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Application Guidelines For ZR90K3 to ZR19M3 and ZR250KC to ZR300KC Copeland Scroll™ Compressors

Introduction

This bulletin describes the operating characteristics, design features, and application requirements for 7.5 to 25 HP R22 and R407C Copeland Scroll Compressors. Typical model numbers are ZR90K3-TWC, ZR16M3-TW7 and ZR300KC-TWD. For additional information on this and other products, please refer to the "On-line Product Information" accessible from the Copeland website at www.copeland-corp.com. Operating principles of the Copeland Scroll are described in Copeland Application Engineering Bulletin 4-1312. Several operating characteristics and design features are described below that differ from those of smaller Copeland Scroll compressor models.

The Large Copeland Scroll compressor is designed for air conditioning and heat pump usage but will work well in other applications that correspond to its operating requirements and envelope. **(See operating envelope Figure 2)**. The 7.5 to 25 HP compressors are characterized by the pilot duty motor protection system that uses internal sensors and an external electronic module to protect the compressor against motor overheating and excessive discharge temperature.

Application Considerations

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

Compressor Handling

It is recommended that the plugs in the compressor line connections be left in place until the compressor is set into the unit. This reduces the chance of contaminants and moisture getting into the compressor especially if the compressor is charged with the more hygroscopic POE oil. If the compressor has two lifting tabs, **both** must be used for lifting. Either connection plug may be removed first, but pulling the discharge connection plug first will allow the escaping dry air pressure inside the compressor to possibly spray the operator with oil. The copper coated steel tubes must be wiped clean of oil before brazing (see **Figure 5**). 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.

IPR Valve

The 7.5 to 25 HP Copeland Scroll Compressors do not have internal pressure relief valves. To ensure safe operation, a high pressure control set no higher than 425 psig (30 kg/cm2) must be used in all applications.

Safety Controls

High Pressure Control: Because these compressors do not have an internal pressure relief valve, a high pressure control with a maximum cut out setting of 425 psig (30 kg/cm2) **must be used** in the system. The high pressure control should have a manual reset feature for the highest level of system protection.

Low Pressure Control: A low pressure control **is highly recommended** for loss of charge 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. Even though these compressors have an internal discharge temperature sensor, loss of system charge etc. will result in overheating and recycling of the motor protector. Prolonged operation in this manner could result in oil pump out and eventual bearing failure.

Operation near 7 psig (-25°F or –32°C saturated suction temperature) is clearly outside the approved operating envelope shown in **Figure 2**. However, heat pumps in some geographical areas have to operate in this range because of the low ambient temperatures. This is acceptable as long as the condensing temperature is not above 90°F (32°C) and the resulting discharge temperature is below 275°F (135°C). Some liquid floodback to the compressor under these conditions can help keep the discharge temperature under control. Certain conditions may allow even the 7 psig (0.5 kg/

cm2) low pressure control to cause nuisance trips. These could be temporary suction blockage during reversing valve operation; or lack of liquid pressure available to the metering device upon startup in heating. For this reason the low pressure control can be moved to the liquid line where it won't be subjected to momentary low suction pressures that can cause nuisance trips. An alternative is to keep the low pressure control in the suction line and provide a 60-second (maximum) low pressure time delay that ignores a signal from the low pressure control and allows the compressor to continue operating.

The low pressure cutout, if installed in the suction line, 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 may starve the compressor for refrigerant and may result in compressor failure. The low pressure cut-out should have a manual reset feature for the highest level of system protection.

Motor Protection Module: The motor protection system consists of an external electronic control module connected to a chain of four thermistors embedded in the motor winding with a fifth thermistor located at the internal scroll discharge port. The module will trip and remain off for 30 minutes if either the motor or discharge temperature exceeds a preset point. Note: Turning off power to the module will reset it immediately. The module has a 30 minute time delay to allow the scrolls to cool down after the discharge temperature limit has been reached. Restarting the compressor sooner will cause a destructive temperature build up in the scrolls. For this reason module power must never be switched 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 AE Bulletin 10-1244. The contactor must meet both the Copeland Rated Load Amps (RLA) and Locked Rotor Amps (LRA) specified for the compressor.

Protector Specification:

Models	071-0520-04	071-0520-05
Voltage	24 V	120/240 V
Control Rating	60 VA	300/375 VA
	25 A Inrush	25/15 A Inrush

Normal PTC resistance:	250 to 2250 Ohms
Trip resistance:	>4500 Ohm +/- 20%
Reset resistance:	<2750 Ohms
Module time out:	30 minutes +/- 5 minutes
Low Voltage Sensing:	None
Phase Monitor:	No

See "Solid State Module Field Trouble Shooting" at the end of this bulletin. It may take as long as two hours for the motor to cool down before the protector will reset. If current monitoring to the compressor is available, the system controller can take advantage of the compressor protector operation. The controller can be designed to lock out the compressor if current draw is not coincident with a signal for the unit to run, implying that the compressor has shut off on its protector. This will prevent unnecessary compressor cycling on a fault condition until corrective action can be taken. The same logic can be applied using voltage monitoring across the contacts M1 and M2 of the protector module as well as those of other safety devices to detect a trip in place of current monitoring if this is more convenient.

Accumulators

Due to the Copeland Scroll's inherent ability to handle liquid refrigerant in flooded start and defrost cycle operation, an accumulator may not be required for durability in most systems, especially those systems designed with thermostatic expansion valves. However, large volumes of liquid refrigerant which repeatedly flood back to the compressor during normal off cycles or excessive liquid refrigerant floodback during defrost or varying loads, no matter what the system charge is, can dilute the oil. As a result, bearings are inadequately lubricated and wear may occur. To test for these conditions see the section entitled EXCESSIVE LIQUID FLOODBACK TESTS at the end of this bulletin. If an accumulator must be used, an oil return orifice size in the range of 0.070 - 0.090 inches (1.8 – 2.3 mm) is recommended. 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 with system debris. Tests have shown that a small screen with a fine mesh can easily become plugged causing oil starvation to the compressor bearings. Accumulators are a standard item in air to air heat pumps and are used even when a thermostatic expansion valve is used to meter refrigerant in the heating mode. During low ambient conditions, the oil returning from the outdoor coil will be very viscous and difficult to return through the accumulator if the expansion valve is working properly by maintaining superheat. To prevent slow oil return it may be possible to remove the accumulator from systems that use expansion valves in heating. To determine if the accumulator can be removed, a defrost test must be run at an outdoor ambient of around 30°F (-1° C) in a high humidity environment. This is to ensure that excessive liquid does not flood back to the compressor during reversing valve operation, especially when coming out of defrost. Excessive flood back occurs when the sump temperature drops below the safe operation line shown in **Figure 1** for more than 10 seconds.

Screens

The use of screens finer than 30 x 30 mesh (0.6 mm openings) anywhere in the system is not recommended. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes, or accumulators can become temporarily or permanently plugged with normal system debris and block the flow of either oil or refrigerant to the compressor. Such blockage can result in compressor failure.

Crankcase Heaters

Table 4 lists crankcase heaters required for these compressors when the system charge exceeds that shown in **Table 6**. The crankcase heater must be mounted below the oil removal valve located on the bottom shell. **The crankcase heater must remain energized during compressor off cycles.** If the crankcase heaters require a conduit, one possible solution is to use a conduit adapter box shown in **Table 4** and **Figure 4**.

The initial start in the field is a very critical period for any compressor because all load bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions. **The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor**. This will prevent oil dilution and bearing stress on initial start up. If it is not feasible to turn on the crankcase heater 12 hours in advance of starting the compressor, then use one of the techniques listed below to prevent possible flooded-start damage to the compressor: 1) Direct a 500 watt heat lamp or other safe heat source **(do not use torch)** at the lower shell of the compressor for approximately 30 minutes to boil off any liquid refrigerant prior to starting; or 2) Bump start the compressor by manually energizing the compressor contactor for about one second. Wait five seconds and again manually energize compressor for one second. Repeat this cycle several times until the liquid in the shell has been boiled off and the compressor can be safely started and run continuously.

Pumpdown Cycle

Recycling pumpdown for control of refrigerant migration may be used instead of, or in conjunction with, a crankcase heater when the compressor is located so that cold air blowing over the compressor makes the crankcase heater ineffective. The compressor discharge check valve is designed for low leak back and will allow the use of recycling pump down without the addition of an external check valve. The low pressure control cut-in and cut-out settings have 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. A one time pump down at the end of a run cycle is not recommended since refrigerant can still migrate into the compressor after a long shut down. If a one time pump down is used a crankcase heater must be installed.

Minimum Run Time

There is no set answer to how often scroll compressors can be started and stopped in an hour, since it is highly dependent on system configuration. There is no minimum off time, because the scrolls start unloaded, even if the system has unbalanced pressures. The most critical consideration is the **minimum run time required to return oil to the compressor after startup.** This is easily determined since these compressors are equipped with a sight glass. The minimum on time becomes the time required for oil lost on compressor startup to return to the compressor sump and restore a normal level in the sight glass. Cycling the compressor for a shorter time than this, for instance to maintain very tight temperature control, can result in progressive loss of oil and damage to the compressor. See Application Engineering Bulletin 17-1262 for more information on preventing compressor short cycling.

Reversing Valves

Since Copeland Scroll compressors have a very high volumetric efficiency, their displacements are lower than those of comparable capacity reciprocating compressors. As a result, Copeland 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. This will 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

Low ambient cut-outs are not required to limit heat pump operation. However, the discharge temperature must be limited to 275°F (135°C) or below. Otherwise, the internal discharge sensor may trip the motor protection.

Oil Type and Oil Removal

In HCFC R-22 applications mineral oil is used in the compressors. 3GS oil may be used if the addition of oil in the field is required. Polyol ester lubricants must be used with HFC refrigerants (R134a, R407C, etc.). Compressors using polyol ester oil are identified with an "E" in the model number. An example is the ZR12ME-TWD. Copeland Ultra 22 CC should be used if additional POE 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.

When a compressor is exchanged in the field it is possible that a major portion of the oil from the replaced compressor may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage. To remove this excess oil, an access valve has been added to the lower shell of the compressor. The compressor should be run for 10 minutes, shut down and the access valve opened until oil is between ¼ to 1/3 of the sight glass. This operation should be repeated at least twice to make sure the proper oil level has been achieved. In tandem applications where sight glasses are not available, a Schrader valve may be added to the lower portion of the common oil/gas and equalization line. The compressor should then be run for 10 minutes, shut down and the access valve opened until no oil flows. This should be repeated twice to make sure that the proper oil level has been achieved.

Shutoff Sound

Since Copeland Scroll compressors are also excellent gas expanders, they may run backward for a brief period at shutoff as the internal pressures equalize. A low mass, disc-type check valve in the discharge tube of the compressor prevents the compressor from running backward for more than a second. This momentary reversal of direction of the scrolls has no effect on compressor durability and is entirely normal. Development testing should include a review of the shutoff sound for acceptability in a particular system.

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 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 20:1 with a 30:1 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 vibration characteristic of the scroll compressor may result in a low level "beat" frequency that may be detected as noise coming along the suction line into the building under some conditions. Elimination of the "beat" can be achieved by attenuating the contributing frequency. The most important frequency to avoid is the power supply line frequency for three phase compressors. See **Table 3** for common combinations of design configurations. The scroll compressor makes both a rocking and torsional motion, and enough flexibility must be provided in the suction 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.

Electrical Connections

The orientation of the electrical connections on the Copeland Scroll compressors is shown in **Figure 3** and is also shown on the wiring diagram inside the terminal box cover. The screw terminals used on this compressor should be fastened with a torque of 21 to 23 in-lb (2.5 to 2.6 Nm).

Deep Vacuum Operation

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 2**. Low suction pressures will result in overheating of the scrolls and permanent damage to the compressor drive bearing. (See Application Engineering Bulletin 24-1105 for proper system evacuation procedures.)

Nomenclature

The model numbers of the Copeland Scroll compressors include the approximate nominal 60 HZ capacity at ARI rating conditions. An example would be the ZR90K3-TWD, which has approximately 90,000 Btu/hr cooling capacity at the ARI high temperature air conditioning rating point when operated on 60 Hz. The letter "K" in the 5th place of the model number indicates that the number preceding it is to be multiplied by 1000, "M" by 10,000. Note that the same compressor will have approximately 5/6 of this capacity or 75000 Btu/hr when operated on 50 Hz current. Please refer to the file "Nomenclature" found in "Online Product Information" on the Copeland Web page for details pertaining to other information contained in the model number.

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

The compressors are available with stub tube or a combination Rotalock connection and flanged connection. The stub tube version has copper plated steel suction and discharge fittings. These fittings are far more rugged than copper fittings used on other compressors. Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used. See **Figure 5** for assembly line and field brazing procedures. **Table 5** contains torque values for those compressors with valve connections.

Rotation Direction of 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. 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 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 of the scroll compressor also results in substantially reduced current draw compared to specification sheet 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. Oil loss can be prevented during reverse rotation if the tubing is routed at least six inches (15 cm) above the compressor. After several minutes of operation in reverse, the compressor's protection system will trip. If allowed to repeatedly restart and run in reverse without correcting the situation, the compressor will be permanently damaged.

All three phase scroll compressors are identically wired internally. Therefore, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the identified compressor terminals will insure proper rotation direction.

Brief Power Interruptions

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

Assembly Line Brazing Procedure

Figure 5 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 be of oil or refrigerant – is capable of doing damage resulting in compressor failure.

Assembly Line System Charging Procedure

Because scrolls have discharge check valves, systems should be charged on both the high and low side simultaneously to assure refrigerant pressure is present in the compressor before it is Hi-Pot tested or operated. The majority of the charge should be placed in the high side of the system to prevent Hi-Pot 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 (0.5 kg/cm2) suction pressure. Do not operate with a restricted suction. Do not operate with the low pressure cut-out jumpered.

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 setpoint of 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. If uncertainty exists as to the source of the current leakage, test the system with a resistance meter. If the resistance reading does not show a direct short to ground, lower the current leakage reading by operating the system for a brief period of time to redistribute the refrigerant to a more normal configuration and Hi-Pot the system 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. The solid state module and sensors are delicate electronic components and can easily be damaged by high voltage. Under no circumstances should a high potential test be made of the sensors with the sensor leads attached to the module. If the sensors need to be high potential tested, remove the leads from the module and short them together. Apply a maximum of 600 volts to the sensor leads during this test.

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 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. If a brazing torch is then applied to the low side while the low side shell and suction line contains pressure, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. To prevent this occurrence, **it is important to check both the high and low side with manifold gauges before unbrazing.** Instructions should be provided in appropriate product literature and assembly (line repair) areas. If compressor removal is required, the compressor should be cut out of system rather than unbrazed. See **Figure 5** for proper compressor removal procedure.

Copeland Scroll Functional Check

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

1. Proper voltage to the unit should be verified.

2. The normal checks of motor winding continuity and short to ground should be made to determine if an internal motor short or ground fault has developed. If the protector has opened, the compressor must be allowed to cool sufficiently to allow it to reset.

3. Proper indoor and outdoor blower/fan operation should be verified.

4. With service gauges connected to suction and discharge pressure fittings, turn on the compressor. If suction pressure falls below normal levels, the system is either low on charge or there is a flow blockage in the system.

5. 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 compressor was not wired to run in reverse direction. If pressures still do not move to normal values, either the reversing valve (if so equipped) or the compressor is faulty. Reconnect the compressor leads as originally configured and use normal diagnostic procedures to check operation of the reversing valve.

6. To test if the compressor is pumping properly, the compressor current draw must be compared to published compressor performance curves using the operating pressures and voltage of the system. If the average measured current deviates more than ±15% from published values, a faulty compressor may be indicated. A current imbalance exceeding 15% of the average on the three phases may indicate a voltage imbalance and should be investigated further. A more comprehensive trouble-shooting sequence for compressors and systems can be found in Section H of the Copeland 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.

More than one-third of compressors returned to Copeland for warranty analysis are determined to have nothing found wrong. They were mis-diagnosed in the field as being defective. Replacing working compressors unnecessarily costs everyone.

Tandem Operation

The 7.5 to 25 HP models are designed so that the compressors may be piped together for parallel tandem operation offering two steps of modulation. Either one or both compressors can run, depending upon the capacity requirement. A discharge and suction manifold provide a single point discharge and suction line connection. An oil equalization tube is installed between the compressors to ensure that oil is distributed equally. The compressors are mounted directly on two steel rails. This rigid mounting keeps the interconnecting tubing stresses to a minimum. The tandem assembly should be mounted on rubber isolating grommets to the unit basepan. Both compressors must be at the same level to prevent oil from migrating to the lowest compressor through the oil equalization line.

Handling: See handling instruction label on tandem. The tandem must be lifted so that the lifting chains go straight up from the hanger tabs. If the tandem is hoisted from a single point so that the chain makes a "V " the mounting rails will bend and possibly collapse.

The individual compressors that make up the tandem are wired independently using the electrical values of the single compressors. It is recommended that compressors be wired to change lead/lag position. This will ensure equal run time for both compressors, thereby increasing reliability.

Table 4 lists crankcase heaters that must be mounted on each compressor when the system charge exceeds that shown in **Table 6** by 20%.The crankcase heater must be located below the oil removal spud. See previous section on Crankcase Heaters.

Pumpdown may be used instead of or in conjunction with crankcase heaters. See previous section on Pumpdown.

Compressor Replacement

In the case of a motor burn, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned through use of suction and liquid line filter dryers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. See Application Engineering Bulletin 24-1105 for clean up procedures and AE Bulletin 11-1297 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.

When a single compressor or tandem is exchanged in the field it is possible that a major portion of the oil may still be in the system. While this may not affect the reliability of the replacement compressor, the extra oil will add to rotor drag and increase power usage. See previous section on **Oil Type and Oil Removal.**

See **Table 5** for Rotalock valve, flange fitting, sight glass, and mounting bolt torque values.

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 jumpered.

A minimum suction pressure of 25 psig (1.75 kg/cm2) must be maintained during charging. 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. Never install a system in the field and leave it unattended when it has no charge, a holding charge, or with the service valves closed without securely locking out the system. This will prevent unauthorized personnel from accidentally operating the system and potentially ruining the compressor by operating with no refrigerant flow.

Excessive Liquid Floodback 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** applies only during floodback, not when the suction gas is superheated, and must be used to determine the effectiveness of an accumulator. The compressor sump temperature during any unit test where flood back occurs must remain within the "safe zone" shown in **Figure 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 floodback 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 floodback 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 floodback. If an accumulator is used, an oil return orifice size of 0.070 - 0.090 inches (1.8 – 2.3 mm) is recommended. (See information on Accumulators in Application Considerations and also Copeland Application Engineering bulletin 11-1247). 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 floodback.

To test for **repeated excessive liquid floodback** 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 25 feet (8 m) of connecting tubing and no traps between the indoor and outdoor units. If the system is designed to be field charged, the system should be overcharged by 15% in this test to simulate overcharging commonly found in field installations. Operate the system in the cooling mode at the outdoor ambients, on/off cycle times, and number of cycles specified in **Table 1.** 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 Copeland Application Engineering to determine if an accumulator is required for the application. The criteria for pass/fail is whether the liquid level is above the compressor suction connection. Liquid levels higher than these allow any compressor oil floating on top of the refrigerant to be ingested by the scrolls and pumped out of the compressor on startup, a hazardous situation.

Field Trouble Shooting Solid State Module Part Number 071-0520-XX

The module used in the 7.5 to 25 HP scroll compressor works in conjunction with a thermistor chain inside the scroll compressor to protect against excessive motor and discharge gas temperature. A problem in either area will cause the module to interrupt the control circuit (open M1 & M2) for 30 minutes +/- 5 minutes. Follow the steps listed below to trouble shoot the module in the field. See wiring diagram below or on 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.

   CAUTION: THE MOTOR PROTECTION SYSTEM WITHIN THE COMPRESSOR IS NOW BYPASSED. USE THIS CONFIGURATION TO TEMPORARILY TEST MODULE ONLY !

2. 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.

3. 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.

   CAUTION ! 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:

- 250 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 or the thermistors.

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. Reset values are 2250-3000 ohms.

4. 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.

Notes: The module has a 30-minute time out after a trip. Interrupting the module power for 1 second or longer will reset the module.

The voltage should be disconnected between tests in order to avoid short circuits and accidental arcing of contacts. The function of the module should be checked each time there is an open fuse or breaker trip to insure that the module contacts did not stick.

Fig. 1
Oil Dilution Chart

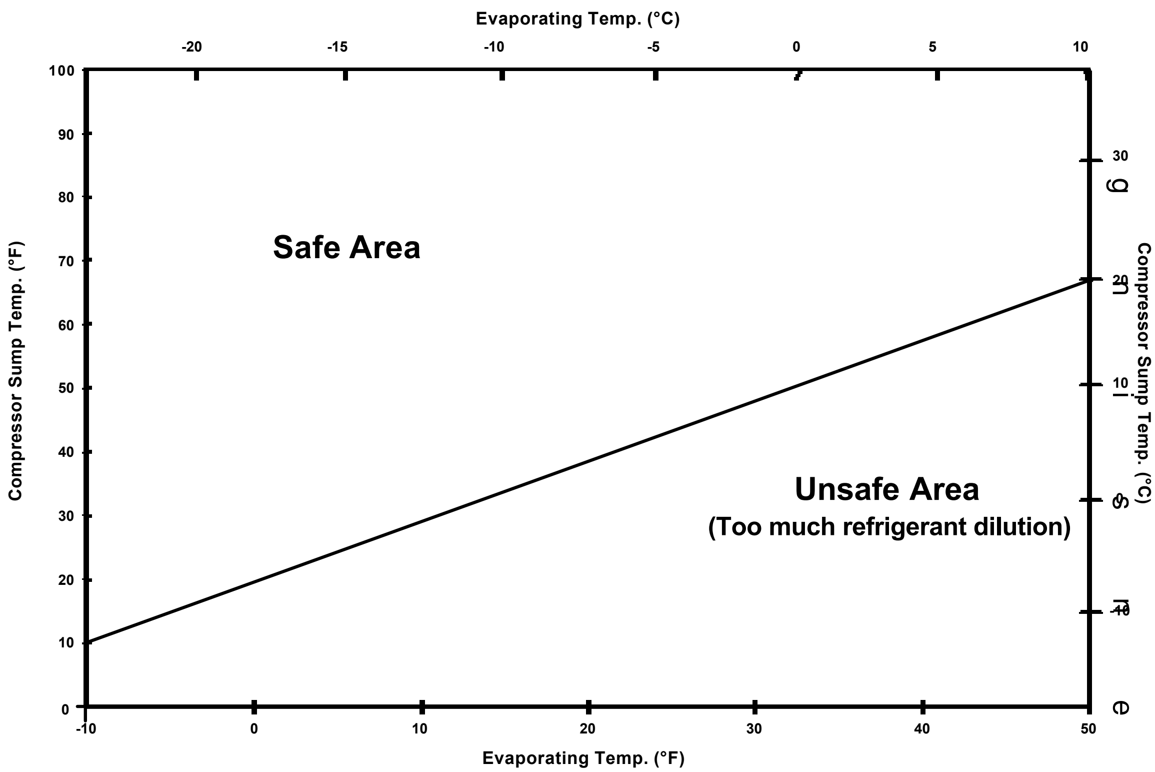
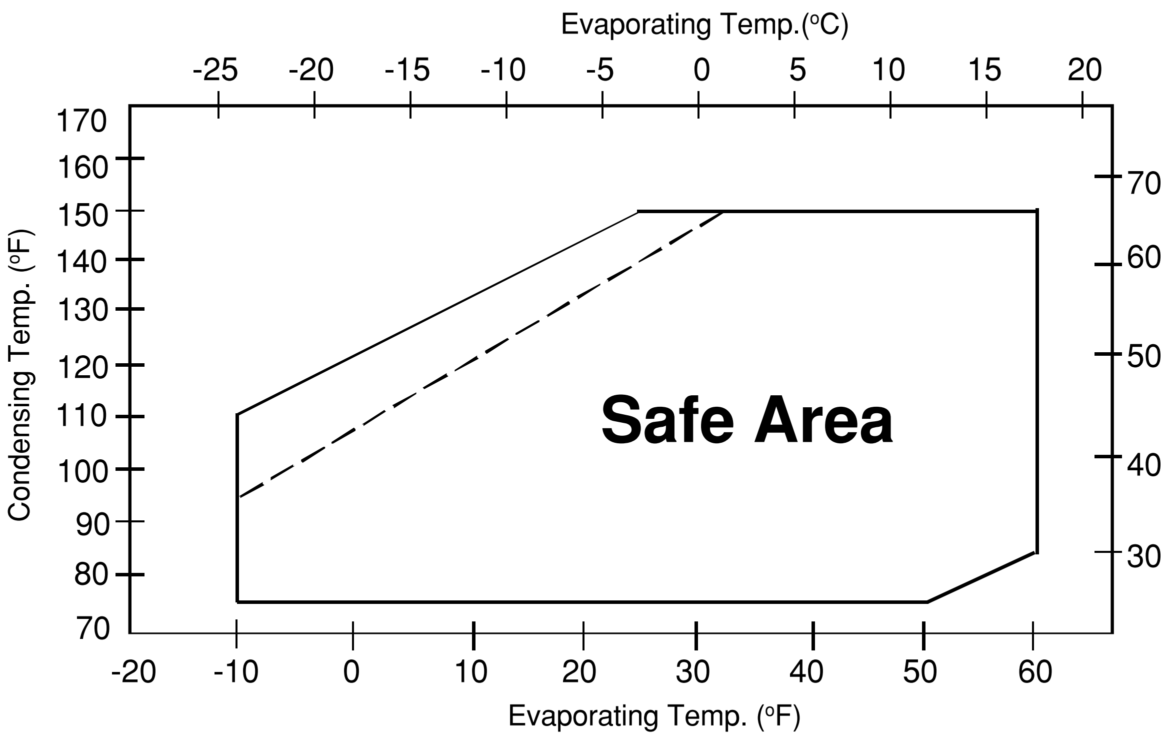


Fig. 2
R22 & R407C Scroll Operating Envelope



Full operating envelope is for ZR90K3E toZR19M3E and ZR250KCE and ZR300KCE with R407C at dewpoint. Dashed line indicates reduced operating envelope required for ZR90K3 to ZR19M3 and ZR250KC to ZR300KC with R22.

Fig. 3

Wiring Diagram

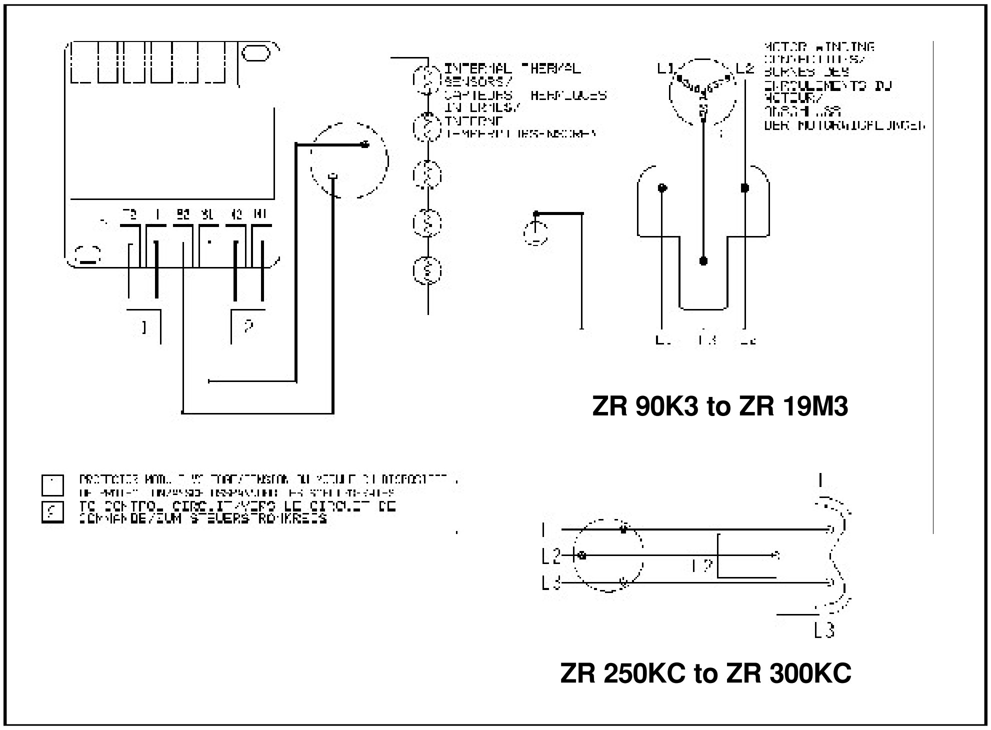


Fig. 4

Crankcase Heater Conduit Box Drawing

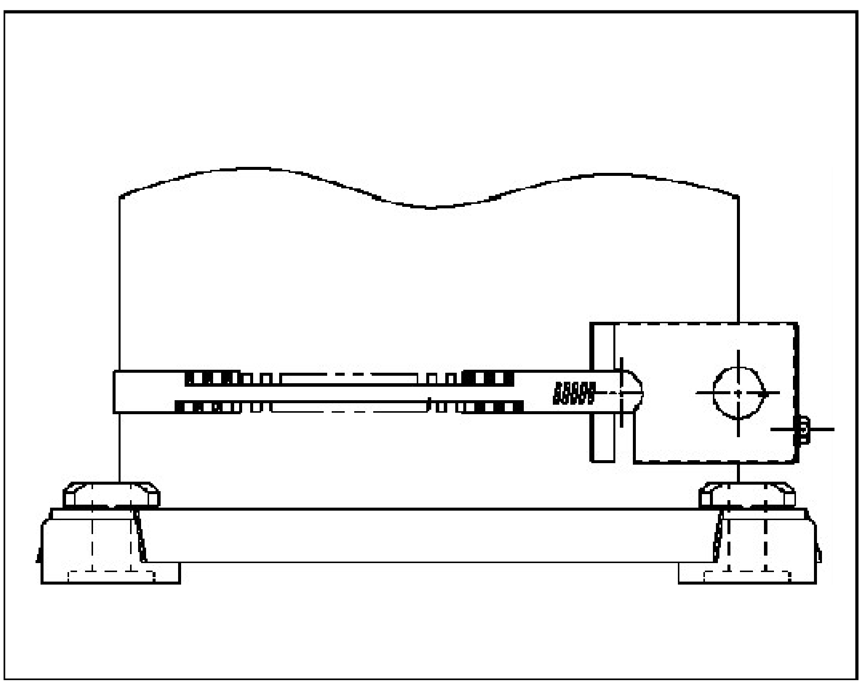
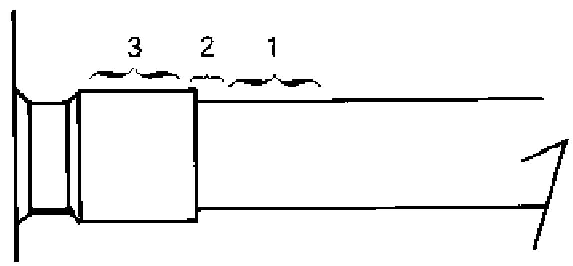


Fig. 5
Brazing instructions



New Installations

- The copper-coated steel tubes 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 both tube fitting I.D. and 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

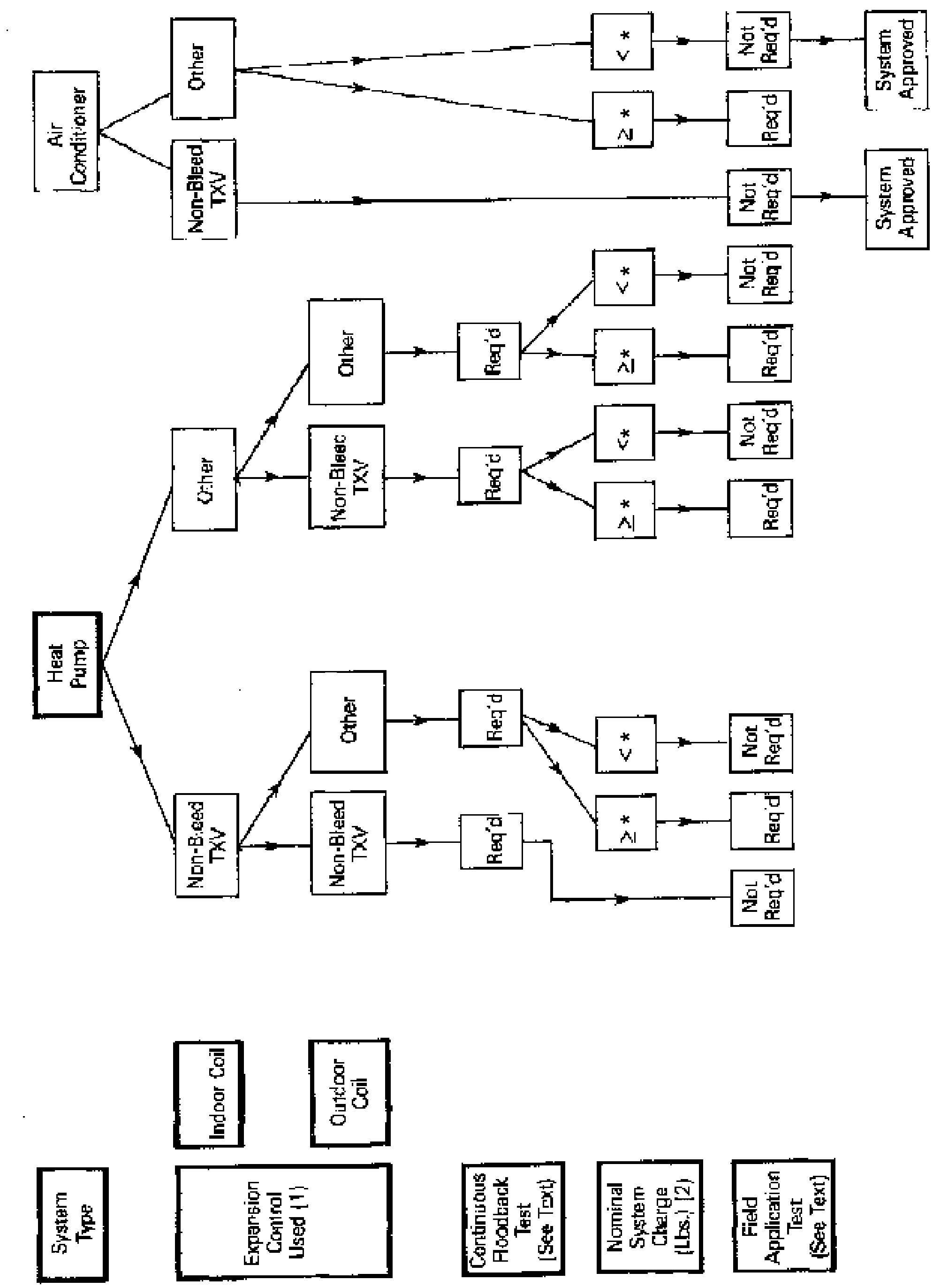
- To disconnect: Reclaim refrigerant from both the high and low side of the system. Cut tubing near compressor
- To reconnect:
  - Recommended brazing materials: Silfos with minimum 5% silver or silver braze material with flux.
  - Insert tubing stubs into fitting and connect to the system with tubing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

Table 1
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 (°F)	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

Scroll Compressor Application Diagram



(1) "Other" includes bleed-type TXVs, capillary tubes, and fixed orifices.
(2) "Nominal System Charge" is defined as the design charge for a system.
* See text for crankcase heater or pump down requirements if system charge exceeds Compressor refrigerant charge limit in **Table 6**.

Piping Configuration to Reduce Vibration Transmission

Recommended Configuration

Component	Description
Tubing configuration	shock loop
Service valves	"angled valves" rigidly attached to the unit preferably to base pan.
Suction muffler	not required

Alternate Configuration

Component	Description
Tubing configuration	shock loop
Service valve	"straight-through" valve or line not attached to unit.
Suction muffler	may be required to add mass to the suction line to shift line resonance away from excitation frequencies.

Table 4
Crankcase Heater Table

Copeland Models:	Copeland Part #:	Tutco Part #:	Volts:	Watts:	Lead Length:	Conduit Box
ZR90K3 - ZR19M3	018-0036-01	02-7150-02	120	70	26" (66cm)	998-7015-00
	018-0036-00	02-7150-00	240	70	26" (66cm)	
	018-0036-02	02-7150-03	480	70	26" (66cm)	
	018-0036-03	02-7150-06	575	60	26" (66cm)	
ZR300KC	018-0056-01	02-6331-00	240	150	28" (71 cm)	TBD
	018-0056-00	02-6331-03	480	150	28" (71 cm)	
	018-0056-02	02-6331-02	120	150	28" (71 cm)	
	018-0056-03	02-6331-06	575	150	28" (71 cm)	
ZR250KC		02-6333-00	240	120	28" (71 cm)	TBD
		02-6333-03	480	120	28" (71 cm)	
		02-6333-02	120	120	28" (71 cm)	
		02-6333-06	575	120	28" (71 cm)	

Table 5
Torque Values

	Torque	
	Foot-Pound	Newton-Meter
Rotalock 3/4"-16UN	30 - 37	40 - 50
Rotalock 1-1/4"-12UN	74 - 81	100-110
Rotalock 1-3/4"-12UN	125 - 133	170-180
Rotalock 2-1/4"-12UN	140 - 148	190-200
Flange w. M16 bolts	75 - 83	102 - 113
Sight Glass	18 - 19	25 - 25.5
Mounting Bolts 5/16", M 9	20 max.	27 max.

Table 6
Refrigerant Charge Limits

	LBS.	KG
ZR90K3 to ZR19M3	17	7.7
ZR250KC	25	11.3
ZR300KC	30	13.6