

Application Guidelines

Copeland™ Scroll Horizontal Compressors for Transport Applications ZRH(V)*KTE/KTR



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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 it is not used according to these guidelines or is misused.

These application guidelines cover mainly transport applications. In transport, special considerations such as high vibration and shocks, power supply characteristics, high ambient temperatures, frequent cycling and other factors may apply. It is the responsibility of the system designer/planner to define the individual requirements to qualify the compressor and the complete system for their specific needs. Please contact the Application Engineering department at Emerson for additional support.

1 Safety instructions

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







These compressors are intended for installation in systems in accordance with the European Machinery Directive MD 2006/42/EC, the Pressure Equipment Directive PED 2014/68/EU and the Low Voltage Directive LVD 2014/35/EU. 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) for the individual refrigerant shall be considered when working with this type of refrigerant – please check this 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, 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 on 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! Polyol ester oil (POE) lubricant 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 cover Copeland™ scroll horizontal compressor models ZRH(V)*KTE/KTR (fixed- and variable-speed models). The Copeland scroll horizontal compressor utilizes the same fundamental technology as the vertical models but incorporates a specific lubrication system to enable horizontal operation. The variable-speed scroll compressors allow precise matching of capacity over a much wider range than the fixed-speed models.

Compressor	Cooling capacity (kW)			Motor	Frequency range (Hz)
	R407C	R134a	R513A		
ZRH72KTE	15.3	10.4	-	TFD	50-60 Hz
ZRHV72KTE	15.3	10.4	-	TX7	30-80 Hz 25-100 Hz*
ZRH81KTE	17.0	11.6	-	TFD	50-60 Hz
ZRHV81KTE	17.0	11.6	-	TX7	30-80 Hz 25-100 Hz*
ZRH87KTE	19.1	12.3	-	TFD/TF7	50-60 Hz
ZRHV94KTE	19.6**	13.0**	-	TF5/TF7	35-80 Hz
ZRH100KTE	22.1	14.2	-	TFD/TF7	50-60 Hz
ZRH116KTE	24.9	16.9	-	TFD/TF7	50-60 Hz
ZRH72KTR	-	-	10.55	TFD	50-60 Hz
ZRHV72KTR	-	-	13.0**	TX7	30-80 Hz
ZRH81KTR	-	-	11.85	TFD	50-60 Hz
ZRHV81KTR	-	-	14.35**	TX7	30-80 Hz
ZRH87KTR	-	-	13.5	TFD	50-60 Hz
ZRH100KTR	-	-	15.4	TFD	50-60 Hz
ZRH116KTR	-	-	18.15	TFD	50-60 Hz

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

* Frequency range valid for R407C

** Cooling capacity values at 60 Hz

Table 1: ZRH(V)*KTE/KTR model overview

2.2 Special requirements for transport applications

Transport applications for air conditioning, refrigeration or heat pump can be particularly sensitive and require experience and thorough case-by-case analysis. Compared to stationary systems, transport applications can have significantly higher requirements with regard to mechanical load, system design, general function, tightness, conditions of the electrical net and many other details.

The qualification for the whole system and all individual requirements, eg, for the components, piping, piping layout, fixation, as well as a study about shock, vibration and load requirements must be carried out by the system designer. Emerson can provide support and assistance with individual projects.

Emerson requirements and recommendations for transport applications are as follows:

- careful selection of mounting parts based on noise and vibration test results;
- addition of external low leak check valves in the discharge line of the compressor for all models;
- refrigerant charging into the liquid line and after the external check valve to avoid damage;
- external discharge temperature protection for all compressors mandatory;
- installation of a solenoid valve in the liquid line to the evaporator for pump-out or pumpdown purposes;
- installation of low- and high-pressure controls, preferably direct acting;
- carefully set inverter current limit for TX* motor versions, because there is no internal motor protection;
- addition of external phase sequence control to avoid reverse rotation and lubrication issues;
- installation of hot gas bypass not recommended.

2.3 Nomenclature

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

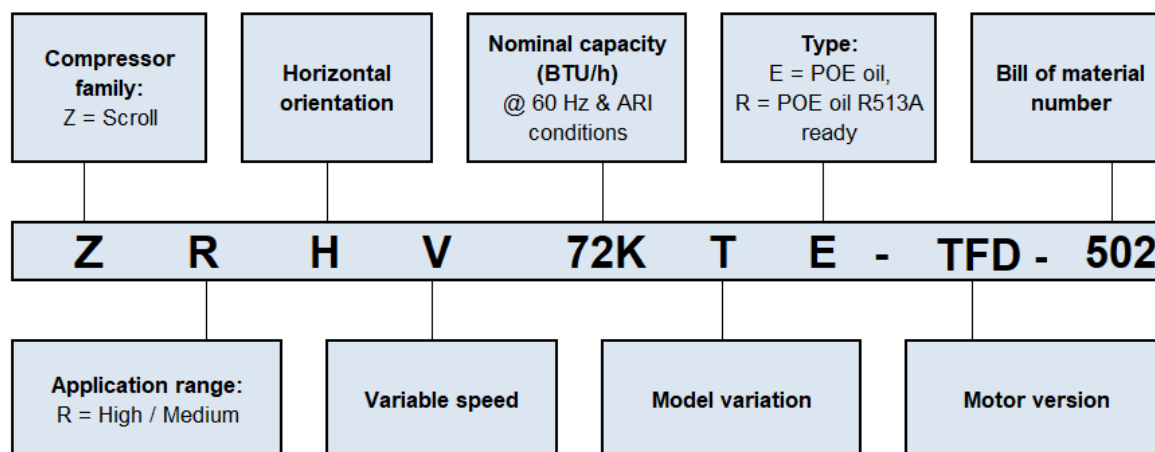


Figure 1: Nomenclature

2.4 BOM Variations

The BOM (bill of material) number at the end of the compressor designation indicates the different compressor layouts and details. ZRH(V)*KTE/KTR compressor models are available in the following BOM version:

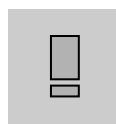
BOM	Suction and discharge connections	T-Box	Mounting parts	Features
502	Brazing stub tubes	IP56, aluminium	Without	Single compressor

Table 2: BOM variation

Please refer to the Emerson price list for more details.

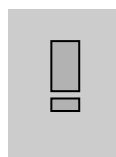
2.5 Application range

2.5.1 Qualified refrigerants and oils



IMPORTANT

Always consider the temperature glide of refrigerant blends. Some refrigerant blends have a significant temperature glide. This requires special attention when adjusting pressure and superheat controls.



IMPORTANT

Refrigerant blends with low GWP containing HFO's have a low chemical stability in presence of air or humidity. The same levels of cleanliness, dryness and evacuation in the refrigerant circuit are required as in HFC & POE applications, including the use of filter dryers.

Compressors	ZRH(V)*KTE/KTR
Qualified and approved refrigerants	R407C, R134a and R513A*
Approved oil type	Emkarate RL 32 3MAF
Servicing oil	Emkarate RL 32 3MAF

Table 3: Qualified refrigerants and oils

Oil recharge values can be taken from the compressor name plate or from Copeland™ Select software available at www.climate.emerson.com/en-gb.

2.5.2 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.climate.emerson.com/en-gb.

2.5.3 PED category and maximum allowable pressure PS

ZRH(V)72KT* & ZRH(V)81KT* compressor models are PED class I, while ZRH87KT* to ZRH116KT* & ZRHV94KTE models are PED class II, according to the Pressure Equipment Directive PED 2014/68/EU.

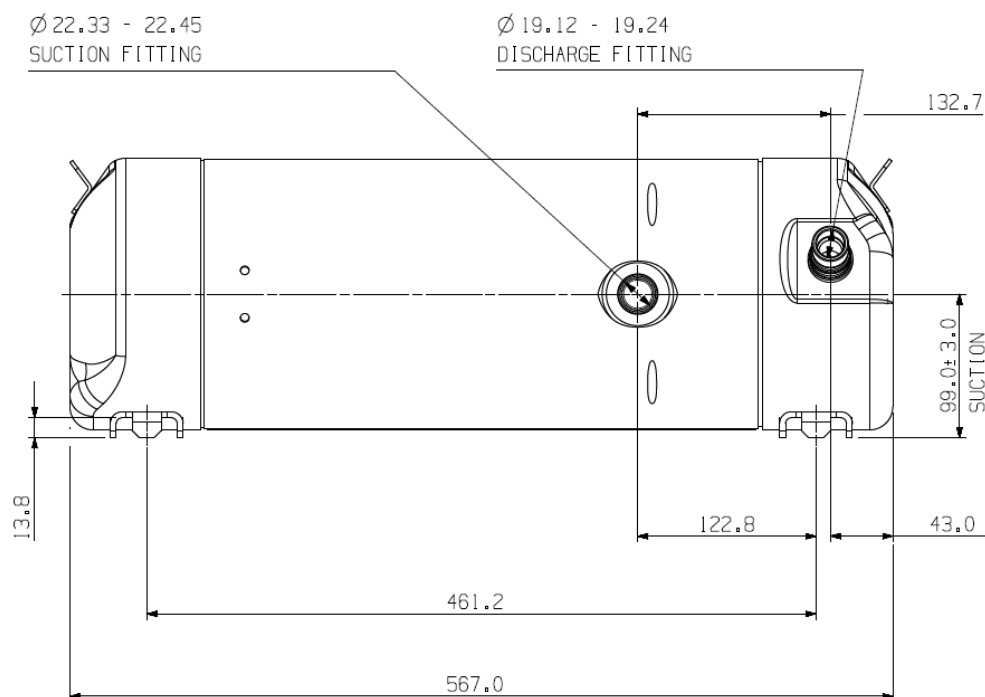
The pressure PS is the maximum allowable pressure at the low- and high-pressure sides of the compressor. The maximum pressure value PS for the individual compressor type is printed on the nameplate of the compressor. Safety is established in compliance with the relevant standards applicable to the given product.

Compressor	PS High-pressure side	PS Low-pressure side	TS Low-pressure side	PED Class
ZRH(V)72KT* & ZRH(V)81KT*	32 bar(g)	20 bar(g)	50 °C	I
ZRH87KT* to ZRH116KT* ZRHV94KTE	32 bar(g)	20 bar(g)	50 °C	II

Table 4: Maximum allowable pressures and PED category

2.6 Dimensions

2.6.1 ZRH(V)72KT* & ZRH(V)81KT*



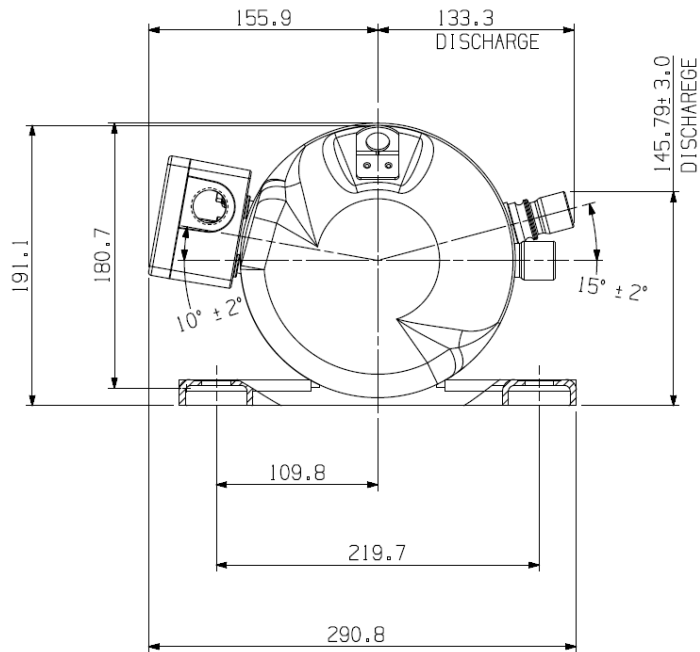


Figure 2

2.6.2 ZRH87KT* to ZRH116KT* & ZRHV94KTE

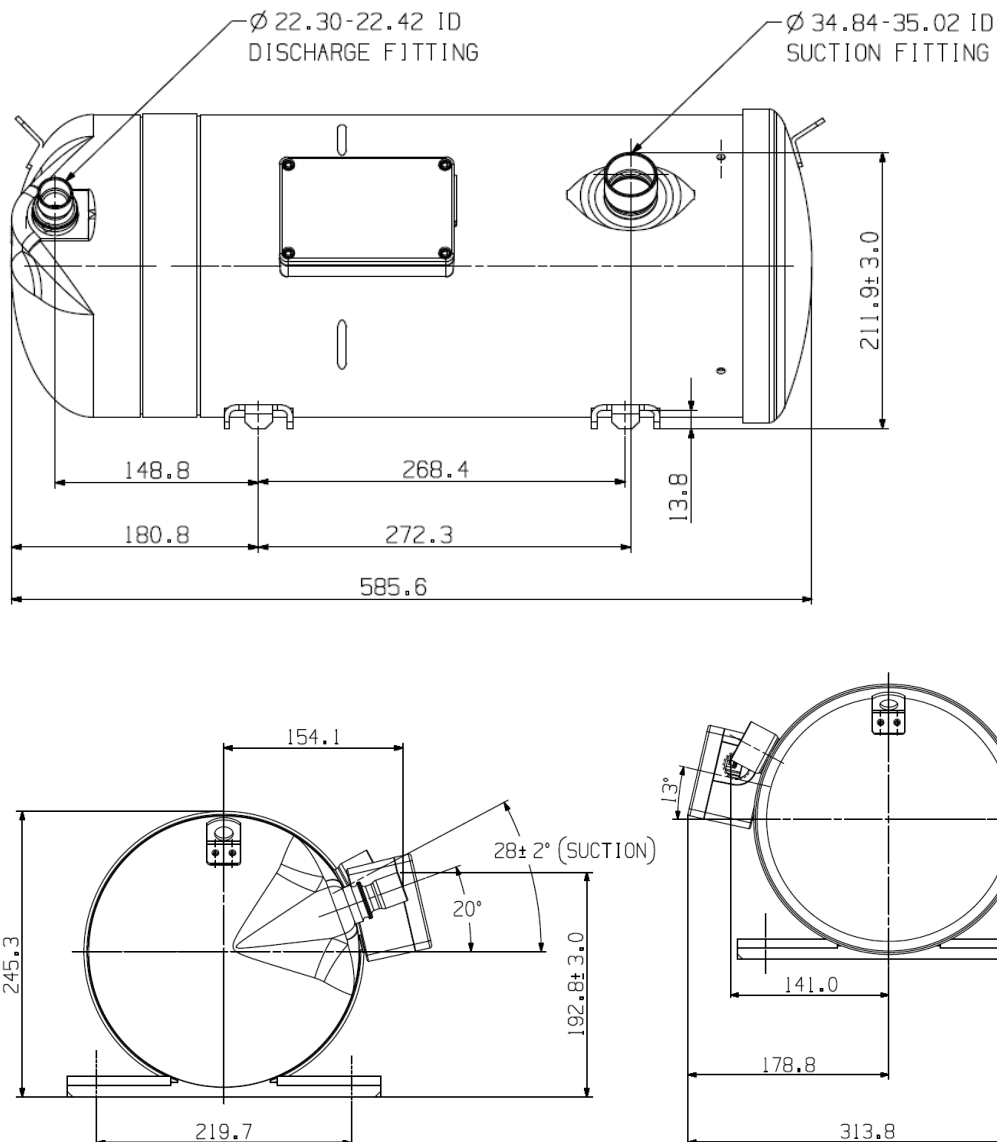


Figure 3

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

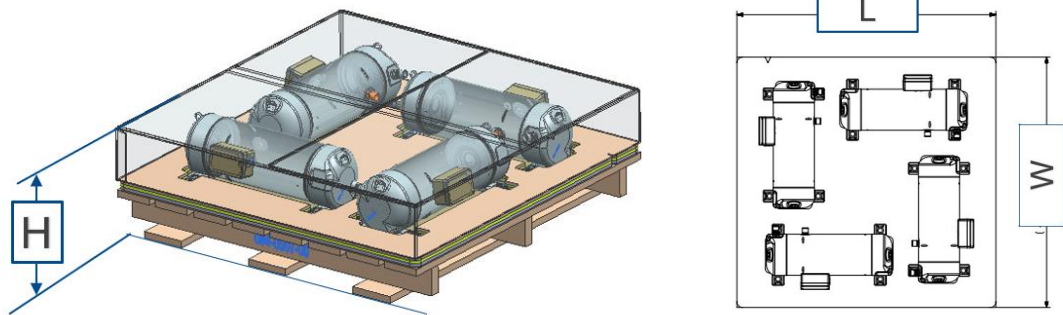
Risk of collapse! Personal injuries! Move compressors only with appropriate mechanical or handling equipment according to weight. Respect stacking loads according to **Figure 4**. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Keep the packaging dry 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 = 2**
- **Storage: n = 4**

Figure 4: Maximum stacking loads for transport and storage



Compressor model	L (mm)	W (mm)	H (mm)	Gross weight (kg)	Net weight (kg)
ZRH(V)72KT* & ZRH(V)81KT*	1175	1130	345	230	196
ZRH87KT* to ZRH116KT*	1175	1130	450	300	260

Figure 5: Packaging dimensions for ZRH*KTE/KTR transportation

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.

Two lifting tabs are located on the side of the compressor shell end caps. It is essential to use these lifting devices to maintain the compressor in the horizontal position during handling, installation or removal in order to avoid damage to the compressor.

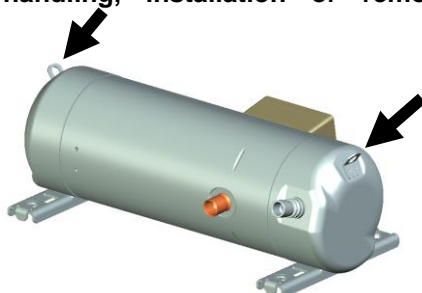


Figure 6: Handling of a horizontal scroll compressor

Horizontal scroll compressors have a holding charge and are factory filled with dry air. It is recommended to remove the discharge connection plug first before pulling the suction connection plug to allow the dry air pressure inside the compressor to escape.

Care must be taken when removing the plugs from the discharge and suction connections, because oil mist might come out and coat the tube, making the brazing process on the copper-coated tubes 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.

No object, eg, a swaging tool should be inserted into the suction tube as it might damage the internal parts of the compressor.

3.1.3 Installation location, maximum tilting and rotating angle

Scroll compressors are capable of operating correctly with compressor ambient humidity between 30 and 95%. For correct operation the compressor ambient air temperatures must be from -35 to 60 °C and the compressor PS and TS have to be respected at all times during operation and at standstill.

Ensure the compressors are installed on a solid level base. The recommended horizontal scroll compressor installation direction is perpendicular to the vehicle direction – see **Figure 7**. Maximum degree for rotating angles is 7° and for tilting angles is 15° – see **Figure 8**.

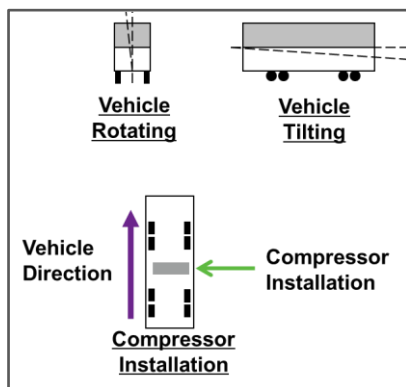


Figure 7: Compressor installation direction

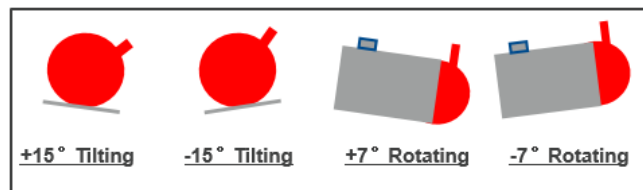


Figure 8: Rotating and tilting angles

3.1.4 Mounting parts

ZRH(V)*KT* horizontal scroll compressors can be mounted solidly on the chassis using steel spacers. Alternatively, rubber mounting parts of different hardness can be used. The unit designer should make a choice after observing the shock/vibration test results.

For the individual system review and qualification, Emerson can offer some mounting part kit options.

3.2 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.

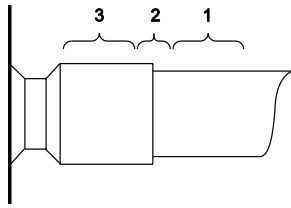


Figure 9: Tube brazing areas

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. Due to the different thermal properties of steel and copper, brazing must be carried out in an appropriate manner.

Refer to **Figure 9** and 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 Pressure safety controls

Emerson requires the installation of low- and high-pressure controls, preferably direct acting, for all transport systems.

3.3.1 High-pressure protection

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.

3.3.2 Low pressure protection



CAUTION

Operation outside the application envelope! Compressor breakdown! A low-pressure protection shall be fitted in the suction line to stop the compressor when it operates outside the envelope limits.

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 allowable 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 the allowed operation envelope – see Select software at www.climate.emerson.com/en-gb.

3.4 Crankcase heater

For stationary applications with permanent available power supply, crankcase heater are the most effective solution to keep liquid refrigerant out of the compressor oil during off cycles. For such systems and refrigerant charges above 4.5 kg, Emerson recommends the installation of a crankcase heater.

In transport and mobile applications, crankcase heaters are not effective since typically there will be no voltage present during extended off cycle periods. A check valve in the discharge line along with a liquid line solenoid valve (pumpdown) should be used to limit off-cycle migration to the compressor.

The low leak check valve must be qualified for discharge line service. See also **section 5.12 "Refrigerant migration"** and **section 5.13 "Pumpdown cycle"** for further information.

3.5 Discharge gas temperature protection



IMPORTANT

Inadequate lubrication! Scroll set damage! All ZRH(V)*KTE/KTR 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 guarantee positive compressor protection, a discharge temperature protection sensor must be used. This protection must not be used as an operating envelope controller, it is a safety device only.

The maximum discharge gas temperature is 120 °C for all ZRH(V)*KT* horizontal scroll compressor models.

3.5.1 External discharge line temperature sensor

The use of an external discharge sensor is required for all ZRH(V)*KT* horizontal scroll compressor models.

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

Assembly of the discharge line sensor

- Install the discharge line sensor on the discharge tube 120 mm from the top cap.
- The sensor should be placed on the discharge tube in upward position.
- The wire must not be in contact with the top cap of the compressor or the discharge tube. Care should be taken to route the 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 sensor must be properly insulated.

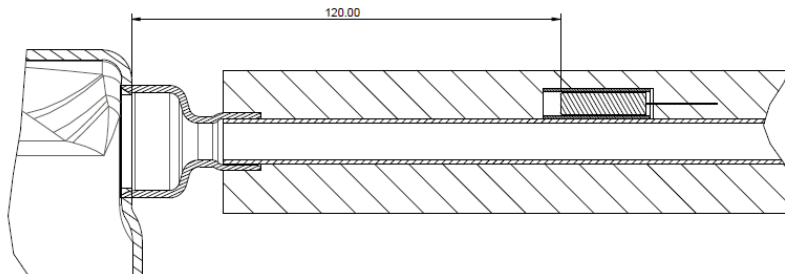


Figure 10: Discharge line sensor with insulation

3.5.2 Internal pressure relief valve

ZRH(V)*KT* horizontal scroll compressors do NOT have any internal pressure relief valve. To ensure safe operation, a high-pressure control must be used in all applications.

3.6 Discharge check valve

ZRH(V)*KT* horizontal scroll compressors contain an internal check valve on the discharge connection. The check valve prevents the high-pressure discharge gas from flowing rapidly back through the compressor after shutdown. The main function of the internal check valve is to reduce the reverse rotation noise after compressor stop, but it is not completely gas-tight.

Emerson recommends adding a gas-tight external check valve in the discharge line of the ZRH(V)*KT* compressor range in transport applications, to avoid liquid refrigerant migration into the compressor during standstill. The external check valve must be qualified for operation in the discharge line.

3.7 Filter screens



CAUTION

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

The use of filter 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.

3.8 Compressor oil return, floodback and 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 level, mass flow, and density.

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 and a refrigerant floodback test.

A sample compressor equipped with an external oil sight tube can be ordered from Emerson 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 and liquid floodback. Typically, the following situations should be considered:

- **general oil return test:** testing conditions shall be at full and minimum mass flow and density of suction gas in continuous and frequent start-stop cycling.
- **liquid floodback and oil dilution test:** 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 or oil dilution, please refer to the chart in **Figure 11** below. The bottom shell temperature of the compressor and the evaporating temperature have to be monitored.

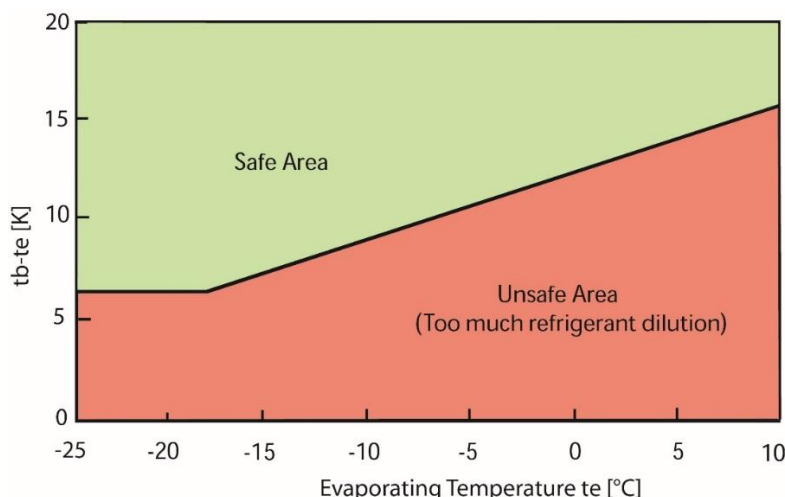


Figure 11: Oil dilution chart (t_b = bottom shell temperature; t_e = evaporating temperature)

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 oil dilution chart in **Figure 11**. 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 lower part of the compressor housing, preferably in the oil collection area, opposite the end with the discharge connection.

3.9 Suction line accumulator

Due to Copeland scroll's inherent ability to handle liquid refrigerant, for example in flooded start and defrost cycle operation, an accumulator is not required 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 3.8 "Compressor oil return, floodback and oil dilution tests"**.

If an accumulator is used, the oil-return orifice should be from 1 to 1.4 mm in diameter for all ZRH(V)*KT* models 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.

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 and between each test.

The recommended wiring diagrams are shown in figure hereunder.

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

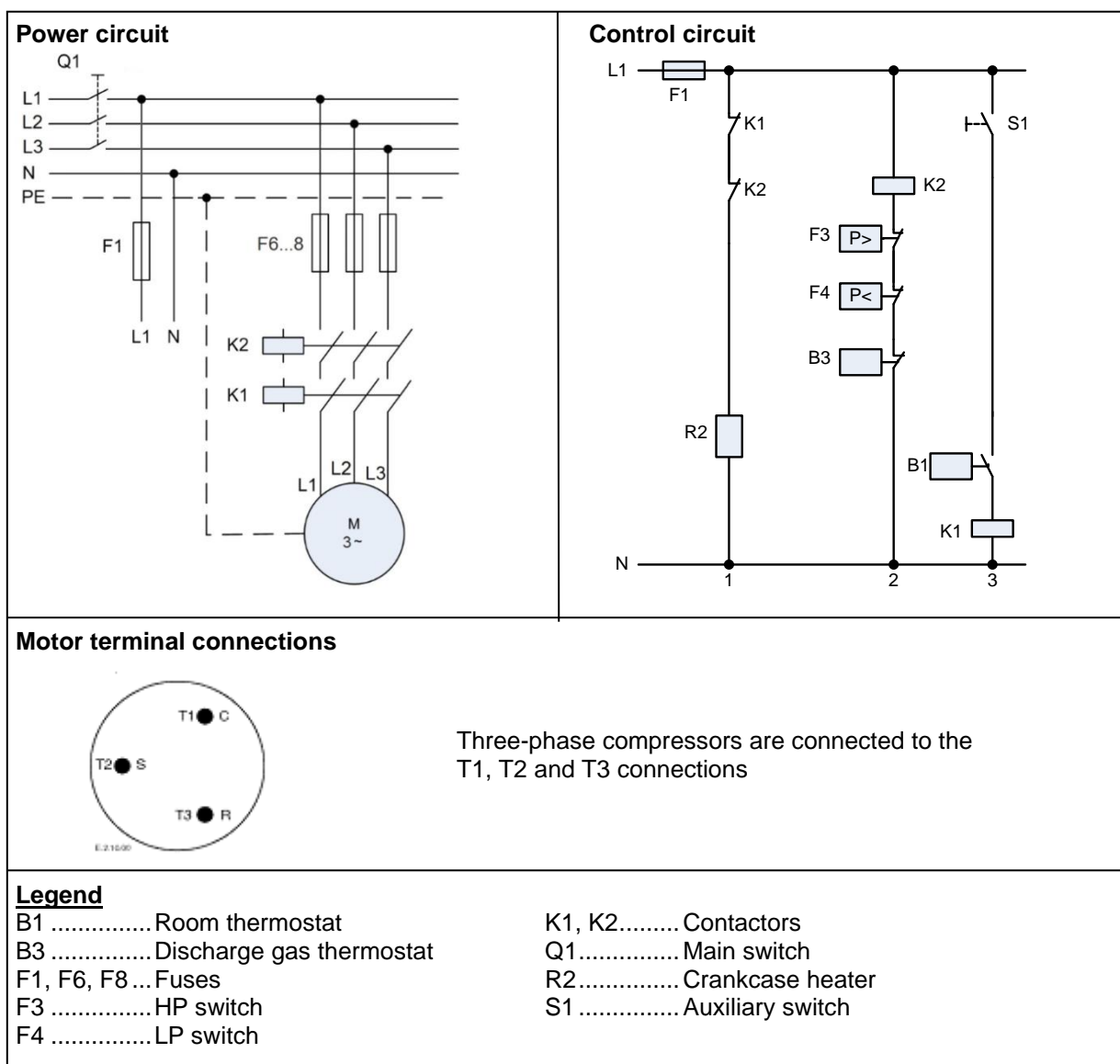


Figure 12: Wiring diagrams for three-phase compressors with internal motor protection

4.3 Terminal box – IP56



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 hermeticity 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. Emerson strongly recommends using appropriate cable glands according to EN 50262 in order to reach the rated protection class. An example of a correct electrical installations is shown in **Figure 13** below.

ZRH(V)*KT* horizontal scroll compressors are equipped with a metallic t-box with an IP56 protection class.



Figure 13: IP56 terminal box on ZRH(V)*KT* compressors

4.4 Motor winding

ZRH(V)*KT* horizontal scroll compressors have a three-phase induction asynchronous motor. All three-phase motors are connected in star.

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). Failing to install fuses before the compressor or selecting inappropriate fuses may result in compressor failure.

Conventional inherent internal line break motor protection Klixon is provided with all TFD/TF5 compressor models covered in these guidelines. TX7 variable-speed models do not have an internal protector. For these TX7 models, motor protection must be handled by setting the correct maximum current value in the inverter.

4.6 Inverter operation

Fixed-speed horizontal scroll compressors ZRH72KT*, ZRH81KT* and ZRH87KT* to ZRH116KT* are limited to operation at 50 or 60 Hz.

Compressor models ZRHV72KT* and ZRHV81KT* can be operated on inverter-derived power over the range of 30 to 80 Hz with R134a/R513A and 25 to 100 Hz with R407C. The frequency range for compressors ZRHV94KTE is 35 to 80 Hz.

The inverter drives used to power these compressors must comply with the provisions of technical specification IEC 600034-17. In particular, the motor input voltage must be limited to 1.35 kV/microsecond line-to-line impulse voltage. These provisions are required to avoid motor insulation breakdown, to limit motor heating and to extend motor lifetime.

The compressor operating voltage must vary with frequency according to the diagrams shown in **Figures 15 & 16**. Matching voltage to frequency according to these guidelines will prevent motor saturation and overheating.

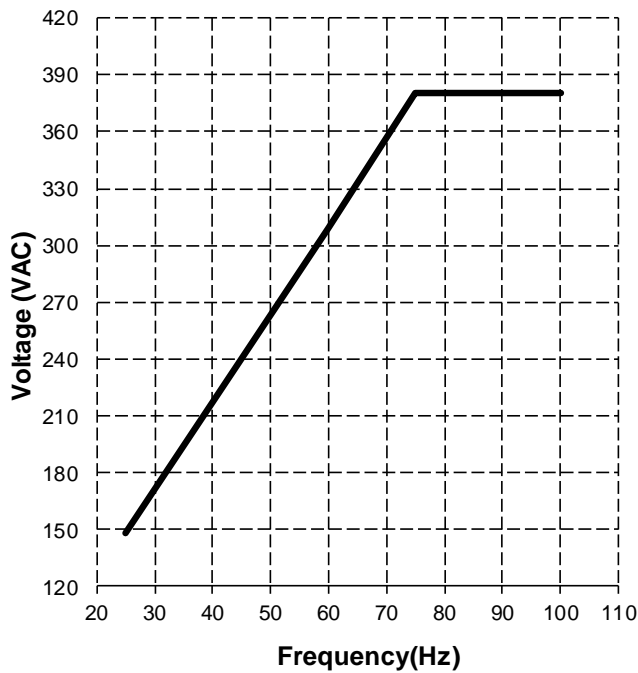


Figure 14: Voltage versus operating frequency for ZRHV72KT*, ZRHV81KT* TX7 & ZRHV94KTE TF7

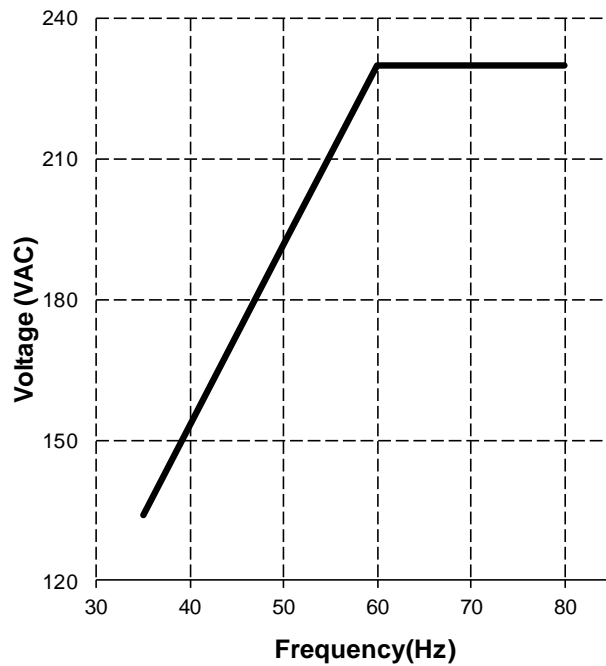


Figure 15: Voltage versus operating frequency for ZRHV94KTE TF5

Operating compressor models ZRHV72KT* to ZRHV81KT* and ZRHV94KTE over a defined frequency range will result in different application envelopes – see **Figures 17 to 20**. These envelopes are more restricted at lower operating speeds. This is to prevent bearing overloading and overheating of the compressor motor during low-speed operation.

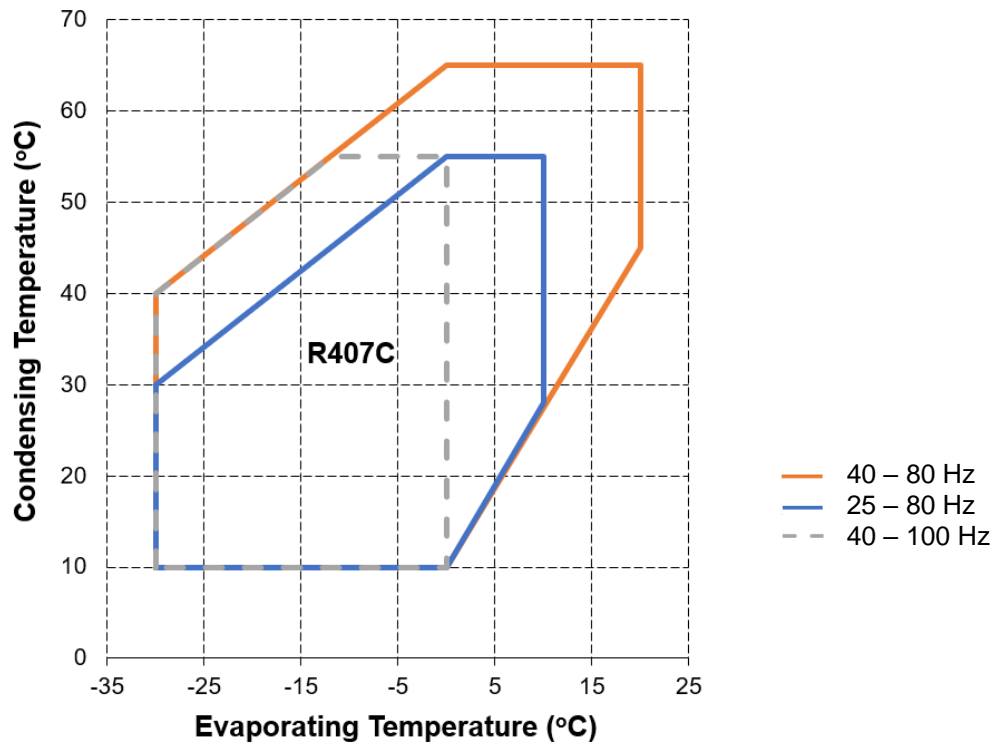


Figure 16: Operating envelope for variable speed ZRHV72KTE & ZRHV81KTE with R407C

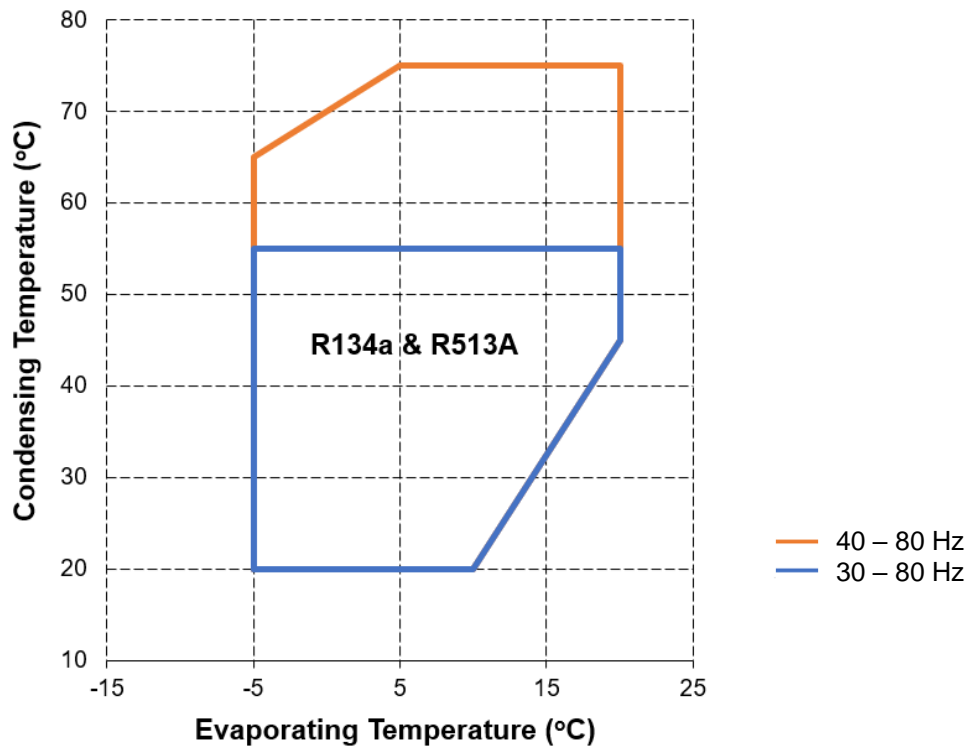


Figure 17: Operating envelope for variable speed ZRHV72KT* & ZRHV81KT* with R134a/R513A

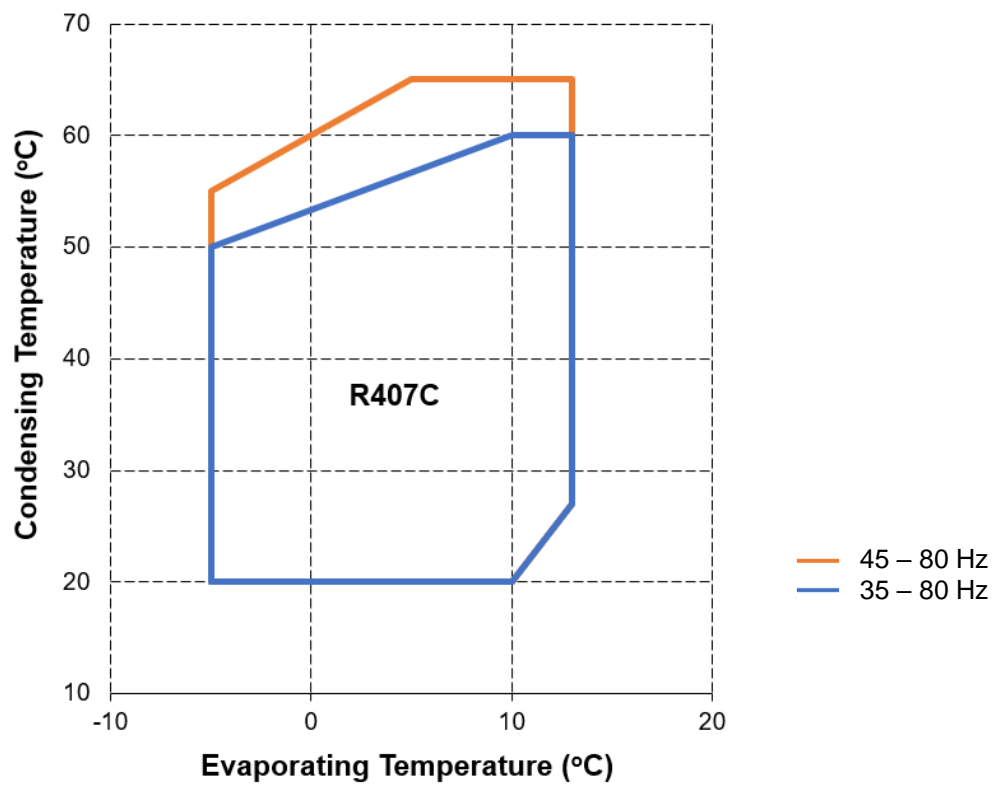


Figure 18: Operating envelope for variable speed ZRHV94KTE with R407C

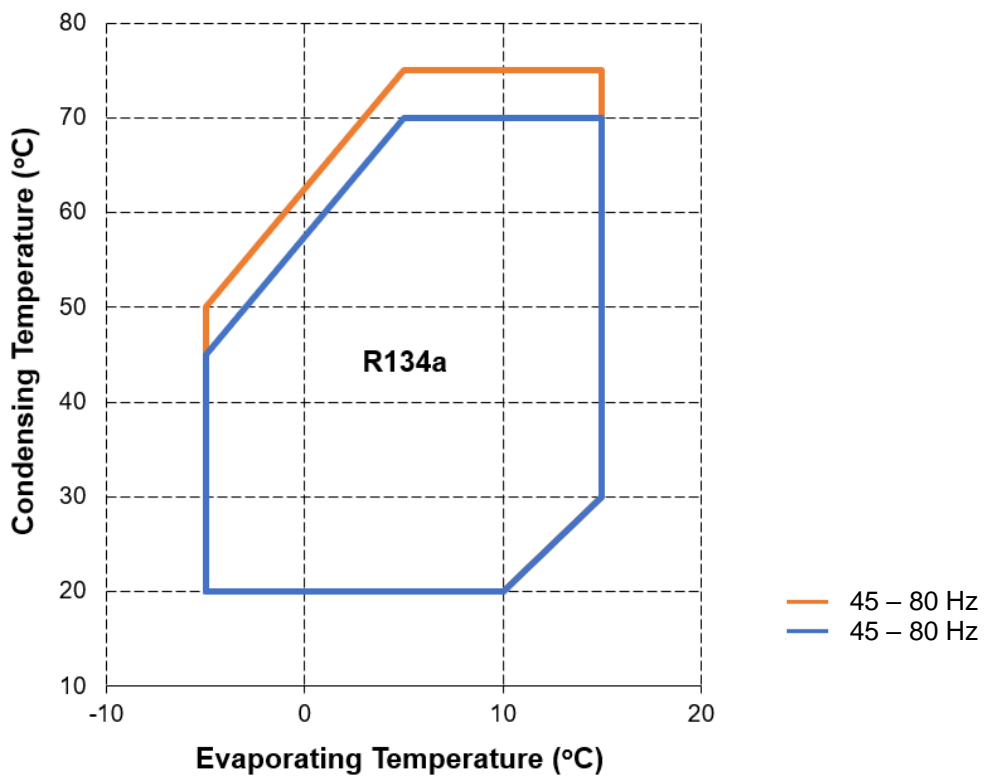


Figure 19: Operating envelope for variable speed ZRHV94KTE with R134a

4.7 High-potential testing



WARNING

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



CAUTION

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

Emerson 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 it has to be done for any reason, it shall not be made with the compressor charged with refrigerant. Run the test with a lower voltage, as described above. Disconnect all electronic devices, eg, motor protection module, fan speed control, etc prior to testing.

5 Starting up & operation



WARNING

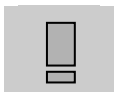
Diesel effect! Compressor destruction! The mixture of air and oil at high temperature can lead to an explosion. Avoid operation with air.

5.1 Strength pressure 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 nitrogen for pressure testing. DO NOT USE other industrial gases.

5.1.1 Compressor strength-pressure test

The compressor has been strength-pressure tested in the Emerson 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:

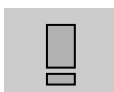
- System high-pressure section:
 - Define the system high-side PS \leq compressor high-side PS.
 - Isolate the high- and low-pressure sections of the system by closing valves, solenoid valves, expansion valves or by other means.
 - Use the internal check valve of the compressor on the discharge side 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 $1.1 \times$ 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 \leq compressor low-side PS.
 - The system test pressure of $1.1 \times$ 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 Emerson factory.

All compressors get a factory holding charge of dry air (about 0.2 to 0.7 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 on 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 – refer to, eg, 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 checklist 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 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.

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

Ensure that the 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 drier 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. A 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 system with refrigerant.

5.6 Run-in time

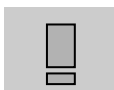
Scroll compressors exhibit a slight decrease in input power during the initial running period. Published performance ratings are based on calorimeter testing which is carried out after run-in. Therefore, users should be aware that before the performance specified by EN 12900 is achieved the compressor needs to be run in. Recommended run-in times for ZRH(V)*KTE/KTR compressors to attain the published performance are 17 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. Bearings are susceptible to damage before they have had several hours of normal running in.

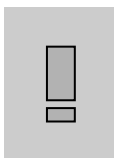


IMPORTANT

Oil dilution! Bearing malfunction! It is important to ensure that new compressors are not subject to liquid abuse.

Liquid and high-pressure loads could be detrimental to new bearings. It is therefore important to ensure that new compressors are not subject 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.

5.8 Rotation direction



IMPORTANT

Insufficient internal lubrication! Bearing malfunction! Do not operate ZRH(V)*KTE/KTR horizontal scroll compressors in reverse rotation. Make sure to electrically connect in a right rotating field and check the running compressor for proper rotation direction.

The lubrication in ZRH(V)*KT* horizontal scroll compressors will only work properly if compressors run in the correct rotation direction. Three-phase compressors will rotate in either direction depending upon phasing of the power. Since there is a 50-50 chance of connecting power in such a way as to cause rotation in the reverse direction, **it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction when the system is operated and serviced.** Observing that suction pressure drops and discharge pressure rises when the compressor is energized allows verification of proper rotation direction.

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 Starting sound

Due to the design of the Copeland scroll compressors, the internal compression components always start unloaded even if system pressures are not balanced. In addition, since internal compressor pressures are always balanced at start-up, low voltage starting characteristics are excellent for Copeland scroll compressors.

5.10 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 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 120 °C – see **section 3.5 "Discharge gas temperature protection"**.

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

5.12 Refrigerant migration

Liquid migration to the compressor and consequent flooded starts after standstill, especially in a cool ambient, must be avoided.

In mobile applications, a crankcase heater might not be effective due to lack of power. This could lead to situations where there will be no voltage present during extended off-cycle periods. A pumpdown cycle in combination with a low leak check valve in the discharge line could be an alternative to reduce off-cycle refrigerant migration to the compressor. This extra low leak check valve must be qualified for discharge line service.

For further support, please contact the Application Engineering department at Emerson or your local Emerson representative.

5.13 Pumpdown cycle



CAUTION

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

The system can be set to pump down for a fixed number of seconds after the setpoint is reached and the liquid line solenoid valve and/or the expansion valve is closed. The exact time should be determined by testing but should not exceed 20 seconds. The system should pump down until the pressure is close to the cut-out pressure of the low-pressure switch. It is not necessary to pump down to pressure values lower than the low-pressure switch cut-out setpoint. If the low-pressure switch opens, the pumpdown should stop immediately. The system should not restart when the low-pressure switch resets; restart should be in response to controller demand. In heat pumps the 4-way valve should not be allowed to shift after pumpdown.

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, but it is not completely gas-tight. 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.

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.

5.14 Minimum run time

Emerson 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 Emerson. 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.

5.15 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.

5.16 Supply frequency and voltage

There is no general release for the fixed-speed horizontal scroll compressors ZRH72KT*, ZRH81KT* and ZRH87KT* to ZRH116 KT* for use with variable-speed AC drives. Only frequencies from 50 to 60 Hz are acceptable.

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.

Variable-speed horizontal scroll compressor models ZRHV72KT*, ZRHV81KT* and ZRHV94KTE can be applied in the frequency band, as shown in **section 4.6 "Inverter operation"**.

The last digit of the model motor code indicates which net frequency and voltage must be applied – see **section 2.3 "Nomenclature"**.

50 Hz	60 Hz	Code
380-420 V – 3 ph	460 V – 3 ph	D
-	380 V – 3 ph	7
200-220 V – 3 ph	220-230 V – 3 ph	5

Table 5: Electrical motor codes for ZRH(V)*KTE/KTR compressors

5.17 Oil level

There is no oil sight glass on ZRH(V)*KT* compressors. Consequently, it is difficult to get an indication about the actual oil level in the compressor during operation.

During the system development phase, adequate oil return from the system to the compressor should be evaluated and qualified. For this purpose, a sample compressor for lab testing, equipped with an external oil sight tube, is available from Emerson. A sufficient oil level must be present in the compressor at all times to ensure compressor reliability.

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.



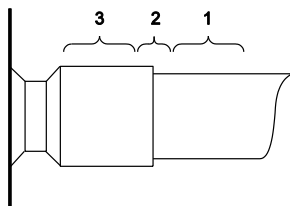
WARNING

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 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 re-connected into 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.

Figure 20: Tube connecting areas

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.

6.2 Provisions of legislation & leak check requirements

According to EN 378-4, systems with a refrigerant charge of 3 kg or more shall be subject to tightness inspection at least on an annual basis. The owner/operator shall keep an updated logbook of the refrigerant system containing all details with regard to maintenance and repair works (quantities and type of refrigerant changed or transferred, system components changes and replacements etc.). The EN 378 legislation covers HFO's as well as natural refrigerants.

The F-gas Regulation (EU) No 517/2014 applies to operators of equipment such as stationary refrigeration/air-conditioning equipment and heat pumps that contain fluorinated greenhouse gases. Mandatory documented leak checks must be made based on how much damage could be caused to the atmosphere if the whole charge were released. The frequency of the test inspections is based on the GWP of the refrigerant multiplied by the estimated volume contained in each individual system – this gives the CO₂e (CO₂ equivalent) figure.

Leak checking shall be carried out with the following frequency:

- (a) once per year if the system contains between 5 and <50 tonnes CO₂e;
- (b) once every 6 months if the system contains between 50 and <500 tonnes CO₂e;
- (c) once every 3 months if the system contains more than 500 tonnes CO₂e.

NOTE: The leak checking frequency can be halved if permanent leak detection systems are fitted. Permanent leak detection systems are mandatory for system charges of 500 tonnes CO₂e and above.

NOTE: Hermetically sealed equipment that contains fluorinated greenhouse gases in quantities of less than 10 tonnes of CO₂e, shall not be subject to leak checks, provided the equipment is labelled as hermetically sealed.

Table 6 below sets out the

- F-gas thresholds, in tonnes CO₂ equivalent, at which leak check intervals are specified;
- maximum allowed interval between leak checks for equipment that meets each threshold;
- quantities of commonly used HFCs/refrigerant equal to each threshold.

Refrigerant	GWP	Maximum interval between leak checks 1 year	Maximum interval between leak checks 6 months	Maximum interval between leak checks 3 months
		5 to <50 T CO ₂ e	50 to <500 T CO ₂ e	>500 T CO ₂ e
R134a	1430	3.49 kg	34.96 kg	349.65 kg
R513A	631	7.93 kg	79.36 kg	793.65 kg
R407C	1774	2.81 kg	28.18 kg	281.84 kg

Table 6: F-gas Regulation leak check intervals (based on refrigerant type and system charge thresholds)

The F-gas Regulation contains additional requirements depending on the system and stipulates training requirements for alternative refrigerants.

HFO refrigerants are covered by the F-gas Regulation as far as reporting of placing on the market is concerned.

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 2.5.1**.

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 shutdown 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 a 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 refrigerant and oil completely from the replaced compressor.

6.4.1 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. 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.

6.4.2 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 R407C, R134a and R513A is a polyolester (POE) lubricant Emkarate RL 32 3MAF. 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 22**. 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. The compressors supplied by Emerson contain oil with low moisture content, which may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-drier be 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.

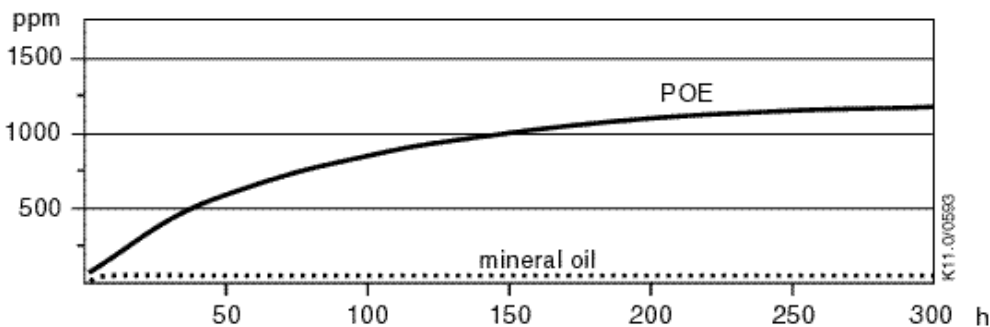


Figure 21: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25 °C and 50 % relative humidity (h= hours)

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.

NOTE: ZRH(V)*KTE/KTR horizontal scroll compressors are fitted with an internal oil pump.

6.6 Oil additives

Although Emerson 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 according to national legislation and regulations.

Dispose of compressor according to national legislation and regulations

8 References

Please visit www.climate.emerson.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.climate.emerson.com/en-gb.

Spare parts and accessories:

Visit www.climate.emerson.com/en-gb/tools-resources for an online version of the Emerson spare parts and accessories software.

Appendix1: Tightening torques

Connection	Torque (Nm)
M10	45 - 55
Mounting bolts 5/16", M9	27 max
Mounting bolts M8	13 ± 1
Terminal block screw	2.8
Ground screw	2.3

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