Copeland Scroll™ Compressors for Heat Pumps with R410A

ZH04K1P to ZH19K1P, ZHI05K1P to ZHI46K1P
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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. It is intended to answer the questions raised while designing, assembling and operating a system with these products.

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

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

1 Safety instructions

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

These compressors are intended for installation in systems according to the EC Machinery Directive MD 2006/42/EC. They may be put to service only if they have been installed in these systems according to instructions and conform to the corresponding provisions of legislation. For relevant standards please refer to the Manufacturer’s Declaration, available on request.

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

You are strongly advised to follow these safety instructions.

1.1 Icon explanation

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

1.2 Safety statements

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

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

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

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

WARNING
Pressurized system! Serious personal injuries and/or system breakdown! The system contains refrigerant and oil under pressure. The mixture of air and oil at high temperature can lead to an explosion (Diesel effect). Avoid operating with air.

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

Only approved refrigerants and refrigeration oils must be used.

Remove refrigerant from both high- and low-pressure sides with a suitable recovery unit before removing compressor.

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

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

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

IMPORTANT
Transit damage! Compressor malfunction! Use original packaging. Avoid collisions and tilting.
2 Product description

2.1 Common information about Copeland Scroll™ compressors

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

These application guidelines deal with all vertical single Copeland Scroll compressors for dedicated heat pump applications from ZH04K1P to ZH19K1P. They also cover vapour injection compressors from ZHI08K1P to ZHI46K1P.

<table>
<thead>
<tr>
<th>Compressor</th>
<th>Heating capacity kW</th>
<th>Motor</th>
<th>Compressor</th>
<th>Heating capacity kW</th>
<th>Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZH04K1P</td>
<td>4.17</td>
<td>PFZ/TFM</td>
<td>ZHI05K1P</td>
<td>5.26</td>
<td>TFM</td>
</tr>
<tr>
<td>ZH05K1P</td>
<td>4.98</td>
<td>PFZ/TFM</td>
<td>ZHI08K1P</td>
<td>8.13</td>
<td>PFZ/TFM</td>
</tr>
<tr>
<td>ZH06K1P</td>
<td>6.62</td>
<td>PFZ/TFM</td>
<td>ZHI11K1P</td>
<td>10.87</td>
<td>PFZ/TFM</td>
</tr>
<tr>
<td>ZH09K1P</td>
<td>8.96</td>
<td>PFZ/TFM</td>
<td>ZHI14K1P</td>
<td>14.03</td>
<td>TFM</td>
</tr>
<tr>
<td>ZH12K1P</td>
<td>11.45</td>
<td>PFZ/TFM</td>
<td>ZHI18K1P</td>
<td>19.00</td>
<td>TFM</td>
</tr>
<tr>
<td>ZH15K1P</td>
<td>15.05</td>
<td>TFM</td>
<td>ZHI23K1P</td>
<td>23.40</td>
<td>TFM</td>
</tr>
<tr>
<td>ZH19K1P</td>
<td>18.70</td>
<td>TFM</td>
<td>ZHI27K1P</td>
<td>26.56</td>
<td>TFD</td>
</tr>
<tr>
<td>ZHI32K1P</td>
<td>31.88</td>
<td>TFD</td>
<td>ZHI35K1P</td>
<td>35.80</td>
<td>TFD</td>
</tr>
<tr>
<td>ZHI40K1P</td>
<td>39.98</td>
<td>TFD</td>
<td>ZHI46K1P</td>
<td>46.57</td>
<td>TWD</td>
</tr>
</tbody>
</table>

Evaporating temperature: -7°C; Condensing temperature: 50°C; Suction gas superheat: 5K; Liquid sub-cooling: 4K; Injection superheat: 5K

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

2.2 Nomenclature

The model designation contains the following technical information about the standard and vapour injection compressors:

![Nomenclature Diagram](image)

Figure 1: Nomenclature
2.3 Application range

2.3.1 Qualified refrigerants and oils

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

<table>
<thead>
<tr>
<th>Compressors</th>
<th>ZH04K1P to ZH19K1P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualified refrigerants</td>
<td>R410A</td>
</tr>
<tr>
<td>Copeland brand products standard oil</td>
<td>Emkarate RL 32 3MAF</td>
</tr>
<tr>
<td>Servicing oil</td>
<td>Emkarate RL 32 3MAF</td>
</tr>
</tbody>
</table>

Table 1: Qualified refrigerant and oil

2.3.2 Application limits

**CAUTION**

Inadequate lubrication! Compressor breakdown! Copeland Scroll compressors are qualified for operation inside the envelope published by Emerson Climate Technologies. The envelope is defined according to Emerson Climate Technologies testing and experience. Operating a compressor outside the envelope might lead to compressor failure which would be the heat pump manufacturer’s responsibility. The superheat at the compressor suction inlet must always be sufficient to ensure that no refrigerant droplets enter the compressor. For a typical evaporator-expansion valve configuration a minimum stable superheat of at least 5K is required. In the same way, the superheat at the compressor suction must always stay below a maximum limit specified by Emerson Climate Technologies, depending on the model and for which the operating envelope is defined.

**NOTE:** The application envelopes shown below are for R410A.

ZH04K1P, ZH05K1P (up to S/N 15F)  
ZH04K1P, ZH05K1P (from S/N 15G onwards)  
ZH06K1P to ZH19K1P (all S/N)

**NOTE:** The application envelopes shown below are for R410A.

<table>
<thead>
<tr>
<th>Condensing Temperature (°C)</th>
<th>Evaporating Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>-35</td>
</tr>
<tr>
<td>70</td>
<td>-30</td>
</tr>
<tr>
<td>65</td>
<td>-25</td>
</tr>
<tr>
<td>60</td>
<td>-20</td>
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<td>55</td>
<td>-15</td>
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<tr>
<td>50</td>
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<td>40</td>
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<td>-20</td>
<td>65</td>
</tr>
<tr>
<td>-25</td>
<td>70</td>
</tr>
<tr>
<td>-30</td>
<td>75</td>
</tr>
</tbody>
</table>

**Max 10K suction superheat**  
**Max 10K suction superheat**, limited operation <2000 hours on a compressor lifetime  
**Max 5K suction superheat**  
**Max 5K suction superheat**, limited operation <2000 hours on a compressor lifetime
For air-to-water heat pump applications, an additional envelope extension may be required for high temperature water production in case of low outdoor temperature. This can be achieved by the use of wet vapour injection. For further information about wet vapour injection, contact Application Engineering at Emerson Climate Technologies.

**NOTE:** For information and design recommendations regarding vapour injection, please refer to Technical Information C7.4.3 “Vapour injection Scroll compressors for heat pumps”.

Figure 2: Application envelopes with R410A
2.4 Dimensions

**ZH04K1P, ZH05K1P**

**ZHI05K1P**

**ZH06K1P to ZH12K1P**

**ZHI08K1P to ZHI23K1P**

**ZH18K1P for tandem**

**ZHI23K1P for tandem**

**ZH15K1P, ZH19K1P**

**ZHI27K1P to ZHI32K1P**

**ZHI35K1P, ZHI40K1P**

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**Discharge**

- Ø 12.75 – 12.95

**Suction**

- Ø 19.12 – 19.30

---

**Injection**

- Ø 15.87 – 16.17

**Oil level**

- Ø 5.60 – 5.70

---

**Dimensions**

- ZH04K1P, ZH05K1P, ZH06K1P to ZH12K1P, ZHI08K1P to ZHI23K1P, ZHI27K1P to ZHI32K1P, ZHI35K1P, ZHI40K1P
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 3. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Do not stack single boxes on top of each other. 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 3:** 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.

The suction stub on compressor models ZHI27K1P to ZHI46K1P is located at low level. Oil might flow through the suction stub and get trapped in the system. To avoid this, Emerson Climate Technologies strongly recommends mounting the suction piping turning vertically upward from the compressor connection. This will ensure that the oil gets back into the oil sump even when tilting at 30°.

#### 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.

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 or it might damage the suction screen and motor.

#### 3.1.3 Installation location

Scroll compressors are capable of operating correctly with compressor ambient humidity within 30% to 95% and at altitudes up to 1000 meters. For correct operation the compressor ambient air temperatures have to be within -40°C to 60°C and the compressor PS and TS have to be respected at all times during operation and at a standstill.

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

3.1.4 Mounting parts

The compressors are designed to be mounted on vibration absorber grommets (part of the standard delivery). The grommets dampen the start-up surge of the compressor and minimise sound and vibration transmission to the compressor base during operation. The grommets are supplied with the compressors. 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 that the grommet is not compressed.

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

**NOTE:** For more information, please refer to Technical Information C7.11.2 "Scroll Mounting Parts".

**Mounting parts for single compressor applications:**
ZH04K1P, ZH05K1P: 3 pieces per compressor
ZH06K1P to ZH19K1P, ZHI05K1P to ZHI23K1P: 4 pieces per compressor

**Mounting parts for single compressor applications:**
ZHI27K1P to ZHI46K1P: 4 pieces per compressor

![Figure 4: Rubber mounting parts with sleeve and washer](image)

3.2 Brazing procedure

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

**Contamination or moisture! Bearing failure!** Do not remove the plugs until the compressor is set into the unit. This minimises any entry of contaminants and moisture.
Copeland Scroll compressors have copper-plated steel suction, injection and discharge tubes. These tubes are far more robust and less prone to leaks than copper tubes. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

Refer to Figure 5 and procedure below for the brazing of the suction and discharge lines to a Scroll compressor.

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

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

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

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

**NOTE:** Since the injection tubing design of the ZHI*K1P compressors includes some O-rings, a wet rag or any other suitable heat protection device must be used when brazing the injection line to the compressor.

### 3.3 Accumulators

**CAUTION**

*Inadequate lubrication! Bearing and moving parts destruction!* Minimise liquid refrigerant returning to the compressor. Too much refrigerant dilutes the oil. Liquid refrigerant can wash the oil off the bearings and moving parts leading to overheating and bearing or compressor failure.

Due 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. However, large volumes of liquid refrigerant repeatedly flooding back to the compressor during normal off cycles, or excessive liquid refrigerant flooding back during defrost or varying loads, can dilute the oil, no matter what the system charge is. As a result, bearings and moving parts will be inadequately lubricated and wear may occur.

To determine if the accumulator can be removed, dedicated tests must be carried out to ensure that excessive liquid does not flood back to the compressor during defrost or varying loads. The defrost test must be done at an outdoor ambient temperature of around 0°C in a high humidity environment. Liquid floodback must be monitored during reversing valve operation, especially when coming out of defrost. Excessive floodback occurs when the sump temperature drops below the safe operation line shown in Figure 6.

If an accumulator has to be used, the oil-return orifice should be from 1 to 1.4 mm in diameter for models ZH04K1P to ZH19K1P and ZHI05K1P to ZHI23K1P, and 2.0 mm for models ZHI27K1I to ZHI46K1P, depending on compressor size and compressor floodback results. A large-area protective screen no finer than 30 x 30 mesh (0.6 mm openings) is required to protect this small
orifice from plugging with system debris. 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 subcooling and subsequent head pressure allowed by the refrigerant control. System modelling indicates that heat pumps that operate down to and below -18°C will require an accumulator that can hold around 70% to 75% of the system charge.

![Figure 6: Dilution chart for transient operation (tb = bottom shell temperature; te = evaporating temperature)](image)

**Note 1:** Low load operation may be acceptable in the yellow marked area. Please contact the Application Engineering department at Emerson Climate Technologies.

### 3.4 Screens

**CAUTION**

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

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

### 3.5 Mufflers

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

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

A hollow shell muffler will work quite well. Locate the muffler at minimum 15 to maximum 45 cm from the compressor for the most effective operation. The 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.

### 3.6 Reversing valves

Since Copeland Scroll compressors have a very high volumetric efficiency their displacements are lower than those of equivalent capacity reciprocating compressors. As a result, Emerson Climate Technologies recommends that the capacity rating on reversing valves be no more than 1.5 to 2 times the nominal capacity of the compressor in order to ensure proper operation of the reversing valve under all operating conditions.

The reversing valve solenoid should be wired so that the valve does not reverse when the system is shut off by the operating thermostat in the heating or cooling mode. If the valve is allowed to reverse at system shut off, suction and discharge pressures are reversed to the
compressor. This results in a condition of system pressures equalising through the compressor which can cause the compressor to slowly rotate until the pressures equalise. This condition does not affect compressor durability but can cause unexpected sound after the compressor is turned off.

3.7 Suction line noise and vibration

Proper pipe design must be taken into consideration when connecting a scroll compressor to the system.

![Figure 7: Suction tube design](image)

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.
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

4.2.1 Wiring diagrams

The recommended wiring diagrams are shown in figures hereunder.

**NOTE:** Emerson Climate Technologies recommends using a contactor K2 for the safety chain in order to comply with EN 60335.

**Single-phase (PF*) compressors**

For the ZH04K1P to ZH12K1P and ZHI05K1P & ZHI11K1P ranges of compressors the following circuit diagrams can be used:

*Figure 8: Wiring diagrams for single-phase compressors*
Three-phase compressors (TF*) with internal motor protection

For the ZH04K1P to ZH19K1P and ZHI05K1P to ZHI40K1P ranges of compressors the following circuit diagrams can be used:

**Power circuit**

**Control circuit**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Q1...... Main switch</td>
</tr>
<tr>
<td>L1, L2, L3</td>
<td>L1, L2, L3...Fuses</td>
</tr>
<tr>
<td>N, PE</td>
<td>F3....... HP limiter</td>
</tr>
<tr>
<td>F1</td>
<td>F4....... LP switch</td>
</tr>
<tr>
<td>K1, K2</td>
<td>K1, K2.... Contactors</td>
</tr>
<tr>
<td>R2</td>
<td>R2....... Crankcase heater</td>
</tr>
<tr>
<td>Y5</td>
<td>Y5....... Solenoid valve for injection (if available)</td>
</tr>
<tr>
<td>K1</td>
<td>S1....... Auxiliary switch</td>
</tr>
<tr>
<td>B1</td>
<td>RCD....... Residual current device</td>
</tr>
<tr>
<td>B1</td>
<td>RCD....... Residual current device</td>
</tr>
</tbody>
</table>

**Motor terminal connections**

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

Figure 9: Wiring diagrams for three-phase compressors with internal motor protection
Three-phase compressors (TWD) with external motor protection INT69SU2

For ZHI46K1P compressors the following circuit diagrams can be used:

**Power circuit**

<table>
<thead>
<tr>
<th>Q1</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>N</th>
<th>PE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F1</th>
<th>L1</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F6...8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Control circuit**

<table>
<thead>
<tr>
<th>L1</th>
<th>F1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>M1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Motor terminal connections**

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

**Legend**

- A1 ................. Motor protection module INT69SU2
- B1 ................. Room thermostat
- F1, F6, F8 ... Fuses
- F3 ................. HP limiter
- F4 ................. LP switch
- K1, K2 ....... Contactors
- Q1 ................. Main switch
- R2 ................. Crankcase heater
- S1 ................. Auxiliary switch

**Figure 10: Wiring diagrams for three-phase compressors with external motor protection**

### 4.2.2 Terminal box

The terminal box is IP21 for ZH04K1P to ZH19K1P and ZHI08K1P to ZHI14K1P models, ie, TF*/PF*.

For compressor ZHI18K1P single BOM 526 the terminal box is IP21 and for compressor ZHI18K1P tandem ready BOM 476 the terminal box is IP54.

For ZHI27K1P to ZHI40K1P models, the terminal box is IP54, enclosure class according to IEC 60034-5.

Respect the torques for the screw connections at the terminals according to **Table 2** hereunder:

<table>
<thead>
<tr>
<th>Compressor model</th>
<th>Grounding screw torques</th>
<th>Terminals screw torques</th>
<th>Maximum thickness of cable shoe according to Fig. 11</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZH04K1P to ZH09K1P</td>
<td>2.4 - 2.6 Nm</td>
<td>Fast-on cable shoes</td>
<td></td>
</tr>
<tr>
<td>ZHI05K1P to ZHI08K1P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZH12K1P to ZH19K1P</td>
<td>2.4 - 2.6 Nm</td>
<td>2.4 - 2.6 Nm</td>
<td>1 mm</td>
</tr>
<tr>
<td>ZHI11K1P to ZHI23K1P</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZHI27K1P to ZHI46K1P</td>
<td>2.4 - 2.6 Nm</td>
<td>1.5 - 2.1 Nm</td>
<td>2 mm</td>
</tr>
</tbody>
</table>

**Table 2: Torques of screws for electrical connection**
Cable glands have an influence on the protection class of the terminal box. It is strongly recommended to use appropriate cable glands in order to reach the rated protection class. Emerson Climate Technologies advises installers/service providers to pay attention to this aspect every time they install or replace a Copeland Scroll compressor and to use cable glands according to EN 50262 or any other relevant standard of application in their country/region. Examples of correct electrical installations are shown in Figures 12 & 13 below.

**4.2.3 Motor winding**

The ZH Scroll compressors are offered with either a single-phase or a three-phase induction motor, depending on the size. All three-phase motors are connected in star; single-phase motors need a run capacitor.
The motor insulation material is class "B" (PF* and TF*) or "H" (TW*) for compressor models covered in these guidelines.

4.2.4 Protection devices

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

4.2.5 Crankcase heaters

**IMPORTANT**

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

A crankcase heater is required when the system charge exceeds the compressor charge limit, listed in Table 3.

<table>
<thead>
<tr>
<th>Compressor model</th>
<th>Refrigerant charge limit Single compressor systems</th>
<th>Refrigerant charge limit Even Tandem systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZH04K1P &amp; ZH05K1P</td>
<td>3.6 kg</td>
<td>5.0 kg</td>
</tr>
<tr>
<td>ZH06K1P to ZH12K1P</td>
<td>4.5 kg</td>
<td>6.3 kg</td>
</tr>
<tr>
<td>ZHI05K1P to ZHI14K1P</td>
<td>4.5 kg</td>
<td>6.3 kg</td>
</tr>
<tr>
<td>ZHI27K1P to ZHI46K1P</td>
<td>7 kg</td>
<td>10.9 kg</td>
</tr>
</tbody>
</table>

Table 3: Refrigerant charge limit

For compressor models ZH04K1P to ZHI19K1P and ZHI05K1P to ZHI23K1P, the crankcase heater must be mounted 10 to 40 mm above compressor legs (see Figure 14).

For compressor models ZHI27K1P to ZHI46K1P, the crankcase heater must be mounted below the oil removal valve located on the bottom shell for tandem versions (see Figure 15).

**NOTE:** The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor and must remain energised during compressor off cycles.

4.2.6 Soft starters

Soft starters can be used with the 20 to 40 hp Copeland Scroll compressors to reduce inrush current. Soft starters should be selected in accordance with the soft starter manufacturer's recommendations, taking into consideration ambient temperature, number of starts per hour, and compressor amps. The maximum ramp-up time should not exceed 3 seconds.
4.3 Pressure safety controls

4.3.1 High-pressure protection

The high-pressure protection should be installed according to EN 378.

4.3.2 Low-pressure protection

**IMPORTANT**

<table>
<thead>
<tr>
<th>Loss of system charge and lubrication!</th>
<th>Bearing malfunction and compressor breakdown! A low-pressure control is highly recommended.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not bridge or by-pass the low-pressure cut out.</td>
<td></td>
</tr>
</tbody>
</table>

Heat pumps in some geographical areas have to operate at low evaporating pressure because of the low ambient temperatures, sometimes combined with a high level of relative humidity. Good evaporator sizing and adequate defrost strategy control should prevent the system from operating outside the operating envelope published by Emerson Climate Technologies, whatever the climatic conditions and the heating or cooling demand.

However, in some extreme cases – for example loss of system charge, extreme heat transfer restriction at the evaporator, any defect or blocked flow control component (expansion valve, screens...) – the evaporating conditions may be such that the compressor will tend to operate outside the Emerson operating envelope limits. All those conditions may starve the compressor in refrigerant and oil, and may result in compressor failure.

Therefore, Emerson Climate Technologies strongly recommends the installation of a low pressure limiter in the suction line that will shut down the compressor when it operates outside the published envelope limits.

4.4 Discharge gas temperature protection

**IMPORTANT**

| Inadequate lubrication! | Scroll set damage! Compressors ZH04K1P to ZH19K1P and ZHI05K1P to ZHI46K1P must be equipped with a discharge gas temperature protection. |

A good control should prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the heating 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, discharge gas temperature protection is required for any application with Copeland brand compressors. This protection must not be used as an operating envelope controller but as a safety device.

For compressors ZH04K1P to ZH19K1P the maximum discharge gas temperature is 140°C. For compressors ZHI18K1P and ZHI23K1P single BOM 526 and ZHI05K1P to ZHI14K1P it is 135°C. These compressors must be equipped with an external discharge gas temperature protection (see Figure 16). The protection shall be installed 120 mm from the compressor shell, along the straight or bended pipe.

![Figure 16: Sketch of discharge gas temperature protection for compressors with external sensor](image)

For compressors ZHI18K1P and ZHI23K1P tandem-ready BOM 477 and for compressors ZHI27K1P to ZHI46K1P, the maximum discharge gas temperature is 135°C. These compressors are equipped with a NTC-temperature sensor in the top cap (see Figure 17). This sensor measures the discharge gas temperature in the top cap and must be connected to the controller, eg, EXD TEVI (under development, please contact Emerson Climate Technologies). The controller has to stop the compressor when the maximum discharge gas temperature is exceeded.
In case the NTC top cap sensor shown in Figure 17 has to be replaced please refer to the Spare parts catalogue available at www.emersonclimate.eu for the replacement kit with all needed parts.

Please follow instructions hereunder:

- Remove the existing thermally conductive compound from the thermal well.
- Dispense 0.75-1 cm³ of thermally conductive compound into the bottom of the thermal well.
- Clean any debris, grease or dirt from the upper cap surface outside the thermistor tube opening along with the inside tube surface. If the areas shown are not clean, the silicone sealant will not adhere to the compressor.
- Apply a 5 mm bead of silicone sealant (99-5170-66) on the thermistor in areas indicated.
- After installation, the thermistor must be flushed with the top cap on, and the seal must be water tight.

**NOTE:** For more information, please refer to Technical Information C7.8.6 "Discharge Gas Temperature Protection for Copeland™ Heat Pump compressors".

### 4.5 Motor protection

#### 4.5.1 Internal line break motor protection

For the ZH04K1P to ZH19K1P and ZHI05K1P to ZHI40K1P range of compressors, conventional inherent internal line break motor protection is provided.

#### 4.5.2 External protection with Kriwan

The electronic motor protection system used in ZHI46K1P is identified by a "W" as the centre letter in the motor code. This system utilizes the temperature-dependent resistance of the thermistors (also called PTC-resistance) to read the winding temperature. A chain of four thermistors connected in series is embedded in the motor windings so that the temperature of the thermistors can follow the winding temperature with little inertia. An electronic module is required to process the resistance values and trip a control depending on the thermistor resistance.

**Kriwan module**

For protection in case of blocked rotor one thermistor for each phase is embedded in the winding heads on the upper (suction gas) side of the compressor motor. A fourth thermistor is located in...
a winding head at the lower end of the motor. The entire chain is internally led to the fusite from where it is connected to the module connections S1 and S2. When any resistance of the thermistor chain reaches the tripping value, the module interrupts the control line and causes the compressor to switch off. After the thermistor has cooled sufficiently, its resistance drops to the reset value but the module itself resets after a time delay of 30 minutes and restarts the compressor.

**Control circuit wiring**

![Diagram of motor protection module wiring](image)

**Figure 19: Wiring of the motor protection module**

**IMPORTANT**

Different sources for power supply and contact M1-M2! Module malfunction! Use the same potential for power supply and the switch contact of the control loop (M1-M2).

<table>
<thead>
<tr>
<th>Supply voltage: Dual voltage</th>
<th>115-230V AC 50 Hz, -15%...+10%, 3VA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120-240V AC 60 Hz, -15%...+10%, 3VA</td>
</tr>
<tr>
<td>Supply voltage</td>
<td>24V AC 50/60 Hz, -15%...+10%, 3VA</td>
</tr>
<tr>
<td>Ambient temperature range</td>
<td>-30…+70°C</td>
</tr>
<tr>
<td>R&lt;sub&gt;25&lt;/sub&gt;, total</td>
<td>&lt; 1.8kΩ</td>
</tr>
<tr>
<td>Trip resistance</td>
<td>4.50kΩ ± 20%</td>
</tr>
<tr>
<td>Reset time delay type 1 / type 2</td>
<td>30 min ± 5 min / 60 min ± 5 min</td>
</tr>
<tr>
<td>Reset of running time</td>
<td>Power interruption / mains failure for approx. 5 sec</td>
</tr>
<tr>
<td>Short circuit monitoring system</td>
<td>Typically &lt; 3Ω</td>
</tr>
<tr>
<td>Protection class according to EN 60529</td>
<td>IP00</td>
</tr>
<tr>
<td>Weight</td>
<td>Approximately 200 g</td>
</tr>
<tr>
<td>Mounting</td>
<td>Screw in or snap in</td>
</tr>
<tr>
<td>Housing material</td>
<td>PA66 GF25 FR</td>
</tr>
</tbody>
</table>

**Table 4: Protection module specifications INT69SU2**

**4.6 Kriwan protector functional check and failure detection**

**WARNING**

Conductor cables! Electrical shock! Shut off power supply before and between each test.

Prior to start-up of the fully connected compressor a functional check shall be carried out:

- Disconnect one terminal either S1 or S2 of the protection module. If the compressor is now switched on, the motor should not start (simulation of an open thermistor chain).
- Reconnect the disconnected thermistor line. If the compressor is now switched on, the motor must start.
If the motor does not start up during the functional check, this indicates a disturbance in operation. The following steps should be followed:

### 4.6.1 Checking the connection
- Check the connection of the thermistor leads in the terminal box and at the protection module for possible loose connections or cable breakage.

If there is neither loose connectionnor cable breakage the resistance of the thermistor chain must be checked.

### 4.6.2 Checking the compressor thermistor chain
**Caution:** Use maximum measuring voltage of 3V!
The thermistor leads at terminals S1 and S2 of the module shall be disconnected and the resistance measured between the leads. The resistance must be between 150 Ω and 1250 Ω.
- If the thermistor chain has a higher resistance (2750 Ω or higher), the motor temperature is still too high and it must be allowed to cool. Then measure again.
- If the resistance is below 30 Ω, the compressor has to be exchanged due to shorted sensor circuit.
- An infinite value indicates an open sensor circuit and the compressor has to be replaced.

If no defect is detected in the thermistor chain the module must be checked.

### 4.6.3 Checking the protection module
The control connections at M1 and M2 have to be removed and the switching conditions must be checked by an ohmmeter or signal buzzer:
- Simulation of a short circuit in the thermistor chain (0 Ω): Bridge the already disconnected thermistor terminals S1 and S2 and switch on the voltage supply; the relay must switch on then off again after a short period; connection established then interrupted between terminals M1 and M2.
- Simulation of an open thermistor chain (∞ Ω): Remove the jumper used for the short-circuit simulation and switch on the voltage supply; the relay remains switched off; no connection between terminals M1 and M2.

If one of the above conditions is not met, the module is defective and has to be exchanged.

**NOTE:** The function of the module should be tested each time the fuse in the control circuit breaks the power supply. This ensures the contacts did not stick.

### 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 carry out high-voltage or insulation tests if the compressor housing is under vacuum.

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

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

**WARNING**

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

5.1 Strength pressure test

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

5.2 Tightness/pressure test

**WARNING**

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

**WARNING**

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

**CAUTION**

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

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

5.3 Preliminary checks – Pre-starting

Discuss details of the installation with the installer. If possible, obtain drawings, wiring diagrams, etc. It is ideal to use a check-list but always check the following:

- Visual check of the electrics, wiring, fuses etc.
- Visual check of the plant for leaks, loose fittings such as TXV bulbs etc.
- Compressor oil level
- Calibration of HP & LP switches and any pressure actuated valves
- 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

5.4 Charging procedure

**CAUTION**

Low suction pressure operation! Compressor Damage! Do not operate with a restricted suction. Do not operate with the low-pressure cut-out bridged. Do not operate compressor without enough system charge to maintain at least 0.5 bar suction pressure. Allowing pressure to drop below 0.5 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage.

The system should be liquid-charged through the liquid-receiver shut-off valve or through a valve in the liquid line. The use of a filter drier in the charging line is highly recommended. Because R410A and R407C are blends and scrolls have discharge check valves, systems should be liquid-charged on both the high and low sides simultaneously to ensure a positive refrigerant pressure is present in the compressor before it runs. The majority of the charge should be placed in the high side of the system to prevent bearing washout during first-time start on the assembly line.
5.5 Initial start-up

**CAUTION**

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

**CAUTION**

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

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

5.6 Rotation direction

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 three-phase compressors will rotate in either direction depending upon the 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.

5.7 Starting sound

During the very brief start-up, a clicking sound is audible, resulting from initial contacting of the spirals and is normal. Due to the design of the Copeland Scroll, 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.

5.8 Deep vacuum operation

**CAUTION**

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

The scroll compressor can be used to pump down refrigerant in a unit as long as the pressures remain within the operating envelope. Low suction pressures will result in overheating of the scrolls and permanent damage to the compressor drive bearing.

5.9 Shell temperature

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

### 5.10 Pump-down cycle

A pump-down cycle for control of refrigerant migration may be used in conjunction with a crankcase heater when the compressor is located so that cold air blowing over the compressor makes the crankcase heater ineffective.

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

**Pressure control setting:** Never set the low-pressure control 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 control should not be set lower than 12 to 15K equivalent suction pressure below the lowest design operating point.

### 5.11 Pump-out cycle

A pump-out cycle has been successfully used by some manufacturers of large rooftop units. After an extended off period, a typical pump-out cycle will energize the compressor for up to one second followed by an off time of 5 to 20 seconds. This cycle is usually repeated a second time, the third time the compressor stays on for the cooling cycle.

### 5.12 Minimum run time

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

### 5.13 Shut-off sound

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

### 5.14 Supply frequency and voltage

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

The last digit of the model motor code indicates which frequency and voltage must be applied - see paragraph 2.2 "Nomenclature". The availability of codes per compressor model can be checked in paragraph 2.1 "Common information about Copeland Scroll™ compressors".

If the inverter can only deliver a maximum voltage of 400V, the amps will increase when the speed is above 50 Hz, and this may give rise to nuisance tripping if operation is near the maximum power limit and/or compressor discharge temperature limit.
### Table 5: Typical electrical codes in ZH compressors

<table>
<thead>
<tr>
<th>50 Hz</th>
<th>60 Hz</th>
<th>Code</th>
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<tbody>
<tr>
<td>380 – 420 – 3ph</td>
<td>460 – 3ph</td>
<td>D</td>
</tr>
<tr>
<td>220 – 240 – 1ph</td>
<td>265 – 1ph</td>
<td>J</td>
</tr>
<tr>
<td>380 – 420 – 3ph</td>
<td>---</td>
<td>M</td>
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<tr>
<td>220 – 240 – 3ph</td>
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<td>R</td>
</tr>
<tr>
<td>220 – 240 – 1ph</td>
<td>---</td>
<td>Z</td>
</tr>
</tbody>
</table>

#### 5.15 Oil level

During the system development, adequate oil return in any operation should be checked whatever the compressor model. For this purpose, sample compressors equipped with sight tubes can be ordered from Emerson Climate Technologies. Oil return check test recommendations are also available on demand from Application Engineering.

#### 5.16 Oil stub

Compressors ZHI27K1P to ZHI46K1P are equipped with an oil Schraeder valve. The torque for the insert of the Schraeder valve is 5.9 to 6.8 Nm.

For tandemization remove the insert with the Schraeder valve and braze the oil equilization line into the stub.

![Figure 20](image-url)
6  Maintenance & repair

6.1  Exchanging the refrigerant

Qualified refrigerants and oils are given in section 2.3.1.

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

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

6.2  Rotalock valves

Rotalock valves should be periodically re-torqued to ensure that leak tightness is maintained.

6.3  Replacing a compressor

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

6.3.1  Compressor replacement

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

6.3.2  Start-up of a new or replacement compressor

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

A minimum suction pressure of 1.75 bar must be maintained during charging. Allowing pressure to drop below 0.5 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage. Never install a system in the field and leave it unattended when it has no charge, a holding charge, or with the service valves closed without securely electrically locking out the system. This will prevent unauthorised personnel from accidentally operating the system and potentially ruining the compressor by operating with no refrigerant flow. Do not start the compressor while the system is in a deep vacuum. Internal arcing may occur when a scroll compressor is started in a vacuum causing burnout of the internal lead connections.

6.4  Lubrication and oil removal

CAUTION
Chemical reaction! Compressor destruction! Do not mix up ester oils with mineral oil and/or alkyl benzene when used with chlorine-free (HFC) refrigerants.
The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerant R410A is a polyolester (POE) lubricant Emkarate RL 32 3MAF. In the field the oil level could be topped up with Mobil EAL Arctic 22 CC if 3MAF is not available. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1 litre less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (see Figure 21). Only brief exposure to ambient air is needed for POE to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since POE holds moisture more readily than mineral oil it is more difficult to remove it through the use of vacuum. Compressors supplied by Emerson Climate Technologies contain oil with low moisture content, and it may rise during the system assembling process. Therefore it is recommended that a properly sized filter-drier is installed in all POE systems. This will maintain the moisture level in the oil to less than 50 ppm. If oil is charged into a system, it is recommended to use POE with a moisture content no higher than 50 ppm.

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

### 6.5 Oil additives

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

### 6.6 Unbrazing system components

**WARNING**

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

Before opening up a system it is important to remove all refrigerant from both the high and low sides of the system. If the refrigerant charge is removed from a scroll-equipped unit from the high side only, it is possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized. If a brazing torch is then applied to the low side while the low side shell and suction line contain pressure, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and low sides with manifold gauges before unbrazing. Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required, the compressor should be cut out of system rather than unbrazed.
7 Troubleshooting

Most in-warranty electrical failures are a result of mechanical problems (particles in the oil, liquid refrigerant in the oil, etc.) and most mechanical problems are a result of system problems. Unless the reason for the failure is found, replacing the compressor will probably lead to another compressor failure.

If the compressor fails to start and run properly, it is important that the compressor be tested to determine its condition. It is possible that electrical components may be defective, the protector may be open, or a safety device may be tripped. The most common compressor problems encountered in the field are listed below.

**WARNING**

**Electrical connections! Electrical shock!** Before attempting any electrical troubleshooting, make sure all grounds are connected and secure and there is ground continuity throughout the compressor system. Also ensure the compressor system is correctly grounded to the power supply. If you are not a qualified service person familiar with electrical troubleshooting techniques, **DO NOT PROCEED** until a qualified service person is available.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Corrective action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wired incorrectly</td>
<td>Check the power supply on the compressor terminals if there is voltage measured. Trace the wiring diagram to see where the circuit is interrupted.</td>
<td></td>
</tr>
<tr>
<td>Low supply voltage</td>
<td>If the voltage falls below 90% of the nameplate voltage, the motor may develop insufficient torque. Make sure the compressor is supplied with rated nominal voltage.</td>
<td></td>
</tr>
<tr>
<td>Defective capacitor or relay</td>
<td>For a single-phase motor, a defective capacitor or relay may prevent the compressor from starting. Check these components by substituting “a known-to-be-good” component if available. Make sure that the capacitors are electrically discharged before checking.</td>
<td></td>
</tr>
<tr>
<td>Shorted or grounded motor windings</td>
<td>Check the motor for ground by means of a continuity check between the terminals. If grounded replace compressor.</td>
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</tbody>
</table>

The Scroll compressor does not run, instead a buzz sound can be heard

- **Internal compressor mechanical damage**
  - Refrigerant migration: When the compressor is switched off for a long period refrigerant can condense in the crankcase. If the compressor body is colder than the evaporator, refrigerant will move from the evaporator to the compressor crankcase. Refrigerant migration normally occurs when the compressor is installed in a cold area. A crankcase heater and/or a pump down cycle provide good protection against refrigerant migration.
  - Acid formation: Acid forms in the presence of moisture, oxygen, metal, salts, metal oxides and/or high discharge temperatures. The chemical reactions are accelerated at higher temperatures. Oil and acid react with each other. Acid formation leads to damage of the moving parts and in extreme cases to motor burnout. Several different test methods can be used to test for acid formation. If acid is present a complete oil change (including the oil in the oil separator) will help. A suction filter which removes acid should also be fitted. Check filter-drier condition.
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<tr>
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<th>Corrective action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defective system control components</td>
<td>Check if the pressure control or thermostat works properly or if the controls are open.</td>
<td></td>
</tr>
<tr>
<td>Power circuit open</td>
<td>Check the fuse for a tripped circuit breaker or for an open disconnected switch.</td>
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</tr>
<tr>
<td>Burned motor winding</td>
<td>If motor burned due to undersized contactors, you will observe that the contacts welded together. Complete motor burnout on all three phases despite the presence of a functioning protection system can be the result. For sizing information please consult with Contactor manufacturer data sheet. If the application of the compressor is changed the contactor sizing should be rechecked. Check for unbalanced voltage.</td>
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</tbody>
</table>
| High discharge pressure / suction pressure | For high discharge pressure:  
- Check for system leaks.  
- Check the system design. Make sure the discharge line is correctly sized: undersized discharge line can increase discharge pressure. This is also true for an undersized condenser. Correct the component selection as needed.  
- Check the fan motor, make sure it is running properly in the right direction. Check the condenser: if dirt has been accumulated it will clog the airflow; clean as necessary. High discharge pressure is also caused by an overcharged system and high ambient temperature surrounding the condenser.  
- For high suction pressure, check the “evaporator superheat” first to diagnose the problem:  
  - High superheat at the evaporator outlet: this is likely in case of excessive pressure-drop in the liquid line or too much vertical lift on the pipe work.  
  - Low superheat at the evaporator outlet is characterized by oversized selection of the expansion valve or incorrect bulb sensor mounting. The valve may freeze up in the open position due to accumulation of debris in the system. For a system with very short refrigeration lines an accumulator is recommended. |
<p>| The Scroll compressor trips on motor protection | - Check the compressor suction and discharge pressures while it is running. Make sure they are within the operating envelope. |</p>
<table>
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<tr>
<th>Condition</th>
<th>Cause</th>
<th>Corrective action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defective motor protector</td>
<td>If all operating conditions are normal, the voltage supply at the compressor terminals is balanced and within limits, the compressor crankcase temperature is within normal limits, and the amperage drawn is within the specified range, the motor protector may be defective.</td>
<td></td>
</tr>
<tr>
<td>Insufficient cooling medium injected</td>
<td>For compressors using vapour injection, make sure the expansion valve is connected at a distance between 150 mm and 200 mm from the economizer inlet and at a position not lower than inlet connection. The injection line economizer to compressor should be properly sized to avoid pressure drop. For good refrigerant distribution in the economizer respect the recommendations especially those regarding the inlet pipes for the vapour injection according to BHE-manufacturer. The liquid line from the BHE to the expansion valve(s) need to be well insulated as well. A solenoid valve should be installed on the liquid line to prevent refrigerant migration.</td>
<td></td>
</tr>
<tr>
<td>Excessive discharge temperature</td>
<td>Make sure the compressor operates within the acceptable superheat range published by Emerson.</td>
<td></td>
</tr>
<tr>
<td>The Scroll compressor runs continuously</td>
<td>Check the load design; make sure that proper insulation is applied. Correct it as necessary.</td>
<td></td>
</tr>
<tr>
<td>Control circuit inoperative</td>
<td>Check the thermostat, measure the temperature of the room and compare with the thermostat; replace or re-calibrate the thermostat. Check the LP control switch and replace it if it is found defective.</td>
<td></td>
</tr>
<tr>
<td>Oil trap due to incorrect piping layout / sizing</td>
<td>Check the piping layout design. Installations of pipe being routed over or around obstacles can inadvertently create unwanted traps for the oil return. As much as possible the refrigerant line should travel a direct and straight course between the evaporator and compressor. It should also be remembered that the entire system will be coated in oil to some extent. Oil viscosity changes with temperature. More oil stays in the system than was originally expected. Make sure the line is correctly sized.</td>
<td></td>
</tr>
<tr>
<td>Compressor lubrication problem</td>
<td>A high cycling rate will pump oil into the system and lead to lubrication failure. Oil leaves the compressor at start-up and the short running time is insufficient to return the oil to the compressor via the suction side. Try to limit the number of cycles to maximum 10 per hour.</td>
<td></td>
</tr>
<tr>
<td>Low gas velocity</td>
<td>System gas velocity changes depending on temperature and load (capacity control). In low load conditions gas velocity may not be high enough to return oil to the compressor.</td>
<td></td>
</tr>
<tr>
<td>Low discharge pressure</td>
<td>Fit a fan cycling control system.</td>
<td></td>
</tr>
<tr>
<td>Refrigerant undercharge</td>
<td>Check the system for leaks. Observe sight glass for bubbles. Add refrigerant until the sight glass is clear.</td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>Cause</td>
<td>Corrective action</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Low suction pressure</td>
<td>System design load too small</td>
<td>If the compressor is running in a tandem or in parallel, modulate the running process.</td>
</tr>
<tr>
<td></td>
<td>Inadequate refrigerant going to the evaporator</td>
<td>Lower normal discharge pressure values can lead to insufficient refrigerant flow to the system. This can also be verified by checking the evaporator outlet superheat, if it is found unusually high. Check the selection of the expansion valve (likely undersized).</td>
</tr>
<tr>
<td>Noise during shut-off</td>
<td>Anti-reverse device</td>
<td>This does not have any effect on the durability of the compressor, no action is necessary.</td>
</tr>
</tbody>
</table>
8 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.

9 References

Please visit http://www.emersonclimate.com/europe/en-eu/resources for free download of the latest update of these application guidelines and for the documents listed below.

Additional technical information:
- C7.9.1 "Motors for Copeland Scroll™ compressors"
- C7.10.1 "Single-phase Scroll compressor start assist components"
- C7.11.2 "Mounting parts for Copeland Scroll™ compressors"
- C7.11.4 "Sound shell installation instructions for Copeland Scroll™ compressors"
- C7.4.3 "Vapour injection Scroll compressors for heat pumps"
- C7.17.3 "Paralleling of ZH Copeland Scroll™ compressors for heat pump applications"
- C7.8.6 "Discharge gas temperature protection with ZH compressors"

2D-Drawings and certificates:
The latest updates of the drawings and certificates are available from our home page.

Performance and technical data:
The latest version of Emerson Climate Technologies Select software with performance data and technical data is available from our home page.

Spare parts and accessories:
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