



Scroll compressors for Dedicated Heat Pumps

ZH15 K4E...ZH45 K4E

Application Guidelines

APPLICATION GUIDELINES: COPELAND SCROLL™ COMPRESSORS FOR DEDICATED HEAT PUMPS, ZH15K4E ... ZH 45 K4E

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1 Introduction

The Scroll compressor has been under development at Copeland since 1979 and is the most efficient and durable compressor Copeland has ever developed for air-conditioning and refrigeration. Copeland has now invested significant resources and carried out extensive testing to optimize a completely new range of ZH Scroll compressors for dedicated Heat Pump applications. It offers very low vibration and sound levels and is tolerant to stresses caused by liquid slugging, flooded starts, and debris commonly found in refrigeration systems. Available product range in this family is from 2 to 6 hp. For detailed information, please, refer to the Copeland Selection Software accessible from the Copeland website at www.ecopeland.com.

These guidelines are not meant to replace the system expertise available from system manufacturers.

2 Safety Instructions

Only qualified personnel should install and repair COPELAND compressors.



- Refrigerant compressors must be employed only for the use they are made for.
- Only approved refrigerant and refrigerating oils must be used.
- Do not start the compressor until it is charged with refrigerant.
- Correctly used, the compressor and the pressure line piping may reach temperatures that may cause burning if touched.



- Wear safety goggles when working on open systems.
- If the refrigerant needs to be removed from the system, do not disperse it in the environment, use the correct equipment & method of removal.
- For storage, use original packaging and avoid collisions and tilting.



- Trained electrical personnel must connect the compressor and its accessories.
- All valid standards for connecting electrical and refrigeration equipment must be observed.
- Limit values for the supply voltage of the unit may not be exceeded.



It is not allowed to run a test without the compressor being connected to the system and without refrigerant. It is of vital importance that the discharge stop valve has been fully opened before the compressor is started. If the discharge stop valve is closed or partly closed an unacceptable pressure with accordingly high temperatures may develop. When operating with air the so-called diesel effect may occur, i.e. the air sucked in is mixed with oil gas and can explode due to the high temperature, and thereby destroy the compressor.

3 Nomenclature

The model numbers of Copeland Scroll™ compressors have been designed to include a coded nominal capacity at dedicated heat pump operating conditions. All heat pump scroll compressors are charged with Ester oil, which is indicated by the letter “E”.

Model Designation

Z H 26 K 4 E - TFD - 524
 1 2 3 4 5 6 7 8

- 1 Z = Compressor family: Z = Scroll
- 2 H = Dedicated heat pump compressor
- 3 Nominal heating capacity [kW] @ 50 Hz and -7°C evaporating/50 °C condensing using multiplier 1/3.
Ex: 26K = 8.6 kW
- 4 Nominal heating capacity multiplier: K= 1 & M= 10
- 5 Model variation
- 6 POE Oil
- 7 Motor version
- 8 Bill of Material

4 Application Envelope

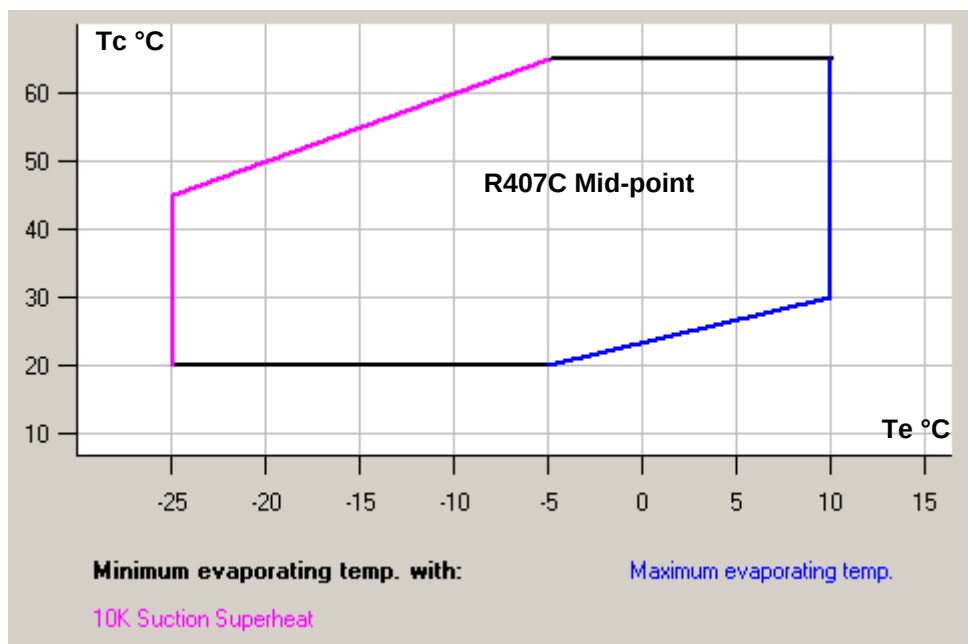


Figure 1: Application envelope of ZH compressors

5 Qualified Refrigerants

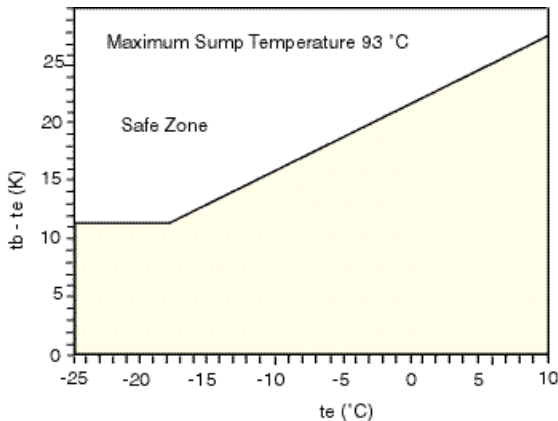
R407C has been qualified for the compressor models ZH 15 K4E ... ZH 45 K4E.

6 Lubrication

The compressor is supplied with an initial charge of polyolester (POE) lubricant. In the field the oil level could be topped up with Mobil EAL Arctic 22 CC. The recharge values can be taken from Copeland Selection Software.

Although there is no flexible mounting of the internal compressor parts, the number of start/stop cycles should be limited to 10 per hour. A high cycling rate will pump oil into the system and may lead to lubrication failure. Oil leaves the compressor at start-up regardless of the low oil carry over of the Copeland Scroll. The short running time is insufficient to return the oil to the compressor and possibly results in a lack of lubricant.

It must be considered that the entire system will be coated with oil to some extent. Oil viscosity changes with temperature. System gas velocity changes depending on temperature and load. In low load conditions gas velocity may not be high enough to return oil to the compressor. System piping should be designed to return oil under all operating conditions.



For proper lubrication the minimum differential between bottom shell (tb) and evaporating (te) temperatures should be carefully observed as laid out in Figure 2. On the other hand, the maximum bottom shell temperature should never exceed 93°C, measured close to the bottom center of the compressor.

Figure 2: Minimum bottom shell temperature (tb)

One characteristic of POE is that it is far more hygroscopic than mineral oil (Figure 3). 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 retains moisture chemically it is not possible to completely remove it through the use of vacuum.

Compressors supplied by Copeland contain oil with a low moisture content, and this 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 charge systems with POE containing no more than 50 ppm moisture content. If the moisture content of the oil in a refrigeration system reaches unacceptable high levels, corrosion and copper plating may occur.

The system should be evacuated down to 0.3 mbar or lower. If there is uncertainty, as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the HFC refrigerants and lubricants; however, the moisture indicator will just show the moisture contents of the refrigerant. The actual moisture level of POE would be higher than the sight glass specifies. This is a result of the high hygroscopicity of the POE oil. Oil samples would have to be taken from the system and analyzed to determine the actual moisture content of the lubricant.

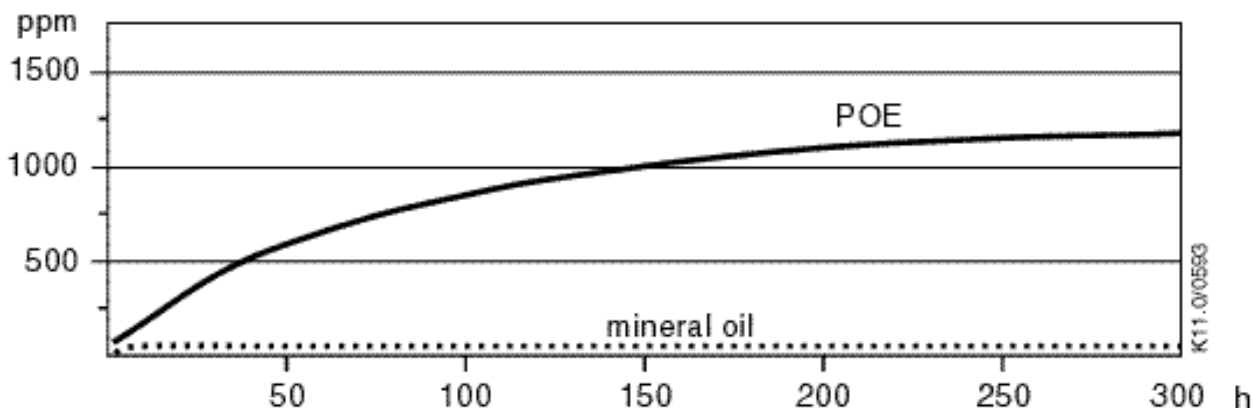


Figure 3: Absorption of moisture in ester oil in comparison to mineral oil in [ppm] by weight at 25°C and 50% relative humidity. h = hours.

7 Accumulators

An accumulator is normally not required in dedicated heat pump applications. Durability is ensured by the Copeland Scroll's inherent ability to handle liquid refrigerant in flooded start and defrost cycle operation. However, large volumes of liquid refrigerant which repeatedly flood back to the compressor during normal off cycles or excessive liquid refrigerant floodback during steady operation can dilute the oil in any compressor to the point where bearings become inadequately lubricated and wear may occur. If an accumulator is fitted, and there is no crankcase heater, it should be piped to allow free liquid drainage during the off cycle as shown in Figure 4.

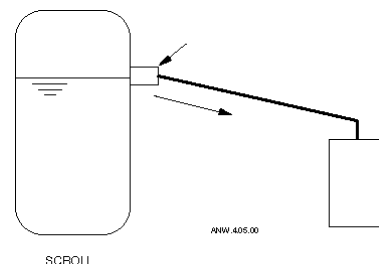


Figure 4: Accumulator

8 Crankcase Heaters

No crankcase heater (CCH) is required when the system charge does not exceed the following values:

3,6 kg	for	ZH 15 K4E ... ZH 26 K4E
4,5 kg	for	ZH 30 K4E ... ZH 45 K4E

A CCH is to prevent refrigerant migrating into the shell during standstill periods. It is recommended to fit a CCH if the compressor is located outside the building, the system charge is above the limits shown, and no accumulator is piped to provide free liquid drainage during the off cycle as shown. For correct mounting location of a CCH please see Figure 5.

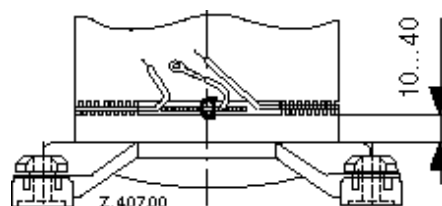


Fig. 5: Crankcase heater location

9 Discharge Temperature Protection

Internal discharge temperatures reached under some extreme operating conditions (such as loss of charge or extremely high compression ratio) can cause compressor damage. In order to guarantee positive compressor protection, the compressor should be equipped with an external discharge temperature sensor.

Copeland can provide such a thermostat as an accessory (see spare parts list ZH). This thermostat is not insulated and the equivalent set point for an insulated sensor is 120°C maximum. The thermostat should be positioned as shown in Figure 6 below.

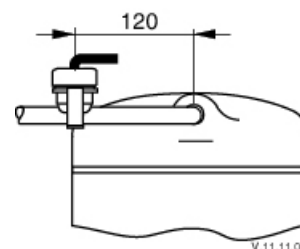


Figure 6: Discharge line thermostat



10 Standard Motor Protection

Conventional inherent internal line break motor protection is provided with models ZH15K4E to ZH45K4E.

11 Low Ambient Cut-Out

A low ambient cut-out may be required for systems using air as a heat source.

12 Pressure Controls

A high pressure cut-out may be required according to individual national regulations and is strongly recommended with three-phase compressors due to their capabilities of pumping to high pressures once the discharge is obstructed. There is an internal pressure relief valve in the ZH 15 K4E...ZH 45 K4E models, which opens at a differential pressure of 28 bar $\pm$ 3 bar between high and low pressure sides. For the low-pressure side a minimum working pressure setting of 0.3 bar is recommended.

13 Shut-Off

A check valve in the discharge connection of the compressor prevents the compressor from running backwards for more than one second or two. This momentary reversal of direction of the scrolls has no effect on compressor durability and is entirely normal. Additionally there is a dynamic discharge valve mounted on the fixed Scroll, which effectively eliminates reverse rotation.

14 Starting

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

15 Deep-Vacuum Operation

The danger of pulling deep vacuums is avoided due to an internal low vacuum protection which prevents the scrolls pumping (unloads) when the pressure ratio exceeds approximately 20:1. In order to avoid nuisance trips, it is recommended to set the low-pressure control as described in Section 12 above.

16 Brief Power Interruptions

With single-phase Copeland Scroll compressors brief power interruptions of less than 1/2 second may result in powered reverse rotation. This occurs as a result of the high-pressure discharge gas expanding backwards through the scrolls at power interruption, causing the scroll to orbit in the reverse direction. When power is reapplied while reverse rotation is occurring, the compressor may continue to run in the reverse direction for several minutes until the compressor's internal protector trips. This has no effect on durability. When the protector resets the compressor will start and run normally.

To avoid the loss of heating resulting from powered reverse rotation Copeland strongly encourages the use of an electronic control which can sense brief power interruptions and will lock the compressor out of operation for five minutes. This control could be incorporated with the other system controls (such as defrost or thermostat), or be a stand-alone control. Functional specifications for this control are the following:

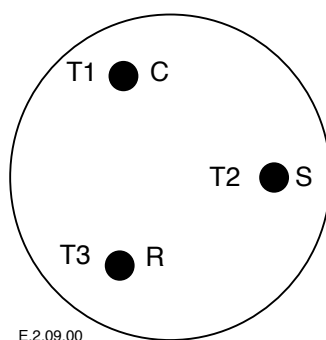
Timer opens: 1 electrical cycle (0,02 sec at 50-Hz operation) after power is removed and closes: 5 minutes ($\pm$ 20 %) delayed whether power is restored or not. No such device is required on three-phase models.

17 Electrical Installation

Independently from the internal motor protection, fuses F6...8 have to be installed before the compressor as shown in Figure 8 and Figure 9. Selection of fuses has to be carried out according to VDE 0635 or DIN 57635 or IEC 269-1 or EN60-269-1. Motor insulation material class is "B" for models ZH 15 K4*...ZH 45 K4* according to IEC 34-1 or DIN 57530.

The fuse connections are marked as in Figure 7. Recommended wiring diagrams are shown in Figure 8 and Figure 9. Single-phase compressors are connected to the common (C), start (S) and run (R) connections as usual. Three-phase models are connected (L1,L2,L3) to T1, T2 and T3.

Figure 7: Motor terminal connections



Scroll compressors, like several other types of compressors, will only compress in one rotational direction. Direction of rotation is not an issue with single-phase compressors since they will always start and run in the proper direction (except as described in Section 16). However, three-phase compressors will rotate in either direction depending upon phasing of the power to L1, L2 and L3. Since there is a 50/50 chance of connecting power in such a way as to cause rotation in the reverse direction, it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction is achieved when the system is installed and operated. Verification of proper rotation direction is made by observing that suction pressure drops and discharge pressure rises when the compressor is energized. Reverse rotation results in a sound level above that with correct rotation direction, as well as substantially reduced current draw compared to tabulated values and after several minutes of operation the compressor's internal protector will trip.

All three-phase compressors are wired identically internally. As a result, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the same terminals should maintain proper rotation direction.

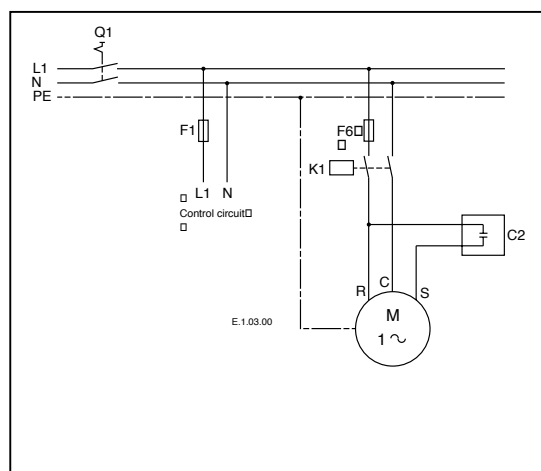


Figure 8: Power circuit single phase

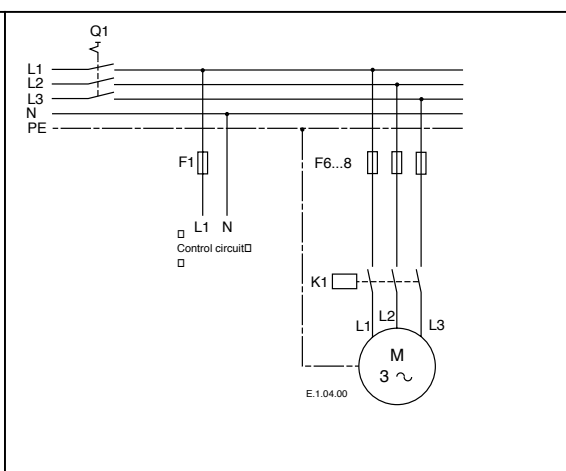


Figure 9: Power circuit three phase



18 High Potential Testing

Copeland subjects all motor compressors to a high voltage test after final assembly. This is carried out according to IEC-34-1.

Since high voltage tests lead to premature aging of the winding insulation we do not recommend additional tests of that nature. They may also be carried out with new machines only.

If it has to be done for any reason disconnect all electronic devices (e.g. motor protection module, fan speed control, etc.) prior to testing. The test voltage of 1000 V plus twice the nominal voltage is applied for 1 - 4 seconds between motor winding (each one of the phases) and the compressor shell: The maximum leak current limit is approximately 10 mA. Repeated tests have to be performed at lower voltages.

Caution: Do not carry out high voltage or insulation tests if the compressor housing is under vacuum. Copeland Scroll compressors are configured with the motor down and the pumping components at the top of the shell. As a result, the motor can be immersed in refrigerant to a greater extent than hermetic reciprocating compressors when liquid refrigerant is present in the shell. In this respect, the scroll is more like semi-hermetics (which have horizontal motors partially submerged in oil and refrigerant). When Copeland Scroll compressors are high potential tested with liquid refrigerant in the shell they can show higher levels of leakage current than compressors with the motor on top because of the higher electrical conductivity of liquid refrigerant than refrigerant vapour and oil. However, this phenomenon can occur with any compressor when the motor is immersed in refrigerant. The levels of current leakage do not present any safety issue. To lower the current leakage reading the system should be operated for a brief period of time to redistribute the refrigerant to a more normal configuration and the system high potential tested again.

19 Compressor Functional Check

It is not desirable to perform functional compressor tests where the compressor is turned on with the suction service valve closed to check how low the compressor will pull suction pressure. Rather, the following diagnostic procedure should be used to evaluate whether the Copeland Scroll compressor is functioning properly.

1. Proper voltage to the unit should be verified.
2. The normal checks of motor winding continuity and short to ground should be made to determine if the internal overload motor protector has opened or if an internal short to ground has developed. If the protector has opened, the compressor must be allowed to cool sufficiently to allow it to reset.
3. Proper indoor and outdoor fan/blower operation should be verified.
4. With service gauges connected to suction and discharge pressure fittings, turn on the compressor. If suction pressure falls below normal levels the system is either low on charge or there is a flow blockage in the system.
5.
 - a) Single-phase compressors
If suction pressure does not drop and discharge pressure does not rise to normal levels, either the reversing valve (if so equipped) or the compressor is faulty. Use normal diagnostic procedures to check operation of the reversing valve.
 - b) Three-phase compressors
If suction pressure does not drop and discharge pressure does not rise to normal levels, reverse any two of the compressor power leads and reapply power to make sure compressor was not wired to run in reverse direction. If pressures still do not move to normal values, either the reversing valve (if so equipped) or the compressor is faulty. Reconnect the compressor leads as originally configured and use normal diagnostic procedures to check operation of the reversing valve.
6. If the reversing valve (if so equipped) checks out satisfactorily, then the compressor current draw must be compared to published compressor performance data at the compressor operating conditions (pressures and voltages) and significant deviations (more than $\pm 15\%$) from published values may indicate a faulty compressor.

20 Excessive Liquid Floodback

The following tests are for those Air/Water system configurations and charge levels, which need special testing to verify exemption from the need of an accumulator.

20.1 Continuous Floodback

To test for excessive continuous liquid refrigerant floodback, it is necessary to operate the system in a test room at conditions where steady state floodback may occur (low ambient air/water heating). Thermocouples should be attached to the suction and discharge lines of the compressor (approximately 150 mm from the shell) and insulated. If the system is designed to be field charged it should be overcharged by 15 % in this test to simulate overcharging commonly found in field installations.

The system should be operated at an indoor temperature of 20°C and outdoor temperature extremes (-18°C or lower) which produce floodback conditions. The compressor suction and discharge pressures and temperatures should be recorded. The system should be allowed to frost up for several hours (disabling the defrost control and spraying water on the outdoor coil may be necessary) to cause the saturated suction temperature to fall to -30°C or below. The compressor sump temperature must remain above the saturated suction temperature as determined from Figure 2 or design changes must be made to reduce the amount of floodback. If an accumulator is used an oil return orifice size of 1,4 mm is recommended.

20.2 Repeated Floodback during Defrost

For systems using hot gas bypass defrost, and having refrigerant charge levels above the limits given in Section 8 it may be necessary to fit an accumulator to trap a certain amount of the returning liquid. A good indication of liquid return can be low sump temperatures (Figure 2). Obtain a sample compressor with a side sight tube to measure liquid level in the compressor. Set the system up in a configuration with the indoor unit elevated approximately 1 m above the outdoor unit with approximately 7 m of connecting tubing with no traps between the indoor and outdoor units. If the system is designed to be field charged, the system should be overcharged by 15% in this test to simulate overcharging commonly found in field installations. Record the height of the liquid in the compressor during each cycle, any protector trips, or any compressor stalls during each test. Review all test results with Copeland Application Engineering to determine if an accumulator is required for the application.

21 Installation

Four vibration absorber grommets are supplied with each compressor (see Figure 10). They dampen the start-up surge of the compressor and prevent sounds and vibrations from being transmitted to the compressor base during operation to a large extent. The metal sleeve inside is intended as a guide to hold the grommet in place. It is not designed as a load-bearing member, and excessive torquing can crush the sleeve. Its inner diameter is approximately 8.5 mm to fit e.g. an M8 screw. The mounting torque should be 13 ± 1 Nm. It is critically important that the grommet is not compressed. A clearance space of approximately 2-mm between the bottom of the washer and the top of the grommet spacer is recommended (see Figure 10).

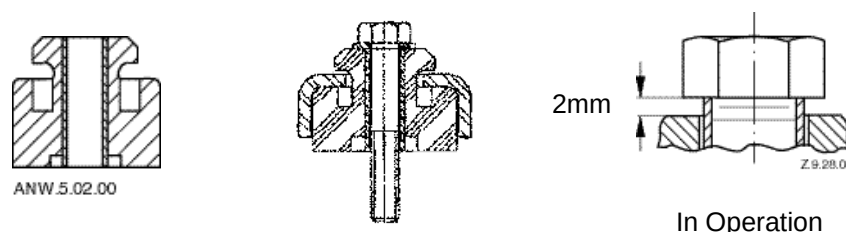


Figure 10: Mounting Parts

22 Service

Copeland Scroll compressors have copper plated steel suction and discharge tubes. These tubes are far more robust and less prone to leaks than copper tubes 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. For brazing of the tubes see Figure 11 and the following procedures. Since the discharge stub contains a check valve, care must be taken not to overheat it as well as to prevent brazing material from flowing into it.

23 New Installations

- 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
- 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.

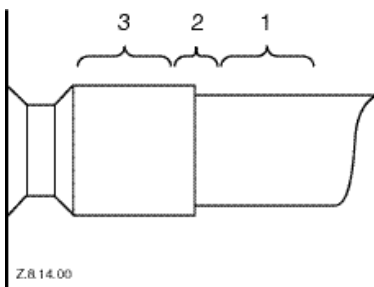


Figure 11: Suction tube brazing

24 Field Service

To disconnect:

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

To reconnect:

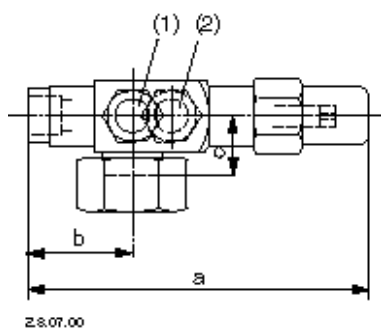
- Recommended brazing-materials: Silfos with minimum 5% silver or silver braze used on other compressors. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used. For brazing of the tubes see Figure 11 and the following procedures. Since the discharge stub contains a check valve, care must be taken not to overheat it as well as to prevent brazing material to flow into it.

25 Shut-off Valves and Adapters

The Scroll compressors ZH15K4E to ZH45K4E are delivered with brazing connections. Rotalock type shut-off valves can also fit compressors with braze connections (by the mean of Rotalock adapters. Rotalock-shut-off valves are available for the suction as well as the discharge side (see Figure 12 & spare parts list “ZH”).

	Torque [Nm]
Rotalock 1"-12UNF	70 – 80
Rotalock 1"1/4-12UNF	110-135

It is strongly recommended to periodically retorque all pipe and fixing connections to the original setting after the system has been put into operation.



- (1) pressure control connection
- (2) gauge connection

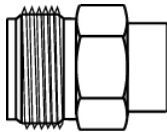


Figure 12: Shut-off valves and adapters

26 Shell Temperature

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

27 System Charging Procedure

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

28 Unbrazing System Components

If the refrigerant charge is removed from a scroll-equipped unit by bleeding the high side only, it is sometimes possible for the scrolls to seal preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized. If a brazing torch is applied to the low side while the low side shell and suction line contains pressure, the pressurized refrigerant and oil mixtures could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and the low side with gauges before unbrazing, or in the case of repairing a unit on an assembly line, bleed refrigerant from both the low and the high side. Instructions should be provided in appropriate product literature and assembly (line repair) areas.

29 Suction Line Noise and Vibration

Copeland Scroll compressors inherently have low sound and vibration characteristics. However, in some respects, the sound and vibration characteristics differ from reciprocating compressors and, in rare instances, could result in unexpected sound complaints.

One difference is that the vibration characteristic of the Scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally suspended compressor. These frequencies, which are present in all compressors, may result in a low level “beat” frequency that can be detected as noise coming along the suction line into a house under some conditions. Elimination of the “beat” can be achieved by attenuating either of the contributing frequencies. This is easily done by using one of the common combinations of design configuration described below.

A second difference of the Copeland Scroll compressor is that under some conditions the normal starting motion of the compressor can transmit an “impact” noise along the suction line. This phenomenon, like the one described above, also results from the lack of internal suspension, and can be easily avoided by using standard line isolation techniques as described below.

Recommended configuration (Figure 13):

- Tubing configuration: small shock loop
- Service valve: “angled valve” fastened to unit/wall
- Suction muffler: not required

Alternative configuration:

- Tubing configuration: small shock loop
- Service valve: “straight-through” valve fastened to unit/wall
- Suction muffler: may be required

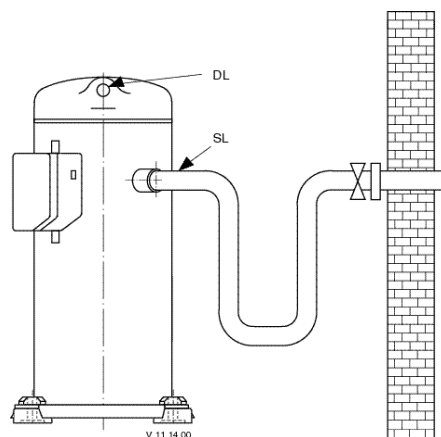


Figure 13: Suction tube design

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