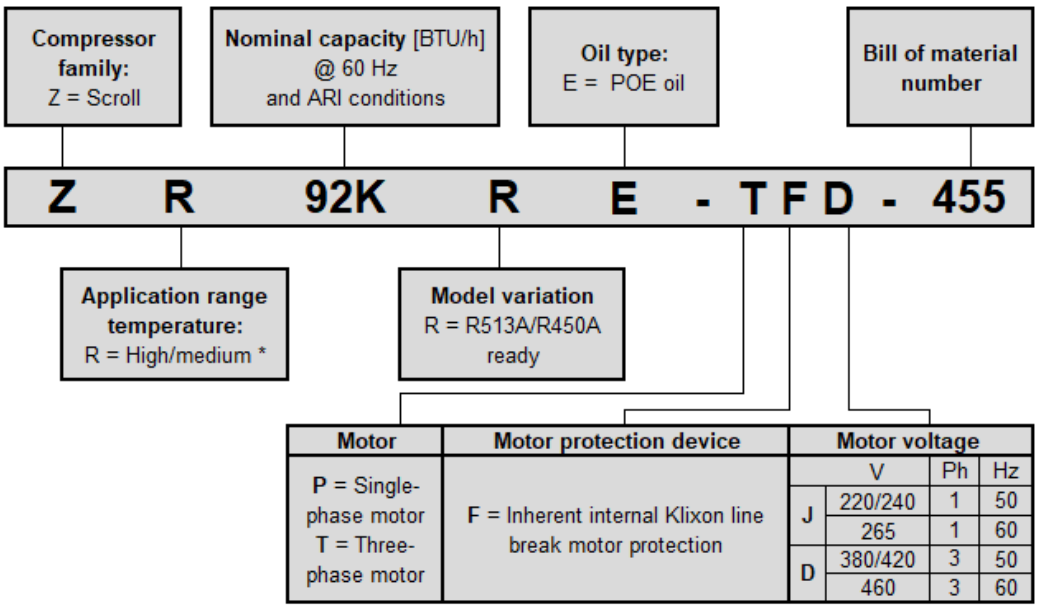


Figure 1: Compressor nomenclature

2.3 BOM variations

The BOM (bill of material) number at the end of the compressor designation indicates the compressor layout and details.

ZR24KRE to ZR92KRE:

BOM 455 Braze connections, oil sight glass, oil service connection, IP21 T-box, no mounting parts.

ZR108KRE to ZR190KRE:

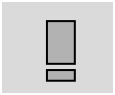
BOM 455 Braze connections, oil sight glass, oil service connection, IP21 T-box, no mounting parts.

BOM 411 Braze connections, oil sight glass, oil service connection, IP65 T-box, no mounting parts.

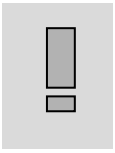
More information about available BOM versions can be found in the Copeland price list. Also refer to Technical Information TI_Scroll_BOM "Copeland scroll compressors – BOM Overview", available at www.copeland.com/en-gb for more details.

2.4 Application range

2.4.1 Qualified refrigerants and oils



IMPORTANT
It is essential that the glide of refrigerant blends (R450A, R407C) be carefully considered when adjusting pressure and superheat controls.



IMPORTANT
Refrigerant blends with low GWP containing HFOs have a low chemical stability in presence of air or humidity. This requires the same level of cleanliness, dryness and evacuation of the refrigerant circuit as in HFC and POE applications including the use of filter-dryers.

Compressors	ZR24KRE to ZR92KRE	ZR108KRE to ZR190KRE
Qualified refrigerants	**R450A, R513A, R134a, R407C**	**R513A, R134a, R407C**
Qualified oils (factory charged)	Emkarate RL 32 3MAF	Emkarate RL 32 3MAF
Servicing oils	Emkarate RL 32 3MAF Mobil EAL Arctic 22 CC	Emkarate RL 32 3MAF Mobil EAL Arctic 22 CC

Table 2: Qualified refrigerants and oils.

Oil recharge values can be taken from Copeland Select software available at www.copeland.com/en-gb/tools-resources.

2.4.2 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 5 K is required.

For application envelopes and technical data, please refer to Copeland Select software available at www.copeland.com/en-gb/tools-resources.

2.4.3 PED category and maximum allowable pressure PS

The nameplate of the compressor contains information about the maximum allowable pressure PS, the minimum and maximum allowed temperature TS, the internal free volumes and the fluid groups of the refrigerants qualified for the compressor model range. Values are given for both pressure ranges on low- and high-pressure sides.

The PED category is assigned according to the Pressure Equipment Directive PED 2014/68/EU. Requirements apply to the relevant pressure levels in the compressor when the product of "pressure relative to the environment" by "related internal free volume" (P x V) exceeds given limits. When calculating the PED category, the high- and low-pressure sides have to be calculated separately. The highest of the calculation results is considered.

Compressor	PS low pressure side	PS high pressure side	TS max. low pressure side	Internal free volume (litres)	
				LP side	HP side
ZR24KRE to ZR92KRE	21 bar(g)	29 bar(g)	50 °C	21	29
ZR108KRE to ZR190KRE	20.5 bar(g)	32 bar(g)	53 °C	20.5	32

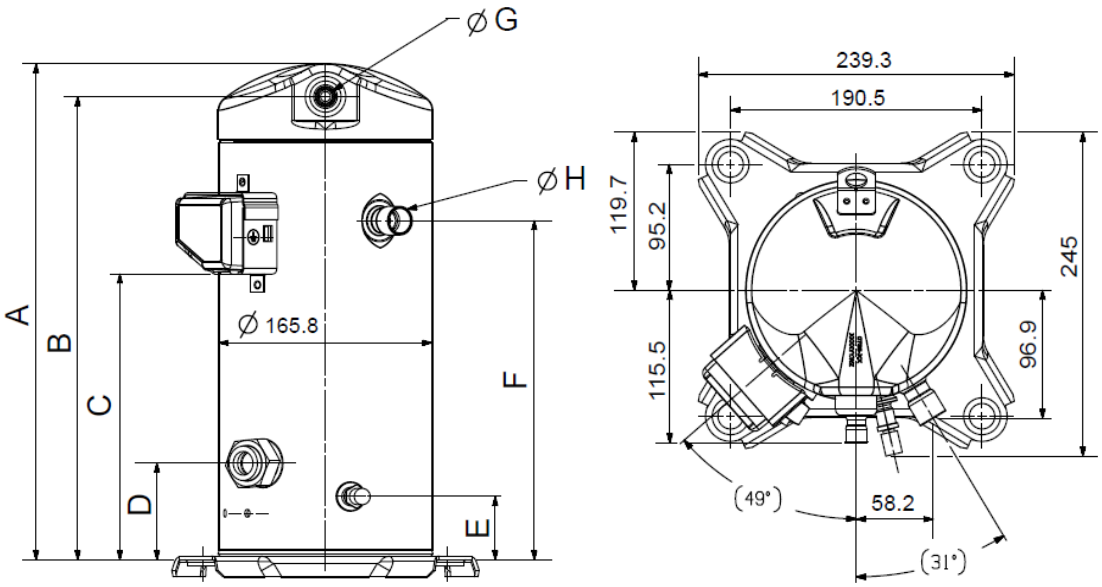
Table 3: Maximum allowable pressures, temperatures and internal free volumes

The PED category also depends on the fluid group of the qualified refrigerants, also shown on the nameplate. A distinction is made between refrigerants of fluid group 1 (flammable) and fluid group 2 (non-flammable). The ZR*KRE compressors covered in these guidelines are operated with A1 (group 2) refrigerants.

Compressor range	Refrigerants	Fluid group	PED category
ZR24KRE to ZR92KRE	R450A, R513A, R134a, R407C	2	I
ZR108KRE to ZR190KRE	R513A, R134a, R407C	2	II

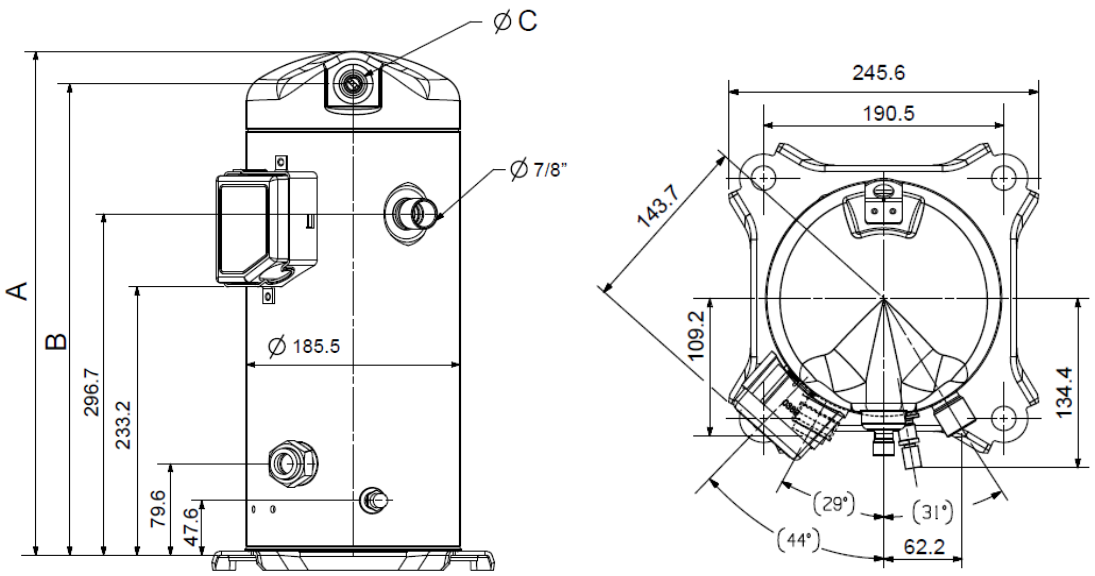
Table 4: PED category based on refrigerant used and fluid group

2.5 Dimensions



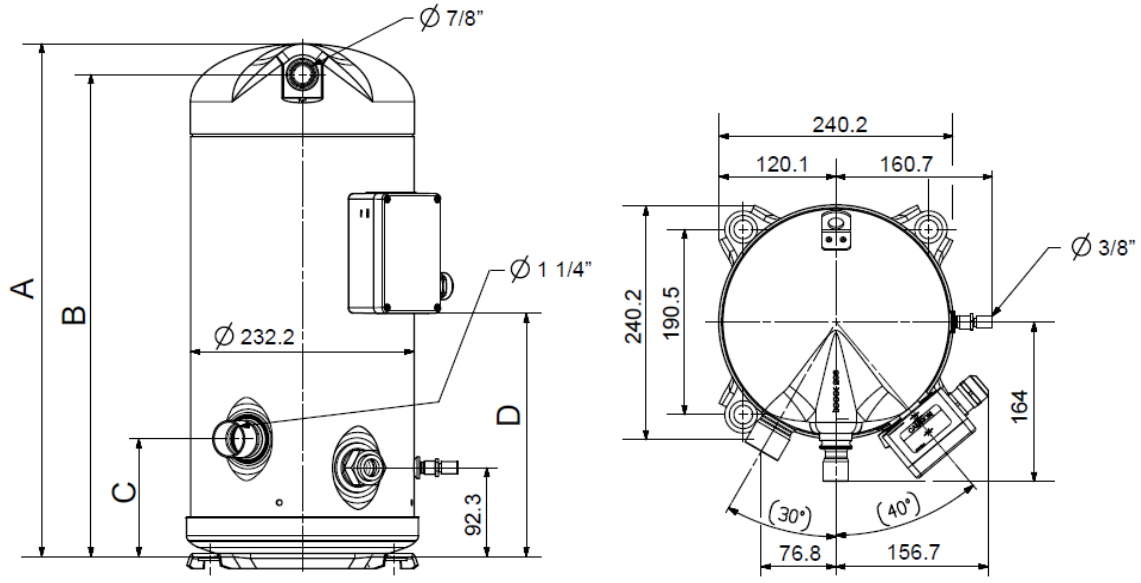
Compressor model	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	Ø G	Ø H
ZR24KRE & ZR28KRE	364.1	338.5	202.9	69.6	43.7	244.5	1/2"	3/4"
ZR36KRE	386.7	361.1	222.8	75.3	49.4	264.4	1/2"	3/4"
ZR42KRE	400.4	374.9	235.5	75.3	49.4	277.1	1/2"	3/4"
ZR48KRE	417.4	391.9	252.5	75.3	49.4	294.1	1/2"	7/8"

Figure 2: Dimensions of models ZR24KRE to ZR48KRE



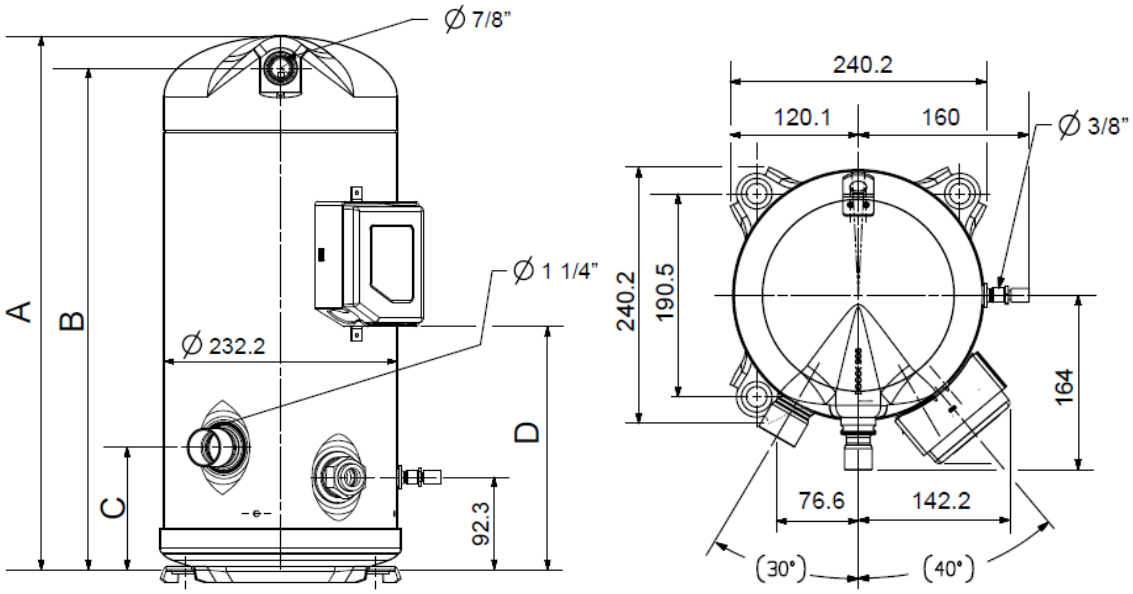
Compressor model	A (mm)	B (mm)	Ø C
ZR61KRE to ZR72KRE	437.8	409.6	1/2"
ZR81KRE & ZR92KRE	443.2	413.7	3/4"

Figure 3: Dimensions of models ZR61KRE to ZR92KRE



Compressor model	A (mm)	B (mm)	C (mm)	D (mm)
ZR108KRE to ZR144KRE	533.2	501.1	122.1	252.7
ZR160KRE & ZR190KRE	551.5	519.5	140.4	271

Figure 4: Dimensions of models ZR108KRE to ZR190KRE - BOM411



Compressor model	A (mm)	B (mm)	C (mm)	D (mm)
ZR108KRE to ZR144KRE	533.2	501.1	122.1	242.8
ZR160KRE & ZR190KRE	551.5	519.5	140.4	261.2

Figure 5: Dimensions of models ZR108KRE to ZR190KRE - BOM455

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. Respect stacking loads according to **Figure 6**. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Keep the packaging dry at all times.

Respect the maximum number of identical packages which may be stacked on one another, where "n" is the limiting number:

- **Transport: n = 1**
- **Storage: n = 2**

Figure 6: Maximum stacking loads for transport and storage

The compressor tilt angle should not be more than 30° during transport and handling. This will prevent oil from exiting through the suction stub. A tilt angle of maximum 45° is allowed for a very short time. Tilting the compressor more than 45° might affect its lubrication at start-up.

***NOTE*: The compressor is pre-charged with dry air to avoid any moisture contamination.**

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.

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.

The plugs must be removed as late as possible before brazing so that the air humidity does not affect the oil characteristics.

For models ZR108KRE to ZR190KRE, as 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.

No object, eg, a swaging tool should be inserted deeper than 51 mm into the suction tube as it might damage the suction screen and motor.

3.1.3 Installation location

Ensure the compressors are installed on a solid level base. For single compressor applications, the compressor tilt angle during operation should not exceed 15° to allow adequate lubrication. For multiple compressor parallel configurations, the compressors must be positioned completely vertically on a totally horizontal surface or rail.

3.2 Mounting parts

A kit of vibration absorber grommets can be ordered 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.

See Copeland spare parts catalogue at www.copeland.com/en-gb/tools-resources for references.

Mounting parts: ZR24KRE to ZR190KRE – Soft mountings

Alternative mounting parts for ZR24KRE to ZR190KRE – Hard mountings

Figure 7: Mounting parts

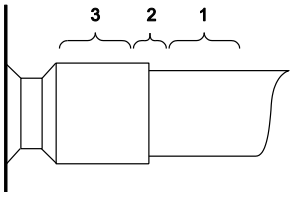
NOTE: **For more information, please refer to Technical Information TI_Scroll_Mounting_01 "Copeland scroll compressors – Mounting parts".**

3.3 Brazing procedure

WARNING
High temperature! Burning! Proceed with caution when brazing system components. Do not touch the compressor until it has cooled down. Ensure that other materials in the area of the compressor do not come into contact with it.

CAUTION
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.

3.3.1 General brazing procedure



Copeland scroll compressors have copper-plated steel suction and discharge stub tubes. These stub tubes are far more robust and less prone to leaks than copper tubes. Make sure the brazing procedures are carried out in an appropriate manner taking into account the different thermal properties of steel and copper.

Refer to **Figure 8** and the procedure below for the brazing of the stub tube connections of 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.

***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.**

*3.3.2 Brazing procedure for ZR*KRE compressors in parallel applications*

Only compressor models officially approved by Copeland in the qualified configuration may be used for parallel applications. For ZR*KRE compressors in parallel applications with passive oil management, additional precautions shall be taken before brazing the oil and gas equalization ports. The sequence shall be as follows:

First, install the compressors on the base frame and tilt the assembly so that oil will not be lost when opening the cap. The gas and oil equalization line assembly should be ready for brazing at this point. For new compressors, release the protective gas charge: the rubber plug from the discharge port of the compressor has to be removed first, then the rubber plugs from the oil port.

Most probably the oil port will be coated with some oil. It is mandatory to clean out the oil before brazing. If the inner surface is contaminated with oil the brazing material will not adhere to the surface and the joint will fail, generating leakage. The oil should be carefully wiped out with industrial absorption paper. Industrial solvents on a clean cloth can be used too but only with great care. Note that emery cloth will not remove the oil.

It is possible that the oil cannot be completely cleaned out. In this case additional measures should be taken. For instance, if a connection is coated with flux then the residual oil will be removed when brazing due to the applied heat.

If an active oil level control is to be used, eg, OM* Traxoil from Copeland Flow Controls, please refer to the product documentation when brazing the connection adaptor.

3.4 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 ZR*KRE compressors are delivered with a discharge check valve fitted inside the discharge port and stub tubes as standard.

Brazing connections can be converted to Rotalock by means of adaptors. Rotalock shut-off valves are available for the suction as well as discharge sides.

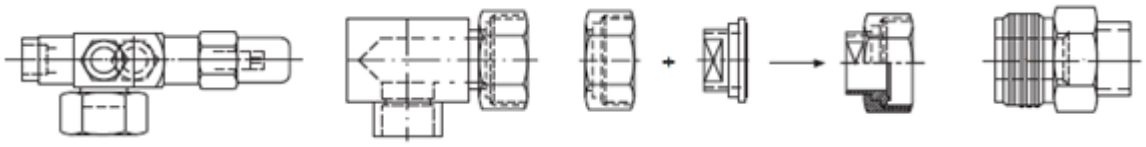


Figure 9: Shut-off valves and connection adapters

Torque settings from system valves and adaptors with Rotalock connections might decrease significantly after some time of operation. Recurring temperature changes, vibration and other influencing parameter could lead to expansion and contraction of the metal material and a relaxation of the gaskets. Periodically retorquing the Rotalock connections to the original settings is recommended.

However, pipe plugs with sealant applied at the factory are not to be retorqued or seal broken, as this may create a leak path in the cured sealant.

Refer to **Appendix 1** for proper tightening torques.

***NOTE:* More information about adaptors and shut-off valves can be found in the Copeland spare parts catalogue, available at www.copeland.com/en-gb/tools-resources.**

3.5 Pressure safety controls

3.5.1 High-pressure protection

Applicable regulations and standards, for example EN 378-2, shall be followed to apply appropriate control and ensure that the pressure never exceeds the maximum pressure limit.

High-pressure protection is required to stop the compressor operating outside the allowable pressure limits. The high-pressure control must be installed correctly, which means that no service valve is allowed between the compressor and the pressure protection.

The high-pressure cut-out setting shall be determined according to the applicable standard, the type of system, the refrigerant and the maximum allowable pressure PS.

3.5.2 Low-pressure protection

CAUTION
Operation outside the application envelope! Compressor breakdown! A low-pressure protection should be fitted in the suction line in order to stop the compressor when it operates outside the envelope limits. Do not bridge or by-pass the low-pressure limiter.

Applicable regulations and standards shall be followed to apply appropriate control and ensure that the pressure is always above the required minimum limit.

Low-pressure protection is required to stop the compressor operating outside the published envelope limits. The low-pressure control must be installed correctly into the suction line, which means that no service valve is allowed between the compressor and the pressure protection.

The minimum cut-out setting shall be determined according to the refrigerant and to the allowed operation envelope – see Select software at www.copeland.com/en-gb/tools-resources.

3.6 Crankcase heater

CAUTION
Overheating and burnout! Compressor damage! Never apply power to the crankcase heater in free air, before the crankcase heater is installed on the compressor or when it is not in complete contact with the compressor shell.

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 as long as the system charge does not exceed the charge limits indicated in **Table 6**.

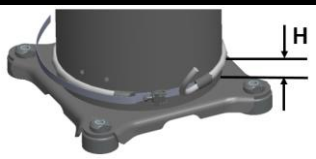
Compressor model	Refrigerant charge limit	Crankcase heater	
		Position	Height
ZR24KRE to ZR48KRE	3.6 kg		5 - 12 mm
ZR61KRE to ZR92KRE	4.5 kg		9.5 - 41 mm
ZR108KRE to ZR144KRE	7.3 kg		14 - 24 mm
ZR160KRE to ZR190KRE	8.2 kg		13 - 18 mm

Table 5: Refrigerant charge limits & crankcase heater position

The initial start-up in the field is a very critical period for any compressor because all load-bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions. **The crankcase heater must be turned on 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 energized during compressor off cycles.**

***NOTE:* Please refer to the Copeland spare parts catalogue available at www.copeland.com/en-gb/tools-resources to select the correct crankcase heater model.**

Caution: Crankcase heaters must be properly grounded!

For installation, the manufacturer/installer shall follow the recommendations below.

Assembly instructions

- Select the appropriate model according to compressor size and required wattage.
- Check the compressor application guidelines for crankcase heater connection and operation.
- Position the crankcase heater between the lower cover and the lower bearing weld projection **(Fig. 10)**.
- Fit the heater horizontally around the crankcase, ensuring that it is in close contact with the compressor housing along the entire length.
- Avoid having the heating portion of the heater in contact with any weld projection **(Fig.11 & 12)**.
- Avoid having the heater assembly inclined **(Fig. 13)**.
- Close the lock and tighten the screw, torque: 2-3 Nm.
- The excess clamp bracket may be trimmed. Sharp edges must not come into contact with wires.
- The presence of the heater shall be made evident by the posting of caution signs or markings at appropriate locations.

Figure 10

Figure 11

Figure 12

Figure 13

Electrical connection

- Connect the crankcase heater according to the compressor application guidelines.
- The crankcase heater must be connected only to its rated voltage.
- The metal braid of the heater must be connected to a suitable earthing terminal.
- Check the resistance according to the technical data.
- Perform an insulation test before start-up.
- Electrical security and safety measures are to be provided on site.

3.7 Soft starter and single-phase compressor start assists

Copeland scroll can generally be operated with soft starters. Soft starter versions and sizes should be selected according to the soft starter manufacturer's recommendations, taking into consideration the compressor amps. Typically, the ramp-up time should not exceed 1 second.

Due to the inherent design of the Copeland scroll, the internal compression components start unloaded, even if system pressures are not balanced. Since the compressor internal pressures are balanced at start-up, low voltage starting characteristics are excellent, and starting components are normally not required.

However, for extreme electrical conditions such as weak power supplies, single-phase start-assist components are available from Copeland upon request.

3.8 Discharge gas temperature protection

CAUTION
Inadequate lubrication! Scroll set damage! All ZR*KRE compressors must be equipped with a discharge gas temperature protection.

A good system control shall prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the capacity demand. However, under some extreme operating conditions such as loss of charge or improper control operation, the internal discharge gas temperature reached can cause compressor damage. In order to ensure positive compressor protection, discharge gas temperature protection is required for any application with Copeland compressors.

The maximum discharge gas temperature is 130 °C for all ZR*KRE models.

Discharge gas temperature protection is the "fall-back" for failure of the system control. It is essential that proper control of both the evaporating and condensing pressures and the superheat is maintained and has the ability to cope with all likely conditions and high loads. Reliance on protectors will cause inadequate system performance and short cycling.

***NOTE:* The maximum discharge gas temperatures indicated in this chapter are valid for safe operation within the approved application envelope. The discharge line thermostat has the function of a compressor safety device; it is not designed to control the operating envelope. For compressor envelope control, an additional control device or regulation must be used.**

3.8.1 Excessive discharge gas temperatures

A few of the possible consequences of excessive discharge gas temperatures are listed below:

- Since the oil circulates in the system with the refrigerant, it is subjected to high discharge gas temperatures. If the discharge gas temperature becomes too high, the so-called "cooking" effect will occur (heating of oil under exclusion of air). Carbon deposits can form at points of high temperature, for example on the valves, oil channels, oil filters, etc. The oil lubricity will be reduced and a progressive wear process will occur which will prematurely damage the compressor.
- The stability of the refrigerant can also be affected, particularly if traces of contaminant are present.

The problems described above frequently occur simultaneously, particularly since the chemical reaction speed approximately doubles with every 10 °C temperature rise. This directly leads to chemical reactions of the oil with the refrigerant and the compounds extracted from sealants and insulation material. As a consequence, contaminants of various types, among them acids, will form inside the system.

3.8.2 Internal thermo-disc

ZR24KRE to ZR81KRE compressor models have an internal thermo-disc discharge gas temperature protection. This thermo-disc opens a gas passage from the discharge port to the suction side near the motor protector when the discharged gas reaches a critical temperature. The hot gas then causes the motor protector to trip shutting down the compressor. It opens at 146 °C ± 4 K and closes at 91 °C ± 7 K.

3.8.3 Advanced Scroll Temperature Protection (ASTP)

ZR108KRE to ZR190KRE compressors are equipped with an Advanced Scroll Temperature Protection (ASTP). ASTP is a temperature sensitive thermo-disc that acts to protect the compressor from discharge gas overheating. Once the discharge gas reaches a critical temperature, the ASTP feature will cause the scrolls to separate and stop pumping although the motor continues to run. After running for some time without pumping gas, the motor protector will open.

***NOTE:* ASTP was developed to protect the compressor, not for system envelope control.**

If the system engineer wants to prevent ASTP trips and to limit the maximum compressor discharge temperature to a lower value, a discharge sensor can be used. The recommended setpoint is 130 °C. This value should be determined and verified according to the application. Any protector attached to the discharge line must be well insulated with good quality material that will last for the unit lifetime.

Compressors with Advanced Scroll Temperature Protection can be identified by a dedicated label located above the terminal box.

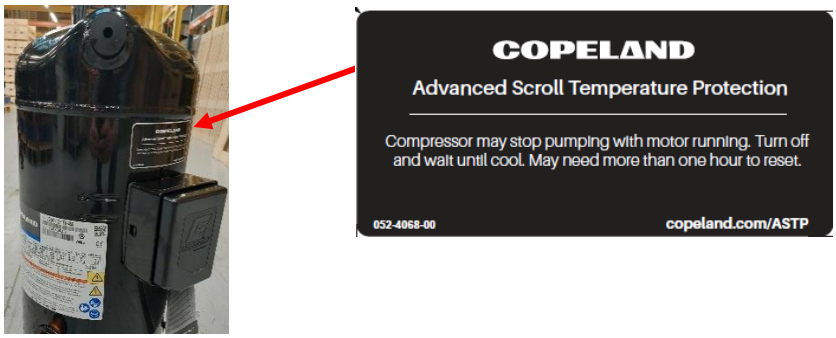


Figure 14: Scroll compressor with Advanced Scroll Temperature Protection (ASTP) sticker

***NOTE:* Depending on the heat build-up in the compressor, it may take more than one hour for the ASTP and motor protector to reset.**

3.8.4 Discharge line thermostat

ZR92KRE compressors have no internal discharge gas temperature protection. Therefore, an external discharge line thermostat must be installed.

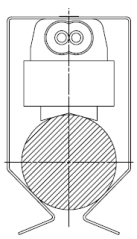


Figure 15: Discharge line thermostat with clamp

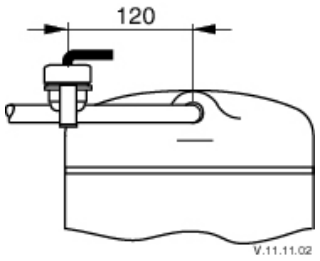
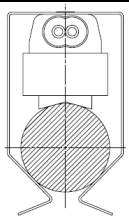
Technical data of the discharge line thermostat

Voltage		120 - 240 VAC
Maximum amperage		5 A / 240 V
Operating temperatures	Open	130 °C (± 4 K)
	Close	101 °C (± 8 K)
Wire insulation maximum temperature		150 °C
Clips for tube		Ø 15.8 - 19.1 mm (5/8+3/4")

Table 6: Discharge line thermostat technical data

To ensure proper functioning and to avoid false readings, the discharge line thermostat must be installed and insulated according to the procedure and recommendations hereunder.

Assembly of the discharge line thermostat

▪ Install the discharge line thermostat on the discharge tube 120 mm from top cap.	
▪ Snap the retainer clip over the tube and onto the thermostat. ▪ The thermostat should be placed on the discharge tube so that its body is in upward position on a horizontal tube installation. ▪ Ensure that the thermostat is not tilted.	
▪ The wire must not be in contact with the top cap of the compressor or the discharge tube. Care should be taken to route wires so that they do not come into contact with sharp objects.	
▪ To avoid any impact on tripping temperature by the ambient, the discharge line thermostat must be insulated. ▪ Wrap thermal insulation around the pipe left and right of the thermostat and secure it with plastic straps.	
▪ Wrap a second layer of insulation around the first one and around the thermostat, secure it with plastic straps.	

3.9 Internal pressure relief valve

ZR24KRE to ZR92KRE compressors are equipped with an internal pressure relief valve. It opens at a differential pressure of 28 bar ± 3 bar between high- and low-pressure sides. A high-pressure protection must be provided by the system manufacturer/installer for each system and according to EN 378-2, clause 6.2.6.2. The IPR valve is a safety device, not a high-pressure switch. It is not designed for repeated operation and there is no guarantee that it will reset correctly if it does have repeated operation.

3.10 Discharge check valve

All ZR*KRE compressors contain an internal check valve on the discharge connection. The discharge check valve prevents the high-side high pressure discharge gas from flowing rapidly back through the compressor after shutdown. This check valve is not designed to be used with recycling pumpdown because it is not entirely leak-proof.

3.11 Filter 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.

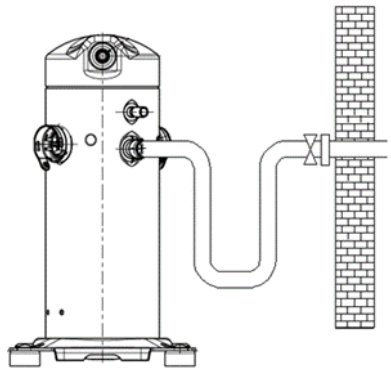
3.12 Mufflers

Gas flow through scroll compressors is continuous with relatively low pulsation. External mufflers may not necessarily be required on Copeland scroll compressors. Due to system variability, individual tests should be conducted by the system manufacturer to verify acceptable levels of sound and vibration.

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 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.

3.13 Sound and vibration

Vibrations during compressor operation can cause cracks which could lead to refrigerant leakage. This situation must be avoided by the system manufacturer/installer. Therefore, proper pipe design must be achieved when connecting a scroll compressor to a system.



A scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the pipe-lines to allow starting, stopping and steady state running of the compressor without transmitting excessive stress into any line attached to the unit. In a split system, the most important goal is to ensure minimal vibration in all directions to avoid transmitting vibrations to the structure to which the lines are fastened.

Under some conditions, the Copeland scroll has a normal starting rotational motion that can transmit a transient noise along the lines. This may be particularly pronounced in compressors using a three-phase motor due to their inherently higher starting torque. This phenomenon, like the one described previously, can easily be avoided by using standard line isolation techniques.

The sound level of a system is the result of design, quality and application. Scroll compressors sound power levels generally increase with the compressor model capacity and the condition pressure ratio.

3.14 Compressor oil return, oil balancing, refrigerant floodback & oil dilution tests

CAUTION
Inadequate lubrication! Bearing and moving parts destruction! Ensure adequate oil return from the system into the compressor at any time. No liquid refrigerant return to the compressor. Liquid refrigerant dilutes the oil, could wash the oil off the bearings and moving parts and could lead to overheating and compressor failure.

The system piping must be carefully designed to ensure sufficient refrigerant gas velocity, so that oil returns to the compressor at all times and conditions. Individual piping diameter calculation depends on the refrigerant properties, pressure, mass flow and density.

For system components such as suction accumulators, the extra amount of oil which will be required in the system must be checked with the suppliers of these components. If needed, the system should be pre-charged accordingly including the additional oil quantity.

Once a new system design is set and assembled, a functional test is required. The functional test includes a qualification for the general system oil return, a refrigerant floodback test and an oil dilution test. Systems with multiple compressors (two, three, or more) require additional oil balancing qualification between the parallel compressors.

A sample compressor equipped with an external oil sight tube can be ordered from Copeland for lab testing.

Records of the evaporating temperature and the bottom shell temperature shall be taken with a high sampling rate during the entire oil return or oil balance testing and under all tested conditions. The liquid level in the sight tube has to be observed and recorded too. Testing conditions shall include defrost and varying loads. If the system is reversible, the tests should be conducted in both operation modes.

System engineers should review the system design and operation to identify the critical conditions and to check oil return, oil balancing, liquid floodback and oil dilution. For discussion of individual test results and system behaviour, eg, with regard to oil dilution, please contact the Application Engineering department. Typically, the following situations should be considered:

- **In single compressor systems**: to check oil return, testing conditions shall be at minimum mass flow and minimum density of suction gas in continuous and frequent start/stop cycling.
- **In multiple compressor systems**: to check oil return and oil balancing in the tandem or trio, testing conditions shall be at the corner points of the system application envelope in continuous and frequent start/stop cycling.
- **In all systems**: to test liquid floodback and oil dilution, all possible transient operation conditions in the system should be checked, eg, compressor frequent start/stop, compressor start after long off time with migration, defrost, switching between the operation modes in reversible systems, load changes, fans or pumps cycling at low load and more. To evaluate the risk of liquid floodback and oil dilution, please refer to the chart in **Figure 17**.

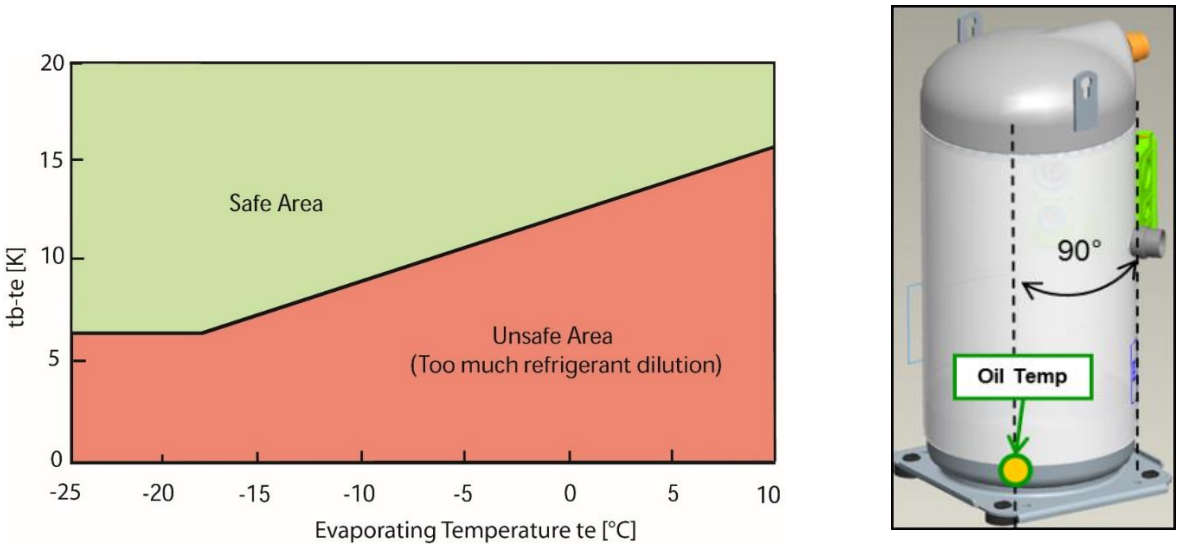


Figure 17: Oil dilution chart (tb = bottom shell temp.; te = evaporating temp.) and oil temperature

The bottom shell temperature together with the evaporating temperature gives an indication whether liquid refrigerant is returning or diluted in the compressor oil sump. The compressor sump temperature must remain in the (green) safe area, as shown in the chart in **Figure 17**. In case of operation in the (red) unsafe area, adjustments are required in order to modify the system design, refrigerant charge or superheat setting of the expansion device(s). The bottom shell temperature should be measured accurately. The thermo-probe must be properly insulated and positioned on the opposite side of the sight glass or at an angle of 90° clockwise from the suction inlet with view on the top.

3.15 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.

Thanks to Copeland scroll compressors' inherent ability to handle liquid refrigerant in flooded start and defrost cycle operation, an accumulator is not required for durability in most systems.

To determine if a suction line accumulator is required, the system designer must check this with an appropriate test scenario. See **section 3.14 "Compressor oil return, oil balancing, refrigerant floodback & oil dilution tests"**.

If an accumulator is used, the oil-return orifice should be sized based on compressor size and compressor floodback results. To protect this small orifice from plugging with system debris a large-area protective screen no finer than 30 x 30 mesh (0.6 mm openings) is required. Tests have shown that a small screen

with a fine mesh can easily become plugged causing oil starvation to the compressor bearings. The size of the accumulator depends upon the operating range of the system and the amount of sub-cooling and subsequent head pressure allowed by the refrigerant control. For the correct selection and size of the suction line accumulator, refer to the manufacturer's specifications.

Check with supplier whether an extra charge of oil for the suction accumulator is required. Pre-charge additional oil to the system accordingly.

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.

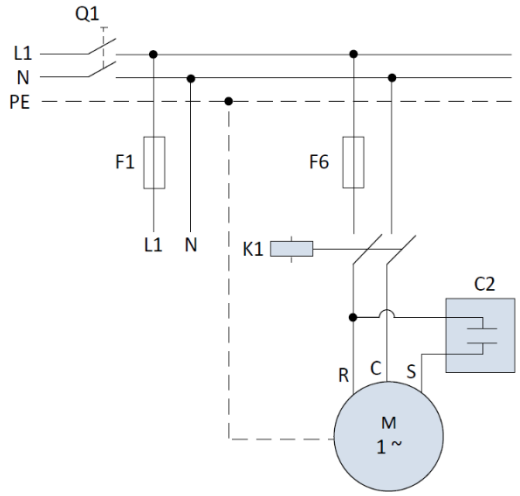
4.2 Electrical installation

WARNING
Conductor cables! Electrical shock! Shut off power supply before undertaking any task on electrical equipment.

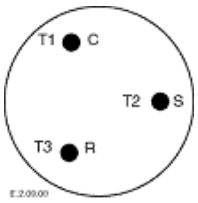
The recommended wiring diagrams are shown in figures hereunder.

Single-phase (PF*) compressors:

Power circuit

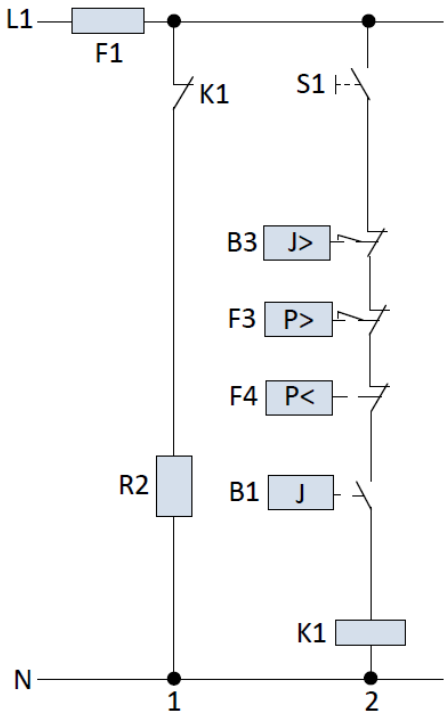


Motor terminal connections



Single-phase compressors are connected to the Common (C), Start (S) and Run (R) connections

Control circuit



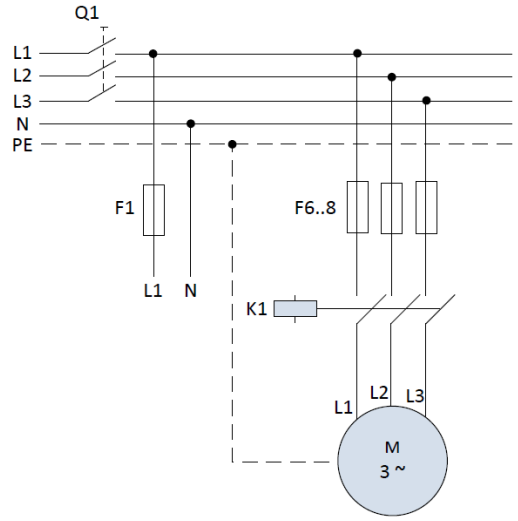
Legend

B1 ..... Room thermostat
B3 ..... Discharge gas thermostat
C2 ..... Run capacitor
F1 ..... Fuse
F3 ..... HP switch
F4 ..... LP switch
K1 ..... Contactor
R2 ..... Crankcase heater
S1 ..... Auxiliary switch

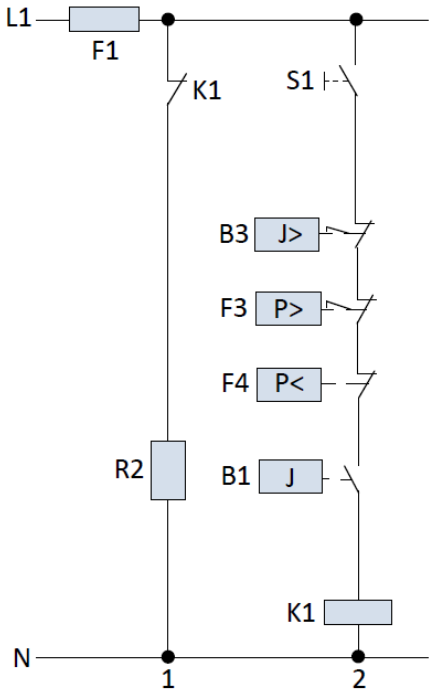
Figure 18: Wiring diagrams for single-phase compressors

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

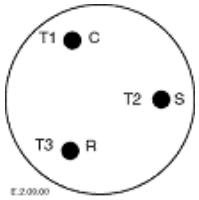
Power circuit



Control circuit



Motor terminal connections



Three-phase compressors are connected to the T1, T2 and T3 connections

Legend

B1 ..... Room thermostat
B3 ..... Discharge gas thermostat
F1 ..... Fuse
F3 ..... HP switch
F4 ..... LP switch
K1 ..... Contactor
R2 ..... Crankcase heater
S1 ..... Auxiliary switch

Figure 19: Wiring diagrams for three-phase compressors with internal motor protection

4.3 Terminal box

CAUTION
Mechanical stress or shock! Overheating! Terminal Fusite damage!
Mechanical stress and shocks to the Fusite must be avoided as they could damage the glass and/or ceramic. This might result in hermetic failure or loss of terminal performance. Precautions are required to prevent striking or bending of pins.
Ensure correct connection of cables to the compressor terminal Fusite to avoid local overheating.

Cable glands have an influence on the protection class of the terminal box. Copeland strongly recommends to use appropriate cable glands according to EN 50262 in order to reach the rated protection class. Examples of correct electrical installations are shown in **Figures 20 to 22** below.

4.3.1 Terminal box – IP21

The standard terminal box is IP21 for all ZR24KRE to ZR190KRE BOM455 compressors.

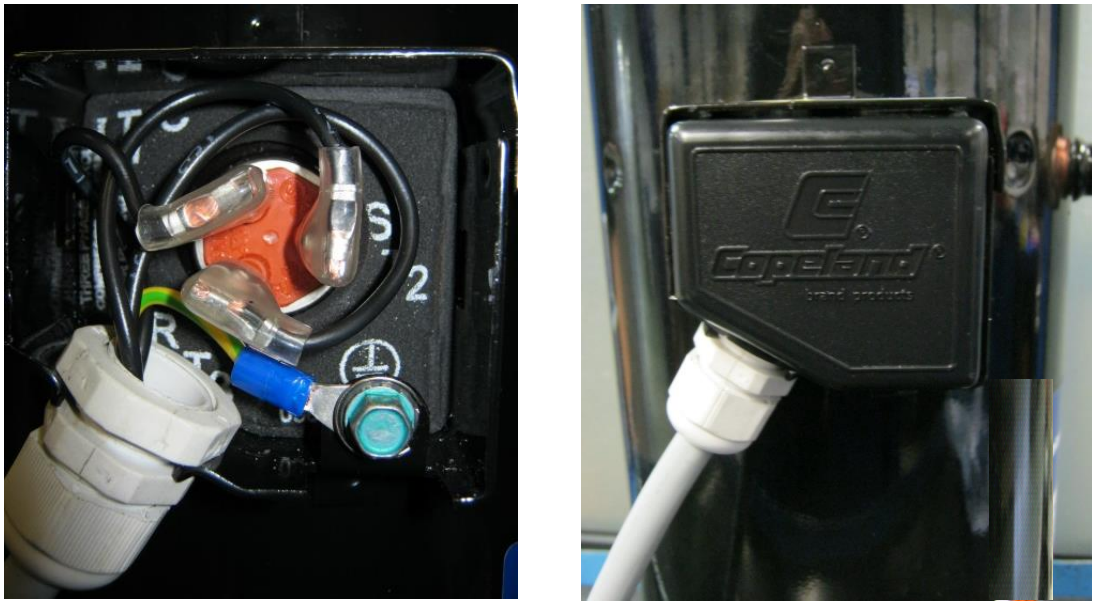


Figure 20: Electrical installation with cable glands for IP21 T-box, models ZR24KRE to ZR92KRE

Figure 21: Electrical installation with cable glands for IP21 T-box, models ZR108KRE to ZR190KRE

4.3.2 Terminal box – IP65

Compressor models ZR108KRE to ZR190KRE with BOM 411 have a metal terminal box IP65.

The first two nuts already installed on the Peko bolts shall not be removed, as they will ensure a good tightness of the terminal box assembly. Make sure to assemble the ground connection of the Peko bolt with a torque of 4 - 4.4 Nm and the ground connection between the cover and the body of the terminal box with a torque of 1.8 - 2 Nm.

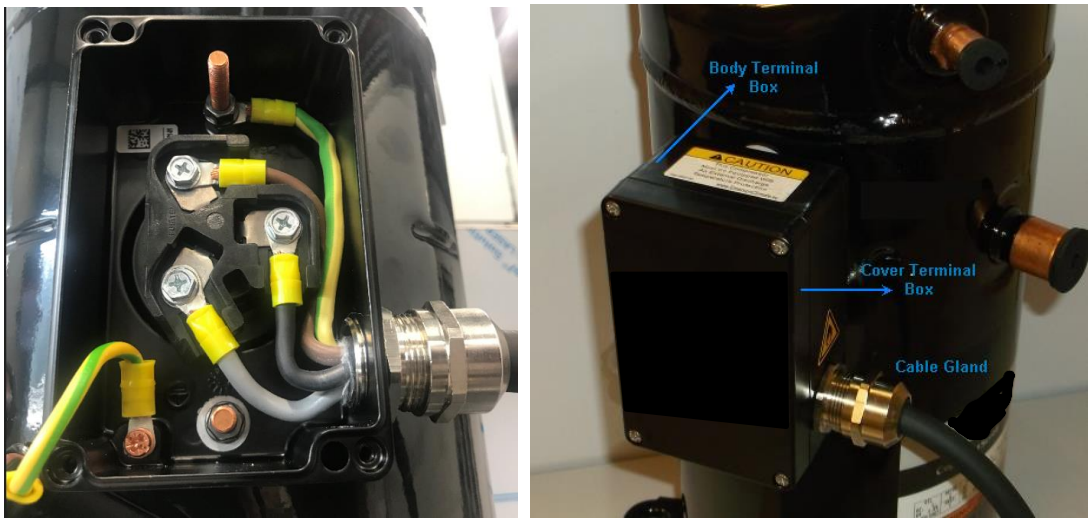


Figure 22: Electrical installation for IP65 T-box, models ZR108KRE to ZR190KRE BOM 411

Make sure to assemble the cable gland M25 with a torque of 9.8 - 10 Nm. The cable gland is designed for cable diameters of 10 to 17 mm – see **Figure 22**. The degree of protection (IP) will be safeguarded only if sealing and cable glands are properly assembled. Only run the compressor with permanently wired cables. The system manufacturer/installer shall provide the required strain relief.

Finally, close the cover of the terminal box applying a torque of 1.8 - 2 Nm. The degree of protection (IP) will be safeguarded only if the cover is properly assembled.

4.4 Motor insulation

The motor insulation material is class "B" (T**F***) for all ZR*KRE models within maximum allowable operating temperatures according to IEC 34-1 or DIN 57530.

4.5 Motor protection

Independently from the internal motor protection, fuses must be installed before the compressor. The selection of fuses has to be made according to EN 60269-1 or EN 60204-1 and compressor maximum operating current (MOC). Not installing fuses before the compressor or selecting inappropriate fuses may result in compressor failure.

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

4.6 High-potential testing

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

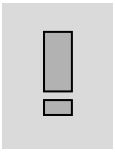
CAUTION
Internal arcing! Motor destruction! Do not carry out high-voltage or insulation tests if the compressor housing is under vacuum.

Copeland subjects all scroll compressors to a high-voltage test after final assembly. Each motor phase winding is tested according to EN 60034-1 at a differential voltage of 1000 V 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. However, if they are absolutely needed, they should be conducted with a lower voltage than described above. DO NOT perform any high-potential test when the compressor is charged with refrigerant. Disconnect all electronic devices, eg, motor protection module, fan speed control, etc prior to testing.

5 Start-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! It is important to ensure that new compressors are not subjected to liquid abuse. It is mandatory to have a crankcase heater installed if the refrigerant charge exceeds a defined value – see **Table 6**. Turn the crankcase heater on 12 hours before starting the compressor.

5.1 Strength pressure test

5.1.1 Compressor strength-pressure test

The compressor has been strength-pressure tested in the Copeland factory. Therefore, it is not necessary for the system manufacturer/installer to strength-pressure test the compressor again.

Scroll compressors are divided into two pressure zones. The compressor high-side and low-side maximum allowable pressures PS have to be respected at all times.

5.1.2 System strength-pressure test

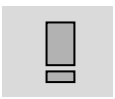
A strength-pressure test of individual sections of the entire system is permitted. Once the compressor is isolated, the rest of the system can be tested with the required pressure values.

The strength-pressure test can also be conducted with the compressor connected, but in that case the two pressure zones of the scroll compressor need to be respected:

- System high-pressure section:
  - Define the system high-side PS ≤ compressor high-side PS.
  - Isolate the high- and low-pressure sections of the system by closing valves, solenoid valves, expansion valves or by other means.
  - Use the internal check valve of the compressor on the discharge side or add an external check valve. To protect the compressor internal check valve, observe a maximum pressure delta of ≤ 40 bar between the high-pressure side and the low-pressure side.
  - Activate the check valve with a fast pressure increase. Once the check valve is activated, the pressure increase can be slowed down.
  - At this stage the system test pressure of 1.1 x system high-side PS can be applied for a short time.
  - During the system test, make sure the pressure inside the compressor does not exceed the maximum PS value, which corresponds to the compressor low-pressure PS.
- System low-pressure section:
  - Define the system low-side PS ≤ compressor low-side PS.
  - The system test pressure of 1.1 x system low-side PS can be applied for a short time.

5.2 Compressor tightness test

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



IMPORTANT
System contamination! Bearing malfunction! Use only dry inert gases (for example nitrogen) for leak testing. DO NOT USE other industrial gases.

The compressor has been leak-pressure tested in the Copeland factory.

All compressors get a factory holding charge of dry air (about 1 to 2.5 bar, relative pressure). An intact holding charge serves as a proof of quality against penetrating moisture.

When removing plugs from the compressor, the plugs may pop out due to pressure and oil can spurt.

Any later modification to compressor connections can have an impact on the compressor tightness. Always leak-pressure test the compressor after opening or modifying the connections.

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. The installation should be evacuated down to an absolute pressure of 3 mbar. Proper evacuation reduces residual moisture to 50 ppm. During the initial procedure, suction and discharge shut-off 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. The pressure must be measured using a vacuum pressure 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 highest demands are placed on the leak-proof design of the installation and on the 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 compressor with a restricted suction or with the low-pressure limiter bridged. Do not operate at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

Prior to charging or re-charging, the system must be leak- and pressure-tested with appropriate purging gas.

Ensure that the refrigerant system is grounded prior to charging with refrigerant.

The system shall be liquid-charged through the liquid-receiver shut-off valve or through a valve in the liquid line. The use of a filter-dryer in the charging line is highly recommended. Systems shall 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 shall be placed in the high side of the system to prevent bearing washout during first-time start on the assembly line.

Extreme care shall be taken not to overfill the refrigerant system.

***NOTE:* The system manufacturer/installer must respect the charge limitations according to valid standards, such as EN 378.**

5.6 Run-in time

Scroll compressors exhibit a slight decrease in input power during the initial running period. Published performance ratings are based on calorimeter testing which is carried out after run-in. Therefore, users should be aware that before the performance specified by EN 12900 is achieved the compressor needs to be run in. Recommended run-in times for ZR*KRE compressors to attain the published performance are 16 hours at the standard conditions.

5.7 Initial start-up

CAUTION
High discharge pressure operation! Compressor damage! Do not use compressor to test opening setpoint of high-pressure cut-out. Internal parts 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. The 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.

5.8 Rotation direction

Scroll compressors, like several other types of compressors, will only compress in one rotational direction. Direction of rotation is not an issue with single-phase compressors since they will always start and run in the proper direction. All other 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 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.

5.9 Start-up and shut-off sound

During the very brief start-up, a clicking sound resulting from the initial contacting of the spirals is audible; this sound 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.

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 too and it has no effect on compressor durability.

5.10 Deep vacuum operation

CAUTION
Vacuum operation! Compressor damage! Copeland scroll compressors should never be used to evacuate refrigeration or air-conditioning systems. Operating scroll compressors in deep vacuum could damage internal motor parts and lead to unacceptable high temperatures in the compressor housing.

5.11 Pumpdown cycle

CAUTION
Vacuum operation! Compressor damage! Compressor operation outside the operating envelope is not allowed.

A pumpdown cycle to control refrigerant migration may have to be used for several reasons, for example when the compressor is located outdoors without any housing so that cold air blowing over the compressor makes the crankcase heater ineffective.

If a pumpdown 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 might in some cases leak, 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.

NOTE: **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 Shell temperature

During normal operation, the discharge gas as well as the compressor top shell and discharge line can reach temperatures up to the maximum discharge gas temperature of 130 °C – see **section 3.8. "Discharge gas temperature protection"**.

In a failure mode, the discharge gas temperatures can get even higher. Care must be taken to ensure that wiring or other materials that could be damaged by these temperatures do not touch the shell.

5.13 Minimum run time

Copeland 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, a sample compressor equipped with an external oil sight glass is available from Copeland. The minimum on time becomes the time required for oil lost during compressor start-up to return to the compressor sump and to 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.

5.14 Supply frequency and voltage

There is no general release of standard Copeland scroll compressors for use with variable speed AC drives. A number of considerations must be taken into account when applying scroll compressors with variable speed, including system design, inverter selection, and operating envelopes at various conditions. Only frequencies from 50 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 400 V, 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.

The 3rd letter of the motor code indicates which frequency and voltage must be applied – see **section 2.2 "Nomenclature"**.

For example, motor code TFD:

- T = Three-phase motor
- F = Internal motor protection
- D = Voltage and frequency range

50 Hz	60 Hz	Code
380-420 V / 3 ph	460 V / 3 ph	D

Table 7: Explanation of the 3rd letter of the electrical code

5.15 Oil level

The oil level should be maintained at mid-point of the sight glass.

Some systems may contain higher than normal refrigerant charges. Systems with large coils, low ambient condenser flooding, or systems with multiple heat exchangers are among some system configurations that may require additional lubricant.

Adequate oil return from the system to the compressor should be evaluated and qualified during the system development phase. For this purpose, a sample compressor for lab testing, equipped with an external oil sight tube, is available from Copeland.

If an oil regulator is used, the oil level should be set within the top half of the oil regulator sight glass.

6 Maintenance & repair

WARNING
Conductor cables! Electrical shock! Follow the lockout/tag out procedure and the national regulations before carrying out any maintenance or service work on the system.
Use compressor with grounded system only. Screwed electrical connections must be used in all applications. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

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

6.1 Qualification of workers

Personnel working on the maintenance, repair and decommissioning of the system shall be adequately trained. Any work procedure affecting safety shall only be executed by qualified and trained personnel in compliance with national or other equivalent certification systems.

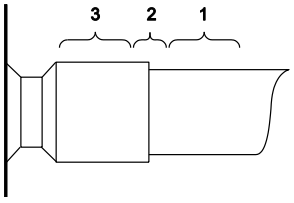
Examples of such work procedures are:

- breaking into the refrigerating circuit;
- opening sealed components;
- opening ventilated enclosures…

6.2 Disassembling system components

When disassembling system components please follow the main steps described hereunder:

1. Recover refrigerant and evacuate system using a recovery unit and vacuum pump. All the refrigerant shall be recovered to avoid significant release.
2. Flush system with inert gas (dry nitrogen). Compressed air or oxygen shall not be used for purging refrigerant systems.
3. Disassemble components with a cutting tool.
4. Drain, recover and dispose of compressor oil as appropriate.



To disconnect:

- Using a pipe cutting tool, cut off the suction and discharge lines in such a manner that the new compressor can easily be reconnected to the system.
- Heat joint areas 2 and 3 slowly and uniformly until the braze material softens and the tube end can be pulled out from the fitting.

To reconnect:

- Recommended brazing material: 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.**

6.3 Exchanging the refrigerant

CAUTION
Low suction pressure operation! Compressor damage! Do not operate with a restricted suction. Do not operate with the low-pressure limiter bridged. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

For qualified refrigerants and oils, see **Section 2.4.1**.

It is not necessary to replace the refrigerant unless contamination, for example due to an error such as topping up the system with a non-condensable gas or 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.

6.4 Replacing a compressor

CAUTION
Inadequate lubrication! Bearing destruction! For systems with refrigerant accumulator, 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.
Remove the refrigerant and oil completely from the replaced compressor.

6.4.1 Compressor replacement

In case of motor burnout, most of the contaminated oil will be removed with the compressor. The rest of the oil is cleaned through the use of suction and liquid line filter-dryers. A 100 % activated alumina filter-dryer is recommended for the suction line. It 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 compressor is exchanged in the field, it is possible that a large portion of the oil remains 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.

6.4.2 Start-up of a new or replacement compressor

Rapid charging only on the suction side of a scroll-equipped system can occasionally result in a temporary no-start condition for the compressor. The reason for this is that, if the flanks of the scrolls 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 specified in the published operating envelope must be maintained during charging. Allowing the suction pressure to drop below that value may overheat the scrolls and cause early drive bearing and moving parts 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. **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.

6.5 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 R450A / R513A / R134a / R407C 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 oil is that it is far more hygroscopic than mineral oil – see **Figure 24**. 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.

Copeland compressors contain oil with low moisture content, which however may rise during the system assembling process. Therefore, it is recommended to install a properly sized filter-dryer in all POE systems to maintain the moisture level in the oil to less than 50 ppm. If POE oil is charged into a system, it is recommended that its moisture content be no higher than 50 ppm.

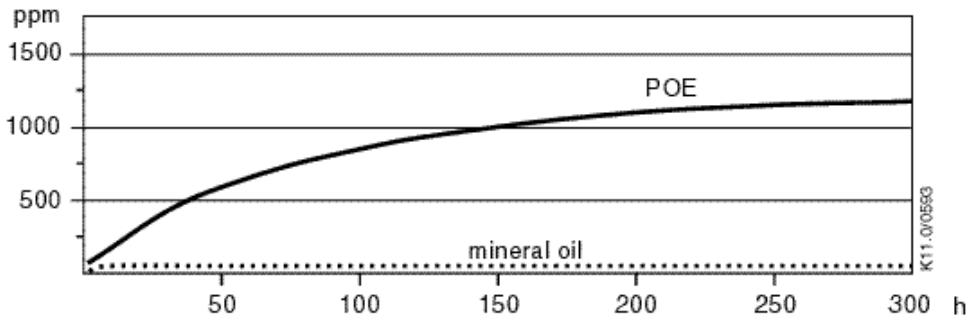


Figure 24: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25 °C and 50 % relative humidity (h=hours)

If the moisture content of the oil reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 3 mbar in accordance with EN 378-4. Sight glass/moisture indicators can be used with HFC refrigerants and lubricants. However, they will only show the moisture content of the refrigerant. The actual moisture level in the oil is likely to be higher than indicated by the sight glass. This is due to the high hygroscopicity of POE oil. If there is uncertainty as to the moisture content in the system, or to measure the actual moisture level, oil samples should be taken and analysed.

6.6 Oil additives

Although Copeland 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.

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 in accordance with national legislation and regulations.**

Dispose of compressor in accordance with national legislation and regulations.

8 References

Please visit www.copeland.com/en-gb for free download of Application Guidelines and Technical Information.

Performance and technical data:

The latest version of Copeland Select software with performance data and technical data is available from the webpage www.copeland.com/en-gb/tools-resources.

Spare parts and accessories:

An online version of the Copeland spare parts and accessories catalogue is available from the webpage www.copeland.com/en-gb/tools-resources.

Appendix 1: Tightening torques

Connection	Torque (Nm)
M10	45 - 55
Rotalock ¾"	40 - 50
Rotalock 1"	70 - 80
Rotalock 1 ¼"	100 - 110
Rotalock 1 ¾"	170 - 180
Rotalock 2 ¼"	190 - 200
Sight glass external 1 ¾"	71 - 88
Sight glass fitting TPTL	34 - 41
Mounting bolts 5/16", M9	27 max
Mounting bolts M8 (grommet for single operation)	13 ± 1
Mounting bolts M8 (hard mounting parts for parallel operation)	27 ± 1
Crankcase heater	2 - 3
Digital coil screw	2
Terminal block screw	2.8
Ground screw	2.3
IP65 box ground screw (Peko bolt)	4 - 4.4
IP65 ground screw cover / T-box	1.8 - 2
IP65 cable gland M25	9.8 - 10
IP65 T-box cover screws	1.8 - 2

Table 8: Tightening torques

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