Application Engineering

Application Guidelines for Copeland RFT, RRT, RST Compressors for Refrigerants R-134A, R-450A, R-513A, R-290, R-404A, R-448A, R-449A and R-507

BULLETIN NO: AE4-1344 R21

Contents

COPELAND

Safety

Important Safety Information

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

Responsibilities, Qualifications and Training

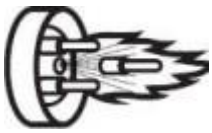
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• OEMs are also responsible for ensuring that all product, service, and cautionary labels remain visible or are appropriately added in a conspicuous location on the system to ensure they are clear to any personnel involved in the installation, commissioning, troubleshooting or maintenance of this equipment.

• Only qualified and authorized HVAC or refrigeration personnel are permitted to install, commission, troubleshoot and maintain this equipment. Electrical connections must be made by qualified electrical personnel.

• Observe all applicable standards and codes for installing, servicing, and maintaining electrical and refrigeration equipment.

Terminal Venting and Other Pressurized System Hazards



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

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

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

See copeland.com/terminal-venting for more details about terminal venting. Additionally, a compressor's refrigerant lines keep refrigerant and oil under pressure. When removing or recharging refrigerant from this component during service, this can pose a pressurized fluid hazard.

Flammable Refrigerant Hazards

If flammable refrigerant is released from a system, an explosive concentration can be present in the air near the system. If there is an ignition source nearby, a release of flammable refrigerant can result in a fire or explosion. While systems using flammable refrigerant are designed to mitigate the risk of ignition if the refrigerant is released, fire and explosion can still occur.

See copeland.com/flammable-refrigerants for more information on flammable refrigerant safety.

Electrical Hazards

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

Hot Surface and Fire Hazards

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

Lifting Hazards

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

POE Oil Hazards

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

Precautions

• Always wear personal protective equipment (gloves, eye protection, etc.).

• Keep a fire extinguisher at the jobsite at all times.

• Keep clear of the compressor when power is applied.

- IMMEDIATELY GET AWAY **if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.**

• Never reset a breaker or replace a blown fuse without performing appropriate electrical testing

- **A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault.**

• Disconnect power and use lock-out/tag-out procedures before servicing.

- Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (Note: The system may have more than one power supply.)

- Discharge capacitors for a minimum of two minutes

- Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.

• Allow time for the compressor to cool before servicing.

- Ensure that materials and wiring do not touch high temperature areas of the compressor.

• Keep all non-essential personnel away from the compressor during service.

• For A3 refrigerants (R290) remove refrigerant from both the high and low sides of the compressor. Use a recovery machine and cylinder designed for flammable refrigerants. Do not use standard recovery machines because they contain sources of ignition such as switches, high- and low-pressure controls and relays. Only vent the R290 refrigerant into the atmosphere if the system is in a well-ventilated area.

• Never use a torch to remove the compressor. Only tubing cutters should be used for both A2L and A3 refrigerants.

• Use an appropriate lifting device to install or remove the compressor.

• Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.

• Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.

• Charge the system with only approved refrigerants and refrigeration oils.

• Keep POE oils away from certain polymers (e.g., PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.

• Before energizing the system:

1. Securely fasten the protective terminal cover or molded plug to the compressor, and

2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

Signal Word Definitions

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

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

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

Introduction

Hermetic compressors have been developed for the 1/3 hp to 1 ¼ hp refrigeration applications. These compressors are designed to operate safely and reliably in the high, medium, and extended medium temperature ranges. In addition, some of the extended medium temperature compressors have the ability to operate in the low temperature range with **SPECIAL APPLICATION ENGINEERING APPROVAL**. It must be noted however, that under low evaporating conditions and when operating with R-448A, R-449A, and R-507, the operating envelope for these models is restricted.

Nomenclature

The SystemPro™ HFC/HFO compressor model numbers include the nominal capacity at the standard ARI 60Hz rating conditions. Please refer to product literature for specific model number details.

See **Figure 1**.

Operating Envelope

There are various refrigerants that have been approved for use with this family of compressors, see **Table 1** at the end of this bulletin. The SystemPro models RFT, RRT, RST are intended for refrigeration type duty. The approved operating envelopes are depicted in **Figure 10** to **Figure 16**. These compressors are approved to operate down to a 70ºF (21°C) condensing temperature, with the exception of the R-290 units which are rated down to 90°F.

The envelopes are defined by the following compressor limitations:

- Discharge line temperature 225°F (107°C)
- Discharge valve backer 275°F (135°C)
- Oil sump 200°F (93°C)
- Motor windings 275°F (135°C)

If the system design is such that operation within these guidelines cannot be guaranteed, then the following additional controls must be added:

1. Discharge line thermostat - Located 6" from the compressor and set to cut-out the compressor at 225°F maximum.
2. Low pressure control - Refer to **Table 2** for recommended low pressure cut-out settings based on the various refrigerants.

Note: For additional data on the proper use of R-290, please reference Application Bulletin AE-1380.

R-290 is flammable and should be handled by qualified personnel in accordance with appropriate care for safe use. Copeland highly recommends that service personnel use spark proof tools, anti-static gloves for hand and anti-static clothes. Avoid the build-up of electrostatic charge, work in a well-ventilated area. Fire and smoking are forbidden!

There are only a limited number of R-290 compressors available at this time; the compressor's nomenclature will be designated with a "**U**" in the eighth character for R-290 application. Example: RFT22C1**U**-CAA

Compressors designed for the use of R-290 will not be charged with a positive dry air charge but will have a slight vacuum from the factory.

Superheat Requirements

In order to assure that liquid refrigerant does not return to the compressor during the running cycle, attention must be given to maintaining proper superheat at the compressor suction inlet. Copeland recommends a minimum of 20°F (11°C) superheat, measured on the suction line 6 inches (152mm) from the suction valve, to prevent liquid refrigerant flood back.

Another method to determine if liquid refrigerant is returning to the compressor is to accurately measure the temperature difference between the compressor oil crankcase and the suction line. During continuous operation we recommend that this difference be a minimum of 50°F (27°C). This “crankcase differential temperature” requirement supersedes the minimum

suction superheat requirement in the last paragraph. To measure oil temperature through the compressor shell, place a thermocouple on the bottom center (not the side) of the compressor shell and insulate from the ambient.

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

Contact the Application Engineering Department regarding any exceptions to the above requirements.

Suction Accumulator

The addition of a suction accumulator can be an effective method to prevent damage to the compressor due to liquid flood back. Through extensive testing, Copeland recommends the use of a suction accumulator if the system refrigerant charge exceeds the refrigerant charge limit. For the RFT, RRT, and RST compressors the refrigerant charge limit is 3.5 pounds (1.6 kg).

Note: R-290 charge limits are limited to 150 grams (5.3 ounces) in retail food refrigerators and freezers and 57 grams (2.0 ounces) in residential refrigerators and freezers.

Discharge Line Check Valve

On pre-charged units that use RFT, RRT or RST compressors with charge levels greater than 3.5 lbs., a check valve is required in the discharge line close to the compressor. This will reduce the potential for liquid refrigerant migrating to the compressor during transport and storage. The addition of a crankcase heater on precharged units will also assist in forcing any refrigerant that might have migrated to the compressor sump during an extended off or storage time. It is recommended that the crankcase heater be energized a minimum of 4 hours before initial startup.

Crankcase heaters are recommended on all outdoor applications or indoor applications below 40°F. A crankcase heater is also required on any system with an accumulator. Reference **AE-1182** for liquid refrigerant control in refrigeration and air conditioning systems. New crankcase heaters are available for use with RFT, RRT, and RST compressors. See Table 3 for part numbers.

Note: Models possessing the slightly flammable R290 refrigerant will not have crankcase heaters.

Lubricants

SystemPro compressors that are approved for use with HFC/HFO refrigerants are charged with polyol ester lubricant (POE). HFC/HFO refrigerants require the use of a POE lubricant to provide proper miscibility and lubricity.

The model nomenclature denotes if the compressor is charged with a POE lubricant. If the eighth character in the model nomenclature is the letter E then the compressor is charged with a POE lubricant, **example RST55C1E-CAA**.

POE may cause an allergic skin reaction and must be handled carefully and the proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. POE must not come into contact with any surface or material that might be harmed by POE, including without limitation, certain polymers (e.g., PVC/ CPVC and polycarbonate). Refer to the Safety Data Sheet (SDS) for further details.

In the event lubricant needs to be added to the system, the proper Copeland approved lubricant must be used. See Form 93-11, Refrigerants/Lubricants Approved for Use in Copeland Compressors, for a complete list of approved lubricants. The compressor recharge is 2 oz. less than the oil charge listed on the nameplate.

Practical Considerations

The application restrictions imposed on these models may require careful system design. Some considerations for the designer are as follow:

1. Units operating at low evaporator temperatures will be susceptible to overheating with dirty condensers and/or restricted air flow. Large condensers (with low TD's) should be designed into systems using these compressors and proper condenser coil maintenance will be more critical. System Air flow across the compressor and condenser should be designed to maintain a Discharge line temperature (Measured 6 inches from the compressor) below 225°F while functioning within the approve operating envelope of each compressor. Minimum suction line pressure drops will be important to maintain SST limits at the compressor.
2. Traditional superheat settings at the TXVs may be too high to maintain the return gas temperature limits specified.
3. Suction lines should be well insulated.
4. Suction line to liquid line heat exchangers may not be desirable if return gas temperatures specified are to be maintained.
5. Minimum suction line pressure drops will be important to maintain saturated suction temperature limits at the compressor.
6. RF model compressors are not approved for remote outdoor applications using R-448A and R-449A. The RF model compressor may be used for low temperature indoor, and indoor remote applications using R-448A and R-449A if the required compressor superheat settings can be met. To assist in keeping the compressor cool the following recommendation should be followed:
   - A 220°F discharge line temperature cut out is required to be applied 6" from the compressor on the discharge line when applying R-448A and R-449A refrigerants. Highly insulated suction lines from the evaporator to the compressor may be required to reduce superheat gains.
   - Liquid line to suction line heat exchangers are not recommended.

Use of R-450A and R-513A Refrigerants

Note: Refrigerant migration of R-450A and R-513A into the compressor crankcase could cause low oil viscosity, which could lead to compressor damages.

When using R-450A and R-513A it is critical to meet the following requirements:

- Maintain adequate superheat settings with a minimum superheat of 20°F at the compressor.
- No liquid refrigerant migration into the compressor at any time, especially during standstill or during or after defrosting.
- Pump down recommended.
- The use of a crankcase heater is recommended.
- Retrofit to R-450A and R-513A is only allowed for compressors which are approved for these refrigerants.

Deep Vacuum Operation

Never attempt to start a compressor while it is in a vacuum; always break the vacuum with a refrigerant charge before applying power.

Operating a compressor in a deep vacuum could cause electrical arcing inside the compressor.

A low-pressure control is required for protection against deep vacuum operation. Refrigerant compressors are not designed for and should not be used to evacuate a refrigeration or air conditioning system. See AE-1105 for proper system evacuation procedures.

Compressor Cycling

The largest stress on the compressor running gear is experienced during the compressor startup and shut down periods.

Reciprocating

In design, it must be noted that the inherent design of the spring suspension in reciprocating compressors has a

finite life as with any spring suspension. The ideal suggested compressor cycle rate for reciprocating compressors is a maximum of 12 cycles per hour. This includes a recommended off time between cycles of 10 seconds minimum. The recommended minimum run time from startup to shutdown is 5 minutes. For designs outside of these parameters it is suggested to contact the Application Engineering department for review and approval.

Cycle rate in relation to oil logging

Cycle rate also contributes to oil logging in the evaporator. Each time the compressor starts; there is a quick reduction in the suction pressure and therefore the crankcase pressure. The pressure drop causes a reduction in the saturation temperature, resulting in the oil-refrigerant mixture flashing into foam and vapor with the frequent result that a large percentage of the crankcase oil is pumped out of the compressor.

If the compressor operates for sufficient time to stabilize the system, the oil will return to the compressor, but if the running period is very short, the oil may still be trapped in the system when the compressor cycles off. Under such conditions the compressor can operate without lubrication to the bearings, with the obvious potential for damage.

Starting Components

All of the capacitors should be Heavy Duty Type I. The starting capacitors should have a bleed resistor across them to extend the life of the relay. Increasing the starting capacitors voltage may also help to extend its operational life.

Electrical Connections

Only use Copeland listed start components for R-290 compressor applications, as only these components have been tested to and meet the safety guidelines set forth by UL.

Single phase motor connections are shown in **Figure 2** to **Figure 4.**

It is recommended that insulated terminal connectors be used within the compressor's terminal box whenever possible. Ensure that the terminal connections do not interfere with the closing of the terminal box cover.

Flag Terminal connectors

To provide flag terminal connections for all RFT, RRT, and RST models, a terminal connector (P.N. 021-0373- 00) is provided with the compressor models listed in **Table 4**.

This small white connector found in the R*T platform compressors is used as a connector block going from the pin terminals on the compressor to a standard ¼" flag style terminal connector to the start and run leads of the unit. **Figure 5** shows two drawings of this connector detailing its terminals. **Figure 6** and **Figure 7** show pictures of terminal box less and with wires.

The tab with the pentagon shaped hole slides over the common terminal and the S (start terminal #3) and M (main / Run / terminal# 2) are inserted over the start and run pins on the compressor.

When installing the start and run leads to the compressor terminal it is recommended to use the top two connections labeled 3 and 2. If required connector 4 and 1 could also be used but care should be taken not to stretch the connector sockets while forcing on the flag connectors, doing so could cause a lose connection and lead to the connector failure.

It is recommended to apply the flag terminals to the connector and then the connector to the compressor while assuring a tight/flush fit.

Terminal covers must be installed properly prior to energizing the compressor.

Three Phase Scott-T Motor Design

Note that the RST70C1, RST80C1, RST97C1 and the RST10K1 in the TA5 three phase motors use a modified "Scott-T" connection and don't have equal resistance on all three windings. Two windings will have equal resistances, and the third winding will be lower than the other two. See **Figure 9**. Carefully compare measured motor resistance values to the two different published resistance values for a given compressor model before replacing the compressor as being defective. Due to the nature of the Scott-T construction there is an inherent current imbalance in the motors that is much larger than what is seen in a standard 3-phase motor. Effectively you will have two terminals draw similar currents while the third will draw a higher current. The current draw on the Scott-T motors as shown in the performance data and in the operating envelope (available at Copeland.com/OPI) comes from the two main windings.

The Scott-T motor in the RST product line uses both an internal and external motor protector.

IPR Valve

RFT, RST and RRT compressors have internal pressure relief valves which open when the suction to discharge pressure differential is between 450 to 550 psi.

This results in increased compressor current and protector ambient causing the protector to open and interrupt the power to the compressor.

High Potential (Hipot) Testing

The RFT, RRT and RST compressors are configured with the motor below the compressor. As a result, when liquid refrigerant is within the compressor shell the motor can be immersed in liquid refrigerant to a greater extent than with standard hermetic compressors. In this respect these compressors are more like semi-hermetic compressors (which have horizontal motors partially submerged in oil and refrigerant). When the RFT, RRT and RST compressors are Hipot tested and liquid refrigerant is in the shell, they can show higher levels of leakage current than compressors with the motor on top because of the higher electrical conductivity of liquid refrigerant than refrigerant vapor and oil. This phenomenon can occur with any compressor when the motor is immersed in refrigerant. The level of current leakage does not present any safety issue. To lower the current leakage reading the system should be operated for a brief period of time to redistribute the refrigerant to a more normal configuration and the system high potential tested again. See bulletin AE-1294 for Megohm testing recommendations. Under no circumstances should the Hipot or Megohm test be performed while the compressor is under a vacuum.

High Potential Testing (Hipot)/Megohm Testing with R-290

Special attention should be taken when using a Hipot/ Megohm reading on an R-290 compressor. These tests can induce an electrical arc and cause a potential fire/explosion hazard. Compressors removed from an R-290 system will need to have the oil drained and a nitrogen purge introduced to flush any remaining R-290 from the compressor prior to Hipot /Megohm testing.

Mounting

SystemPro compressors are internally spring mounted to reduce vibrations. Resilient type mounts have been developed specifically for these compressors. The approved ECT mounting kit part is **527-C001-00** for both 60 and 50 hertz applications.

A typical mounting assembly is shown in **Figure 8**.

General Guidelines and More Information

For general Copeland compressor please log in to Online Product Information at Copeland.com/OPI, refer to the Application Engineering bulletins listed below, or contact your Application Engineer

AE-1380	**Guide for the Use of R-290 Refrigerant in Copeland™ Refrigeration Compressors**
AE-1182	**Liquid Refrigerant Control in Refrigeration and Air Conditioning Systems**
AE-1294	**Megohm Values of Copeland Compressors**
AE-1105	**Principles of Cleaning Refrigeration Systems**

R Family Nomenclature

*Figure 1 R*T Nomenclature*

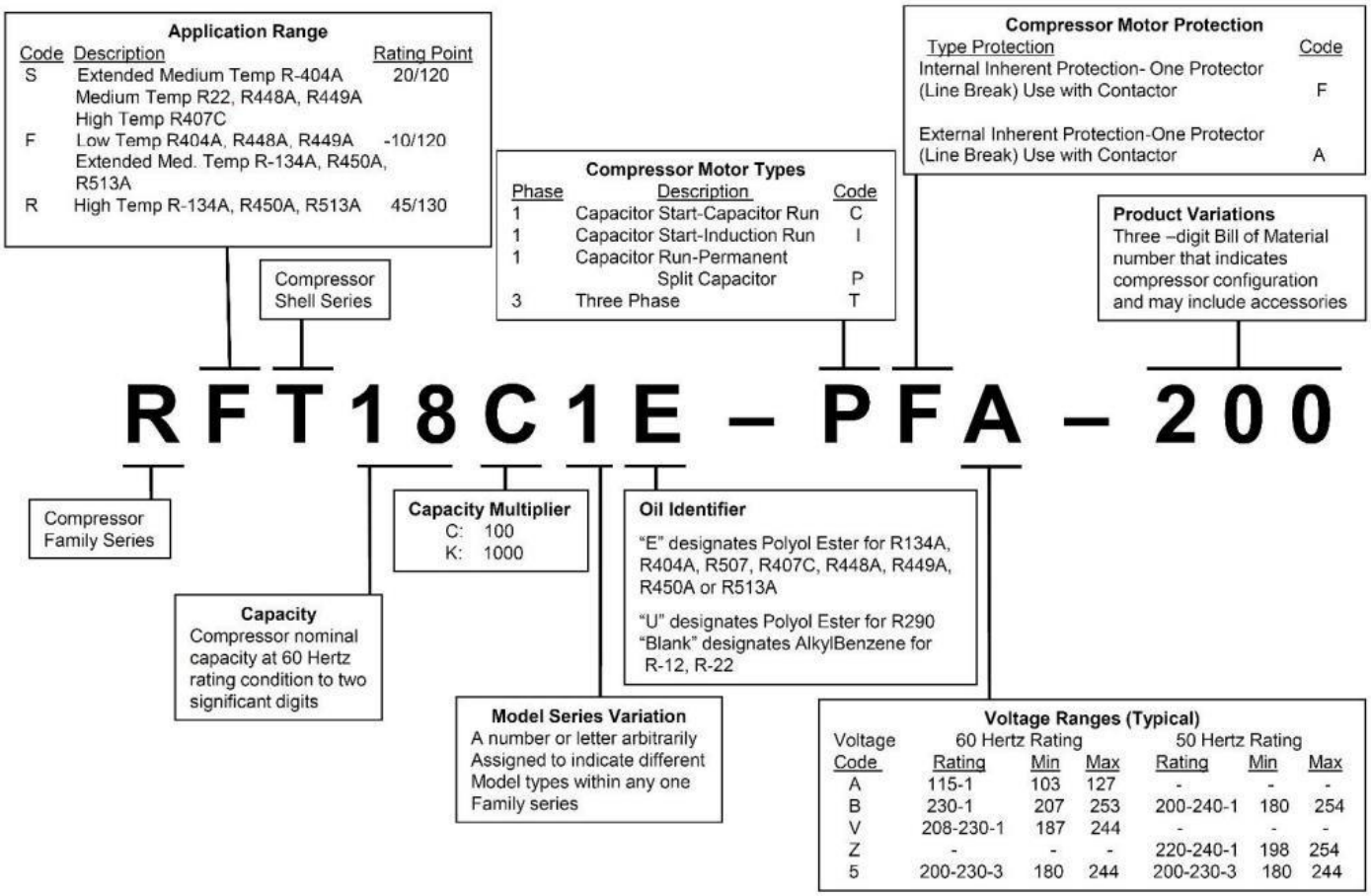


Figure 2 Capacitor Start - Induction Run Motor

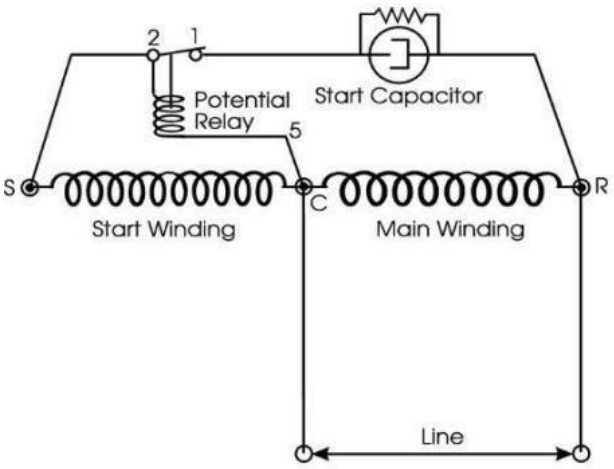


Figure 3 Capacitor Start - Capacitor Run Motor

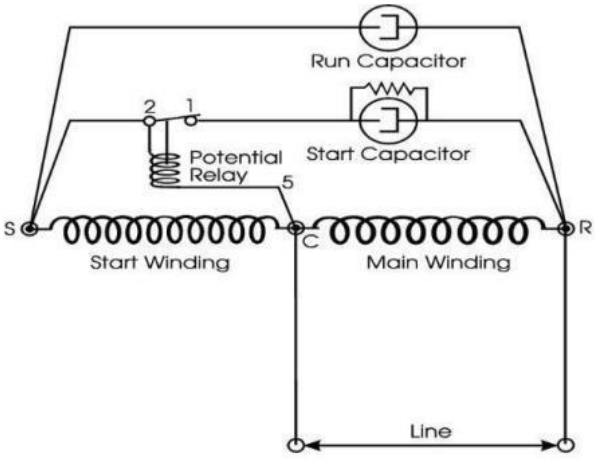


Figure 4 Permanent Split Capacitor Motor (PSC) with PTC Start Assist

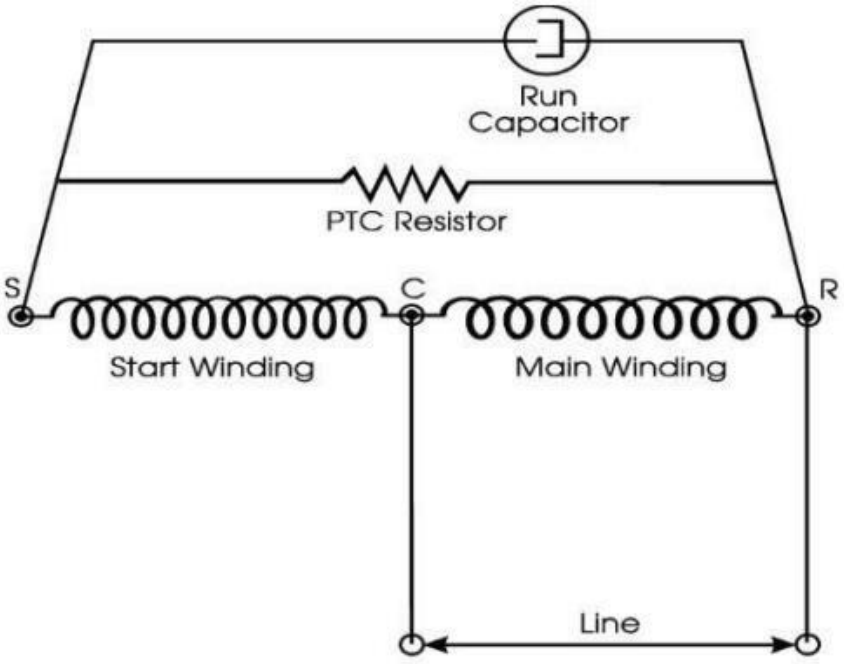


*Figure 5 R*T electrical connector (P.N. 021-0373-00)*

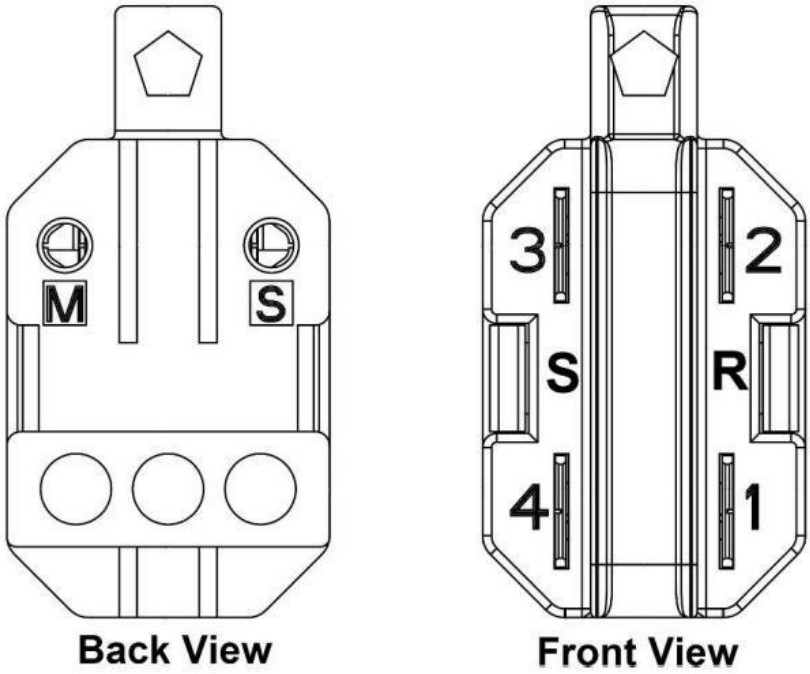


*Figure 6 R*T Electrical Connector Less Wires*

*Figure 7 R*T Electrical Connector with Wires*

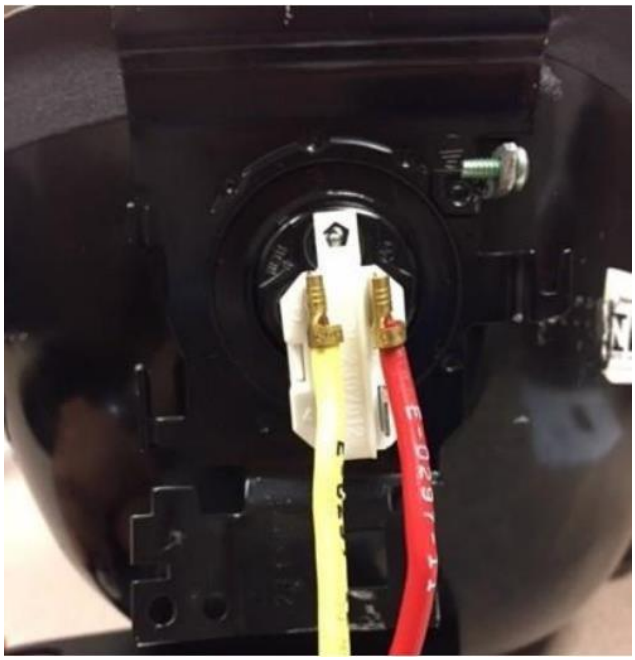


Figure 8 Mounting Kit 527-C001-00

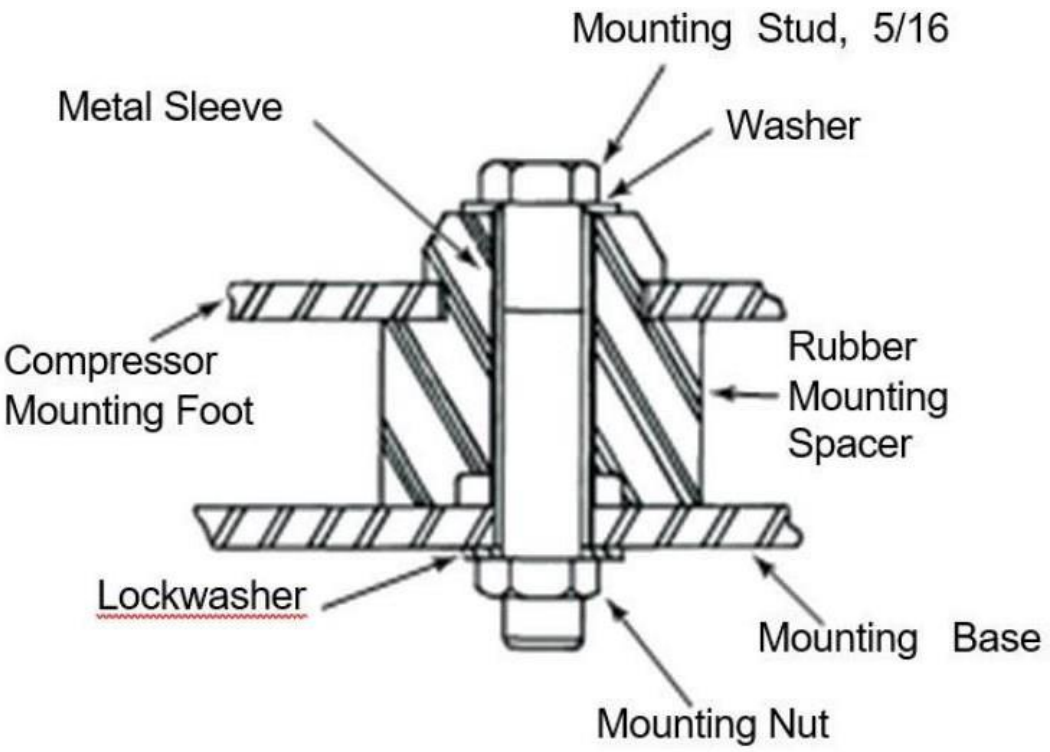


Figure 9 Scott-Tee Three Phase

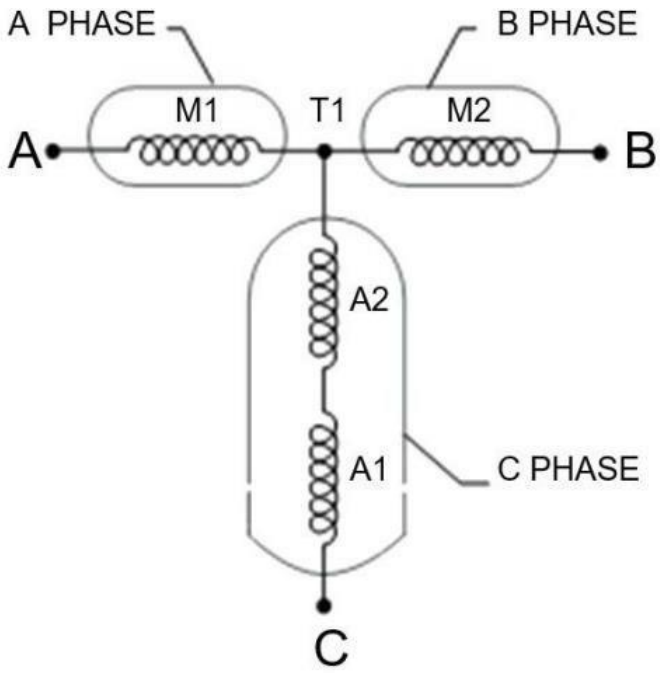


Figure 10 RFT 404A/R-290 LOW TEMP*

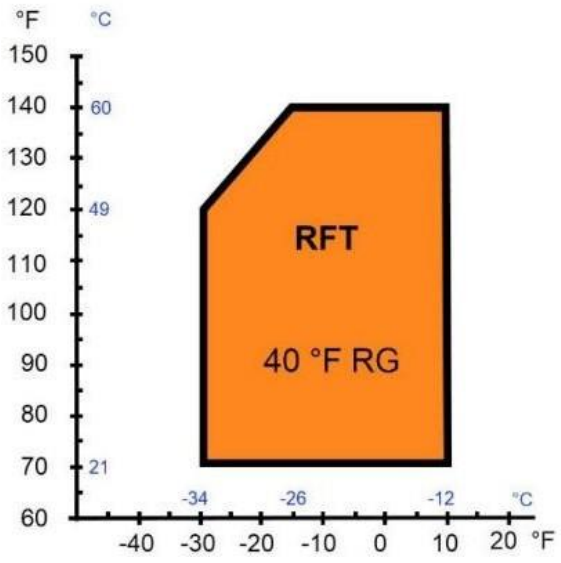


Figure 11 RST 404A/R-507 EXT. MED. TEMP

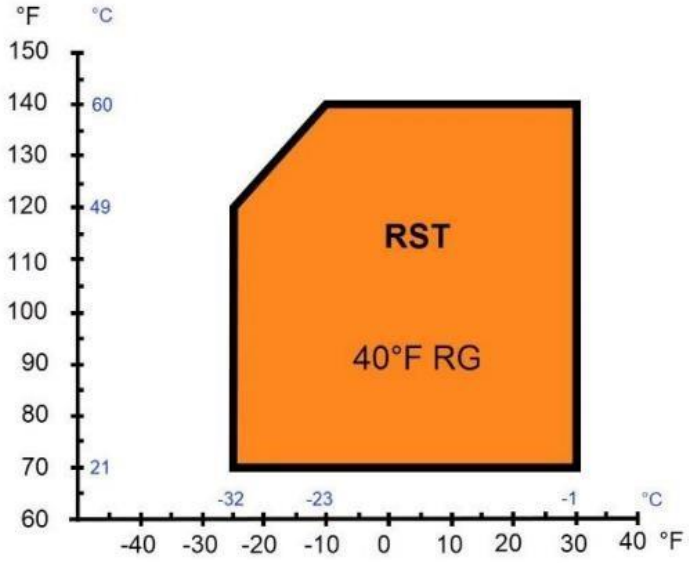


Figure 12 RFT R-448A / R-449A Low Temp

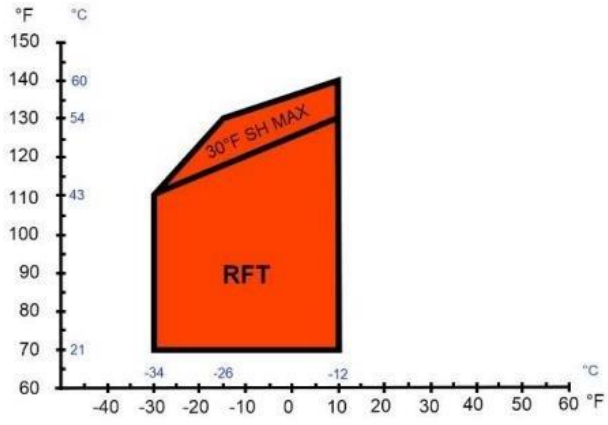
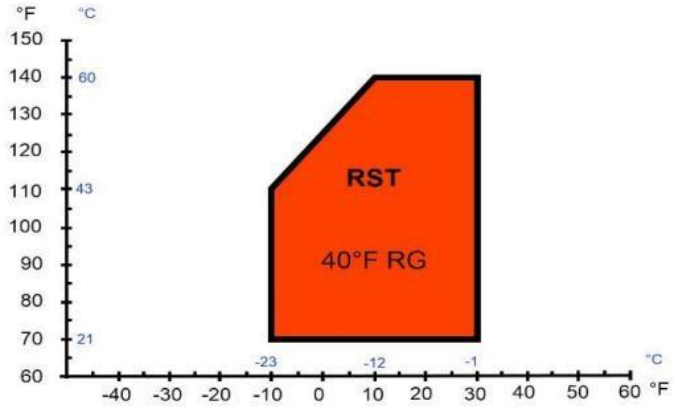


Figure 13 RST R-290/R-448A/R-449A MED. TEMP.*



Note: See additional restrictions under Practical Considerations, item 6 page 7.

Figure 14 RFT 134a /R-450A/R-513A LOW TEMP.

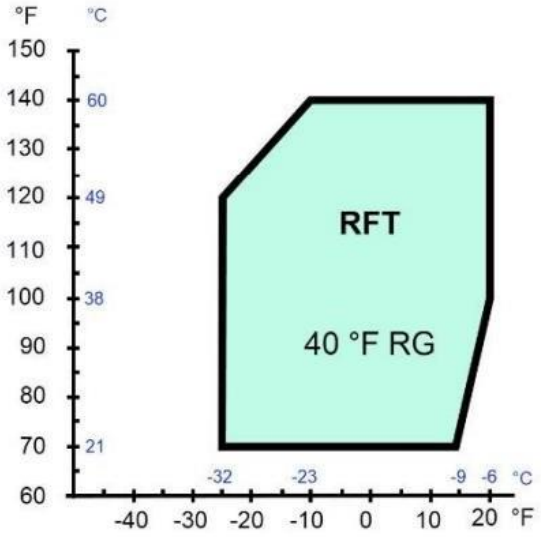


Figure 15 - RRT 134a/R-450A/R-513A HIGH TEMP

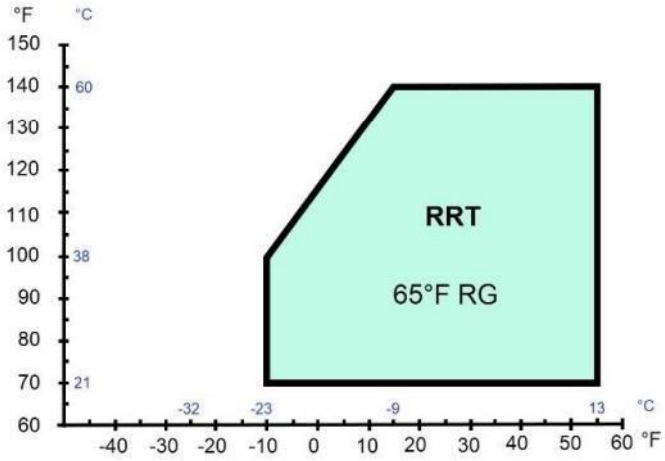


*Figure 16 – RST**C3 R-290 EXT. MED. TEMP.*

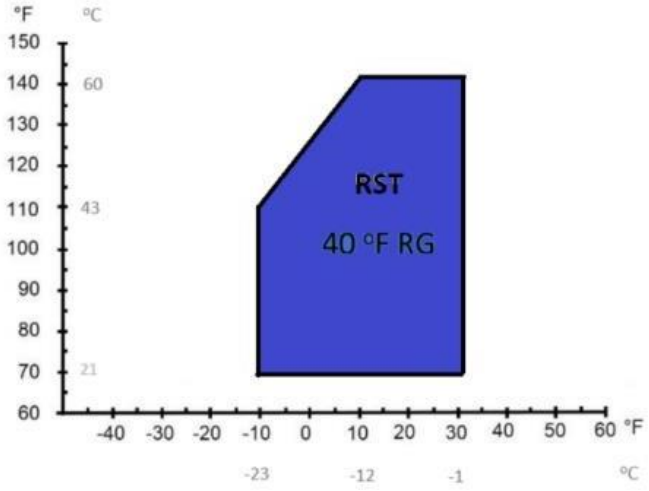


Table 1 Approved Refrigerants/Lubricants

Model	Refrigerant	Lubricant	Envelope
RFT	R-404A/ R-290*	Emkarate RL22HB/POE	Figure 10
RST	R-404A/R-507	Emkarate RL22HB/POE	Figure 11
RFT	R-448A/R-449A	Emkarate RL22HB/POE	Figure 12
RST	R-290*/R-448A/R-449A	Emkarate RL22HB/POE	Figure 13
RFT	R-134a/R-450A/R-513A	Emkarate RL22HB/POE	Figure 14
RRT	R-134a/R-450A/R-513A	Emkarate RL22HB/POE	Figure 15
RFT**C3U	R-290	Emkarate RL32HB/POE	Figure 10
RST**C3U	R-290	Emkarate RL32HB/POE	Figure 16

Table 2 Recommended Low Pressure Cut-Out Limits

Application	R-404A	R-22	R-290	R-448A/R-449A	R-134a	R-450A	R-513A	R-407C
Low Temp (RFT)	7.5 PSIG Min	N/A	3.4 PSIG Min	7.5 PSIG Min	20.1 in. Hg Min	17.7 in. Hg Min	23.5 in. Hg Min	N/A
Medium Temp (RST)	10.3 PSIG Min	20.1 PSIG Min	13.6 PSIG Min	20.8 PSIG Min	N/A	N/A	N/A	25 PSIG Min
High Temp (RRT)	N/A	N/A	N/A	N/A	29.9 in. Hg Min	6.1 in. Hg Min	2.2 PSIG Min	N/A

Table 3 Crankcase Heater Part Numbers

Part Number	Volts	Watts
018-0097-00	120	20
018-0097-01	240	20

Table 4 Compressor Models with New Connector Design

RFT Models	RRT Models	RST Models
22C1E-CAV	64C1E-IAA	40C1E-CAA
22C1E-CAB	64C1E-CAA	40C1E-CAV
26C1E-CAV	64C1E-CAV	45C1E-CAB
26C1E-CAB	64C1E-CAB	55C1E-CAV
29C1E-CAV	73C1E-CAA	55C1E-CAB
29C1E-CAZ	73C1E-CAB	40C1E-CAB
32C1E-CAV		45C1E-CAV
32C1E-CAZ		

Table 5 Discharge line Temperature Cut-Out (220°F Cut-Out)

Tube size	Kit #	Part #
1/4"		085-7022-13
3/8"	998-7022-01	085-7022-07

Revision Tracking R21

The document format has been updated to the new Copeland format

All occurrences of "Emerson" have been removed

A note regarding A3 and R290 venting has been updated