Copeland Scroll

R410A Air-Conditioning Scroll Compressors, Tandem

ZPT180 KCE ... ZPT590KCE

ZPU415KCE ... ZPU530KCE

Application Guidelines

EMERSON
Climate Technologies

R410A AIR CONDITIONING SCROLL COMPRESSORS, TANDEM

1 Introduction

These Guidelines describe the application requirements for ZPT & ZPU A/C Tandem scroll assemblies. For additional information, please refer to the "Copeland Selection Software" accessible from the Copeland website at http://www.ecopeland.com.
There are several operating characteristics and design features described below that are different from those of the single Copeland Scroll compressor models.

Tandem compressors make possible great flexibility in system design for a wide range of applications. Since each compressor may be operated individually, this design provides simple, foolproof capacity reduction and maximum power savings, and greatly simplifies system control. In any well designed system, this kind of design offers a much greater factor of redundancy than a single compressor, and provides emergency protection for the product. In addition to greater reliability, one great advantage of the multiple compressor design over other large horsepower compressors is the fact that in the event of compressor damage, replacement of either compressor in the Tandem can be easily and quickly made with a Copeland scroll compressor stocked worldwide by Copeland wholesalers.

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.
- Approved refrigerant and refrigeration oils must be used.
- Do not start the compressor / system until it is charged with refrigerant.
- Correctly used, the compressor and the pressure line piping may reach temperatures that may cause severe burning if touched.

- Wear safety goggles when working on open systems.
- If refrigerant needs to be removed from the system, do not disperse it into the atmosphere, 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 must 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 Tandem Scroll compressors include the approximate nominal 60 Hz capacity at standard operating conditions. An example would be the ZPT180KCE-TFD, 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	PT	470	KC	E	-	TWD	-	XXX
1	2	3	4	5		6		7

Z	PU	530	KC	E	-	TWD	-	XXX
1	2	3	4	5		6		7

1 - Compressor family: Z = Scroll
2 - Application range
  P = High pressure Design
  T = Tandem design even compressors
  U = Tandem design uneven compressors
3 - Nominal capacity [kBTU/h] @ 60 Hz and ARI conditions (*see below)
4 - Model variation
5 - Oil type: E = POE oil
6 - Motor versions
7 - Bill of Material number

***ARI-Conditions:**

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

4 Qualified Refrigerants

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

5 TANDEM Compressors

Tandem compressors consist of two compressors, which can be equal or different models and offer advantages over single compressors with equivalent capacity:

- Efficient capacity control - through cycling one compressor (modulation),
- Increased reliability - fewer starts/stops than a single large compressor,
- Reduced load starting, individual compressors can be started up with a time delay between them,
- Redundancy - part load capacity if one compressor fails, reduced replacement cost - If one compressor fails, it is less costly to replace than a single larger compressor.

The following tandems were approved by Copeland and can be assembled on site:

ZPT 180KCE = ZP 90KCE + ZP 90KCE	ZPU 415KCE = ZP 235KCE + ZP 180KCE
ZPT 206KCE = ZP 103KCE + ZP 103KCE	ZPT 470KCE = ZP 235KCE + ZP 235KCE
ZPT 240KCE = ZP 120KCE + ZP 120KCE	ZPU 530KCE = ZP 235KCE + ZP 295KCE
ZPT 274KCE = ZP 137KCE + ZP 137KCE	ZPT 590KCE = ZP 295KCE + ZP 295KCE
ZPT 360KCE = ZP 180KCE + ZP 180KCE	

6 Applications

Since each compressor motor operates independently, each compressor may be wired with a separate control system. If starting current limitation is a problem, a time delay relay may be used to stagger motor starting. Tandem Scroll compressors, because of their large capacity, are often installed in systems with larger refrigerant charges and long connecting lines, and adequate system protective devices must be installed. A generously sized liquid line filter-drier, and a heavy-duty suction line filter, both of the replaceable element type, are highly recommended for all these systems. Suction line filters prevent flux, dirt, copper filings, and other contaminants from entering the compressor, and are the best investment in preventive maintenance that can be made. A suction line filter further provides both protection for the system in the event of a compressor failure, and a convenient means of installing a suction line filter-drier if required for system cleaning. A suction line accumulator should be installed wherever large fluctuations in system capacity and operating conditions are apt to occur, or in any system where liquid floodback is possible. On systems with long lines and large refrigerant charges, an adequately sized suction line accumulator is especially important. Motors in individual compressors may run at slightly different speeds, and it is possible as a result a resonant noise condition in the discharge lines may occasionally be encountered. This rarely occurs, but it may be prevented by the use of discharge line mufflers in the individual compressor discharge line. Care must be taken in sizing lines for multiple compressor applications to insure that system velocities are maintained at an adequate level to return oil to the compressor during periods when only one compressor is operating. If the load on individual evaporators can vary independently, it is advisable to run individual suction lines to a header near the compressor to maintain adequate suction line velocities.

7 Oil Equalization

When compressors are operating in a tandem, the flow of returning gas and oil enter the header and divides with flow to the operating compressor(s). In order to ensure adequate oil levels in all compressors under all operating conditions, the oil sump of the compressors must be equipped either with oil equalization line or oil and gas equalization line (two phase tube line).

The two compressors that make up the tandem are the same as standard single compressors with the following additions:

	ZPT180KCE …. ZPT274KCE	ZPT360KCE	ZPT470KCE …. ZPT590KCE ZPU415KCE … ZPU530KCE
Oil Equalizing Line	Ø 3/8”	-	-
Oil & Gas Equalizing Line	-	Ø 7/8”	Ø 1 3/8”

8 Single compressor replacement

The question frequently arises as to the effect on the remaining compressor in the event one compressor motor fails due to a motor burn. Unless the compressors are interlocked with a starting time delay relay, the compressor motors operate independently of each other, and the operative compressor can continue to run, circulating refrigerant through the system. There have been so few field failures of this nature to date, although there are thousands in operation, which is difficult to predict with absolute certainty just what may occur. Extensive laboratory testing and experience on the very few units on which one compressor motor has suffered a burn, indicates that on units equipped with adequate liquid line filter-driers and suction line filters at the time of failure, no harm is done to the operating compressor. There is little circulation of refrigerant and oil through the crankcase of the inoperative compressor(s), so any carbon, sludge, or other impurities will have little tendency to leave the scroll shell. There will be some mixing of oil through the equalization line and some slight amount of acid will undoubtedly be in circulation in the refrigerant. The percentage of contamination of the operating system is very small due to the relatively stagnant condition of the inoperative compressor, and any acid and contaminants in circulation will be effectively removed if the system is equipped with an adequate liquid line filter-drier and a suction line filter when the failure occurs. It is probable that pressure drop through the liquid line filter-drier will increase as contaminants are removed, the amount of increase being dependent on the filter-drier size and the nature of the motor burn. Although emergency operation is possible until replacement of the inoperative compressor, it is recommended that the replacement be made as soon as possible. Before removing the damaged compressor, the oil from all compressors should be removed and discarded. When the inoperative compressor is replaced, install a suitable suction line filter-drier and replace the liquid line filter-drier. The unit may be put back into operation immediately after the replacement is made, resulting in a minimum of down time.

9 Compressor Handling

It is recommended that the plugs in the compressor line connections be left in place until the compressors are set into the unit. This reduces the chance of contaminants and moisture getting into the compressors especially as the compressors are charged with the more hygroscopic POE oil. If the compressors have 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 compressors to escape. Pulling the plugs in this sequence prevents oil mist from coating the suction tube making brazing difficult. The copper suction tube should be cleaned before brazing.

10 Lubrication and Oil Removal

The compressors are 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.

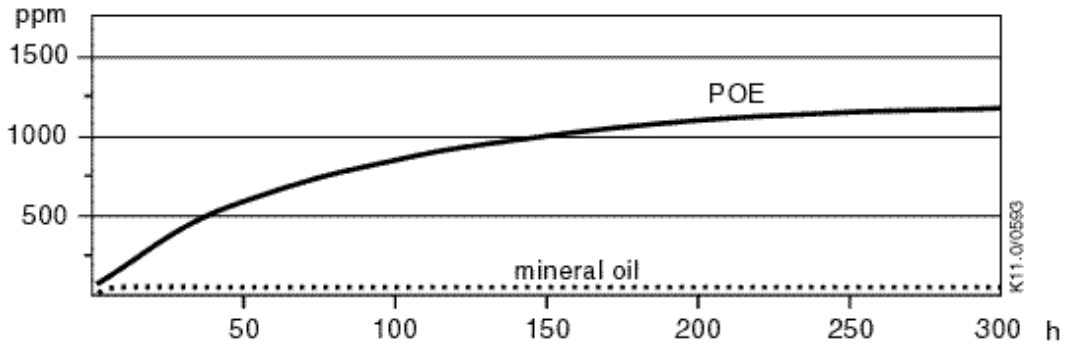


Figure 1: Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 25°C and 50% relative humidity. h = hours

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.

11 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. 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 2.0mm2 is recommended. A large-area protective screen no finer than 30 x 30 mesh (0.6 mm2 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.

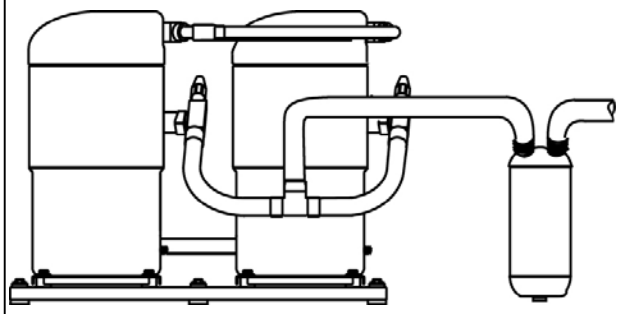


Figure 2: Suction Accumulator

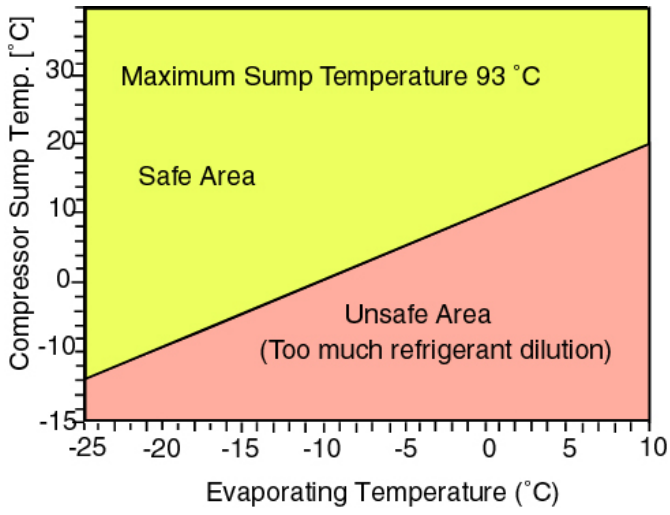


Figure 3: Bottom Shell Temperature

12 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:

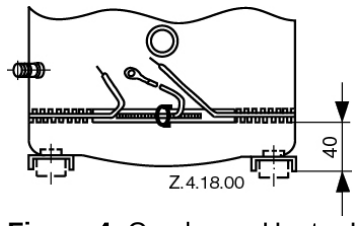


Figure 4: Crankcase Heater Location

6,6 kg for	ZPT 180KCE to ZPT 274KCE
9,2 kg for	ZPT 360KCE
11,4 kg for	ZPU 415KCE
13,6 kg for	ZPT 470KCE
15,0 kg for	ZPU 530KCE
16,3 kg for	ZPT 590KCE

For correct mounting location of such a heater 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**. It 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.

13 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 startup. This is easily determined for the ZPT360KCE to ZPT590KCE compressors since they are equipped with a sight glass. For the ZPT180KCE to ZPT274KCE 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. The individual compressors that make up the tandem are wired independently using the electrical values of the single compressors. It is recommended that compressors be wired to change lead/lag position. This will ensure equal run time for both compressors, thereby increasing reliability.

14 Design

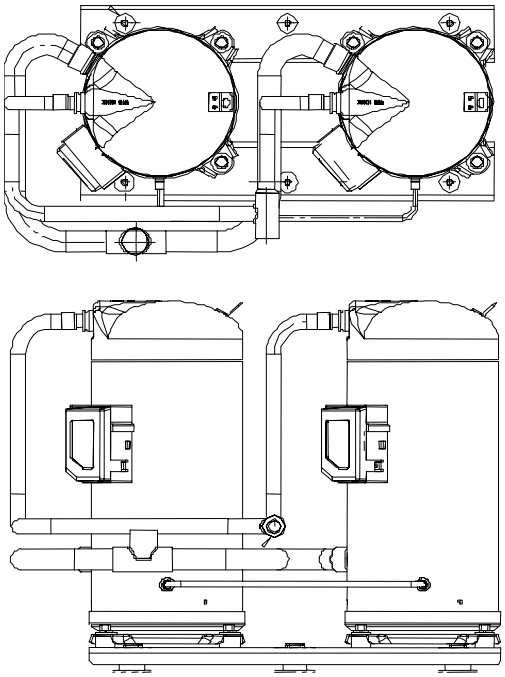
The two compressors are rigidly mounted by means of steel grommets onto two rigid rails to form a tandem unit. The reason for the rigid mounting is to keep the stresses in the tubing between the two compressors at reasonable levels. The compressors should be mounted as close to each other as possible so as to keep the equalization lines as short as possible. The shorter the lines, the better the equalization. This unit should then be bolted to the installation base through isolating rubber grommets. It should be installed on a level surface to ensure proper equalization between the two compressors. Install flexible hoses or vibration absorbers to connect the suction and discharge tubing to the system.

It is recommended that the unit is wired so that the lead compressor alternates between the two compressors. This will ensure an even life for both compressors and will give optimum reliability for the unit. It will also prevent an undesirable situation where one compressor lies idle for long periods of time during low load operation when only one compressor is required.

With increasing cooling capacity usually the pipework becomes more complex. In this case the installation of an oil separator may be recommended.

15 Piping

ZPT 180KCE to ZPT 274KCE



ZPT 360KCE

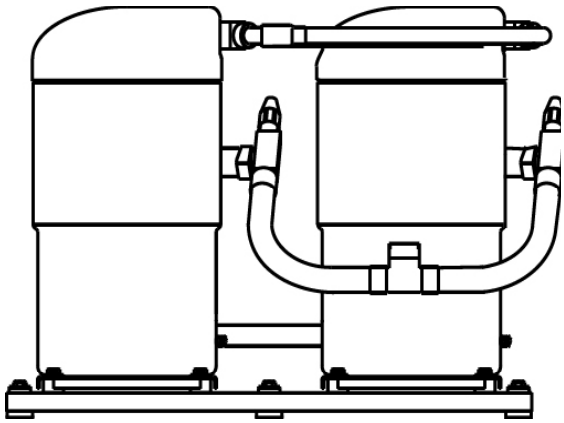


Figure 5: Tandem configurations

ZPT470KCE & ZPT590KCE

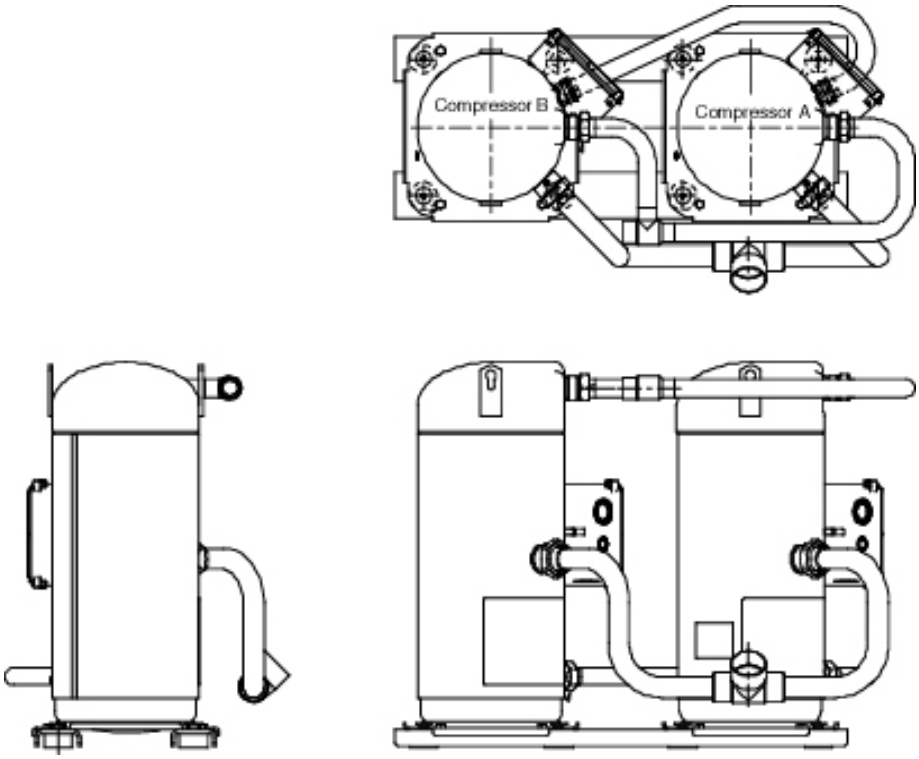


Figure 5: Tandem configurations (continued)

The system piping must be carefully designed to ensure that the gas velocity is sufficiently high under all circumstances so that oil is returned to the compressors, and as little as possible remains in the evaporator. High oil content in the evaporator leads to a loss of cooling and a lack of oil in the compressor. With a modulated tandem unit running on one compressor the gas velocity will be 1/2 of when both compressors are running. Minimum velocities of 4 m/s in horizontal lines and 8 m/s in vertical lines are recommended. Figure 5 shows typical Copeland tandem arrangements.

Above the maximum system charges of refrigerant as indicated in Section 12 a suction accumulator should be provided to protect the compressors from liquid refrigerant floodback.

The discharge line connection of each compressor is provided with a non-return valve. These prevent the build-up of liquid refrigerant in the idle compressor during long periods of shutdown if this compressor is colder than the condensing temperature. In order to minimize vibration transmissions into the system it is recommended to install vibration absorbers into suction- as well as discharge lines.

16 Assembling of ZPT 180KCE…ZPT 274KCE (15 to 24 HP) Tandem compressors

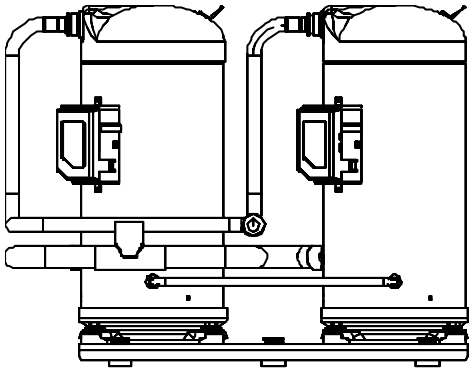


Figure 6: Piping Positions

1 Mount and bolt both compressors onto the mounting rails tighten to 45 – 55 Nm torque.
2 Remove rubber plugs from suction ports then clean, position and braze the suction line.
3 Remove rubber plugs from discharge ports then clean, position and braze the discharge line.
4 Tilt the two assembled compressors backwards with the oil ports to the front.
5 Remove seals from oil equalizing ports.
6 Braze into position oil equalizing line.
7 Return assembly into upright position.

17 Assembling the Tandem-Models ZPT 360KCE, ZPU 415KCE, ZPT 470KCE, ZPU 530KCE and ZPT 590KCE

The tandem design for these compressors incorporate a special “2-phase” tube which connects the compressors via the sight glass fittings by a 1” 3/8-diameter tube (see Figure 7). This design allows both proper crankcase pressure and oil level balance between the two compressors. To monitor the oil level a sight glass might be fitted in this gas/oil equalization line. The dimensions and the shape of this tube can be taken from the drawing package provided by Copeland in case you want to build the Tandem. The suction and discharge tube designs as well as the rail design are available with this package too.

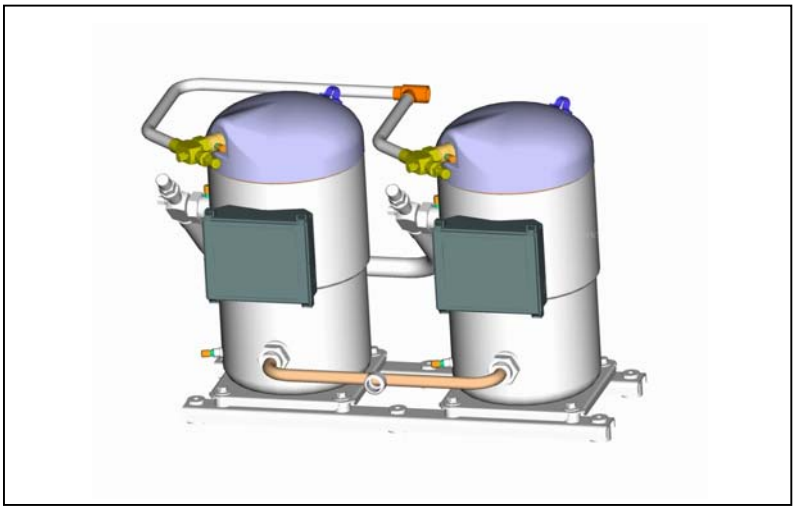


Figure 7: Two-Phase Gas & Oil Equalization Line

Compressors in tandem applications should be hard mounted to a common base to reduce stress on the tubing between tandem tubing. This reduces the chance of stress fractures and subsequent refrigerant leaks. With the ZP180KCE metal spacers are used between the compressor and the rails.
The ZP180KCE, ZP235KCE and ZP295KCE scrolls use a new approach to secure the compressor to rails. The base plates of the scrolls have 4 holes which one uses to bolt the compressor to the tandem rails No metal spacers are needed, which reduces cost.
Rubber grommets are used to connect the tandem assembly to the system base to isolate the system from any vibration (see Figure 8).

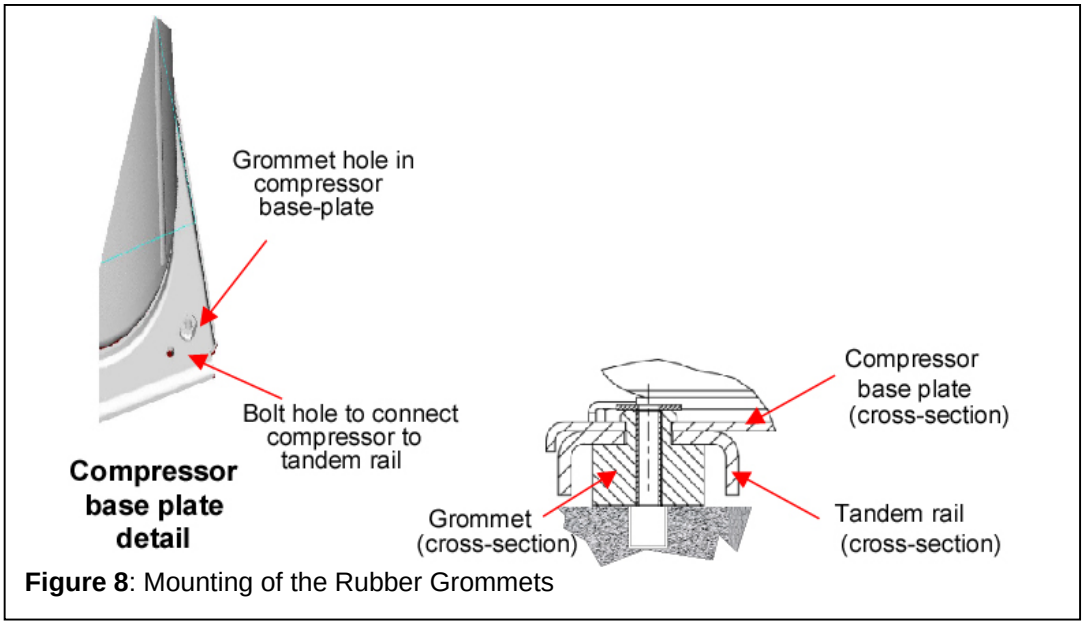


Figure 8: Mounting of the Rubber Grommets

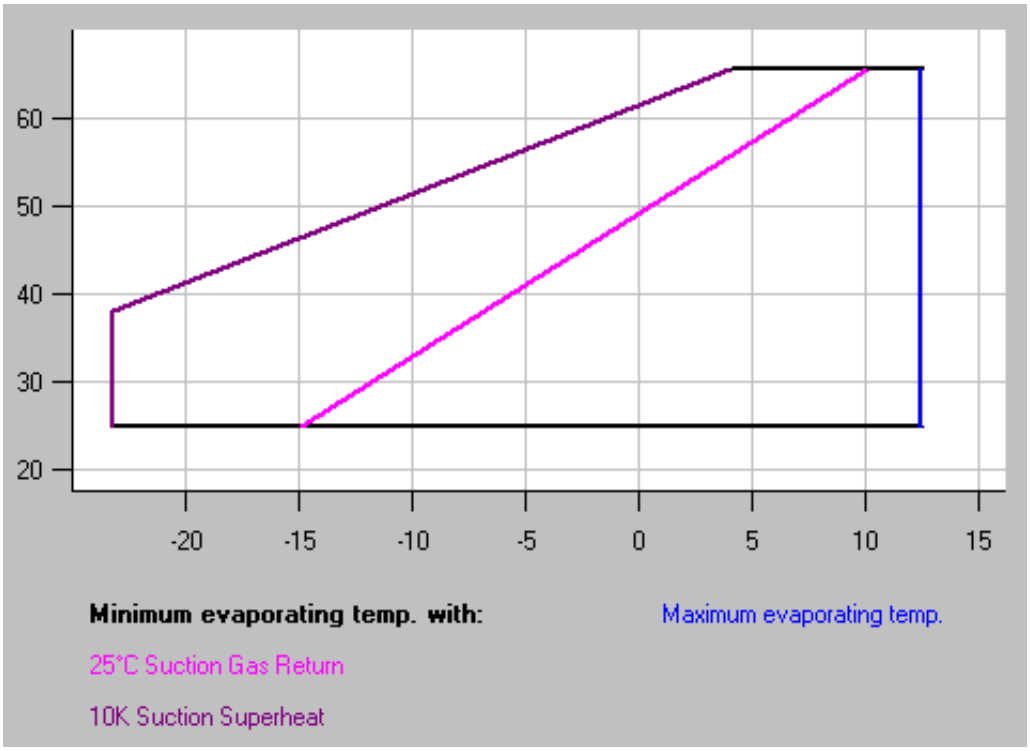
Transportation

Figure 9: Lifting

The tandem must be lifted so that the lifting chains go straight up from the hanger tabs. If the tandem is hoisted from a single point so that the chain makes a “V “ the mounting rails will bend and possibly collapse.

18 Operating Envelopes

ZPT180KCE to ZPT274KCE



ZPT360KCE to ZP590KCE

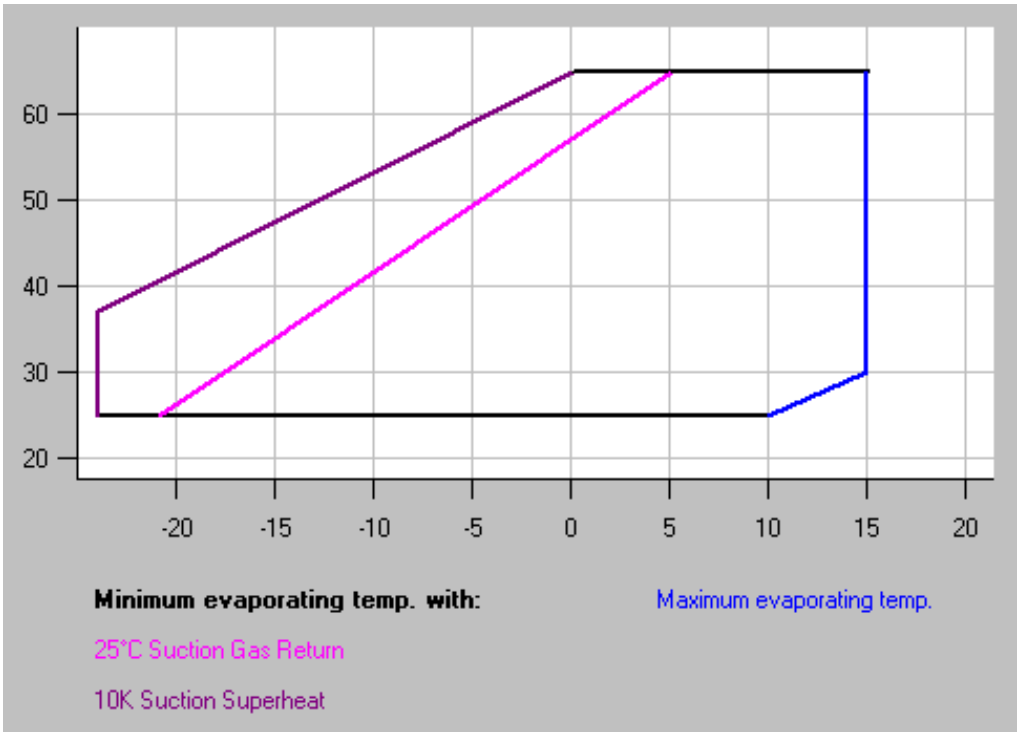


Figure 10: Application Ranges

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