AE4-1388 R4 September 2023

20 to 40 Ton ZP*KC, ZR*KC, & ZH*KC Copeland Scroll™ Air Conditioning Compressors

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Figures & Tables

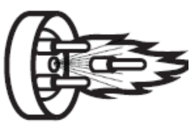
IMPORTANT SAFETY INFORMATION

Those involved in the design, manufacture, and installation of a system, system purchasers, and service personnel may need to be aware of hazards and precautions discussed in this section and throughout this document. OEMs integrating the compressor into a system should ensure that their own employees follow this bulletin and provide any necessary safety information to those involved in manufacturing, installing, purchasing, and servicing the system.

Responsibilities, Qualifications and Training

- OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.
- OEMs are also responsible for ensuring that all product, service and cautionary labels remain visible or are appropriately added in a conspicuous location on the system to ensure they are clear to any personnel involved in the installation, commissioning, troubleshooting or maintenance of this equipment.
- Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission, troubleshoot and maintain this equipment. Electrical connections must be made by qualified electrical personnel.
- Observe all applicable standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment.

Terminal Venting and Other Pressurized System Hazards



If a compressor's electrical terminal pin loses its seal, pressurized oil, refrigerant, and debris may spray out. This is called "terminal venting".

The ejected debris, oil, and refrigerant can injure people or damage property. The oil and refrigerant spray can be ignited by electrical arcing at the terminal or any nearby ignition source, producing flames that may project a significant distance from the compressor. The distance depends on the pressure and the amount of refrigerant and oil mixture in the system. The flames can cause serious or fatal burns and ignite nearby materials.

Each compressor has a terminal cover or molded plug that covers electrical connections. The cover or plug helps to protect against electric shock and the risks of terminal venting. If terminal venting occurs, the cover or plug helps contain the spray of refrigerant and oil and reduces the risk of ignition. If ignition occurs, the plug or cover helps contain the flames. However, neither the terminal cover nor the molded plug can completely eliminate the risk of venting, ignition, or electric shock.

See www.Climate.Emerson.com/terminal for more details about terminal venting.

Additionally, a compressor's refrigerant lines keep refrigerant and oil under pressure. When removing or recharging refrigerant from this component during service, this can pose a pressurized fluid hazard.

Electrical Hazards

Until a system is de-energized and capacitors have been discharged, the system presents a risk of electric shock.

Hot Surface and Fire Hazards

While the system is energized, and for some time after it is deenergized, the compressor may be hot. Touching the compressor before it has cooled can result in severe burns. When brazing system components during service, the flames can cause severe burns and ignite nearby combustible materials.

Lifting Hazards

Certain system components may be very heavy. Improperly lifting system components or the compressor can result in serious personal injury. Use proper lifting techniques when moving.

POE Oil Hazards

This equipment contains polyolester (POE) oils. Certain polymers (e.g. PVC/CPVC and polycarbonate) can be harmed if they come into contact with POE oils. If POE oil contacts bare skin, it may cause an allergic skin reaction.

Precautions

- Always wear personal protective equipment (gloves, eye protection, etc.).
- Keep a fire extinguisher at the jobsite at all times.
- Keep clear of the compressor when power is applied.
    - IMMEDIATELY GET AWAY if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.
- Never reset a breaker or replace a blown fuse without performing appropriate electrical testing
    - A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault. (See troubleshooting guide at [link to come]).
- Disconnect power and use lock-out/tag-out procedures before servicing.
    - Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (*Note: The system may have more than one power supply*.)
    - Discharge capacitors for a minimum of two minutes
    - Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.
- Allow time for the compressor to cool before servicing.
    - Ensure that materials and wiring do not touch high temperature areas of the compressor.

- Keep all non-essential personnel away from the compressor during service.
- Never us a torch to remove the compressor. Only tubing cutters should be used.
- Use an appropriate lifting devices to install or remove the compressor.
- Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.
- Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.
- Charge the system with only approved refrigerants and refrigeration oils.
- Keep POE oils away from certain polymers (e.g. PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.
- Before energizing the system:
    1. Securely fasten the protective terminal cover or molded plug to the compressor, and
    2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

Signal Word Definitions

The signal word explained below are used throughout the document to indicate safety messages.

⚠ DANGER	DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury

INTRODUCTION

The 20 to 40 ton ZR250-380*KC, ZH100-150*KC and ZP235-485*KC Copeland Scroll™ compressors are designed for a variety of commercial air conditioning and chiller applications. This bulletin describes the operating characteristics, design features, and application requirements for these models. Compressors in this size range include a number of features outlined in Table 1 below.

For additional information, please refer to [Copeland Mobile].

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 ZP236KCE-TED, which has 236,000 Btu/hr (69.1kW) cooling capacity at the AHRI high temperature air conditioning rating point when operated at 60 Hz. Note that the same compressor will have approximately 5/6 of this capacity or 196,000 Btu/hr (57.4kW) when operated at 50 Hz. See Figure 1 for more information regarding nomenclature.

APPLICATION CONSIDERATIONS

The following application guidelines should be considered during the design of a system using ZR*KC, ZP*KC, and ZH*KC scroll compressors. Some of this information is recommended, whereas other guidelines must be followed. The Application Engineering department will always welcome suggestions that will help improve these types of documents.

Operating Envelopes

Figure 5 illustrates the operating envelope for the ZR*KC, ZP*KC and ZH*KC compressors. The operating envelopes represent operating conditions with 20°F (11K) superheat in the return gas. The steady-state operating condition of the compressor must remain inside the prescribed operating envelope. Excursions outside of the envelope should be brief and infrequent. Use of refrigerants other than the qualified refrigerant voids the compressor UL recognition and may increase the risk of malfunction and serious injury or death.

Figure 2 illustrates the operating envelope for the expanded frequency range of the 20 to 40 ZP*KC Copeland Scroll compressors. Please note that the envelope is truncated versus the standard 50/60 Hertz operating envelope. In addition, please note the restrictions on operating frequency/speed within the envelope. For more information on the application of the expanded frequency range compressors please refer to the section Variable Speed Operation.

Superheat Requirements

To assure that liquid refrigerant does not return to the compressor during the running cycle, attention must be given to maintaining proper superheat at the compressor suction inlet. A minimum of 9°F (5°K) superheat is required and it's recommended to control the superheat to 20°F (11°K) to ensure the superheat doesn't drop below 9°F (5°K). Superheat is measured on the suction line 6 inches (152mm) from the suction fitting on the compressor. This is to prevent liquid refrigerant floodback.

During rapid system changes, such as defrost or ice harvest cycles, this temperature difference between the compressor oil crankcase and the suction line may drop rapidly for a short period of time. When the crankcase temperature difference falls below the recommended 50°F (27°K), our recommendation is the duration should not exceed a maximum (continuous) time of two minutes and should not go lower than a 25°F (14°K) difference.

High Pressure Control

⚠WARNING

A high pressure control must be used in all applications.

The 20 to 40 ton Copeland Scroll compressors do not have internal pressure relief valves. To avoid abnormally high operating pressures, a high pressure control must be used in all applications. The maximum cut out setting is 425 psig (30 bar) for R-22, R-407C, R513A and R-134a and 650 psig (45 bar) for R-410A. The high pressure control should have a manual reset feature for the highest level of system protection.

If any type of discharge line shut-off valve is used, the high pressure control must be installed between the compressor discharge fitting and the valve. Compressors with rotalock discharge fittings have a connection on the rotalock fitting for the high pressure cut-out switch connection.

ASHRAE Standard 15 and UL 984/60335-2-34 requires a system pressure relief valve when the compressor displacement is greater than 50 CFM. The floating seal device during blocked discharge conditions. Please refer to UL File SA2337 to reference UL's acceptance of this method.

Discharge Temperature Protection

High discharge temperature protection is provided by a thermistor probe in the discharge plenum of the scroll. Compressors with TW* motor nomenclature use a positive temperature coefficient (PTC) thermistor and compressors with TE* motor nomenclature use a negative temperature coefficient (NTC) thermistor. In either case the module M1-M2 contacts are opened if the internal discharge temperature exceeds safe limits. Discharge temperature data are stored in the CoreSense module and can be made available to a system controller.

Compressors requiring certification to the Pressure Equipment Directive (PED):

The nameplate will be marked with a TS min which is defined as the minimum allowable temperature. The nameplate will also be marked with a TS max which is defined as the maximum allowable temperature (max design temperature, highest temp that can occur during operation or standstill of the refrigeration system or during test under test conditions, specified by the manufacturer). Refer to Copeland Mobile for PED specific information.

Low Pressure Control

A low pressure control is highly recommended for loss of charge protection and other system fault conditions that may result in very low evaporating temperatures. Loss of system charge will result in overheating and recycling of the motor overload protector. Prolonged operation in this manner could result in oil pump out and eventual bearing failure. The low pressure cut-out setting will depend on the application type and minimum expected evaporating temperature. The low pressure cut-out should be selected to prevent compressor overheating and other system failure modes such as coil icing in air conditioning systems and frozen heat exchangers in chiller systems. The minimum, recommended low pressure cut-out switch settings are:

Air conditioning and chiller:
55 psig/3.8 bar (R-410A), 25 psig/1.7 bar (R-22 & R-407C), and 10 psig/0.7 bar (R-134a & R513A)

Heat pumps:
407C, & R513A)

Shut Down Device

All scrolls in this size range have floating valve technology to mitigate shut down noise. Since Copeland scroll compressors are also excellent gas expanders, they may run backwards for a brief period after shutdown as the internal pressures equalize.

Discharge Check Valve

A spring assist, disk-type check valve in the discharge fitting of the compressor prevents the high pressure gas in the condenser from flowing back through the compressor after shutdown. Performance of the check valve for recycling pump down applications hasn't been evaluated at all pressure differentials. Low pressure differentials may result in unacceptable leak-back rates.

Shell Temperature

⚠ WARNING

Compressor top cap temperatures can be very hot. Care must be taken to ensure that wiring or other materials which could be damaged by these temperatures do not come into contact with these potentially hot areas.

Compressor Cycling

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 Copeland scroll compressors start unloaded, even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after startup. To establish the minimum run time, obtain a sample compressor equipped with a sight tube (available from Copeland) and install it in a system with the longest connecting lines and highest internal volume that the system may have. The minimum on time becomes the time required for oil lost during compressor startup to return to the compressor sump and restore a minimal oil level that will assure oil pick up through the crankshaft. The minimum oil level required in the compressor is 1.5" (40 mm) below the center of the compressor sight-glass. The oil level should be checked with the compressor "off" to avoid the sump turbulence when the compressor is running. Cycling the compressor for a shorter period than this, for instance to maintain very tight temperature control, will result in progressive loss of oil and damage to the compressor.

Long Pipe Lengths / High Refrigerant Charge

Some systems may contain higher than normal refrigerant charges. Systems with large reheat coils, low ambient condenser flooding, or systems with multiple heat exchangers are among some system configurations that may require additional lubricant. If the compressors have a sight glass for oil level viewing, the oil level should always be checked during OEM assembly, field commissioning, and field servicing. An estimation of the amount of additional lubricant to add to the compressor(s) when the circuit charge exceeds 20 pounds of refrigerant is as follows:

Single compressor application: 0.5 fluid ounce of oil per pound of refrigerant.

Tandem compressor application: 0.7 fluid ounce of oil per pound of refrigerant.

Trio compressor application: 1.0 fluid ounce of oil per pound of refrigerant.

The oil level must be carefully monitored during system development, and corrective action should be taken if the compressor oil level falls more than 1.5" (40 mm) below the center of the sight-glass. The compressor oil level should be checked with the compressor "off" to avoid the sump turbulence when the compressor is running.

These compressors are available to the OEM with a production sight-glass that can be used to determine the oil level in the compressor in the end-use application. These compressors are also available to the OEM with an oil Schrader fitting on the side of the compressor to add additional oil if needed because of long lengths of piping or high refrigerant charge. No attempt should be made to increase the oil level in the sight-glass above the 3/4 full level. A high oil level is not sustainable in the compressor and the extra oil will be pumped out into the system causing a reduction in system efficiency and a higher-than-normal oil circulation rate.

Suction and Discharge Fittings

The compressors have copper plated steel suction and discharge or threaded rotalock fittings. See **Figure 4** for assembly line and field brazing recommendations and **Table 2** for rotalock torque requirements.

System Tubing Stress

System tubing should be designed to keep tubing stresses under the endurance limit of the copper tubing type used (i.e. Type K, L, etc.). Start, stop and running (resonance) cases should be evaluated to ensure long term reliability.

For variable speed applications, the suction and discharge tubing must be evaluated to determine the resonant frequencies. Once the resonant frequencies are known, they can be shifted to a desired range by changing the mass of the line for constant speed applications or they can be avoided for variable speed applications. Application engineering is available to recommend additional tests and to evaluate test results.

Accumulators

The use of accumulators is very dependent on the application. The Copeland scroll compressor's inherent ability to handle liquid refrigerant during occasional operating flood back situations make the use of an accumulator unnecessary in most applications. The OEM is responsible for determining if an accumulator is needed and the selection of the accumulator. Consideration for additional oil needed for the accumulator should be taken.

Off-Cycle Migration Control

Excessive migration of refrigerant to the compressor during the off-cycle can result in oil pump-out on start up, excessive starting noise and vibration, bearing erosion, and broken scrolls if the hydraulic slugging pressure is high enough. For these reasons, off-cycle refrigerant migration must be minimized. The following three sections summarize off-cycle migration techniques.

Crankcase Heaters

A crankcase heater is required when the system charge exceeds the values listed in **Table 3**. This requirement is independent of system type and configuration. The initial start-up 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 help prevent oil dilution and bearing stress on initial startup.

To properly install the crankcase heater, the heater should be installed in the location illustrated in **Figure 5**. Tighten the clamp screw carefully, ensuring that the heater is uniformly tensioned along its entire length and that the circumference of the heater element is in complete contact with the compressor shell. It's important that the clamp screw is torqued to the range shown in **Table 2** to ensure adequate contact and to prevent heater burnout. Never apply power to the heater in free air or before the heater is installed on the compressor to prevent overheating and burnout.

WARNING

Crankcase heaters must be properly grounded to reduce the potential of a fire or shock hazard.

Pump Down Cycle

If a pump down cycle is required by the system designer, a onetime pump down at the end of the cooling cycle is preferred over a recycling pump down. Although not preferred, a recycling pump down cycle can be used to minimize off-cycle refrigerant migration to the compressor. The risk of a short cycling condition that can lead to oil pump out, excessive contactor wear, unnecessary energy use, and excessive low pressure cut-out switch cycles make recycling pump down undesirable. In lieu of the pump down cycles mentioned above, simply closing a liquid line solenoid valve when the compressor cycles off is a good, simple, and cost effective method of minimizing off-cycle refrigerant migration.

Pump Out Cycle

A pump out cycle has been successfully used by some manufacturers of large rooftop units. After an extended off period, a typical pump out cycle will energize the compressor for up to one second followed by an off time of 5 to 20 seconds. This cycle is usually repeated a second time, the third time the compressor stays on for the cooling cycle. If pump out cycle is employed, a crankcase heater must be used if the circuit charge amount exceeds the values listed in **Table 3**.

Reversing Valves

Since Copeland scroll compressors have very high volumetric efficiency, their displacements are lower than those of comparable capacity reciprocating compressors.

Reversing valve sizing must be within the guidelines of the valve manufacturer. Required pressure drop to ensure valve shifting must be measured throughout the operating range of the unit and compared to the valve manufacturer's data. Low ambient heating conditions with low flow rates and low pressure drop across the valve can result in a valve not shifting. This can result in a condition where the compressor appears to be not pumping (i.e. balanced pressures). It can also result in elevated compressor sound levels.

During a defrost cycle, when the reversing valve abruptly changes the refrigerant flow direction, the suction and discharge pressures will go outside of the normal operating envelope. The sound that the compressor makes during this transition period is normal, and the duration of the sound will depend on the coil volume, outdoor ambient temperature, and system charge level. If the compressor is operating during a defrost cycle the compressor should operate between 50-60Hz. The preferred method of mitigating defrost sound is to shut down the compressor for 20 to 30 seconds when the reversing valve changes position going into and coming out of the defrost cycle. This technique allows the system pressures to reach equilibrium without the compressor running. The additional start-stop cycles do not exceed the compressor design limits, but suction and discharge tubing design should be evaluated.

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 shutoff, suction and discharge pressures are reversed to the compressor. This results in pressures equalizing through the compressor which can cause the compressor to slowly rotate backwards until the pressures equalize. This condition does not affect compressor durability but can cause unexpected sound after the compressor is turned off.

Contaminant Control

Manufacturing processes have been designed to minimize the introduction of solid or liquid contaminants. Dehydration and purge processes ensure minimal moisture levels in the compressor, and continuous auditing of lubricant moisture levels ensures that moisture isn't inadvertently introduced into the compressor. However, due to the manufacturing processes, Copeland scroll compressors will contain a miniscule amount of solid and liquid contaminants when they leave the factory.

During unit assembly and field servicing, compressors shouldn't be left open to the atmosphere for longer than five minutes. It is generally accepted that system moisture levels should be maintained below 50 ppm. A filter-drier is required on all POE lubricant systems to prevent solid particulate contamination, oil dielectric strength degradation, ice formation, oil hydrolysis, and metal corrosion. It is the system designer's responsibility to make sure that the filter-drier is adequately sized to accommodate the contaminants from system manufacturing processes which leave solid or liquid contaminants in the evaporator coil, condenser coil, and interconnecting tubing plus any contaminants introduced during the field installation process. Molecular sieve and activated alumina are two filter-drier materials designed to remove moisture and mitigate acid formation. A 100% molecular sieve filter can be used for maximum moisture capacity. A more conservative mix, such as 75% molecular sieve and 25% activated alumina, should be used for service applications.

Oil Type

Mineral oil is used in the ZR*KC compressors for R22 applications. Polyolester oil (POE) is used in all other models. Please refer to Copeland publication 93-11 for specific POE oil grade in centistokes for each refrigerant.

See the compressor nameplate for the original oil charge. A complete recharge should be approximately four to eight fluid ounces (203ml) less than the nameplate value. Please refer to Online Product Information at Copeland Mobile for model specific oil charge and recharge values. If additional oil is needed in the field, there are multiple POE brands available at your local distributor and wholesalers.

⚠ WARNING

POE may cause an allergic skin reaction and must be handled carefully. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. POE must not come into contact with any surface or material that might be harmed by POE, including, certain polymers (e.g. PVC/CPVC and polycarbonate). Refer to the Safety Data Sheet (SDS) located at Copeland Mobile for the specific oil.

Three Phase Scroll Compressor Electrical Phasing

Compressors that employ CoreSense technology have phase protection and will be locked out after one reverse phase event.

Copeland 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. Since there is a 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 that proper rotation direction is achieved when the system is installed and operated. Verification of proper rotation direction is made by observing that suction pressure drops and discharge pressure rises when the compressor is energized. Reverse rotation will result in no pressure differential as compared to normal values. A compressor running in reverse will sometimes make an abnormal sound.

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 (under one hour). After a few minutes of reverse operation, the motor and scroll thermistor circuit will exceed the temperature trip point and the M1-M2 contacts will open, shutting off the compressor. If allowed to repeatedly restart and run in reverse without correcting the situation, the compressor bearings will be permanently damaged because of oil loss to the system. All three-phase scroll compressors are wired identically internally. As a result, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the identified compressor electrical (Fusite®) terminals will maintain the proper rotational direction (see **Figure 6**).

Power Factor Correction

If power factor correction is necessary in the end-use application, please see **AE-1249** for more information on this topic.

Soft Starters

Soft starters can be used with the compressors to reduce inrush current. Soft starters should be selected in accordance with the soft starter manufacturer's recommendations, taking into consideration ambient temperature, number of starts per hour, and compressor amps. The maximum ramp up time should not exceed 3 seconds.

Motor Overload Protection

The Kriwan and CoreSense Communications modules are U.L. recognized safety devices and must be used with all compressors that have TW* and TE* electrical codes respectively.
Compressors with an "E" in the electrical code (i.e. ZP236KCE-TED) employ CoreSense™ Communications as the motor overload protection device. **CoreSense** Communications provides advanced diagnostics, protection, and communications that enhance compressor performance and reliability. For more information please refer to the CoreSense Communications application engineering bulletin, AE8-1384.

Models with a "W" in the electrical code (i.e. ZP285KCE-TWD) have a Kriwan motor overload system that consists of an external electronic control module connected to a chain of thermistors embedded in the motor windings and scroll discharge plenum. The module will trip and remain off for a minimum of 30 minutes if the motor or scroll temperature exceeds the maximum allowable temperature.
Note: Turning off power to the module will reset it immediately, however, if the fault is still present that caused the trip the module will lock out the compressor for another 30 minutes.

The module has a 30 minute time delay to allow the motor and scrolls to cool down after the temperature limit has been reached. CAUTION Restarting the compressor sooner may cause a destructive temperature build up in the compressor. For this reason, module power must never be switched off with the control circuit voltage. Since the compressor is dependent upon the contactor to disconnect it from power in case of a fault, the contactor must be selected in accordance with AE10-1244. The contactor must meet both the Rated Load Amps (RLA) and Locked Rotor Amps (LRA) specified for the compressor.

If the Kriwan module is applied in conjunction with a programmable logic controller (PLC), it is important that a minimum load is carried through the M1-M2 control circuit contacts. The minimum required current through the module relay contacts needs to be greater than 20 milliamps, but no more than 2.5 amps. If this minimum current is not maintained, long-term contact resistance of the relay may be compromised resulting in nuisance, unexplained trips. PLC operated control circuits may not always provide this minimum current. In these cases modifications to the PLC control circuit, or the addition of a relay, may be required.

Manifolded Compressors

Tandem and trio compressor assemblies are available for purchase from Copeland. In lieu of purchasing the assembled tandem or trio, OEMs can purchase the manifold-ready compressors and perform the assembly in their factory. Drawings of tandem and trio compressor assemblies are available from Copeland by contacting your Application Engineer. Part numbers for manifolds and other service parts are available by contacting Application Engineering. Customers who choose to design and build their own manifolds for tandem and trio compressor assemblies are ultimately responsible for the reliability of those manifold sets.

Reference the AE-1430 bulletin for information on multiple compressors applications and design considerations.

VARIABLE SPEED OPERATION

Introduction

The 20 to 40 ton Copeland scroll compressors described in this bulletin are qualified for a speed range listed in the operating envelope in **Figure 5**.

Performance

Ten coefficients are available for calculating performance. Evaporating and condensing temperature are the terms for the ten coefficient equation to calculate mass flow, power, and capacity. Twenty coefficients are also available for calculating performance. Evaporating and condensing temperature and speed are the terms of the equation. The coefficients are for the compressor only and do not account for the drive. These coefficients are available by contacting Application Engineering.

Operating Envelope

The system controller must have the ability to keep the operating condition inside of the prescribed operating envelope. The operating envelope listed in **Figure 5** is for single compressor applications only. Contact Application Engineering for multiple compressor applications.

Drive Selection

A Copeland EVM or EVH drive can be used with the compressors. Contact Application Engineering or reference Copeland Mobile for more details.

Electrical Requirements

The drive must be sized to accommodate the maximum expected running amps of the compressor. For operation throughout the operating envelope at +/-10% voltage variation the drive should be selected based on the compressor maximum continuous current (MCC). The electrical data for the specific compressor can be referenced at Copeland Mobile.

The recommended switching frequency of the drive is 2 to 3 kHz. Higher switching frequencies can result in motor overheating and reduced efficiency.

The normal ratio of the voltage/frequency should be kept constant throughout the 35 to 60 Hertz range. At frequencies higher than 60 Hertz, the voltage/frequency ratio cannot be kept constant because the output voltage of the drive cannot be higher than the drive input voltage. **Figure 10** illustrates the voltage- frequency curves for nominal 230, 460, and 575 volt power supplies.

The CoreSense™ Communications M1-M2 contacts and other safety/protection controls (i.e. high pressure cut-out switch) should be wired in-series with the compressor contactor coil. The compressor contactor should be wired upstream of the variable frequency drive so the drive and compressor are immediately stopped when a safety/protection control trips.

Autotuning

If an Autotuning drive sequence is to be performed with a compressor that has a Coresense Communication module, the following steps must be taken.

1. De-energize control circuit and module power. Remove the control circuit wires from the module (terminals M1 & M2).Connect a jumper across these "control circuit" wires. This will bypass the "control contact" of the module.

⚠WARNING

The motor protection system within the compressor is now bypassed. Use only temporarily during autotuning sequence.

2. Run the Autotuning sequence of the drive.
3. Remove jumper and reconnect control circuit wires to the module.

Starting and Ramp Up

The starting frequency should be equal to or greater than the minimum speed. After starting the compressor at the minimum speed, the speed should be ramped up to 3,000 RPM (50Hz) to 3,600 RPM (60Hz) within 3 seconds. The compressor should operate at 3,000-3,600 RPM for a minimum of 10 seconds before ramping the speed up or down to the desired operating speed. A normal ramp speed is 200 revolutions per second.

Stopping

Ramping down the frequency to the minimum speed before stopping the drive-compressor is considered a good shutdown routine. However, given the operating frequency and speed range of the compressor it is not necessary to decelerate the compressor prior to shutdown. Depending on the drive interface and control, the drive should be given a "stop" command to stop the compressor. In rare cases when a system protection device trips (i.e. high pressure cut-out switch) power to the drive input should be immediately interrupted.

Vibration

A compressor driven at a variable speed will impose different frequencies at each speed, so the framework and piping design to accommodate vibration throughout the speed range can be more complex. As a rule of thumb, the system should be designed, or the drive control should be configured (skip frequencies program), such that there is no operation at resonant frequencies between the minimum and maximum speeds.

Oil Recovery Cycle

Particular attention must be given to the system refrigerant pipe size with the variable speed scrolls. ASHRAE guidelines for pipe sizing should be followed to ensure that refrigerant velocities are high enough at low speeds to ensure oil return to the compressor. At the same time, high refrigerant velocities at high speed operation can result in excessive pressure drop and loss of system efficiency. A careful evaluation and compromise in pipe sizing will likely have to be settled upon. A compressor sample with a sight-tube for monitoring the oil level should be used during system development to ensure an adequate oil level is maintained during all operating conditions and speeds.

If testing shows a gradual, continuous loss of oil in the compressor sight-tube over long run cycles at low speed, an oil recovery cycle should be incorporated into the system logic. A recovery cycle is accomplished by ramping the compressor up to a higher speed to increase the refrigerant flow rate to flush or sweep oil back to the compressor. How often a recovery cycle is initiated depends on many variables and would have to be determined through testing for each system type and configuration.

Variable Speed Multiples Applications

Testing for oil balance is required when more than one compressor is manifolded together. If only one VFD is applied to one compressor in a tandem set, the VFD should be applied to the compressor in the "A" position (see **Figures 7 & 8**). Trio manifolded compressor configurations have not been tested and qualified for variable speed operation. Contact Copeland for operating envelopes for tandems in variable speed applications.

CORESENSE COMMUNICATIONS

Description

The 20 to 40 ton Copeland scroll compressors are used with a CoreSense protection module. The CoreSense Communications module, installed in the compressor electrical box, provides advanced diagnostics, protection, and communications that enhance compressor performance and reliability. Refer to the **AE8-1384 CoreSense** bulletin for more information.

APPLICATION TESTS

The system designer is responsible for testing the system to ensure it operates as designed. These tests should be performed during system development and are dependent on the system type and amount of refrigerant charge. These application tests are to help identify errors in system design that may produce conditions that could lead to compressor failure.

For manifolded compressor assemblies, oil balancing tests must be performed to demonstrate oil balancing between the compressors. Compressors with sight-tubes for viewing a wide range of oil levels are appropriate for this type of testing. The testing must evaluate the minimum and maximum flow conditions at which the compressors will be required to operate, with min and max suction superheat.

For variable speed applications, the above oil balancing and system oil return tests must be performed. The concern is that a very low oil level will develop after extended hours of operation at low speed. In addition to oil balancing and system oil return tests, the suction and discharge tubing must be evaluated to determine the resonant frequencies. Once the resonant frequencies are known, they can be shifted to a safe range by changing the mass of the line for constant speed applications or they can be avoided for variable speed applications.

Application Engineering is available to recommend additional tests and to evaluate test results.

ASSEMBLY LINE PROCEDURES

Installing the Compressor

⚠WARNING

Use care and the appropriate material handling equipment when lifting and moving compressors. Personal protective equipment must be used.

Copeland scroll compressors leave the factory dehydrated and with a positive dry air charge. Plugs should not be removed from the compressor until the compressor has had sufficient time to warm up if stored outside, is ready for assembly in the unit and has been set into the unit. The suggested warm up time is one hour per 4°F (2 Kelvin) difference between outdoor and indoor temperature. The larger suction plug should be removed first to relieve the internal dry air pressure. Removing the smaller discharge plug could result in a spray of oil out of this fitting since some oil accumulates in the head of the compressor after Copeland's run test and may also result in oil mist coating the suction tube making brazing difficult. The inside of both fittings should be wiped with a lint free cloth to remove residual oil prior to brazing. A compressor containing POE oil should never be left open longer than 5 minutes.

The copper coated steel suction tube should be cleaned before brazing (see **Figure 1**). No object (e.g. a swaging tool) should be inserted deeper than two inches (51 mm) into the suction tube, or it might damage the suction screen and motor.

Mounting

Many OEM customers buy the mounting parts directly from the supplier, but Copeland 's grommet design and durometer recommendations should be followed for best vibration reduction through the mounting feet.

Suction and Discharge Fittings

These compressors are available with stub tube or rotalock connections. The stub tube version has copper-plated steel suction and discharge fittings. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used. See **Figure 1** for assembly line and field brazing procedures and **Table 1** for Rotalock torque values.

Assembly Line Brazing Procedure

⚠WARNING

Personal protective equipment must be used during brazing operation. Heat shields should be used to prevent overheating or burning nearby temperature sensitive parts. A fire extinguisher should be accessible.

Figure 1 discusses the proper procedures for brazing the suction and discharge lines to a scroll compressor.

It is important to flow nitrogen through the system while brazing all joints during the system assembly process.

Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to form, the copper oxide flakes 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 is of oil or refrigerant - is capable of doing damage resulting in compressor failure.

Unbrazing System Components

CAUTION

Before attempting to braze, it is important to recover all refrigerant from both the high and low side of the system.

If the refrigerant charge is removed from a scroll-equipped unit by evacuating the high side only, it is possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized.

Removing Compressors

CAUTION

Before attempting to cut copper tubing, it is important to recover all refrigerant from both the high and low side of the system.

Instructions should be provided in appropriate product literature and assembly (line repair) areas. If a compressor removal is required, the compressor should be cut out of system rather than unbrazed. See **Figure 1** for the proper compressor removal procedure.

Pressure Testing

WARNING

Never pressurize the compressor to more than 475 psig (33 bar) for ZP*KC and 400 psig (27.6 bar) for ZR*KC and ZH*KC compressors for leak checking purposes. Never pressurize the compressor from a nitrogen cylinder or other pressure source without an appropriately sized pressure regulating and relief valve.

Higher pressure may result in permanent deformation of the compressor shell and possible misalignment, bottom cover distortion and/or shell rupture.

Assembly Line System Charging Procedure

Systems should be charged with liquid on the high side to the extent possible. The majority of the charge should be pumped in the high side of the system to prevent low voltage starting difficulties, hipot motor test failures, and bearing washout during the first-time start on the assembly line. If additional charge is needed, it should be added as liquid to the low side of the system with the compressor operating. Pre-charging on the high side and adding liquid on the low side of the system are both meant to protect the compressor from operating with abnormally low suction pressures during charging. Do not operate the compressor without enough system charge to maintain at least 55 psig (3.8 bar suction pressure for R-410A and 20 psig (1.4 bar) for R-22 & R-407C. Do not operate the compressor with the low pressure cut-out disabled. Do no operate with a restricted suction or liquid line.

Depending on the discharge pressure, allowing pressure to drop below the limit for more than a few seconds may overheat the scrolls and cause early drive bearing damage.

WARNING

Do not use the compressor to test the opening set point of a high pressure cutout.

Bearings are susceptible to damage before they have had several hours of normal running for proper break in.

'Hipot' (AC High Potential) Motor Testing

WARNING

Use caution with high voltage and never hipot test when compressor is in a 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 compressors that have horizontal motors partially submerged in oil and refrigerant. When Copeland scroll compressors are hipot tested with liquid refrigerant in the shell, they can show higher levels of leakage current than compressors with the motor on top. 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 redistribute the refrigerant to a more normal configuration and the system hipot tested again. See AE4-1294 for megohm testing recommendations. Under no circumstances should the hipot test be performed while the compressor is under a vacuum.

U.L. sets the requirement for dielectric strength testing and they should be consulted for the appropriate voltage and leakage values.

Final Run Test

Customers that use a nitrogen final run test must be careful to not overheat the compressor. Nitrogen is not a good medium for removing heat from the compressor, and the scroll tips can be easily damaged with high compression ratios and/or long test times. Copeland scroll compressors are designed for use with refrigerant and testing with nitrogen may result in a situation where the compressor does not develop a pressure differential (no pump condition). When testing with nitrogen, the compressor must be allowed to cool for several minutes between tests.

SERVICE PROCEDURES

Field Replacement

WARNING

Use care and the appropriate material handling equipment when lifting and moving compressors. Personal protective equipment must be used.

Removing Oil

If the oil level is higher than the oil Schrader fitting on the sump of the compressor oil can be drained from this fitting until the oil level reaches the level of the Schrader fitting. To remove oil from the compressor when the oil level is below the oil Schrader fitting one of two different procedures can be used. The first procedure is to remove the compressor from the system and drain the oil from the compressor suction connection. This method ensures complete removal of the oil from the compressor. The second procedure is to remove the compressor sight-glass and insert a hose into the sump of the compressor and draw the oil out with a hand-held pump.

Electrical

When replacing a compressor, especially one that has been in the field for a number of years, it is always a good idea to replace the contactor.

Note: See the locked rotor on the nameplate of the new compressor and make sure the contactor exceeds this locked rotor rating.

Compressor Replacement After a Motor Burn

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 with the use of suction and liquid line filter driers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. See AE24-1105 for clean up procedures and AE11-1297 for liquid line filter-drier recommendations.

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.

Manifolded Compressor Replacement

WARNING

Use care and the appropriate material handling equipment when lifting and moving compressors. Personal protective equipment must be used.

Should a compressor fail in a manifolded set, only the failed compressor should be replaced and not both compressors. The oil from the failed compressor will stay mostly in the failed compressor. Any contaminated oil that does enter the tandem circuit will be cleaned by the liquid line filter drier, and when used, the suction line filter drier.

The suction and discharge manifolds can be reused if the failed compressor is carefully removed and the manifolds are cut in such a way that a coupling and short piece of copper can reconnect the new compressor. Reference the AE4-1430 Compressor Multiples Bulletin for more information on installing a new oil equalization line.

Start-Up of a New or Replacement Compressor

It is good service practice, when charging a system with a scroll compressor, to charge liquid refrigerant into the high side only. It is not good practice to dump liquid refrigerant from a refrigerant cylinder into the crankcase of a stationary compressor. If additional charge is required, charge liquid into the low side of the system with the compressor operating.

WARNING

Follow the unit manufacturer's guidelines for properly evacuating and charging of the system. Do not start the compressor while the system is in a vacuum. Internal arcing may occur when any type of compressor is started in a vacuum which may result in terminal venting.

Do not operate the compressor without enough system charge to maintain at least 55 psig (3.8 bar) suction pressure for R410A and 20 psig (1.4 bar) for R22, R-407C, R134a and R513A. Do not operate with a restricted suction or liquid line. Do not operate with the low pressure cut-out disabled.

Allowing suction pressure to drop below the minimum requirement for more than a few seconds may overheat the scrolls and cause early drive bearing damage. Never install a system in the field and leave it unattended with no charge, a holding charge, or with the service valves closed without securely locking out the system. This will prevent unauthorized personnel from accidentally ruining the compressor by operating with no refrigerant flow.

Field Troubleshooting the Kriwan Module

Follow the steps listed below to troubleshoot the module in the field. See the wiring diagram in the terminal box cover.

1. De-energize control circuit and module power. Remove the control circuit wires from the module (Terminals M1 & M2). Connect a jumper across these “control circuit” wires. This will bypass the “control contact” of the module.

⚠WARNING

The motor protection system within the compressor is now bypassed. Use this configuration to temporarily test module only.

Re-energize the control circuit and module power.

If the compressor will not operate with the jumper installed, then the problem is external to the solid state protection system.

If the compressor operates with the module bypassed but will not operate when the module is reconnected, then the control circuit relay in the module is open. The thermistor protection chain now needs to be tested to determine if the module’s control circuit relay is open due to excessive internal temperatures or a faulty component.

2. Check the thermistor protection chain located in the compressor as follows:

De-energize control circuit and module power. Remove the sensor leads from the module (S1 & S2). Measure the resistance of the thermistor protection chain through these sensor leads with an ohmmeter. Use an Ohmmeter with a maximum of 9 volts to check the sensor chain. The sensor chain is sensitive and easily damaged; no attempt should be made to check continuity through it with anything other than an ohmmeter. The application of any external voltage to the sensor chain may cause damage requiring the replacement of the compressor.

The diagnosis of this resistance reading is as follows:

- 200 to 2250 ohms - Normal operating range
- 2750 ohms or greater - Compressor overheated - Allow time to cool
- zero resistance - Shorted sensor circuit - Replace the compressor
- infinite resistance - Open sensor circuit - Replace the compressor

If the resistance reading is abnormal, remove the sensor connector plug from the compressor and measure the resistance at the sensor fusite pins. This will determine if the abnormal reading was due to a faulty connector.

On initial start-up, and after any module trip, the resistance of the sensor chain must be below the module reset point before the module circuit will close. The reset value is less than 2750 ohms.

3. If the sensor chain has a resistance that is below 2250 ohms, and the compressor will run with the control circuit bypassed, but will not run when connected properly, the solid state module is defective and should be replaced. The replacement module must have the same supply voltage rating as the original module.

Refrigerant Retrofits

⚠WARNING

Only use approved refrigerants, lubricants, and parts in accordance with the system and compressor specifications. Recover all of the refrigerant from the system including the high and low side. Use a tubing cutter to remove the compressor.

ZP compressors are UL recognized and use with any other refrigerant than originally intended for use will void the compressor UL recognition.

For a list of Copeland approved refrigerants please refer to Form 93-11, Refrigerants and Lubricants Approved for Use in Copeland Compressors.

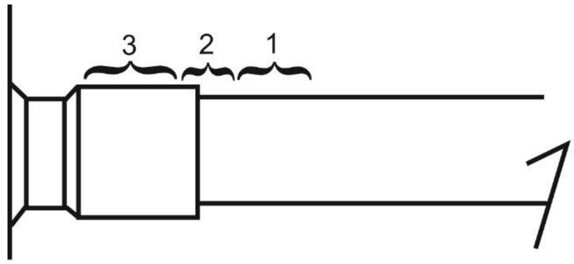


Figure 1 - Scroll Tube Fitting Brazing

New Installations

- The copper-coated steel tube fitting on scroll compressors can be brazed in approximately the same manner as any copper tube.
- Recommended brazing materials: Any silfos material is recommended, preferably with a minimum of 5% silver. However, 0% silver is acceptable.
- Be sure suction tube fitting I.D. and suction tube O.D. are clean prior to assembly. If oil film is present wipe with denatured alcohol, Dichloro-Trifluoroethane or other suitable solvent.
- 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. Add braze material to the joint while moving torch around joint to flow braze material around circumference.
- After braze material flows around joint, move torch to heat Area 3. This will draw the braze material down into the joint. The time spent heating Area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

Field Service

⚠WARNING

Remove refrigerant charge from both the low and high side of the compressor before cutting the suction and discharge lines to remove the compressor. Verify the charge has been completely removed with manifold gauges.

- To disconnect: Reclaim refrigerant from both the high and low side of the system. Cut tubing near compressor. The compressor should be disconnected using a tubing cutter.
- To reconnect:
  - ✓ Recommended brazing materials: Silfos with minimum 5% silver or silver braze material with flux.
  - ✓ Insert tubing stubs into fitting and connect to the system with tubing connectors.
  - ✓ Follow **New Installation** brazing instructions above.

Figure 2 - Nomenclature

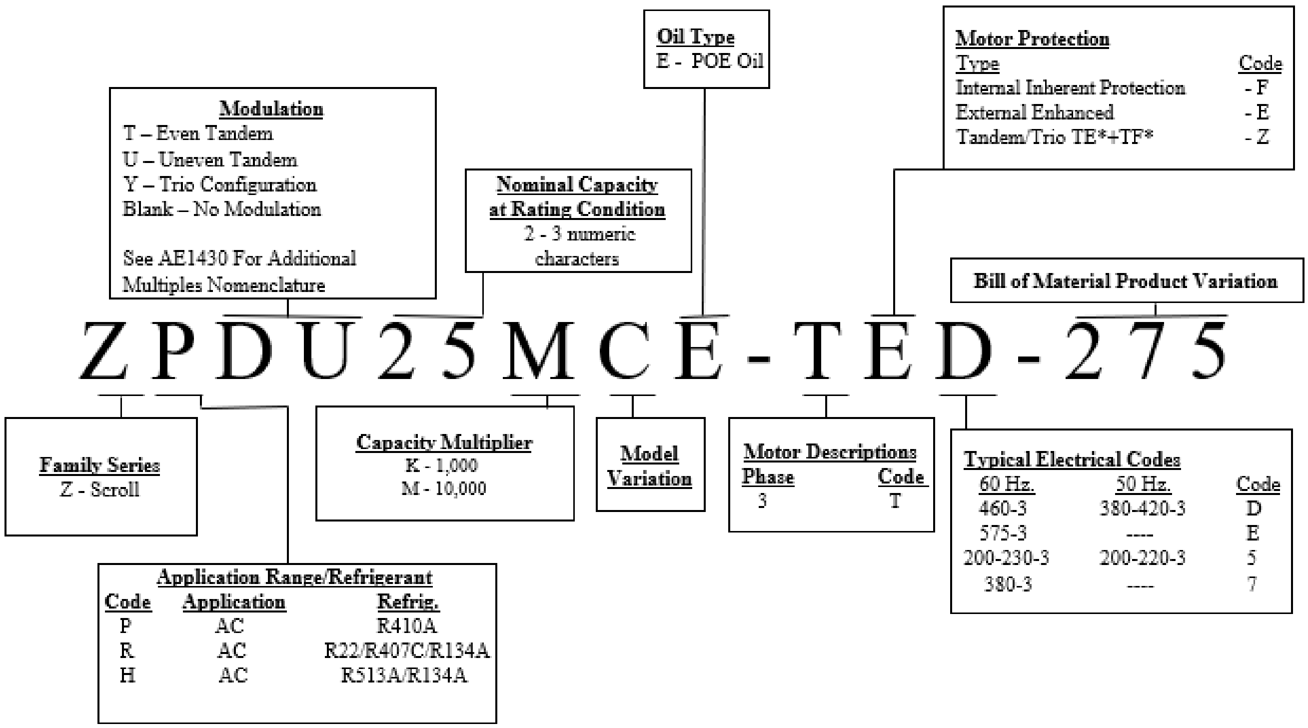


Figure 3 - ZR & ZP 50/60Hz Operating Envelope

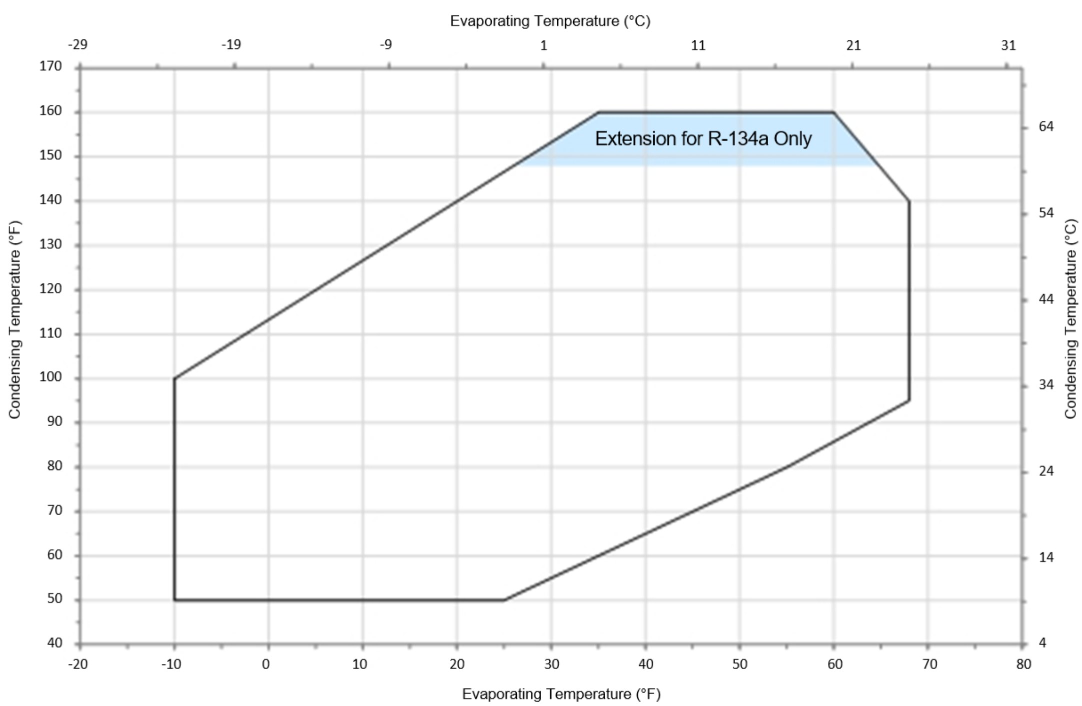


Figure 3 - ZP Variable Speed Operating Envelope

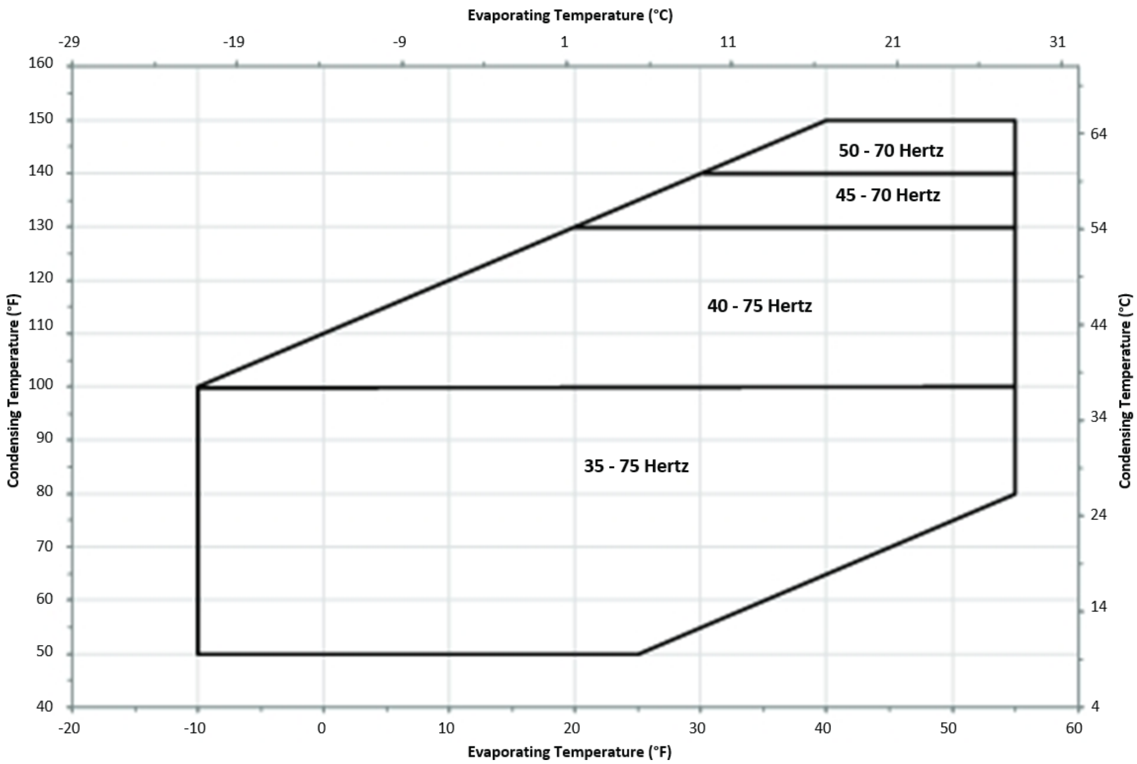


Figure 4 - ZH Operating Envelope

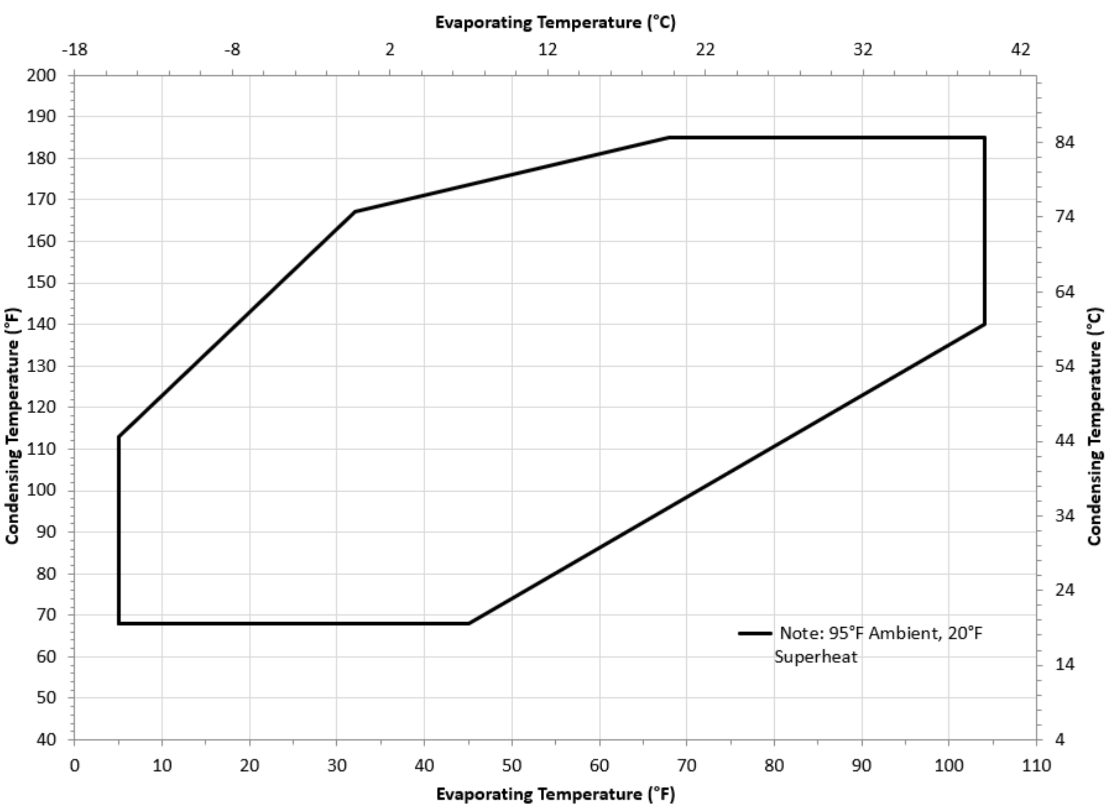


Figure 5 - Crankcase Heater Locations

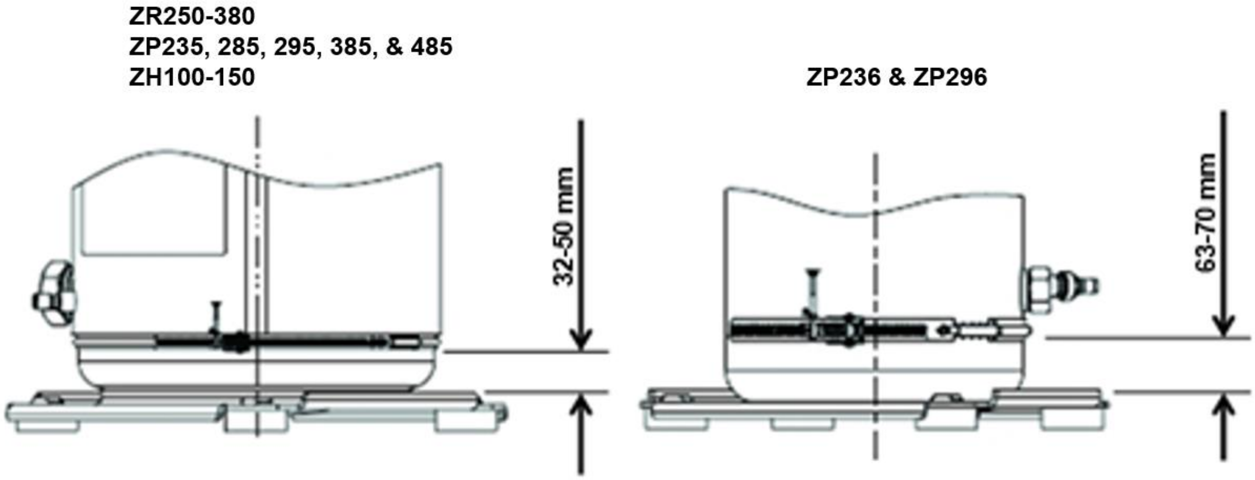


Figure 6 - Typical Rotalock Connected Tandem with TPTL Manifold

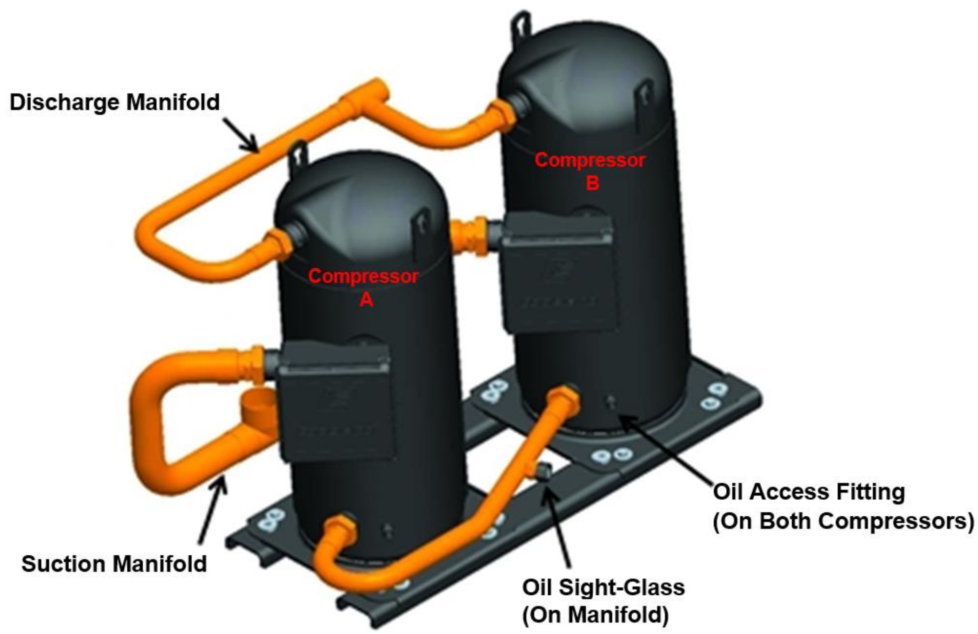


Figure 7 - Typical Braze Connected Tandem with OEL Manifold

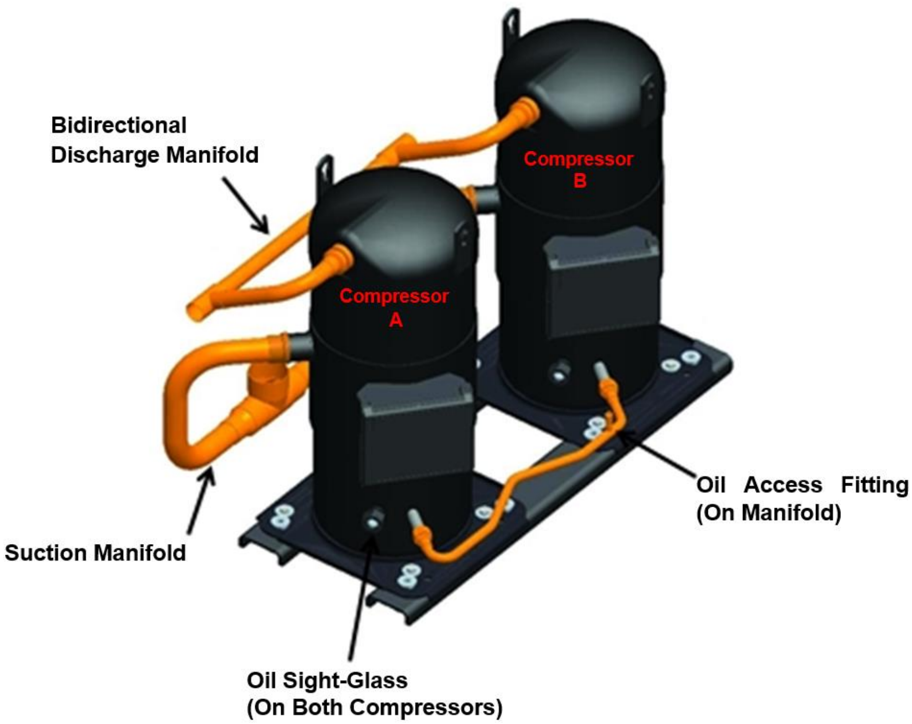


Figure 8 - Typical Braze Connected Trio with TPTL Manifold

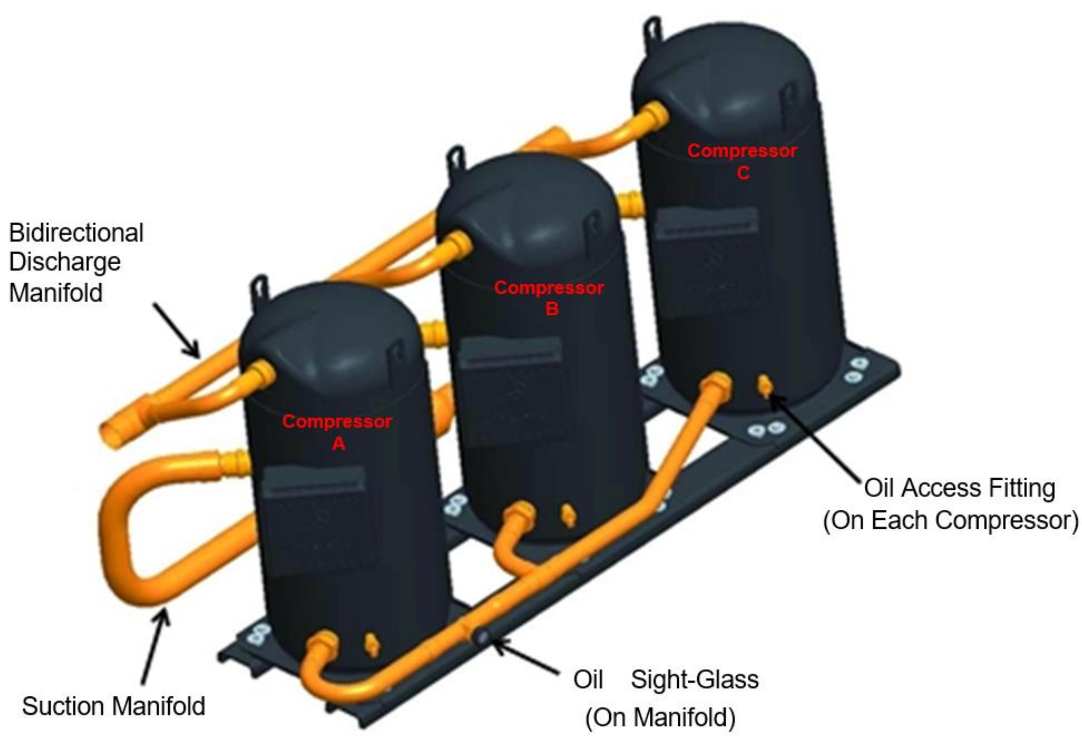


Figure 9 - Drive Output – Frequency vs. Voltage

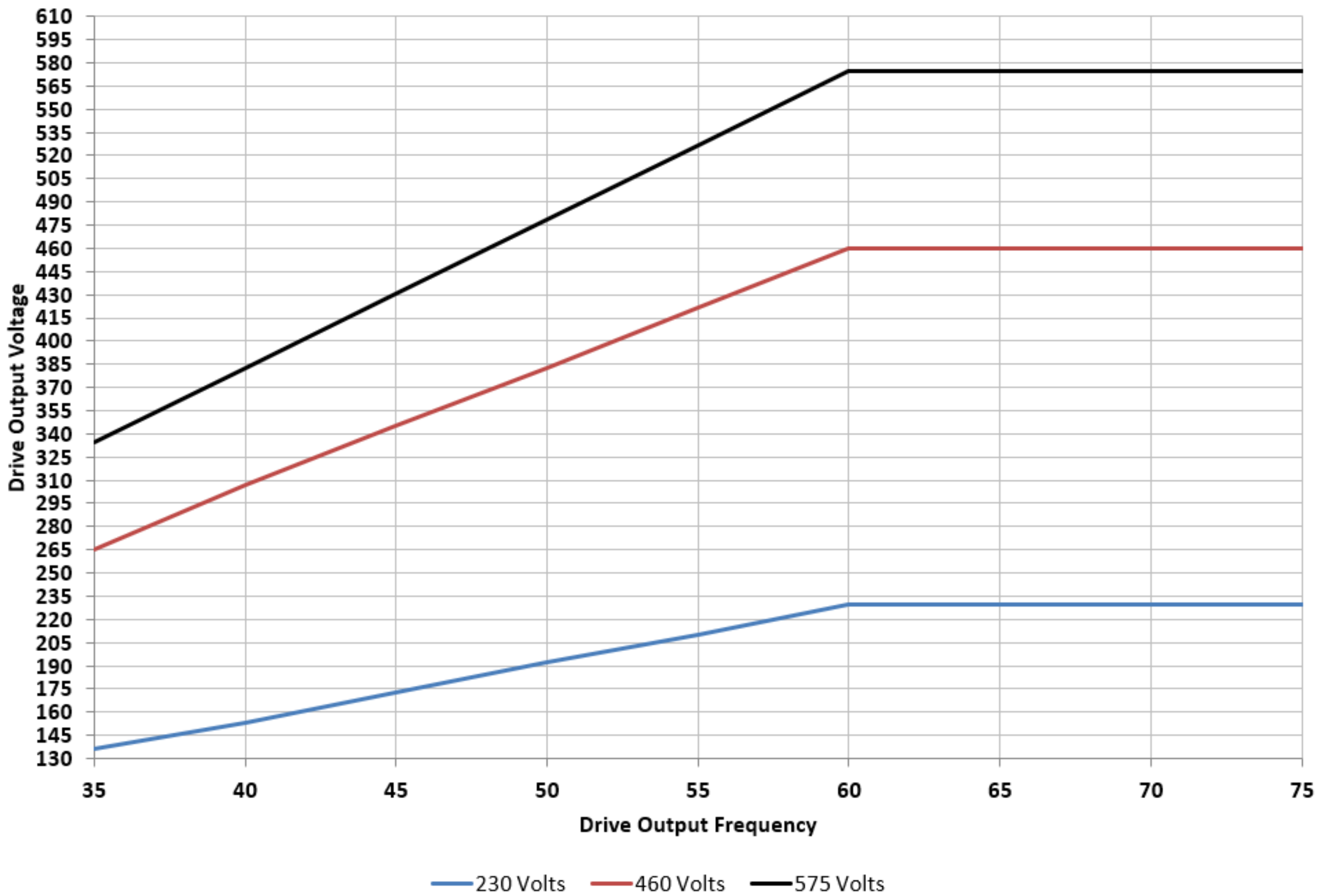


Table 1 - Compressor Features

Model	Refrigerant	Motor Protection	Tandem/Trio Applications	Speed Range
ZR250-380KCE-TW	R407C, R22, R134a	Kriwan	Yes	See Operating Envelope
ZR250-380KCE-TE	R407C, R22, R134a	CoreSense	Yes	
ZP235-485KCE-TW	R410A	Kriwan	Yes	
ZP235-485KCE-TE	R410A	CoreSense	Yes	
ZH100-150KCE-TE	R134a, R513A	CoreSense	Yes	

Table 2 - Torque

Part	Torque		
	ft-lb	in-lb	N-m
Sight-Glass & TPTL Rotalock Fitting	50-58	600-690	68-78
TPTL Rotalock Fitting	125-133	1500-1590	170-180
OEL Rotalock Fitting	50-58	600-690	68-78
Suction Rotalock (Valve or Adapter)	140-148	1680-1770	190-200
Discharge Rotalock (Valve or Adapter)	125-133	1500-1590	170-180
Schrader Valve	17-18	200-220	22.6-24.0
Oil Access Fitting (Threads Into Oil Rotalock)	3.3-5.0	40-60	4.5-6.8
Terminal Block Screws	2.1	25	2.8
Tandem Mounting Bolts (M10)	33-41	398-487	45-55

Table 3 - Refrigerant Charge Limits

Model	Charge Limit	
	Pounds	kg
ZR250KC, ZH100KC	25	11.3
ZR300-380KC	30	13.6
ZR & ZH Tandems	45	20.4
ZR & ZH Trios	65	29.5
ZP235, 236, 296KC	25	11.3
ZP285, 295, 385, 485KC	30	13.6
ZP Tandems	45	20.4
ZP Trios	65	29.5