Application Engineering

3 to 15 Ton Copeland Scroll Digital™ Compressors for Air Conditioning

BULLETIN NO: AE4-1395 R7

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

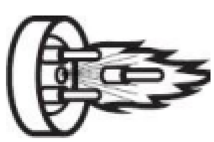
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• 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.

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

Revision Tracking R7

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.

Introduction

The 3 to 15 ton Copeland Scroll Digital™ compressors described in this bulletin include the follow compressor model numbers:

R-410A	R-22 & R-407C
ZPD34 to ZPD54K5	ZRD36 to ZRD81KC
ZPD61-ZPD83, ZPD91, ZPD104, ZPD122KC	ZRD94 to ZRD125KC
ZPD103, ZPD120,	
ZPD137-182KC	

ZPD and ZRD digital scroll compressors are variable capacity compressors that can modulate down to 10% of full load. Digital scrolls are suitable for a variety of applications where a variable capacity compressor is useful, such as VAV applications, dedicated outside air units, units that typically used hot gas bypass for capacity control, and applications that require accurate control of temperature and humidity. Other applications include multiple compressor systems where modulation is required over the entire operating range of the system and in applications where compressor starting and stopping is unacceptable. Typical digital scroll model numbers are ZRD94KCE-TF5 and ZPD182KCE-TWD. This bulletin describes the operating and application differences with respect to the equivalent fixed capacity Copeland Scroll™ compressors. The following Application Engineering bulletins should be consulted for non-modulating scroll application guidelines:

AE4-1331 ZPD34-ZPD54K5

AE4-1365 ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE

AE4-1303 ZPD103KC, ZPD120KC, ZPD137-182KC, ZRD94-125KC

AE4-1312 ZRD36-81KC

Nomenclature

The model number of the Copeland Scroll Digital compressors includes the approximate nominal 60 Hz capacity at the AHRI high temperature full load air conditioning rating point. An example is the ZPD120KCE-TFD, which has approximately 120,000 Btu/hr cooling capacity at the air conditioning rating point when operated on 60 Hz. Note that the same compressor will have approximately 5/6 of this capacity or 100,000 Btu/hr when operated on 50 Hz power. Please refer to the Online Product Information at Copeland.com for more information on performance at part load.

Digital Compressor Operation

The digital scroll is capable of seamlessly modulating its capacity from 10% to 100%. A normally closed (de-energized) solenoid valve is a key component for achieving modulation. When the solenoid valve is in its normally closed position, the compressor operates at full capacity, or loaded state. When the solenoid valve is energized, the two scroll elements move apart axially, or into the unloaded state. During the unloaded state, the compressor motor continues running, but since the scrolls are separated, there is no compression. During the loaded state, the compressor delivers 100% capacity and during the unloaded state, the compressor delivers 0% capacity. A cycle consists of one loaded state and one unloaded state. By varying the time of the loaded state and the unloaded state, an average capacity is obtained. The lowest achievable capacity is 10% which equates to 1.5 seconds of pumping during one 15 second cycle.

An example for the 15 second controller cycle: In any 15 second cycle, if the loaded time is 10 seconds and the unloaded time is 5 seconds, the average capacity is 66% or if the loaded time is 5 seconds and the unloaded time is 10 seconds the capacity during that 15 second period is 33%. See Figure 1 for a graphical representation of the digital cycle, and Figure 4 for a graph showing solenoid on-time vs. compressor capacity.

How it Works

The digital scroll compressor unloads by taking advantage of the Copeland Scroll compressor's axial compliance. All Copeland Scroll compressors are designed so that the compression elements can separate axially a few thousands of an inch. The ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC compressors described in this bulletin use a lift piston mechanism to separate the scrolls during the unloaded state. When the solenoid is energized the volume on top of the piston is vented to the low side allowing the piston and fixed scroll assembly to move axial away from the orbiting scroll. When the solenoid is de-energized the piston is forced down and the scrolls are loaded axially.

The ZPD103KC, ZPD120KC, ZPD137-182KC and ZRD94-125KC digital scroll compressors employ a solenoid valve that is mounted on the side of the compressor that vents the intermediate cavity to the low side of the compressor during the unloaded state. During the loaded state the solenoid valve is de-energized and the intermediate cavity is pressurized to load the floating seal and scrolls axially.

Please refer to Figures 2 and 3 for cross sectional pictures of the two digital modulation mechanisms.

APPLICATION CONSIDERATIONS

Operating Envelope

Refer to the fixed capacity compressor model family application bulletin for approved operating range. System testing is highly recommended to verify adequate oil return during fully loaded and modulated operation.

Solenoid Valve and Coil

Refer to the fixed capacity compressor model family application bulletin for approved operating range. System testing is highly recommended to verify adequate oil return during fully loaded and modulated operation.

Solenoid Valve and Coil

The external solenoid valve and coil specified by Copeland must be used since this is a critical component for the proper functioning of this compressor. The solenoid valve and coil are designed for approximately 32 million cycles. Do not attempt to substitute replacement coils or valves; use only the replacement parts specified in Table 4. Refer to the Service Procedures section for information on changing the modulation valves.

Pressure Fluctuations

During scroll modulation the suction and the discharge pressure will fluctuate. This fluctuation should be observed during unit testing. The installation and setting of pressure controls should take this into account. During the unloaded state, the discharge pressure will decrease and the suction pressure will increase. This normal pressure fluctuation has no observable effect on the reliability of the compressor or system components. System component manufacturers should be consulted to ensure the proper application of their products.

Piping

Unlike a variable speed compressor whose mass flow and gas velocity changes with its speed, the digital scroll's pumping capacity is equal to its 100% capacity while it is pumping. For this reason the gas velocity remains high even during periods when the capacity demand is low. Because the mass flow and gas velocity remain high, piping may be designed as if it were designed for a non capacity controlled compressor. For vertical piping a trap every 20 feet should be sufficient to ensure proper oil return. This recommendation is based upon a minimum 1500 fpm velocity or higher. When the digital scroll compressor is part of a tandem, a double riser should be considered to assure that the velocity remains above 1500 fpm when only the digital scroll is running.

Start Up and Shut Down

To improve the starting characteristics of the digital scroll compressor, the the Copeland controllers delay loading the compressor for 0.1 seconds. Likewise, to eliminate the reverse rotation sound at shut down the compressor is unloaded 0.5 seconds before shut down.

Compressor Cycling

Because of the digital scroll's seamless capacity modulation from 10% to 100%, capacity short cycling should not be a problem for single compressors. Modulating below 10% is not recommended due to possible motor overheat and inadequate oil return. However, if the digital compressor is in tandem with a non modulated scroll, short cycling of the non modulated compressor may be a problem if the system control is not designed and set correctly. The Copeland digital controllers have a built in two minute anti-short cycle timer to prevent short cycling.

Sound Characteristics

The sound spectrum of the loaded state and the unloaded state are different. Special consideration should be given to the transition sound between the loaded and unloaded states. If the transition sound is unacceptable, a heavy sound blanket should be applied to the compressor.

Fabricating Services (www.fabsrv.com) is one source for scroll compressor sound blankets.

The transition sound between the loaded and unloaded states has no observable effect on compressor components or reliability.

The Copeland controllers unload the compressor a fraction of a second before shut down allowing the scroll set to unload, ensuring a relatively quiet shutdown.

Internal Pressure Relief (IPR) Valve

WARNING

A high pressure control must be used in all ZRD94-125KC and ZPD103, ZPD120, ZPD137- 182KC applications because these compressors do not have internal pressure relief (IPR) valves.

High Pressure Control

As mentioned above, not all digital scrolls have IPR valves, therefore high pressure controls are required in some applications. The recommended maximum cut out setting is 425 psig (30 bar) for R-407C & R-22 and 650 psig (45 bar) for R-410A. The high pressure control should have a manual reset feature for the highest level of system protection. This pressure control must act independently of the digital compressor controller.

Low Pressure Control

Air-conditioning units can be protected against high discharge temperatures through a low pressure control in the suction line. Testing has shown that a cut out setting of not lower than 55 psig (3.8 bar) for R-410A and 25 psig (1.7 bar) for R-407C & R-22 will adequately protect the compressor against overheating from loss of charge, blower failure in a TXV system, etc. A higher level of protection is achieved if the low pressure control is set to cut out at 95 psig (6.7 bar) for R-410A and 55 psig (3.8 bar) for R-407C & R-22 to prevent evaporator coil icing. The cut in setting can be as high as 180 psig (12.5 bar) for R-410A and 105 psig (7.2 bar) for R-407C & R-22 to prevent rapid recycling in case of refrigerant loss.

For heat pumps, a cut out setting no lower than 20 psig (1.4 bar) is recommended for R-410A and 10 psig (0.7 bar) for R-407C & R-22.

Scroll Temperature Protection

Most digital scrolls do not have internal discharge gas temperature protection. In order for the Copeland controllers to operate properly an NTC sensor must be attached to the compressor discharge line as close as possible to the compressor discharge fitting. For best response the sensor should be insulated. See Table 6 of AE8-1328 for thermistor temperature vs. resistance values. Refer to Table 4 for part numbers of discharge line thermistors. Figure 5 illustrates the two different types of discharge thermistors.

The ZRD61 through ZRD81KC compressors have a discharge thermistor that is inside of a well in the top cap of the compressor. If this thermistor ever needs to be replaced, it should be replaced with either 985-0199- 00 or 085-0204-00 as listed in Table 4.

Crankcase Heaters

A crankcase heater is required if the system charge exceeds the system charge limits listed in Table 2. For more information regarding regarding heater part numbers and installation location please refer to the equivalent non-digital scroll Application Engineering bulletin listed on Page 4.

Oil Type and Oil Removal

Mineral oil is used in the ZRD*KC compressors for R-22 applications. Polyolester (POE) oil is used in the ZRD*KCE and ZPD*KCE compressors for R-22 & R-407C and R-410A applications respectively. See the compressor nameplate for the original oil charge. A complete recharge should be approximately four fluid ounces (118 ml) less than the nameplate.

It is an approved practice to use ZRD*KCE compressors with POE to replace ZRD*KC compressors with mineral oil in R-22 service applications. R-22 has been approved for use with both mineral and POE and some mixing of these oil in the system is acceptable.

If additional oil is needed in the field for POE applications, Copeland™ Ultra 32-3MAF, Lubrizol Emkarate RL32-3MAF, Parker Emkarate RL32-3MAF/ Virginia LE32-3MAF, or Nu Calgon 4314-66 (Emkarate RL32-3MAF) should be used. Copeland Ultra 22 CC, Hatcol EAL 22CC, and Mobil EAL Arctic 22 CC are acceptable alternatives.

If additional oil is needed in the field for mineral oil applications, Sonneborn Suniso 3GS or Chevron Texaco Capella WF32 should be used.

WARNING

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.

Power Factor

During the loaded state the digital scroll compressor operates at full capacity and the power factor is the same as a standard scroll. However, when the scrolls are unloaded, the power factor is much lower. If power factor is an important consideration, the correcting capacitors should be calculated using the full capacity data to avoid problems associated with over correction. See AE9-1249 for more information on power factor correction.

Tandem Applications

Tandem compressors follow the same application guidelines as single compressors outlined in this bulletin. The refrigerant charge limit for tandem compressors is shown in Table 2. A tandem circuit with a charge over this limit must have crankcase heaters applied to both compressors.

Tandem compressor assemblies are available for purchase from Copeland. In lieu of purchasing the assembled tandem, the OEM has the option to purchase the tandem-ready compressors to assemble the compressors into a tandem configuration in their manufacturing plant. Drawings of the tandem manifolds are available by contacting your application engineer. Figure 7 illustrates a typical tandem compressor assembly using ZPD34-ZPD54K5, ZPD61- ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC scroll compressors. Note that only one compressor in the tandem assembly is a digital scroll compressor. **Customers that choose to design and build their own manifolds for tandem and trio compressor assemblies are ultimately responsible for the reliability of those manifold sets.**

For more information on tandems, please refer to the non-modulating compressor Application Engineering bulletins listed on **Page 4**.

Modulation Control

Two different controls are available from Copeland to provide digital scroll modulation control, the Copeland Scroll Digital Compressor Controller and the Copeland Commercial Comfort Controller.

The Copeland Scroll Digital Compressor Controller is an open loop controller that provides control, protection, and diagnostics for the digital scroll and is suited for OEM applications. The system controller supplied by the OEM calculates the required compressor capacity and communicates that capacity to the digital scroll controller via a 1-5 VDC analog signal. For more information on the Copeland Scroll Digital Compressor Controller please refer to **AE8-1328**.

The Commercial Comfort Controller is a closed loop controller that provides modulation control based on space temperature and is suited for both OEM and retrofit applications. This controller is typically located in the conditioned space and controls the modulation cycle of the compressor without the need for an additional system controller. For more information on the Commercial Comfort Controller, please refer to **AE8-1393**.

NOTICE

For OEMs that choose their own controls package, the controls must include the protection features incorporated into the Copeland Scroll Digital Compressor Controller. Please consult with Application Engineering for a list of these requirements.

APPLICATION TESTS

Oil Level Verification

If the system configuration is more complex than a single circuit packaged system with one compressor, evaporator, and condenser, an oil return test is highly recommended during system development testing. For this test a sample compressor with a sight-tube should be used to observe the oil level over the entire operating range of the system at the expected compressor modulation rates, to ensure an adequate oil level in the compressor at all times. The oil level should not go below the weld points of the lower bearing bracket for the ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36- 81KC compressors. For the ZPD103KC, ZPD120KC, ZPD137-182KC and ZRD94-125KC digital scrolls the minimum oil level is 1.5" (40 mm) below the center of the standard oil sight-glass on the compressor. If the oil level falls below the prescribed level for more than a few minutes either more oil is required in the system or an oil recovery cycle is needed. For more information on what an oil recovery cycle is, please consult with Application Engineering.

If the system contains more than 20 pounds (9 kg) of refrigerant, it is our recommendation to add one fluid ounce of additional oil for every 5 pounds (15 ml/kg) of refrigerant over this amount. This is a starting point and oil should be added as determined through system testing or as required by the end use application in the field.

The compressor oil level should be checked with the compressor 'off' to avoid the sump turbulence when the compressor is running. Manifolded compressors should have their oil levels checked after 20 to 30 seconds of off time, to allow oil balancing between the manifolded compressors.

Excessive Liquid Flood Back Tests

It is expected that the design will not flood during operation at all of the varying loaded and modulation conditions. This places demanding requirements on the flow control device to control refrigerant flow and superheat all the way down to 10% of full load. **Throughout the operating range of the unit, the suction superheat must remain positive**. If the flow control device is unable to maintain superheat, an electronic expansion valve, accumulator, or other means must be taken to maintain at least 20°F of compressor sump superheat.

Operating Envelope Test

System testing should consist of unit/system operation at abnormal operating conditions to verify that suction superheat and compressor discharge temperatures stay in a range that is healthy for the compressor and tripping of the compressor overload is avoided. Please consult with application engineering for recommended tests and analysis of test data.

DIGITAL COMPRESSOR RETROFIT APPLICATIONS

Copeland is not responsible or liable for incorrect energy use predictions.

Successful digital scroll retrofit projects, and resultant energy savings, have been documented by several industry energy groups. Predicting the energy usage and calculating a return on investment before the project is undertaken is not trivial and is best done by experienced companies that use advanced software programs to predict energy use. Before large retrofit projects are considered, as much front-end analysis as possible should be done to better predict how much energy might be saved. Tabular performance data and the ten coefficients for the AHRI polynomial equation for performance at 50% and 100% load are available for modeling purposes in the Online Product Information (OPI) section at Copeland.com.

System Modifications

NOTICE

Always check with the OEM of the equipment being considered for the digital scroll retrofit, before the retrofit is undertaken. The OEM may have specific instructions developed that offer step by step guidance.

Before beginning the retrofit, the system should be operable and system operating conditions should be logged for future reference. The compressor suction and discharge pressures, suction superheat, subcooling, volts, amps, evaporator air flow and leaving temperature, and system charge should all be measured and recorded prior to any system modifications.

Compressor Selection & Change-Out

The replacement digital scroll compressor should be compared to the non-modulating compressor in at least these three areas:

1. Performance - the full load capacity of the digital scroll should be approximately equal to the capacity of the compressor being replaced. In some cases in might make sense to 'right size' the compressor capacity for the load if the compressor is grossly oversized.
2. Electrical - the digital scroll compressor RLA and LRA should be compared to the compressor being replaced. Contactor, wire, breaker/fuse, and run capacitor sizes should be evaluated.
3. Mechanical - in most cases the compressor mounting will be identical for the non-modulating and the digital scroll. There could be minor differences in the suction and discharge tubing locations, as well as the height of the compressor.

The following steps should be followed to remove the non-modulating compressor from the system.

1. Using an EPA approved refrigerant recovery machine, recover the system refrigerant charge from the low and high sides of the system.
2. Disconnect and lockout the power supply. Confirm that all voltage sources have been disconnected by using a voltmeter. Disconnect the conduits and wiring to the compressor and move them out of the way as much as possible.
3. By using manifold gauges, verify that the system refrigerant charge is completely recovered from the system. Suction and discharge pressures must be 0 psig.
4. Using a tubing cutter, cut the suction and discharge lines close to the compressor.
5. Remove the compressor mounting bolts
6. Plug the compressor suction and discharge connections to prevent the spillage of oil from the compressor when removing it from the system.
7. Using the appropriate lifting devices, carefully remove the compressor from the system.

The following steps should be followed to install the digital compressor into the system.

1. Before removing the rubber plugs, install the compressor in the unit on the mounting grommets using the appropriate lifting devices.
2. Install the compressor mounting bolts.
3. Connect the suction and discharge lines using standard brazing practices.
4. If the compressor has an external modulation valve and tubing (ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC only) refer to Figure 6 for the correct valve orientation and position. Wrap a wet rag around the valve and complete the assembly by brazing the valve and tubing into place.
5. Check for leaks using nitrogen with a properly sized regulating and relief valve.
6. Connect conduits and wiring to the compressor. Inspect and/or replace the contactor. If the compressor is 1-phase, install the correct run capacitor.

NOTICE

The above procedures for changing the compressor are not comprehensive and additional steps/procedures may be necessary.

Refrigerant Flow Control

In the system with a digital compressor, the refrigerant flow control valve is required to control flow across a wide range of flow rates and varying pressure differentials. Most balanced port thermostatic expansion valves can control flow down to about 40% of their rated capacity. Excessive hunting and loss of superheat control can result when asking a thermostatic expansion valve to operate outside of its design range. For this reason, the expansion device needs to be evaluated to ensure reliable operation over the expected operating range. Limiting the minimum compressor modulation rate to a value that the expansion valve can tolerate should be considered. Electronic expansion valves should be considered if modulation over the entire range of the compressor's modulation range is anticipated.

Evaporator Air Flow

For the highest level of energy savings, comfort, and efficiency the variable capacity system should be capable of varying the air flow. Variable frequency drives and tapped blowers are two means of reducing air flow. Reducing air flow in humid or maritime climates is important to maintain coil temperatures low enough to remove latent heat. In desert and arid climates, because of low or no latent loads, air flow is less critical.

The controls required for variable air flow are not provided by Copeland so the contractor may need to consult with controls experts in this field.

Condenser Air Flow

Modulating the condenser air flow is not critical to the success of the application. For the highest level of energy savings, condenser air flow will be reduced based on the compressor modulation rate, condensing temperature, ambient temperature, etc.

Modulation Control

The preferred modulation control for retrofit applications is the Commercial Comfort Controller. This controller is a closed loop controller that is installed in the conditioned space. The controller measures the space temperature and through an algorithm in the controller, controls the modulation of the digital scroll. The controller can be positioned up to 300 feet from the compressor/unit, is configurable for roof top unit or heat pump, and is wired like a commercial room thermostat. For more information on the Commercial Comfort Controller please refer to **AE8-1393.**

ASSEMBLY LINE PROCEDURES

Modulation Valve Brazing Procedure

ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC

The external modulation valve is purchased and shipped separately from the ZPD34-ZPD54K5, ZPD61- ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC digital scroll. Therefore, assembly is required in the OEM manufacturing plant. Figure 6 illustrates the correct position and orientation of the modulation valve. Please note the direction of the arrow on the valve, it must point to suction.

When brazing the modulation valve into the system, the valve must be wrapped with a wet rag to help keep the valve cool. The torch flame must be directed away from the valve and the brazing operation should be done quickly so the valve isn't overheated. The brazing operation should be performed with a nitrogen purge to prevent the build-up of copper oxide. The solenoid coil should be installed after the brazing operation, so the leads are kept away from the brazing operation and the wet rag is able to fully contact the valve body.

Pressure Testing

The pressure used on the OEM assembly line to meet the UL burst pressure requirement cannot be higher than 400 psig (27.6 bar) for R-407C & R-22 and 475 psig (32.8 bar) for R-410A. Higher pressure may result in permanent deformation of the compressor shell and possibly cause misalignment or bottom cover distortion.

SERVICE PROCEDURES

Modulation Troubleshooting

The modulation valve and solenoid coil are engineered for specific use with the digital scroll. Don’t attempt to substitute replacement solenoid coils that are not of the correct part number. The ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC modulation valves must be installed in the correct orientation and with the arrow on the valve pointing to suction. Installing a modulation valve in a horizontal position, or with the suction and discharge connections reversed, can result in sporadic operation of the modulation valve. See **Figure 6** for an illustration of the correct valve location and orientation.

Figure 8 is a troubleshooting flow chart to help with simple modulation problems. For more information on troubleshooting the Copeland™ Digital Compressor Controller please refer to **AE8-1328**. For more information on troubleshooting the Commercial Comfort Controller please refer to **AE8-1393**.

Modulation Valve Replacement Procedure ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC

The ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC digital scroll compressors employ a modulation valve that is mounted external to the compressor in the modulation tubing. To replace the modulation valve, follow these recommended steps:

1. Disconnect and lockout the power to the unit.
2. Recover the refrigerant charge from the compressor/ system.
3. Remove the screw holding the coil to the valve using a Phillips screwdriver or appropriate size nut driver.
4. Remove the coil from the valve.
5. **Using manifold gauges, double check to make sure the refrigerant charge is completely recovered from the compressor before proceeding.**
6. Using tubing cutters, cut the modulation tubing close to the valve body leaving the valve tubing stubs in the suction 'T' connection and the swaged tubing from the compressor top cap.
7. Carefully unbraze and remove the tubing stubs from the suction 'T' and top cap tubing swage. Carefully unbrazing and removing these stubs will allow the tubing/suction 'T' fitting to be reused.
8. After these fittings have cooled, clean the fittings and prepare to braze the new valve in place. Wrap a wet rag around the valve body to keep from overheating the valve.
9. Using standard brazing practices for refrigeration systems, carefully braze the new valve into the system, directing the torch flame away from the valve body.
10. Check for leaks using nitrogen with a properly sized regulating and relief valve.
11. Install the solenoid coil and torque the retaining screw to 25 in-lbs.
12. Evacuate the compressor/system and put the system back into operation.

Modulation Valve Replacement Procedure ZPD103KC, ZPD120KC, ZPD137-182KC and ZRD94-125KC

The ZPD103KC, ZPD120KC, ZPD137-182KC and ZRD94-125KC digital scroll compressors have a modulation valve that is replaceable in the event the valve stops functioning. The modulation valve threads into a receptacle that is inside the small terminal box on the compressor. To replace the modulation valve, follow these recommended steps:

1. Disconnect and lockout the power to the unit.
2. Recover the refrigerant charge from the compressor/ system.
3. Remove the cover from the small terminal box and remove the screw holding the coil to the valve using a Phillips screwdriver or appropriate size nut driver.
4. Remove the coil from the valve and clean the area around the valve body to prevent debris and dirt from entering the system when changing the valve.
5. **Using manifold gauges, double check to make sure the refrigerant charge is completely recovered from the compressor before proceeding.**
6. Using a 7/8” deep well socket and ratchet, turn the valve counterclockwise to remove the valve.
7. 7. Visually inspect the valve receptacle on the compressor for damage or debris. Ensure that the black o-ring and white PTFE gasket are removed with the valve and do not remain on the valve receptacle.
8. . The replacement valve should have a new, black o-ring and white, PTFE gasket as shown:

9. Use care when handling the replacement valve - don’t drop the valve or impact the solenoid stem. If the valve is dropped or damaged, discard it and obtain a new valve for replacement.
10. Lightly oil the gaskets with refrigeration oil and hand tighten the new modulation valve into the valve receptacle on the compressor.

11. Using a 7/8” deep well socket and a torque wrench, torque the modulation valve to 230 in-lbs.
12. Check for leaks using nitrogen with a properly sized regulating and relief valve.
13. Install the solenoid coil and torque the retaining screw to 25 in-lbs.
14. Install the terminal box cover, evacuate the compressor/system, and put the system back into operation.

NOTICE

The above procedures for changing the modulation valve are comprehensive. Depending on the equipment being serviced, additional steps may be required. Refer to OEM instructions for more information.

Copeland Scroll Compressor 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 may 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 the inherent overload motor 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.
3. Proper indoor and outdoor blower/fan operation should be verified.
4. Remove power from the unloader solenoid to load the compressor 100% . 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 (this procedure is for 3-phase compressors only) 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.any two of the compressor power leads (this procedure is for 3-phase compressors only) 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.

   The solenoid coil should only be energized when it is installed on the solenoid valve. Energizing the coil when it is not installed on the valve will result in a failed coil.

   Note: It is also possible that the unloader valve is not closed. With the compressor off, cycle power to the unloader solenoid and listen for clicking. If no sound is heard the valve is very likely stuck.

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 ±15% from published values, a faulty compressor may be indicated. A current imbalance exceeding 15% of the average on the three phases 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, Form No. 6400.**

7. Before replacing or returning a compressor: Be certain that the compressor is actually inoperable. 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 misdiagnosed in the field as being inoperable. Replacing working compressors unnecessarily costs everyone.

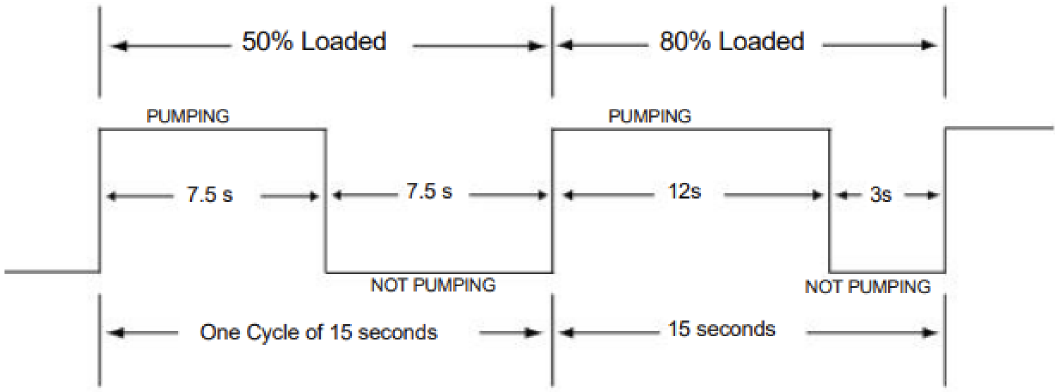


Figure 1
Digital Cycle Example

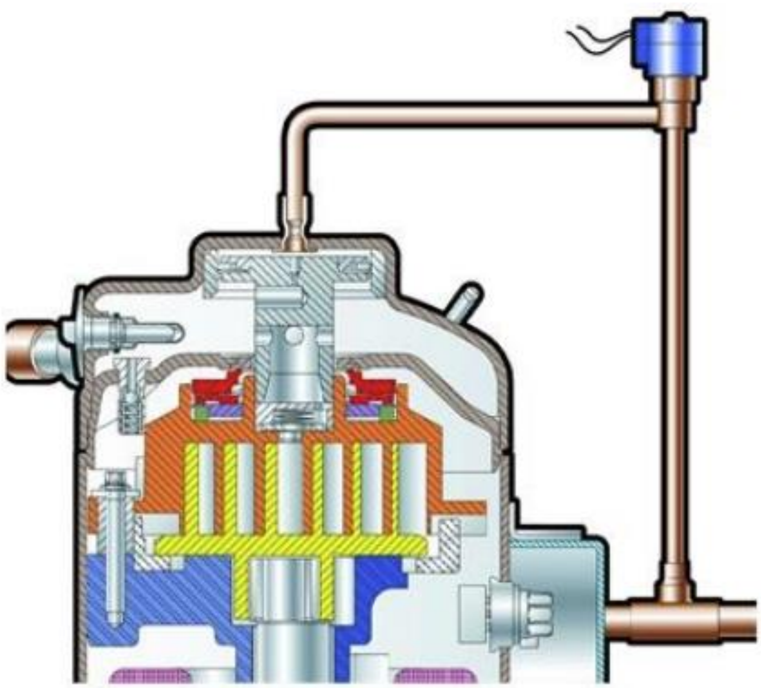


Figure 2
Digital Scroll Cross Sectional View
ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC

Note: Modulation tubing is show for reference only.
Refer to Figure 6 for the correct modulation tubing configuration.

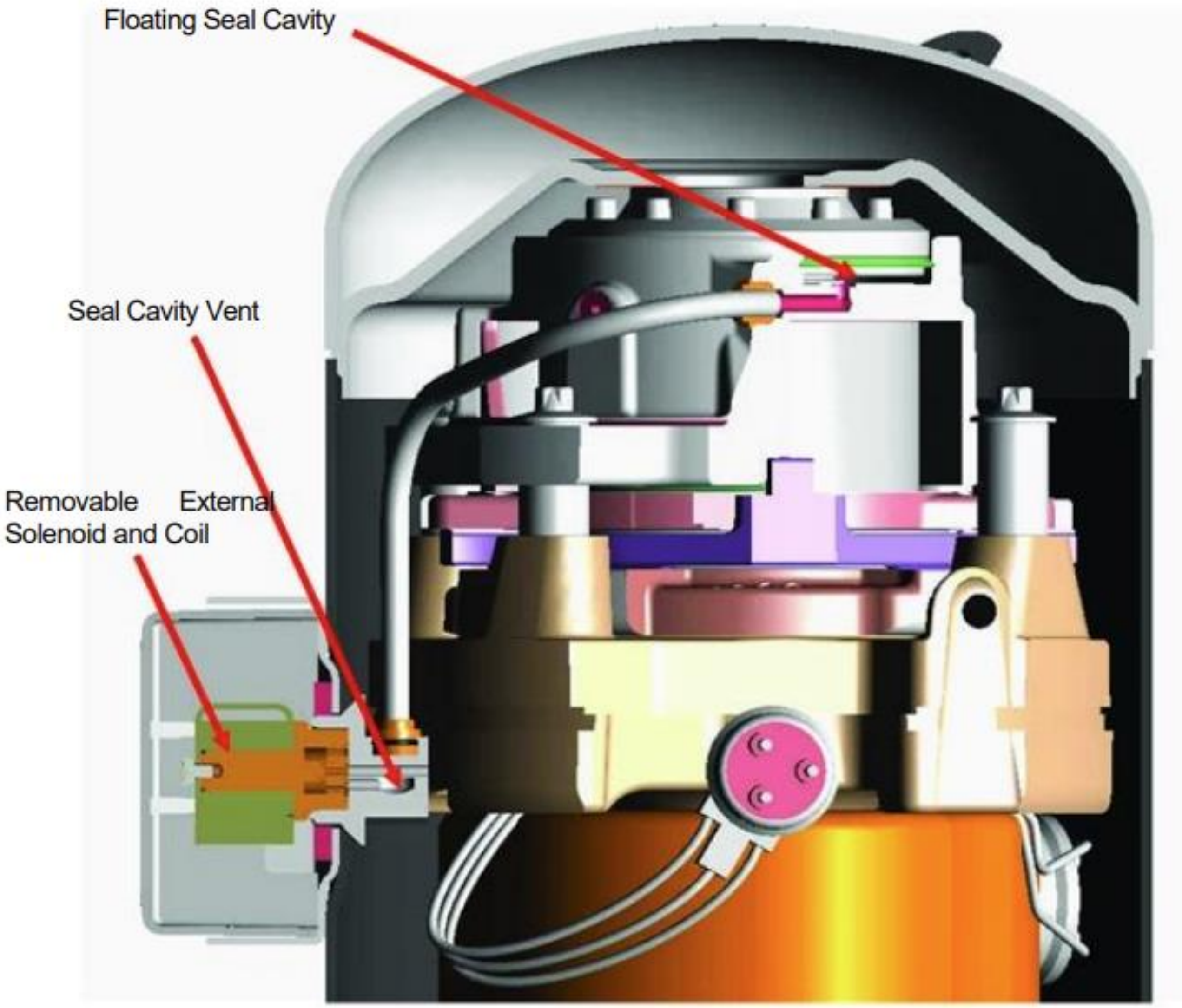


Figure 3
Digital Scroll Cross Sectional View
ZPD103KC, ZPD120KC, ZPD137-182KC and ZRD94-125KC

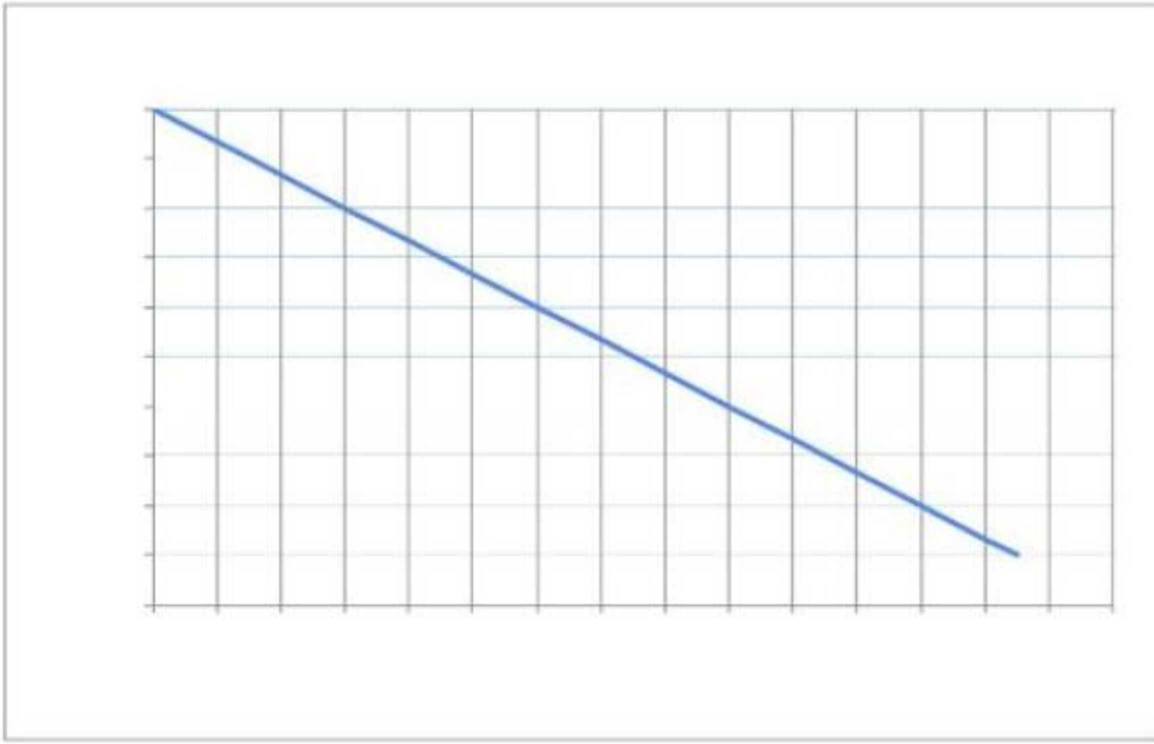


Figure 4
Compressor Capacity Graph

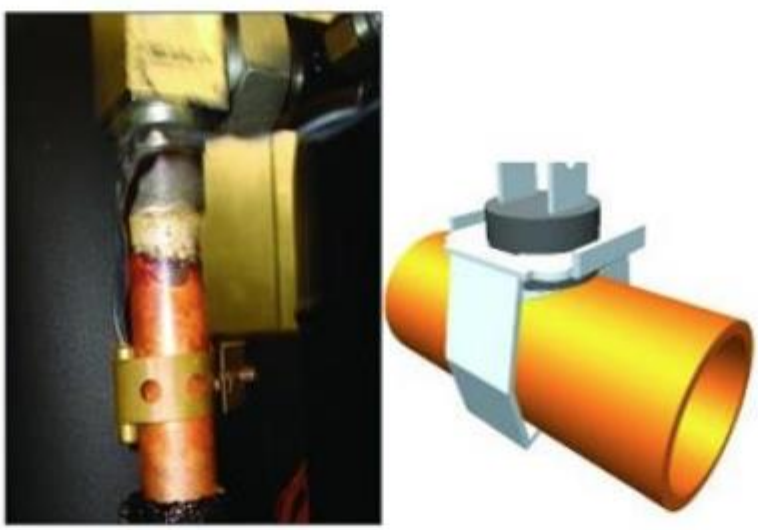


Figure 5
Discharge Thermistors

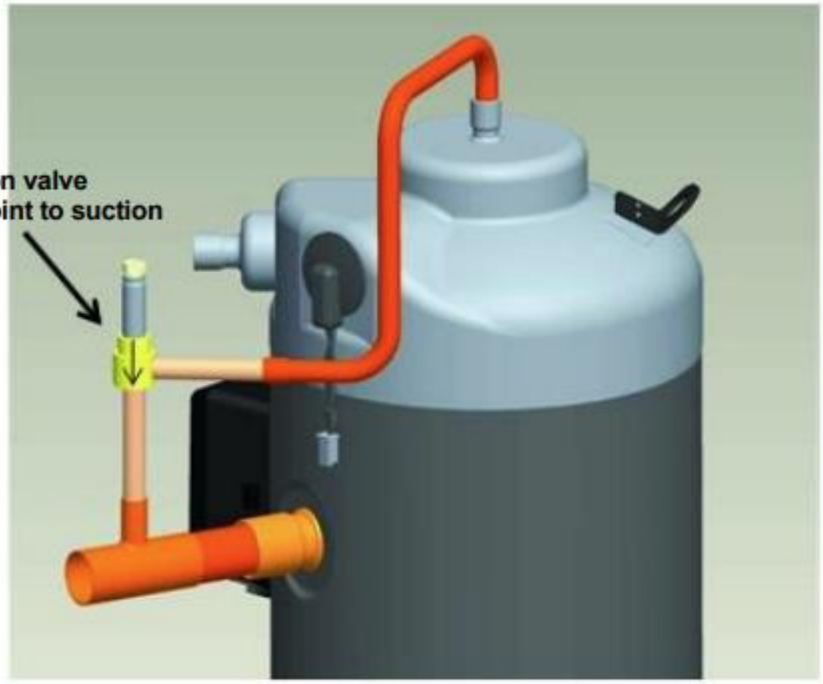


Figure 6
Modulation Valve Piping
ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC

Figure 7
Tandem ZPD34-ZPD54K5, ZPD61-ZPD83KC, ZPD91KC, ZPD104KCE, ZPD122KCE, and ZRD36-81KC

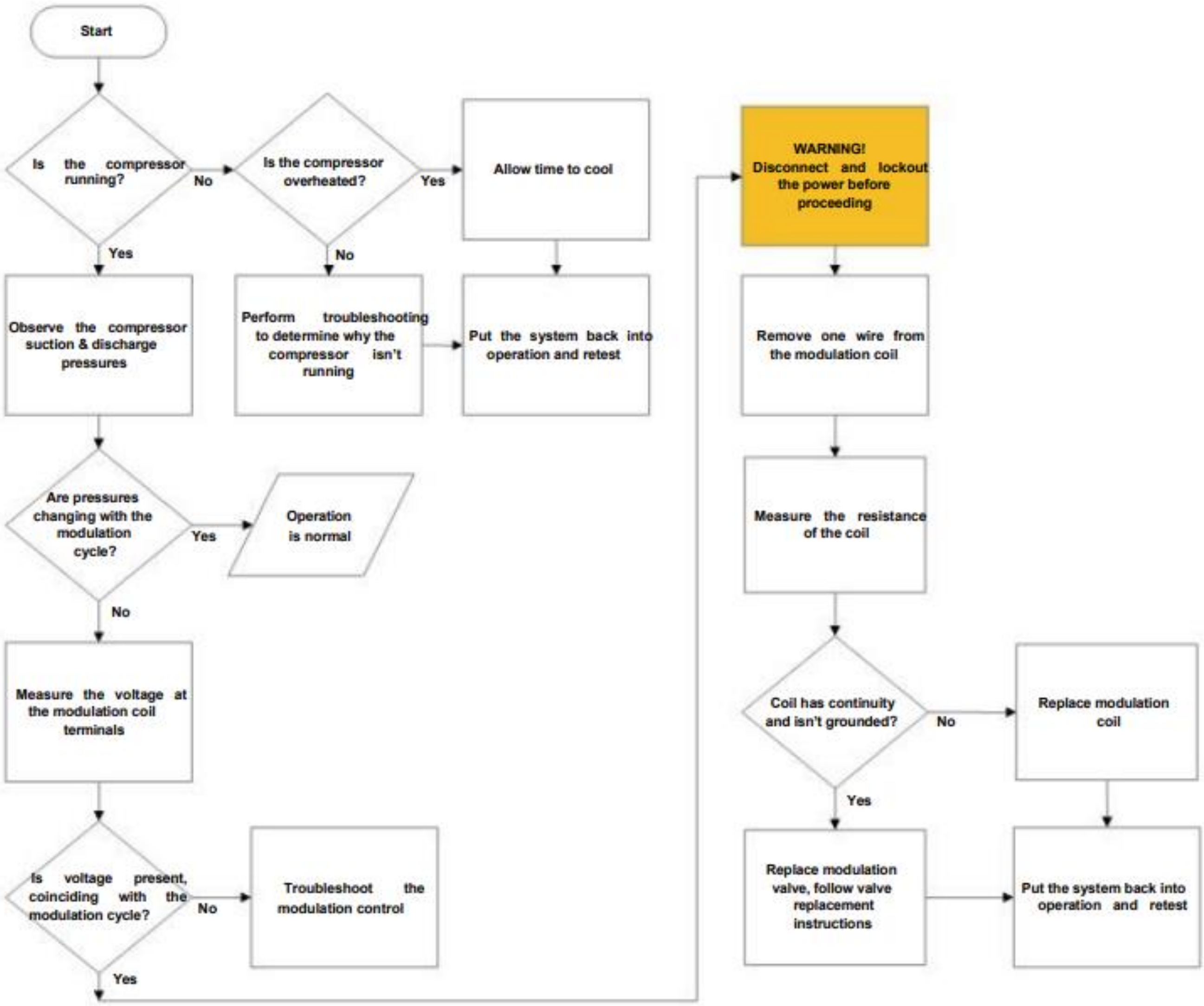


Figure 8
Modulation Troubleshooting

Table 1 -Copeland Scroll Digital Family Features

<table>
<tr><th>Model</th><th>Digital Modulation Valve</th><th>Discharge Gas Temperature Protection</th><th>Discharge Check Valve</th><th>Internal Pressure Relief (IPR) Valve</th><th>Modulation Control</th></tr>
<tr><td>ZPD34-54K5</td><td rowspan="4">Required Accessory</td><td rowspan="3">External Sensor Required</td><td rowspan="4">No</td><td rowspan="4">Yes</td><td rowspan="7">15 Second Cycle</td></tr>
<tr><td>ZRD36-48KC</td></tr>
<tr><td>ZPD61-ZPD83</td></tr>
<tr><td>ZRD61-81KC</td><td>Internal Top Cap Thermistor</td></tr>
<tr><td>ZPD103, ZPD120, ZPD137-182KC</td><td rowspan="2">Installed On Compressor</td><td rowspan="2">External Sensor Required</td><td rowspan="2">Yes</td><td rowspan="2">No</td></tr>
<tr><td>ZRD94-125KC</td></tr>
<tr><td>ZPD91, ZPD104, 122KC</td><td>Required Accessory</td><td>External Sensor Required</td><td>No</td><td>No</td></tr>
</table>

Table 2 - Refrigerant Charge Limits

Model	Charge Limit	
	Pounds	kg
ZPD34-54K5	8	3.6
ZPD61-ZPD83, ZPD91	10	4.8
ZPD90, 103, 120, 137KC	16	7.2
ZPD154-182KC	18	8.2
ZPDT12-18MC	12	5.4
ZPDU13MC	12	5.4
ZPDT21-27MC	24	10.9
ZPDT31-36MC	27	12.2
ZRD36-48KC	8	3.6

Model	Charge Limit	
	Pounds	kg
ZRD61-81KC	10	4.8
ZRD94-125KC	16	7.2
ZRDT96KC	12	5.4
ZRDU11-13MC	12	5.4
ZRDT12-16MC	12	5.4
ZRDT25MC	27	12.2
ZPD104KCE	11	5
ZPD122KCE	11	5

Table 3 - Torque Values

Part	Torque	
	Foot - Pounds	Inch - Pound
Modulation Valve (ZPD103, ZPD120, ZPD137-182KC and ZRD94-125KC)	18.8-19.5	225-235
Solenoid Coil Screw	1.9 - 2.3	22.5 - 27.5

Table 4 - Compressor Accessories

Part Category	Part Description	Part Number	Models	Notes
Modulation	Copeland Scroll™ Digital Compressor Controller	943-0024-01	All	15 Second Modulation Cycle, 24V
	Emerson Commercial Comfort Controller	943-0175-00	All	15 Second Modulation Cycle, 24V
	Modulation Valve & 24V Coil	998-0061-19	ZPD34-54K5 ZPD61-83KC ZPD91KC ZPD104KC ZPD122KC ZRD34-81KC ZPD34-54K5 ZPD61-ZPD83 ZPD91KC ZRD34-81KC	All coils have 1/4" spade electrical terminals
	Modulation Valve & 110V Coil	TBD		
	Modulation Valve, 24V Coil, Tubing Kit	998-0090-02		Tubing kit is for 7/8" compressor suction; All coils have 1/4" spade electrical terminals
	Modulation Valve & Tubing Kit	998-0090-01		
	Modulation Valve	910-0182-00	ZPD103 ZPD120 ZPD137-182KC ZRD94-125KC	All coils have 1/4" spade electrical terminals
	24V Coil: Holding VA (Max) @ 60 Hz = 20.0	998-0060-03		
	120V Coil: Holding VA (Max) @ 60 Hz = 17.3	998-0060-04		
	200/220V Coil: Holding VA (Max) @ 60 Hz = 19.2	998-0060-09		
Mounting	Refer to the application engineering bulletins for the equivalent non-digital compressor model for parts in these categories. Or, refer to the 'service parts' section at EmersonClimate.com			
Crankcase Heaters				
Oil				
Electrical				
Tandems				
Diagnostics & Protection	Discharge Line Thermistor	985-0199-00	ZPD34-54K5 ZPD61-83KC ZRD36-72KC	Fits 1/2" discharge tube
		985-0200-00	ZPD103-182KC ZRD94-125KC	Fits 7/8" discharge tube
		985-0262-00	ZPD91KC ZRD81KC	Fits 3/4" discharge tube
Retrofit Kits	Commercial Comfort Controller, Modulation Valve, 24V Coil, & Tubing Kit	980-7000-00	ZPD34-54K5 ZPD61-ZPD83, ZPD91, ZPD104 ZPD122KC ZRD36-48KC ZRD61-81KC	Thermistor 085-0204-00 and clamp 032-0689-00 must be used with ZRD81KC and ZPD91KC applications
	Commercial Comfort Controller, Discharge Thermistor, & 24V Coil	980-7000-01	ZPD103, ZPD120, ZPD137-182KC ZRD94-125KC	
Flow Washer	14.40 I.D. & 22.13 O.D	102-0164-11	ZPDU-85K	See tandem drawings for flow washer location
	13.50 I.D. & 22.13 O.D.	102-0164-12	ZPDU-10M	