Application Engineering

*ZPV021*E - ZPV041*E and ZHV021*P - ZHV034* Copeland Scroll Variable Speed Compressors*

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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

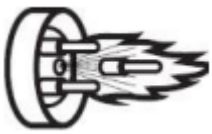
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• 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.

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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.**

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• 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.

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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.

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Introduction

This bulletin provides instructions on how to apply a Copeland Scroll variable speed compressor in a safe and reliable manner. The Copeland Scroll variable speed compressor will be referred to throughout this bulletin as the 'variable speed scroll' or the 'compressor.'

Product Description

The variable speed scrolls have a speed range of 900 to 7000 revolutions per minute and are intended for use in air conditioning, air-source heat pump, and geothermal applications. The scroll compression technology is based on the efficient and reliable ZP*K5 Copeland Scroll platform. The variable speed scrolls use a three-phase brushless permanent magnet (BPM) motor. The variable speed scroll and Copeland Motor Control drive combination has been designed for maximum efficiency and reliability. If use of a non-Copeland drive is desired, please work with Application Engineering to select an appropriate drive for the compressor application. See third party drive requirements on page 5. For more information on the motor control drive see AE-1405.

Compressor Data

Compressor mechanical, electrical, and performance data are available online and can be accessed by selecting the Online Product Information option at www.Copeland.com. From this site, compressor drawings (PDF format) can be downloaded. Other drawing formats (IGES, DXF, and STP) can be obtained by contacting your Application Engineer.

Other performance data available to the system designer includes sound, vibration, and coefficient data for the polynomial equation used to represent tabular performance data.

Power Supply

The Copeland Motor Control drive will convert the 50/60 Hertz input voltage into a variable frequency and voltage to power the compressor. For more information on the drive power input requirements please see AE-1405.

Nomenclature

The model number of the variable speed scroll includes the cubic centimeters per revolution. Figure 1 provides a complete explanation of all of the alpha and numeric characters in the compressor model number.

Agency Approvals

The ZPV and ZHV compressors described in this bulletin will be U.L. recognized.

OEM Lab Testing

Application Engineering should be consulted during the design, development, and production launch of the variable speed system to help ensure that the variable speed scroll is applied as intended, in a safe and reliable manner.

Drive & Variable Speed Scroll Set-Up

Detailed instructions on how to set up the motor control drive and variable speed scroll for “open loop” lab testing are available by contacting Application Engineering. The instructions illustrate how to control the drive and compressor via a user interface (i.e. lap top computer), a USB driver and cable. Application Engineering is available to assist during any part of this process.

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Modeling System Performance

To help the design engineer model system performance for a given speed, coefficients for mass flow, capacity and power are available by request.

Compressor Design Features

Compressor Motor

The variable speed scroll has several design features that enable efficiency and reliability. Figure 2 shows the internal features that are unique to the variable speed scroll.

Oil Pump

The variable speed scroll is equipped with an oil pump to ensure an adequate supply of oil to the bearing system throughout the operating speed range of 900 to 7000 RPM.

Application Considerations

Refrigerant

The variable speed compressors are approved for use with R-410A only. Use of refrigerants other than R-410A voids the UL recognition of these compressor models since the motor overload system could be adversely affected.

Third Party Drive

The customer may use a third-party drive. A third party control system must include discharge temperature protection, current overload protection, and a soft start and stopping routine. Stator heat control is also recommended for optimal performance and reliability. It should also include the operating map parameters. Contact Application Engineering for compressor motor specifications and speed adjustment requirements. It is important to ensure correct wiring at both the compressor and drive connections prior to starting the compressor to avoid a mis-wire or powered reverse situation. Both situations could potentially cause compressor damage.

Operating Envelope

The compressor operating envelope at each speed represents the allowable range of operating conditions for the compressor at the superheat and subcooling values defined on the envelope. The most current and updated operating envelopes can be accessed by selecting the Online Product Information option at Copeland.com.

Each drive is programmed with the performance characteristics of the compressor to protect and ensure reliable operation.

Operating the compressor at evaporating temperatures that are higher than those specified in the envelopes for the given speed will result in a higher oil circulation rate. A higher oil circulation rate can reduce heat exchanger efficiency and possibly result in oil pumpout if the system has long interconnecting piping. Customers that choose to operate in these higher evaporating temperature areas should use a sighttubed compressor sample during system development testing to ensure that an adequate level of oil is maintained in the compressor sump. Sight-tubed compressors for monitoring the oil level are available by contacting Application Engineering.

The lower right boundary of the operating envelope is the minimum compression ratio required to keep the scrolls loaded. Operation below this boundary could result in the compressor intermittently loading and unloading and noisy operation. See the Reversing Valves section of this bulletin for more information on operation in this area of the envelope. (Water heating applications may require longer durations at low compression ratios. Please review with Application Engineering)

The upper left boundary of the envelope represents the maximum compression ratio. If the operating condition approaches this boundary of the envelope the

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compressor discharge temperature will begin to approach the maximum scroll temperature allowed by the discharge line thermistor. The thermistor must signal the drive or system unit controller to shutdown if the discharge line temperature exceeds the specified temperature on the operating envelope. If the suction superheat is less than 20F°, the operating condition can go beyond the boundary without exceeding the discharge line temperature limit.

High Pressure Control



A high pressure control must be used in all applications.

A high pressure control must be used with these compressors since they do not employ an internal pressure relief valve (IPR). The maximum cut-out setting must not exceed 650 psig. The high pressure control must signal the drive or system unit controller to immediately stop compressor operation. The high pressure control should have a manual reset feature for the highest level of system protection. An alternate method is to lock-out compressor operation after three consecutive trips of the high pressure control.

Low Pressure Control

A low pressure control is required to protect against loss of charge and other system fault conditions that can lead to compressor overheating. A low pressure cut-out switch located in the suction line with a cut-out setting no lower than 20 psig is required in all heat pump applications. For air conditioning units, a cut-out setting no lower than 55 psig will adequately protect against most low pressure faults. A higher level of protection for air conditioning units can be realized if the cut-out setting is increased to 95 psig to prevent evaporator coil icing

Discharge Temperature Protection



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

The ZPV and ZHV models described in this bulletin do not have internal discharge gas temperature protection. In order for the drive to operate properly a thermistor must be attached to the compressor discharge line less than 6 inches from the compressor discharge fitting. For best response the sensor must be insulated. Reference the operating map for maximum operating discharge line temperatures.

Motor Overload Protection

The drive will provide motor over current protection in the event the compressor becomes mechanically locked or if the load on the compressor motor is abnormally high.

Oil Type

The variable speed scrolls are charged with Polyolester (POE) oil. See the compressor nameplate for the original oil charge. A complete recharge should be approximately four fluid ounces less than the nameplate value. Copeland Ultra 32-3MAF, available from Copeland Wholesalers, should be used if additional oil is needed in the field. Mobil Arctic EAL22CC, Emkarate RL22, Emkarate 32CF and Emkarate 3MAF are acceptable alternatives.



CAUTION! POE oil 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, and spills should be cleaned up quickly with paper towels, soap and water.

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Screens

Screens finer than 30x30 mesh should not be used anywhere in the system with these compressors. Field experience has shown that finer mesh screens used to protect expansion valves and other system components 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.

Contaminant Control.

Copeland Scroll compressors leave the factory with a miniscule amount of contaminants. Manufacturing processes have been designed to minimize the introduction of solid or liquid contaminants. Dehydration and purge processes ensure minimal moisture levels in the compressor and continuous auditing of lubricant moisture levels assure that moisture isn't inadvertently introduced into the compressor.

Moisture levels should be maintained below 50 ppm for optimal performance. A filter-drier is required on all R-410A and POE lubricant systems to prevent solid particulate contamination, oil dielectric strength degradation, ice formation, oil hydrolysis, and metal corrosion. It is the system designer's responsibility to make sure the filter-drier is adequately sized to accommodate the contaminants from system manufacturing processes that leave solid or liquid contaminants in the evaporator coil, condenser coil, and interconnecting tubing plus any contaminants introduced during the field installation process. Molecular sieve and activated alumina are two filter-drier materials designed to remove moisture and mitigate acid formation. A 100% molecular sieve filter can be used for maximum moisture capacity. A more conservative mix, such as 75% molecular sieve and 25% activated alumina, should be used for service applications.

Refrigerant Piping

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

Oil Recovery

An oil recovery cycle is required for continuous operation of over two hours below 1800 RPM. This cycle is accomplished by ramping the compressor speed up to a higher speed to increase the refrigerant flow rate to flush or sweep oil back to the compressor. The exact parameters for an oil recovery cycle need to be evaluated for each system by oil return tests, as they may differ depending on system application. A recommended cycle would be to ramp the compressor speed up to 3600 RPM for 5 minutes. Please contact and review with Application Engineering for any desired changes to this oil recovery cycle requirement.

Discharge Check Valve

The variable speed scroll uses the same discharge check valve design that is used in other Copeland Scroll compressors. This check valve is not a low leak-back check valve and will have a greater leak rate when pressure differential across the check valve is low.

Suction and Discharge Tube Design

Proper tube design must be taken into consideration when designing the tubing connecting the variable speed scroll to the system. The tubing should provide enough "flexibility" to allow normal starting and stopping of the compressor without exerting excessive stress on the tube joints.

Because the variable speed scroll has a broad running frequency range (15 to 120 Hz), it will be difficult to avoid

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all the natural frequencies that may exist in the system piping. The system designer must carefully evaluate these resonant frequency conditions and either a) avoid them by not allowing the compressor speed to align with the resonant frequency, or b) evaluate the risk and life of the piping system when the compressor is allowed to run at frequencies that are coincident with natural frequencies of the piping system. To do part "b", strain gauging the system piping is required. For assistance in evaluating strain gauging results contact Application Engineering.

In order to properly determine if a design is appropriate for a given application, samples should be tested and evaluated for stress under various conditions of use including frequency, load fluctuations, and shipping vibration. The guidelines above may be helpful; however, testing should be performed for each system designed. For further assistance and analysis of test results please contact Application Engineering.

Starting and Stopping Routine

The Motor control drive controls the starting and stopping routine of the variable speed scroll. This routine allows soft starting allowing for oil priming, and controlled stopping, an advantage over traditional on-off control of fixed capacity units. Please refer to AE-1405 for an exact explanation of the starting and stopping process. The variable speed scroll uses an HVE valve, which prevents reverse rotation during shut down; however, there may be some shutdown sound with the variable speed scroll.

Compressor Mounting

The variable speed compressors have pierced holes in the mounting feet so mounting grommets with a relief are not required. Table 2 lists the recommended mounting parts. It is extremely important to use the correct durometer grommet and to have consistent durometer quality. Wrong or inconsistent durometer of the mounting grommets can result in sound and vibration complaints. For additional information on grommet durometer please consult with Application Engineering.

Discharge Mufflers

For a variable speed compressor, discharge pulse will generally decrease as speed increases or if compression ratio decreases. As speed decreases or if compression ratio increases the discharge pulse will increase. Fixed capacity or two-step capacity units have typically had discharge gas pulsation mufflers only in heat pump applications. The variable capacity heat pump and air conditioner may both require a discharge gas pulsation muffler. Discharge pulse amplitude and frequency and their effects on the piping system must be considered.

Airborne Sound Control

n addition to structure and gas borne sound transmission, special consideration needs to be given to compressor airborne sound. Sound data are also available at the nominal cooling condition of 50°F evaporating and 115°F condensing at 4500 RPM. If airborne sound attenuation is required for the application, Fabricating Services (www.fabsrv.com) is one manufacturer of custom sound solutions.

Expansion Devices

The expansion device is a crucial component of the variable capacity system. Fixed-orifice devices, which are chosen or optimized at one particular operating condition, will not have the ability to control the refrigerant flow across a wide range of operating pressures and flow rates required by the variable capacity system.

To better control superheat, the thermal expansion valve (TXV) is a good choice, the electronic expansion valve (EXV) is a better choice. Electronic expansion valves have the ability to more precisely control superheat at lower settings over a wider operating range than the TXV. They also have the capability to be driven completely closed during the off-cycle, minimizing off-cycle migration.

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Regardless of which expansion device is used, the manufacturer's recommendations on the application of the valve should be followed in all cases.

Charge Compensators

Charge compensators are devices that store excess refrigerant. The size of the compensator is determined by running the system in cooling and optimizing the charge - and then running in heating and optimizing the charge. The difference between the two charge levels becomes the liquid volume capacity of the charge compensator. Unlike an orifice, an EXV/TXV should not allow excessive refrigerant to flood back to the compressor. This means that the excess system refrigerant will either have to back up in the indoor coil during heating, causing high head pressure, or be stored in a charge compensator until needed. A charge compensator is normally a hollow vessel with only one opening that is attached to the vapor line. The shell is usually attached to the outdoor coil or has a line from the outdoor coil running through it for extra cooling during heating and to drive the refrigerant out during the cooling cycle.



The charge compensator must be piped in such a way that the compensator does not discharge the stored liquid charge into the compressor when the cycle reverses.

Reversing Valves

By taking advantage of the higher speeds and flow rates, defrost time will typically be shorter than a system with a fixed or two-step capacity compressor. This reduces the time electric resistance heat is used during the defrost cycle.



Reversing valve sizing must be within the guidelines of the valve manufacturer. Required pressure drop to ensure valve shifting must be measured throughout the operating range of the unit and compared to the valve manufacturer’s data. Conditions that result in low flow rates and low pressure drop across the valve can result in a valve not shifting. This can result in a condition where the compressor appears to be not pumping (i.e. balanced pressure). It can also result in elevated compressor sound levels. During a defrost cycle, when the reversing valve abruptly changes the refrigerant flow direction, the suction and discharge pressures will go outside of the operating envelope. The condition will usually cross the diagonal line representing the lower right hand corner of the envelope. The sound that the compressor makes during this transition period is normal, and the duration of the sound will depend on the coil volume, outdoor ambient, and system charge.

The preferred method for defrost cycles is to have the compressor operating at a minimum of 3600RPM prior to energizing the reversing valve and to allow 30-60 seconds at that speed until pressures stabilize. After 30 to 60 seconds the compressor speed should be increased to some predetermined speed based on the outdoor ambient temperature. The routine at the end of the defrost cycle should be similar. The above method is a suggestion, and the system design engineer should develop the routine that best mitigates compressor sound during defrost while ensuring a defrost cycle that is as short as possible. The maximum recommended defrost duration is 15 minutes.

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

Accumulators

The use of accumulators is very dependent on the application. The variable speed scroll has an inherent

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ability to handle liquid refrigerant during occasional operating flood back situations. Systems designed with EXV or TXV refrigerant control may not require an accumulator if testing assures the system designer that there will be no flood back throughout the operating range. To test for flood back conditions and to determine if the accumulator or EXV/TXV design is adequate, please see the Application Tests section. If an accumulator is required, the oil return orifice should be from .040 to .055 inches in diameter depending on compressor size and compressor flood back results. A large area protective screen no finer than 30x30 mesh is required to protect this small orifice from plugging. Tests have shown that a small screen with a fine mesh can easily become plugged causing oil starvation to the compressor bearings. The size of the accumulator depends upon the operating range of the system and the amount of system refrigerant charge. System modeling indicates that heat pumps that operate down to and below 0°F will require an accumulator that can hold around 70% to 75% of the system charge. Behavior of the accumulator and its ability to prevent liquid slugging and subsequent oil pump-out at the beginning and end of the defrost cycle should be assessed during system development. This will require special accumulators and compressors with sight tubes and/or sight glasses for monitoring refrigerant and oil levels.

Off-Cycle Migration Control

Off-cycle liquid refrigerant migration control is important for long term compressor reliability and to minimize nuisance complaints associated with flooded start conditions. Off-cycle migration control is recommended when the system charge exceeds 8 lbs. Off-cycle migration control is required when the system charge exceeds 9.6 lbs. In lieu of using a conventional wrap-around crankcase heater, the Motor Control drive has a programmable feature that will utilize the motor windings to provide 10 to 50 watts of heat to serve as a crankcase heater. (There is optional external 40W crankcase heater listed in Table 2)

If off-cycle migration control is required, and no off cycle migration testing across the range of expected indoor/outdoor temperatures is performed, the stator heater must be powered to at least 40 watts when the compressor is “off”. To use fewer than 40 watts or to comply with future DOE requirements for off-cycle power consumption, off-cycle migration testing must be performed.



Stator heat for off-cycle migration must not be energized when the system is in a vacuum or if there is no refrigerant charge in the system. The system low pressure cut-out control can be used as an indicator of the presence of refrigerant charge.

Compressor Wiring

Table 2 lists the part number for the molded plug wiring harness that is required to wire the compressor to the Motor Control drive. The molded plug wire harness has an Ingress Protection (IP) 54 rating. The wire harness provides high voltage to the compressor from the drive. This harness is unshielded and should not exceed 60” in length. Figure 3 illustrates the internal windings of the BPM motor. It is important to ensure correct wiring at both the compressor and drive connections prior to starting the compressor to avoid a mis-wire or powered reverse situation. Both situations could potentially cause compressor damage.



The unit contactor must be installed upstream of the drive, not between the drive and the compressor. Nor should a disconnect switch be installed between the drive and compressor. Major faults and irreversible damage to the drive could occur if the drive output is open circuited while the compressor is running.

Maximum Tilt Angle

OEMs and end-users often ask about the maximum allowable tilt angle of the compressor. Some applications may require the compressor to operate at some angle from vertical. Or service personnel may be

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required to maneuver a unit through a stairwell or other cramped area that might require tilting the unit. The maximum allowable tilt angles from horizontal are summarized below:

Max Tilt Angle with Compressor Running = 15°

Max Tilt Angle With Compressor Not Running = 60°

Application Tests

New system designs should be evaluated throughout the entire expected operating range of the unit to ensure the system will perform reliably throughout the life of the product. Test data, taken throughout the operating range of the unit, should be closely scrutinized to help identify gross errors in system design that may produce conditions that could lead to compressor failure.

Air Conditioners

Figure 4 is a hypothetical illustration representing the theoretical cooling load and the expected compressor operation throughout the anticipated outdoor ambient temperature range. The illustration shows that below some outdoor ambient temperature “A” the system will cycle on-off at the minimum cooling speed to satisfy the cooling load requirement. When the design ambient is exceeded, arbitrarily chosen as point “B”, the compressor will operate continuously at the maximum allowable cooling speed. Between points “A” and “B” the compressor speed will vary to match the cooling load. In all three areas of compressor operation represented graphically, the following criteria must be met:

1. Compressor sump superheat must comply with Figure 6 during the running cycle. (See Note 2 on Figure 6. Consult Application Engineering if necessary)
2. The operating conditions must be inside the operating envelope for the given speed.
3. An acceptable oil level must be maintained in the compressor.

Air-Source Heat Pumps

For the cooling mode, air-source heat pumps should comply with the criteria outlined in the Air Conditioners section above. Figure 5 is a hypothetical illustration representing the theoretical heating load and the expected compressor operation throughout the outdoor ambient temperature range. The illustration shows that above some outdoor ambient temperature “A” the system will cycle on-off at the minimum heating speed to satisfy the heating load requirement. Below the heating balance point, arbitrarily chosen as point “B”, the compressor will operate continuously at the maximum allowable heating speed. Between points “A” and “B” the compressor speed will vary to match the heating load. In all three areas of compressor operation represented graphically, the following criteria must be met:

1. Compressor sump superheat must comply with Figure 6 during the running cycle. (See Note 2 on Figure 6. Consult Application Engineering if necessary)
2. The operating conditions must be inside the operating envelope for the given speed.
3. An acceptable oil level must be maintained in the compressor.
4. Excessive flooding and high compression ratios (greater than 6:1) during the defrost cycle should be avoided.

General Application Tests

In addition to the tests outlined above, off-cycle migration tests are recommended if the system charge amount exceeds 9.6 pounds, and less than 30 watts of the stator heat option is selected. The purpose of the off-cycle migration test is to ensure that stator heat is great enough to minimize off-cycle migration after long compressor “off” periods. System faults, such as low or loss of indoor airflow, loss of outdoor air-flow, and low/overcharge conditions should all be evaluated to ensure the compressor and service technician are protected against any adverse condition.

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NOTICE

The tests outlined above are for common applications of compressors in this family. Many other applications of the compressor exist, and tests to ensure those designs can't possibly be covered in this bulletin. Please consult with Application Engineering on applications outside of those outlined above for the appropriate application tests.

Assembly Line Procedures

Installing the Compressor

WARNING

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

Copeland Scroll compressors leave the factory dehydrated and with a positive dry air charge. When compressors are brought into the OEM factory from an outside cold ambient the suction and discharge plugs shall not be removed until the compressor has had sufficient time to warm up to the factory ambient temperature. The suggested warm up time is one hour per 4°F difference between outdoor and indoor temperature. It is suggested that the larger suction plug be removed first to relieve the internal pressure. Removing the smaller discharge plug could result in a spray of oil out of this fitting since some oil accumulates in the head of the compressor after Copeland's run test. The inside of both fittings should be wiped with a lint free cloth to remove residual oil prior to brazing. A compressor containing POE oil should never be left open longer than 15 minutes.

Assembly Line Brazing Procedure

WARNING

Personal safety equipment must be used during brazing operation. Heat shields should be used to prevent overheating or burning nearby temperature sensitive parts. Fire extinguishing equipment should be accessible in the event of a fire.

Figure 7 discusses the proper procedures for brazing the suction and discharge lines to a scroll compressor.

NOTICE

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. Any blockage of oil or refrigerant.

Pressure Testing

WARNING

Never pressurize the compressor to more than 475 psig for leak checking purposes. Never pressurize the compressor from a nitrogen cylinder or other pressure source without an appropriately sized pressure regulating and relief valve.

The pressure used on the line to meet the U.L. burst pressure requirement must not be higher than 475 psig. Higher pressure may result in permanent deformation of the compressor shell and possible misalignment or bottom cover distortion.

Assembly Line System Charging Procedure

Systems should be charged with liquid on the high side to the extent possible. The majority of the charge should be pumped in the high side of the system to prevent low voltage starting difficulties, hipot failures, and bearing washout during the first-time start on the assembly line.

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If additional charge is needed, it should be added as liquid to the low side of the system with the compressor operating. Pre-charging on the high side and adding liquid on the low side of the system are both meant to protect the compressor from operating with abnormally low suction pressures during charging. NOTICE Do not operate the compressor without enough system charge to maintain at least 55 psig suction pressure. Do not operate the compressor with the low pressure cut-out disabled. Do no operate with a restricted suction or liquid line. Depending on the discharge pressure, allowing pressure to drop below 55 psig for more than a few seconds may overheat the scrolls and cause early drive bearing damage. NOTICE Do not use the compressor to test the opening set point of a high pressure cutout. Bearings are susceptible to damage before they have had several hours of normal running for proper break in.

High Potential Testing



Use caution with high voltage and never hipot when compressor is in a vacuum.

Copeland Scroll compressors are configured with the motor down and the pumping components at the top of the shell. As a result, the motor can be immersed in refrigerant to a greater extent than hermetic reciprocating compressors when liquid refrigerant is present in the shell. In this respect, the scroll is more like semi-hermetic compressors that have horizontal motors partially submerged in oil and refrigerant. When Copeland Scroll compressors are hipot tested with liquid refrigerant in the shell, they can show higher levels of leakage current than compressors with the motor on top. This phenomenon can occur with any compressor when the motor is immersed in refrigerant. The level of current leakage does not present any safety issue. To lower the current leakage reading, the system should be operated for a brief period of time to redistribute the refrigerant to a more normal configuration and the system hipot tested again. See AE4-1294 for megohm testing recommendations.

Under no circumstances should the hipot test be performed while the compressor is under a vacuum.

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

Final Run Test

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

Unbrazing System Components



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

If the refrigerant charge is removed from a scroll equipped unit by recovering one side only, it is very possible that either the high or low side of the system remains pressurized. If a brazing torch is then used to disconnect tubing, the pressurized refrigerant and oil mixture could ignite when it escapes and contacts the brazing flame. 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 the system rather than unbrazed. See Figure 7 for proper compressor removal procedure.

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Service Procedures

The Motor Control drive has on-board diagnostics that can communicate to the service technician, via blinking LEDs, if there's a problem with the drive (internal fault) or if there's a problem with communications to the system controller. All other fault conditions (i.e. high discharge temperature, over current, etc.) must be communicated via another device in the system provided by the OEM. Before beginning the troubleshooting process, the fault history should be reviewed by the service technician to gain insight on what the root cause of the problem might be. Please see AE-1405 for more information on troubleshooting the Copeland Motor Control drive and the various fault codes.

Electrical Troubleshooting

The BPM motors used in the variable speed scroll compressors have a three phase winding configuration designed to accept PWM variable frequency voltage from the drive.



Bypassing the variable frequency drive and connecting AC line voltage directly to the compressor can cause irreversible damage to the compressor.

The three windings of the compressor-motor should always have line to line continuity because there is no internal overload in the compressor to open and disconnect the motor. The line to line winding resistance can be measured and verified using values published for each compressor-motor in the Online Product Information.



Energizing a variable speed scroll compressor with a grounded winding can cause irreversible damage to the drive.

Measuring the current in the three wires supplying the compressor amperage provides no useful information to the service technician, other than verifying the compressor is drawing some amount of amperage in each phase from the drive.

Compressor Replacement After a Motor Burn

In the case of a motor burn, the majority of contaminated oil will be removed with the compressor. The rest of the oil is cleaned with the use of suction and liquid line filter driers. A 100% activated alumina suction filter drier is recommended but must be removed after 72 hours. See AE24-1105 for clean up procedures and AE11-1297 for liquid line filter-drier recommendations. NOTICE 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. The system contactor should be inspected for pitted/burnt contacts and replaced if necessary.

Start-Up of a New or Replacement Compressor

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



Do not start the compressor while the system is in a deep vacuum. Internal arcing may occur when any type of compressor is started in a vacuum.



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Do not operate the compressor without enough system charge to maintain at least 55 psig suction pressure. Do not operate with a restricted suction or liquid line. Do not operate with the low pressure cut-out disabled.

Allowing suction pressure to drop below 55 psig for more than a few seconds may overheat the scrolls and cause early drive bearing damage. Never install a system in the field and leave it unattended with no charge, a holding charge, or with the service valves closed without securely locking out the system. This will prevent unauthorized personnel from accidentally ruining the compressor by operating with no refrigerant flow.

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Figures & Tables

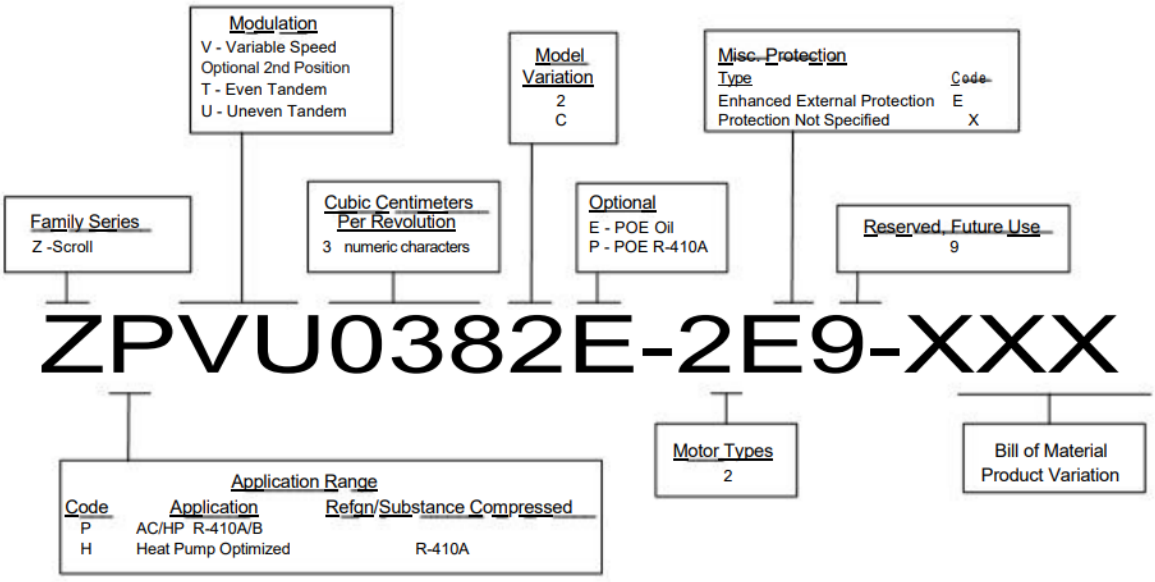


Figure 1 - Compressor Nomenclature

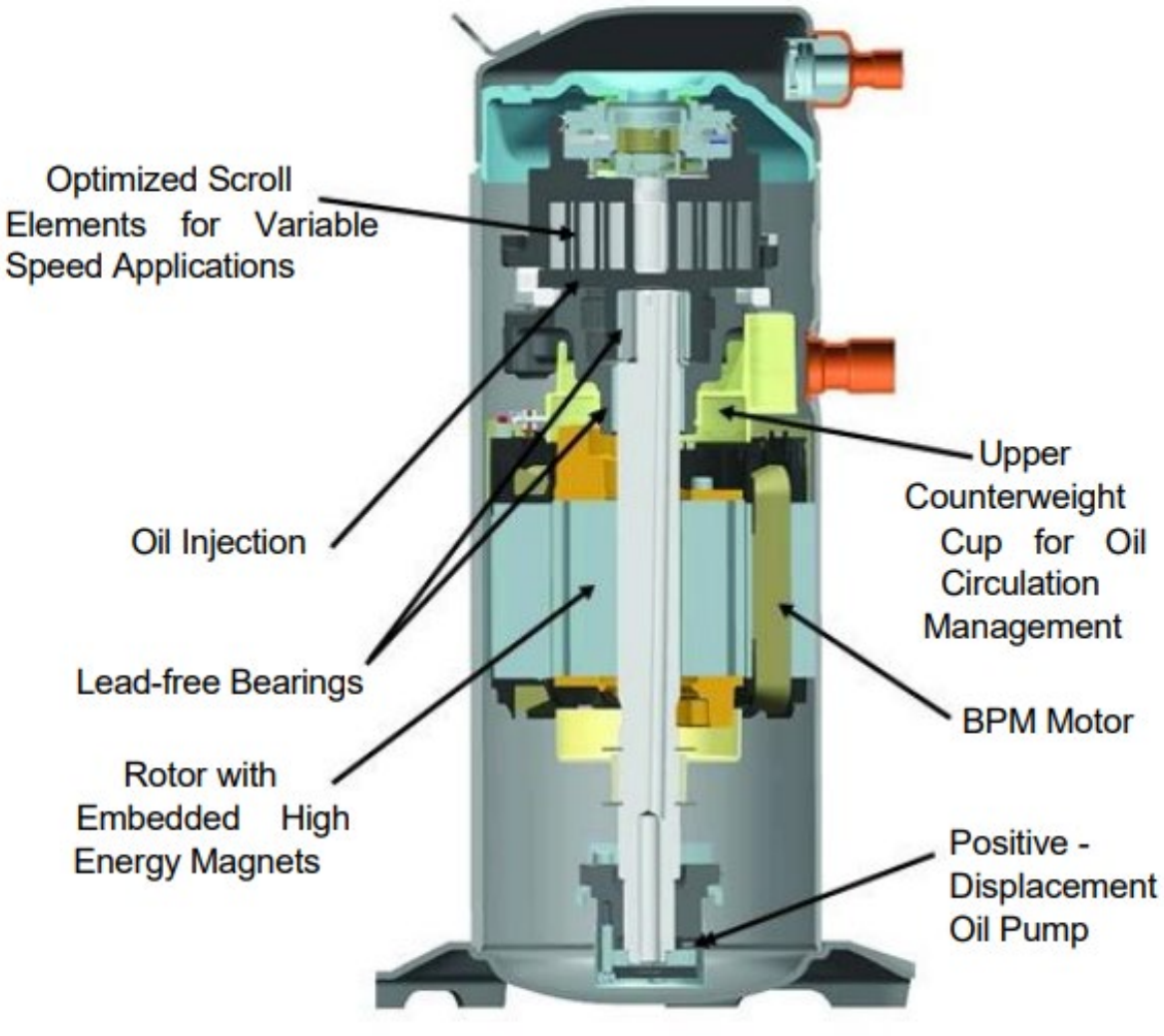


Figure 2 - Variable Speed Scroll Design Features

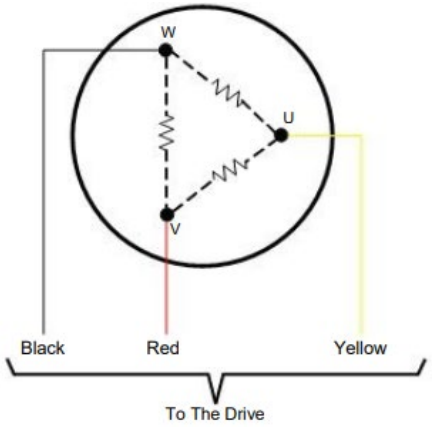


Figure 3 - Motor Winding Diagram

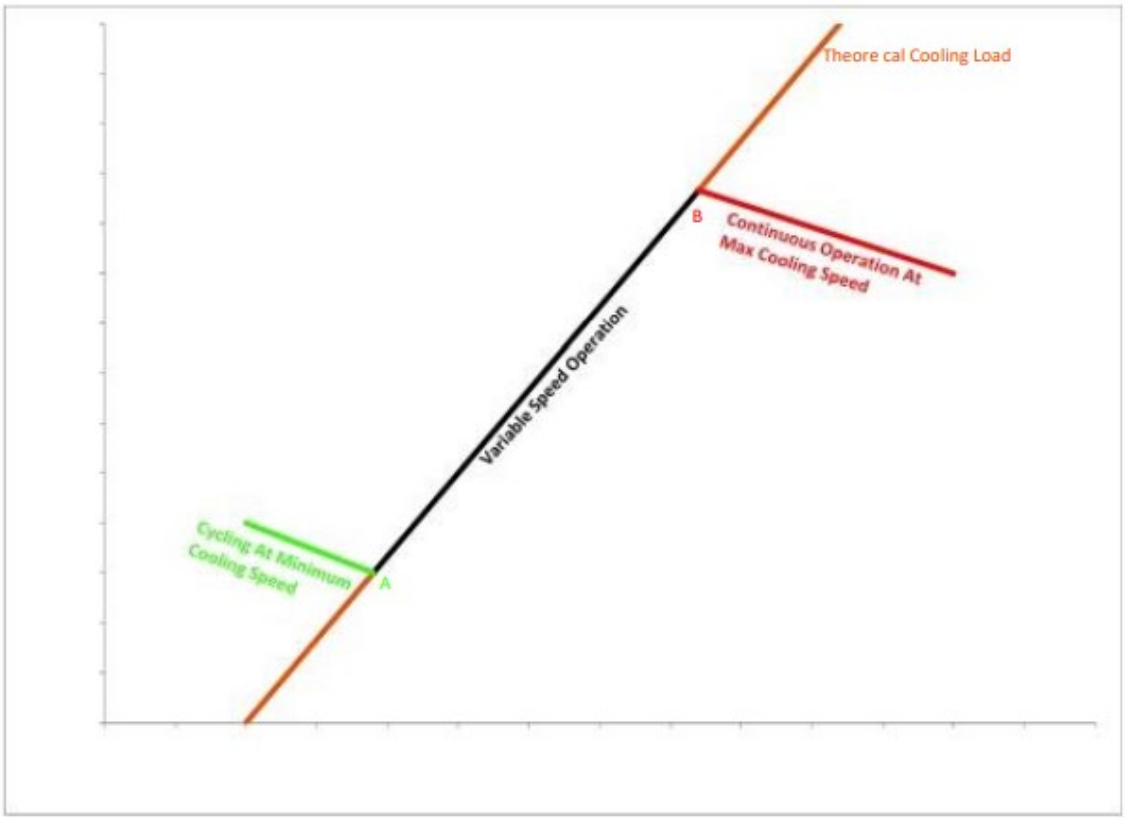


Figure 4 - Hypothetical Cooling Load and Compressor Operation

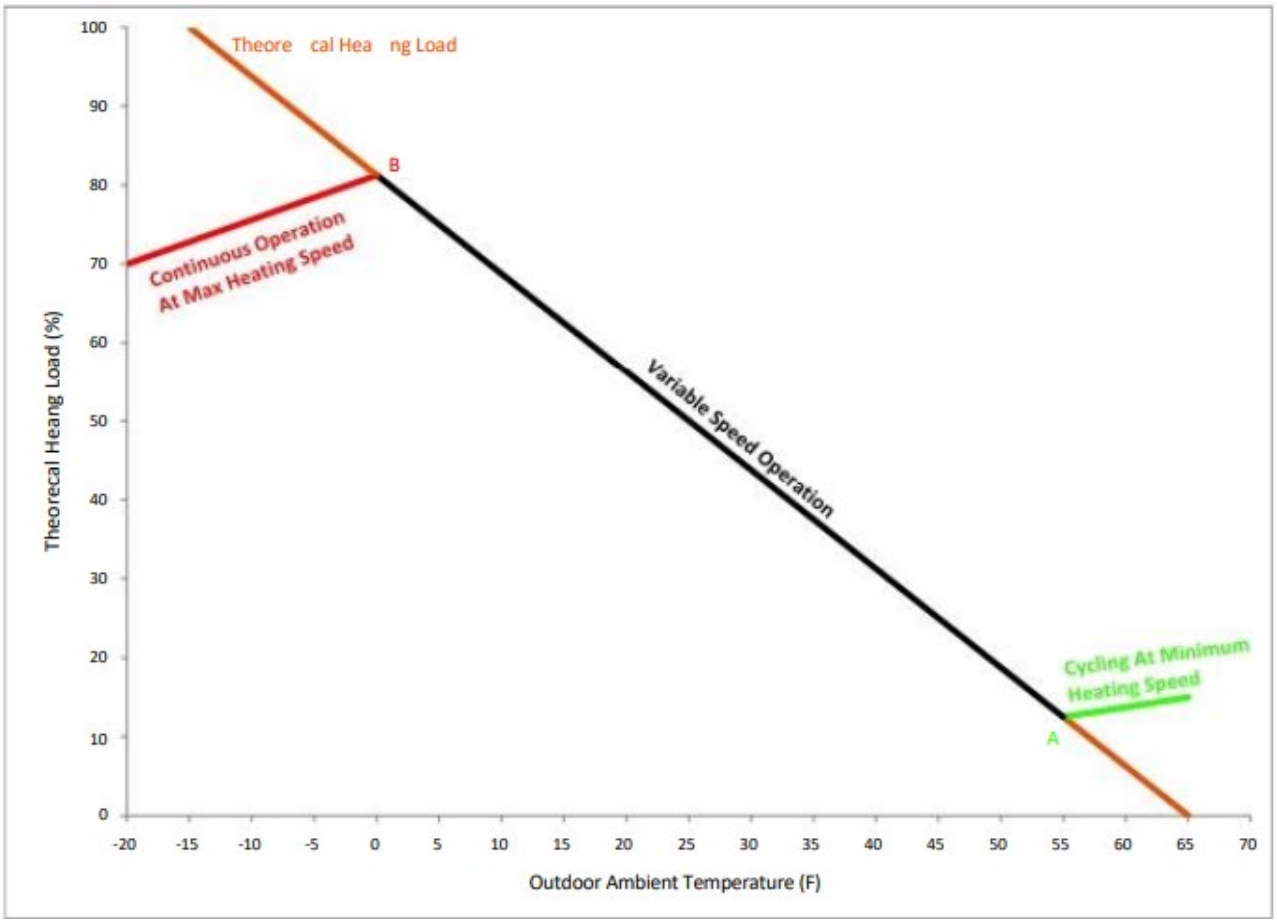


Figure 5 - Hypothetical Heating Load and Compressor Operation

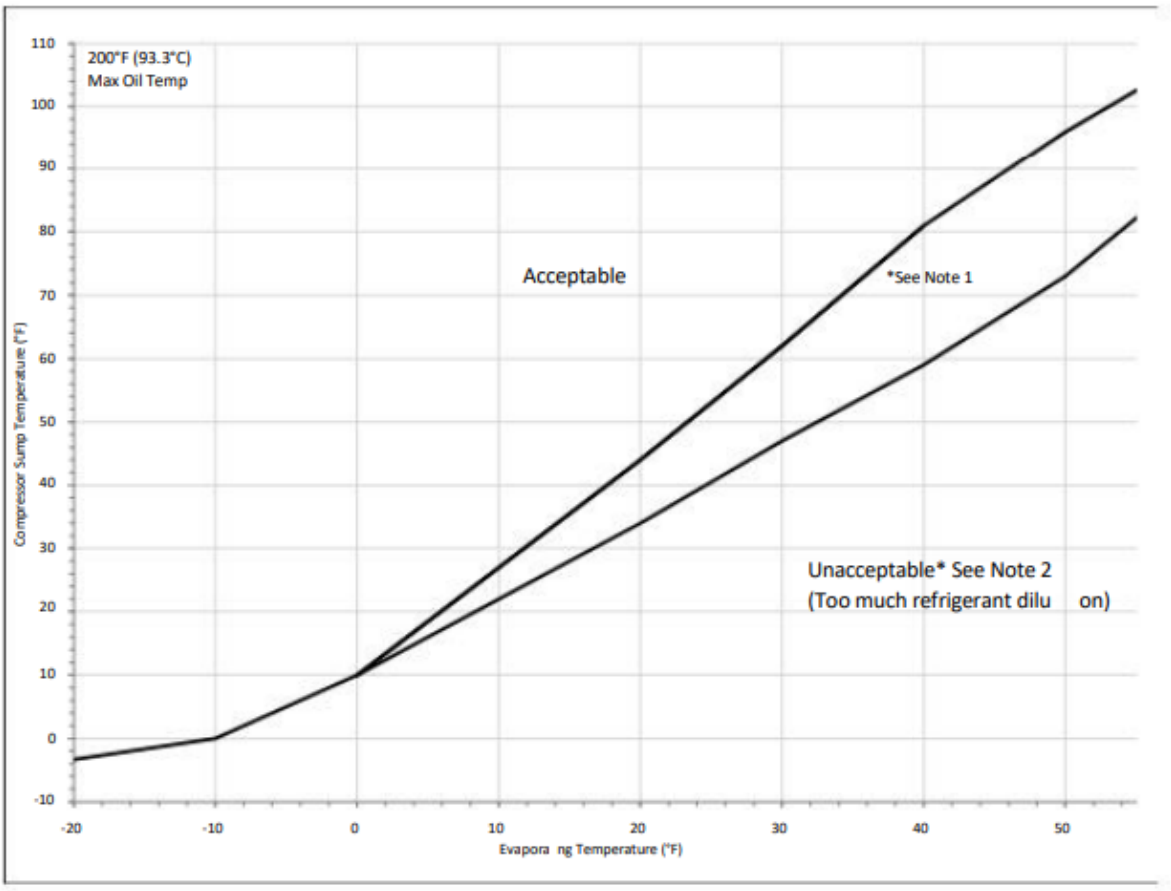


Figure 6 - Oil Dilution Guideline Chart

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

Note 2: Chart does not include all operating speeds. Please consult with Application Engineering for specific needs and evaluation. See 'Application Tests' on pages 9 and 10 for more information.

Figure 6 - Oil Dilution Guideline Chart

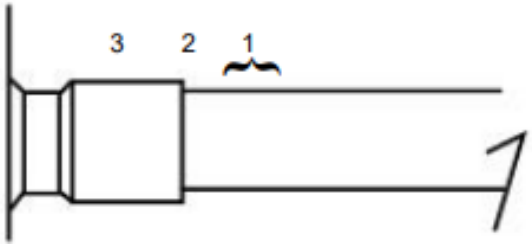


Figure 7 - Scroll Suction Tube Brazing

New Installations

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

Field Service

WARNING

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

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

Table 1 - Compressor Maximum Charge Limits Without Crankcase Heat

Model	Frame Size*	Charge Limit	System Limit
		Pounds	Pounds
ZPV021*-ZPV041*	53	8	9.6

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

Table 2 - Accessory Guide

Accessory	Part Number
Molded Plug Power Cable (OEM)	Reference Drive Bulletin (4)
Molded Plug Power Cable (Service)1	Reference Drive Bulletin (4)
Compressor Mounting Parts Kit	527-0044-15
Compressor Mounting Grommet (2)	027-0262-00
Grommet Sleeve (2)	028-0188-15
Discharge Line Thermistor	085-0271-00
Discharge Line Thermistor Clip - 1/2" Tube	032-0688-02
Crankcase Heater 120V 40W (3)	018-0094-01
Crankcase Heater 240V 40W (3)	018-0094-00

1) Service cable will require field mounting of proper connector type on drive end of power cable
2) Included in 527-0044-15 kit
3) Optional Accessory
4) AE8-1405 (Single Phase) AE8-1411 (Three Phase)

Revision Tracking R2

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

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