Application Guidelines

Copeland™ Scroll Compressors for R744 Refrigeration Applications

ZO18AG to ZO46AG, ZOV18AG to ZOV38AG

COPELAND™

EMERSON™

About these guidelines

The purpose of these guidelines is to provide guidance in the application of Copeland™ scroll compressors and Emerson control drives in users' systems operating with CO_2 (R744). They are intended to answer the questions raised while designing, assembling and operating a system with these products.

Besides the support they provide, the instructions listed herein are also critical for the proper and safe functioning of the compressors and drives. The performance and reliability of the products may be impacted if they are not used according to these guidelines or are misused.

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

1 Safety instructions

Copeland scroll fixed- and variable-speed compressors and Emerson motor control drives are manufactured according to the latest relevant European and US safety standards. Particular emphasis has been placed on the user's safety.

The ZO(V)*AG compressors and drives are intended for installation in systems in accordance with the European Machinery Directive MD 2006/42/EC, the Pressure Equipment Directive PED 2014/68/EU, the Low Voltage Directive LVD 2014/35/EU and the Electromagnetic Compatibility Directive EMC 2014/30/EU. They may be put to service only if they have been installed in systems according to instructions and conform to the corresponding provisions of legislation.

The Material Safety Datasheet (MSDS) for R744 shall be considered when working with this type of refrigerant - please check this document provided by the gas supplier.

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

You are strongly advised to follow these safety instructions.

1.1 Icon explanation

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

1.2 Safety statements

- **Refrigerant compressors must be employed only for their intended use. The system has to be labelled according to the applicable standards and legislation.**
- **Only qualified and authorized RACHP (refrigeration, air conditioning and heat pump) personnel are permitted to install commission and maintain this equipment.**
- **Electrical connections must be made by qualified electrical personnel.**
- **All valid standards for connecting electrical and refrigeration equipment must be observed.**
- **The national legislation and regulations regarding personnel protection must be observed.**

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

1.3 General instructions

WARNING
Pressurized system! Serious personal injuries and/or system breakdown! Accidental system start before complete set-up must be avoided. Never leave the system unattended without locking it out electrically when it is on vacuum and has no refrigerant charge, when it has a holding charge of nitrogen, or when the compressor service valves are closed.
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.
System breakdown! Personal injuries! Only CO_2 and approved refrigeration oils must be used. Remove refrigerant from both high- and low-pressure sides with a suitable recovery unit before removing the compressor.

WARNING
CO_2 refrigerant! Danger of suffocation! Never release significant volumes of CO_2 or the entire contents of the system into closed rooms. In case of closed room, if possible, keep the room well ventilated and/or install a CO_2 detection device. CO_2 is odourless and colourless, so it cannot be perceived directly in case of emission.

WARNING
Leaking CO_2 refrigerant! Danger of dry ice formation! In case of system leakage, the decreasing pressure in the system might cross the triple point of carbon dioxide. Dry ice formation can block pipes & components. Unexpected high pressure inside the system might occur.

WARNING
Earth leakage current! Danger of electric shock! This product can cause both AC and DC earth leakage current. To protect against both kinds of leakage current it is recommended to use an AC/DC sensitive RCD on the power supply side.

WARNING
High voltage! Danger of electric shock and/or system breakdown! Disconnect and lock out power before servicing. Allow drive components to electrically discharge before servicing. Respect the time according to drive manual before servicing the drive. Use compressor with grounded system only. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

WARNING
High surface temperature! Burning! Do not touch the compressor or piping until they have cooled down. Ensure that other materials in the area of the compressor do not come into contact with it. Mark and secure accessible sections.

WARNING
Dry ice formation! Frostbite! Whenever a pressure drop with carbon dioxide occurs, there is a risk of dry ice formation. There is a high risk of frostbite when touching dry ice!

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

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

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

2 Product description

2.1 Compressor range

These application guidelines cover Copeland™ scroll fixed- and variable-speed compressor models ZO(V)*AG using CO_2 (R744). These compressors have a speed range of 1500 to 6000 revolutions per minute, corresponding to 25 to 100 revolutions per seconds (1/s). They are intended for use in refrigeration applications. They feature a three-phase brushless permanent magnet (BPM) motor which is controlled by an Emerson EVM/EVH motor control drive, referred to as the "EVM/EVH drive" or "drive" throughout these guidelines.

Figure 1: ZO(V)*AG compressor and EVM/EVH drive

NOTE: **For more information on the motor control drive please refer to the EVM/EVH User Manual.**

Compressor	Cooling capacity* (kW) with R744				Motor
	1500 rpm	3000 rpm	4500 rpm	6000 rpm	
ZO18AG	-	5.95	-	-	TFD
ZO25AG	-	8.25	-	-	TFD
ZO38AG	-	12.45	-	-	TFD
ZO46AG	-	15.15	-	-	TFD
ZOV18AG	2.90	6.29	9.54	12.45	9X9
ZOV25AG	4.06	8.65	13.20	17.45	4X9
ZOV38AG	6.27	13.15	20.10	27.00	4X9

** Evaporating temperature: -35 °C; condensing temperature: -5 °C; suction gas superheat: 10 K; liquid sub-cooling: 0 K*

Table 1: ZO(V)*AG compressor capacity for LT applications

2.2 Matched pairs of compressor and drive

The ZOV*AG compressors with motor code "X" are offered as matched pairs with the EVM/EVH drive, designed in accordance with EN 60335-1.

The matched pairs have been designed for maximum efficiency and reliability. The drive will power the compressor, control the compressor running speed and communicate with the master controller in Modbus RTU protocol. The drive requires cooling and is typically installed in the unit near the compressor. To optimize drive efficiency and to limit electromagnetic interferences, external chokes must be connected to the three-phase drive.

The ZOV*AG compressors are sold as unprotected compressors. They are dedicated for use with a third-party drive. The motor protection is under the responsibility of the system manufacturer/installer.

A third-party control system must include discharge temperature protection, current overload protection, and a soft start-and-stop routine. Contact the Application Engineering department at Emerson for compressor motor specifications and speed adjustment requirements.

It is important to ensure correct wiring at both the compressor and drive connections prior to

starting the compressor to avoid miswiring or a powered reverse situation. Both situations could potentially cause compressor damage.

The matched pairs of compressor and drive released by Emerson are listed in **Table 2** hereunder:

Compressor	Drive	IP rating	Max. working temperature	Drive power supply
ZOV18AG-9X9	EVM-344012-E20EFN	IP2X	40 °C	3~ / 400 V / 50 Hz
ZOV18AG-9X9	EVM-344016-E20EFN	IP2X	50 °C	3~ / 400 V / 50 Hz
ZOV18AG-9X9	EVH-344016-R21BEN	IP54	50 °C	3~ / 400 V / 50 Hz
ZOV18AG-9X9	EVH-344012-R21BEN	IP54	40 °C	3~ / 400 V / 50 Hz
ZOV25AG-4X9	EVM-344012-E20EFN	IP2X	40 °C	3~ / 400 V / 50 Hz
ZOV25AG-4X9	EVM-344016-E20EFN	IP2X	50 °C	3~ / 400 V / 50 Hz
ZOV25AG-4X9	EVH-344016-R21BEN	IP54	50 °C	3~ / 400 V / 50 Hz
ZOV25AG-4X9	EVH-344012-R21BEN	IP54	40 °C	3~ / 400 V / 50 Hz
ZOV38AG-4X9	EVM-344016-E20EFN	IP2X	40 °C	3~ / 400 V / 50 Hz
ZOV38AG-4X9	EVM-344023-E20EFN	IP2X	50 °C	3~ / 400 V / 50 Hz
ZOV38AG-4X9	EVH-344023-R21BEN	IP54	50 °C	3~ / 400 V / 50 Hz
ZOV38AG-4X9	EVH-344016-R21BEN	IP54	40 °C	3~ / 400 V / 50 Hz

Table 2: Matched pairs EVM/EVH drive with ZOV*AG compressors

Compressor	Drive	Cooling capacity* (kW)			
		1500 rpm	3000 rpm	4500 rpm	6000 rpm
ZOV18AG-9X9	EVM-344012-E20EFN	2.90	6.29	9.54	12.45
ZOV18AG-9X9	EVM-344016-E20EFN	2.90	6.29	9.54	12.45
ZOV18AG-9X9	EVH-344016-R21BEN	2.90	6.29	9.54	12.45
ZOV18AG-9X9	EVH-344012-R21BEN	2.90	6.29	9.54	12.45
ZOV25AG-4X9	EVM-344012-E20EFN	4.06	8.65	13.20	17.45
ZOV25AG-4X9	EVM-344016-E20EFN	4.06	8.65	13.20	17.45
ZOV25AG-4X9	EVH-344016-R21BEN	4.06	8.65	13.20	17.45
ZOV25AG-4X9	EVH-344012-R21BEN	4.06	8.65	13.20	17.45
ZOV38AG-4X9	EVM-344016-E20EFN	6.27	13.15	20.10	27.00
ZOV38AG-4X9	EVM-344023-E20EFN	6.27	13.15	20.10	27.00
ZOV38AG-4X9	EVH-344023-R21BEN	6.27	13.15	20.10	27.00
ZOV38AG-4X9	EVH-344016-R21BEN	6.27	13.15	20.10	27.00

** Evaporating temperature: -35 °C; condensing temperature: -5 °C; suction gas superheat: 10 K; liquid sub-cooling: 0 K*

Table 3: Cooling capacity in kW for selected matched pairs

***NOTE:* Operate Emerson matched pairs of inverter and compressor only. Other combinations could cause problems, such as starting issues, low capacity operation or other unusual errors.**

***NOTE:* For the latest list of matched pairs EVM/EVH with ZOV*AG please refer to the EVM/EVH User Manual or contact the Application Engineering department at Emerson.**

2.3 Variable speed advantages

The variable speed scroll is a key component in the variable capacity system. A variable capacity system will use less electrical energy by minimizing On/Off cyclical losses, maximizing heat exchanger efficiency by operating at part load during a majority of the total operating hours, and by operating with reduced airflow rates and fan power.

The variable speed scroll and drive are suitable for a variety of "best-in-class" applications. Both may be used in other types of applications provided that the envelope and other operating restrictions are met. The primary benefit of this product is to substantially reduce electrical energy consumption and associated expenses.

Additionally, a variable speed scroll offers the capability of controlling temperatures to ranges exceeding simple On/Off control, improving overall system conditions. The onboard electronics embedded in the drive greatly reduce the possibility of operation outside the designed parameters which in turn increases overall system reliability.

2.4 Nomenclature

The model designation contains the following technical information:

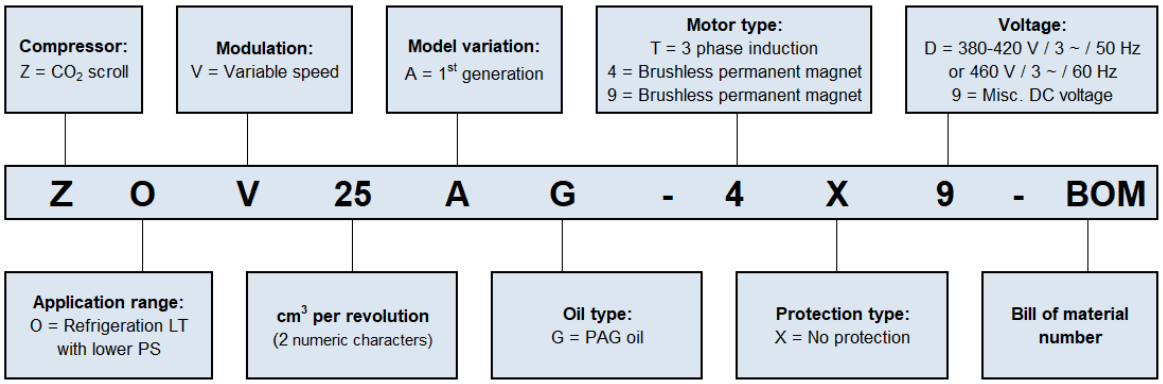


Figure 2: Compressor nomenclature

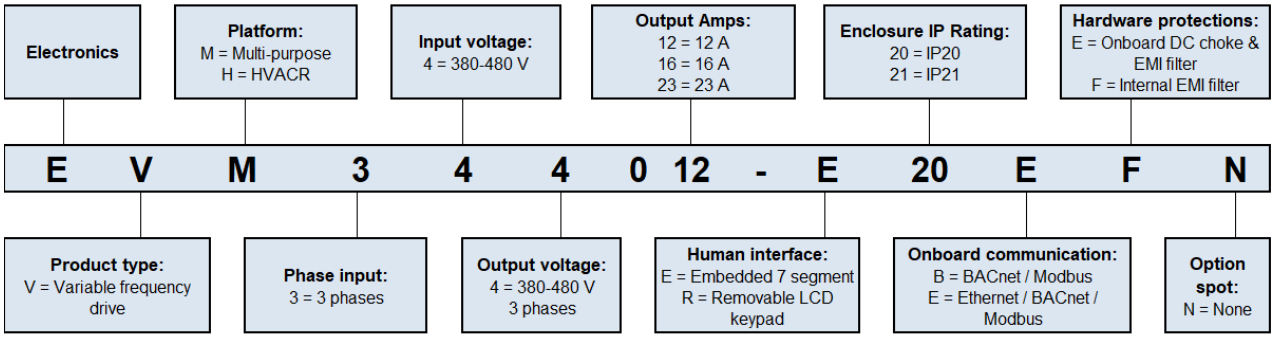


Figure 3: Drive nomenclature

2.5 BOM Variations

The BOM (bill of material) number at the end of the compressor designation indicates the different compressor layouts and details. ZO(V)*AG compressors are available in the following BOM version:

BOM	Suction and discharge connections	T-Box	Mounting parts	Sight glass	Schraeder valve
592	Rotalock	IP54 / IP2X	Without	Yes	Yes

Table 4: BOM designation

Please refer to the Emerson price list for more details.

2.6 Application considerations

2.6.1 Qualified refrigerant and oil

Qualified refrigerant	**R744 (CO_2)**	
Copeland standard oil	Zerol RFL68-EP (PAG)	
Servicing oil	Zerol RFL68-EP (PAG)	
Oil factory charge (in litres)	**ZO*AG**	**ZOV*AG**
	0.9	0.8

Table 5: Qualified refrigerant and oil

ZO(V)*AG compressors are delivered with a factory charge of PAG (polyalkylene glycol) oil.

The compressors should not operate with the oil level below ¼ of the oil sight glass.

Oil recharge values can be taken from Copeland Select software available at www.climate.emerson.com/en-gb.

NOTE: **Use only lubricants that are qualified for the product. The use of non-approved lubricants can damage the product and will result in loss of warranty!**

The recommended quality for carbon dioxide purity class is 4.0 [(≥ 99.99 %) H_2O ≤ 10 ppm, O_2 ≤ 10 ppm, N_2 ≤ 50 ppm] or higher.

The characterization of R744 (CO_2) according to EN 378-1 is safety class A1, not flammable, ODP = 0 and GWP = 1. High concentrations of CO_2 are dangerous. This refrigerant is odourless and colourless. Therefore the use of CO_2 detectors is required.

CO_2 is heavier than air. As a result, local concentrations (especially at floor level or in deeper slots, ie, CO_2 pockets) can be higher than average values in the machine room. The ventilation system must take this into account.

2.6.2 Application limits

CAUTION
Inadequate lubrication! Compressor breakdown! The superheat at the compressor suction inlet must always be sufficient to ensure that no refrigerant droplets enter the compressor. For a typical evaporator-expansion valve configuration a minimum stable superheat of at least 20 K is required.

ZOV*AG compressors operating envelopes depend on the running speed. The envelope limitations are mainly related to lubrication and drive power limitation. ZO*AG compressors are fixed speed and therefore the application limits do not depend on the running speed.

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

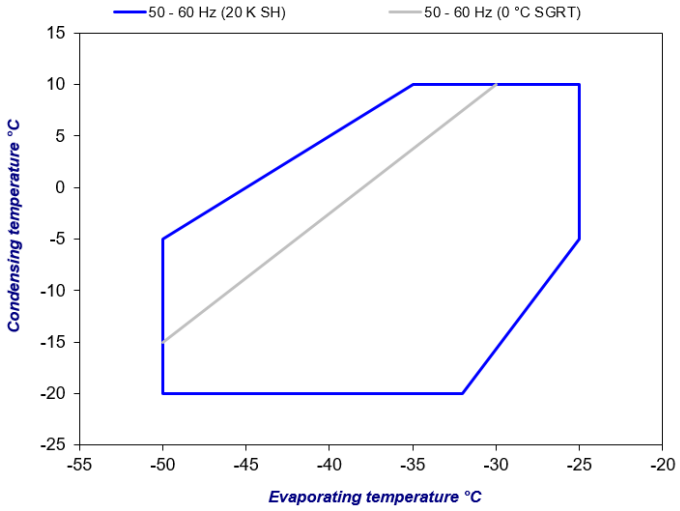


Figure 4: Envelope of the ZO*AG compressors

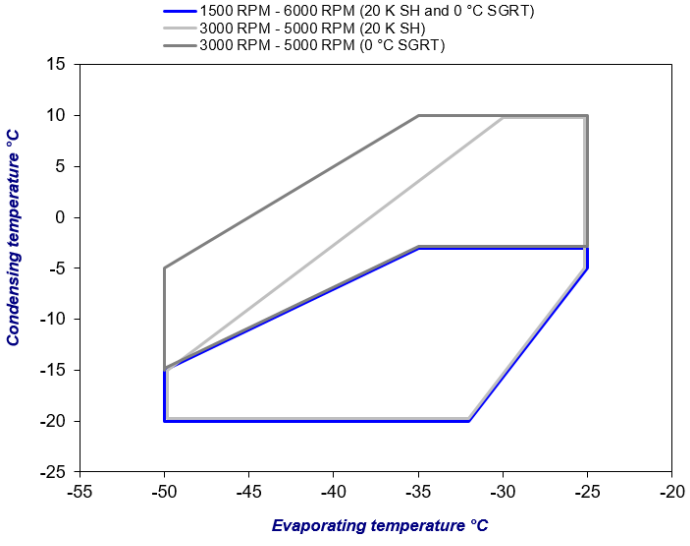


Figure 5: Envelope of the ZOV*AG compressors

NOTE: **For matched pairs with smaller drives, please check the application envelopes in Copeland Select software at www.climate.emerson.com/en-gb.**

Please note the following considerations about operating envelopes:

- Before compressor start with the matched pair of ZOV*AG and the EVM/EVH drive, the pressure difference in the system has to be below 25 bar. If the pressure difference is reduced by opening the expansion valve, care must be taken to avoid liquid floodback to the compressor – also see **section 3.11 "Suction line accumulator"**.
- An oil return test for the system must be performed. If required, the system design should be improved to ensure sufficient oil return from the system to the compressor – also see **section 5.16 "Oil level"**.
- At start-up the system should be able to bring the compressor to a point inside the envelope as fast as possible and to keep the compressor running there. Running outside the envelope is not allowed.
- Running/oscillating the compressor in and out of the envelope borders is not allowed and should be avoided.
- Running the compressor below the envelope at low condensing temperatures is possible for no longer than 30 minutes but the user must be aware that unloading noise from the compressor can occur. In this area the speed limits according to the evaporating temperatures in the envelope should be respected.
- The qualified application envelopes will change with the compressor speed. At all operating conditions the minimum and maximum speed limits according to **Figure 5** have to be respected. With changing operating conditions the speed limits have to be determined by linear interpolation between the limits given in **Figure 5** – also see speed limits animation in Select software available at www.climate.emerson.com/en-gb.
- Fast speed changes can cause instable control, eg, on the superheat control. Per Emerson experience speed changes should be not higher than approximately 200 rpm/s depending on the system reaction.
- The user should adequately take care of controlling the envelope.
- To stop the compressor, see **Figure 6** "Controlled shutdown".

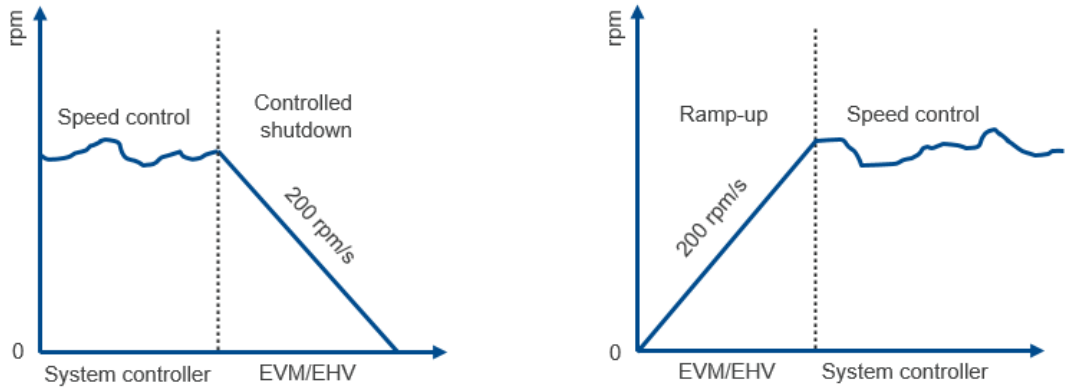


Figure 6: Controlled shutdown and ramp-up

NOTE: **Emerson iProRACK controller series 5 offers all required features to operate the ZO(V)*AG scroll compressors in the low temperature stage of a booster system.**

NOTE: **Before first start, each drive has to be configured according to the compressor model.**

NOTE: **The EVM/EVH drive overload protection aims at protecting the drive and the compressor. It cannot be used in the system as an operating envelope limitation. For more details on the overload protection refer to the EVM/EVH User Manual.**

NOTE: **Paralleling of variable-speed ZOV*AG compressors with fixed-speed ZO*AG models is possible.**

2.6.3 PED category, maximum allowable pressures PS and internal free volume

The ZO(V)*AG compressor models covered in these guidelines are PED Class 1, according to the Pressure Equipment Directive PED 2014/68/EU.

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

Compressor	PS High-pressure side	PS Low-pressure side	TS max LP side	Internal free volume LP side	Internal free volume HP side	PED Class
ZO*AG	60 bar(g)	45 bar(g)	50 °C	2.8 l	0.34 l	1
ZOV*AG	60 bar(g)	45 bar(g)	50 °C	3.3 l	0.34 l	1

Table 6: Maximum allowable pressures PS, TS, internal free volume and PED category

2.6.4 Admissible temperature and relative humidity ranges

ZO(V)*AG compressors must comply with the ambient temperature and humidity ranges specified in **Table 7** below, both for storage and in operation.

Compressor model	Min / max relative humidity	Min / max ambient temperatures in storage or at standstill	Min / max ambient temperatures in operation
ZO*AG	30 % / 95 % No condensing	-50 C° / 50 °C	-50 C° / 50 °C
ZOV*AG	30 % / 95 % No condensing	-50 C° / 50 °C	-50 C° / 50 °C

Table 7: Acceptable ambient temperature and humidity ranges for ZO(V)*AG compressors

***NOTE:* Please refer to the EVM/EVH User Manual for the ambient temperature and humidity ranges.**

2.6.5 Design features

The variable-speed scroll ZOV*AG has a number of design features that improve efficiency and reliability. An HVE valve is part of ZOV*AG models for higher performance at high pressure ratio. This valve prevents reverse rotation during shutdown; however, some shutdown sound may occur.

All ZOV*AG compressors are equipped with a positive displacement oil pump to ensure an adequate supply of oil to the bearing system throughout the operating speed range of 1500 to 6000 rpm.

The motor in the variable-speed scroll is a three-phase, brushless permanent magnet (BPM) design coupled with a rotor embedded with high energy magnets. The input voltage is a series of +DC pulses, spaced in time to create an alternating current frequency.

ZO(V)*AG compressors use a shutdown valve located in the discharge fitting. This check valve is not a low-leak-back check valve and will leak when pressure differential across the check valve is low.

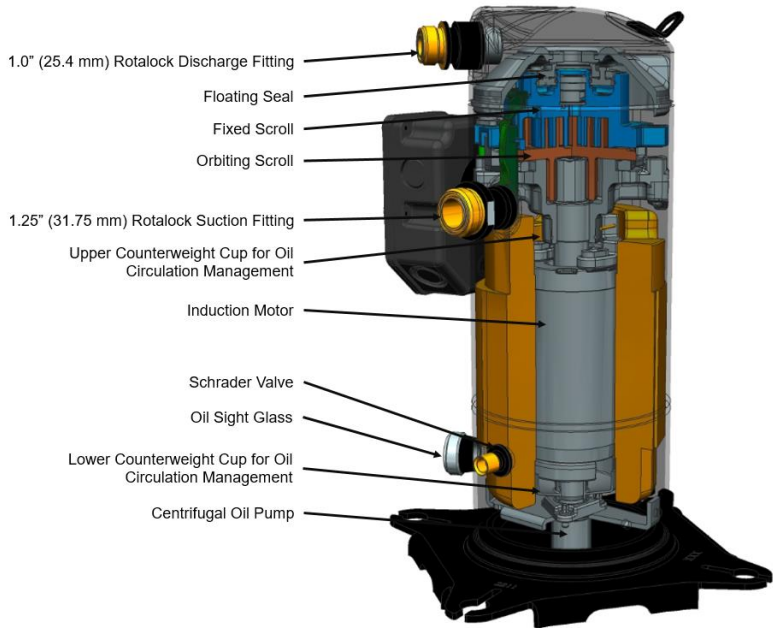


Figure 7: ZO*AG compressor cross sectional view

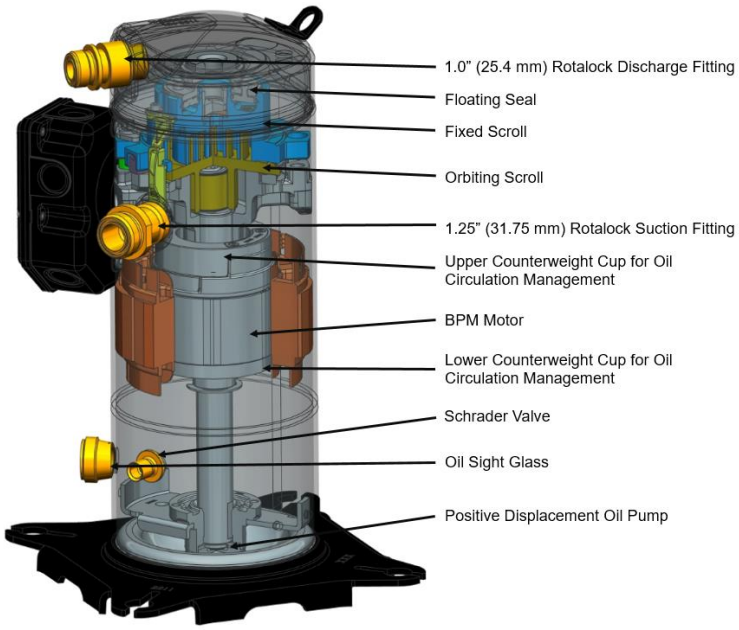


Figure 8: ZOV*AG compressor cross sectional view

2.7 Dimensions

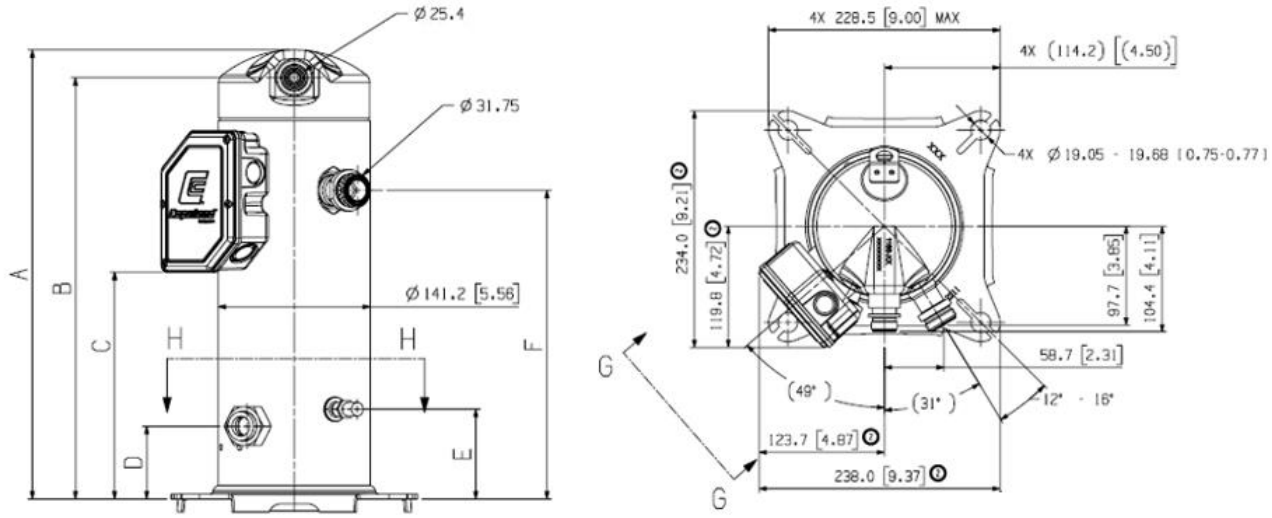


Figure 9: External dimensions of the ZO*AG

Compressor	A	B	C	D	E	F
ZO18AG to ZO46AG	415.8 mm	390.2 mm	209.9 mm	67.4 mm	83.2 mm	285.8 mm

Table 8: Dimensions of the ZO*AG

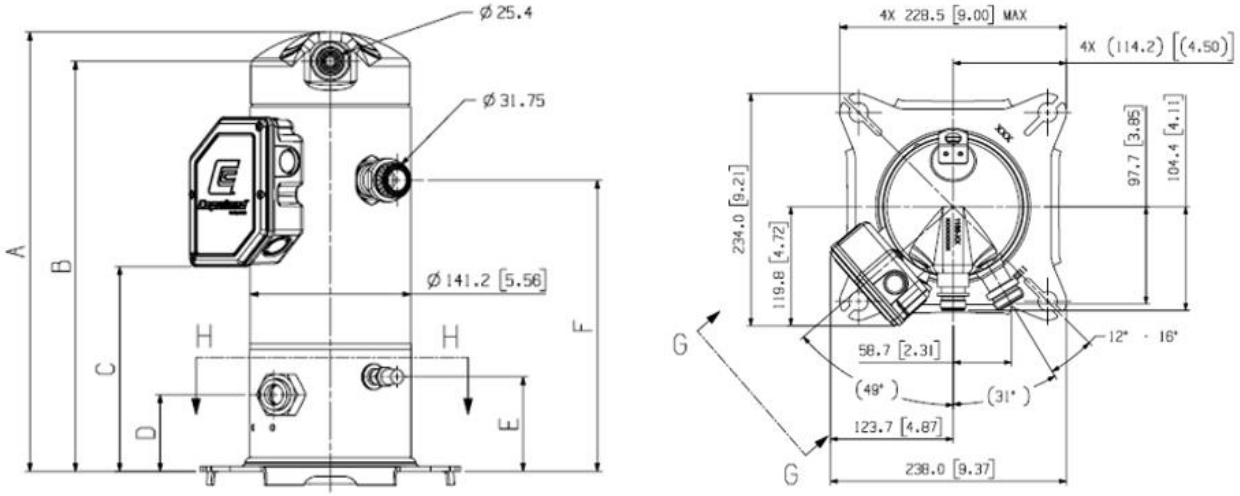


Figure 10: External dimensions of the ZOV*AG

Compressor	A	B	C	D	E	F
ZOV18AG to ZOV38AG	385.8 mm	360.1 mm	179.9 mm	67.4 mm	83.2 mm	255.8 mm

Table 9: Dimensions of the ZOV*AG

3 Installation

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

3.1 Compressor and drive handling

WARNING
Static electricity! Personal injuries! Personnel handling the drives in a manufacturing plant environment should guard against static electricity by using the appropriate equipment, eg, antistatic wrist straps and mats.

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 11**. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Keep the packaging dry at all times.

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

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

Figure 11: Maximum stacking loads for transport and storage

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

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

3.1.2 Positioning and securing

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

The compressor should be kept vertical during handling.

The discharge connection plug should be removed first before pulling the suction connection plug to allow the dry air pressure inside the compressor to escape. Pulling the plugs in this sequence prevents oil mist from coating the suction tube making brazing difficult. The copper-coated steel suction tube should be cleaned before brazing.

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

No object, eg, a swaging tool should be inserted deeper than 45 mm into the suction tube as it might damage the suction screen and motor. Also, no object should be inserted deeper than 30 mm into the discharge tube to avoid damage to the check valve.

3.1.3 Installation location

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

3.2 Compressor mounting parts

The compressors are designed to be mounted on vibration absorber grommets. The grommets dampen the start-up surge of the compressor and minimise sound and vibration transmission to the compressor base during operation. The metal sleeve inside is a guide designed to hold the grommet in place. It is not designed as a load-bearing member, and application of excessive torque to the bolts can crush the sleeve. Its inner diameter is approximately 8.5 mm to fit, eg, an M8 screw. The mounting torque should be 13 ± 1 Nm. It is critically important that the grommet is not compressed.

See Emerson spare parts software for reference.

Standard mounting parts for ZO*AG – Soft mountings

Standard mounting parts for ZOV*AG – Soft mountings

Figure 12: Rubber mounting parts with sleeves

3.3 Shut-off valves and adaptors

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

Torque settings of system valves and adaptors with Rotalock connections might decrease significantly after some time in operation. Recurring temperature changes, vibration and other influencing parameters can lead to expansion and contraction of the metal material and a relaxation of the gaskets. It is recommended to periodically retorque the Rotalock connections to the original settings.

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

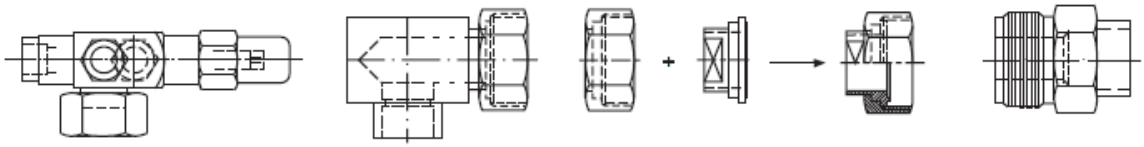


Figure 13: Shut-off valves and connection adapters

Rotalock shut-off valves are available for the suction as well as discharge sides.

Please refer to **Appendix 1** for proper tightening torques.

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

3.4 Pressure safety controls

3.4.1 Pressure relief valves

CAUTION
High pressure! System leak! In the event that a pressure relief valve activates repeatedly, check and replace it in order to avoid a permanent leak. Always check system for CO_2 loss after activation of the pressure relief valve.

Pressure relief valves shall be placed on both the suction and discharge sides of the compressor.

The pressure relief valve does not replace pressure switches or additional safety valves in the system.

- High-pressure side (HP): 60 bar
- Low-pressure side (LP): 45 bar

Usually after a blow-off, pressure relief valves are no longer perfectly tight. It is therefore recommended to control (replace) the pressure relief valves after any blow-off.

3.4.2 High-pressure protection

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

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

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

The high-pressure limiter has to be connected to the drive. For electrical specification please check the drive user manual. Normally the high-pressure limiter must be closed. If the limiter is open, the drive will not operate.

NOTE: **For detailed specifications and instructions to connect the high-pressure limiter to the drive, please refer to the EVM/EVH User Manual.**

3.4.3 Low-pressure protection

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

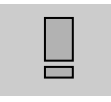
Applicable regulations and standards shall be followed to apply appropriate control and ensure that the pressure is always above the required minimum limit.

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

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

3.5 Crankcase heater

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



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

A crankcase heater is used to prevent refrigerant from migrating into the shell during standstill periods.

The initial start-up in the field is a very critical period for any compressor because all load-bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions. **The crankcase heater must be turned on a minimum of 12 hours prior to starting the**

compressor. This will prevent oil dilution and bearing stress on initial start-up. **The crankcase heater must remain energized during compressor off cycles.**

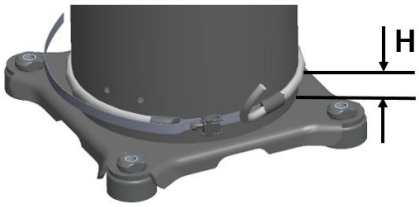
Compressor model	Crankcase heater	
	Position	Height (mm)
ZO18AG to ZO46AG		15
ZOV18AG to ZOV38AG		15

Table 10: Crankcase heater position

NOTE: **Please refer to the Spare Parts list available at www.climate.emerson.com/en-gb/tools-resources to select the correct crankcase heater model.**

Caution: Crankcase heaters must be properly grounded!

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

Assembly instructions

- Choose the appropriate model according to compressor size and required wattage.
- Check the compressor application guidelines for crankcase heater connection and operation.
- Position the crankcase heater between the lower cover and the lower bearing weld projection **(Fig. 14)**.
- Fit the heater horizontally around the crankcase, ensuring that it is in close contact with the compressor housing along the entire length.
- Avoid having the heating portion of the heater in contact with any weld projection **(Fig. 15 & 16)**.
- Avoid having the assembly heater inclined **(Fig. 17)**.
- Close the lock and tighten the screw, torque: 2-3 Nm.
- The excess clamp bracket may be trimmed. Sharp edges must not come into contact with wires.
- The presence of the heater shall be made evident by the posting of caution signs or markings at appropriate locations.

Figure 14

Figure 15

Figure 16

Figure 17

Electrical connection

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

3.6 Discharge gas temperature protection

CAUTION
Inadequate lubrication! Scroll set damage! All ZO(V)*AG compressors must be equipped with a discharge gas temperature protection.

A good system control shall prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the capacity demand. However, under some extreme operating conditions such as loss of charge or improper control operation, the internal discharge gas temperature reached can cause compressor damage.

In order to ensure positive compressor protection, discharge gas temperature protection is required for any application with Copeland compressors.

The maximum discharge gas temperature is 135 °C for ZO(V)*AG compressors.

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

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

3.6.1 Excessive discharge gas temperatures

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

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

The problems listed under the first 2 points frequently occur simultaneously, particularly since the chemical reaction speed approximately doubles with every 10 °C temperature rise. This directly leads to chemical reactions of the oil with the refrigerant and the compounds extracted from sealants and insulation material. As a consequence, contaminants of various types, among them acids, will form inside the system.

3.6.2 Discharge temperature sensor NTC

Variable- and fixed-speed compressors need an external discharge line temperature sensor. The correct reading of this sensor is fundamental for discharge line temperature control. The sensor must ensure accuracy and adequate dynamic behaviour.

Mounting recommendations

- The temperature sensor should be installed along the straight or bended pipe at a distance of 120 mm from the compressor outlet.
- The sensor must be installed in a copper sleeve to improve response time and to reduce setoff. The copper sleeve must be brazed on the surface of the discharge pipe.
- Use thermal compound to improve the heat transfer from the sleeve to the sensor. The thermal compound must be approved for maximum system operating temperatures.
- The discharge pipe including the sensor must be insulated to reduce the impact of ambient temperature.
- Protect the sensor from being moved or removed from its position by transport, vibration or any other incident.

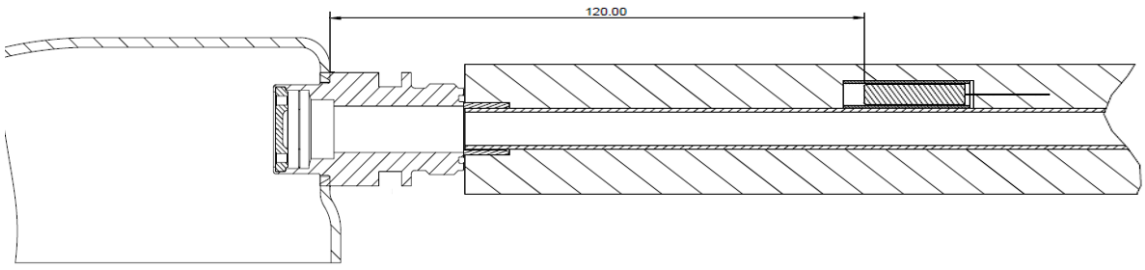


Figure 18: Sensor installation

***NOTE:* For complete mounting recommendations please refer to Assembly Instructions. C30.11 "NTC Mounting Recommendations".**

***NOTE:* When using an Emerson qualified drive, please refer to the drive user manual to see how to connect it.**

The sensor has to be used as a protection device, when the temperature of the discharge line exceeds the limit – see **Table 11**.

Compressor model	Discharge line temperature limit
ZO(V)*AG	135 °C

Table 11: Maximum allowed discharge line temperature

3.7 Filter screens

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

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

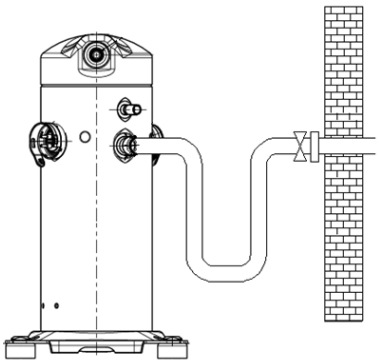
3.8 Mufflers

Gas flow through scroll compressors is continuous with relatively low pulsation. External mufflers may not be required on Copeland scroll compressors.

Due to system variability, individual tests should be conducted by the system manufacturer to verify acceptable levels of sound and vibration. If adequate attenuation is not achieved, use a muffler with a larger cross-sectional area to inlet area ratio. A ratio of 20:1 to 30:1 is recommended.

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

3.9 Sound and vibrations



Vibrations during compressor operation can cause cracks which could lead to refrigerant leakage. This situation must be avoided by the system manufacturer/installer. To this end, the pipework must be carefully designed when connecting a scroll compressor to a system.

A scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the pipework 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.

Figure 19: Example of suction tube design

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

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

3.10 Active oil management

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

In applications with multiple compressors an active oil management system is required. Emerson offers the OM4 TraxOil components for low pressure oil management. Typically, an additional oil reservoir is needed in this case. If the pressure in the oil separator/reservoir is higher than 60 bar Emerson recommends using the OM5 TraxOil components. The OM5 is suitable for both high- and low-pressure oil management systems.

The CO_2 compressors ZO(V)*AG are not released for operation with passive oil management.

For low-pressure oil management systems, Emerson's recommended differential pressure is 3.5 bar in order to achieve sufficient oil flow from the oil reservoir to the compressor. This value will give satisfactory results, while 1.4 bar can be regarded as a minimum required value.

Figure 20: TraxOil OM4 and OM5

3.11 Suction line accumulator

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

To determine if a suction line accumulator is required, the system designer must check this with an appropriate test scenario.

If an accumulator is used, the oil-return orifice should be from 1 to 1.4 mm in diameter for all ZO(V)*AG models depending on compressor size and compressor floodback results. To protect this small orifice from plugging with system debris a large-area protective screen no finer than 30 x 30 mesh (0.6 mm openings) is required. Tests have shown that a small screen with a fine mesh can easily become plugged causing oil starvation to the compressor bearings. The size of the accumulator depends upon the operating range of the system and the amount of sub-cooling and subsequent head pressure allowed by the refrigerant control. For the correct selection and size of the suction line accumulator, refer to the manufacturer's specifications.

4 Electrical connection

4.1 General recommendations

WARNING
Electrical hazard! Serious personal injuries and/or system breakdown! The compressor must always have the ground wire attached to the compressor terminal fence. The other end of the ground wire must be connected to the appropriate ground terminal on the drive.
Disconnect and lock out power before servicing. Allow drive components to electrically discharge before servicing. Respect the time according to drive manual before servicing the drive. Use compressor with grounded system only. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

CAUTION
High voltage! Drive damage! An optional unit contactor must be installed upstream of the drive, not between the drive and the compressor. Nor should a disconnected switch be installed between the drive and the compressor. Major faults and irreversible damage to the drive could occur if the drive output is open-circuit while the compressor is running.

Before connecting the drive to the power network, make sure that all the cables to and from the drive and to the compressor are correctly connected and that the supply voltage, phases and frequency match the drive nameplate data.

Wiring should remain physically separated to minimize the introduction of electrical noise.

Before connecting the compressor, ensure the supply voltage, the phases and the frequency match the nameplate data.

For safety reasons, Emerson recommends that the electrical installation be executed in compliance with standard EN 60335-1 and/or other standards and regulations of application. The wiring must conform to local regulations and codes of practice.

NOTE: **The drive assembly contains accessories such as chokes and EMC filters, which are part of the drive. For detailed list and description please refer to the EVM/EVH Drive User Manual.**

4.2 Electrical wiring

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

For recommended wiring diagrams, see Error! Reference source not found..

The combination of ZOV*AG compressors and inverters can cause earth leakage currents, both AC and DC, due to the presence of the inverter and an EMC filter in the system. Therefore an AC/DC-sensitive residual current device (RCD) must be used on the power supply side. The RCD can be either type B or B+.

NOTE**: For recommendations about the EMC and details about wiring up the drive assembly, please refer to the EVM/EVH User Manual.**

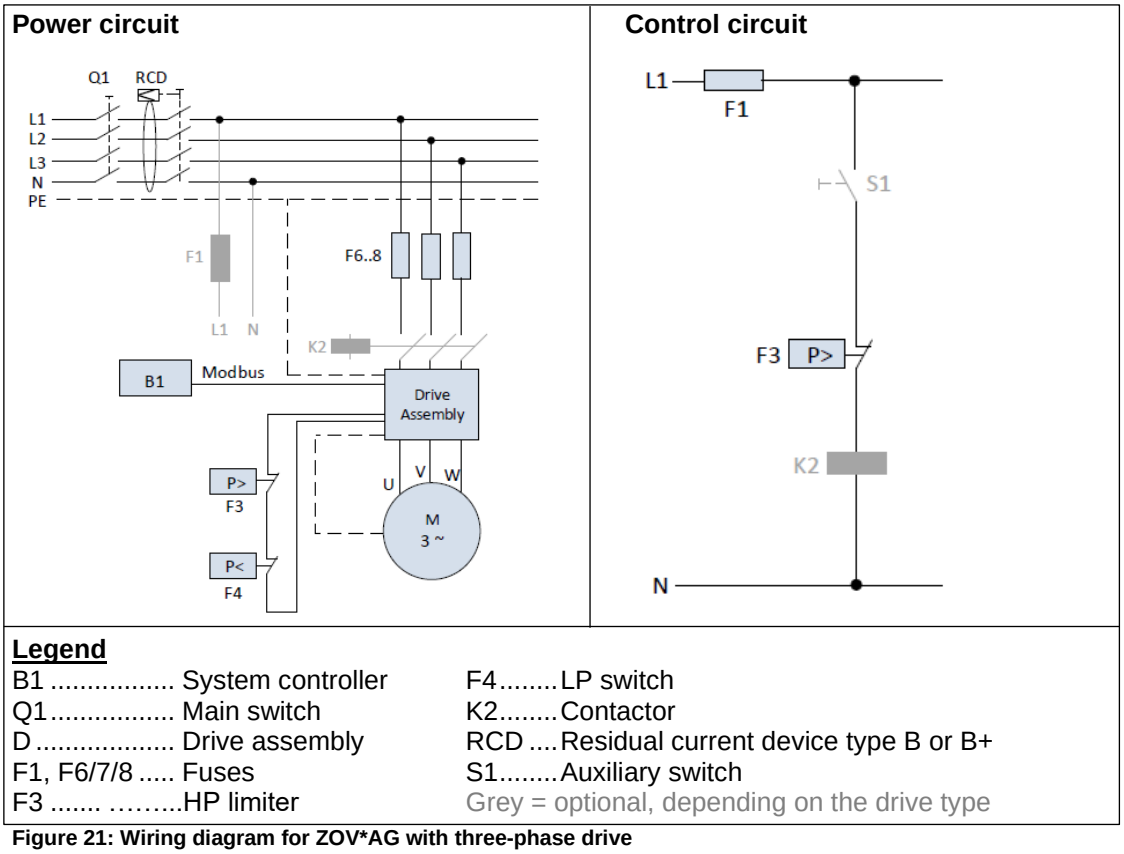


Figure 21: Wiring diagram for ZOV*AG with three-phase drive

4.3 Terminal box

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

Cable glands have an influence on the protection class of the terminal box. Emerson strongly recommends using appropriate cable glands according to EN 50262 in order to reach the rated protection class. An example of correct electrical installation is shown in **Figure 20** below.

The standard terminal box is IP54 for the compressor models ZO(V)*AG.

Figure 22: Terminal box IP54 and correct electrical installation with cable gland

4.4 Electro-magnetic compatibility (EMC) filter

The Emerson qualified EVM/EVH drive can fulfill RSCE120. The user needs to contact the public grid supplier for permission.

For applications and job sites that are sensitive to electro-magnetic interference (EMI), an EMC filter for the EVM/EVH drive is available as an accessory.

Input power cables to the drive should be kept away from the wiring harnesses going to the compressor.

4.5 Line reactors

Line reactors are available as accessories. They reduce the risk of damage to the drive resulting from poor phase balance or severe disturbances on the supply network. Particularly, they will help in:

- reducing harmonic distortion of the input line current;
- improving input line current balance;
- reducing nuisance drive overvoltage trips caused by transient voltage spikes and power line notches;
- protecting input rectifiers from in-rush current caused by sudden power line surges and sags;
- extending the life of the DC bus capacitor bank by reducing the internal heating caused by ripple current;
- protecting motor windings from long lead effects when used on the drive output.

4.6 Motor insulation

The motor insulation material is class "B" (TF*) within maximum allowable operating temperatures according to IEC 34-1 or DIN 57530.

4.7 Motor protection

Fuses must be installed before the drive.

The selection of fuses has to be made according to EN 60269-1 or EN 60204-1 and drive maximum operating current (MOC). Not installing fuses before the compressor or selecting inappropriate fuses may result in compressor failure.

A conventional inherent internal line break motor protection (Klixon) is provided.

4.8 Off-cycle power consumption

The drive will consume approximately 10 Watts from the drive power input line when the drive is powered and there is no command for compressor or crankcase heating operation. The off-cycle power can be eliminated by installing a contactor upstream of the drive and energizing the contactor only when there is a call for compressor, capacitor or crankcase heating.

4.9 High-potential testing

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

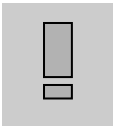
CAUTION
Internal arcing! Motor destruction! Do not carry out high-voltage or insulation tests if the compressor housing is under vacuum.

Emerson subjects all scroll compressors to a high-voltage test after final assembly. Each motor phase winding is tested according to EN 60034-1 at a differential voltage of 1000 V plus twice the nominal voltage.

Since high-voltage tests lead to premature ageing of the winding insulation, further additional tests of that nature are not recommended. However, if it has to be done for any reason, it shall not be made with the compressor charged with refrigerant. Carry out the test with a lower voltage, as described above. Disconnect all electronic devices, eg, motor protection module, fan speed control, drive, etc prior to testing.

5 Start-up & operation

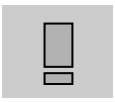
WARNING
Diesel effect! System explosion! The mixture of air and oil at high temperature can lead to an explosion. Avoid operating with air.



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

5.1 Strength-pressure test

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



IMPORTANT
System contamination! Bearing malfunction! Use only dry nitrogen for pressure testing. DO NOT USE other industrial gases.

5.1.1 Compressor strength-pressure test

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

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

5.1.2 System strength-pressure test

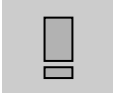
A strength-pressure test of individual sections of the entire system is permitted. Once the compressor is isolated, the rest of the system can be tested with the required pressure values.

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

- System high-pressure section:
  - Define the system high-side PS ≤ compressor high-side PS.
  - Isolate the high- and low-pressure sections of the system by closing valves, solenoid valves, expansion valves or by other means.
  - Use the internal check valve of the compressor on the discharge side or add an external check valve. To protect the compressor internal check valve, observe a maximum pressure delta of ≤ 25 bar between the high-pressure side and the low-pressure side.
  - Activate the check valve with a fast pressure increase. Once the check valve is activated, the pressure increase can be slowed down.
  - At this stage the system test pressure of 1.1 x system high-side PS can be applied for a short time.
  - During the system test, make sure the pressure inside the compressor does not exceed the maximum PS value, which corresponds to the compressor low-pressure PS.
- System low-pressure section:
  - Define the system low-side PS ≤ compressor low-side PS.
  - The system test pressure of 1.1 x system low-side PS can be applied for a short time.

5.2 Compressor tightness test

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



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

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

Never add refrigerant to the test gas (as leak indicator).

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

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

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

5.3 System evacuation

Before the installation is put into commission, it has to be evacuated with a vacuum pump. The installation should be evacuated down to an absolute pressure of 3 mbar. Proper evacuation reduces residual moisture to 50 ppm. During the initial procedure, suction and discharge shut-off valves on the compressor remain closed. The installation of adequately sized access valves at the furthest point from the compressor on the suction and liquid lines is advisable. The pressure must be measured using a vacuum pressure gauge on the access valves and not on the vacuum pump; this serves to avoid incorrect measurements resulting from the pressure gradient along the connecting lines to the pump.

Evacuating the system only on the suction side of a scroll compressor can occasionally result in a temporary no-start condition for the compressor. The reason for this is that the floating seal could axially seal with the scroll set, with the higher pressure on the floating seal. Consequently, until the pressures equalise, the floating seal and scroll set can be held tightly together.

The highest demands are placed on the leak-proof design of the installation and on the leak testing methods – please refer to EN 378.

5.4 Preliminary checks – Pre-starting

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

- visual check of the electrics, wiring, fuses etc;
- visual check of the plant for leaks, loose fittings such as TXV bulbs etc;
- compressor oil level;
- calibration of HP & LP switches and any pressure-actuated valves;
- check setting and operation of all safety features and protection devices;
- all valves in the correct running position;
- pressure and compound gauges fitted;
- correctly charged with refrigerant;
- compressor electrical isolator location & position.

5.5 Charging procedure

CAUTION
Low suction pressure operation! Compressor damage! Do not operate with a restricted suction. Do not operate with the low-pressure limiter 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 CO_2 solidification and blocked valves or pipes. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

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

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

Ensure charging equipment is approved for at least 90 bar. Charge the system with vapour CO_2 up to a minimum pressure of 6 bar(a) to prevent forming of dry ice. Then continue with charging liquid CO_2. The system shall 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. Systems shall be liquid-charged on both the high and low sides simultaneously to ensure a positive refrigerant pressure is present in the compressor before it runs. The majority of the charge shall be placed in the high side of the system to prevent bearing washout during first-time start on the assembly line.

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

5.6 Run-in time

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

5.7 Initial start-up

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

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

5.8 Rotation direction

Scroll compressors, like several other types of compressors, will only compress in one rotational direction. All three-phase compressors will rotate in either direction depending upon phasing of the power. Since there is a 50-50 chance of connecting power in such a way as to cause rotation in the reverse direction, **it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction when the system is installed and operated**.

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

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

5.9 Start-and-stop routine

The drive controls the start-and-stop routine of the variable-speed scroll. This routine allows for soft starting and controlled stopping, an advantage over traditional On/Off control of fixed capacity units.

NOTE: **For more information about this topic please refer to the EVM/EVH User Manual.**

5.10 Starting sound

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

5.11 Deep vacuum operation

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

5.12 Shell temperature

During normal operation, the discharge gas as well as the compressor top shell and discharge line can reach temperatures up to the maximum discharge gas temperature of 135 °C – see **section 3.6 "Discharge gas temperature protection"**.

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

5.13 Pumpdown cycle

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

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

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

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

5.14 Minimum run time

Emerson recommends a maximum of 10 starts per hour. There is no minimum off time because scroll compressors start unloaded, even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after start-up. The minimum on time becomes the time required for oil lost during compressor start-up to return to the compressor sump and to restore a minimal oil level that will ensure oil pick-up through the crankshaft. Cycling the compressor for a shorter period than this, for instance to maintain very tight temperature control, will result in progressive loss of oil and damage to the compressor.

5.15 Shut-off sound

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

5.16 Oil level

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

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

During the system development phase, adequate oil return from the system to the compressor should be evaluated and qualified.

6 Maintenance & repair

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

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

6.1 Qualification of workers

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

Examples of such work procedures are:

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

6.2 Disassembling system components

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

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

6.3 Provisions of legislation & leak check requirements

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

6.4 Exchanging the refrigerant

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

For qualified refrigerant and oil, see **section 2.5.1**.

It is not necessary to replace the refrigerant unless contamination, for example due to an error such as topping up the system with a non-condensable gas or incorrect refrigerant, is suspected. A check can be made during shutdown by comparing the refrigerant temperature and pressure using precision measurements at a location in the system where liquid and vapour phases are present and when the temperatures have stabilised.

6.5 Replacing a compressor

CAUTION
Inadequate lubrication! Bearing destruction! For systems with refrigerant accumulator, exchange the accumulator after replacing a compressor with a burned-out motor. The accumulator oil return orifice or screen may be plugged with debris or may become plugged. This will result in starvation of oil to the new compressor and a second failure.
Remove the refrigerant and oil completely from the replaced compressor.

6.5.1 Compressor replacement

In the case of a motor burnout, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through the use of suction and liquid line filter driers. A 100 % activated alumina suction line filter drier is recommended but must be removed after 72 hours. When a single compressor or tandem is exchanged in the field, it is possible that a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage.

6.5.2 Start-up of a new or replacement compressor

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

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

6.6 Lubrication and oil removal

The compressor is supplied with an initial oil charge. The standard oil for use with R744 is a polyalkylene glycol oil (PAG) lubricant ZEROL RFL68-EP. See nameplate for original oil charge shown in litres.

One disadvantage of PAG is that it is far more hygroscopic than mineral oil – see **Figure 23**. Only brief exposure to ambient air is needed for PAG to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since PAG holds moisture more readily than mineral oil it is more difficult to remove it through the use of vacuum. The compressors supplied by Emerson contain oil with low moisture content, which may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-drier be installed in all PAG 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 PAG with a moisture content no higher than 50 ppm.

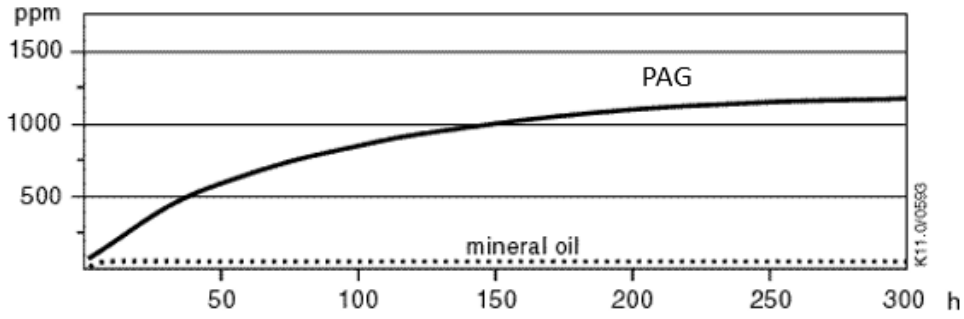


Figure 23: Absorption of moisture in PAG oil in comparison to mineral oil in ppm by weight at 25 °C and 50 % relative humidity (h= hours)

If the moisture content of the oil in a refrigeration system reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 0.3 mbar or lower. If there is uncertainty as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the R744 and lubricants; however, the moisture indicator will just show the moisture content of the refrigerant. The actual moisture level of PAG would be higher than the sight glass indicates. This is due to the high hygroscopicity of the PAG oil. To determine the actual moisture content of the lubricant, samples have to be taken from the system and analysed.

6.7 Oil additives

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

7 Troubleshooting

WARNING

Electrical cables! 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.

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 have tripped. Here is a list of the most common compressor problems encountered in the field.

When troubleshooting a compressor in combination with the drive please follow the recommendations below:

- Read and analyse the alarm registers from the drive and the system controller.
- Before servicing, shut off and secure the power supply and allow drive components to electrically discharge. Discharge times are given in the drive manual and must be respected.
- Drive: Check all the external wiring for miswiring, broken leads or a cable short circuit. Check for loose or burned contacts. Check for burned components on the board.
- Chokes/PFC: Check all the wiring and check for loose or burned contacts.
- External sensors: Make sure that the external sensors are properly connected and still working (discharge temperature sensor and high-pressure switch).
- Drive cooling: For air-cooled drives, make sure that the airflow is not obstructed.
- EMI filter: Check all the wiring and check for loose or burned contacts on the board.
- Compressor: Make sure the compressor is running within the envelope. Check the winding resistances from the compressor motor and the cables between compressor and drive. Check for loose or burned contacts.

Condition	Cause	Corrective action
The scroll compressor does not run, instead a buzz sound can be heard	Wired incorrectly	Check the power supply on the compressor terminals if there is voltage measured. Trace the wiring diagram to see where the circuit is interrupted.
	Low supply voltage	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.
	Shorted or grounded motor windings	Check the motor for ground by means of a continuity check between the terminals. If grounded replace compressor.
	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 pumpdown 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.

Condition	Cause	Corrective action
The scroll compressor does not run, no buzz sound can be heard	Compressor motor protector open	Check if there is continuity on the compressor external protector. If the compressor is warm, it may require considerable time to cool down.
	Defective system control components	Check if the pressure control or thermostat works properly or if the controls are open.
	Power circuit open	Check the fuse for a tripped circuit breaker or for an open disconnected switch.
	Burned motor winding	If motor burned is due to undersized contactors, this is observed when 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.
The scroll compressor trips on motor protection	High discharge pressure / suction pressure	For high discharge pressure: ▪ Check for system leaks. With system leaks at the low-pressure side, air as non-condensable gas could enter the system and create high pressure. ▪ 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 pipework. ▪ Low superheat at the evaporator outlet is usually the consequence of 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 a suction line accumulator is recommended.
	Compressor operating outside the design limits	Check the compressor suction and discharge pressures while it is running. Make sure they are within the operating envelope.
	Defective motor protector	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.

Condition	Cause	Corrective action
Excessive discharge temperature	Too high compressor superheat	Make sure the compressor operates within the acceptable superheat range published by Emerson.
The scroll compressor runs continuously	Excessive cooling / heating load or inadequate insulation	Check the load design. Make sure that proper insulation is applied. Correct as necessary.
	Control circuit inoperative	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.
Compressor lubrication problem	Oil trap due to incorrect piping layout / sizing	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.
	Oil pump out due to high cycling rate	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.
	Low gas velocity	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.
Low discharge pressure	Low ambient temperature	Fit a fan cycling control system.
	Refrigerant undercharge	Check the system for leaks. Observe sight glass for bubbles if fitted. Add refrigerant until the sight glass is clear. If no sight glass is fitted, check the evaporator superheat and fill in with refrigerant.
Low suction pressure	System design load too small	If the compressor is running in a tandem or in parallel, modulate the running process.
	Inadequate refrigerant going to the evaporator	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).
Noise during shut-off	Anti-reverse device	This does not have any effect on the durability of the compressor, no action is necessary.

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 in accordance with national legislation and regulations.**

Dispose of compressor and drive in accordance with national legislation and regulations.

9 References

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

Performance and technical data:

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

Spare parts and accessories:

An online version of the Emerson spare parts and accessories software is available from the webpage www.climate.emerson.com/en-gb/tools-resources.

Appendix1: Tightening torques

Connection	Torque [Nm]
Rotalock 1"	20.3 - 33.9
Rotalock 1 ¼"	27.1 - 40.7
Sight glass external 1 ¼"	45.8 - 53.7
Sight glass fitting TPTL	34 - 41
Mounting bolts M8 (grommet for single operation)	13 ± 1
Mounting bolts M8 (hard mounting parts for //)	27 ± 1
Schraeder valve fitting 5/16, M9	4.5 - 6.8
Crankcase heater	2 - 3
Terminal block screw	1.4 - 1.7
IP54 box ground screw (Peko bolt)	3.6 - 4.4
IP54 ground screw cover / Tbox	3.6 - 4.4
IP54 cable gland M25	9.8 - 10
IP54 Tbox cover screws	1.0 - 1.2

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