Copeland Scroll™

R410A Air-Conditioning Scroll Compressors

ZP 23K3E... ZP295KCE

Application Guidelines

EMERSON™
Climate Technologies

R410A AIR-CONDITIONING SCROLL COMPRESSORS

1. Introduction

The model family of “ZP” compressors is designed for high pressure R410A refrigerant, a chlorine free replacement for R22. R410A operates at approximately 50 to 70 percent higher pressure at the same saturated temperatures than R22.
These guidelines are not meant to replace the system expertise available from system manufacturers.
For additional information, please refer to the “Product Catalogue“ or to the “Copeland Selection Software” accessible from the Copeland website at www.ecopeland.com.

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 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.

Field Replacement of a “ZP” Compressor :

The ZP**K*E-XXX Scroll compressor is a unique design for R410A refrigerant and must never be replaced with a “ZR” family scroll compressor. The “P” in the model number designates that this compressor is designed for the higher pressure encountered with R410A. Use of a compressor that is not specifically designed for R410A may cause shell rupture and personal injury. R410A has greater enthalpy per unit volume than R22. For this reason the displacement is smaller vs. motor power in the “ZP” scroll than an equivalent capacity R22 compressor. Using an R22 compressor in a R410A system may cause the compressor to stall. Conversely using a “ZP” compressor in an R22 system would result in a drastic system capacity reduction.

3. Nomenclature

The model numbers of the Copeland Scroll compressors include the approximate nominal 60 Hz capacity at standard operating conditions. An example would be the ZP180KCE-TWD, which has approximately 180 kBtu/hr cooling capacity at the ARI high temperature air conditioning rating point when operated on 60 Hz. Note that the same compressor will have approximately 5/6 of this capacity or 150 kBtu/hr when operated on 50 Hz current.

Model Designation

Z	**P**	**180**	**KC**	**E**	**-**	**TWD**	**-**	**522**
1	**2**	**3**	**4**	**5**		**6**		**7**

1 - Compressor family: Z = Scroll
2 - Application range: P = High temperature
3 - Nominal capacity kBTU/h @ 60 Hz and ARI conditions (*see below)
4 - Model variation
5 - Oil type: E = POE oil
6 - Motor version: TFD = 380-420V/3/50 Hz, 460V/3/60 Hz, TWD = 380-420V/3/50 Hz, PFJ **=** 220-240V/1/50 Hz
7 - Bill of material number:

***ARI-Conditions:**

Evaporating temperature	7,2 °C	Liquid sub-cooling	8,3 K
Condensing temperature	54,4 °C	Ambient temperature	35 °C
Suction gas superheat	11 K		

4. Qualified Refrigerant

R410A has been qualified for use with all ZP compressor models.

5. Compressor Handling

It is recommended that the plugs in the compressor line connections be left in place until the compressor is set into the unit. This reduces the chance of contaminants and moisture getting into the compressor especially as the compressor is charged with the more hygroscopic POE oil.
With the ZP90KCE to ZP137KCE compressors because the suction tube is located on the lower portion of the shell care must be taken to keep the compressor upright during installation and removal, otherwise oil could spill out of this connection. The suction connection plug must be left in place until the compressor is set into the unit.
If the compressor has two lifting eyes, both must be used for lifting. 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 (see Fig.13). No object (e.g. a swaging tool) should be inserted deeper than 50 mm into the suction tube or it might damage the suction screen and motor.

6. Lubrication and Oil Removal

The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerant R410A is a polyolester (POE) lubricant Copeland 3MAF (32 cSt). In the field the oil level could be topped up with ICI Emkarate RL 32 CF or Mobil EAL Arctic 22 CC if 3MAF is not available. See nameplate for original oil charge shown in litres, a field recharge is from 0,05 to 0,1 litres less.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (Figure 1). 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 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 analysed to determine the actual moisture content of the lubricant.

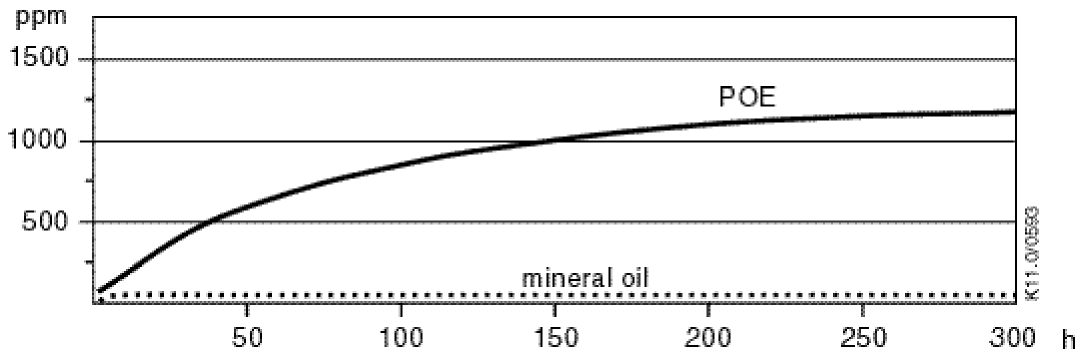


Figure 1: Absorption of moisture in ester oil in comparison to mineral oil in [ppm] by weight at 25°C and 50% relative humidity. h = hours.

7. Accumulators

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, especially for those systems designed with thermostatic expansion valves. However, large volumes of liquid refrigerant which repeatedly flood back to the compressor during normal off cycles, varying loads or excessive liquid refrigerant floodback during defrost can dilute the oil, no matter what the system charge is. As a result, bearings are inadequately lubricated and wear may occur. Use the diagram in figure 16 to determine if your system charge is such that a test is necessary to see if repeated floodback can occur. Recommended tests are described in **Section 28- Excessive Liquid Refrigerant Floodback Tests.**

If an accumulator is used it is recommended that it be sized to hold from 50% to 70% of the system charge. An oil return orifice sized approximately 1.4mm^2 (ZP23K3E to ZP83KCE) or 2.0mm^2 (ZP90KCE to ZP295KCE) is recommended. A large area protective screen no finer than 30 x 30 mesh (0.6 mm^2 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. Accumulator should be piped to provide free liquid drainage during off cycle as shown in figure 2.

Accumulators are a standard item in air to air heat pumps and are used even when a thermostatic expansion valve is used to meter refrigerant in the heating mode. During low ambient conditions the oil returning from the outdoor coil will be very viscous and difficult to return through the accumulator if the expansion valve is working properly by maintaining superheat. To prevent slow oil return it may be possible to remove the accumulator from systems that use expansion valves in heating. To determine if the accumulator can be removed a defrost test must be done at an outdoor ambient of around 0 °C in a high humidity environment to ensure that excessive liquid does not flood back to the compressor during reversing valve operation, especially when coming out of defrost. Excessive flood back occurs when the sump temperature drops below the safe operation line shown in Figure 3 for more than 10 seconds.

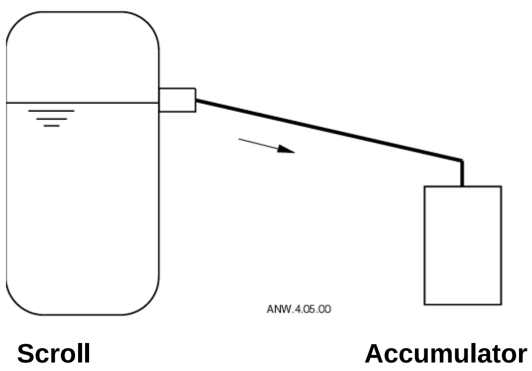


Figure 2: Suction Line Accumulator

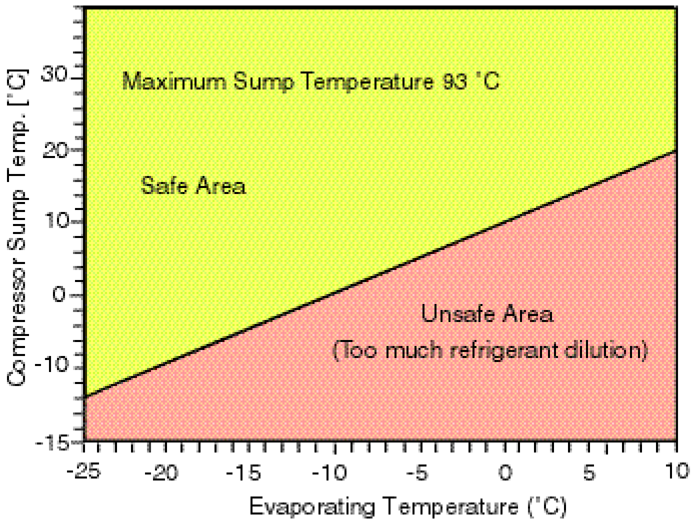


Figure 3: Bottom Shell Temperature

8. Screens

The use of screens finer than 30 x 30 mesh (0,6 mm^2 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 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.

9. Crankcase Heaters

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 following values:

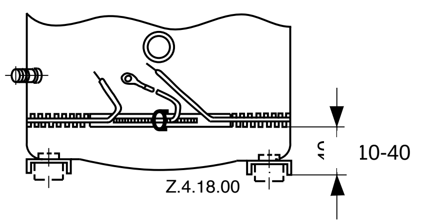


Figure 4: Crankcase Heater Location

4,5 kg for ZP23K3E to ZP83KCE
5,5 kg for ZP90KCE to ZP137KCE
7,7 kg for ZP180KCE
11,3 kg for ZP 235KCE
13,6 kg for ZP 295KCE

For correct mounting location of such a heater please see Figure 4.

When the system charge exceeds the recommended limit, the compressor may fill with refrigerant under certain circumstances and configurations. This may cause excessive clearing noise, or the compressor may lock up and trip on protector several times before starting. A crankcase heater may be of benefit in the initial design or as a field remedy under these circumstances. The crankcase heater must be mounted below the oil level located inside the bottom shell. **The crankcase heater must remain energized during compressor off-cycle.**
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. **The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor**. This will prevent oil dilution and bearing stress on initial start up. If it is not feasible to turn on the crankcase heater 12 hours in advance of starting the compressor, then use one of the techniques listed below to prevent possible flooded-start damage to the compressor:

1) Direct a 500 watt heat lamp or other safe heat source (do not use torch) at the lower shell of the compressor for approximately 30 minutes to boil off any liquid refrigerant prior to starting; or
2) Bump start the compressor by manually energizing the compressor contactor for about one second. Wait five seconds and again manually energize compressor for one second. Repeat this cycle several times until the liquid in the shell has been boiled off and the compressor can be safely started and run continuously.

10. Pump-down

For the models ZP23K3E...ZR137KCE pump down is not recommended. 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 more than reciprocating compressor discharge reeds normally used with automatic pump down causing the compressor to cycle more frequently. If pump down is used a separate external check valve must be added. For large compressors, like ZP180KCE and larger, pump down may be used, but a separate discharge check valve here is not needed, since those models are equipped with a low leak check valve. The low-pressure control differential has to be reviewed since a relatively large volume of gas will re-expand from the discharge plenum of the compressor into the low side on shut down.

11. Minimum Run Time

There is no set answer to how often scroll compressors can be started and stopped in an hour since it is highly dependent on system configuration. There is no minimum off-time, because the scrolls 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. This is easily determined for the ZP180KCE to ZP295KCE compressors since they are equipped with a sight glass. For the ZP23KCE to ZP137KCE compressors the customer can request a sample compressor with sight glass for testing purposes only. The minimum on-time becomes the time required for oil lost on compressor startup to return to the compressor sump and restore a normal level in the sight glass. Cycling the compressor for a shorter time than this for instance to maintain very tight temperature control can result in progressive loss of oil and damage to the compressor.

12. Reversing Valves

Since Copeland Scroll compressors have very high volumetric efficiency, their displacements are lower than for comparable capacity reciprocating compressors. As a result, Copeland 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 valve solenoid 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 equalising through the compressor which can cause the compressor to slowly rotate until the pressures equalise. This condition does not effect compressor durability but can cause unexpected sound after the compressor is turned off.

13. Discharge Temperature Protection

The internal discharge gas temperature protection for the ZP23K3E to ZP83KCE compressors is a thermo-disc that opens a gas passage from the discharge port to the suction side near the motor protector when the discharged gas reaches a temperature of 146 $\pm$ 4°C. The hot gas then causes the motor protector to trip shutting down the compressor.

ZP90KCE to ZP137KCE scroll compressors built in October 2004 and later (04J) have the addition of the Advanced Scroll Temperature Protection which eliminates the need for a discharge line thermostat.
Advanced Scroll Temperature Protection (ASTP) is also a temperature sensitive thermo-disc that acts to protect the compressor from discharge gas overheating. Once the discharge gas reaches a critical temperature the ASTP feature will cause the scrolls to separate and stop pumping although the motor continues to run. After running for some time without pumping gas the motor protector will open.

NOTE: Depending upon the heat build up in the compressor it may take up to two hours for the ASTP to reset followed by the motor protector!

To identify compressors with Advanced Scroll Temperature Protection, a label has been added above the terminal box.

For compressors ZP180KCE to ZP295KCE, a thermistor with a nominal response temperature of 140°C is located in the discharge port of the fixed scroll (Figures 5b and 5c). Excessive discharge temperature will cause the electronic protector module to trip. The discharge gas sensor is wired in series with the motor thermistor chain.

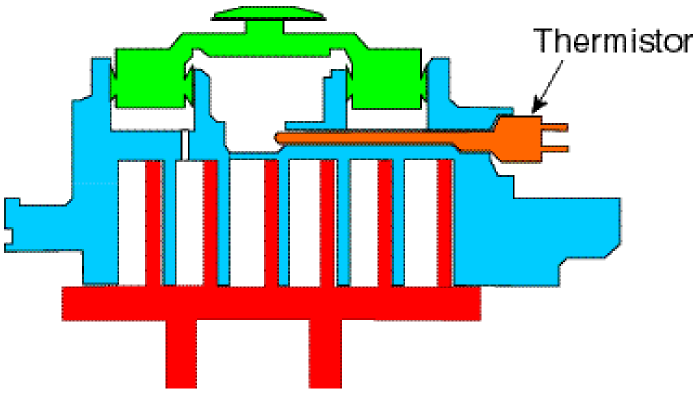


Figure 5b: Internal Discharge Temperature Protection

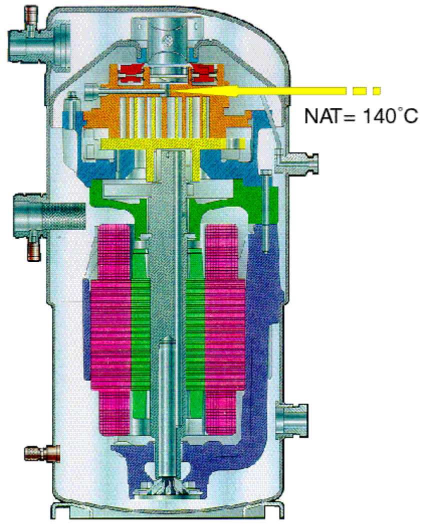


Fig 5c

14. Standard Motor Protection

Conventional inherent internal line break motor protection is provided for the ZP23K3E to ZP137KCE range of compressors.

The electronic motor protection system used in all ZP180KCE to ZP295KCE models is identified by a "W" as the centre letter in the motor code. This system utilizes 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 is required to process the resistance values and trip a control relay depending on the thermistor resistance. The characteristic gradient of a thermistor resistance curve is shown in Figure 6. The resistance curve can be designed for different operating points, the nominal response temperature (NAT), e.g. 100°C, 130°C, 140°C, and must comply with the tolerances laid out in the standard DIN 44081.

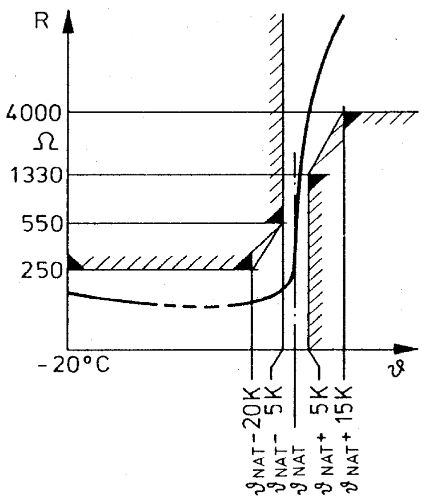


Fig. 6: Thermistor Resistance Curve

Protection Module Specifications :

Type:	Kriwan INT 69 SC / Carel
Voltage:	115/120 V AC; 208/240 V AC – 50/60 Hz
Control Rating:	60 VA, 25 A Inrush 300/375 VA 25/15 A Inrush
Normal PTC resistance:	250 to 1000 Ohms
Trip resistance:	>4500 +/- 20% Ohms
Reset resistance:	<2750 Ohms
Module time out:	30 minutes +/- 5 minutes
Low Voltage Sensing:	None
Phase Monitor:	No

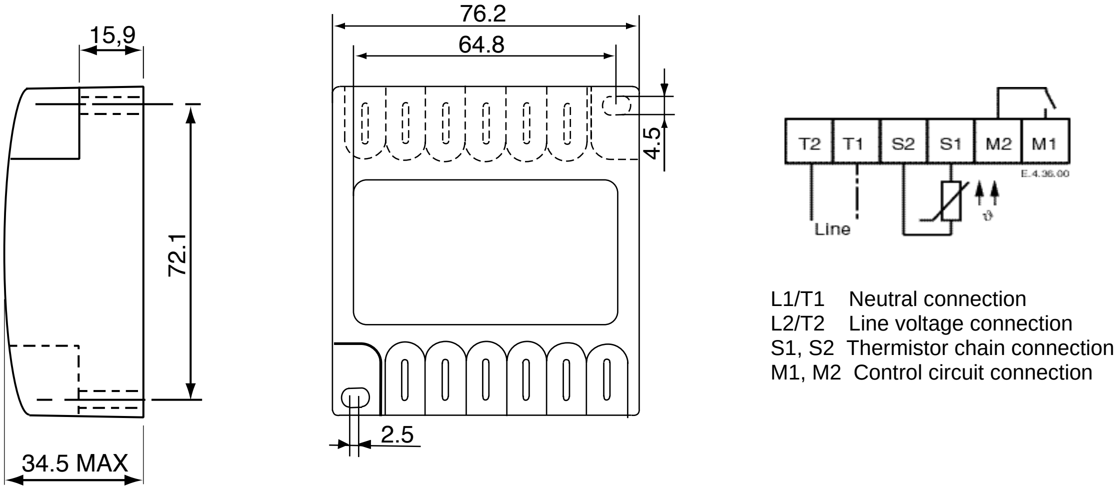


Figure 7 : Carel Module

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 (NAT 100°C). A fourth thermistor is located in a winding head at the lower end of the motor (NAT 140°C). A fifth sensor is located in the discharge port of the fixed scroll to control discharge gas superheat (NAT 130°C). The entire chain is internally led to the fusite from where it is connected to the module connections S1 and S2 (see Figure 7). 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 resets after a time delay of 30 minutes and restarts the compressor.

15. 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.
- 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 between 150 and 1250 ohms.
If the thermistor chain has a higher resistance (2750 ohms or greater) the motor temperature is still too high and it has to be allowed to cool.

If the resistor is 0 ohms, the compressor has to be exchanged due to shorted sensor circuit. ∞ ohms indicates 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 thermistor contactors S1 and S2 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

16. Mufflers

Refrigerant flow through scroll compressors is almost 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 performance especially with reversible heat pumps. When no testing is performed mufflers are recommended with reversible heat pumps. A hollow shell muffler will work quite well. The muffler should be located a minimum of 15 cm to a maximum of 45 cm from the compressor for most effective operation. The further the muffler is placed from the compressor within these ranges, the more effective it may be. If adequate attenuation is not achieved, use a muffler with a larger cross-sectional area to inlet-area ratio. The ratio should be a minimum of 20:1 with a 30:1 ratio recommended. The muffler should be from 4 to 10-15 cm long.

17. 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 generation. 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 the housing 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 recommended design configurations. The scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the line to prevent vibration transmission into any lines attached to the unit. In a split system the most important goal is to ensure minimal vibration in all directions at the service valve to avoid transmitting vibrations to the structure to which the lines are fastened.
A second difference of the Copeland Scroll is that under some conditions the normal rotational starting motion of the compressor can transmit an ‘impact’ noise along the suction line. This may be particularly pronounced in three phase models due to their inherently higher starting torque.This phenomenon, like the one described previously also results from the lack of internal suspension and can be easily avoided by using standard suction line isolation techniques as described below. The sound phenomena described above are not usually associated with reversible heat pump systems because of the isolation and attenuation provided by the reversing valve and tubing bends.

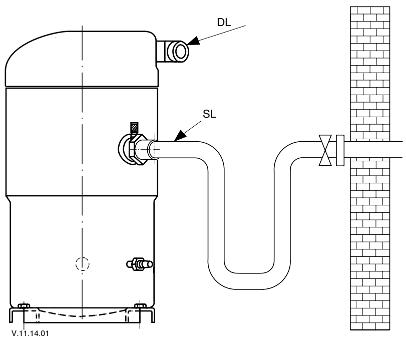


Figure 8: Suction Tube Design

Recommended Configuration

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

Alternate Configuration

-	Tubing Configuration:	small shock loop
-	Service Valve:	“straight through” valve fastened to unit / wall
-	Suction muffler:	may be required (acts as dampening mass)

18. Low Ambient Cut-Out

Low ambient cut-outs are not required to limit heat pump operation. However, the discharge temperature must be limited to 130°C or below otherwise the motor protection may trip.

19. Safety Features

Internal Pressure Relief Valve. The ZP23K3E to ZP83KCE Copeland Scroll compressors have internal pressure relief valve that opens at a discharge to suction differential pressure of 38 to 43 bar.

The ZP90KCE to ZP295KCE scroll compressors do not have an internal pressure relief valve although due to the scroll compressors design the floating seal inside operates as pressure release / equalisation on the off cycle.

These characteristics are safety features and are not intended for control purposes therefore the system designer should ensure a high pressure control is used in all applications.

20. Shut-Off Sound

The "ZP" scroll compressors incorporate a device which prevents reverse rotation and eliminates the shut-off noise associated with earlier scrolls. Since the scroll cannot reverse, it may take two minutes for the high pressure gas trapped in the dome of the compressor to bleed down before the compressor can restart.
A low mass, disc type check valve in the discharge line of the compressor prevents the high pressure discharge gas from re-entering the compressor after shutdown. Additionally with the ZP180KCE to ZP295KCE compressors there is a disk mounted on the fixed scroll that prevents reverse rotation and allows pressure equilisation within the compressor via a small bleed hole. This momentary reversal of direction of the scrolls has no effect on compressor durability and is entirely normal.

21. 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.

22. Deep Vacuum Operation

Copeland Scroll compressors should never be used to evacuate a refrigeration or air conditioning system. The scroll compressor can be used to pump down refrigerant in a unit as long as the pressures remain within the operating envelope. Low suction pressures will result in overheating of the scrolls and permanent damage to the compressor drive bearing. ZP scrolls incorporate internal low vacuum protection, the floating seal unloads when the pressure ratio exceeds approximately 10:1.

23. Shell Temperature

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

24. Brief Power Interruptions

Time delay is not required on three phase models to prevent reverse rotation due to power interruptions. Single-phase ZP scroll compressors incorporate a clutch that prevents backward rotation. Because of this device a time delay is no longer required on this model, however the scroll will stall and trip on protector during a brief power interruption.

25. Electrical Connections

Fusite: The orientation of the pins on the Fusite for Copeland Scroll compressors is shown below and is also shown on the wiring diagram inside the terminal box cover. The screw terminals used on this compressor should be fastened with a torque of 2.5 to 2.6 Nm.

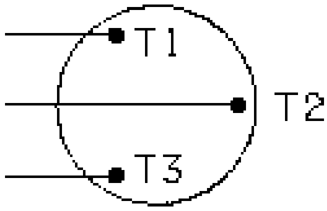
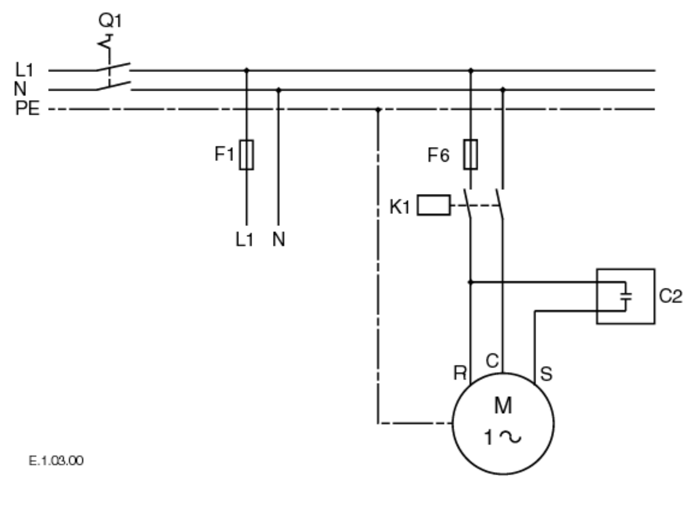


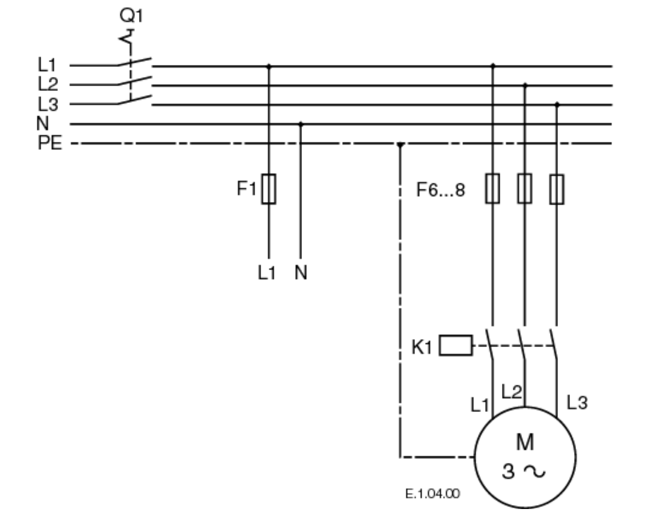
Figure 9: Motor Terminal Connections

Cable sizes are to be selected according to DIN ISO 0100, IEC 364 or National Regulations.

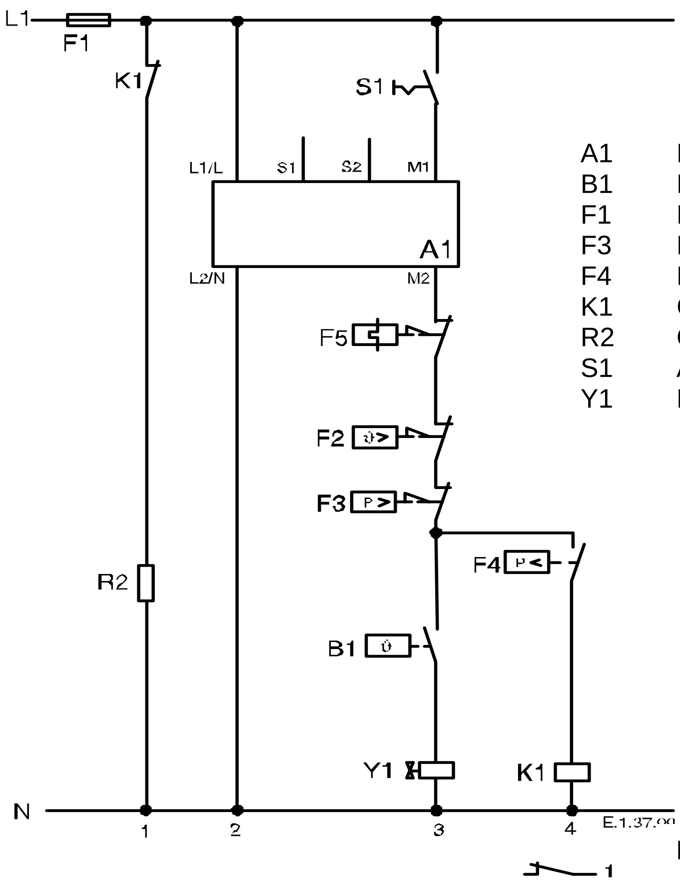
Power Circuit Single-Phase (ZP23K3E – ZP41K3E)



Power Circuit Three-Phase (ZP23K3E – ZP137KCE)



Control Circuit Three-Phase (ZP180KCE – ZP295KCE)



A1	Motor Protection Module
B1	Room Thermostat
F1	Fuse
F3	High Pressure Switch
F4	Low Pressure Swotch
K1	Contactor
R2	Crankcase Heater
S1	Auxillary Swotch
Y1	Liquid Line Solenoid Valve

Figure 10: Control Circuit

26. Single-Phase Models

Start assist devices are not required even if a system utilises non-bleed expansion valves. Due to the inherent 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. ZP Scrolls require two minutes off time to restart after shut-off to allow for internal equalisation of pressure. (See paragraph on “Shut-off Sound” and “Brief Power Interruptions” for explanation)

27. Compressor Functional Check

Since Copeland Scroll compressors do not have internal suction valves or dynamic discharge valves which can be damaged it is <u>not necessary</u> to perform functional compressor tests where the compressor is turned on with the suction service valve closed. This is often done to check how low the compressor can pull down the suction pressure but may actually damage a Copeland Scroll compressor (also other types of compressors).
The following diagnostic procedure should be used to evaluate whether a Copeland Scroll compressor is functioning properly.

1. The correct 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 inherent 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 blower / fan operation should be verified.
4. With service gauges connected to suction and discharge pressure fittings turn on the compressor, if the suction pressure falls below normal levels the system is either low on charge or there is a flow blockage in the system.
5. <u>A) Single Phase Compressors</u>
   If the 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.
   <u>B) Three Phase Compressors</u>
   If the suction pressure does not drop and discharge pressure does not rise to normal levels, reverse any two of the compressor power leads and re-apply power to make sure the 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) functions correctly then the compressor current drawn must be compared to published compressor performance curves at the compressor operating conditions (pressures and voltages). Significant deviations (±15%) from published values may indicate a faulty compressor. A current imbalance exceeding 15% of the average on the three phases may indicate a voltage imbalance and should be investigated further.
7. Before replacing or returning a compressor: Be certain that the compressor is actually defective. As a minimum, re-check a compressor returned from the field in the shop or depot for winding resistance and ability to start before returning. More than one-third of compressors returned to Copeland for warranty analysis are found to have nothing wrong. They were miss diagnosed in the field as being defective. Replacing working compressors unnecessarily costs everyone.

28. Excessive Liquid Floodback Tests

The following tests are for those system configurations and charge levels identified in **Section 9** where special testing is needed to eliminate the use of an accumulator. Figure 3 applies only during floodback, not when the suction gas is superheated, and must be used to determine the effectiveness of an accumulator. The compressor sump temperature during any unit test where flood back occurs must remain within the"safe zone" shown in Figure 3.

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 heating operation). Thermo-couples should be attached to the suction and discharge lines (approximately 150 mm from the shell) as well as the sump (middle of the bottom) of the compressor and insulated. These thermocouples should be insulated from the ambient air with Permagum® or other thermal insulation to be able to record true shell and line temperatures. 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 21°C and outdoor temperature extremes (-18°C or lower) in heating mode which produces floodback conditions. The compressor suction and discharge pressures and sump temperature 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 -23°C or below. The compressor sump temperature must remain above saturated suction temperature as shown in Figure 3 or design changes must be made to reduce the amount of floodback. Increasing indoor coil volume, increasing outdoor air flow, reducing refrigerant charge, decreasing capillary or orifice diameter, and adding a charge compensator can also be used to reduce excessive continuous liquid refrigerant floodback.

To test for **repeated excessive liquid floodback** during normal system off-cycles perform the "Field Application Test". Obtain a sample compressor with a sight tube to measure liquid level in the compressor. Set the system up in a configuration with the indoor unit elevated several metres above the outdoor unit with 8m of connecting tubing and 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. Operate the system in the cooling mode at the outdoor ambient, on/off cycle times, and number of cycles specified in table below. Record the height of the liquid in the compressor at the start of each on cycle, any protector trips, or any compressor stalls during each test. The criteria for pass/fail is whether the liquid level is above the compressor suction connection. Liquid levels higher than these allow any compressor oil floating on top of the refrigerant to be ingested by the scrolls and pumped out of the compressor on startup, a hazardous situation. Review the results with Copeland Application Engineering to determine if an accumulator is required or changes need to be made to the system.

Field Application Test

Operate the system as it would be operated in an actual field installation cycling the unit on and off for the times indicated at each ambient, for the number of cycles stated.

Outdoor Ambient (°C)	29	35	40
System On-Time (Minutes)	7	14	54
System Off-Time (Minutes)	13	8	6
Number of On/Off Cycles	5	5	4

29. High Potential Testing (Hipot)

Copeland subjects all Scroll 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. 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.

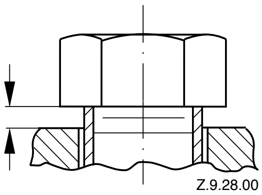
Caution: Do not carry out high voltage or insulation tests if the compressor housing is under vacuum**.** Copeland Scroll compressors are configured with the motor below the compressor. As a result when liquid refrigerant is within the shell the motor can be immersed in refrigerant to a greater extent than with hermetic reciprocating compressors.

In this respect the scroll is more like semi-hermetic compressors (which have horizontal motors partially submerged in oil and refrigerant). When Copeland Scroll compressors are Hipot tested and liquid refrigerant is 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. This phenomenon can occur with any compressor when the motor is immersed in refrigerant. The level of current leakage does not present any safety issue. To lower the current leakage reading the system should be operated for a brief period of time to re-distribute the refrigerant to a more normal configuration and the system high potential tested again.

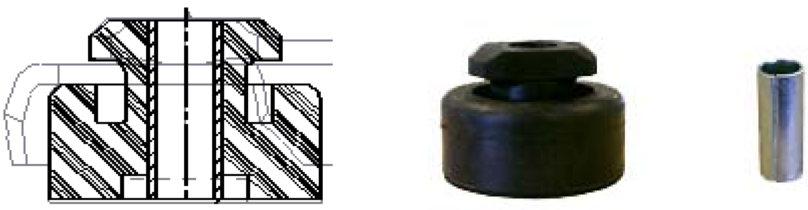
30. Installation

Four vibration absorber grommets are supplied with each compressor (see diagram Mounting Parts). They dampen the start-up surge of the compressor and to a large extent prevent sound and vibration from being transmitted to the compressor base during operation. 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 torque can crush the sleeve. It's inner diameter is approximately 8.5 mm to fit e.g. an M8 screw. The mounting torque should be 13 + 1Nm. It is critically important that the grommet is not compressed. Where applicable a clearance space of approximately 2mm between the underside of the bolt head and the top of the grommet spacer is recommended. (see diagram below "Mounting Clearance".)

2mm Mounting Clearance



Mounting Parts ZP23KCE to ZP137KCE – Soft Mountings



Mounting Parts ZP180KCE – Soft Mountings

Mounting Parts ZP235KCE to ZP295KCE – Soft Mountings

Figure 11: Mounting Parts

31. Installation and Service Brazing Procedure

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.
During installation whilst brazing, the system should be swept with an inert gas such as oxygen free nitrogen at a very low pressure to prevent the formation of oxidation within the pipe-work and fittings. Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to form, the copper oxidation can later be swept through the system and block screens such as those protecting capillary tubes, thermal expansion valves, and accumulator oil return holes. The blockage whether it be of oil or refrigerant is capable of doing damage resulting in compressor failure.
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.

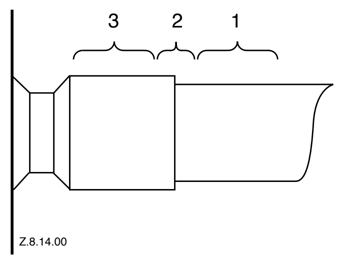


Figure 12: Suction Tube Brazing

- The copper-coated steel tubes on scroll compressors can be brazed in the same manner as any copper tube
- Recommended brazing materials: A copper/phosphorous or copper/phosphorous/silver alloy rod should be used for joining copper to copper whereas to join dissimilar or ferric metals a silver alloy rod either flux coated or with a separate flux would be used.
- Clean the compressor tube fitting I.D. and copper suction or discharge tube O.D. prior to assembly.
- Fit the copper tube into the compressor tube as per figure 12. Using a double-tipped torch apply heat in area 1. As tube approaches brazing temperature, move torch flame to area 2.
- Heat area 2 until braze temperature is attained, moving torch up and down and rotating around tube as necessary to heat tube evenly. Apply the solder to the joint while moving the torch around the joint to allow the fluid flow of the solder around the circumference.
- After the solder flows around the joint, move torch to heat area 3. This will draw the solder material down into the joint (capillary action). The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

To disconnect:
- Heat joint areas 2 and 3 slowly and uniformly until solder softens and tube can be pulled out of the fitting.

To reconnect:
- Recommended brazing materials: A copper / phosphorous or copper/phosphorous/silver alloy rod should be used for joining copper to copper whereas to join dissimilar or ferric metals a silver alloy rod either flux coated or with a separate flux would be used.
- Re-insert tube into fitting.
- Heat tube uniformly in area 1, moving slowly to area 2. When joint reaches brazing temperature, apply solder.
- Heat joint uniformly around the circumference to allow the solder to flow completely around the joint.
- Slowly move torch into area 3 to draw solder into the joint. Do not overheat.

32. System Charging Procedure

Because R410A is a blend and scrolls have discharge check valves, systems should be liquid charged on both the high and low side simultaneously to ensure a positive refrigerant pressure is present in the compressor before it is run. 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.

Do not operate compressor without enough system charge to maintain at least 0.5 bar suction pressure.
Do not operate with a restricted suction.
Do not operate with the low pressure cut-out bridged.
Allowing pressure to drop below 0.5 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage. Do not use compressor to test opening set point of high pressure cutout. Bearings are susceptible to damage before they have had several hours of normal running in.

33. Suction and Discharge Fittings

	Torque [Nm]
Rotalock 3/4"-16 UNF	40 - 50
Rotalock 1"1/4-12 UNF	100-110
Rotalock 1"3/4-12 UNF	170-180
Rotalock 2"1/4-12 UNF	190-200
Sight Glass ZP180KCE	15 - 20
Sight Glass ZP235KCE – ZP290KCE	70 - 90

The Scroll compressors are available with stub tube or a combination Rotalock connections. The stub tube version has copper plated steel suction and discharge fittings. These fittings are far more rugged than copper fittings 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. See Figure 12 for assembly line and field brazing procedures. The table besides contains torque values for those compressors with valve connections.

34. Shut-Off Valves and Adaptors

The Scroll compressors can be delivered with brazing connections to Rotalock (see below).

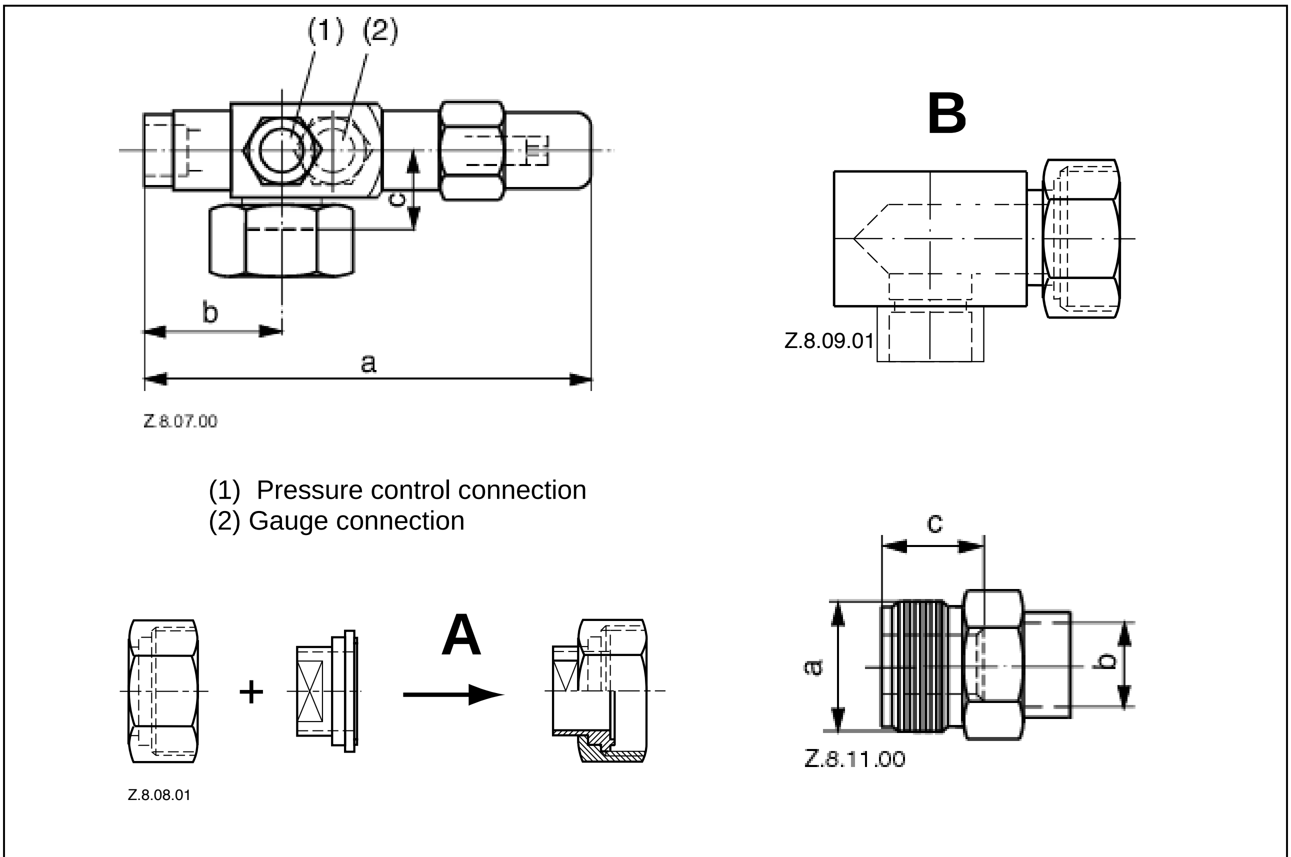


Figure 13: Shut-Off Valves and Adaptors

35. Unbrazing System Components

Caution! If the refrigerant charge is removed from a scroll unit by bleeding the high side only, it is sometimes possible for the scrolls to seal preventing pressure equalization throughout 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 pressurized refrigerant and oil mixture could ignite when it escapes. To prevent this occurrence it is important to check for pressure on both the high and low sides with manifold gauges before applying heat, or in the case of repairing a unit on an assembly line remove refrigerant from both the high and low side. Instructions should be provided in appropriate product literature and assembly (line repair) areas

36. Compressor Replacement

In the case of a motor burnout, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through the use of suction and liquid line filter dryers. A 100% activated alumna suction line filter drier is recommended but must be removed after 72 hours. **It is highly recommended that the suction accumulator be replaced if the system contains one.** This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure. When a single compressor or tandem is exchanged in the field it is possible that a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage. See Section 6 on **Lubrication and Oil Removal**.

37. Start-up of a New or Replacement Compressor

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

A minimum suction pressure of 1.75 bar must be maintained during charging. Allowing pressure to drop below 0.5 bar for more than a few seconds may overheat scrolls and cause early drive bearing damage. Never install a system in the field and leave it unattended when it has no charge, a holding charge, or with the service valves closed without securely electrically locking out the system. This will prevent unauthorised personnel from accidentally operating the system and potentially ruining the compressor by operating with no refrigerant flow. **Do not start the compressor while the system is in a deep vacuum.** Internal arcing may occur when a scroll compressor is started in a vacuum.

38. Direction of Rotation

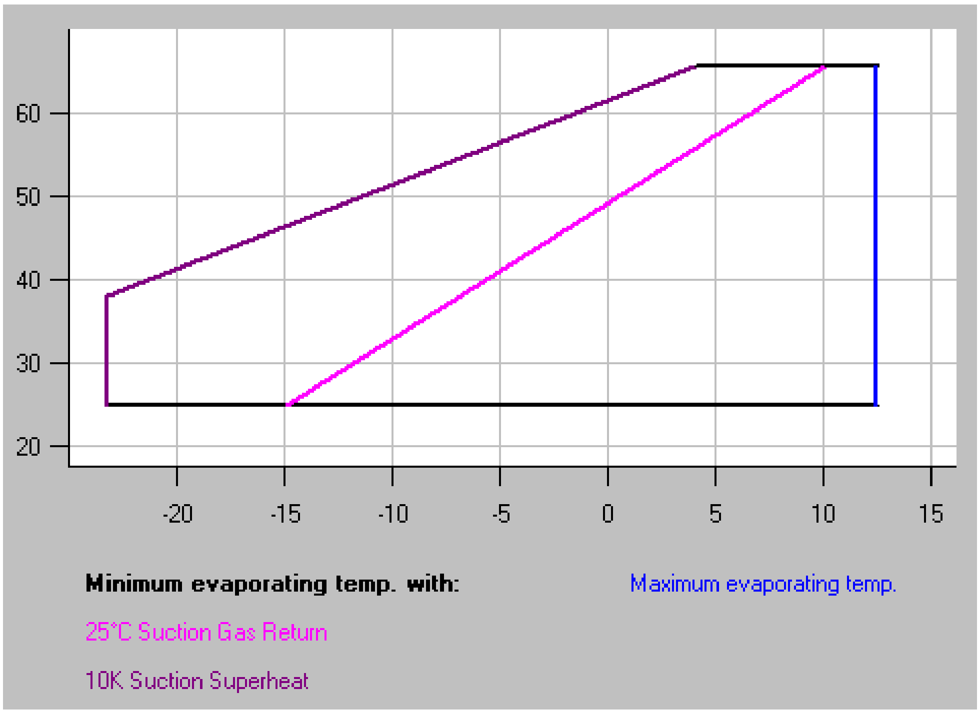
Scroll compressors like several other types of compressors will only compress in one rotational direction. Direction of rotation is not an issue with single phase compressors since they will always start and run in the proper direction.

Three phase compressors will rotate in either direction depending upon phasing of the power. Since there is a 50-50 chance of connecting power in such a way as to cause rotation in the reverse direction **it is important to include notices and instructions in appropriate locations on the equipment to ensure proper rotation direction is achieved when the system is installed and operated.** When the compressor is started the correct direction of rotation can be confirmed by observing that the suction pressure falls and the discharge pressure rises. Reverse rotation results in an elevated sound level as well as substantially reduced current draw compared to tabulated values. There is no negative impact on durability caused by operating three-phase Copeland Scroll compressors in the reversed direction for a short period of time. However, after several minutes of operation the compressor's internal protector will trip. Reverse operation for over one hour may have a negative impact on the bearings.

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

39. Application Envelopes

ZP23K3E to ZP137KCE



ZP180KCE to ZP295KCE

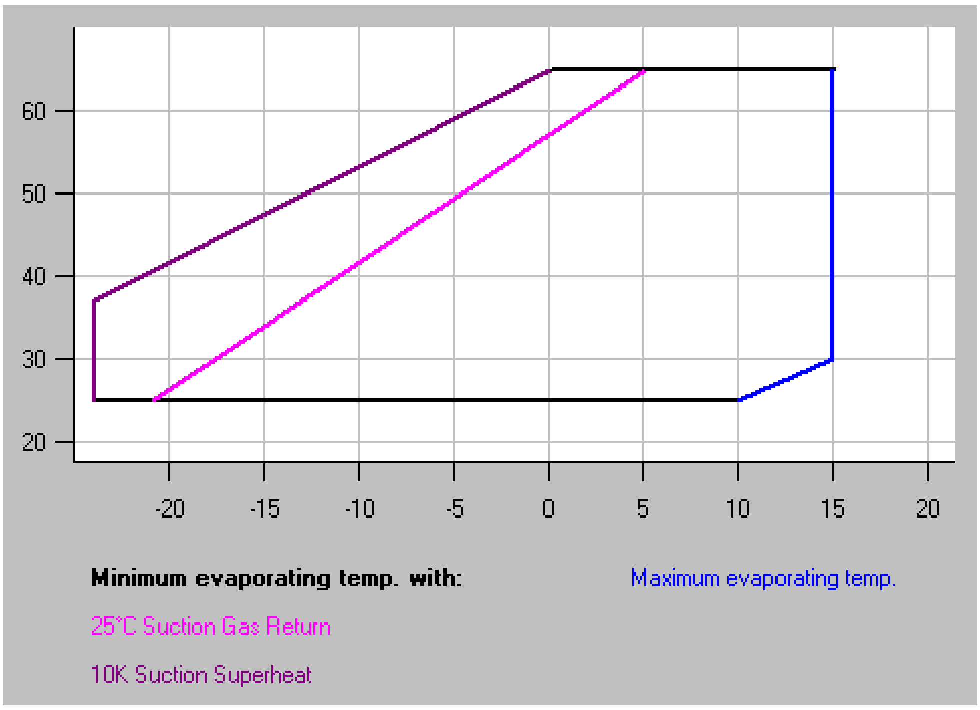
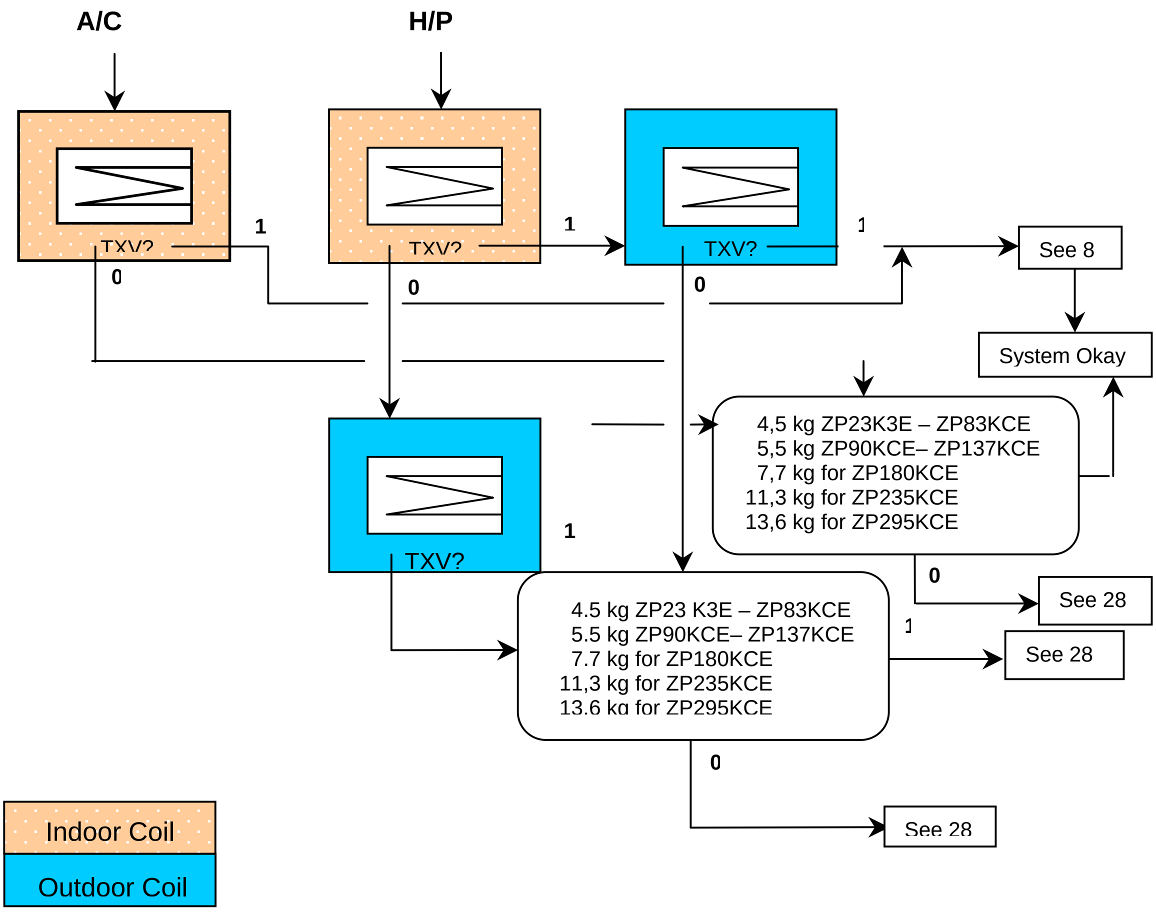


Figure 14

40. Application Diagram

Start at A/C or H/P depending upon your application and follow the chart to see if you need additions or tests on your system.



A/C	Air Conditioner
H/P	Heat Pump
1	Yes
0	No
TXV	Non bleed thermostatic expansion valve (a non flood valve that properly closes below it's operating range is assumed). Different devices are capillary tube, fixed orifices and bleed type valves.

Figure 15

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