Application Guidelines

Copeland Scroll™ Variable Speed Compressors

YHV0182P* to YHV0382P*

COPELAND SCROLL

EMERSON

About these guidelines

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

Besides the support they provide, the instructions listed herein are also critical for the proper and safe functioning of the compressors and motor control drives. The performance and reliability of the product may be impacted if the product is not used according to these guidelines or 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 compressors and Emerson motor control drives are manufactured according to the latest relevant European safety standards. Particular emphasis has been placed on the user's safety.

The YHV*2P 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. For relevant standards please refer to the Manufacturer's Declaration, available at www.climate.emerson.com/en-gb.

NOTE: **Emerson marks all A2L scroll compressors with a sticker for flammable refrigerants. Systems using such refrigerants must comply with applicable legislation and regulations such as but not limited to EN378. It remains the user's responsibility to select products compliant with legislation and regulations applicable for its application.**

The Material Safety Datasheet (MSDS) for individual A2L refrigerants shall be checked and considered when working with such refrigerants. The MSDS is provided by the gas supplier.

These instructions shall be retained throughout the lifetime of the compressor and the drive.

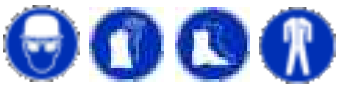
You are strongly advised to follow these safety instructions.

1.1 Icon explanation

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

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 personnel are permitted to install commission and maintain this equipment. Only competent personnel (as specified in EN 13313) qualified for flammable refrigerant handling is permitted to commission, initiate and maintain the compressor/refrigeration systems; non-trained personnel, including the user, are not allowed to do so and must call on an expert.**
- **The maximum refrigerant charge is specified in standards such as, but not limited to EN 378, EN 60335-2-40 and EN 60335-2-89. The system designer shall implement all safety measures defined by the applicable standards and not exceed the maximum refrigerant charge.**
- **If a flammable atmosphere is detected, immediately take all necessary precautions to mitigate the risk as determined in the risk assessment.**
- **Electrical connections must be made by qualified electrical personnel.**
- **All valid standards for connecting electrical and refrigeration equipment must be observed.**
- **The national legislation and regulations regarding personnel protection must be observed.**



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

1.3 General instructions

WARNING
Pressurized system! Serious personal injuries and/or system breakdown! Accidental system start before complete set-up must be avoided. Never leave the system unattended without locking it out electrically when it is on vacuum and has no refrigerant charge, when it has a holding charge of nitrogen, or when the compressor service valves are closed.

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

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

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

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

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

2 Product description

2.1 General information about Copeland Scroll™ compressors

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

These application guidelines deal with the YHV*2P variable speed Copeland Scroll compressors for use with R452B and R454B. These compressors have a speed range of 1200 to 7200 revolutions per minute, corresponding to 20 up to 120 Hz. They are intended for use either in air-source or geothermal residential heat pump applications. They feature a three-phase brushless permanent magnet (BPM) motor which is controlled by an Emerson ED3 motor control drive, referred to as the "ED3 drive" or "drive" throughout these guidelines.

Compressor	Heating capacity for R452B/ R454B [kW]			
	2400 rpm	3000 rpm	4500 rpm	5400rpm
YHV0182P	3.3/ 3.2	4.2/ 4.1	6.4/ 6.2	7.7/ 7.5
YHV0252P	4.6/ 4.4	5.7/ 5.4	8.7/ 8.3	10.5/ 10.1
YHV0382P	6.8/ 6.6	8.6/ 8.3	13.1/ 12.8	15.8/ 15.4

Table 1: Heating capacity in kW at below conditions

Conditions:

Evaporating dew temperature ..... -7 °C
Suction gas superheat ..... 5 K
Ambient temperature ..... 35 °C
Condensing dew temperature .. 50 °C
Condenser sub-cooling ..... 5 K

NOTE: **R452B and R454B are classified as A2L (mildly flammable) refrigerants.**

NOTE: **The drive ED3 is not covered in detail in this document, for more information on the motor control drive please refer to the ED3 User Manual (June 2019 version).**

Figure 1: ED3 drive and YHV*2P compressor

The YHV*2P compressors with protection code "E" are sold as matched pairs with the ED3 drive, designed in accordance with EN 60335-1, as listed in **Table 2**. The motor protection is implemented in the ED3 drive.

The matched pairs have been designed for maximum efficiency and reliability. The drive will power the compressor, control the compressor running speed, provide compressor and drive protection 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 single-phase and three-phase drives.

Compressor	Drive	Drive power supply	Package code ED3 Modbus [318] # OneEmerson [205]
YHV0252P-9**E**9	ED3018B/BU	3~/ 400V/ 50Hz	6
YHV0252P-9**E**9	ED3015A/AU	1~/ 230V/ 50Hz	10
YHV0182P-9**E**9	ED3015A/AU	1~/ 230V/ 50Hz	11
YHV0252P-9**E**9	ED3020A/AU	1~/ 230V/ 50Hz	12
YHV0182P-9**E**9	ED3013B/BU	3~/ 400V/ 50Hz	17
YHV0382P-9**E**9	ED3020A/AU	1~/ 230V/ 50Hz	22
YHV0382P-4**E**9	ED3022B	3~/ 400V/ 50Hz	28

Table 2: Matched pairs ED3 with YHV*2P

The YHV*2P compressors with protection code "X" (see chapter 2.3) listed in **Table 3** 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.

Compressor
YHV0182P-9**X**9
YHV0252P-9**X**9
YHV0382P-4**X**9
YHV0382P-9**X**9

Table 3: Unprotected YHV*2P compressors

A third-party control system must include discharge temperature protection, current overload protection, and a soft start and stopping routine. Stator heat control is also recommended for optimal performance and reliability. It should also include the operating map parameters. 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 powered reverse situation. Both situations could potentially cause compressor damage.

***NOTE:* For the latest list of matched pairs ED3 with YHV*2P please refer to the ED3 User Manual (June 2019 version) or contact the Application Engineering department at Emerson.**

2.2 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 blower 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 space and domestic hot water temperature to ranges exceeding simple on-off control, improving overall comfort levels inside the building. The onboard electronics embedded in the drive greatly reduce the possibility of operation outside the designed parameters which in turn increases overall system reliability.

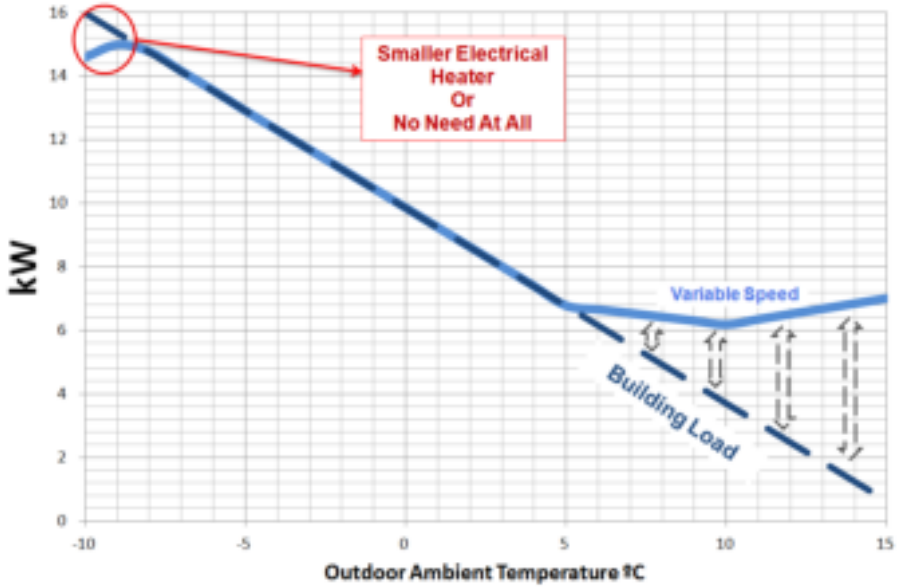


Figure 2: Variable speed solution to follow the building heat demand

2.3 Compressor and drive nomenclature

The compressor and drive model designation contains the following technical information:

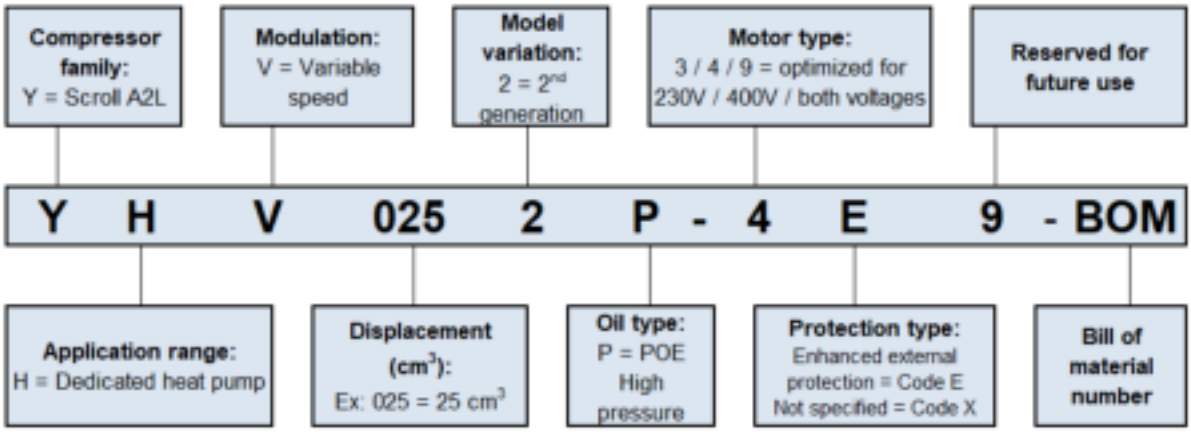


Figure 3: Compressor nomenclature

2.4 Application considerations

2.4.1 Qualified refrigerant and oil

Oil recharge values can be taken from Copeland Scroll compressors brochures or Copeland™ brand products Select software available at www.climate.emerson.com/en-gb.

Compressors	**YHV0182P, YHV0252P, YHV0382P**
Qualified refrigerant	**R452B and R454B**
Copeland brand products standard oil	Emkarate RL 32 3MAF

Table 4: Qualified refrigerant and oil

2.4.2 Admissible temperature and relative humidity ranges

The Scroll compressor must comply with the ambient temperature and humidity ranges specified in **Table 5** below, both for storage and in operation.

Compressor model	Min / max relative humidity	Min / max ambient temperatures	
		in storage or at standstill	in operation
YHV*2P	30 / 95% No condensing	-35 °C / 50 °C	-35 °C / 60 °C

Table 5: Acceptable ambient temperature and humidity ranges for the compressor

Compressor	PS High-pressure side	PS Low-pressure side	TS Low-Pressure side	PED category
YHV*2P	49 bar(g)	28 bar(g)	-35 °C	2

Table 6: Maximum allowable pressure

2.4.3 Application limits & operating envelopes

CAUTION

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

YHV*2P compressors operating envelopes depend on the running speed. The envelope limitations are mainly related to lubrication and power limitation.

The lower right boundary of the operating envelope is the minimum compression ratio required to keep the scrolls loaded. Operation below this boundary could result in the compressor intermittently loading and unloading and noisy operation.

The upper left boundary of the envelope represents the maximum compression ratio. If the operating condition approaches this boundary the compressor discharge temperature will begin to approach the maximum scroll temperature allowed by the discharge line temperature sensor – see details in chapter 4.5 "Discharge gas temperature protection". The temperature sensor must signal the drive or system unit controller to shut down if the discharge line temperature exceeds the specified temperature on the operating envelope.

For DLT-control mode with YHV*2P compressors in the upper left boundary of the envelope, please also refer to chapter 2.4.4 "Discharge line temperature control mode".

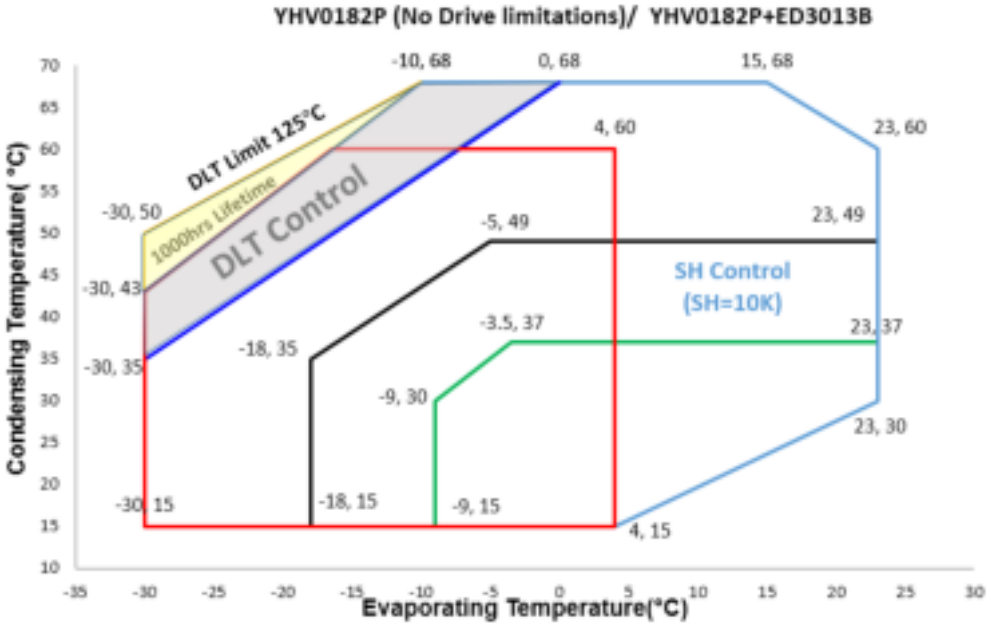


Figure 4: Application envelope for YHV0182P-9E9 using R452B and R454B

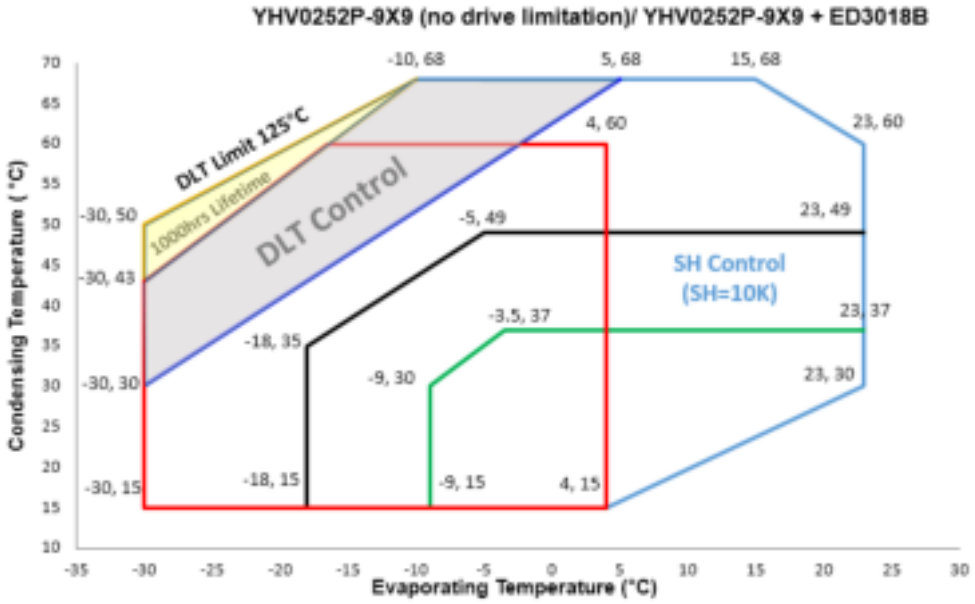
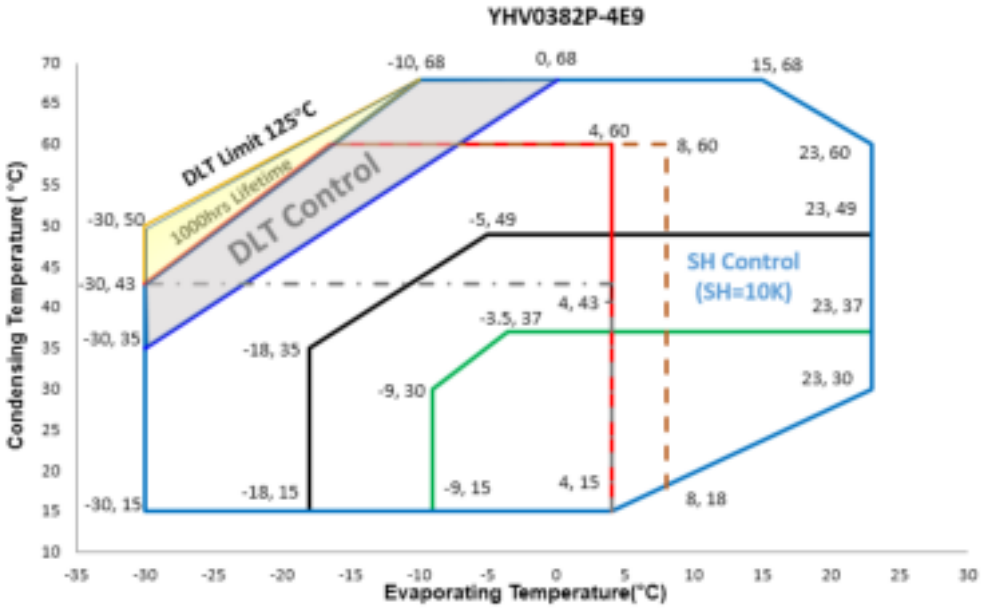
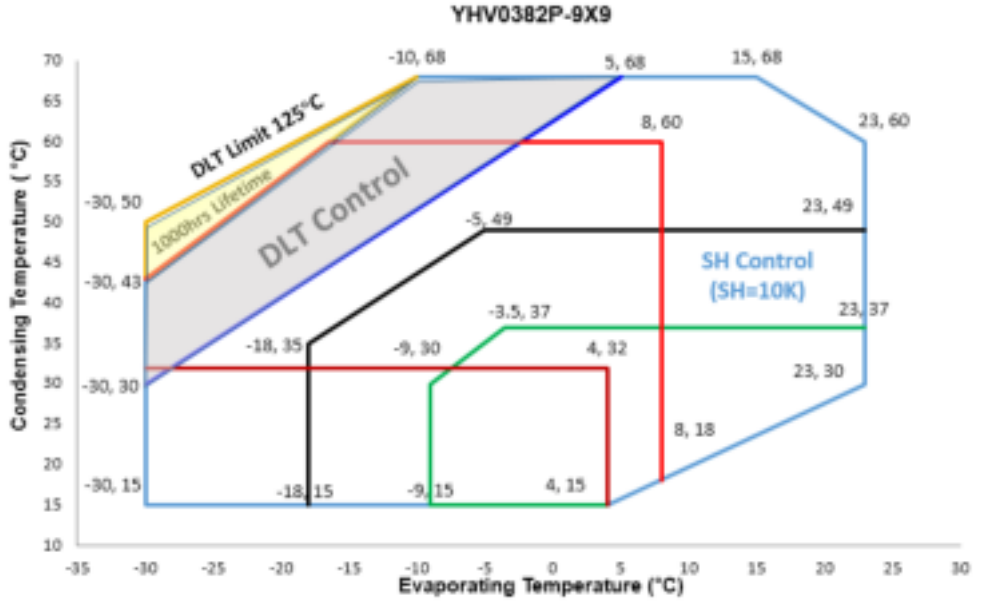


Figure 5: Application envelope for YHV0252P-9E9 using R452B and R454B



Legend	YHV0382P-4X9 No drive limitation (rpm)	YHV0382P-4X9 + ED3018B (rpm)
	1200	1200
	1800	1800
	2400-5400	2400-4500
	2400-7200	Linear interpolation
	Linear interpolation	2400-5400
	Linear interpolation	2400-7200

Figure 6: Application envelope and legend for YHV0382P-4E9 using R452B and R454B



Legend	YHV0382P-9X9 No drive limitation (rpm)	YHV0382P-9X9 + ED3020A (rpm)
	1200-5400	1200-3600
	1800-5400	1800-3600
	2400-5400	2400-3600
	2400-7200	2400-4500
	Not shown	2400-7200

Figure 7: Application envelope and legend for YHV0382P-9X9 using R452B and R454B

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

Please note the following about operating envelopes:

- Before compressor start with the matched pair of YHV*2P and ED3, the pressure difference in the system has to be below 10 bar. If the pressure difference is reduced by opening the expansion valve, care must be taken to avoid liquid flood back to the compressor – also see chapter 3.3 "Accumulators" and **Figure 16**.
- 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 chapter 5.14 "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. Emerson's recommendation is to start with a speed of 3000 rpm and to freeze the speed for minimum 30 seconds or longer until the system is in stable operation – see **Figure 8** "Ramp up".
- 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 **Figures 4 to 7** have to be respected. With changing operating conditions the speed limits have to be determined by linear interpolation between the limits given in **Figures 4 to 7** – 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 in the range of 10 to 60 rpm/s depending on the system reaction.
- The user should adequately take care of controlling the envelope.
- To stop the compressor, reduce the speed to 3000 rpm then stop the compressor – see **Figure 8** "Controlled shutdown".

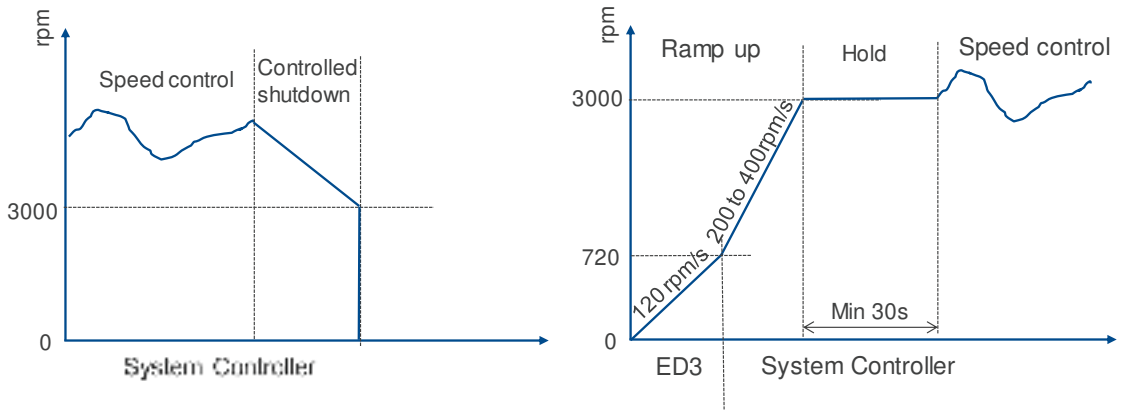


Figure 8: Ramp-up and controlled shutdown

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

NOTE: **The ED3 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 ED3 User Manual (June 2019 version).**

2.4.4 Discharge line temperature control mode

In the lower part of the envelope (Control Suction Superheat) shown below the suction gas at the compressor inlet has to be superheated without liquid droplets. For superheat requirements please also refer to chapter 2.4.3 "Application limits & operating envelopes".

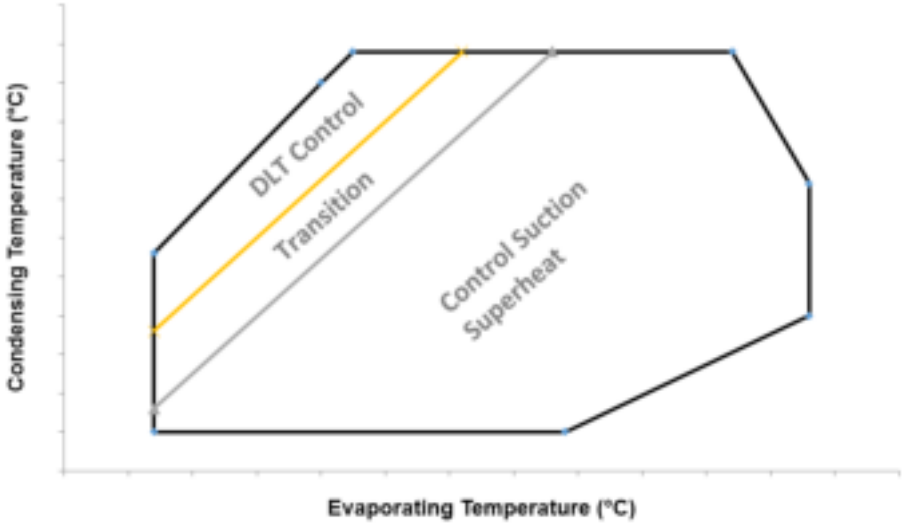


Figure 9: Schematics of expansion valve control mode

In the upper part of the envelope (DLT Control) with operation at low evaporating and high condensing with superheat control mode, the discharge temperature will exceed the limit of 125 °C inside the application envelope – also see chapter 3.3 "Suction line accumulators". In this area, the expansion valve of the evaporator is to be controlled not by superheat but by the discharge line temperature so that some liquid droplets return to the compressor to cool it down. The discharge line temperature DLT must be controlled to stay between minimum 115 °C and maximum 125 °C.

The move from superheat control to DLT control is demand-driven by the discharge line temperature. In the transition phase DLT control and superheat control have to be balanced by the system controller. The superheat at compressor inlet should be reduced gradually to 0 K. As the demand to move to DLT control depends, eg, on system design such as compressor insulation and ambient temperature, there is no specified line at which this will happen.

2.4.5 Design features

The variable speed scroll YHV*2P has a number of design features that improve efficiency and reliability.

All the YVH* models are equipped with a positive displacement oil pump to ensure an adequate supply of oil to the bearing system throughout the operating speed range.

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.

2.4.6 Oil recovery

For oil return the exact parameters for an oil recovery cycle need to be evaluated for each system by oil return tests, as they may differ depending on system application. Please contact and review with Application Engineering at Emerson for any desired changes to this oil recovery cycle requirements.

2.5 Dimensions

The external dimensions of YHV*2P compressors are shown in **Figures 10 & 11** below.

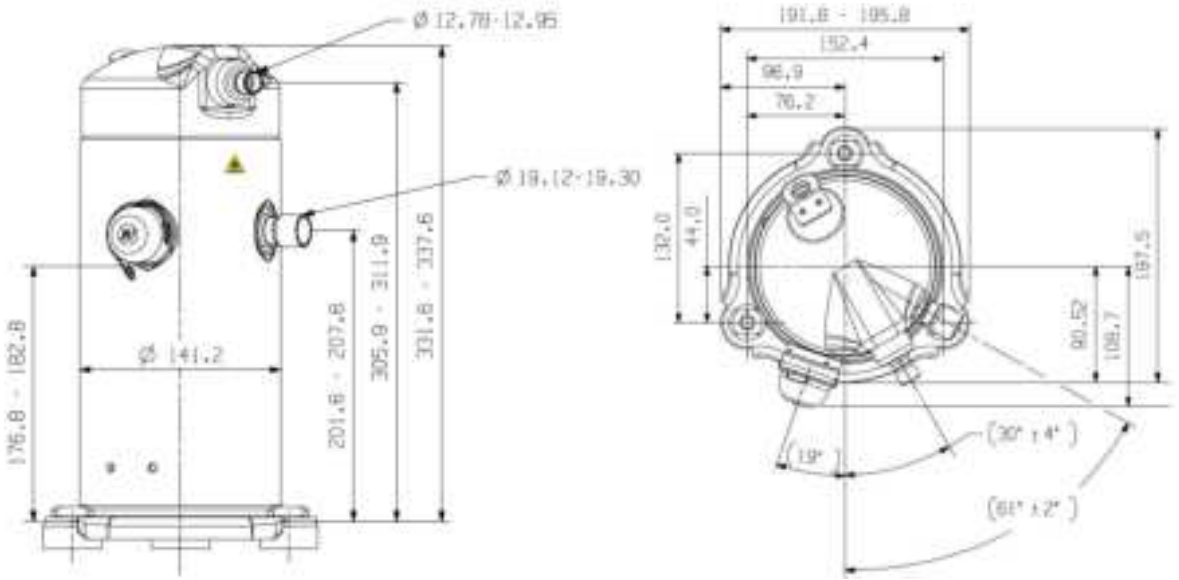


Figure 10: External dimensions of compressor models YHV0182P and YHV0252P

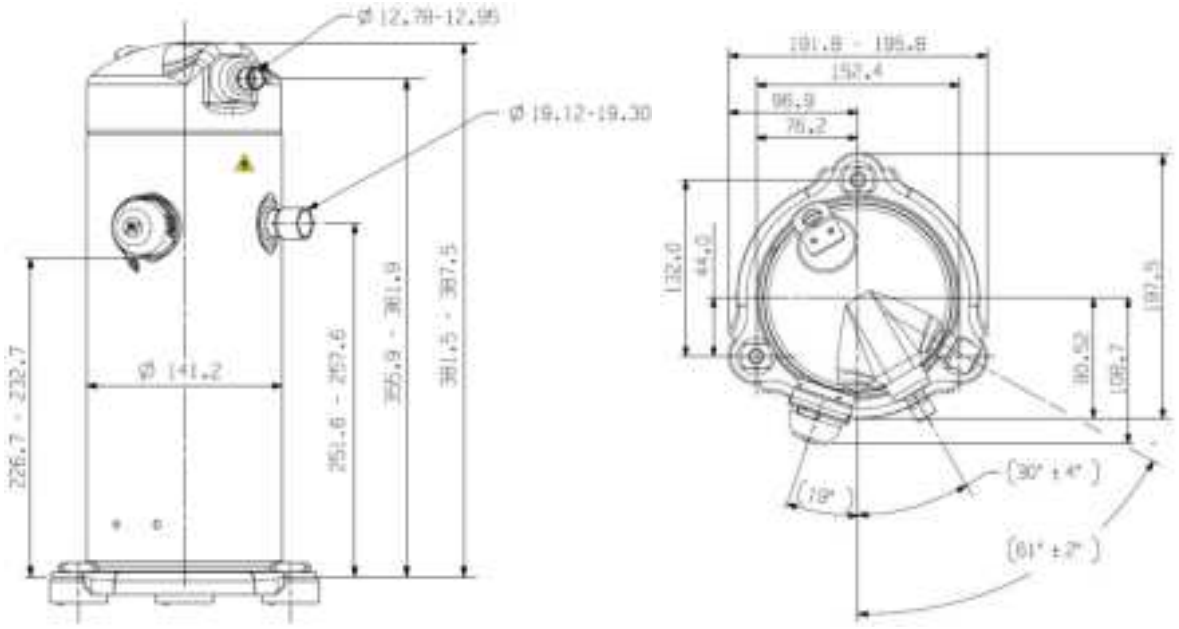


Figure 11: External dimensions of compressors YHV0382P

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 - antistatic wrist straps and mats.

3.1.1 Compressor 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 12**. 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 12: Maximum stacking loads for transport and storage

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

3.1.2 Compressor 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.

As oil might spill out of the suction connection located low on the shell, the suction connection plug must be left in place until the compressor is set into the unit.

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

3.1.3 Installation location

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

3.1.4 Compressor mounting parts

The compressors are designed to be mounted on vibration absorber grommets (part of the standard delivery). The grommets dampen the start-up surge of the compressor and minimise sound and vibration transmission to the compressor base during operation. The 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 suit a M8 screw. The mounting torque should be 13 ± 1 Nm. It is critically important that the grommet is not compressed.

Mounting parts YHV*2P – Soft mountings

Figure 13: Rubber mounting part with sleeve

3.2 Compressor brazing procedure

WARNING
Air/flammable refrigerant mixture! Creation of a potentially flammable atmosphere! Fire hazard! Remove all refrigerant before opening the system. When working on a refrigerant-filled system, make sure to follow the safety and working instructions given in the **Chapter 6 "Maintenance & repair"**.

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

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.

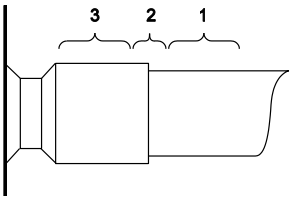


Figure 14: : Brazing areas

Copeland Scroll compressors have copper-plated steel suction and discharge. These tubes are far more robust and less prone to leaks than copper tubes. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

Refer to **Figure 14** and procedure below for the brazing of the suction, discharge and injection lines to a Scroll compressor.

- For systems with A2L refrigerants, it is mandatory to flush oxygen-free nitrogen through the piping during the brazing process.
- The copper-coated steel tubes on scroll compressors can be brazed in approximately the same manner as any copper tube.
- Recommended brazing materials: any silfos material is recommended, preferably with a minimum of 5% silver. However, 0% silver is acceptable.
- Be sure tube fitting inner diameter and tube outer diameter are clean prior to assembly.
- Using a double-tipped torch, apply heat in area 1.
- As the tube approaches brazing temperature, move the torch flame to area 2.

- Heat area 2 until braze temperature is attained, moving the torch up and down and rotating around the tube as necessary to heat the tube evenly. Add braze material to the joint while moving the torch around the joint to flow braze material around the circumference.
- After the braze material flows around the joint, move the torch to heat area 3. This will draw the braze material down into the joint. The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

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

NOTE**: YHV*2P compressors include a suction funnel to guide the suction gas internally directly to the scrolls. Since the funnel is made of plastic, a wet rag or any other suitable heat protection must be used when brazing the suction line to the compressor.**

Figure 15: Suction funnel (purple part) in YHV*2P compressors

3.3 Suction line accumulators

CAUTION
Inadequate lubrication! Bearing and moving parts destruction! Avoid liquid refrigerant returning to the compressor. Liquid refrigerant dilutes the oil, could wash the oil off the bearings, moving parts and could lead to overheating and compressor failure.

Application of A2L refrigerants could have an impact on the PED classification (pressure equipment directive 2014/68/EU). Select and determine the correct PED classification of refrigeration components, such as suction accumulators.

Irrespective of system charge, oil dilution may occur if large amounts of liquid refrigerant repeatedly flood back to the compressor during, e.g.:
- normal off cycles
- defrost
- varying loads

Due to Copeland Scrolls inherent ability to handle liquid refrigerant in flooded start and defrost cycle operation, an accumulator is not required for durability in most systems. However, large volumes of liquid refrigerant repeatedly flooding back to the compressor during normal off cycles, or excessive liquid refrigerant flooding back during defrost or varying loads can dilute the oil, no matter what the system charge is. As a result, bearings and moving parts will be inadequately lubricated and wear may occur.
To determine if the accumulator can be removed, dedicated tests must be carried out to ensure that excessive liquid does not flood back to the compressor during defrost or varying loads. The defrost test must be done at an outdoor ambient temperature of around 0 °C in a high relative humidity environment. Liquid flood back must be monitored during reversing valve operation, especially when coming out of defrost. Excessive flood back occurs when the sump temperature drops below the safe operation line shown in the **oil dilution chart**, see **Chapter 5.13**.

If an accumulator is used, the oil-return orifice should be from 1 to 1.4 mm in diameter for all YHV*2P models depending on compressor size and compressor flood-back 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. System modelling indicates that systems operating down to and below -18 °C will require an accumulator that can hold around 70% to 75% of the system.

3.4 Filter screens

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

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

3.5 Mufflers

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.

3.6 Sound shell

No sound shell attenuation for YHV*2P compressors is available from Emerson at this time. If a sound shell is still needed, particular attention shall be paid to the electrostatic charge of the insulation material, which could be a potential ignition source.

3.7 Insulation material

Insulation material is typically used in a system to insulate the suction line, suction accumulator, expansion valve bulb or discharge line thermostat. When choosing the insulation material, particular attention shall be paid to its electrostatic charge, which could be a potential ignition source.

3.8 Reversing valves

A variable speed scroll brings a significant benefit during the defrost cycle. By taking advantage of the higher speeds and flow rates, the defrost time will typically be shorter than in a fixed-speed compressor system, which will reduce the time electric resistance heat is used during the defrost cycle.

Reversing valve sizing must be within the guidelines of the valve manufacturer. Required pressure drop to ensure valve shifting must be measured throughout the operating range of the unit and compared to the valve manufacturer's data. Conditions that generate low flow rates and low pressure drop across the valve can result in a valve not shifting.

This can result in a condition where the compressor appears to be not pumping, i.e. balanced pressure. It can also produce elevated compressor sound levels. During a defrost cycle, when the reversing valve abruptly changes the refrigerant flow direction, the suction and discharge pressures will go outside of the operating envelope. The condition will usually cross the diagonal line representing the lower right-hand side corner of the envelope. The sound that the compressor makes during this transition period is normal, and the duration of the sound will depend on the coil volume, outdoor ambient and system charge.

Since Copeland Scroll compressors have a very high volumetric efficiency their displacements are lower than those of equivalent capacity reciprocating compressors. As a result, Emerson recommends that the capacity rating on reversing valves be no more than 1.5 to 2 times the nominal

capacity of the compressor in order to ensure proper operation of the reversing valve under all operating conditions.

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

The preferred method of mitigating defrost sound for the variable speed scroll is to signal the drive to go to low speed when a defrost signal is received from the system. When low speed is reached, the reversing valve is signalled to change positions. The system should be allowed to operate for 30 to 60 seconds at low speed for the suction and discharge pressures to stabilize. After 30 to 60 seconds the compressor speed should be increased to some predetermined speed based on the outdoor ambient temperature. The routine at the end of the defrost cycle should be similar. The above method is a suggestion and the system design engineer should develop the routine that best mitigates compressor sound during defrost while ensuring a defrost cycle that is as short as possible.

3.9 Sound and vibration

WARNING
Vibration! Creation of flammable atmosphere! Carefully check the system for vibrations.

When connecting a Scroll compressor to a system, care must be taken to ensure that the piping is properly designed.

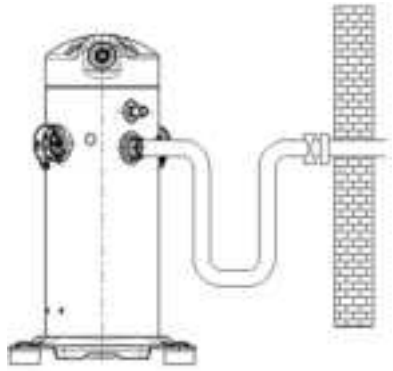


Figure 16: flexible tube design

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

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

Since the variable speed scroll has a broad running frequency range (15-120 Hz), it is almost impossible to avoid all of the natural frequencies that may exist in the system piping. The system designer must carefully evaluate these resonant frequency conditions and either a) avoid them by not allowing the compressor speed to align with the resonant frequency, or b) evaluate the risk and life of the piping system when the compressor is allowed to run at frequencies that are coincident with the natural frequencies of the piping system. If option "b" is chosen, strain gauging of the system piping is required.

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. For variable speed scroll compressors, they also and mainly increase with the compressor speed.

4 Electrical connection

4.1 General recommendations

WARNING
High voltage! Electrical shock hazard! Serious personal injuries! 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. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

CAUTION
High voltage! Drive damage! The unit contactor must be installed upstream of the drive, i.e., not 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.

For safety reasons, Emerson recommends that the electrical installation be executed in compliance with standard EN 60204-1 and/or other standards and regulations of application when dealing with A2L refrigerants.

The compressor mounting area must be in **Zone 2** or outside of any ATEX zone and in line with the requirements of **"Pollution Degree 3"** classification.

NOTE: **For recommendations specific to the ED3 drive please refer to the ED3 User Manual (June 2019 version).**

4.2 Electrical installation

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

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! Any work on the energized terminals in the compressor terminal box could create an ignition. Do not touch the energized terminals with a tool or cable when the compressor is energized.
Compressors operating with flammable refrigerants shall use only the qualified terminal box supplied with the compressor.
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 hermetic 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.

The terminal box rating is IP21. The compressor has to be protected by a cover which can only be opened with a tool.

Special attention shall be paid to the electrical connections owing to possible local overheating.

Scroll compressors, like several other types of compressors, will only compress in one rotational direction. The rotation direction of the variable speed scroll compressors depends on the order of the phases between compressor and drive, and not on the order of the phases between power supply and drive. Since there is a 50-50 chance of connecting compressor and drive 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 variable speed scroll compressors in the reversed direction for a short period of time (maximum 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. In case of reverse rotation, the operator will notice a lack of cooling or heating. If allowed to repeatedly restart and run in reverse without correcting the situation, the compressor will be permanently damaged.

All variable speed scroll compressors are identically wired as shown in **Figure 17**. 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.

Figure 17: Terminal box and correct electrical installation

NOTE: **For recommendations about cable dimensions please refer to the ED3 User Manual (June 2019 version).**

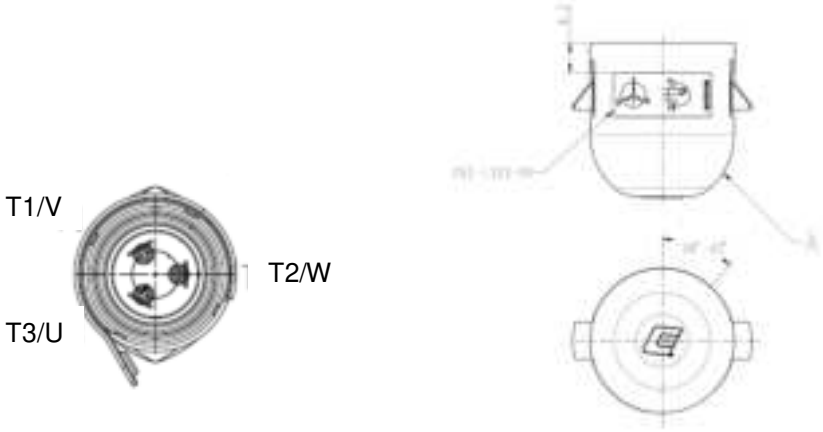


Figure 18: Electrical connections for compressor terminal and terminal cover

When installing YHV*2P compressors in a system, the following measures must be taken:

- Add the foam gasket and the plastic terminal cover.
- To connect the power leads, use suitable 90° insulated female crimp connector terminals from "250 series" suitable for 6.35 mm (0.250 inch) male tab width.
- To ensure the wires are properly terminated, the correct terminal and clamping tool for the selected wire size shall be used.
- The ground wiring must conform to local regulations and codes of practice (only the provided parts must be used).
- The grounding screw must be torqued to 2.4 to 2.6 Nm.
- Add a cable strain-relief device.
- Protect cable and wires against sharp edges.

NOTE: **The wiring should remain physically separated to minimize the introduction of electrical noise.**

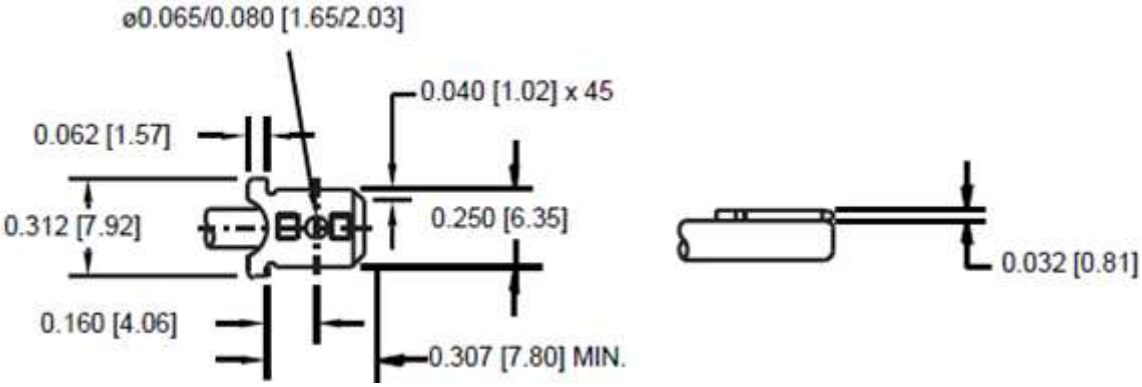


Figure 19: Tab detail - Connection dimensions in inches [mm]

4.3 Wiring diagrams

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! Any work on the energized terminals in the compressor terminal box could create an ignition. Do not touch the energized terminals with a tool or cable when the compressor is energized

WARNING
High voltage! Electrical shock hazard! Serious personal injuries! Disconnect and lock out power before servicing. Allow drive components to electrically discharge before servicing, respecting the time delay specified in the drive manual. Use compressor with grounded system only. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.
Earth leakage current! Danger of electric shock! The combination of compressor and drive 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.

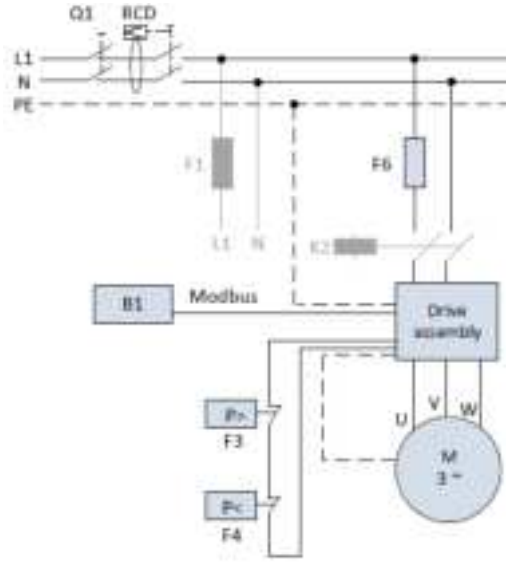
The combination of YHV*2P compressors and inverters can cause earth leakage currents, both AC and DC, due to the presence of the inverter and an EMC filter in the system. Therefore, an AC/DC-sensitive Residual Current Device (RCD) should be used on the power supply side. The RCD can be either **type B or B+**.

***NOTE:* A K2 contactor is optional.**

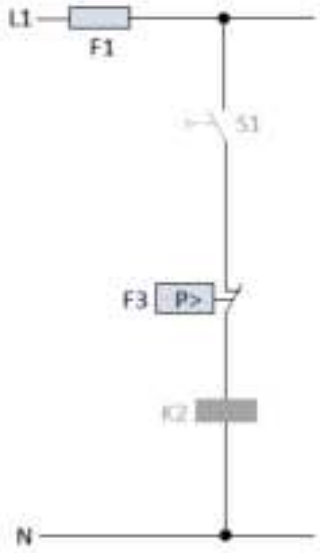
***NOTE*: For recommendations about electromagnetic compatibility and how to wire up the drive assembly please refer to the ED3 User Manual (June 2019 version).**

For the single-phase matched pairs of YHV*2P with ED3 drive, the following circuit diagrams can be used:

Power circuit



Control circuit



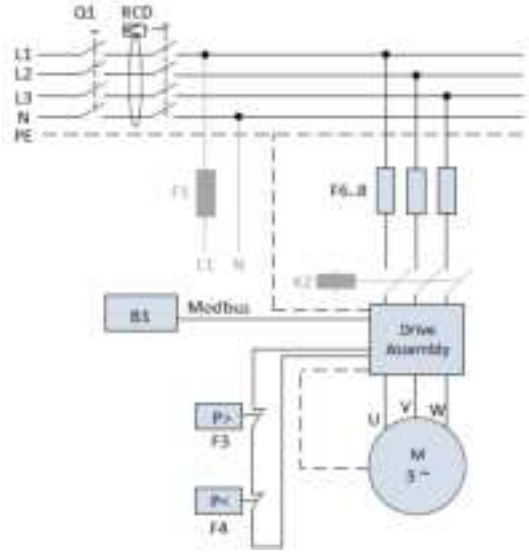
Legend

B1 ..... System controller	F4.....LP switch
Q1 ..... Main switch	K2.....Contactor (optional)*
D ..... Drive assembly	RCD ....Residual current device type B or B+
F1, F6 . Fuses	S1.....Auxiliary switch
F3 ..... HP limiter	Grey = optional, depending on the system type

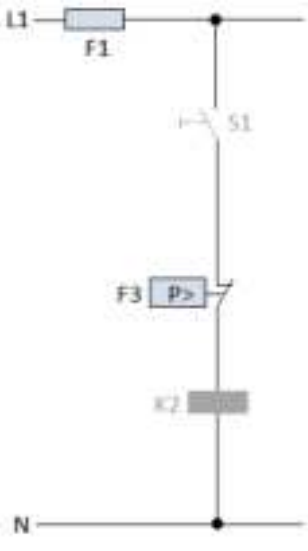
Figure 20: Wiring diagram for YHV*2P with single-phase drive

For the three-phase matched pairs of YHV*2P with ED3 drive, the following circuit diagrams can be used:

Power circuit



Control circuit



Legend

B1 ..... System controller	F4.....LP switch
Q1 ..... Main switch	K2.....Contactor (optional)*
D ..... Drive assembly	RCD ....Residual current device type B or B+
F1, F6/7/8 ..... Fuses	S1.....Auxiliary switch
F3 ..... ……..HP limiter	Grey = optional, depending on the system type

Figure 21: Wiring diagram for YHV*2P with three-phase drive

* Additional contactor (K2) needed only on drives without STO (Safe torque off) safety input!

4.3.1 Motor windings

YHV*2P compressors feature a three-phase brushless permanent magnet motor. The motor is connected in star.

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

4.3.2 Protection devices

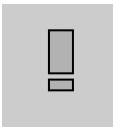
Fuses must be installed before the drive.

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 or selecting inappropriate fuses may result in compressor and/or drive failure.

4.3.3 Crankcase heating function

WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! Incorrect wiring during installation or service could create a spark on the connection.

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! Follow the off-cycle migration statement described below for long term reliability and to minimize nuisance associated with flooded start conditions.

Contrary to standard fixed-speed Copeland Scroll compressors, the YHV*2P models do not require any optional external crankcase heater to be mounted on the compressor.

Instead, the ED3 drive has a programmable feature that will utilize the motor windings to provide up to 50 Watts DC of heating to serve as a crankcase heater.

The crankcase heating function activation is recommended when the system charge exceeds the refrigerant charge limit indicated in **Table 7** below:

Compressor	Refrigerant charge limit
YHV0182P / YHV0252P	3.6 kg
YHV0382P	4.5 kg

Table 7: Refrigerant charge limit

If this function is required and no off-cycle migration testing across the envelope for winter and summer situations is performed, the crankcase heating function must always be powered to 50 Watts when the compressor is "Off".

To use less than 50 Watts, off-cycle migration testing must be performed. To perform migration testing, a compressor fitted with a sight-tube showing the oil level and any accumulation of liquid in the compressor is required and can be ordered from Emerson.

NOTE: **At first start, the crankcase heating function must be turned on a minimum of 12 hours prior to starting the compressor.**

4.4 Pressure protection devices

4.4.1 High-pressure protection

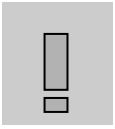
The high-pressure protection should be installed according to EN 378. The high-pressure limiter has to be connected to the ED3 drive (see **Figure 20&F3** **…**…...HP limiter Grey = optional, depending on the system type

Figure 21). The output is a 5 VDC signal. 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 ED3 User Manual (June 2019 version).**

4.4.2 Low-pressure protection

WARNING
Operation under ambient pressure! Fire hazard! During operation under ambient pressure, a flammable mixture can form inside the system. Make sure that air does not enter the system.



IMPORTANT
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 to ensure that the pressure is always above the required minimum limit.

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

In order to avoid any air entering the system during operation, make sure that the system pressure never falls below atmospheric pressure. If it does, immediately de-energize the power supply of the compressor and check the cause of the low pressure before restarting the compressor.

In dependence of the approved application envelope, the cut-out setting of the pressure limiter may be below atmospheric pressure, when observing the following rules:

- valid only for hermetically sealed systems, see safety standards for definition
- the minimum absolute pressure is 0.5 bar
- a discharge temperature control is mandatory to stop the compressor not exceeding the maximum discharge temperature, see chapter 4.5

4.5 Discharge gas temperature protection

IMPORTANT
Overheating and inadequate lubrication! Compressor damage! YHV*2P compressors must be equipped with an external discharge gas temperature protection.

A good system control should prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the heating demand. However, under some extreme operating conditions (such as loss of charge or improper control operation), the internal discharge gas temperature reached can cause compressor damage. To guarantee positive compressor protection, discharge gas temperature protection is required for any application with Copeland brand compressors. This protection must not be used as an operating envelope controller but as a safety device.

The maximum discharge gas temperature is 125 °C for models YHV*2P.

YHV*2P compressors do not have an internal discharge temperature protection. In order for the drive to operate properly a thermistor must be attached to the compressor discharge line less than 12 cm from the compressor discharge fitting. For best response the sensor must be insulated and placed in a sleeve braced on the discharge pipe (see **Figure 22**). If thermal compound is used to improve the heat transfer from sleeve to sensor, make sure it is approved for these temperatures. Also protect the sensor from being removed from its position by transport; vibration or any other incident. Refer to the operating map for maximum operating discharge line temperatures.

The discharge line temperature must be limited to 125 °C.

Figure 22: Discharge temperature sensor mounting

4.6 High-potential testing

WARNING
High potential testing in a potentially flammable atmosphere! Fire hazard!
Make sure the atmosphere is non-flammable before performing high potential testing. Do not perform any high potential test when the compressor is charged with flammable refrigerant.

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

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

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, etc prior to testing.

Special attention should be paid when performing a high-potential test and reading the Megohm resistance on A2L compressors, as such tests can induce an electrical arc and cause a fire hazard.

For the same reason, compressors removed from a system with A2L refrigerant will need to have the oil drained and a nitrogen purge introduced to flush any remaining refrigerant from the compressor prior to high-potential testing and Megohm resistance reading.

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.

WARNING
Air/flammable refrigerant mixture! Creation of a flammable atmosphere! Make sure the atmosphere is non-flammable before starting the system. Ensure that the system contains only refrigerant.

5.1 Strength pressure test

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

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

5.1.1 Compressor strength-pressure test

The compressor has been strength-pressure tested in the Emerson factory. It is not necessary for the customer to strength-pressure test the compressor another time.
The scroll compressors are divided into two pressure zones. The compressor high-side and low side PS (maximum allowable pressure) have to be respected at any time.

5.1.2 System strength-pressure test

A strength-pressure test of individual sections of the entire system is permissible. Once the compressor is isolated, the rest of the system could be tested with the desired pressure values.

The strength-pressure test could also be carried out with the connected compressor, but then the two pressure zones of the scroll compressor would need to be respected:

- System high pressure section
  - define the system high side PS ≤ compressor high side PS
  - separate 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 internal check valve of the compressor respect a maximum delta pressure between high- pressure side and low-pressure side ≤ 40 Bar
  - activate the check valve with a fast pressure increase. Once the check valve is activated, the pressure increase could be slowed down
  - now the system test pressure of 1,1 x system high side PS could be applied for a short time
  - during this test, make sure the pressure inside the compressor does not exceed the maximum PS value, which corresponds to 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 could 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.

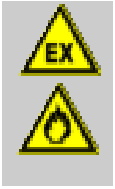
CAUTION
System contamination! Bearing malfunction! Use only dry inert gases (for example nitrogen) for leak testing. DO NOT USE other industrial gases.

The compressor has been leak-tested in the Emerson factory. As the compressor complies with EN 60335-2-34, it is not necessary for the installer to leak-test the compressor.

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

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

5.3 Preliminary checks – Pre-starting



WARNING
Air/A2L refrigerant mixture in a potentially flammable or explosive atmosphere! Fire and explosion hazard! Whenever starting up a system charged with A2L refrigerant, eg, after filling, repair, or maintenance, make sure not to start and operate accidentally in a flammable or explosive atmosphere.

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:

- No explosive atmosphere or flammable gas in the ambient
- Suitable ventilation according to the room volume and to the refrigerant charge
- 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 limiters 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

WARNING
Air/A2L refrigerant mixture in a potentially flammable or explosive atmosphere! Fire and explosion hazard! Only use filling equipment designed and approved for use and operation with A2L refrigerants. Make sure all connections are tight to avoid leakage. Make sure to fill with pure A2L refrigerant.

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 the compressor at pressures not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

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

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

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

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

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

5.5 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.

Therefor users should be aware that before the performance specified by EN 12900 is achieved the compressor needs to be run in.

For YHV*2P compressors it is recommended to run the break in at 2400 rpm, +7 °C evaporating temperature and 55 °C condensing temperature with a superheat of 10 K for a period of 16 h.

5.6 Initial start-up

CAUTION
Oil dilution! Bearing and moving parts malfunction! It is important to ensure that new compressors are not subjected to liquid abuse. Turn the crankcase heating on 12 hours before starting the compressor.
High discharge pressure operation! Compressor damage! Do not use compressor to test opening setpoint of high-pressure limiter. Bearings and moving 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.

5.7 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 ED3 User Manual (June 2019 version).**

5.8 Starting sound

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

5.10 Shell temperature

During normal operation, the discharge gas as well as the compressor top shell and discharge line can reach temperatures up to 135 °C – see **Chapter 4.5 “Discharge gas temperature protection”.**

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

5.11 Pump-down cycle

WARNING
Vacuum operation! Creation of a flammable mixture! Fire hazard! During operation in vacuum a flammable mixture can form inside the system. Extreme attention shall be paid to system tightness. Prevent ambient air from entering the system.

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

A pump-down 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 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 causing the scroll compressor to recycle more frequently. Repeated short-cycling of this nature can result in a low oil situation and consequent damage to the compressor. The low-pressure control differential has to be reviewed since a relatively large volume of gas will re-expand from the high side of the compressor into the low side after shutdown.

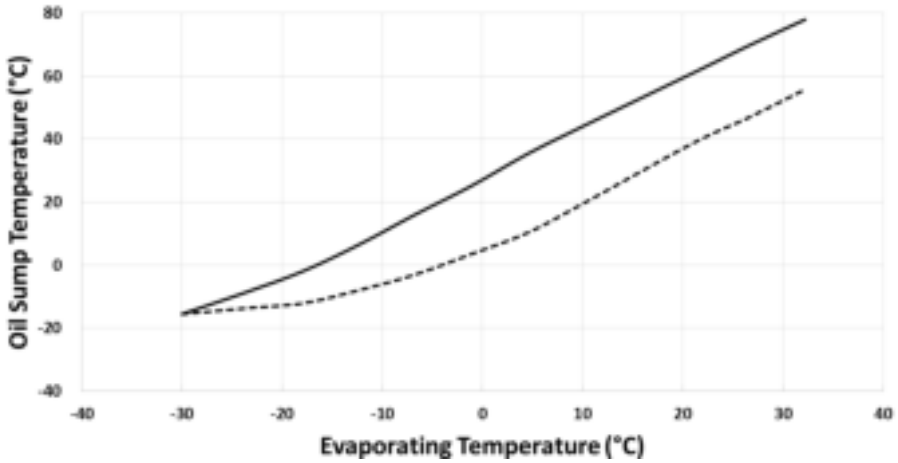
For pressure control setting, never set the low-pressure control to shut off outside of the operating envelope. To prevent the compressor from running into problems during such faults as loss of charge or partial blockage, the control should not be set lower than the minimum suction pressure allowed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

5.12 Refrigerant floodback and oil dilution

One of the major causes of compressor failure is damage caused by liquid refrigerant entering the compressor in excessive quantities. Improper control of liquid refrigerant in a system can cause a loss of lubrication and compressor failure.

Within the general refrigeration system qualification, Emerson recommends a refrigerant floodback and oil dilution test. During the system testing and under all possible operation conditions, the evaporating temperature and the bottom shell temperature shall be recorded.

The bottom shell temperature together with the evaporating temperature gives an indication whether liquid refrigerant is returning or diluted in the compressor oil sump. The compressor sump temperature must remain in the (green) safe area, as shown in the oil dilution chart, see **Figure 23** below. In case of operation in the (red) unsafe area, adjustments are required in order to modify the system design, refrigerant charge or superheat setting of the expansion device(s). The bottom shell temperature should be measured accurately. The thermo-probe must be positioned on the opposite side of the sight glass or at an angle of 90° clockwise from the suction inlet with view on the top.



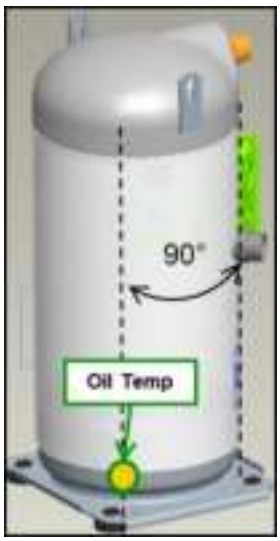


Figure 23: Preliminary oil dilution chart for transient operation with R452B and R454B

5.13 Minimum run time

Emerson recommends a maximum of 10 starts per hour. There is no minimum off time because scroll compressors start unloaded, even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after start-up. To establish the minimum run time, obtain a sample compressor equipped with a sight tube (available from Emerson) 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.

5.14 Oil level

YHV*2P compressors are not equipped with any oil sight glass.

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

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
Ignition source in a potentially flammable and explosive atmosphere! Fire and explosion hazard!
When opening the system, the atmosphere could be explosive. All electrical components, which are a source of ignition and must always be switched off during service and maintenance. Ensure that hot surface temperatures of any component never exceed the limit set by the applicable safety standard (e.g. EN378-2).
Air/flammable refrigerant mixture may create a potentially flammable and explosive atmosphere! Fire and explosion hazard! Remove all refrigerant before opening the system. Make sure to remove refrigerant completely from all components, such as heat exchangers, refrigerant accumulators and so on. Flush the system and the components with inert gas before undertaking any work and before brazing.

WARNING
Open flame in a potentially flammable atmosphere! Fire hazard! The area shall be checked with an appropriate refrigerant detector prior and during work, to ensure the technician is aware of potentially toxic or flammable atmospheres. Ensure that the leak detection equipment being used is suitable for use with all applicable refrigerants.
No person carrying out work in relation to a refrigeration system which involves exposing any pipe work shall use any sources of ignition in such a manner that it may lead to the risk of fire or explosion. All possible ignition sources, shall be kept sufficiently far away from the site of installation, repairing, removing and disposal, during which refrigerant can possibly be released to the surrounding space.
Open flames and smoking are strictly forbidden at all times.
During service make sure that:

- the area is well ventilated
- the materials and equipment used are suitable for use under flammable conditions
- only non-sparking tools are used
- antistatic gloves and clothes are used
- build-up of electrostatic charges is avoided
- no unshielded or naked flame is allowed
- if parts of the refrigeration system are charged with flammable refrigerant, be sure that all the valves are tightly closed and that the open pipes after the valves are free of refrigerant and oil

A risk analysis to evaluate all possible risks shall be executed by the service technician before any repair work.

6.1 Qualification of workers

The working personnel for maintenance, repair, and decommissioning shall be adequately trained. Each working procedure that affects safety means shall be carried out only by competent personnel according to national or other equivalent certification systems.

Examples of working procedures are:

- breaking into the refrigerating circuit;
- opening of sealed components;
- opening of ventilated enclosure

6.2 Preparation and working procedure

A working procedure shall be provided in the preparation stage. All maintenance personnel and other staff working at the site shall be instructed of the nature of the work being carried out.

If any work is to be conducted on the refrigeration systems or any associated parts, appropriate fire extinguishing equipment shall be provided. Dry powder or CO_2 fire extinguisher are considered appropriate. Confirm that appropriate fire extinguishing equipment is available near the working area.

Work shall be undertaken according to a controlled procedure so as to minimize the risk of a flammable gas or vapour being present while the work is being performed.

Prior to starting to work on systems containing flammable refrigerants, safety checks are necessary to ensure that the risk of ignition is minimized.

Avoid working on systems filled with flammable refrigerant in a confined space.

6.3 Disassembling system components

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

1. Recover refrigerant and evacuate system using an A2L - dedicated recovery unit and vacuum pump. All refrigerants shall be recovered to avoid significant release. Ensure that the outlet of the vacuum pump is not close to any potential ignition source and that ventilation is available.
2. Flush system with inert gas (dry nitrogen). Compressed air or oxygen shall not be used for purging refrigerant systems.
3. Disassemble components with a cutting tool.
4. Drain, recover and dispose of compressor oil as appropriate.

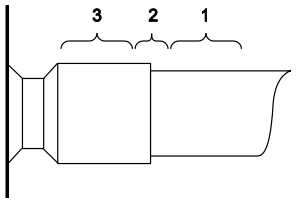


Figure 24: Tube connecting areas

To disconnect:

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

To reconnect:

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

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

6.4 Provisions of legislation and leak check requirements

According to EN 378-4, systems with a refrigerant charge above 3 kg 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 F-gas Regulation (EU) No 517/2014 contains additional requirements depending on the system and stipulates training requirements for alternative refrigerants.

6.5 Exchanging the refrigerant

WARNING
Air/A2L mixture! Flammable and explosive atmosphere! Fire and explosion hazard! In any case avoid air/A2L mixture in the refrigeration system. Make sure that the system is filled with pure A2L refrigerant. In the event that the refrigerant needs replacing, the charge should be recovered using A2L qualified refrigerant recovery unit and recycling bottles.

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 **Chapter 2.4.1.**

It is not necessary to replace the refrigerant with new unless contamination due to an error such as topping up the system with an incorrect refrigerant is suspected. To verify correct refrigerant composition, a sample can be taken for chemical analysis. A check can be made during 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.

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

6.6 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.

6.6.1 Compressor replacement

In the case of A2L refrigerant compressor replacement, the oil has to be drained out of the compressor and the compressor should be flushed with dry nitrogen. DO NOT close the stubs with plugs.

In the case of a motor burnout, the majority of contaminated oil will be removed with the compressor. The rest of the oil will be 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 compressor 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.

6.6.2 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, specified by 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 flow. **Do not start the compressor while the system is in a deep vacuum.** Internal arcing may occur when a scroll compressor is started in a vacuum causing burnout of the internal lead connections.

6.6.3 Compressor return procedure

If a compressor has to be returned to the manufacturer for analysis the procedure below shall be followed:

- During the entire working procedure continuously check if the ambient atmosphere is flammable. If flammable atmosphere is detected ensure proper ventilation of the working space and immediately cut-off the power supply.
- Resume working after the atmosphere is no longer dangerous.
- Recover the refrigerant from the system using a suitable recovery unit. During this action, the compressor crankcase heater could be energized – immediately de-energize in case a flammable atmosphere is detected.
- Recover to minimum 0.3 bar absolute or lower. For best result to recover most of the refrigerant, which is also solved in the oil, run a second and third times the recovery unit as it may be necessary
- Flush the whole system with oxygen free dry nitrogen (OFDN).
- Open the system with a cutting tool and flush the entire system with OFDN.
- Disassemble the compressor with a cutting tool. Drain and recover compressor oil properly. Flush the compressor with OFDN for a few minutes.
- The compressor should be returned free of oil and with connections open - do not close connections with plugs.
- Properly collect and secure the oil. Provide information about the quantity of oil drained from the compressor and its colour. Ideally, send a good picture.
- Dispose of the oil according to local rules and regulations.
- Use a proper cardboard box package when preparing the compressor for shipment. Place warning icons  on each side and on the top of the box. Mention the following message on the box: **"Warning! Flammable refrigerant compressor for analysis"**.
- The compressor package must be kept in the upright position – mark it accordingly.
- If more than one compressor has to be returned, each compressor has to be packed individually.

NOTE: **Check with your transport company that all the requirements applying to such shipment are complied with.**

6.7 Lubrication and oil removal

WARNING
Air/A2L mixture! Flammable and explosive atmosphere! Fire and explosion hazard!
Use suitable recovery unit and recycling bottles also for oil disposal as A2L refrigerant may still be solved in the oil.

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 R452B and R454B is a polylester (POE) lubricant Emkarate RL 32 3MAF. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1 litre less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (see **Figure 25**). 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 contain oil with low moisture content, and it may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-drier is installed in all POE systems. This will maintain the moisture level in the oil to less than 50 ppm. If oil is charged into a system, it is recommended to use POE with moisture content no higher than 50 ppm.

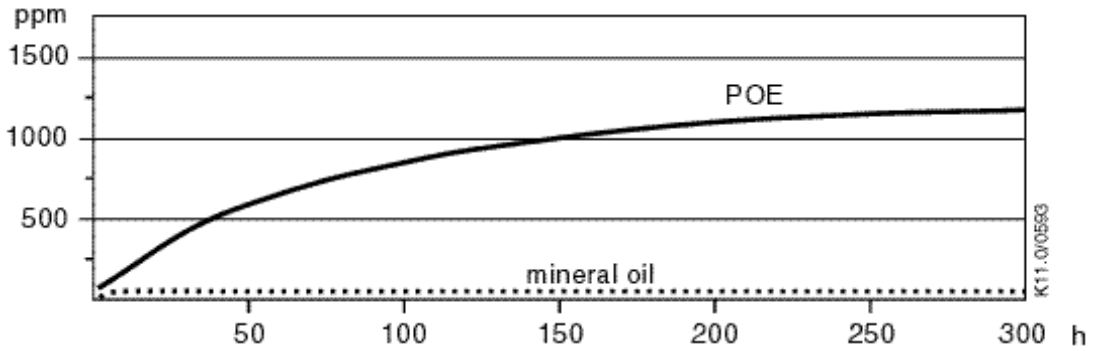


Figure 25: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25 °C and 50% relative humidity (h=hours)

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

6.8 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

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

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

WARNING
Electrical connections! Electrical shock hazard! 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.

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

- Before servicing shut off and secure the power supply. Wait for 2 minutes before performing any servicing on the drive.
- Drive: Check all the external wiring for miss-wiring, 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.
	Defective capacitor or relay	For a single-phase motor, a defective capacitor or relay may prevent the compressor from starting. Check these components by substituting “a known-to-be-good” component if available. Make sure that the capacitors are electrically discharged before checking.
	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 pump-down cycle provide good protection against refrigerant migration.

Condition	Cause	Corrective action
The Scroll compressor does not run, instead a buzz sound can be heard	Internal compressor mechanical damage	▪ 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.
The Scroll compressor does not run, no buzz sound can be heard	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 due to undersized contactors, you will observe that the contacts welded together. Complete motor burnout on all three phases despite the presence of a functioning protection system can be the result. For sizing information please consult with Contactor manufacturer data sheet. If the application of the compressor is changed the contactor sizing should be rechecked. ▪ Check for unbalanced voltage.
	High discharge pressure / suction pressure	▪ For high discharge pressure: - Check for system leaks. - Check the system design. Make sure the discharge line is correctly sized: undersized discharge line can increase discharge pressure. This is also true for an undersized condenser. Correct the component selection as needed. - Check the fan motor, make sure it is running properly in the right direction. Check the condenser: if dirt has been accumulated it will clog the airflow; clean as necessary. High discharge pressure is also caused by an overcharged system and high ambient temperature surrounding the condenser. ▪ For high suction pressure, check the “evaporator superheat” first to diagnose the problem: - High superheat at the evaporator outlet: this is likely in case of excessive pressure-drop in the liquid line or too much vertical lift on the pipe work. ▪ Low superheat at the evaporator outlet is characterized by oversized selection of the expansion valve or incorrect bulb sensor mounting. The valve may freeze up in the open position due to accumulation of debris in the system. For a system with very short refrigeration lines an accumulator is recommended.

Condition	Cause	Corrective action
The Scroll compressor trips on motor protection	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.
Excessive discharge temperature	Insufficient cooling medium injected	For compressors using vapour injection, make sure the expansion valve is connected at a distance between 150 mm and 200 mm from the economizer inlet and at a position not lower than inlet connection. The injection line economizer to compressor should be properly sized to avoid pressure drop. For good refrigerant distribution in the economizer respect the recommendations especially those regarding the inlet pipes for the vapour injection according to BHE-manufacturer. The liquid line from the BHE to the expansion valve(s) need to be well insulated as well. A solenoid valve should be installed on the liquid line to prevent refrigerant migration.
	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 it 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.

Condition	Cause	Corrective action
Low discharge pressure	Low ambient temperature	Fit a fan cycling control system.
	Refrigerant undercharge	Check the system for leaks. Observe sight glass for bubbles. Add refrigerant until the sight glass is clear.
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 Reference list of related technical information

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

Additional technical information:

- C30.11/0419/E “NTC Mounting Recommendations”
- ED3 User Manual (June 2019 version)

Performance and technical data:

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

Spare parts and accessories:

Join the webpage **www.climate.emerson.com/en-gb** under *tools & resources* for an online version of the Emerson spare parts and accessories software.

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