Application Guidelines

Copeland Scroll™ Variable Speed Horizontal Refrigeration Compressors for R290 Applications



COPELAND SCROLL™

EMERSON™

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About these guidelines

The purpose of these guidelines is to provide guidance in the application of Copeland Scroll™ compressors and Emerson control drives in users' systems working with propane. 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. Emerson cannot guarantee the performance and reliability of the products if they are misused in regard of these guidelines.

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 control drives are manufactured according to the latest European and US safety standards. Particular emphasis has been placed on the user's safety.

The YBVH* compressors are released for R290 applications. For all systems, an active safety system concept such as gas detection and ventilation are required.

The YBVH* 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 A3 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 EN 378. It remains the user's responsibility to select products compliant with legislation and regulations applicable for its application.**

The Material Safety Datasheet (MSDS) for R290 shall be considered when working with this type of refrigerant - please check this document provided by the gas supplier.

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

You are strongly advised to follow these safety instructions as well as those delivered with the compressor. Failure to do so could result in serious injury.

1.1 Icon explanation

	**WARNING** This icon indicates instructions to avoid personal injury and material damage.		**Risk 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 HVAC or refrigeration 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 shall 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 come into contact with it. Lock and mark accessible sections.



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



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



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

2 Product description

2.1 General information about Copeland Scroll™ compressors

These application guidelines deal with the YBVH* variable speed horizontal Copeland scroll compressors using R290. These compressors have a speed range of 1500 to 5500 revolutions per minute, corresponding to 25 up to 92 Hz. They are intended for use in refrigeration applications. They feature a three-phase brushless permanent magnet (BPM) motor which is controlled by a motor control drive (for example Emerson drive ED3), either single-phase or three-phase, referred to as the "ED3 drive" throughout these guidelines.

***NOTE:* For more information on the motor control drive refer to the Emerson User Manual for ED3.**

2.2 Matched-pairs of compressor and drive

The matched-pairs of compressor and drive released by Emerson are listed in **Table 1** below:

Compressor	Drive	Drive power supply	Package code ED3 Modbus [318] #OneEmerson [205]
YBVH021 1U-3E9	ED3011A	1~/ 230V/ 50Hz	27
YBVH021 1U-9E9	ED3013B	3~/ 400V/ 50Hz	43
YBVH029 1U-3E9	ED3015A	1~/ 230V/ 50Hz	29
YBVH029 1U-9E9	ED3013B	3~/ 400V/ 50Hz	30
YBVH046 1U-9E9	ED3020A	1~/ 230V/ 50Hz	46
YBVH046 1U-4E9	ED3018B	3~/ 400V/ 50Hz	32

Table 1: Matched pairs ED3 with YBVH*

The YBVH* compressors have been qualified for use with the ED3 motor control drive, and 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.

YBVH* compressors with motor code "E9" are offered in 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.

Compressor	Drive	Cooling capacity [kW]			
		1500 rpm	3000 rpm	4500 rpm	5500 rpm
YBVH021 1U-3E9	ED3011A	0.90	1.75	2.65	3.26
YBVH029 1U-3E9	ED3015A	1.20	2.44	3.68	4.49
YBVH029 1U-9E9	ED3013B	1.20	2.44	3.68	4.49
YBVH046 1U-9E9	ED3020A	1.88	4.00	6.07	7.41
YBVH046 1U-4E9	ED3018B	1.88	4.00	6.07	7.41

Table 2: Cooling capacity in kW at -10°C/45°C/10K/0K for selected matched pairs

It is important to ensure correct wiring at both the compressor and drive connections prior to starting the compressor to avoid a miswire or powered reverse situation. Both situations could potentially cause compressor damage.

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

2.3 Variable speed advantages

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

2.4 Compressor and drive nomenclature

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

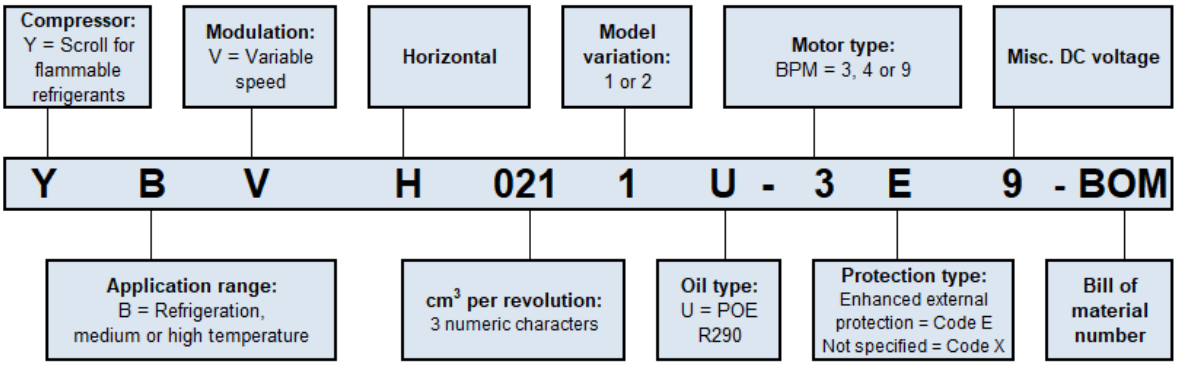


Figure 1: Nomenclature

2.5 BOM Variations

The Bill-Of-Material indication at the end of the compressor designation describes the different compressor layouts and details.

YBVH* compressor models are available in the following BOM version:

BOM NBE brazing stub tubes, horizontal 4-foot housing design, electrical connections ready for molded plug IP65, no mounting parts

2.6 Application considerations

2.6.1 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	**YBVH021, YBVH029, YBVH046**
Qualified refrigerant	**R290**
Copeland brand products standard oil	Hatcol 4467 (Ident number 8410785)
Servicing oil	Hatcol 4467 (Ident number 8410785)

Table 3: Qualified refrigerant and oil

2.6.2 Pressure Equipment Directive Category

The YBVH* compressor models in this document are classified as category class I, according to the Pressure Equipment Directive PED 2014/68/EU.

2.6.3 Oil filling and oil level

Owing to operation with flammable refrigerant, YBVH* compressors have no oil sight glass which ensures maximum hermeticity. Consequently, it is difficult to get an indication about the actual oil level in the compressor during operation. A sample compressor equipped with an external oil sight tube can be ordered from Emerson for lab testing – see **Figure 3**.

For all new systems with YBVH* compressors, it is mandatory to check and test the oil distribution and compressor oil filling using a dedicated sample compressor equipped with an external oil sight tube.

The factory oil filling for all YBVH* compressor models has been optimized to a value of 600 ml, which corresponds to a level between 116 mm and 75 mm on the external oil sight tube. The oil level should be within these limits for all applications.

All YBVH* compressors are equipped with a positive displacement twin oil pump. The oil sump is located on the lower end of the compressor housing – see right-hand side of the compressor housing in **Figure 2**. The oil level in the oil sump does not reflect the oil filling in the rest of the compressor housing.

Figure 2 shows the acceptable oil level between 116 mm and 75 mm.

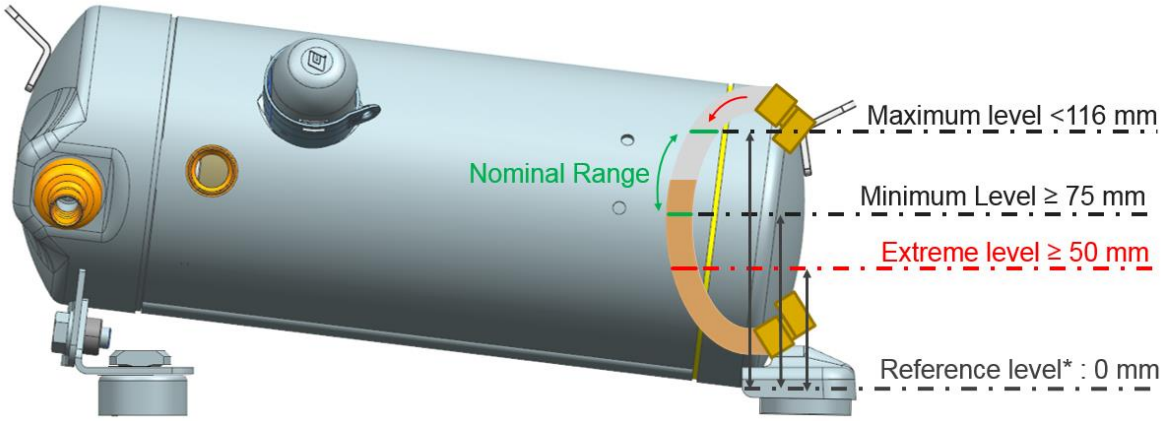


Figure 2: Acceptable oil level between 116 mm and 75 mm

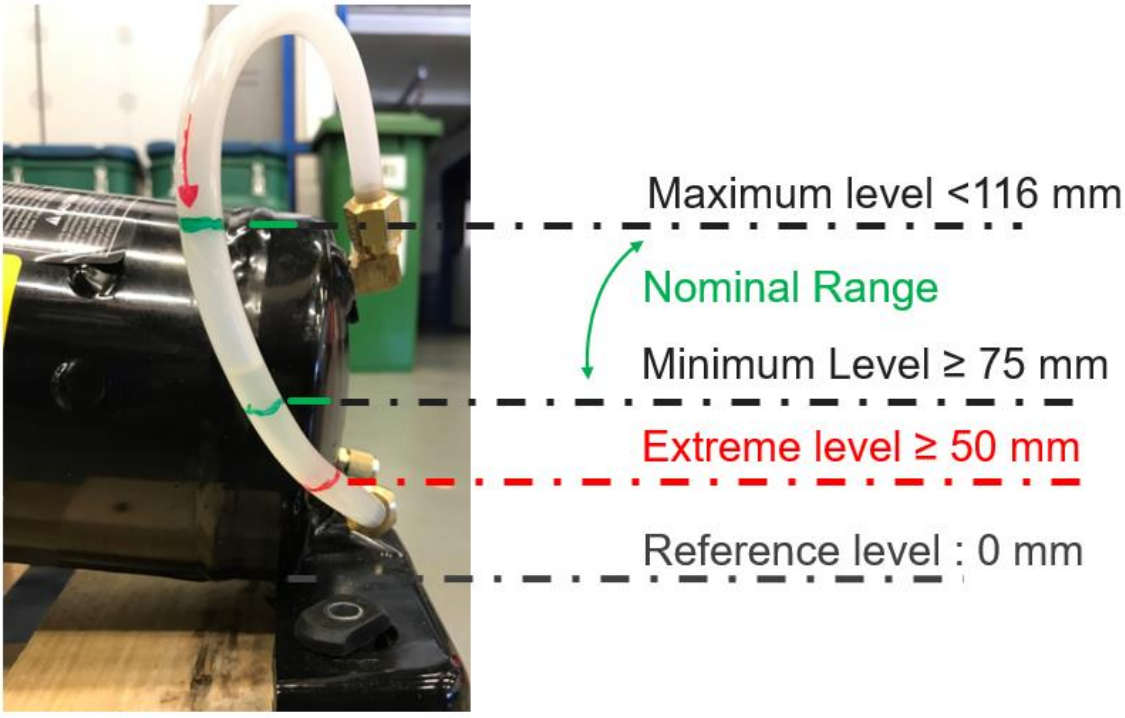


Figure 3: YBVH* sample compressor with external oil sight tube and markings

The oil tests on sample compressors with an external oil sight tube must be carried out by the system designer in the lab. This will allow to investigate the oil return behaviour to the compressor. In case some oil remains in the system, eg, in the tubes, heat exchangers or other components, oil top-up is required. A sufficient oil level must be present in the compressor at all times to ensure proper compressor reliability.

2.6.4 Test procedure

- Before first compressor start, mark the 116-mm maximum oil level, the 75-mm minimum level and the 50-mm extreme minimum level. The distance to the markings can be measured from the lower end of the compressor housing – see **Figure 2**.
- Start the compressor with a nominal speed of 3500 revolution per minute and run the system until it reaches stable conditions, then run at stable conditions for a minimum of 15 minutes. Any oil level between 116 mm and 75 mm is in the nominal range and is acceptable.
- Always check the level in the external oil sight tube. The oil level between 116 and 75 mm is the target. During the measurements and for short and transient periods, an oil level between 75 and 50 mm can be tolerated. Once the level falls below the 50-mm marking, stop the compressor immediately. Any oil level below the 50-ml marking is not acceptable.
- Top-up some oil if necessary and record the amount of topped-up oil. This could be the reference for all future systems with the same design. Perform the test anew to check the oil return behaviour again, as described above.
- If the oil level rises above the maximum level, compressor performance could start to drop due to the extra amount of oil. This situation will not harm the compressor, but it is recommended to remove the extra oil quantity in order to reach the nominal range.
- Repeat the test at different operating conditions, starting with the main operating point. Test different operating points in the corners of the operating envelope as well. Refer to **Figure 4** for main operating point, high load HL, maximum differential pressure MDP, high compression ratio HCR, low density flow LDF, high density flow HDF.
- Also perform tests for different system operations, eg, part load, defrost, bypass etc. Make sure the tests cover all possible different system conditions.
- The influence of the variable speed operation must also be observed. Perform additional tests with low speed at the MDP/HCR corner and with low speed + high speed at the HL point.
- Record the bottom shell temperature under all tested conditions. The bottom shell temperature together with the evaporating temperature give an indication whether liquid refrigerant is returning or diluted in the compressor oil sump. The compressor sump temperature must remain above the evaporating temperature as shown in **Figure 5**. Otherwise adjustments need to be done in the design, refrigerant charge or superheat setting of the expansion device in order to always operate in the safe area.

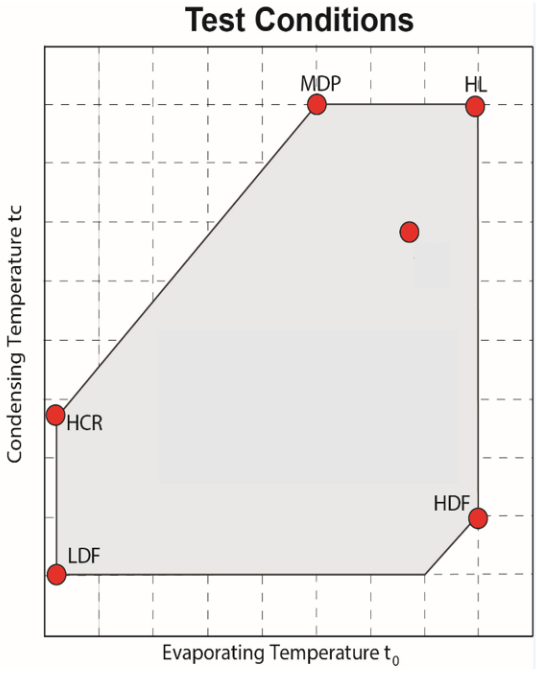


Figure 4: Testing points for oil return behaviour investigation

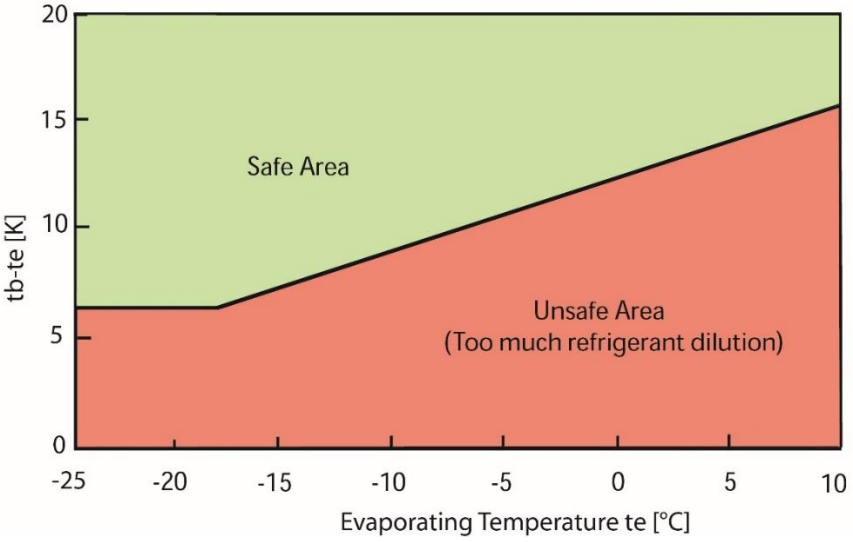


Figure 5: R290 oil dilution chart (tb = bottom shell temp.; te = evaporating temp.)

2.6.5 Admissible pressure, temperature and relative humidity ranges

The pressure PS is the maximum allowable pressure at the low- and high-pressure sides of the compressor. Safety is established in compliance with the relevant standards applicable to the given product.

Compressor model	PS (low-pressure side)	PS (high-pressure side)
YBVH021	16.5 bar(g)	28 bar(g)
YBVH029	16.5 bar(g)	28 bar(g)
YBVH046	16.5 bar(g)	28 bar(g)

Table 4: Maximum allowable pressures

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

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

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

2.6.6 Application limits – Operating envelope

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 system designer'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 10K 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.

The YBVH* compressors operating envelope is shown in **Figure 6**.

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

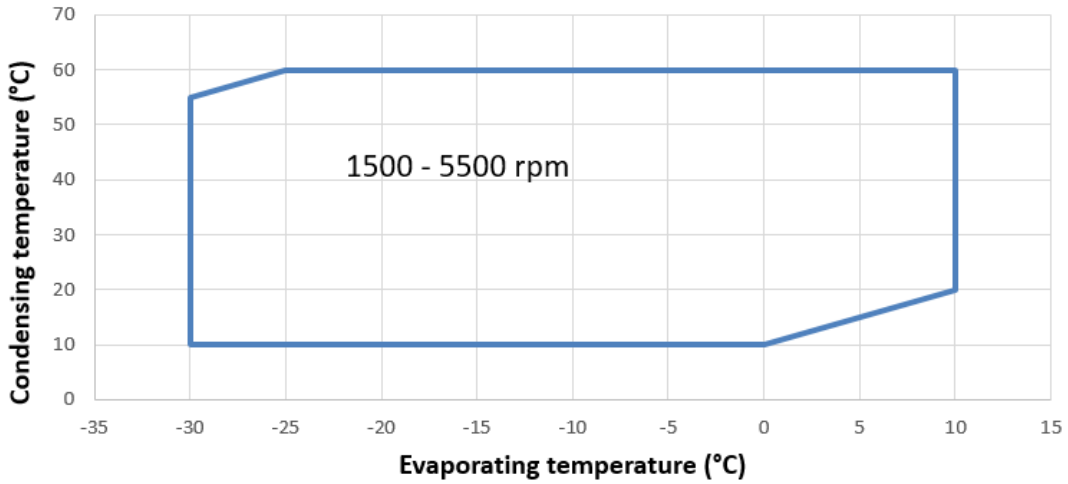


Figure 6: R290 application envelope for YBVH* compressors with 10K suction superheat, 25-92 Hz

Please note some comments about the envelope:

- Before compressor start with the matched pair of YBVH* and the ED3 drive, 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 oil dilution chart in **Figure 5**.
- An oil return test for the system must be performed. If required, the system design must be improved to ensure sufficient oil return from the system to the compressor – also see **Chapter 2.6.3 "Oil filling and oil level"**.
- The use of 1500 rpm for low condensing and high evaporating temperatures is possible as shown in the envelope.
- The system should be able to bring the compressor to a point inside the envelope as fast as possible at the start, and to keep the compressor running there. Running outside the envelope is not allowed.
- 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 7** "Ramp up".

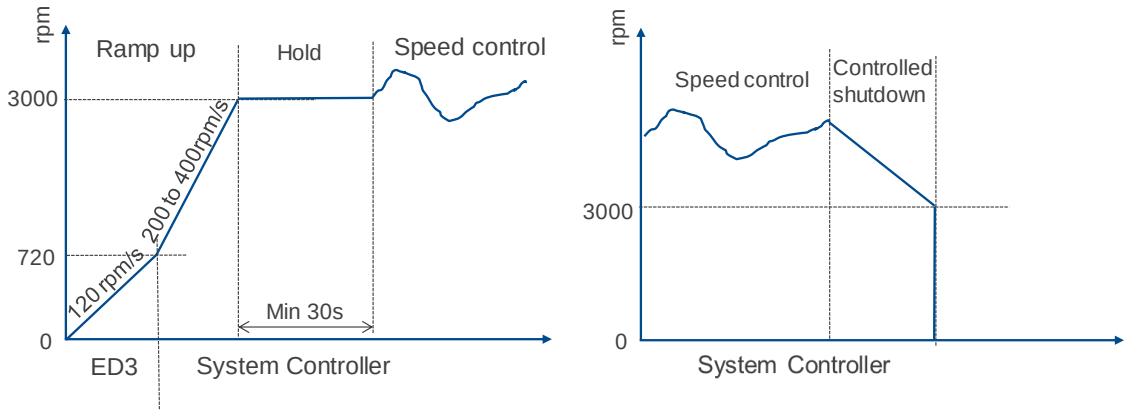


Figure 7: Ramp up and controlled shutdown

- 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 users must be aware that unloading noise from the compressor can occur.
- 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 system controller should adequately take care of controlling the envelope.
- To stop the compressor, reduce the speed to 3000 rpm then stop the compressor – see **Figure 7** "Controlled shutdown".

Before first start, each drive has to be set with the compressor model. This provides a speed-dependent maximum torque protection related to the compressor model. The maximum torque requirement will follow, with some margin, the maximum condensing temperature line for each speed. If the torque exceeds the maximum torque allowed for a specific speed, the drive will reduce the speed of the compressor in an attempt to keep the operating condition within the operating envelope. If reducing the speed of the compressor does not bring the condensing temperature back down within the envelope, the drive will go to the next level of protection and shut down the compressor.

This drive feature aims to protect the drive and the compressor. It cannot be used in the system as an operating envelope limitation.

The operating envelopes published in these guidelines are qualified for a minimum superheat of 10K. The maximum superheat at high evaporating temperature should not exceed 20K.

NOTE: **Operate matched pairs of compressor and drive combinations only.**

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 Emerson User Manual for ED3.**

2.6.7 Design features

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

All YBVH* compressors are equipped with a positive displacement twin oil pump to ensure an adequate supply of oil to the bearing system throughout the operating speed range of 1500 to 5500 rpm.

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

2.7 Dimensions

The external dimensions of YBVH* compressors are shown in **Figures 8 & 9** below.

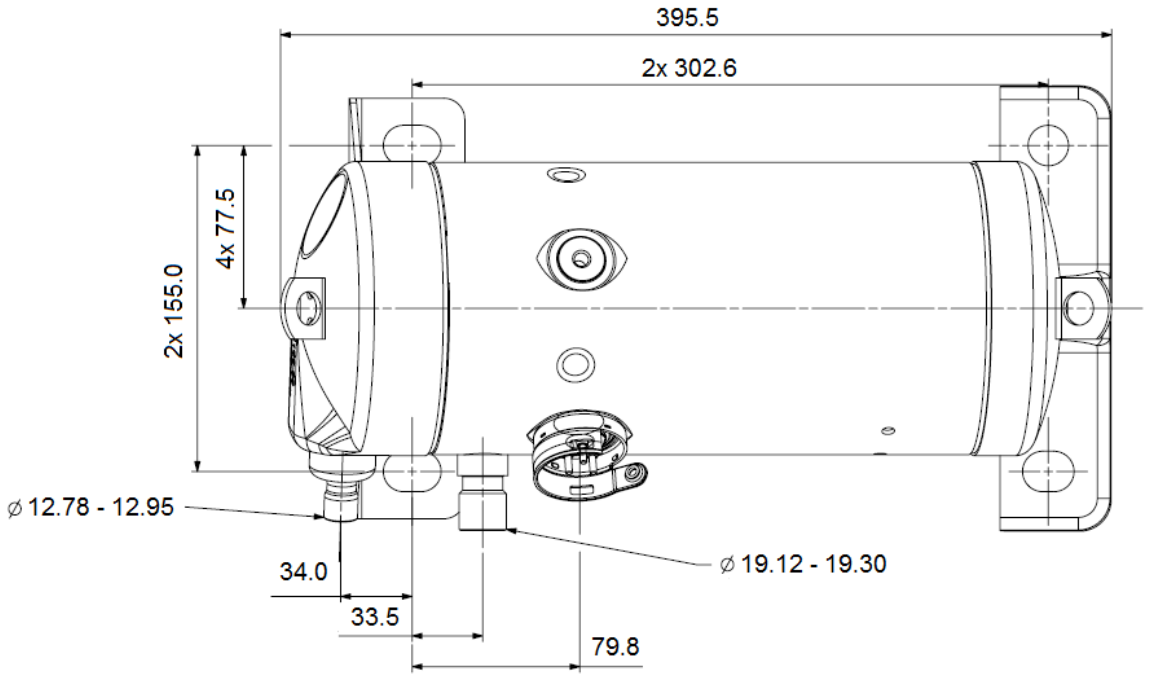


Figure 8: YBVH* compressors external dimensions – top view

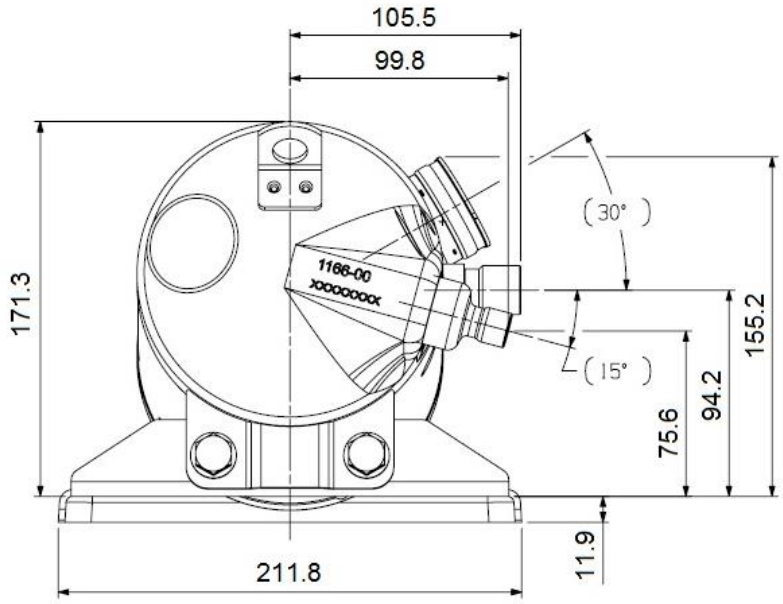


Figure 9: YBVH* compressors external dimensions – side view

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 horizontal position. Respect stacking loads according to **Figure 10**. 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 10: Maximum stacking loads for transport and storage

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 horizontal 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, eg, a swaging tool should be inserted deeper than 35 mm into the suction tube as it might damage the suction screen and other internal parts.

3.1.3 Installation location

Ensure that the compressor and drive are installed on a solid level base.

3.2 Compressor mounting parts

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

Mounting parts YBVH021, YBVH029, YBVH046 – Soft mountings

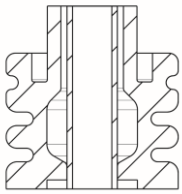




Figure 11: Rubber mounting part with sleeve

3.3 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 **Chapter 6 "Maintenance & repair**Error! R eference source not found.**"**.

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 touch it.

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.

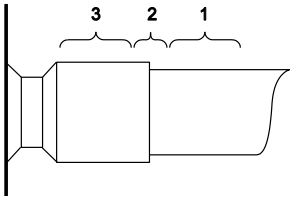


Figure 12: Suction tube connecting areas

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

Refer to **Figure 12** and procedure below for the brazing of the suction, discharge and injection lines to a Scroll compressor.

- For systems with A3 flammable refrigerants, it is mandatory to flush oxygen-free nitrogen trough the piping during 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.**

3.4 Suction 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 A3 refrigerants has an impact on the PED classification (Pressure Equipment Directive PED 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:

- normal off cycles
- defrost
- varying loads

Due to Copeland Scroll's 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 floodback must be monitored during reversing valve operation, especially when coming out of defrost. Excessive floodback occurs when the sump temperature drops below the safe operation line shown in the oil dilution chart – see **Figure 5**.

If an accumulator has to be used, the oil-return orifice should be from 1 to 1.4 mm in diameter depending on compressor size and compressor floodback results. A large-area protective screen no finer than 30 x 30 mesh (0.6 mm openings) is required to protect this small orifice from plugging with system debris Tests have shown that a small screen with a fine mesh can easily become plugged causing oil starvation to the compressor bearings.

The behaviour of the accumulator and its ability to prevent liquid slugging and subsequent oil pump-out at the beginning and end of the defrost cycle should be assessed during system development. This will require special accumulators and compressors with sight tubes for monitoring refrigerant and oil levels.

3.5 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.

3.6 Sound shell

No sound shell attenuation for YBVH* 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 – see EN 60079-0, clause 7.4.

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 – see EN 60079-0, clause 7.4.

3.8 Mufflers

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

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

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

3.9 Reversing valve

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, ie, 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 operating thermostat in the heating or cooling mode. If the valve is allowed to reverse at system shut off, suction and discharge pressures are reversed to the compressor. This results in a condition of system pressures equalizing through the compressor which can cause the compressor to slowly rotate until the pressures equalize. 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.

3.10 Sound and vibrations



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

It is necessary to ensure that the piping design is adequate when connecting a scroll compressor to a system.

A scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the 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 (25-92 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

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

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

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

For safety reasons, Emerson recommends that the electrical installation be executed in compliance with standard EN 60204-1 and/or other standards and regulations of application when dealing with A3 flammable refrigerants.

When installing YBVH* compressors in a system, the following measures must be taken:

- 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.

4.2 Electrical installation



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



WARNING
Ignition source in a potentially flammable atmosphere! Fire hazard! The electrical connection could be a source of ignition. System capacitors may remain charged for several minutes after shutdown. Before starting to work on the electrical installation make sure accidental sparking is not possible. Continuously check if the ambient atmosphere is non-flammable when working on the electrical installation.

For recommended wiring diagrams, see **Figures 17 & 18** in **Chapter 4.3 "Wiring diagrams"**.

***NOTE:* A K2 contactor, used usually for the safety chain, is optional.**

***NOTE*: An RCD Type B is needed. It can also protect against a DC current leakage.**

***NOTE*: For recommendations about the EMC and details about wiring up the drive assembly, please refer to the Emerson User Manual for ED3.**



Figure 13: Residual current device

4.2.1 Terminal connections



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

4.2.2 Molded plug connection



WARNING
Electric arc! Explosion hazard! Removing the molded plug cable while under load or electrically energized will create arcing between the connection pins and the cable connectors. Always shut off power supply before attaching or removing the molded plug cable from the connection pins.
The molded plug connector must be smoothly pushed by hand towards the connection pins of the compressor. Never use a tool to knock the molded plug connector on the terminal pins as this could damage the glass inserts of the pins.
It is mandatory to secure the molded plug cable on the connection pins with a retainer.
Any rework on the terminal pins is strictly prohibited.



WARNING
Electrical shock hazard! Serious personal injuries and/or system breakdown! Use R290 qualified and dedicated molded plug cables with grounding connection only. Make sure to connect the grounding first before attaching the molded plug cable to the connection pins of the compressor. When removing the molded plug cable from the connection pins, disconnect the grounding last.

YBVH* horizontal compressors are equipped with electrical connection pins ready for molded plug connection. Their protection class is IP65. Specific molded plug power cables have been qualified for use with R290. The R290 dedicated kit includes a special O-ring, a grounding connection and a retainer – see **Figures 14 to 16**.



Figure 14: Circle fence with motor teminals



Figure 15: Power cable molded plug (IP65)

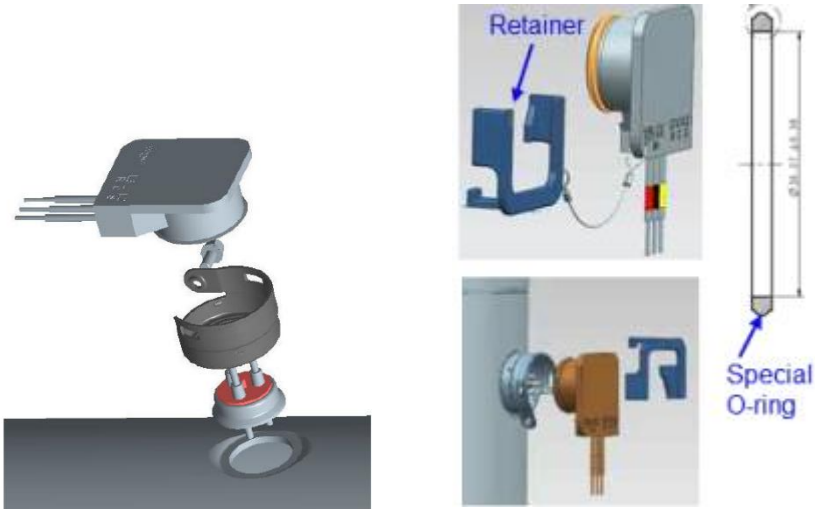


Figure 16: Connecting the molded plug power cable to the connection pins

4.2.3 Assembly of the molded plug cable

- Make sure to use only R290 qualified and dedicated molded plug power cables with grounding connection and retainer.
- Check that the O-ring on the molded plug connector is in place and not damaged.
- Shut off power supply.
- Check that the circle fence is clean and dry before connecting the molded plug power cable.
- Connect the grounding of the molded plug power cable to the compressor circle fence.
- Attach the molded plug connector to the compressor connection pins. Smoothly push the molded plug connector by hand as far as possible towards the pins. Never use a tool to knock the molded plug as this could damage the glass inserts of the pins
- Secure the connection with the retainer.

4.2.4 Removing the molded plug power cable

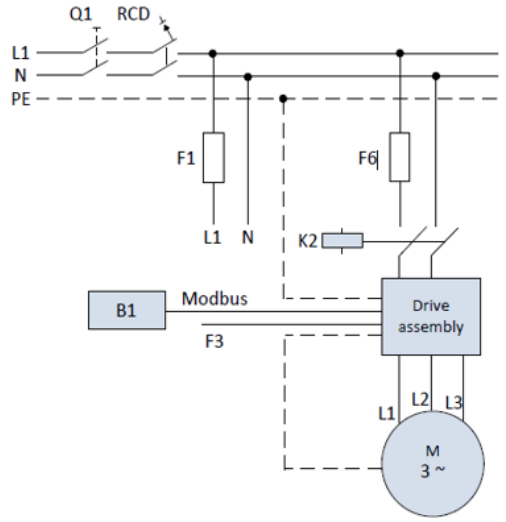
- Shut off power supply.
- Remove the retainer from the connection.
- Remove the molded plug connector from the connection pins.
- Disconnect the grounding from the compressor circle fence.

NOTE: **To select the appropriate molded plug power cables, please refer to the Emerson spare parts software available at www.climate.emerson.com/en-gb.**

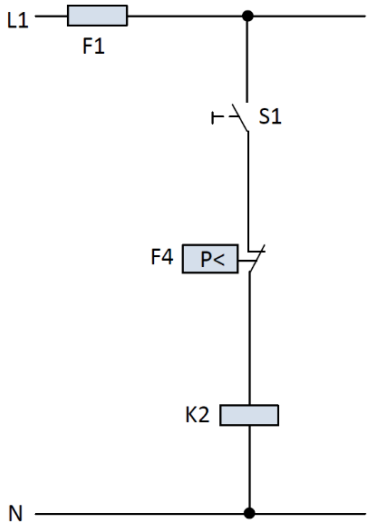
4.3 Wiring diagrams

For the single-phase and three-phase matched pairs of YBVH* compressor and ED3 drive, the following circuit diagrams can be used:

Power circuit



Control circuit

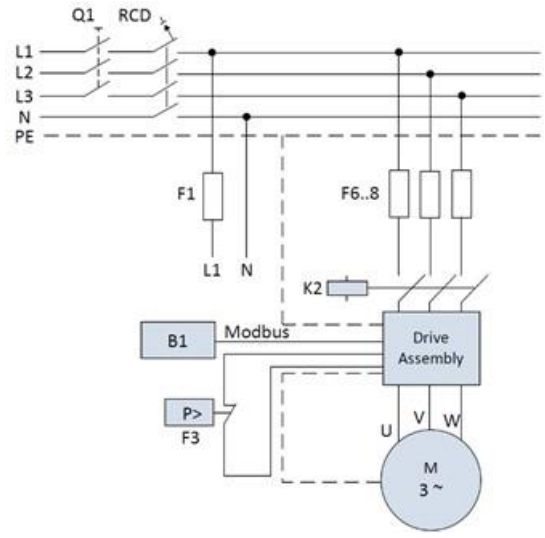


Legend

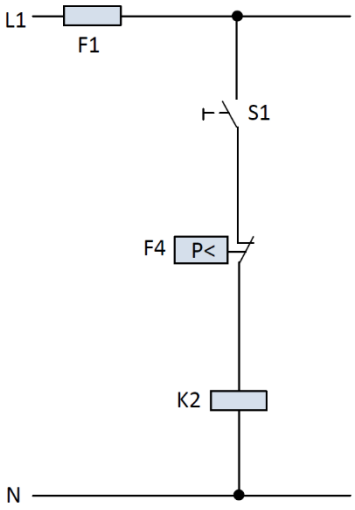
B1 ..... System controller
Q1..... Main switch
D ..... Drive assembly
F1, F6 . Fuses
F3 ..... HP limiter
F4 ..... LP switch
K2..... Contactor (optional)
RCD .... Residual current device
S1..... Auxiliary switch

Figure 17: Wiring diagram for YBVH* compressors with single-phase drive

Power circuit



Control circuit



Legend

B1 ..... System controller
Q1..... Main switch
D ..... Drive assembly
F1, F6, F7, F8.. Fuses
F3 ..... HP limiter
F4 ..... LP switch
K2 ..... Contactor (optional)
RCD ..... Residual current device
S1 ..... Auxiliary switch

Figure 18: Wiring diagram for YBVH* compressors with three-phase drive

4.3.1 Motor windings

YBVH* compressors feature a three-phase brushless permanent magnet motor. It is exactly the same whether the drive supply is single-phase or three-phase. The motor is connected in star.

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

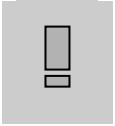
4.4 Protection devices

Fuses must be installed before the drive. The selection of fuses has to be carried out in accordance with VDE 0635, DIN 57635, EC 269-1 or EN 60-269-1.

4.5 Crankcase heating function



CAUTION
Motor overheating! Compressor damage! The crankcase heating function must not be energized when the system is in a vacuum or if there is no refrigerant charge in the system. The system low-pressure cut-out control can be used as an indicator of the presence of refrigerant charge.



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 the standard fixed-speed Copeland Scroll compressors, the YBVH* 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 6** below.

If this function is required, the crankcase heating function must be used and the power has to be determined by tests across the envelope for winter and summer situations.

Compressor	Refrigerant charge limit
YBVH021 YBVH029	1.2 kg
YBVH046	1.2 kg

Table 6: Refrigerant charge limit

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

4.6 Pressure safety controls

4.6.1 High-pressure protection

A high-pressure cut-out control must be used in all applications to avoid abnormally high operating pressures. The maximum cut-out setting should be defined referring the high-side PS (maximum allowable pressure) according to the requirements of applicable standards and directives.

The high-pressure cut-out limiter has to be connected to the ED3 drive – see the wiring diagram. The output is a 5VDC signal. Normally the high-pressure cut-out limiter must be closed. If the limiter is open, the drive will not operate.

***NOTE*: For the connection of the high-pressure limiter to the drive, please refer to the Emerson User Manual for ED3.**

4.6.2 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.

Make sure that the 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.

The minimum operating pressure could go below atmospheric pressure when observing the following rules:

- valid only for hermetically sealed systems, according to the safety standards
- minimum absolute pressure above 0.5 bar.
- use temperature control on the discharge line to stop the compressor; the temperature shall never exceed the value given in **Chapter 4.7 "Discharge gas temperature protection".**

Systems in some instances must operate at low evaporating pressure because of the low ambient temperatures, sometimes combined with a high level of relative humidity. Proper evaporator sizing and adequate defrost strategy control will prevent the system from operating outside the operating envelope published by Emerson, whatever the climatic conditions and the capacity demand.

However, in some extreme cases – such as loss of system charge, extreme heat transfer restriction at the evaporator, any defect or blocked flow control component (expansion valve, screens, etc.) – the evaporating conditions may be such that the compressor will operate outside the published operating envelope limits. These conditions may result in compressor failure.

Therefore, Emerson requires that all YBVH compressors without exception be fitted with a low-pressure protection in the suction line, meaning that no service valve between compressor and pressure limiter is allowed. The mandatory inclusion of a low-pressure control will stop the compressor operating outside the published envelope limits.

Customer shall follow all applicable regulations and standards to apply appropriate control to ensure that the pressure is always above the required minimum limit.

4.7 Discharge gas temperature protection

IMPORTANT
Inadequate lubrication! Scroll set damage! All YBVH* compressors must be equipped with an external discharge gas temperature protection.

A good system control shall prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the capacity demand. However, under some extreme operating conditions (such as loss of charge or improper control operation), the internal discharge gas temperature reached can cause compressor damage. In order to guarantee positive compressor protection, 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. If not used, the warranty of the compressor will be lost.

The maximum discharge gas temperature is 135°C for all YBVH* models. These compressors have no internal discharge gas temperature protection. Therefore, an external discharge gas temperature protector must be installed.

4.7.1 Excessive discharge gas temperatures

A few of the possible consequences are listed below:

- Since the oil circulates in the system with the refrigerant, it is subjected to high discharge gas temperatures. If the discharge gas temperature becomes too high, the so-called "cooking" effect will occur (heating of oil under exclusion of air). Carbon deposits can form at points of high temperature, for example on the valves, oil channels, oil filters, etc. The oil lubricity will be reduced and a progressive wear process will occur which will prematurely damage the compressor.
- The stability of the refrigerant can also be affected, particularly if traces of contaminant are present.
- The problems listed under the first 2 points frequently occur simultaneously, particularly since the chemical reaction time approximately doubles at every 10°C temperature rise. This directly leads

to chemical reactions of the oil with the refrigerant and the compounds extracted from sealants and insulation material. As a consequence contaminants of various types, among them acids, will form inside the system.

4.7.2 Compressor discharge gas temperature protection

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.

YBVH* compressors do not have an internal discharge temperature protection. Emerson offers NTC-discharge temperature sensors for the installation on the discharge piping of the compressor, to be connected electrically to the ED3 inverter – see the Emerson User Manual for ED3 for correct connection and further details. The NTC-sensor 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 19**. If you use thermal compound 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.

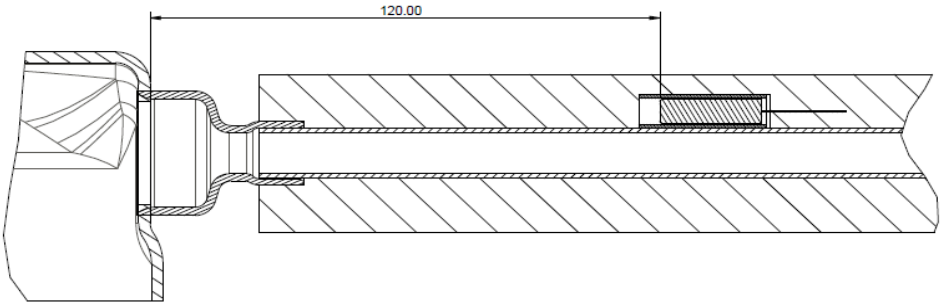


Figure 19: Discharge temperature sensor mounting

4.8 High-potential testing



WARNING
High potential testing in a 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! 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 1000V plus twice the nominal voltage.

Since high-voltage tests lead to premature ageing of the winding insulation, further additional tests of that nature are not recommended. 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 Megaohm resistance on an R290 compressor as these tests can induce an electrical arc and cause a potential fire/explosion hazard.

For the same reason, compressors removed from an R290 system 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 Megaohm resistance reading.

5 Start-up & operation



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



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.

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

Since it is not possible to isolate the compressor from the rest of the system, system strength pressure testing according to EN 378-2 should be carried out in two steps at two different test pressures, the high-side test pressure HPT and the low-side test pressure LPT:

- First, apply for a short time the HPT in the high-pressure section of the system up to the compressor discharge stub. The compressor check valve automatically closes to isolate the low-pressure side. During that test, make sure that the low-pressure side of the system does not exceed the compressor maximum standstill pressure, ie, the compressor low side PS.
- Then, test the low-pressure section of the system by applying the LPT not exceeding the low side PS.

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 system manufacturer/installer to leak-test the compress

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

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.

5.3 System evacuation

Before the installation is put into commission, it has to be evacuated with a vacuum pump. The vacuum pump and all tools have to be approved for A3 refrigerant/air mixture. The installation should be evacuated down to 0.3 mbar. Proper evacuation reduces residual moisture to 50 ppm. During the initial procedure, suction and discharge shut-off valves on the compressor remain closed. The installation of adequately sized access valves at the furthest point from the compressor in the suction and liquid lines is advisable. The pressure must be measured using a vacuum pressure gauge on the access valves and not on the vacuum pump; this serves to avoid incorrect measurements resulting from the pressure gradient along the connecting lines to the pump.

Evacuating the system only on the suction side of a scroll compressor can occasionally result in a temporary no-start condition for the compressor. The reason for this is that the floating seal could

axially seal with the scroll set, with the higher pressure on the floating seal. Consequently, until the pressures equalise, the floating seal and scroll set can be held tightly together.

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

5.4 Preliminary checks – Pre-starting



WARNING
Air/R290 refrigerant mixture in a potentially flammable atmosphere! Explosion hazard! Whenever starting up a system charged with R290 refrigerant, eg, after filling, repair, or maintenance, make sure not to start and operate accidentally in a flammable or explosive atmosphere.

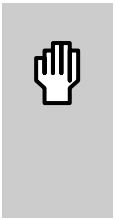
Discuss details of the installation with the installer. If possible, obtain drawings, wiring diagrams, etc.. It is ideal to use a check-list but always check the following:

- 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
- Cable glands in good state, all electrical connections well connected and terminal box closed to ensure corresponding IP protection
- Visual check of the plant for leaks, loose component parts such as TXV bulbs or solenoid valve coil, loose wires in electrical installation, etc
- Functional test of HP & LP switches and any pressure actuated valves
- Check setting and operation of all safety features and protection devices
- All valves in the correct running position
- Pressure and compound gauges fitted
- Correctly charged with refrigerant
- Compressor electrical auxiliary switch location and position

5.5 Charging procedure



WARNING
Air/R290 refrigerant mixture in a potentially flammable atmosphere! Explosion hazard! Only use filling equipment designed and approved for use and operation with R290. Make sure all connections are tight to avoid leakage. Make sure to fill with pure R290.



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.

5.6 Run-in time

Scroll compressors exhibit a slight decrease in input power during the initial running period. Published performance ratings are based on calorimeter testing which is carried out after run-in. Therefore, the users should be aware that before the performance specified by EN 12900 is achieved the compressor needs to be run in. Recommended run-in times for YBVH* compressors to attain the published performance are 16 hours at the saturation evaporating and condensing temperature conditions -10/45°C with a superheat of 10K.

5.7 Initial start-up



CAUTION
High discharge pressure operation! Compressor damage! Do not use compressor to test opening set point 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.

5.8 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. For more information about this topic please refer to the Emerson User Manual for ED3.

5.9 Starting sound

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

5.10 Deep vacuum operation



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

5.11 Shell temperature

5.12 Shell temperature

The top shell and discharge line can briefly but repeatedly reach temperatures up to 135°C. Care must be taken to ensure that wiring or other materials that could be damaged by these temperatures do not touch the shell.

5.13 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. Pumping down outside the operating envelope or below atmospheric pressure is not allowed. If this happens, immediately stop the compressor and/or de-energize the power supply of the compressor.

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 in conjunction with the crankcase heating function when the compressor is located outside without any housing so that cold air blowing over the compressor makes the crankcase heating function 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.

5.14 Minimum run time

Emerson recommends a maximum of 10 starts per hour. There is no minimum off time because scroll compressors start unloaded, even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after start-up. To establish the minimum run time, a sample compressor equipped with a sight tube can be ordered from Emerson for oil return qualification and minimum oil level – see **Chapter 2.6.3 "Oil filling and oil level"**. 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.

5.15 Shut-off sound

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

5.16 Oil level

YBVH* compressors are not equipped with any oil sight glass to ensure maximum hermeticity.

During the system development phase, adequate oil return in any operation should be checked whatever the compressor model. For this purpose, a sample compressor equipped with a sight tube can be ordered from Emerson for lab testing. Oil return check test recommendations are also available on request from the Application Engineering department at 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.
All electrical components could be a source of ignition and must always be switched off during service and maintenance.



WARNING
Air/flammable refrigerant mixture may create a potentially flammable atmosphere! Fire 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. Every working procedure that affects safety means shall only be carried out by competent personnel according to national or other equivalent certification systems.

Examples of such working procedures are:

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

6.2 Preparation and work procedure

A work procedure shall be provided in the preparation stage. All maintenance staff and others working at the site shall be instructed on 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 extinguishers are considered appropriate. Confirm that appropriate fire extinguishing equipment is available near the work area.

Work shall be undertaken under 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 A3-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 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.

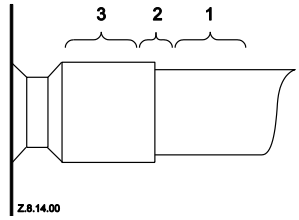


Figure 20: Tube connecting areas

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 of 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/R290 mixture! Flammable atmosphere! Explosion hazard! In any case avoid air/R290 mixture in the refrigeration system. Make sure that the system is filled with pure R290 refrigerant. In the event that the refrigerant needs replacing, the charge should be recovered using R290 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.

Qualified refrigerant and oil can be found in **Chapter 2.5.1.**

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

6.6 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 an R290 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 is cleaned through the use of suction and liquid line filter driers. A 100% activated alumina suction line filter drier is recommended but must be removed after 72 hours.

6.6.2 Start-up of a new or replacement compressor

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

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

6.6.3 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 explosive. If explosive 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 should be energized - immediately de-energize in case an explosive atmosphere is detected.
- Do not allow the recovery unit to recover below atmospheric pressure. Make sure the low-pressure switch that stops the recovery process is not set below 0.5 bar(g).
- At this pressure some refrigerant will still be in the system. Therefore, before opening the system, pressurize to 1 bar(g) with dry nitrogen.
- Open the system with a cutting tool and flush the entire system with dry nitrogen.
- Disassemble the compressor with a cutting tool. Drain and recover compressor oil properly. Flush the compressor with dry nitrogen 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! Hydrocarbon compressor for analysis"**.
- The compressor shipment has to 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 that apply to such shipments are complied with.**

6.7 Lubrication and oil removal



WARNING
Air/R290 refrigerant mixture in a potentially flammable atmosphere! Fire hazard! Use suitable recovery unit and recycling bottles also for oil disposal as R290 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 R290 is a polyolester (POE) lubricant. See nameplate for original oil charge shown in litres. A field recharge is from 0.05 to 0.1litre less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil – see **Figure 21**. Only brief exposure to ambient air is needed for POE to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since POE holds moisture more readily than mineral oil it is more difficult to remove it through the use of vacuum. Compressors supplied by Emerson 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.

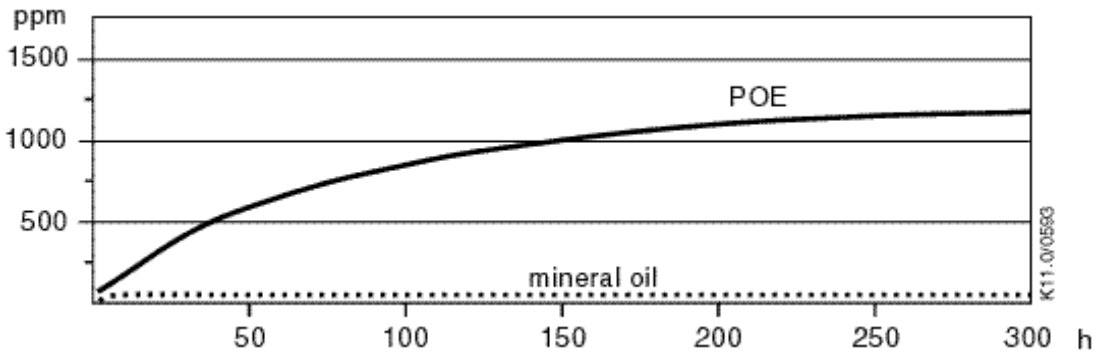


Figure 21: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25° C and 50% relative humidity (h=hours)

If the moisture content of the oil in a refrigeration system reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 0.3 mbar or lower. If there is uncertainty as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the R290 refrigerant and lubricants; however, the moisture indicator will just show the moisture contents of the refrigerant. The actual moisture level of POE would be higher than the sight glass indicates. This is due to the high hygroscopicity of the POE oil. To determine the actual moisture content of the lubricant, samples have to be taken from the system and analysed.

6.8 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! 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.

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. ▪ Acid formation: Acid forms in the presence of moisture, oxygen, metal, salts, metal oxides and/or high discharge temperatures. The chemical reactions are accelerated at higher temperatures. Oil and acid react with each other. Acid formation leads to damage of the moving parts and in extreme cases to motor burnout. Several different test methods can be used to test for acid formation. If acid is present a complete oil change (including the oil in the oil separator) will help. A suction filter which removes acid should also be fitted. Check filter-drier condition.

Condition	Cause	Corrective action
The scroll compressor does not run, no buzz sound can be heard	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.
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.

Condition	Cause	Corrective action
	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.
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.

Condition	Cause	Corrective action
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.

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 miswiring, broken leads or a cable short circuit. Check for loose or burned contacts. Check for burned components on the board.
- Chokes/PFC: Check all the wiring and check for loose or burned contacts.
- External sensors: Make sure that the external sensors are properly connected and still working (discharge temperature sensor and high-pressure switch).
- Drive cooling: For air-cooled drives, make sure that the airflow is not obstructed.
- EMI filter: Check all the wiring and check for loose or burned contacts on the board.
- Compressor: Make sure the compressor is running within the envelope. Check the winding resistances from the compressor motor and the cables between compressor and drive. Check for loose or burned contacts.

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.

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