



Refrigeration Scroll Enhanced Vapour Injection

ZF24KVE ... ZF48KVE

Application Guidelines

APPLICATION GUIDELINES: ENHANCED VAPOUR INJECTION (EVI) REFRIGERATION SCROLL COMPRESSORS ZF24KVE-ZF48KVE

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1 Introduction

This Guideline describes the operating characteristics of the Enhanced Vapour Injection (EVI) refrigeration scroll compressors ZF24KVE to ZF48KVE.

EVI Compressor systems present benefits over standard refrigeration compressors due to the following:

- Capacity Improvement

The capacity is improved by increasing the enthalpy difference in the system rather than increasing mass flow. This is accomplished without increasing displacements.

- Increased COP

The efficiency improves due to the fact that the gain in capacity is greater than the increase in power that the compressor consumes.

- Cost and Energy Advantage

Because a smaller size compressor can be used to achieve the same capacity as a larger conventional model, there is an inherent cost advantage

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 EVI Theory of Operation

Copeland EVI Scroll compressors are equipped with a vapour injection connection for Economizer Operation. Economizing can be accomplished by utilising a subcooling circuit similar to the circuit shown in Figure 1. This increases the refrigeration capacity and the system efficiency. The benefits provided will increase as the compression ratio increases.

The schematic shows a system configuration for the economizer cycle. A heat exchanger is used to provide additional subcooling to the refrigerant before it enters the evaporator. This subcooling process provides the increased capacity gain measured in the system. During the subcooling process, a certain amount of refrigerant is evaporated. This evaporated refrigerant is injected into the compressor and provides additional cooling at higher compression ratios.

The P-h diagram (Figure 2) shows the theoretical gain in system performance acquired by using the economizer cycle. The extension outside of the vapour dome provides the enthalpy increase, enhancing system performance. Although power increases due to the vapour injection into the compressor, there is still a significant efficiency gain because the capacity gain exceeds the power increase.

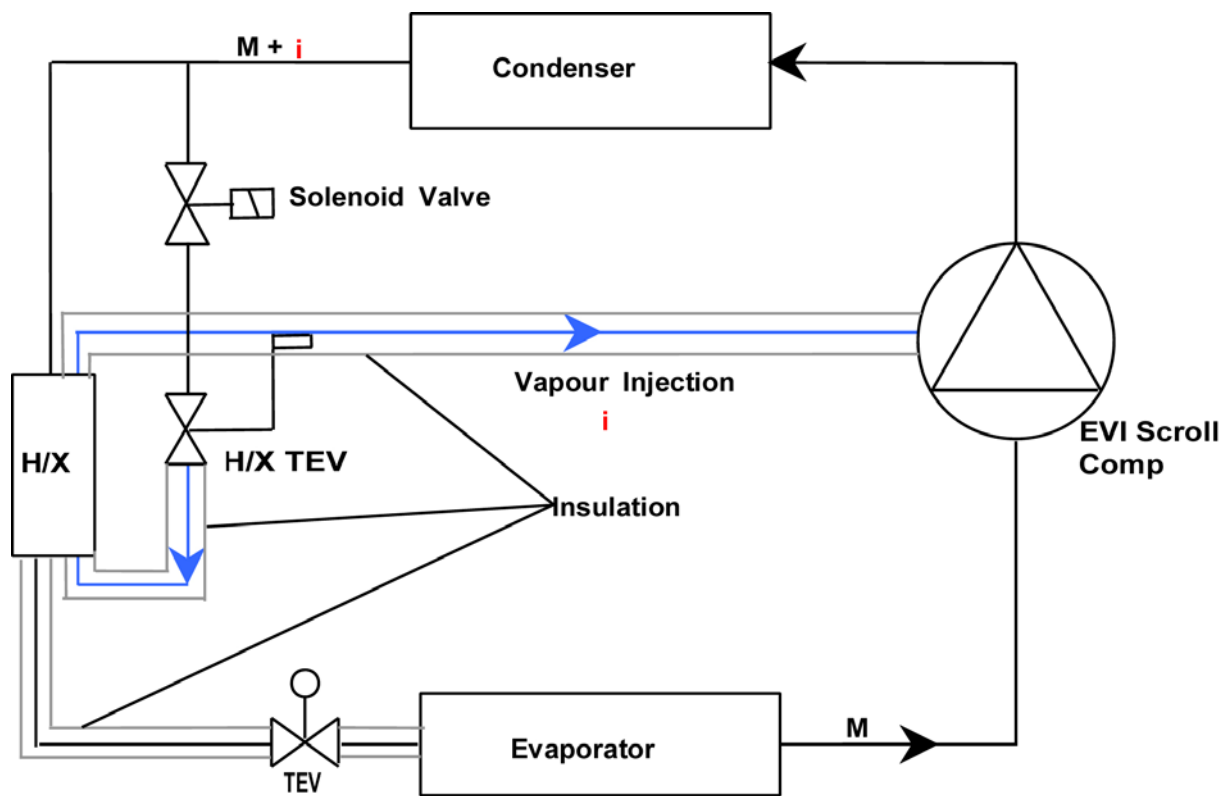


Figure 1. EVI Schematic

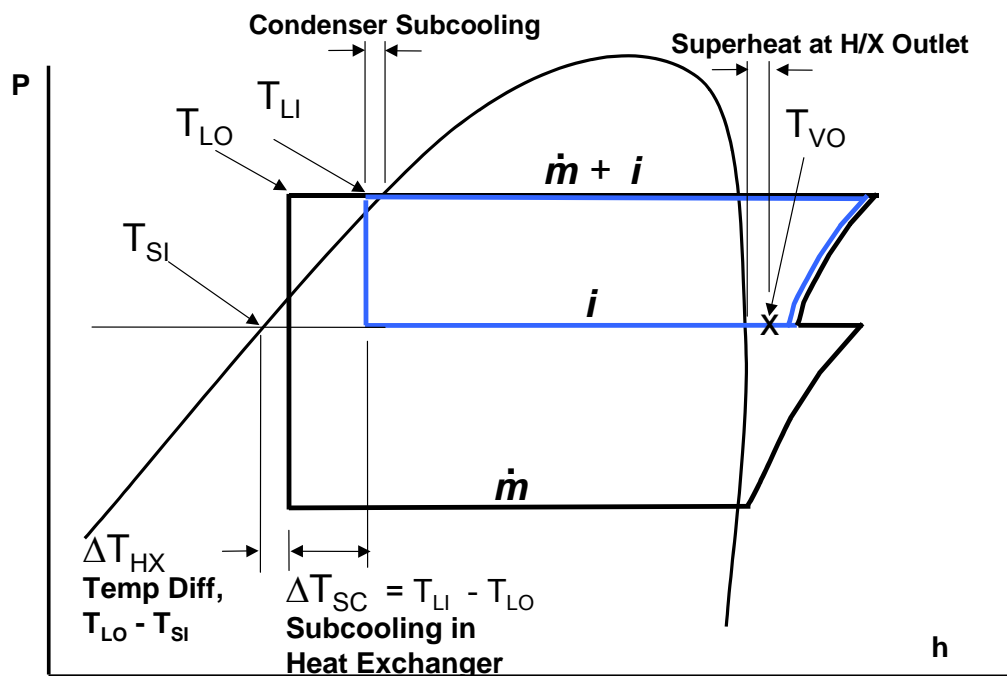


Figure 2. EVI Ph chart

Definition(s)	Description
Tc	Condensing Temperature
Tli	Liquid temperature entering H/X
Tlo	Subcooled liquid leaving H/X
Pi	Intermediate Pressure
Tsi	Saturated temperature at intermediate pressure
Tvo	Vapour temperature leaving H/X
Tvi	Vapour temperature entering H/X
Tsc	Liquid subcooling in H/X
M	Evaporator Mass Flow
I	Vapour Injection Mass Flow
ΔT_{HX}	Liquid temp out H/X-Liquid- Saturated temperature at intermediate pressure
ΔT_{SC}	Liquid temp in to H/X- subcooled liquid temp out H/X

7 System Configuration

7.1 Liquid Extraction

Upstream liquid extraction (before the heat exchanger) is recommended as it optimises the heat exchanger performance. The TXV regulates the flow of subcooled refrigerant out of the condenser and into the heat exchanger (Figure 4). Minimum level of condenser natural subcooling has to be guaranteed at the TXV inlet to avoid flash gas, which would cause the valve to hunt.

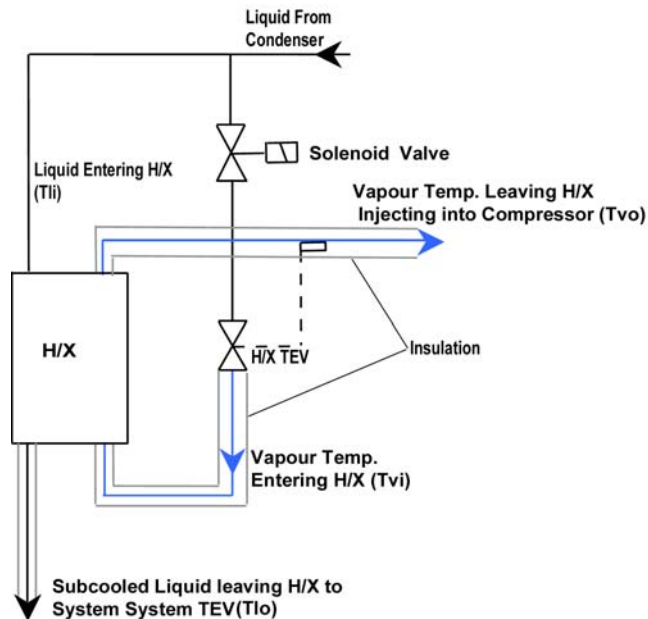


Figure 4. Upstream Extraction

7.2 Heat Exchanger Piping Arrangements

Best subcooling effect is assured if counter flow of gas and liquid is provided as shown (see figure 5). In order to guarantee optimum heat transfer, the plate heat exchanger should be mounted vertically and vapour should exit it at the top.

VO = Vapour temperature leaving H/X
 VI = Vapour temperature entering H/X
 LI = Liquid temperature entering H/X
 LO = Subcooled liquid leaving H/X

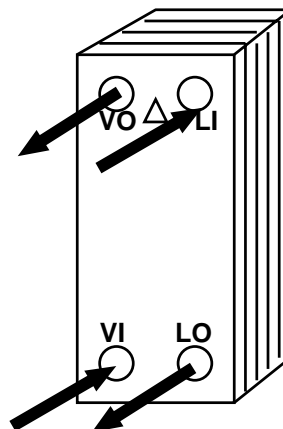


Figure 5 H/X Piping Arrangement

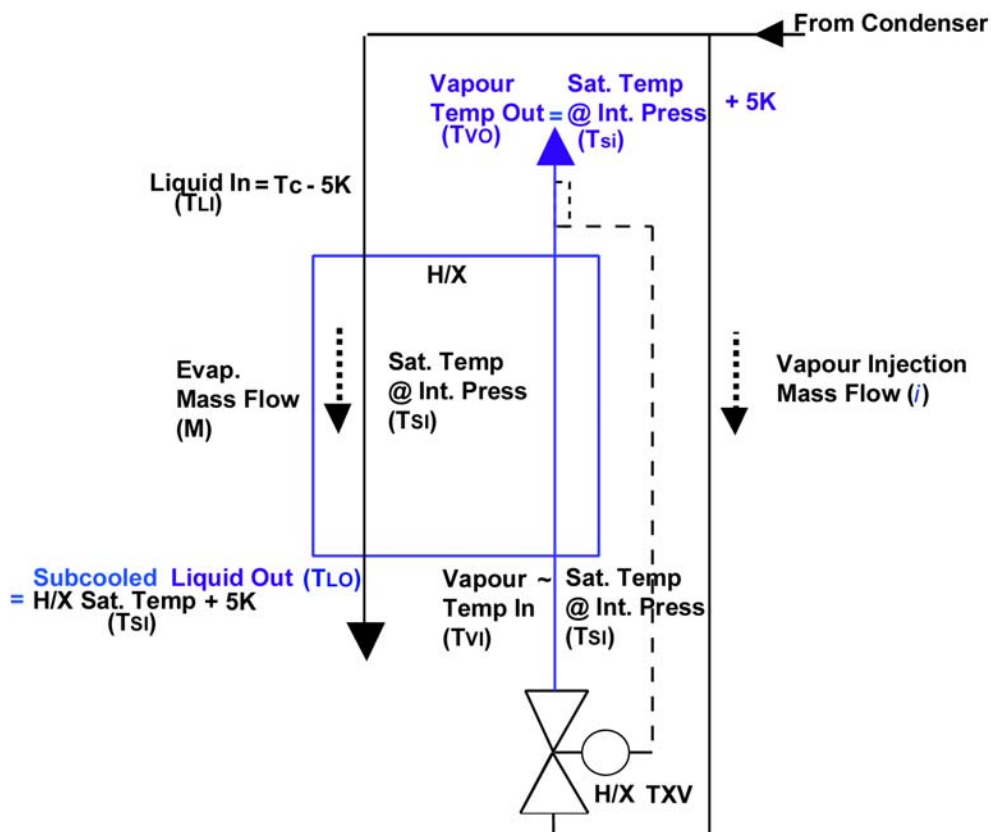
8 System Design Guidelines:

The following sections discuss system design guidelines for the EVI product.

Please use Copeland Selection software, where all parameters are given for selecting a single heat exchanger. The Copeland Selection software can be downloaded from www.eCopeland.com.

The key parameter in determining the proper heat exchanger size is the Saturated Injection Temperature (T_{si}). The T_{si} has been determined through extensive testing. This value can vary for each compressor and should be obtained from SELECT.

After determining the T_{si} , a 5K condenser natural subcooling, 5 K heat exchanger ΔT_{HX} and 5 K heat exchanger superheat are targeted. This is done to optimise system performance while maintaining system reliability and functionality at the same time. Once these parameters are known, the heat exchanger capacity (kW) can be determined, which gives the required heat exchanger size. (See Figure 6 below)



Energy Balance Equation

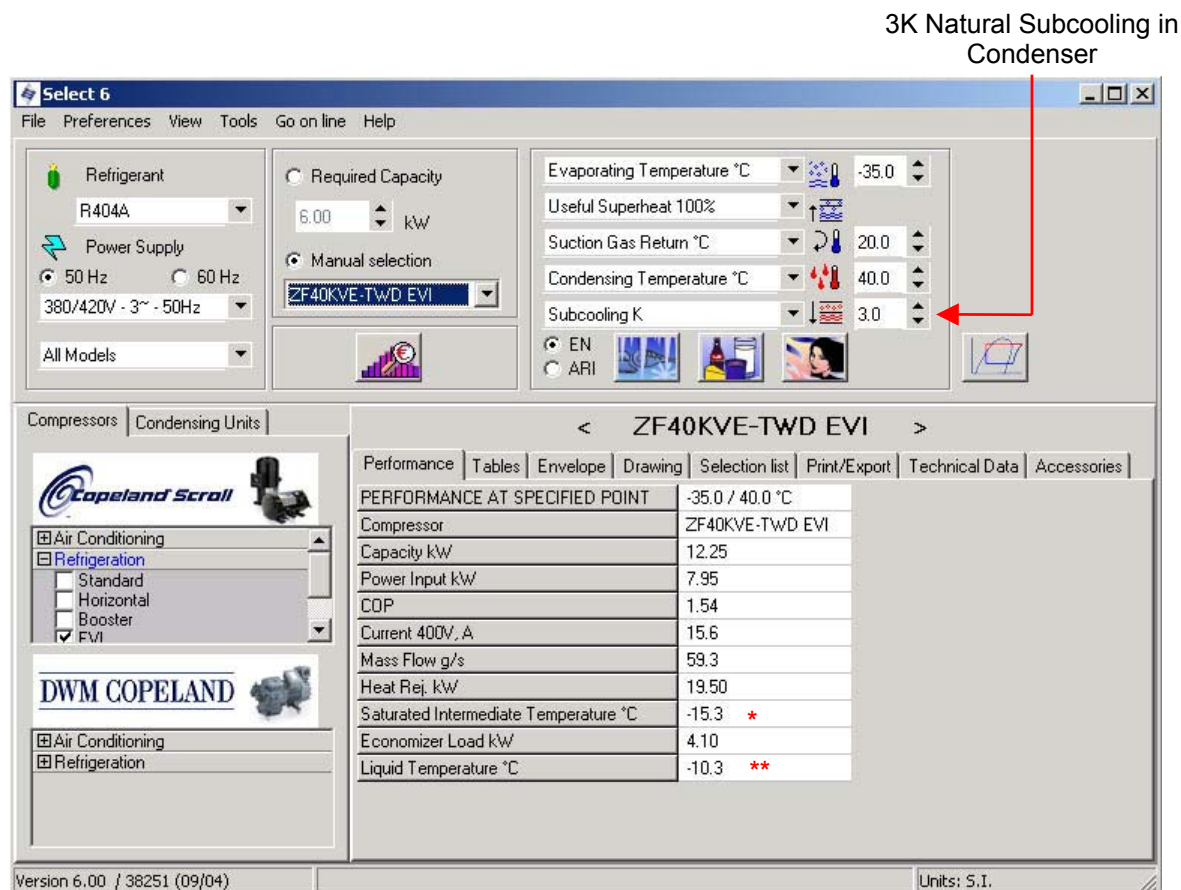
$$Q_{hx} \text{ (kW)} = \text{Evap. Mass Flow (Enthalpy of liquid entering H/X - Enthalpy of liquid leaving H/X)}$$

$$= \text{Vapour Injection Mass Flow (Enthalpy of vapour leaving H/X - Enthalpy of vapour entering H/X)}$$

Figure 6. Heat Exchanger Details

8.1 Heat Exchanger sizing using Select

Figure 7 is an extract from SELECT which gives details of Economiser/heat exchanger load (kW) saturated intermediate temperature (T_{si}) and sub-cooled liquid out of heat exchanger.



- * T_{si} temperature
- ** T_{lo} Liquid temperature leaving the Heat exchanger

Figure 7. Details on EVI performance given by SELECT software.



8.2 Exchanger Sizing

Heat exchangers should be sized for nominal operating conditions with adequate design margin to allow for the entire range of system operation.

8.3 Liquid and Vapour Injection Line Sizing

The liquid line from the heat exchanger to the evaporator should be insulated and kept as short as possible in order to maximise the subcooling effect.

The vapour injection line from the heat exchanger to the compressor should be 5/8" and kept as short as possible in order to minimise pressure drop loss.

8.4 Heat Exchanger TXV Sizing

The heat exchanger thermostatic expansion valve should be designed for maximum load while taking into account partial load conditions.

8.5 Solenoid valve

A liquid line solenoid valve is required to prevent migration of refrigerant to the compressor when it is switched off.

For Multiple compressor application, a solenoid valve in the vapour injection line of each individual compressor is required. Each solenoid valve has to be energised in parallel to the compressor contactor. See "Multiple compressor application" Section for more information.

8.6 Multiple Compressor Application

Multiple EVI compressors can be used with either a single heat exchanger for each compressor or a common heat exchanger for all compressors.

In case of a common heat exchanger, a solenoid valve should be installed on each individual vapour injection line.

Special care has to be given to the design of the heat exchanger and of the thermostatic expansion valve (TXV) to allow for part load operation. Good refrigerant distribution is required in the common heat exchanger as well as sufficient velocities for oil return, even at part load.

In the case of a large range of capacity modulation (more than 2 compressors in parallel), the use of an Electronic Expansion Valve (EXV) or of two different TXV(s) controlled by individual solenoid valves, may be necessary. For example, one at 100% full load and the second solenoid valve for 30% of full load. (See Figure 8 and Figure 9).

It is necessary to ensure that the solenoid valves, vapour injection lines and header(s) are adequately sized in order to keep pressure drop to a minimum. At the same time, the layout should be such that excessive amounts of oil do not accumulate in the header.

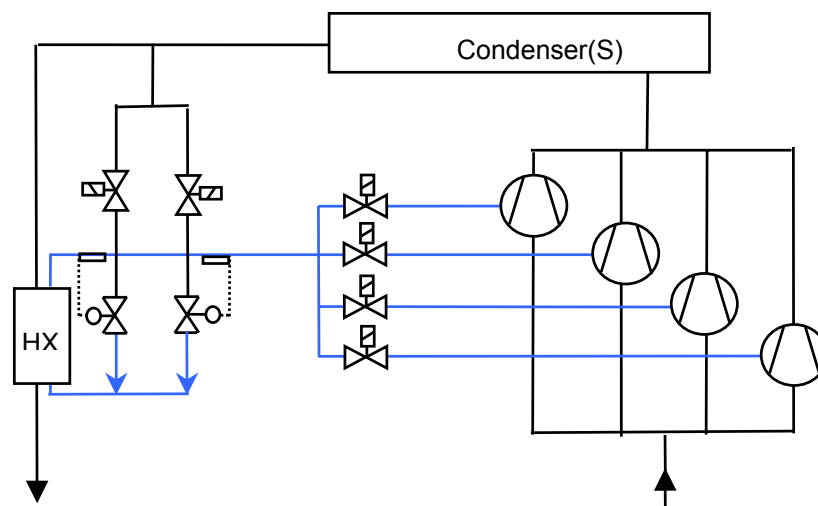


Figure 8. EVI Paralleling with HX Thermostatic valves of different capacity

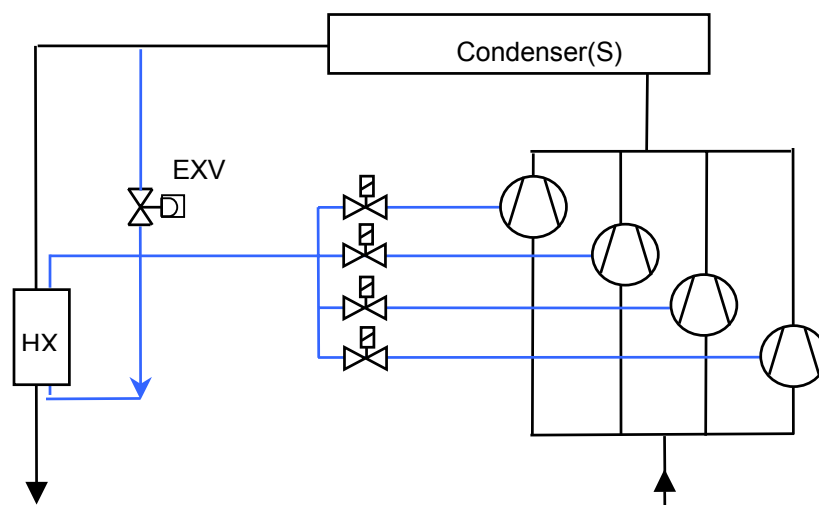


Figure 9. EVI Paralleling with HX Electronic Expansion valve (EXV)

9 Lubrication

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

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.

The compressors must be operated with these specific oils only. Under no circumstances are ester oils to be mixed with mineral oil and/or alkyl benzene when used with chlorine-free refrigerants.

Ester oil behaves extremely hygroscopically (see Figure 10), and this influences the chemical stability of the oil.

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 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.

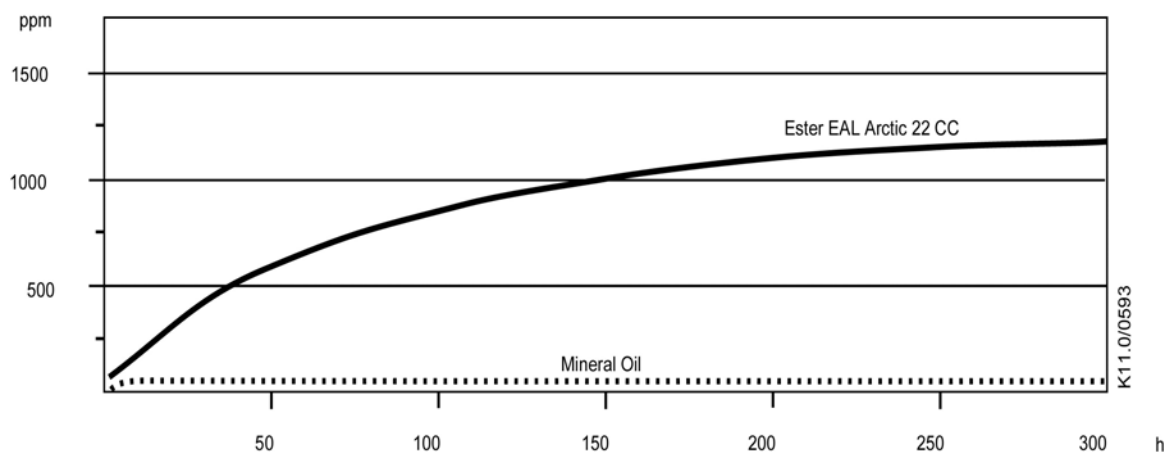


Figure 10. Absorption of moisture in ester oil in comparison to mineral oil (ppm) by weight at 25°C and 50% relative humidity. h = hours

The system should be evacuated down to 0.3 mbar/ 0.22 Torr or lower. If there is uncertainty, as to the moisture content in the system, an oil sample should be taken from various points and tested for moisture. The residual moisture in the installation should be brought below 50 PPM (please refer to section 30 system evacuation and charging procedure) and the use of a suitable filter drier, with an equilibrium point dryness (EPD) of 50ppm or less.

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.

As POE oil is very hygroscopic, it is recommended that the plugs in the compressor line connections be left in place until the compressor is set into position.

10 Crankcase Heaters

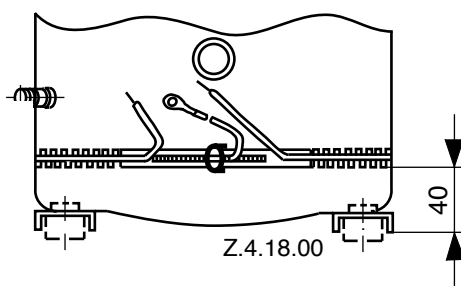
Equipment for heating the oil in the crankcase is necessary if the system configuration enables large amounts of refrigerant to condense in the compressor and be absorbed by the oil. At the high temperature produced by the heater refrigerant is constantly vaporised and problems in oil supply are reduced. For correct mounting location of such a heater, please see Figure 11.

The crankcase heater must be mounted below the oil removal valve located on the bottom shell. The crankcase heater must remain energised during compressor off cycles.

The initial start in the field is a very critical period for any compressor because all load bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions.

Due to the Copeland Scroll's inherent ability to handle liquid refrigerant in flooded conditions, no crankcase heater is required when the system charge does not exceed 7.5 kg. If a crankcase heater is fitted, it is recommended the heater must be turned on for a minimum of 12 hours prior to starting the compressor. This will prevent oil dilution and bearing stress on initial start up.

Figure 11 Crankcase Heater Location



11 Screens

The use of screens finer than 30 x 30 mesh (0,6 mm² openings) anywhere in the system is not recommended. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes, or accumulators could become temporarily or permanently plugged. Such blockage can result in compressor failure.

12 Pump down

To control refrigerant migration a pump down system could be used. The discharge check valve with refrigeration scroll compressor is designed for low leak back, and will allow the use of a pump down without the addition of an external check valve.

If the compressor is stationary for prolonged periods, refrigerant could migrate into the compressor and therefore a crankcase heater must be installed.

If constant cold air is drawn over the compressor, this could make the crankcase heater ineffective, and therefore a pump down system is recommended.

13 Mufflers

Flow through Copeland Scroll Compressors is semi-continuous with relatively low pulsation. External mufflers, where they are normally applied to piston compressors today, may not be required for Copeland Scroll. Because of variability between systems, however, individual system tests should be performed to verify acceptability of sound levels.

14 Deep Vacuum Operation

Do not run a "refrigeration scroll" compressor in a deep vacuum. Failure to heed this advice can result in arcing of the Fusite pins causing permanent damage to the compressor.

A low pressure control is required for protection against deep vacuum operation.

15 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 start-up, low-voltage starting characteristics are excellent for Copeland scroll compressors.

16 Rotation Direction

Scroll compressors, like several other types of compressors, will only compress in one rotational direction. Three phase compressors will rotate in either direction depending upon phasing of the power. The electronic protection unit (INT69SCY) will not let the compressor operate if the phasing of the wires is incorrect. It is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction when the system is installed and operated.

Verification of proper rotation direction is made by observing that suction pressure drops and discharge pressure rises when the compressor is energised.

17 Shut off Sound

Scroll compressors may run backward for a brief period at shut off as the internal pressures equalise. A low mass, disc-type check valve in the discharge tube of the compressor prevents high pressure gas entering the compressor after shut down. Additionally there is a dynamic discharge valve mounted on the fixed Scroll, which effectively eliminates reverse rotation.

18 Brief Power Interruptions

No time delay is required on three phase models to prevent reverse rotation due to power interruptions. The torque of the motor is strong enough to assure proper rotation under all starting circumstances.

19 Discharge Temperature Control

A thermistor with a nominal response temperature of 140 °C is located in the discharge port of the fixed scroll (Figure 12). Excessive discharge temperature will cause the electronic protector module to trip (see also section 22). The discharge gas sensor is wired in series with the motor thermistor chain.

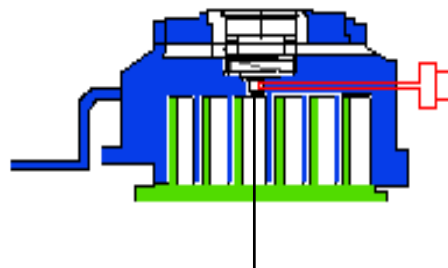


Figure 12 Discharge Thermistor

20 Pressure Controls

Both high and low pressure controls are required and the following working pressures are recommended: the normal minimum setting should be 0.3 bar g (R404A). Maximum is 28 bar g.

21 Electrical Installation

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

Motor insulation material class is "H" for models for all refrigeration scroll compressors, according to IEC 34-18-1, EN 0530, VDE 0530 or DIN 57530.

Recommended wiring diagram is shown in Figure 13.

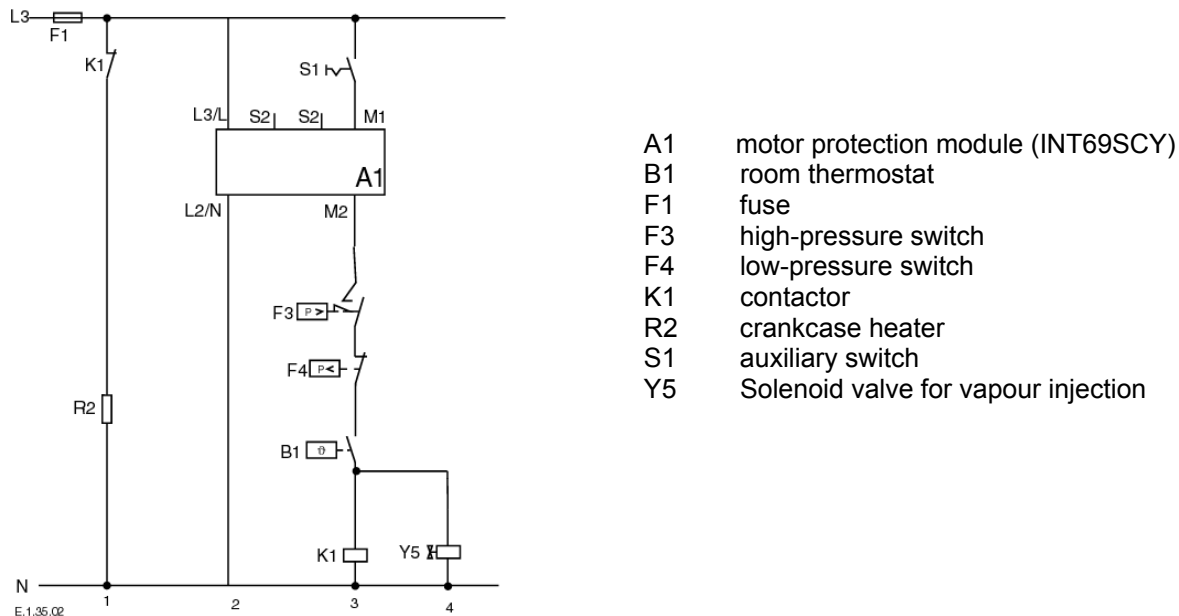
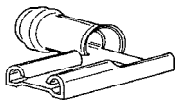


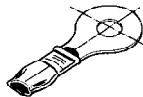
Figure 13 Control Circuit

22 Cable Connectors

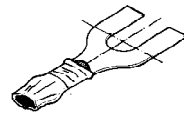
The following table lists recommended types of cable connectors to be used for the various electric terminals of the compressors and the motor protection module. "A" and "B" must fit 1/4" or 6.3 mm tab sizes. "C" is to be selected for #10 studs. Cable sizes are to be selected according to DIN ISO 0100, IEC 364 or national regulations. The screw terminals used on this compressor should be fastened with a torque of 2.5 to 2.6 Nm.



A Flag receptacle



B Ring Tongue



C Spade

Model	TW*	Thermistor Module
ZF24KVE - ZF48KVE	B/C	A

Figure 14 Cable Connectors

23 Electronic Protection

The electronic protection system as used in all 7.5HP to 15.0HP EVI refrigeration scroll compressors is identified by a "W" as the centre letter in the motor code. This system utilises the temperature dependent resistance of thermistors (also called PTC-resistances) to read the winding temperature. A chain of four thermistors connected in series is embedded in the motor windings so that the temperature of the thermistors can follow the winding temperature with little inertia. An electronic module (INT69SCY) is required to process the resistance values and trips a control relay depending on the thermistor resistance. The characteristic gradient of a thermistor resistance curve is shown in Figure 17. The resistance curve can be designed for different operating points, the nominal response temperature (NAT), e.g. 80°C, 100°C, 140°C, and must comply with the tolerances laid out in the standard DIN 44081.

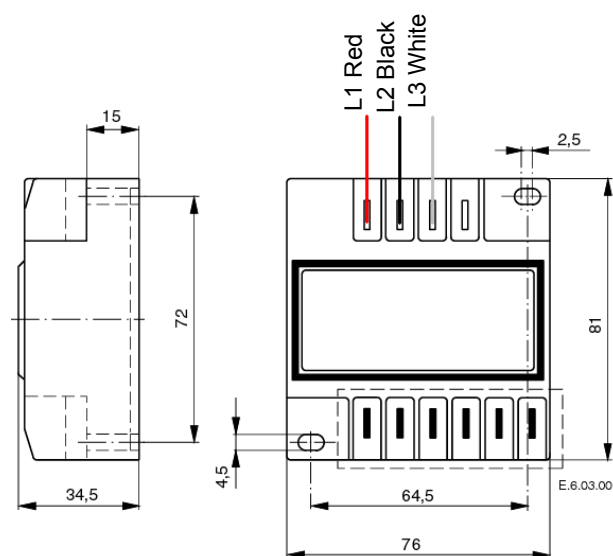
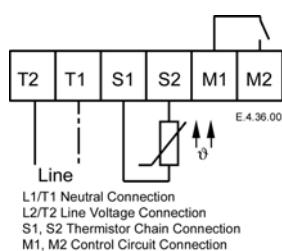


Figure 16
Electronic Module



Protector Specifications

Type	INT69 SCY
Voltage	120/240V AC
Normal PTC resistance	250 to 1000 Ohms
Trip resistance	>4500 Ohm ±
Reset resistance	<2750 Ohms
Module time out	30 minutes ± 5 Min.
Phase monitor:	Yes

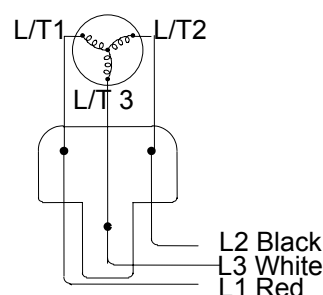
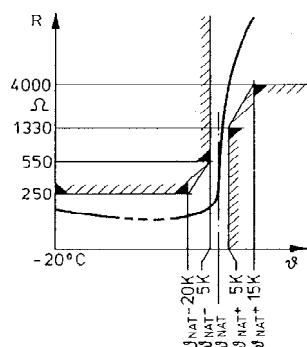


Figure 15 Compressor Terminals



For protection in case of blocked rotor one thermistor for each phase is embedded in the winding heads on the upper (suction gas) side of the compressor motor.

A fourth thermistor is located in a winding head at the lower end of the motor. A fifth sensor is located in the discharge port of the fixed scroll to control discharge gas superheat. The entire chain is internally led to the fusite from where it is connected to the module connections S1 and S2 (see figure 15). When any resistance of the thermistor chain reaches the tripping value, the module interrupts the control line and causes the compressor to switch off. After the thermistor has cooled sufficiently, its resistance drops to the reset value but the module itself, however, resets after a time delay of approx. 30 minutes.

Figure 17 Thermistor Resistances

24 Phase Protection

The phase protection capabilities of the INT69SCY module will sense the correct phase sequence of L1, L2, and L3 incoming power. Three phase power must be wired in the correct phase sequence that will ensure the compressor will start and operate in the correct rotation. When the INT. 69SCY trips on phase loss a delay of 5 minutes is activated. If all three phases are present then the compressor will continue to run, if not the module will lock out. After 10 attempts to restart the compressor, the module will lock out, which could be reset by re-establishing incoming power to the module (See Figure 15 and 16).

25 Protector Functional Check and Failure Detection

Prior to start-up of the compressor a functional check shall be carried out:

- Switch off power!
- Disconnect one terminal either S1 or S2 of the electronic module. If the compressor is now switched on, the motor should not start.
- Switch off power.
- Reconnect the disconnected thermistor line. If the compressor is now switched on the motor must start.

Protector Fault Diagnosis:

If the motor does not start-up during the functional check, this indicates a disturbance in operation:

- Switch off power.
- Verify correct phase lead operation (See Figure 16).
- Check the connection of the thermistor leads in the terminal box and at the protection module for possible loose connections and check the connection cable for possible breakage.
- The resistance of the thermistor chain shall be measured in a cold condition; i.e. after the motor has sufficiently cooled down.

Caution: Use maximum measuring voltage of 3 V!

In doing so, the thermistor leads at terminals S1 and S2 of the module shall be disconnected and measured between the leads. Resistance must be less than 1800 ohms at room temperature (25°C).

If the thermistor chain has a higher resistance of 2750 ohms \pm 20% the resistance is still too high and it has to be cooled down.

If the resistor is 0 ohms, the compressor has to be exchanged due to shorted sensor circuit. ∞ Ohms indicate an open sensor circuit and the compressor has to be replaced.

If no defect is located in the thermistor chain or there is no loose contact or conductor breakage, the module shall be checked. Then the control connections at M1 and M2 have to be removed (**Caution!** Switch off voltage supply first!) and check the switching conditions by an ohmmeter or signal buzzer:

- short-cut the already disconnected (see above) thermistor contactors and switch on the voltage supply; the relay must switch; connection established between contactors M1 and M2
- remove the jumper between S1 and S2, the relay must switch off; no connection between contactors M1 and M2
- shortcut the contactors S1 and S2 again, the relay remains switched off; no connection between contactors M1 and M2
- switch off the voltage supply for approximately 4 sec and switch it on again, the relay must switch on now; connection between contactors M1 and M2

If one of the above conditions is not met, the module is defective and has to be exchanged.

Note: The power should be switched off between the tests, in order to avoid short circuits and accidental touching of contacts. The function of the module should be tested each time the fuse in the control circuit breaks the power supply. This makes sure that the contacts did not stick. High

26 Potential Testing

Copeland subjects all motor compressors to a high voltage test after final assembly. This is carried out according to EN 0530 or VDE 0530 part 1.

Since high voltage tests lead to premature ageing 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-hermetic (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 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.

27 Shell Temperature

Certain types of system failures, such as condenser or evaporator fan blockage or loss of charge may cause the top shell and discharge line to 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 in contact with these potentially hot areas.

28 Installation

Four vibration absorber grommets are supplied with each compressor (see Figure. 18). 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 18)

For multiple or parallel operation please refer to guidelines "Refrigeration Scroll for Parallel Applications" (C6.2.5/E) and the spares parts list.

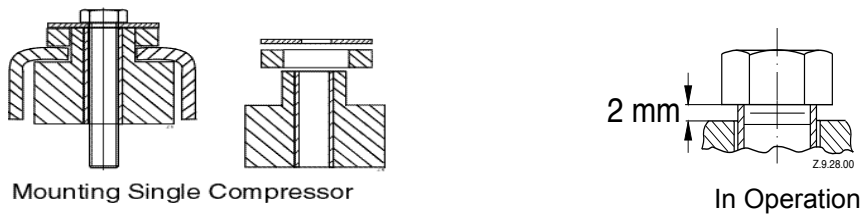


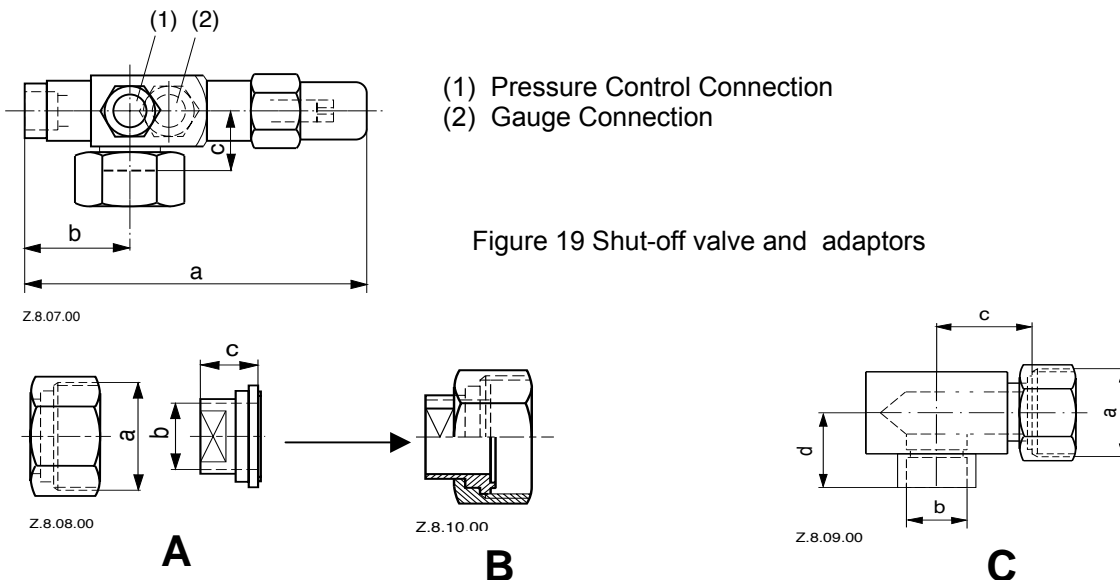
Figure 18 Mounting Parts

29 Shut-off Valves and Adaptors

The refrigeration scroll compressors are delivered with threads for Rotalock shut off valves.

Brazed pipework can also fit compressors with Rotalock conNections using adaptors "A" and "B" in either straight or angled "C".

It is strongly recommended to periodically re-torque all fixing connections to the original setting after the system has been put into operation. (See Figure 19 and spare parts list).



	Torque [Nm]
Rotalock 3/4"-16UNF	40 - 50
Rotalock 1 1/4"-12UNF	110-135
Rotalock 1 3/4"-12UNF	170-180
Rotalock 2 1/4"-12UNF	190-200
Mounting Bolts 5/16", M 9	34 max.

30 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, which can be detected as noise coming along the suction line into a building under some conditions. Elimination of the “beat” can be achieved by attenuating either of the contributing frequencies. This is easily done by using one of the common combinations of 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 20):

- 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

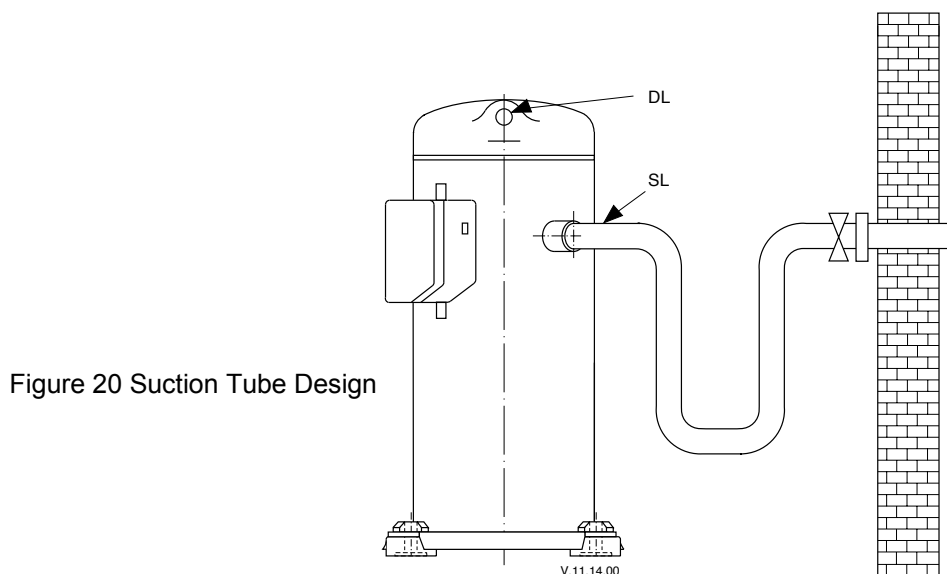


Figure 20 Suction Tube Design



31 System Evacuation and Charging Procedure

Before the installation is put into commission, it has to be evacuated with a vacuum pump. 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 line is advisable. Pressure must be measured using a vacuum pressure (Torr) 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. These valves could also be used to measure the operating pressures to ensure there are no excessive pressure drops in the suction line and liquid line. It will also give an indication that the expansion device receives full bore liquid, ensuring the system performs at its most efficiently.

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 equalize, the floating seal and scroll set can be held tightly together.

The installation should be evacuated down to 0.3 mbar/ 0.22 Torr or lower. Subsequently, the factory holding charge of dry air in the compressor is released to the ambient. The shut-off valves are opened and the installation, including the compressor, is once more evacuated as described after the system has been re-charged with dry nitrogen.

Highest demands are placed on the leak proof design of the installation and on leak testing methods (please refer to EN378).

Rapid charging on the suction side of Scroll compressors 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. Consequently, 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 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.

- Suction muffler: may be required

32 Compressor Functional Check

A functional compressor test with the suction service valve closed to check how low the compressor will pull suction pressure is not a good indication of how well a compressor is performing. Such a test will damage a scroll compressor. The following diagnostic procedure should be used to evaluate whether a Copeland Scroll compressor is working 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 an internal motor short or ground fault has developed. If the protector has opened, the compressor must be allowed to cool sufficiently to allow it to reset.
3. 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.

To test if the compressor is pumping properly, the compressor current draw must be compared to published compressor performance curves using the operating pressures and voltage of the system. If the average measured current deviates more than $\pm 15\%$ from published values, a faulty compressor may be indicated. A current imbalance more than 15% of the average on the three phases may indicate a voltage imbalance and should be investigated further.

Before replacing or returning a compressor: Be certain that the compressor is actually defective. As a minimum, recheck a compressor for Hipot, winding resistance, and ability to start before returning. More than one-third of compressors returned to Copeland for warranty analysis are determined to have nothing found wrong. They were miss-diagnosed in the field as being defective. Replacing working compressors unnecessarily costs everyone.



33 Unbrazing System Components

Caution! Before opening a system, it is important to remove all refrigerants from both the high and low side. If the refrigerant charge is removed from a scroll-equipped unit by bleeding the high side only, it is possible for the scrolls to seal preventing pressure equalisation through the compressor. This may leave the low side shell and suction line tubing pressurised. If a brazing torch is then applied to the low side while the low side shell and suction line contains pressure, the pressurised refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, it is important to check both the high and low side with manifold gauges before unbrazing. Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required, the compressor should be cut out of system rather than unbrazed.

34 Compressor Replacement

In the case of a motor burn, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through use of suction and liquid line filter dryers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. It is highly recommended that the suction accumulator be replaced if the system contains one. This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure.

When a single compressor or tandem is exchanged in the field, a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage.

See Section for Rotalock valve, flange fittings, sight glass, and mounting bolt torque's values.

35 Pressure Equipment Directive

All the Refrigeration Scroll Compressors covered in this guideline conform to the European Pressure Equipment directive. The nameplate shows the PED marking CE 0062 with the refrigerant group and low side temperature.

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