Scroll Compressors for CO₂ Subcritical Refrigeration
ZO34K* to ZO104K* & ZOD104K*
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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 Machines directive. They may be put to service only if they have been installed in these systems according to instructions and conform to the corresponding provisions of legislation. For relevant standards please refer to Manufacturers Declaration, available 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>Icon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>WARNING</td>
</tr>
<tr>
<td></td>
<td>This icon indicates instructions to avoid personal injury and material damage.</td>
</tr>
<tr>
<td>⚠️</td>
<td>CAUTION</td>
</tr>
<tr>
<td></td>
<td>This icon indicates instructions to avoid property damage and possible personal injury.</td>
</tr>
<tr>
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<td>High voltage</td>
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<td></td>
<td>This icon indicates operations with a danger of electric shock.</td>
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<tr>
<td>⚠️</td>
<td>IMPORTANT</td>
</tr>
<tr>
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<td>This icon indicates instructions to avoid malfunction of the compressor.</td>
</tr>
<tr>
<td>⚠️</td>
<td>Danger of burning or frostbite</td>
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<tr>
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<td>This icon indicates operations with a danger of burning or frostbite.</td>
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<tr>
<td>⚠️</td>
<td>NOTE</td>
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<td>This word indicates a recommendation for easier operation.</td>
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<tr>
<td>⚠️</td>
<td>Explosion hazard</td>
</tr>
<tr>
<td></td>
<td>This icon indicates operations with a danger of explosion.</td>
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</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.

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

**WARNING**

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

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

**WARNING**

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

**CAUTION**

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

**IMPORTANT**

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

2.1  Common information about Copeland Scroll™ compressors

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

This application guideline deals with all single Copeland Scroll™ compressors for refrigeration applications using CO₂ (R744) for a subcritical operation, from ZO34K* to ZO104K*, including digital compressor ZOD104K*.

<table>
<thead>
<tr>
<th>Compressor</th>
<th>Capacity kW</th>
<th>Motor</th>
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<tbody>
<tr>
<td>ZO34K3E</td>
<td>7.20</td>
<td>TFD</td>
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<tr>
<td>ZO45K3E</td>
<td>10.25</td>
<td>TFD</td>
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<td>ZO58K3E</td>
<td>12.95</td>
<td>TFD</td>
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<tr>
<td>ZO104KCE</td>
<td>22.60</td>
<td>TFD</td>
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<td>ZOD104KCE</td>
<td>22.10</td>
<td>TFD</td>
</tr>
</tbody>
</table>

These compressors have one Scroll compression set driven by a 3-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  About this guideline

This guideline is intended to enable users to ensure the safe installation, starting, operation and maintenance of the Scroll compressors.

This guideline is not intended to replace the system expertise available from system manufacturers.

2.3  Nomenclature

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

ZO D 104 K C E - TFD - 551

- Bill of material number
- Motor version
- Oil type: 
  E = POE oil
- Model variation
- Nominal capacity [BTU/h] @ 60 Hz, subcritical conditions*
- Specification: D = Digital; blank = standard
- Released refrigerant
  R744 (Subcritical operation)
- Compressor family: Z = Scroll

* Subcritical conditions:
  Evaporating temperature .......35°C
  Condensing temperature .......-10°C
  Suction superheat ............20 K
  Liquid sub-cooling ..........0 K
  Suction gas return ..........-15°C
2.4 Application range

2.4.1 Qualified refrigerants and oils

Oil recharge values can be taken from Copeland Scroll™ compressors brochures or Copeland® brand products Selection Software.

<table>
<thead>
<tr>
<th>Qualified refrigerant</th>
<th>CO₂ (R744)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copeland® brand products</td>
<td>Emkarate RL 68 HB</td>
</tr>
<tr>
<td>standard oil</td>
<td></td>
</tr>
<tr>
<td>Servicing oil</td>
<td>Emkarate RL 68 HB</td>
</tr>
</tbody>
</table>

Table 1: Qualified refrigerants and oils

2.4.2 Application limits

CAUTION
Oil dilution! Bearing malfunction! A minimum superheat of 20K at the compressor inlet is required at all operating conditions to avoid oil dilution with CO₂ (R744).

The compressor superheat should be controlled so that it is always above 20K to avoid oil dilution in the compressor but low enough to keep the compressor discharge temperature below 125°C, especially at high compressor ratios (high condensing and low evaporating temperatures).

Figure 1: Compressor operating envelope
3 Installation

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

3.1 Compressor handling

3.1.1 Transport and storage

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

![Diagram of storage and transport](image)

Figure 2

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.

3.1.3 Installation location

Ensure the compressors are installed on a solid level base.

3.1.4 Mounting parts

Four vibration absorber grommets are supplied with each compressor. They dampen the start-up surge of the compressor and minimise sound and vibration transmission to the compressor base during operation. The metal sleeve inside is intended as a guide to hold the grommet in place. It is not designed as a load-bearing member, and application of excessive torque to the bolt 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.

![Diagram of soft mounting parts](image)

Figure 3
3.2 Solenoid valves for model ZOD104K*

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

Care must be taken during the brazing process that no solid parts can enter the control piston compartment or the solenoid valve tubing. To prevent solid parts from entering the control valve seat, the solenoid valve kit contains a filter screen, which has to be placed into the horizontal tube of the valve before brazing the tube connections as shown in Figure 4 below.

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

### 3.2.1 Securing the filter screen into position

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

![Filter screen with washer](image1)

Figure 4

![Position of external solenoid valve](image2)

Figure 5: Position of external solenoid valve

![Recommended piping](image3)

Figure 6: Recommended piping

### 3.2.2 Solenoid valve installation – General recommendations

- The solenoid valve must be mounted vertically, within ± 15° of vertical. Horizontal mounting is not permitted.
- If a suction Rotalock fitting is used, the threaded shipping plug in the Rotalock fitting must be removed prior to brazing in the vertical solenoid line.
- The valve operation is directional. See Figures 7 & 8 below for inlet and outlet locations.
- Do not restrict the line size coming to or leaving the solenoid. Use 3/8” soft drawn copper.
### 3.2.3 Solenoid valve installation – Tubing recommendations

**IMPORTANT**

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

The tube from the solenoid to the suction, marked “A” (see Figure 6), should be as short as possible (less than 7.5 cm). Dimensions for a typical tube going from the top of the compressor are shown in Figures 7 & 8.

### 3.3 Safety relief valves

**WARNING**

High pressure! Personal injuries! Use of safety relief valves according to EN 378 is mandatory.

In a closed system filled with CO₂ the pressure can rise above 50 bar under some ambient conditions. The system must be equipped with safety relief valves according to EN 378 to ensure that the compressor’s approved operating pressures are not exceeded (see Table 2).

<table>
<thead>
<tr>
<th></th>
<th>Maximum operating pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suction</td>
<td>28 bar(g)</td>
</tr>
<tr>
<td>Discharge</td>
<td>43 bar(g)</td>
</tr>
</tbody>
</table>

Table 2

If the unit is shut down for service or other reasons, the pressure will rise due to ambient heat. To prevent the loss of charge at shut down by reaction of the relief valves, it is recommended to provide additional cooling in order to keep the pressure below the maximum operating pressure of suction side.
3.4 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 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.

**Figure 9** shows the proper procedures for brazing the suction and discharge lines to a Scroll compressor.

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

**To disconnect:**

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

**To reconnect:**

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

**NOTE:** Since the discharge stub contains a check valve, care must be taken not to overheat it to prevent brazing material from flowing into it.
3.5 Shut-off valves and adaptors

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

**Figure 10**

Copeland Scroll™ compressors are delivered with a discharge check valve fitted inside the discharge port and rubber plugs fitted to the suction and discharge port as standard.

The ZO compressors are prepared for Rotalock valves. Rotalock shut-off valves are available for the suction as well as discharge side. Using either straight or angled adaptors provides a way to convert a Rotalock into a brazing connection.

Refer to the following table for proper tightening torques:

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Torque [Nm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotalock 3/4&quot;-16 UNF</td>
<td>40-50</td>
</tr>
<tr>
<td>Rotalock 1&quot;1/4-12 UNF</td>
<td>100-110</td>
</tr>
<tr>
<td>Rotalock 1&quot;3/4-12 UNF</td>
<td>170-180</td>
</tr>
<tr>
<td>Rotalock 2&quot;1/4-12 UNF</td>
<td>190-200</td>
</tr>
</tbody>
</table>

Table 3

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

3.6 Active oil management

Where an electronic oil level management system is to be used the OM4 Traxoil comes highly recommended. It is suitable for both high- and low-pressure oil management systems.

The differential pressure required for sufficient oil flow from the oil reservoir to the compressor crankcase depends upon the system. For most applications, a value of 3.5 bar will give satisfactory results, while 1.4 bar can be regarded as a minimum required value.
3.7 Accumulators

**CAUTION**

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

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

- Normal off cycles
- Defrost
- Varying loads

3.8 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.

3.9 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.

3.10 Suction line noise and vibration

Copeland Scroll™ compressors inherently have low sound and vibration characteristics. However in some respects the sound and vibration characteristics differ from reciprocating compressors and in rare instances could result in unexpected sound generation. One difference is that the vibration characteristic of the scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally suspended compressor. These frequencies which are present in all compressors may result in a low level "beat" frequency that can be detected as noise coming along the suction line into the building under some conditions. Elimination of the beat can be achieved by attenuating either of the contributing frequencies. This is easily done by using one of the common combinations of recommended design configurations. The scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the line to prevent vibration transmission into any lines attached to the unit. In a split system the most important goal is to ensure minimal vibration in all directions at the service valve to avoid transmitting vibrations to the structure to which the lines are fastened.
A second difference of the Copeland Scroll is that under some conditions the normal rotational starting motion of the compressor can transmit an “impact” noise along the suction line. This may be particularly pronounced in three-phase models due to their inherently higher starting torque. This phenomenon, like the one described previously, also results from the lack of internal suspension and can be easily avoided by using standard suction line isolation techniques as described below.

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

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

4.1 General recommendations

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

4.2 Electrical installation

The motor insulation material is class "B" for ZO Scroll compressors. This is according to VDE 0530, IEC 34-1 or DIN 57530.

![Power circuit diagram](image)

**Figure 12: Power circuit - Three phase**

4.2.1 Terminal box

The terminal box is IP21 for all models from ZO34K* to ZO104K*.

4.2.2 Motor winding

The ZO Scroll compressors have three-phase induction motors connected in star.

4.2.3 Protection devices

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

4.2.4 Crankcase heaters

**IMPORTANT**

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

A crankcase heater is always required.

![Crankcase heater diagram](image)

**Figure 13: Crankcase heater location**

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

4.3.1 High-pressure control

A high-pressure control with a maximum cut-out setting of 43 bar(a) is recommended. The high-pressure cut-out should have a manual reset feature for the highest level of system protection.

4.3.2 Low-pressure control

A minimum cut-out setting of 5.8 bar(g) is required for ZO compressors (-50°C). Note that CO₂ solidifies at 4.2 bar (g).

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

4.4 Discharge temperature protection

The ZO34K* to ZO104K* and ZOD104K* compressors do not have internal temperature protection and hence require an external thermostat.

For ZOD104K* model, a discharge temperature sensor (NTC thermistor) mounted as close as possible to the discharge fitting in order for the Digital Scroll controller to operate properly could be installed. For best response the sensor should be insulated.

Emerson Climate Technologies provides the correct thermostat and the NTC thermistor as accessories to fit the discharge line of these compressors. The resistance values for the NTC thermistor are provided in Table 4.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Resistance (kOhm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>2,889.60</td>
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<td>-35</td>
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Table 4
4.5 Motor protection

For the ZO range of compressors, conventional inherent internal line break motor protection is provided.

4.6 High-potential testing

**WARNING**

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

**CAUTION**

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

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

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

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

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

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

5.2 Tightness/pressure test

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

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

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

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

5.3 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 6 bar(a) suction pressure. Allowing pressure to drop below 6 bar(a) for more than a few seconds might cause CO₂ solidification and blocked valves or pipes. It may also overheat the scrolls and cause early drive bearing damage.

Ensure charging equipment is approved for at least 90 bar. Charge the system with vapour CO₂ up to a minimum pressure of 6 bar(a) to prevent forming of dry ice. Then continue with charging liquid CO₂. The system should be 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 there may be several valves in the system it is recommended to charge 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.

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. Three-phase compressors will rotate in either direction depending upon phasing of the power. Since there is a 50-50 chance of connecting power in such a way as to cause rotation in the reverse direction, it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction when the system is installed and operated.

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

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

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

5.8 Starting sound

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

5.9 Deep vacuum operation

**CAUTION**

Vacuum operation! Compressor damage! Copeland 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. ZO Scrolls incorporate internal low vacuum protection; the floating seal unloads when the pressure ratio exceeds approximately 10:1.

5.10 Shell temperature

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

5.11 Pump down cycle

A pump down cycle 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 on 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 -50°C equivalent suction pressure below the lowest design operating point.

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 Sound characteristics

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

5.14 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.

5.15 Frequency

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

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

5.16 Oil level

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

6.1 Exchanging the refrigerant
Qualified refrigerants and oils are given in section 2.4.1.

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 6 bar(a) must be maintained during charging. Allowing pressure to drop below 6 bar(a) 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.

6.4 Lubrication and oil removal

CAUTION
Chemical reaction! Compressor destruction! Do not mix up ester oils with mineral oil and/or alkyl benzene.

The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerant R744 is a polyolester (POE) lubricant Uniquema RL68H. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1 litres less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (see Figure 14). 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 a 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.

![Absorption of moisture in ester oil in comparison to mineral oil in (ppm) by weight at 25°C and 50% relative humidity (h = hours)](image)

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 refrigerants and lubricants; however, the moisture indicator will just show the moisture content of the refrigerant. The actual moisture level of POE is 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, Emerson Climate Technologies generally does 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.
6.7 Loss of charge by ambient heat with stopped refrigeration cycle

**CAUTION**
Loss of charge! High pressure! Additional cooling is recommended to prevent loss of charge by reaction of the relief valves. This will keep the pressure below the maximum working pressure level.

Please see maximum working pressures in Table 2 in section 3.3.

7 Dismantling & disposal

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