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Application Guidelines for 1.5 to 6.75 Ton Refrigerant R-22, 407C, 134A Copeland Scroll® Compressors

Introduction

The ZR*KA, ZR*KC, ZR*K3, & ZR*K4 Copeland Scroll® compressors include a wide range of capacities, electrical options, and features. Typical model numbers are ZR24K4-PFV and ZR81KC-TF5. This bulletin describes the operating characteristics, design features, and application requirements for these models. For additional information, please refer to the online product information accessible from the Emerson Climate Technologies website at www.emersonclimate.com. Operating principles of the Copeland Scroll are described in **Figure 7** at the end of this bulletin.

The ZR*KA scroll compressors are designed for **air conditioning systems only** in the 12+ SEER range but may be applied to 10 SEER A/C systems if desired. They range in size from 16,000 to 54000 Btu/hr (4.7 to 15.8 kw-hr).

The ZR*K3 and K4 are models designed for 11+ SEER A/C and heat pump usage ranging in size from 16,000 to 61,000 Btu/hr (4.7 to 17.9 kw-hr).

The ZR*KC models are designed for 10 SEER A/C and heat pump usage ranging in size from 16,000 to 81,000 Btu/hr (4.7 to 23.7 kw-hr).

The models include a number of features outlined in the matrix below:

IPR Valve-Internal Pressure Relief Valve

The internal pressure relief valve is located between the high side and the low side of the compressor. It is designed to open when the discharge to suction differential pressure exceeds 375 to 450 psid (26 – 32 kg/cm²). When the valve opens, hot discharge gas is routed back into the area of the motor protector to cause a trip. During developmental blocked fan testing, it is sometimes noted that the valve opens, but the compressor does not shut off while the discharge pressure continues to climb. This condition is normally caused by refrigerant flood back and may be corrected by using a more restrictive expansion device or reducing the refrigerant charge.

Internal Temperature Protection

The Therm-O-Disc® or TOD is a temperature-sensitive snap disc device located between the high and low pressure side of the scroll. It is designed to open and route excessively hot discharge gas back to the motor protector. During a situation such as loss of charge, the compressor will be protected for some time while it trips on the protector. However, as refrigerant leaks out, the mass flow and the amperage draw are reduced and the scrolls will start to overheat. Normally, during air conditioning operation the problem is detected because of rising indoor temperatures before damage is done. This may not be the case during heat pump

	Motor Frame Size*	Application		IPR	TOD	Quiet Shut Down	Discharge Check Valve	Motor Protector
		AC	HP					
ZR16-29KC	53	X	X	NO	X	X	X	X
ZR16-24K4	53	X	X	NO	X	X	X	X
ZR16-34KA	53	X	NO	X	X	X	X	X
ZR38-54KA	63	X	NO	X	X	X	X	X
ZR18-48K3	63	X	X	X	X	X	X	X
ZR26-48KC	63	X	X	X	X	X	X	X
ZR54-61K3	70	X	X	X	X	X	X	X
ZR54-81KC	70	X	X	X	X	X	X	X

* Approximate Shell Diameter (e.g. 53 = 5.5 Inches)

operation since backup heat will make up the deficit. A low pressure control is recommended for loss of charge protection in heat pumps for the highest level of system protection. A cut out setting no lower than 25 psig (2 kg/cm²) for air conditioning and 7 psig (0.5 kg/cm²) for heat pumps is recommended. The low pressure cut-out, if installed in the suction line to the compressor, can provide additional protection against a TXV failed in the closed position, outdoor fan failure in heating, a closed liquid line or suction line service valve, or a blocked liquid line screen, filter, orifice, or TXV. All of these can starve the compressor for refrigerant and result in compressor failure. The low pressure cut-out should have a manual reset feature for the highest level of system protection. If a compressor is allowed to cycle after a fault is detected, there is a high probability that the compressor will be damaged and the system contaminated with debris from the failed compressor and decomposed oil. If current monitoring to the compressor is available, the system controller can take advantage of the compressor TOD and internal protector operation. The controller can lock out the compressor if current draw is not coincident with the contactor energizing, implying that the compressor has shut off on its internal protector. This will prevent unnecessary compressor cycling on a fault condition until corrective action can be taken.

Quiet Shut down

All scrolls in this size range have one of several types of “quiet” shutdown solutions. The ZR..KC/K3/K4 Scrolls up to four tons use a cam-type device that separates the scrolls when they are driven backwards as high-pressure gas equalizes from the high side of the compressor to the low side during shutdown. Larger scrolls with 70 frame motors through ZR61 use a different type of cam that stops backward rotation during shut down. Models ZR68KC through ZR81KC will continue to be built with the fluid brake design, so a momentary reverse rotation sound will be heard from these compressors. The newer ZR..KA scrolls incorporate a non dynamic discharge port check valve that prevents high pressure gas trapped in the dome from returning through the scroll set. All of these quiet shut down solutions allow the scroll compressor to restart immediately even if the system is not equalized eliminating the need for a time delay. Development testing should include a review of the shutdown sound for acceptability in a particular system. Also refer to section on “Brief Power Interruption”.

Discharge Check Valve

A low mass, disc-type check valve in the discharge fitting of the compressor prevents the high side, high pressure discharge gas from flowing rapidly back through the compressor. This check valve was not designed to be

used with recycling pump down because it is not entirely leak-proof.

Motor Protector

Conventional internal line break motor protection is provided. The protector opens the common connection of a single-phase motor and the center of the Y connection on three-phase motors. The three-phase protector provides primary single-phase protection. Both types of protectors react to current and motor winding temperature.

Field Replacement of obsolete Single Phase ZR*K1 or ZR*K2 with Equivalent Capacity ZR*K3/K4/KA/KC, Scroll Compressors

The discharge and suction fitting sizes as well as the mounting foot pattern of the new models are identical to the ZR*K1 or ZR*K2. Tubing location is identical in most cases for easy field replacement. The ZR*K1 has an external top cap thermostat to limit discharge temperature. This feature has been replaced by the Therm-O-Disc® located inside the new scrolls. When replacing the ZR*K1, the top cap thermostat wires must be removed and the control circuit wires spliced together. See section on **Compressor Replacement after Motor Burn** for further tips on field replacement. The replacement compressor will need a new run capacitor if the old capacitor is more than 5 microfarads different or the voltage rating of the old capacitor is lower than the new one. See **compressor nameplate or Table 4** for recommended run capacitor. Note that the ZR*KA may only be used to replace compressors used for A/C, not heat pumps.

Application Considerations

The Copeland Scroll compressor has a number of application characteristics that are different from those of the traditional reciprocating compressor. These are detailed below.

Accumulators

The use of accumulators is very dependent on the application. The Copeland Scroll's inherent ability to handle liquid refrigerant during occasional operating flood back situations make the use of an accumulator unnecessary in standard designs such as condensing units. Applications, such as heat pumps with orifice refrigerant control, that allow large volumes of liquid refrigerant to flood back to the compressor during normal steady operation can dilute the oil to such an extent that bearings are inadequately lubricated and wear will occur. In such a case an accumulator must be used to reduce flood back to a safe level that the compressor can handle. To test for flood back conditions

and determine if the accumulator design is adequate, please see the section entitled **Excessive Liquid Flood back Tests** at the end of this bulletin. The accumulator oil return orifice should be from .040 to .055 inches (1 – 1.4 mm) in diameter depending on compressor size and compressor flood back results. A large-area protective screen no finer than 30 x 30 mesh (0.6 mm openings) is required to protect this small orifice from plugging. Tests have shown that a small screen with a fine mesh can easily become plugged causing oil starvation to the compressor bearings.

Screens

The use of screens finer than 30 x 30 mesh (0.6mm openings) anywhere in the system should not be used with these compressors. 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.

Crankcase Heat - Single Phase

Crankcase heaters are not required on single phase compressors when the system charge is not over the 120% limit shown in **Table 5**. A crankcase heater is required for systems containing more than 120% of the compressor refrigerant charge limit listed in **Table 5**. This includes long line length systems where the extra charge will increase the standard factory charge above the 120% limit.

Experience has shown that compressors may fill with liquid refrigerant under certain circumstances and system configurations, notably after longer off cycles when the compressor has cooled. This may cause excessive start up clearing noise or the compressor may lock up and trip on protector several times before starting. The addition of a crankcase heater will reduce customer noise and dimming light complaints since the compressor will no longer have to clear out liquid during start. **Table 6** lists the crankcase heaters recommended for the various models and voltages.

Crankcase Heat – Three-Phase

A crankcase heater is required for three-phase compressors when the system charge exceeds the compressor charge limit listed in **Table 5** and an accumulator cannot be piped to provide free liquid drainage during the off cycle (See **Figure 2** and **Table 6**).

Pump down Cycle

A pump down cycle for control of refrigerant migration is not recommended for scroll compressors of this size. **If a pump down cycle is used, a separate external check valve must be added.** 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 pump down, causing the scroll compressor to recycle more frequently. Repeated short-cycling of this nature can result in a low oil situation and consequent damage to the compressor. The low-pressure control differential has to be reviewed since a relatively large volume of gas will re-expand from the high side of the compressor into the low side on shut down.

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. Other than the considerations in the section on Brief Power Interruptions, there is no minimum off time because 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 Emerson Climate Technologies) and install it in a system with the longest connecting lines that are approved for the system. 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. 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. See Application Engineering Bulletin 17-1262 for more information on preventing compressor short cycling.

Reversing Valves

Since Copeland Scroll compressors have very high volumetric efficiency, their displacements are lower than those of comparable capacity reciprocating compressors. As a result, Emerson recommends that the capacity rating on reversing valves be no more than 2 times the nominal capacity of the compressor with which it will be used 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 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 until the pressures equalize. This condition does not affect compressor durability but can cause unexpected sound after the compressor is turned off.

Low Ambient Cut-Out

A low ambient cut-out is not required to limit air-to-air heat pump operation. Air-to-water heat pumps must be reviewed since this configuration could possibly run outside of the approved operating envelope (**Figure 5**) causing overheating or excessive wear.

Oil Type

Several types of compatible mineral oils are used in the R-22 compressors. A standard 3GS oil may be used if the addition of oil in the field is required. See the compressor nameplate for original oil charge. See Application Engineering bulletin 17-1248 for more information about oil types Emerson uses. A complete recharge should be four fluid ounces (118 ml) less than the nameplate value. Some models have been released for use with R407C or 134a and use polyol ester oil, identified as POE, along with the charge quantity on the nameplate. These models have an "E" in the 7th place of the model number. An example would be the ZR24K3E-PFJ compressor. Copeland® Ultra 22 CC should be used if additional oil is needed in the field. Mobil Arctic EAL22CC or ICI Emkarate RL32CF oil may be used to recharge these compressors if Ultra 22 is not available. Compressors charged with POE may be used with R-22 but compressors charged with mineral oil may not be used with HFC refrigerants such as 407C or 134a because they are not miscible.

Discharge Mufflers

Flow through Copeland Scroll compressors is semi-continuous with relatively low pulsation. External mufflers, where they are normally applied to piston compressors today, may not be required for Copeland Scroll. Because of variability between systems, however, individual system tests should be performed to verify acceptability of sound performance. When no testing is performed, mufflers are recommended in heat pumps. A hollow shell muffler such as the Alco APD-1 or APD-054 will work quite well. The muffler should be located a minimum of six inches (15 cm) to a maximum of 18 inches (46 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 to 1 with a 30 to 1 ratio recommended. The muffler should be from four to six inches (10-15 cm) long.

Air Conditioning System Suction Line Noise and Vibration

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

One difference is that the vibration characteristic of the scroll compressor, although low, includes two very close frequencies, one of which is normally isolated from the shell by the suspension of an internally suspended compressor. These frequencies, which are present in all compressors, may result in a low level "beat" frequency that may be detected as noise coming along the suction line into a house under some conditions. Elimination of the "beat" can be achieved by attenuating either of the contributing frequencies. The most important frequencies to avoid are line and twice-line frequencies for single-phase compressors and line frequency for three phase compressors. This is easily done by using one of the common combinations of design configurations described in **Table 3**. The scroll compressor makes both a rocking and torsional 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 in **Table 3**.

The sound phenomena described above are not usually associated with heat pump systems because of the isolation and attenuation provided by the reversing valve and tubing bends.

Single Phase Starting Characteristics

Start assist devices are usually not required, even if a system utilizes 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 startup, low voltage starting characteristics are excellent for Copeland Scroll compressors. Starting current on **any** compressor may result in a significant “sag” in voltage where a poor power supply is encountered. The low starting voltage reduces the starting torque of the compressor and subsequently increases the start time. This could cause light dimming or a buzzing noise where wire is pulled through conduit. The start components listed in **Table 7** will substantially reduce start time and consequently the magnitude and duration of both light dimming and conduit buzzing.

PTC Start Components

For less severe voltage drops or as a start boost, solid state Positive Temperature Coefficient devices rated from 10 to 25 ohms may be used to facilitate starting for any of these compressors.

Electrical Connection

The orientation of the electrical connections on the Copeland Scroll compressors is shown in **Figure 4**. Three electrical connection options are available for these compressors. These include the “Molded Plug” one piece push-on connection, available in certain markets, and “Quick Connect” flag termination available on all scrolls of this size. Some four-ton and larger models also offer “T-block Screw Connection” for ring termination.

Deep Vacuum Operation

Scrolls incorporate internal low vacuum protection and will stop pumping (unload) when the pressure ratio exceeds approximately 10:1. There is an audible increase in sound when the scrolls start unloading.

Copeland Scroll compressors (as with any refrigerant compressor) **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 shown in **Figure 5**. Prolonged operation at low suction pressures will result in overheating of the scrolls and permanent damage to the scroll tips, drive bearings and internal seal. (See **AE24-1105** for proper system evacuation procedures.)

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 ZR24K3-TFD, which has 24,500 Btu/hr (7 kw) 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 20,200 Btu/hr (5.9 kw) when operated on 50 Hz current. Please refer to Online Product Information at www.emersonclimate.com for details.

Shell Temperature

Certain types of system failures, such as condenser or evaporator fan blockage or loss of charge, may cause the top shell and discharge line to briefly but repeatedly reach temperatures above 350°F (177°C) as the compressor cycles on its internal protection devices. Care must be taken to ensure that wiring or other materials, which could be damaged by these temperatures, do not come in contact with these potentially hot areas.

Suction and Discharge Fittings

Copeland Scroll compressors have copper plated steel suction and discharge fittings. These fittings are far more rugged and less prone to leaks 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 6** for assembly line and field brazing procedures.

Three Phase Scroll Compressors

Scroll compressors, like several other types of compressors, will only compress in one rotational direction. Direction of rotation is not an issue with single phase compressors since they will always start and run in the proper direction (except as described in the section “Brief Power Interruptions”). 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.** 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 substantially-reduced current draw compared to normal 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 (under one hour) but oil may be lost. After several minutes of reverse operation, the compressor's internal protector will trip. If allowed to repeatedly restart and run in reverse without correcting the situation, the compressor will be permanently damaged because of oil loss to the system. Oil loss can be prevented during reverse rotation if the tubing is routed at least six inches (15 cm) above the compressor. 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 proper rotation direction. See **Fig 4**. It should be noted that all three phase scrolls will continue to run in reverse until the protector opens or the phasing is corrected.

Brief Power Interruptions

Brief power interruptions (less than 1/2 second) may result in powered reverse rotation of single-phase Copeland Scroll compressors. This occurs because high-pressure discharge gas expands backward through the scrolls during power interruption, causing the scroll to orbit in the reverse direction. When power is reapplied while reverse rotation is occurring, the compressor may continue to run in the reverse direction for some time before the compressor's internal protector trips. This has no effect on durability. When the protector resets, the compressor will start and run normally.

To avoid disruption of operation, an electronic control that can sense brief power interruptions may be used to lock out the compressor for a short time. This control could be incorporated in other system controls (such as defrost or thermostat), or be a stand-alone control. Functional specifications for this control as well as a suggested wiring diagram are shown in **Figure 3**.

Because three-phase models have high enough torque to prevent reverse rotation after power interruptions no time delay is necessary.

ASSEMBLY LINE PROCEDURES

Installing the compressor

Scroll compressors leave the factory dehydrated 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 and is ready for assembly to the unit. It is suggested that the larger suction plug be removed first to relieve the internal pressure. Removing the smaller discharge plug could

result in a spray of oil out of this fitting since some oil would accumulate in the head of the compressor after Emerson test runs the compressor. The inside of both fittings should be wiped with a lint free wipe to remove residual oil prior to brazing. A compressor containing mineral oil should never be left open longer than 15 minutes or 5 minutes if it contains POE oil.

Assembly Line Brazing Procedure

Figure 6 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 resulting blockage of oil or refrigerant may do damage resulting in compressor failure.

Pressure Testing

The pressure used on the line to meet the UL burst pressure requirement **can not** be higher than **400 psig**. Higher pressure might result in permanent deformation of the compressor shell and possibly cause rotor slip.

Assembly Line System Charging Procedure

Systems should be charged on both the high and low sides simultaneously. The majority of the charge should be placed in the high side of the system to prevent low volt start difficulties, Hipot failures, and bearing washout during first-time start on the assembly line. It is best to charge only vapor into the low side of the system. **Do not operate compressor without enough system charge to maintain at least 7 psig (0.5kg/cm²) suction pressure. Do not operate with a restricted suction. Do not operate with the low pressure cut-out disabled.** Allowing pressure to drop below 7 psig (0.5 kg/cm²) 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 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) Testing

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 which can 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 AE Bulletin 4-1294 for Megohm testing recommendations. Under no circumstances should the Hipot test be performed while the compressor is under a vacuum.

Final Run Test

Single phase scrolls with an electrical characteristic of "PFV" (208-230 volt, 1Ø, 60 Hertz) at the end of the model number may not be started at a voltage lower than 187 volts and must have a voltage no lower than 197 volts once the compressor is running under load.

Variable transformers used on assembly lines are often not capable of starting larger compressors at a particular voltage setting. To test for voltage sag during the initial locked rotor starting phase the first compressor in a production run should be used to preset the voltage. Remove the start wire from the compressor and apply 200 volts to the compressor. With the start winding removed the compressor will remain in locked rotor long enough to read the voltage supply. If the voltage sags below the minimum guaranteed starting voltage the variable transformer must be preset to a higher voltage to start the compressor at a higher voltage.

Other compressor voltages. All other compressor voltages, both single and three phase are guaranteed to start and run at 10% below the lowest voltage shown on the nameplate.

Unbrazing System Components

Caution! Before opening a system it is important to remove all refrigerant from both the high and low side. If the refrigerant charge is removed from a scroll-equipped unit by bleeding one side only, it is very possible that either the high or low side of the system remains pressurized. If a brazing torch is then used to disconnect tubing, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. **It is important to check both the high pressure and low pressure side with manifold gauges before unbrazing.** Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required,

the compressor should be cut out of system rather than unbrazed. See **Figure 6** for proper compressor removal procedure.

Copeland Scroll Functional Check

A functional compressor test during which the suction service valve is closed to check how low the compressor will pull suction pressure is not a good indication of how well a compressor is performing. **Such a test will damage a scroll compressor.** The following diagnostic procedure should be used to evaluate whether a Copeland Scroll compressor is functioning properly:

1. Proper voltage to the unit should be verified. Determine if the internal motor overload protector has opened or if an internal motor short or ground fault has developed. If the protector has opened, the compressor must be allowed to cool sufficiently to allow it to reset.
2. Check that the compressor is correctly wired.
3. Proper indoor and outdoor fan/blower operation should be verified.
4. With service gauges connected to suction and discharge pressure fittings, turn on the compressor. If suction pressure falls below normal levels the system is either low on charge or there is a flow blockage in the system.

5. Single Phase Compressors

If the compressor starts and 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.

Three Phase Compressors

If suction pressure does not drop and discharge pressure does not rise to normal levels, reverse any two of the compressor power leads and reapply power to make sure the compressor was not wired to run in reverse. 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. To test if the compressor is pumping properly, the compressor current draw must be compared to published compressor performance curves using the operating pressures and voltage of the system. If the measured average current deviates more than $\pm 15\%$ from published values, a faulty compressor may be indicated. A current imbalance exceeding

15% of the average on the three phases of a three-phase compressor should be investigated further. A more comprehensive trouble-shooting sequence for compressors and systems can be found in Section H of the Emerson Climate Technologies Electrical Handbook.

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

Tandem Scroll Compressors

The refrigerant charge limit for tandem compressors is shown in **Table 5**. A three-phase unit with a charge over this limit must have crankcase heaters added to both compressors. The ZRT90 – ZRT122 compressors are mounted on rails using rubber mounting parts. The ZRT136 – ZRT162 compressors are rigidly mounted on rails using solid steel mounting parts. These mounts are installed at the factory and should not be loosened. Tighten to 125 inch pounds (14 NM) if it becomes necessary to tighten these mounts. Holes in the mounting rails may be used to mount isolation grommets under the entire tandem.

A discharge check valve must be placed in the common discharge line when pump down is used. Both compressors must be at the same level to prevent oil from migrating to the lowest compressor through the oil equalization line.

Compressors may be individually cycled. Individual compressors should not be replaced in the field. The entire tandem compressor unit must be replaced if it becomes necessary to replace one compressor. Individual compressors configured for tandem usage may not be available for field replacement. See section below for further tips on field replacement of compressors.

Compressor Replacement after 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 through use of suction and liquid line filter dryers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. 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.

Start-up of a New or Replacement Compressor

It is good service practice, when charging a system, to charge liquid refrigerant into the high side only and charge the low side of the system with vapor only. It is not good for any compressor to have liquid refrigerant dumped from a refrigerant cylinder into the crankcase of the compressor. **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. **Do not operate compressor without enough system charge to maintain at least 7 psig (0.5 kg/cm²) suction pressure. Do not operate with a restricted suction. Do not operate with the low pressure cut-out disabled.** Allowing suction pressure to drop below 7 psig (0.5 kg/cm²) 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 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 operating the system for comfort cooling and potentially ruining the compressor by operating with no refrigerant flow.

Excessive Liquid Flood back Tests

The following tests are for those system configurations and charge levels identified in **Table 1** that need special testing to verify exemption from need of an accumulator. **Figure 1** should be used to determine the effectiveness of an accumulator. The compressor sump temperature during any test where the return gas superheat is near zero must always meet the guidelines of **Figure 1**.

To test for **excessive continuous liquid refrigerant flood back**, it is necessary to operate the system in a test room at conditions where steady state flood back may occur (low ambient heating operation). Thermocouples should be attached with glue or solder to the center of the bottom shell and to the suction and discharge lines approximately 6 inches (15 cm from the shell). 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 70°F (21°C), and outdoor temperature extremes (0°F or -18°C or lower in heating) to produce flood back conditions. The compressor suction and discharge pressures and temperatures as well as the 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 below -10°F (-23°C). The compressor sump temperature must remain above the sump temperature shown in **Figure 1** or design changes must be made to reduce the amount of flood back. If an accumulator is used, an oil return orifice size of 0.040 - .055" (1 - 1.4 mm) is recommended. (See information on Accumulators in Application Considerations and also **AE11-1247**). 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 flood back.

To test for **repeated excessive liquid flood back** during normal system off-cycles perform the "**Field Application Test**". Obtain a sample compressor with a side sight tube to measure liquid level in the compressor. Set the system up in a configuration with the indoor unit elevated several feet above the outdoor unit with twenty-five feet (8 meters) of connecting tubing with no traps between the indoor and outdoor units. If the system is designed to be field charged, the system should be overcharged by 15% in this test to simulate overcharging commonly found in field installations. Operate the system in the cooling mode at the outdoor ambient, on/off cycle times, and number of cycles specified in **Table 2**. 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. Review the results with Emerson Climate Technologies Application Engineering to determine if an accumulator is required for the application. The criteria for pass/fail is whether the liquid level reaches the height of the scroll compressor suction fitting on the side of the shell. Liquid levels higher than the suction fitting will allow compressor oil floating on top of the refrigerant to be ingested by the scrolls and pumped out of the compressor.

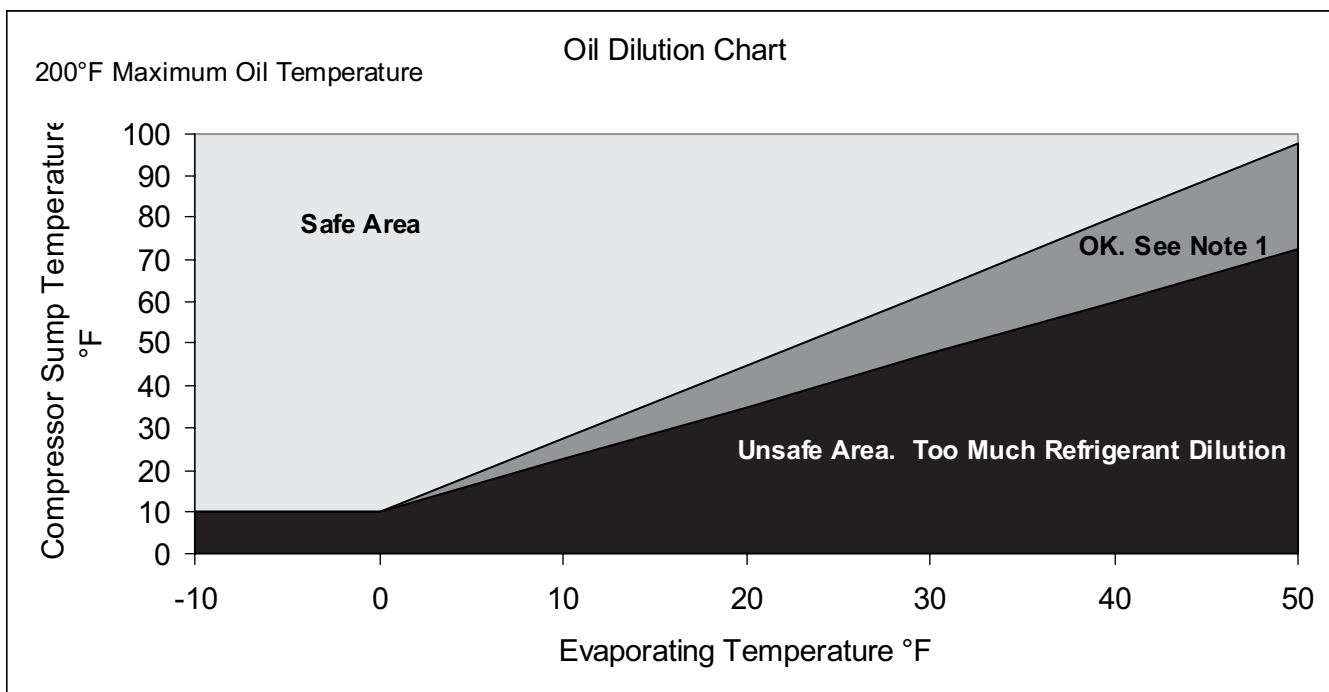


Figure 1

Note 1: Operation in this refrigerant dilution area is safe in air to air heat pump heating mode. For other applications, such as AC only, review expansion device to raise superheat. A cold sump may result in high refrigerant migration after shut down.

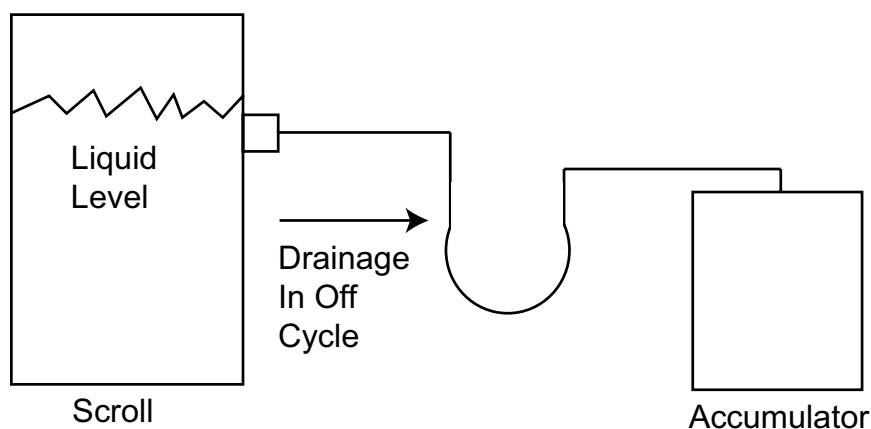
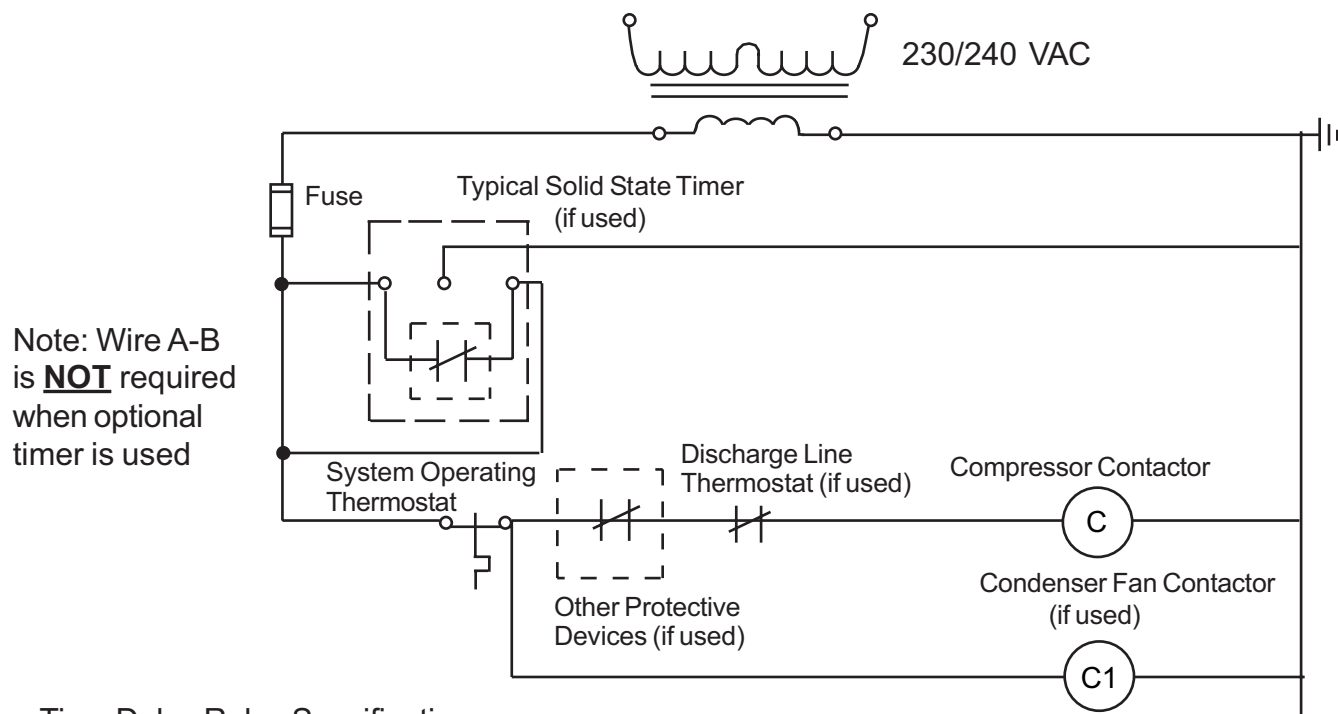


Figure 2

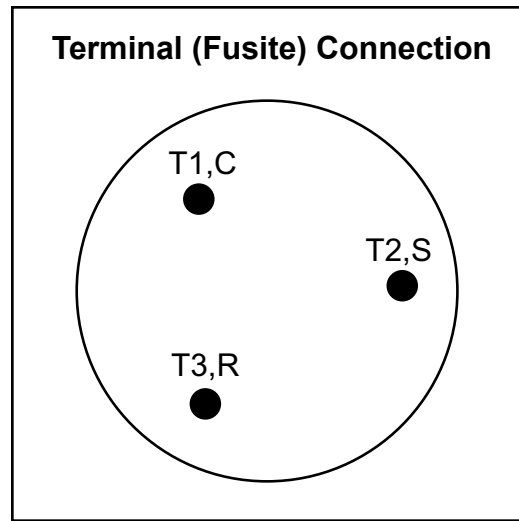
To prevent flooded start damage on 3 phase scrolls due to off cycle migration, the accumulator may be configured on some systems to allow free drainage from the compressor to the accumulator during the off cycle. When the above configuration is not possible and the unit charge is over the charge limit shown in Table 5, a crankcase heater is required.



Time Delay Relay Specifications

Timer Opens	1 Electrical cycle (.016 sec. with 60 HZ operation)	Timer Closes	Greater than 5 seconds later power is restored or not after power is removed
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Figure 3



Motor Terminal (Fusite) Connections

Figure 4

R22 Scroll Operating Envelope

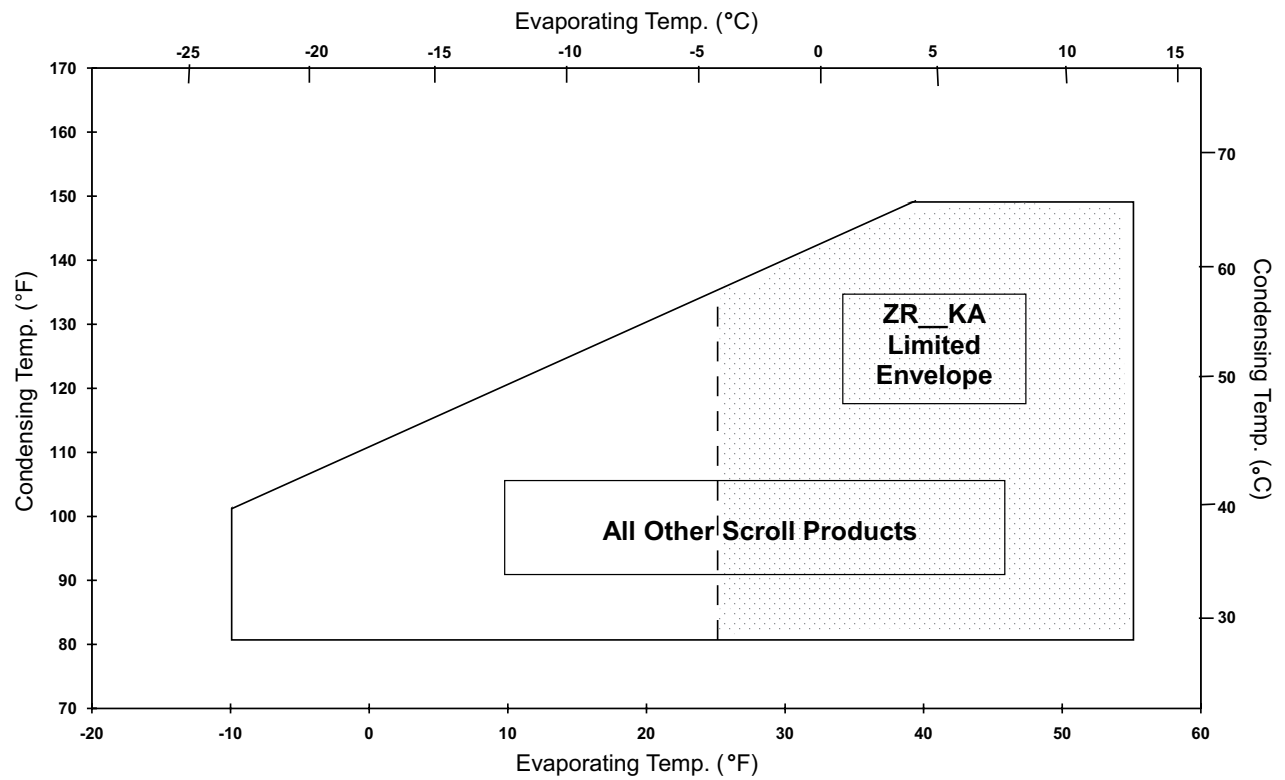
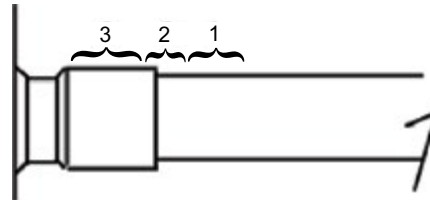


Figure 5

Scroll Suction Tube Brazing



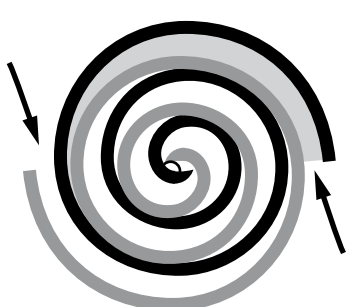
New Installations

- The copper-coated steel suction tube on scroll compressors can be brazed in approximately the same manner as any copper tube.
- Recommended brazing materials: Any silfos material is recommended, preferable 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.

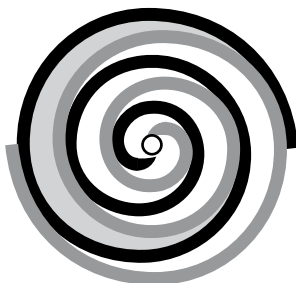
Field Service

- To disconnect: Reclaim refrigerant from both the high and low side of the system. Cut tubing near compressor.
- 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.

Figure 6



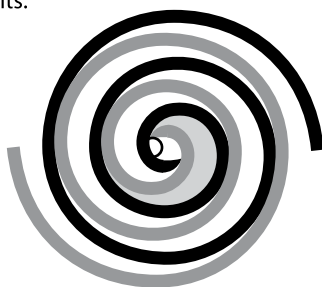
Compression in the scroll is created by the interaction of an orbiting spiral and a stationary spiral. Gas enters the outer openings as one of the spirals orbits.



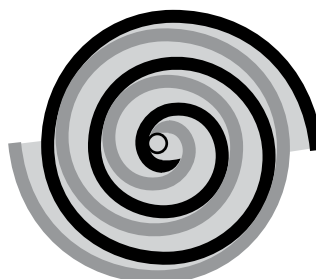
The open passages are sealed off as gas is drawn into the spiral.



As the spiral continues to orbit, the gas is compressed into two increasingly smaller pockets.



By the time the gas arrives at the center port, discharge pressure has been reached.



Actually, during operation, all six gas passages are in various stages of compression at all times, resulting in nearly continuous suction and discharge.

How a Scroll Works

The scroll is a simple compression concept first patented in 1905. A scroll is an involute spiral which, when matched with a mating scroll form as shown above, generates a series of crescent-shaped gas pockets between the two members. During compression, one scroll remains stationary (fixed scroll) while the other form (orbiting scroll) is allowed to orbit (but not rotate) around the first form. As this motion occurs, the pockets between the two forms are slowly

pushed to the center of the two scrolls while simultaneously being reduced in volume. When the pocket reaches the center of the scroll form, the gas, which is now at a high pressure, is discharged out of a port located at the center. During compression, several pockets are being compressed simultaneously, resulting in a very smooth process. Both the suction process (outer portion of the scroll members) and the discharge process (inner portion) are continuous.

**Operating Principle of Scroll
Figure 7**

Table 2
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.

Outdoor Ambient	85°F (29°C)	95°F (35°C)	105°F (40°C)
System On-Time (Minutes)	7	14	54
System Off-Time (Minutes)	13	8	6
Number of On/Off Cycles	5	5	4

Table 3

Recommended Configuration	
Component	Description
Tubing Configuration	Shock loop
Service Valve	"Angled valve" fastened to unit
Suction muffler	Not required
Alternate Configuration	
Component	Description
Tubing Configuration	Shock loop
Service Valve	"Straight through" valve not fastened to unit
Suction muffler	May be required (Acts as dampening mass)

Table 4
Recommended Run Capacitors for Field Replacement
of a ZR*K1 or K2 with a ZR*K3, K4, or KC

	K1	*K2	K3	K4	KC
ZR18	25µf/370 volt		30µf/370 volt	35µf/370 volt	30µf/370 volt
ZR23	30µf/370 volt		40µf/370 volt	35µf/370 volt	35µf/370 volt
ZR26	35µf/370 volt		40µf/370 volt		30µf/440 volt
ZR28	35µf/370 volt		45µf/370 volt		35µf/440 volt
ZR34	35µf/440 volt		50µf/370 volt		40µf/370 volt
ZR40	35µf/440 volt		55µf/370 volt		40µf/440 volt
ZR46		40µf/440 volt	60µf/370 volt		
ZR49		40µf/440 volt	60µf/370 volt		45µf/440 volt
ZR57		55µf/440 volt	80µf/370 volt		60µf/370 volt
ZR61		55µf/440 volt	80µf/370 volt		60µf/370 volt

Table 5
Compressor Refrigerant Charge Limits

Model	Frame Size*	Charge Limit		120% x Limit **	
		Pounds	kg	Pounds	kg
ZR16-ZR29KC	53	6	2.7	7.2	3.24
ZR16-ZR24K4	53	6	2.7	7.2	3.24
ZR26-ZR48KC	63	8	3.6	9.6	4.32
ZR18-ZR48K3	63	8	3.6	9.6	4.32
ZR54-ZR81KC	70	10	4.5	12.0	5.40
ZR54-ZR61K3	70	10	4.5	12.0	5.40
ZR16-ZR34KA	53	8	3.6	9.6	4.32
ZR38-ZR54KA	63	10	4.5	12.0	5.40
TANDEM	63	10	4.5	12.0	5.40
TANDEM	70	12	5.5	14.4	6.60

*Approximate Shell Diameter (e.g. 63 = 6.5 Inches)

** Charge Allowance for system

Table 6
Crankcase Heaters

Copeland® Model	Frame Size	Emerson Part #	Volts	Watts	Tutco Part #	Leads
ZR16KC/4 - ZR29KC/4 ZR16KA - ZR34KA	53	018-0052-00	240	40	02-6319-00	21"
	53	018-0052-01	120	40	02-6319-02	21"
ZR18K3 - ZR48K3 ZR26KC - ZR48KC ZR38KA - ZR54KA	63	018-0041-00	240	40	02-6307-00	21"
	63	018-0041-01	120	40	02-6307-02	21"
	63	018-0041-02	480	40	02-6307-03	21"
	63	018-0041-03	575	40	02-6307-06	21"
	63	018-0041-04	240	40	02-6311-00	48"
	63	018-0041-05	480	40	02-6311-03	48"
	63	018-0041-06	240	40	02-6313-00	32"
ZR54K3 - ZR61K3 ZR54K3 - ZR81KC All 018-0057-XX Heaters fit both 63 and 70 frame* shells	70	018-0057-00	240	70	02-6332-00	21"
	70	018-0057-01	480	70	02-6332-03	21"
	70	018-0057-02	575	70	02-6332-06	21"
	63 & 70	018-0057-03	240	70	02-6334-00	32"
		018-0057-04	240	70	02-6335-00	48"
		018-0057-05	480	70	02-6335-03	48"
		018-0057-06	575	70	02-6335-06	48"
		018-0057-07	120	70	02-6335-02	48"
		018-0057-08	400	70	02-6335-12	48"
		018-0057-09	277	70	02-6332-04	21"

*Approximate Shell Diameter (e.g. 70 = 7.3 Inches)

Table 7
Approved Start Components for Scroll Compressors

Model	MFD	Volts	Part Number	G.E. p/n	Emerson p/n	Pick-up Volts	Drop-out Volts	Coil Voltage
ZR16K(x) to ZR48K(x)-PFV	88-108	330	014-0036-03	3ARR3CT3P5	040-0001-79	170-180	40-90	332
ZR46K(x) to ZR68K(x)-PFV	270-324	330	014-0006-10	3ARR3CT3P5	040-0001-79	170-180	40-90	332

x = C, 3, 4 or CE, 3E, 4E (ZR_KA Start components still in development)