

Application Engineering

10-25 Ton YAV Copeland Scroll Variable Speed Compressors

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Safety

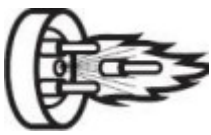
Important Safety Information

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](https://www.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](https://www.copeland.com/flammable-refrigerants) for more information on flammable refrigerant safety.

Electrical Hazards



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

Hot Surface and Fire Hazards



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

Lifting Hazards



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

POE Oil Hazards

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

Precautions

- Always wear personal protective equipment (gloves, eye protection, etc.).
 - Keep a fire extinguisher at the jobsite at all times.
 - Keep clear of the compressor when power is applied.
- **IMMEDIATELY GET AWAY if you hear unusual sounds in the compressor. They can indicate that terminal pin ejection may be imminent. This may sound like electrical arcing (sizzling, sputtering or popping). However, terminal venting may still occur even if you do not hear any unusual sounds.**

- Never reset a breaker or replace a blown fuse without performing appropriate electrical testing
 - **A tripped breaker or blown fuse may indicate an electrical fault in the compressor. Energizing a compressor with an electrical fault can cause terminal venting. Perform checks to rule out an electrical fault.**
- Disconnect power and use lock-out/tag-out procedures before servicing.
 - Before removing the terminal cover or molded plug, check that ALL electrical power is disconnected from the unit. Make sure that all power legs are open. (Note: The system may have more than one power supply.)
 - Discharge capacitors for a minimum of two minutes
 - Always use control of hazardous energy (lock-out/tag-out) procedures to ensure that power is not reconnected while the unit is being serviced.
- Allow time for the compressor to cool before servicing.
 - Ensure that materials and wiring do not touch high temperature areas of the compressor.
- Keep all non-essential personnel away from the compressor during service.
 - For A3 refrigerants (R290) remove refrigerant from both the high and low sides of the compressor. Use a recovery machine and cylinder designed for flammable refrigerants. Do not use standard recovery machines because they contain sources of ignition such as switches, high- and low-pressure controls and relays. Only vent the R290 refrigerant into the atmosphere if the system is in a well-ventilated area.
- Never use a torch to remove the compressor. Only tubing cutters should be used for both A2L and A3 refrigerants.
- Use an appropriate lifting device to install or remove the compressor.
- Never install a system and leave it unattended when it has no charge, a holding charge, or with the service valves closed without electrically locking out the system.
- Always wear appropriate safety glasses and gloves when brazing or unbrazing system components.
- Charge the system with only approved refrigerants and refrigeration oils.
- Keep POE oils away from certain polymers (e.g., PVC/CPVC and polycarbonate) and any other surface or material that might be harmed by POE oils. Proper protective equipment (gloves, eye protection, etc.) must be used when handling POE lubricant. Handle POE oil with care. Refer to the Safety Data Sheet (SDS) for further details.
- Before energizing the system:
 1. Securely fasten the protective terminal cover or molded plug to the compressor, and
 2. Check that the compressor is properly grounded per the applicable system and compressor requirements.

Signal Word Definitions

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



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



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



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

Introduction

This bulletin provides instructions on how to apply 10–25-ton Copeland Scroll™ variable speed compressors 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

YAV066 to YAV160 variable speed compressors are intended for use in commercial air conditioning, chiller, and heat pump applications. The variable speed scrolls utilize three-phase brushless permanent magnet (BPM) motors. The compressors have been qualified for use with Copeland EVM/EVH Drives. If using a non-Copeland drive is desired, please work with Application Engineering to select an appropriate drive for the compressor application.

Compressor Data

Compressor mechanical, electrical, and performance data are available online at Copeland Mobile. 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 compressor and drive are an integral and optimized combination. The drive will convert the input voltage into a variable frequency and voltage to power the compressor. For more information on the drive power input requirements please see the Copeland EVM/EVH Drive user guide.

Ensure correct wiring at both the compressor and drive connections prior to starting the compressor to avoid a mis-wire or powered reverse situation. These situations may cause compressor damage.



The variable speed compressor must be paired with the appropriate variable speed drive. Do not connect the power supply directly to the compressor.

Nomenclature

The model number of the variable speed scroll includes the approximate displacement in cubic centimeters per revolution. **Figure 2** provides a complete explanation of all the alpha and numeric characters in the compressor model number.

Agency Approval

Contact Application Engineering for agency approval details.

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.

Modeling System Performance

Modeling at any speed range in the approved envelope is facilitated by 20 coefficient data available from Application Engineering.

Compressor Design Features

The variable speed scroll has a few design features that improve efficiency and reliability.

Compressor Motor

The brushless permanent magnet (BPM) motor in the variable speed scroll is a six-pole motor consisting of a three-phase stator and a rotor embedded with high energy permanent magnets. The input voltage is a series of pulses

of varying frequency at 120-degree intervals between phases.

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.

Application Considerations

Compressor Temperature Protection

A discharge line thermistor must be used to protect the compressor. The discharge line thermistor should be installed within 6" (15cm) of the compressor and well insulated. The maximum discharge line temperature should be no greater than 275°F (135°C). For enhanced protection, a lower discharge line temperature limit may be used.

Third Party Drive

The customer may use a third-party drive. The third-party drive must be qualified as the protector for the compressor. The drive is required to have the motor protection for the compressor to achieve UL compliance.

Copeland EVM/EVH Drive Features

It's recommended that the Copeland variable speed drive (VSD) be used with the variable speed compressor. The Copeland VSD has custom-built features that may improve the longevity of the compressor and efficiency of the system. Refer to the Copeland EVM and EVH drive user guide for more information.

A smaller drive than what is listed in **Table 1** may be acceptable for certain applications. Contact Copeland Application Engineering for testing recommendations when a smaller drive is required.

Motor Protection

The Copeland EVM/EVH drive includes motor protection features for the compressor. The drive sets the maximum current limit which protects the compressor.

The drive includes foldback protection for high IGBT temperatures and maximum speeds.

The drive includes lost rotor avoidance and locked rotor detection.

Missing Phase Protection

The Copeland EVM/EVH drive includes compressor missing phase protection. The drive checks for a missing phase connection.

Low Ambient Operation

The Copeland EVM/EVH drive includes a cold weather feature. If operating at ambient temperatures below 14°F (-10°C), it's recommended to set parameter enable Cold Weather Mode. This can be done by setting the EVM drive parameter P6.2.8 and EVH drive parameter P6.2.12 to Enabled (1).

Other Features

Refer to the Copeland EVM and EVH drive user guide for more features and functions of the drive.

System Control Requirements

For proper compressor operation and reliability, a third-party controller is required to provide the features listed in this section. The EVM/EVH drive doesn't include these features.

Oil Boost

The system controller must implement an oil boost when the compressor operates at less than 1,800 RPM. The oil boost cycle is required when the compressor operates for

two hours at less than 1,800 RPM. During the oil boost cycle, the compressor should run for five minutes at 3,600 RPM. The five minutes can be broken into smaller time frames in a more frequent occurrence to total five minutes in two hours. The oil boost cycle is required for internal lubrication and does not guarantee proper oil return for the system.

Operating Envelope Control

The system controller must implement envelope control for the compressors. Refer to **Figures 6-8** for the operating envelopes.

Starting and Stopping Routine

The system controller must implement a starting and stopping routine. The compressor must start at a minimum of 1,800 RPM. The compressor should operate above 1,800 RPM and remain above 1,800 RPM for two minutes. The compressor must reach 1,800 RPM within three seconds to ensure proper internal lubrication.

A stopping sequence to shut down the compressor at a maximum speed of 3,600 RPM is recommended. Hard stops due to trips above 3,600 RPM is acceptable. A soft stop routine is optional where the RPM is reduced to a lower speed inside the operating envelope. Once the minimum speed is achieved, the compressor must shutdown within three seconds from 1,800 RPM to ensure proper internal lubrication. The EVM drive parameter P4.1.9 Stop Mode can be set to "0" (coast) if a soft shutdown sequence is used. Setting the EVM drive parameter P4.1.9 to "1" (Ramp) will ramp down the compressor at the deceleration rate until it comes to a full stop. If the Ramp option is selected, a noise from the compressor motor will occur. This noise is not harmful to the compressor or drive.

The variable speed scroll compressor incorporates a fluid brake design to help mitigate reverse rotation during shutdown. A momentary reverse rotation sound may be heard.

Discharge Temperature Protection

The system controller is required to provide discharge temperature protection. A thermistor may be used to signal the controller drive to shut down if the temperature exceeds 275°F (135°C).

Short Cycle Protection

It's recommended for the system controller provide short cycle protection. A short cycle occurs if the runtime of the compressor isn't long enough for the oil to return to the compressor from the system. The OEM must determine the length of time for a short cycle to be detected.

Refrigerant

YAV066 to YAV160 compressors are approved for use with R454B only. Use of refrigerants other than R454B voids the UL recognition of these compressor models since the motor overload system could be adversely affected.

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. Refer to **Figures 6-8** for the operating envelopes. Contact Application Engineering if desired to operate at different speeds than published in the operating envelope.

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 pump-out if the system has long interconnecting piping. Customers that choose to operate in these higher evaporating temperature areas should use a compressor sample with a sight-tube 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.

The upper left boundary of the envelope represents the maximum compression ratio when operating with 20F° (11°C) suction superheat. If the operating condition approaches this boundary of the envelope the compressor discharge temperature will begin to approach the maximum scroll temperature allowed by the discharge line thermistor.

If operating the compressor is below 1,800 RPM, an oil boost cycle is required.

The YAV066 compressor can operate down to 1,000 RPM at certain operating conditions. Contact Application Engineering for more details.

For applications where the voltage is below the rated minimum voltage, the drive speed may be limited. The limitation may also be affected by the ambient temperature.

High Pressure Control



A high-pressure control must be used in all applications.

The YAV066 to YAV160 Copeland compressors do not have internal pressure relief valves. The system designer should determine the required high pressure value cutout for the desired system and application. If any type of discharge line shut-off valve is used, the high-pressure control must be installed between the compressor discharge fitting and the valve.

The high-pressure control should have a manual reset feature for the highest level of system protection.

If an auto reset high pressure control is used, the compressor should be locked out after three consecutive trips. If a pressure transducer is used to protect against high discharge pressure events the transducer and control

logic should comply with U.L. and/or local safety requirements.

Low Pressure Control

A low-pressure control is highly recommended for loss of charge protection and other system fault conditions that may result in very low evaporating temperatures. Loss of system charge will result in overheating and recycling of the motor overload protector. Prolonged operation in this manner could result in oil pump out and eventual bearing failure. The low-pressure cut-out setting will depend on the application type and minimum expected evaporating temperature. The low-pressure cut-out should be selected based on the specific application and expected operating conditions. A cut out setting no lower than 20 psig (1.4 bar) is recommended.

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 YAV066 to YAV160 Copeland compressors do not have an internal discharge gas temperature protection.

A discharge line thermistor must be used to protect the compressor. The discharge line thermistor should be installed within 6" (15cm) of the compressor and well insulated. The maximum discharge line temperature should be no greater than 275°F (135°C). For enhanced protection, a lower discharge line temperature limit may be used.

The thermistor is designed for a 7/8" (22 mm) line and should be properly insulated. See **Table 7 of AE-1328** for thermistor temperature vs resistance values. Refer to **Copeland Mobile** for part numbers of discharge line thermistors. **Figure 5** illustrates the discharge thermostat.

Motor Overload Protection

The EVM/EVH 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. The input power supply to the drive must be properly fused.

The molded plug power connection option is not available for all compressor models and voltages due to the current limit of the molded plug power cable.

Oil Type

The variable speed scrolls are charged with polyol ester (POE) oil. See the compressor nameplate for the original oil charge. A complete recharge should be approximately four fluid ounces (118cc) 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.



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.

Maximum Tilt Angle

Applications, such as transportation air conditioning or mobile radar applications, may require the compressor to operate at some angle from vertical. Service personnel may be 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 for individual compressors (not tandem or trio applications) are summarized below:

Max Tilt Angle with Compressor Running = 15°

Max Tilt Angle with Compressor Not Running = 60°

Contaminant Control

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 ensures that moisture isn't inadvertently introduced into the compressor. However, due to the manufacturing processes, Copeland scroll compressors will contain a miniscule amount of solid and liquid contaminants when they leave the factory.

During unit assembly and field servicing, compressors shouldn't be left open to the atmosphere for longer than five minutes. It is generally accepted that system moisture levels should be maintained below 50 ppm. A filter-drier is required on all 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 that the filter-drier is adequately sized to accommodate the contaminants from system manufacturing processes which 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 filterdrier 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 at operating conditions and speeds.

If testing shows a gradual, continuous loss of oil in the compressor sight-tube over long run cycles at low speed, an oil boost cycle should be incorporated into the system logic. An oil boost cycle is accomplished by ramping the compressor up to a higher speed to increase the refrigerant flow rate to flush or sweep oil back to the compressor. Frequency and duration of a recovery cycle depends on many variables and would have to be determined through testing for each system type and configuration. A default method could be to initiate a recovery cycle at regular intervals.

Long Pipe Lengths / High Refrigerant Charge

Some system configurations may contain higher-than-normal refrigerant charges either because of large internal coil volumes or long line sets. If such a system also contains an accumulator, then the permanent loss of oil from the compressor may become critical. If the system contains more than 20 pounds (9 kg) of refrigerant, it is our recommendation to add one fluid ounce of oil for every 5 pounds (15 ml/kg) of refrigerant over this amount. If the system contains an accumulator the manufacturer of the accumulator should be consulted for a pre-charge recommendation.

Other system components such as shell and tube evaporators can trap significant quantities of oil and should be considered in overall oil requirements. Reheat coils and circuits that are inactive during part of the normal cycle can trap significant quantities of oil if system piping allows the oil to fall out of the refrigerant flow into the inactive circuit. The oil level must be carefully monitored during system development, and corrective action should be taken if the compressor oil level falls more than 2.7" (70 mm) for the YAV066 and YAV096 compressors and 2.5" (65 mm) below the center of the sight-glass. **The compressor oil level should be checked with the compressor 'off' to avoid the sump turbulence when the compressor is running.**

These compressors are available to the OEM with a production sight-glass that can be used to determine the oil level in the compressor in the end-use application. These compressors are also available to the OEM with an

oil Schrader fitting on the side of the compressor to add additional oil if needed because of long lengths of piping or high refrigerant charge. **No attempt should be made to increase the oil level in the sight-glass above the 3/4 full level. A high oil level is not sustainable in the compressor and the extra oil will be pumped out into the system causing a reduction in system efficiency and a higher-than-normal oil circulation rate.**

falls below the top of the lower bearing bracket for more than two minutes. The lower bearing bracket weld points on the compressor shell can be used as a low-oil-level marker.

Discharge Check Valve

The YAV066 and YAV096 Copeland compressors use a shutdown valve located in the discharge fitting. The YAV134 and YAV160 compressors includes a valve on the muffler plate. These valves are not a low-leak-back check valve and will leak when pressure differential across the check valve is low. An external discharge check valve should be considered in some applications.

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 mechanical running frequency range, it will be almost impossible to avoid all of 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.

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.

Compressor Mounting

The YAV066 to YAV160 Copeland compressors have pierced holes in the mounting feet so mounting grommets with relief are not required. Refer to **Copeland Mobile** for 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 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. A variable capacity heat pump and/or 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. If testing determines that a muffler is needed to attenuate discharge pulse, a hollow shell muffler such as the Copeland Flow Controls APD164S must be used.

The mufflers should be located a minimum of six inches (15 cm) to a maximum of 18 inches (46cm) from the compressor for most effective operation. The farther the muffler is placed from the compressor within these ranges the more effective it may be. If adequate attenuation is not achieved, use a muffler with a larger cross-sectional area to inlet-area ratio.

Airborne Sound Control

In addition to structure and gas borne sound transmission, special consideration needs to be given to compressor airborne sound. A-weighted, steady-state sound data is available from Application Engineering. Sound data is also available at the nominal cooling condition of 50°F (10°C) evaporating and 115°F (46°C) condensing at 5400 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 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, an electronic expansion valve (EXV) is recommended. Electronic expansion valves can more precisely control superheat at lower settings over a wider operating range than a TXV. They also have the capability to be driven completely closed during the off cycle, minimizing off cycle migration.

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

Reversing Valves

A variable speed scroll has a real advantage during the defrost cycle. 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 heat is required 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 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 sounds after the compressor is turned off.

Accumulators

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

Excessive migration of refrigerant to the compressor during the off-cycle can result in oil pump-out on start-up, excessive starting noise and vibration, bearing erosion, and broken scrolls if the hydraulic slugging pressure is high enough. For these reasons, off-cycle refrigerant migration must be minimized. The following three sections summarize off-cycle migration techniques.

Crankcase Heaters

Preventing refrigerant migration to the compressor during the off cycle is required. A crankcase heater can be used to mitigate refrigerant migration to the compressor during the off cycle. The initial start-up in the field is a very critical period for any compressor because all load-bearing surfaces are new and require a short break-in period to carry high loads under adverse conditions. The crankcase heater must be turned on a minimum of 12 hours prior to starting the compressor. This will help prevent oil dilution and bearing stress on initial startup.

To properly install the crankcase heater, the heater should be installed in the location illustrated in **Figure 9**. Tighten the clamp screw carefully, ensuring that the heater is uniformly tensioned along its entire length and that the circumference of the heater element is in complete contact with the compressor shell. It's important that the clamp screw is torqued to the range shown in **Table 3** to ensure adequate contact and to prevent heater burnout. Never apply power to the heater in free air or before the heater is installed on the compressor to prevent overheating and burnout.



Crankcase heaters must be properly grounded to reduce the potential of a fire or shock hazard.

Pump Down Cycle

If a pump down cycle is required by the system designer, a onetime pump down at the end of the cooling cycle is preferred over a recycling pump down. Although not preferred, a recycling pump down cycle can be used to minimize off-cycle refrigerant migration to the compressor. The risk of a short cycling condition that can lead to oil pump out, excessive contactor wear, unnecessary energy use, and excessive low pressure cut-out switch cycles make recycling pump down undesirable. In lieu of the pump down cycles mentioned above, simply closing a liquid line solenoid valve when the compressor cycles off is a good, simple, and cost-effective method of minimizing off-cycle refrigerant migration.

Pump Out Cycle

A pump out cycle has been successfully used by some manufacturers of large rooftop units. After an extended off period, a typical pump out cycle will energize the compressor for up to one second followed by an off time of 5 to 20 seconds. This cycle is usually repeated a second time, the third time the compressor stays on for the cooling cycle.

Manifolded Compressors

Multiple compressor assemblies are available for purchase from Copeland. In lieu of purchasing the assembled manifold, the OEM can choose to purchase the manifold-ready compressor and perform the assembly in their factory. Drawings of tandem and trio compressor assemblies are available from Copeland by contacting your Application Engineer. **NOTICE: Customers who choose to design and build their own manifolds for tandem and trio compressor assemblies are ultimately responsible for the reliability of those manifold sets.**

The suction manifold is close to a symmetrical layout with the design intent of equal pressure drop to each compressor. A straight length of pipe is connected to the suction manifold "T" connection to serve as a flow straightener to make the flow as uniform as possible. The discharge manifold is the less critical of the two manifolds in terms of pressure drop. Low pipe stress and reliability

are its critical design characteristics. Support for the discharge manifold between the compressors should be no closer than a straight distance of 14" (356 mm) from the discharge tee.

For tandem compressor applications, tubing stress levels should be closely evaluated. If excess stress levels occur, the Resonance Avoidance Feature in the Copeland EVM/EVH drive may be used.

Manifolded Applications

Manifolded compressors follow the same application guidelines as single compressors outlined in this bulletin. The refrigerant charge limit for manifolded compressors is shown in **Table 2**. A manifolded circuit with charge over the limit must have a crankcase heater or stator heating applied to both compressors.

Oil levels in the individual sight-glasses will vary, depending on whether one or more compressors in the manifolded set are operating and if the manifolded set is made up of equal or unequal compressor capacities. Because of the unequal oil levels that can exist, oil levels should be viewed with the compressors off to allow the oil level to stabilize between the compressor sumps. With the compressors off, oil should be visible in the individual compressor sight-glasses.

Suction and discharge manifolds are not designed to support system piping. Support means must be provided by the system designer to support suction and discharge lines so that stress is not placed on the manifolds.

The compressors in a manifolded set can be started/stopped in any desired sequence. To help reduce inrush current, starting the compressors individually is recommended. Should a compressor fail in the tandem set the complete tandem should be removed from the unit and replaced with a new tandem set. Replacing individual compressors is discouraged because of the care that must be used when installing the oil equalization tube and the availability of manifolds to the aftermarket.

Please consult with Application Engineering during the development of systems with trio compressor assemblies. Trio compressor assemblies are sensitive to system

operating conditions and configurations which will affect oil balancing. Trio compressor assemblies must be qualified for each application.

Manifolded 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. Drawings of the tandem manifolds are available by contacting your application engineer. Customers that choose to design and build their own manifolds for tandem and trio compressors are ultimately responsible for the reliability of those manifold sets.

Application Test

The system designer is responsible for testing the system to ensure it operates as designed. These tests should be performed during system development and are dependent on the system type and amount of refrigerant charge. These application tests are to help identify errors in system design that may produce conditions that could lead to compressor failure.

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.

The evaporating temperature and the bottom shell temperature shall be taken with a high sampling rate during the entire oil return or oil balance testing and under all tested conditions. The liquid level in the sight tube should be observed and recorded also. Testing conditions shall include defrost and varying loads. If the system is reversible, the tests should be conducted in both operation modes.

System engineers must review the system design and operation to identify the critical conditions and test to verify oil return, oil balancing and liquid floodback. The concern is that a very low oil level will develop after extended hours

of operation at low speed. In addition to oil balancing and system oil return tests, the suction and discharge tubing must be evaluated to determine the resonant frequencies. Once the resonant frequencies are known, they can be shifted to a safe range by changing the mass of the line for constant speed applications or they can be avoided for variable speed applications.

- **In single compressor systems:** to check oil return, testing conditions shall be at minimum mass flow and minimum density of suction gas in continuous and frequent start-stop-cycling.
- **In multiple compressor systems:** to check oil return and oil balancing in tandem or trio, testing conditions shall be at the corner points of the system application envelope in continuous and frequent start-stop-cycling.
- **In all systems:** to test liquid floodback, all possible transient operation conditions in the system should be checked, compressor frequent start/stop, compressor start after long off time with migration, defrost, switching between the operation modes in reversible systems, load changes, fans or pumps cycling at low load and more. To evaluate the risk of liquid floodback, please refer to the oil dilution chart in **Figure 4**. Liquid level and superheat at compressor suction should be checked.

Application Engineering is available to recommend additional tests and to evaluate test results.

General Application Tests

In addition to the tests outlined above, off-cycle migration tests are recommended. 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.

The tests outlined above are for common applications of compressors in this family. Please consult with Application Engineering on applications outside of those outlined above for the appropriate application tests.

Assembly Line Procedures

Installing the Compressor



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, with a dry air holding charge. If compressors are stored in a cold ambient (i.e. outside during the winter), the suction and discharge plugs should not be removed until the compressor has had sufficient time to warm up to the plant ambient temperature. The suggested warm up time is one hour per 4°F (2°C) 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.

Assembly Line Brazing Procedure



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



It is important to flow nitrogen through the system while brazing all joints during the system assembly process. Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to

form, the copper oxide flakes can later be swept through the system and block screens such as those protecting capillary tubes, thermal expansion valves, and accumulator oil return holes. Any blockage of oil or refrigerant may damage the compressor resulting in failure.

Pressure Testing



Never pressurize the compressor to more than 475 psig (33 bar) 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 UL burst pressure requirement must not be higher than 475 psig (33 Bar). 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. 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



Do not operate the compressor without enough system charge to maintain at least 55 psig (3.8 bar) suction pressure. Do not operate the compressor with the low-pressure cut-out disabled. Do not operate with a restricted suction or liquid line. Depending on the discharge pressure, allowing pressure to drop below 55 psig (3.8 bar) 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

Hipot (AC High Potential) Testing**⚠ WARNING**

Use caution with high voltage and never hipot test 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 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 not to 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**⚠ WARNING**

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.

Service Procedures

The drive offers a two wire 485 interface. This enables the drive set-up, operation and monitoring to be carried out with a PC or controller if required. The drive only supports Modbus RTU protocol. Refer to the Copeland EVM/EVH drive user guide for more information.

Electrical Troubleshooting**⚠ WARNING**

The compressor must always have green ground wire attached to the ground. The other end of the green wire must be connected to the appropriate ground terminal on the drive.

The BPM motors used in the variable speed scrolls are three-phase. The winding resistance for each compressor-motor is published in the **Copeland Mobile**. The three

windings should always have line to line continuity because there is no internal overload at the center of the motor windings to open and take the motor off-line. If one or more of the windings shows continuity to ground, the compressor must be replaced.



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

Measuring the current in the three individual wires feeding the compressor will provide no useful information to the service technician, other than to show that each winding of the compressor is drawing current. The more appropriate measurement is the current input to the drive. Current input to the drive can be compared to the published values of MCC and RLA.

Compressor Replacement After a Motor Burn

In the case of a motor burn, most of the 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 cleanup procedures and AE11-1297 for liquid line filter-drier recommendations. It is highly recommended that the suction accumulator be replaced if the system contains one. This is because the accumulator oil return orifice or screen may be plugged with debris or may become plugged shortly after a compressor failure. This will result in starvation of oil to the replacement compressor and a second failure.

Start-Up of a New or Replacement Compressor:

It is good service practice, when charging a system 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.



Follow the unit manufacturer's guidelines for properly evacuating and charging of the system. Do not start the compressor while the system is in a vacuum. Internal arcing may occur when any type of compressor is started in a vacuum which may result in terminal venting.



Do not operate the compressor without enough system charge to maintain at least 55 psig (3.8 bar) suction pressure. Do not operate with a restricted suction or liquid line. Do not operate with the low-pressure cutout disabled.

Allowing suction pressure to drop below 55 psig (3.8 bar) 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.

Figures & Tables

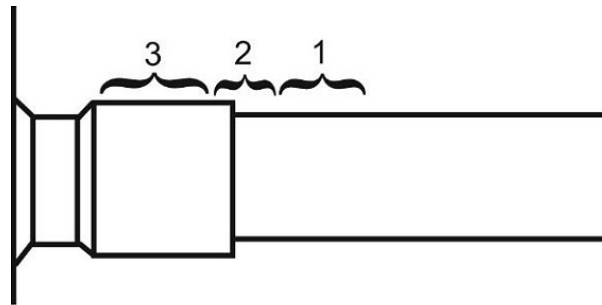


Figure 1 Figures & Tables

New Installations

- The copper-coated steel tube fitting 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, Dichloro-Trifluoroethane or other suitable solvent.
- Using a double-tipped torch apply heat in Area 1. As the 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 the torch around joint to flow braze material around circumference.
- After braze material flows around joint, move torch to heat Area 3. This will draw the braze material down into the joint. The time spent heating Area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the result.

Field Service



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. The compressor should be disconnected using a tubing cutter.
- 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 the New Installation brazing instructions above.

Figure 2 YAV Compressor Nomenclature

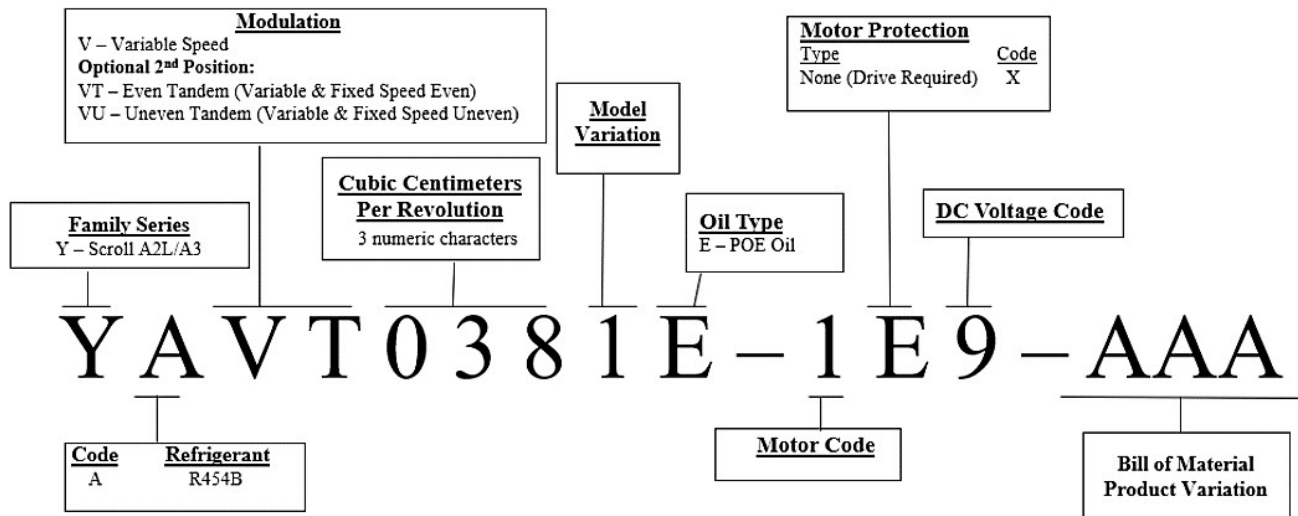


Figure 3 EVM/EVH Nomenclature

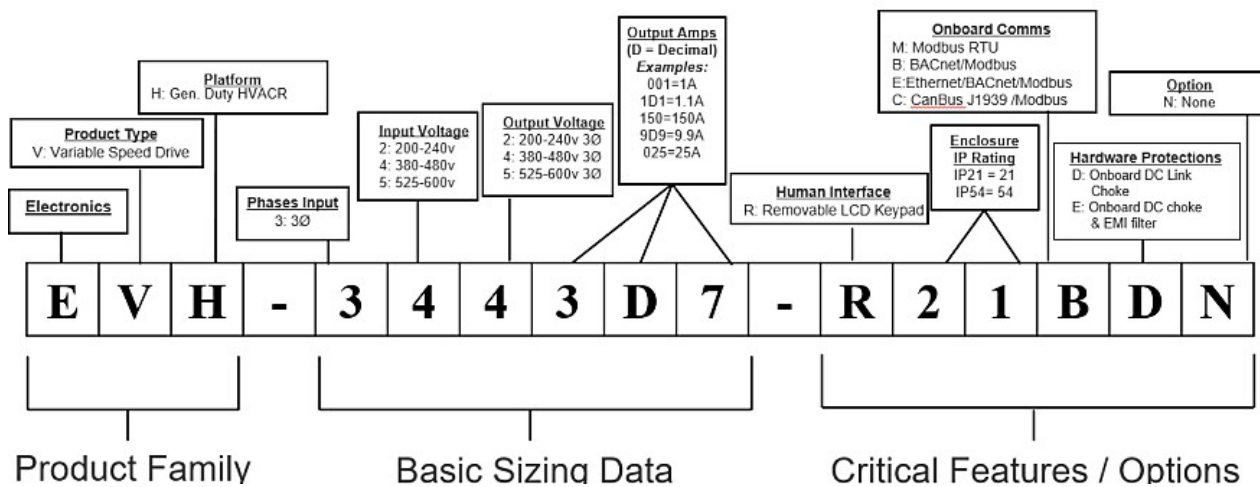
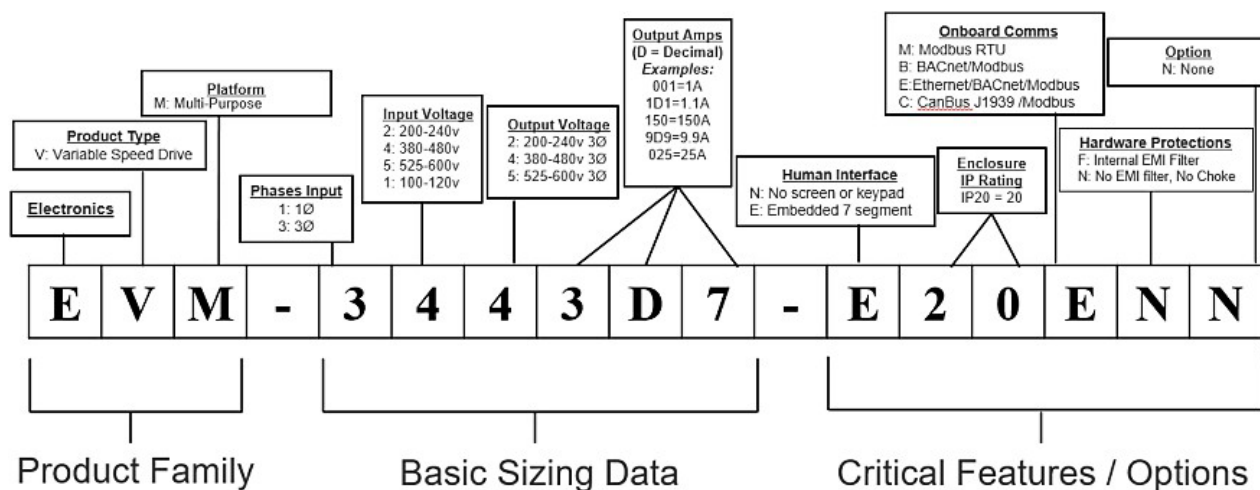


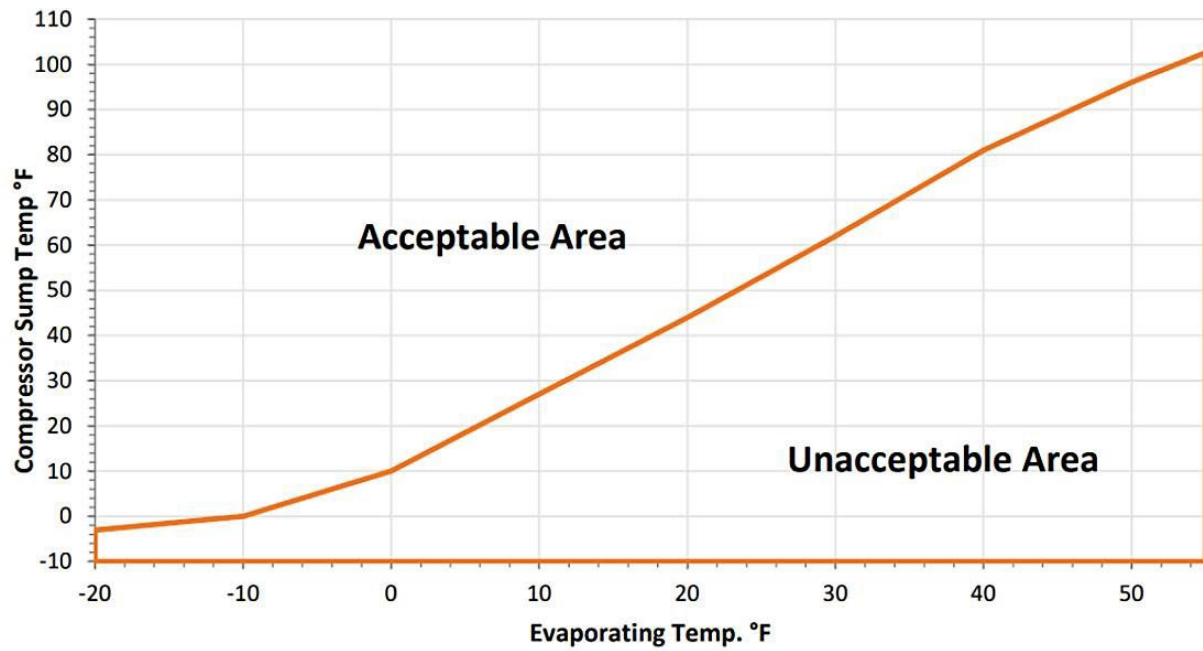
Figure 4 Oil Dilution Chart*Figure 5 Discharge Thermostat*

Figure 6 YAV066 Operating Envelope

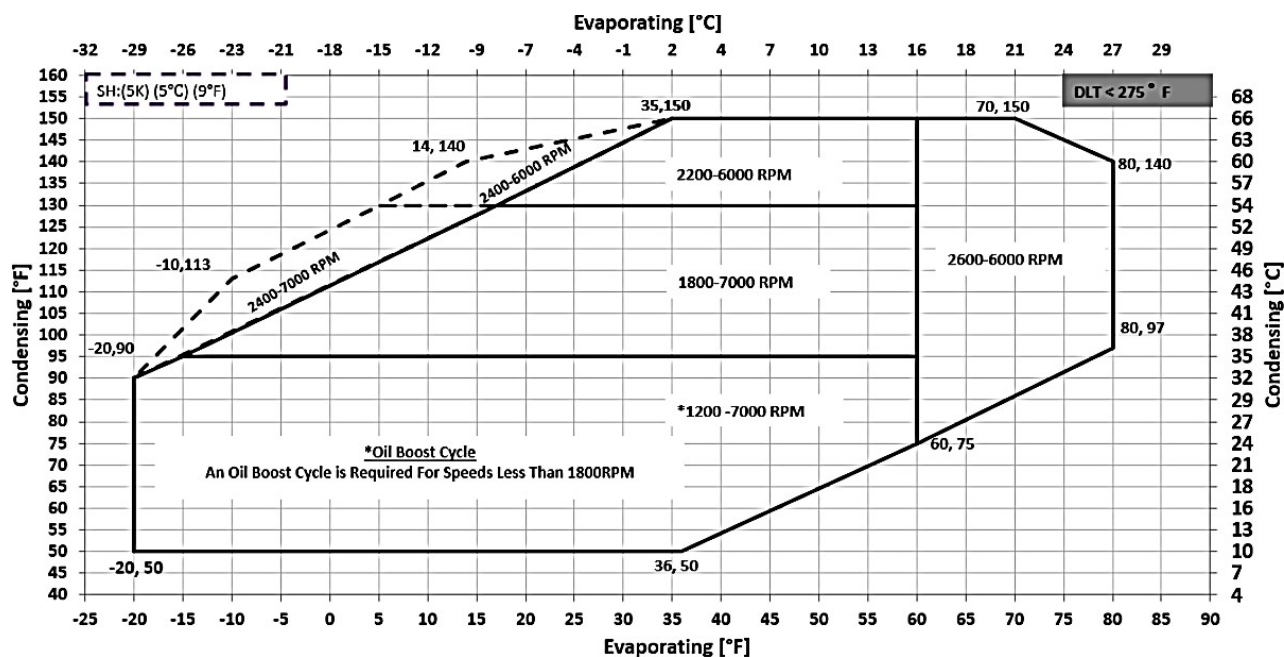


Figure 7 YAV096 Operating Envelope

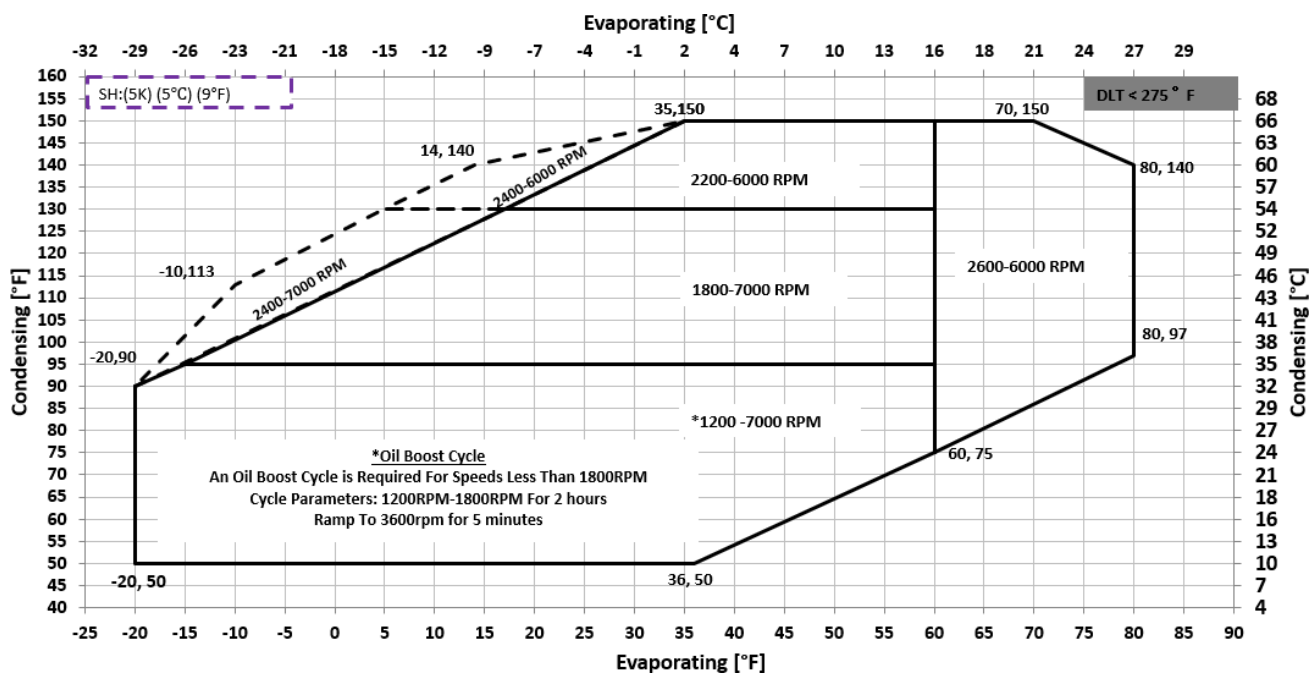


Figure 8 YAV134 & YAV160 Operating Envelope

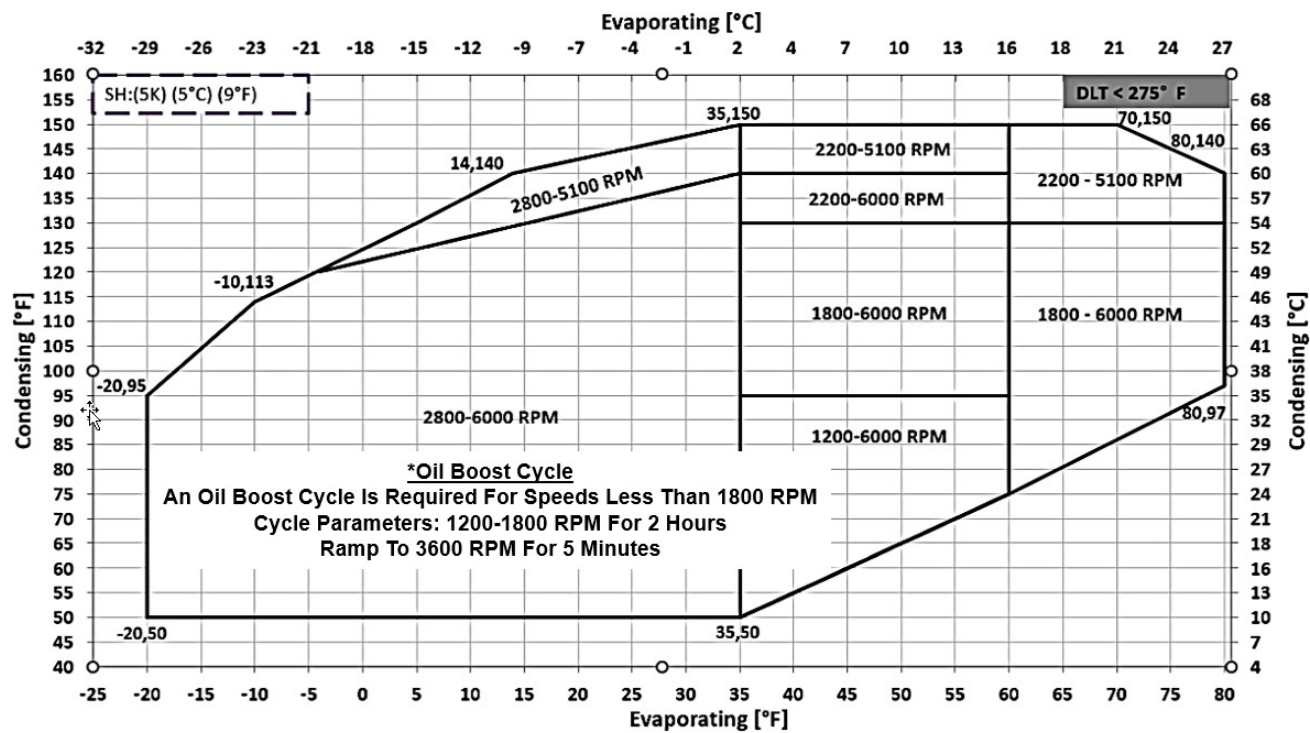


Figure 9 Crankcase Heater Location

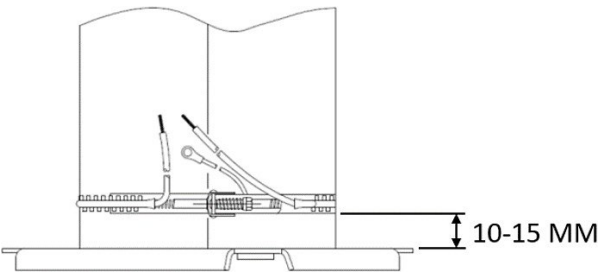


Table 1 Copeland Compressor & Drive Selection

Compressor Model	Drive Model	Drive Input Voltage	Drive Max Output Amps
YAV0661E-5X9	EVM-322048	230	48
YAV0661E-7X9	EVM-344023	460	23
YAV0661E-7X9	EVM-355027	575	18
YAV0961E-5X9	EVM-322062	230	62
YAV0961E-7X9	EVM-344031	460	31
YAV0961E-7X9	² EVM-355027 or EVH-355034	575	27 or 34
YAV1341E-5X9	EVH-322114	230	114
YAV1341E-7X9	EVH-344061	460	61
YAV1341E-7X9	EVH-355052	575	52
YAV1601E-5X9	EVH-322114	230	114
YAV1601E-7X9	EVH-344061	460	61
YAV1601E-7X9	EVH-355062	575	62

Notes:

- 1 Drive selections are based on maximum amperage of the compressor while operating inside the operating envelope. A smaller drive may be selected if the maximum condensing temperature or maximum speed are below the operating envelope limits. Contact Application Engineering for more details on drive options.
- 2 Drive limited to 6000 RPM max speed. If a higher maximum speed is required, use the EVH-355034 drive.

Table 2 Compressor Refrigerant Charge Limits

Model	Charge Limit	
	Pounds	Kg
YAV066 & YAV096	15	7
YAV134 & YAV160	22	10

Table 3 Torque Values

Part	Torque		
	ft-lb	in-lb	N-m
1-1/4" Sight Glass	34-39	405-475	45.8-53.6
3/8" Schrader Valve	3.3-5.0	40-60	4.5-6.7
Terminal Block Screws	1.0-1.3	15-Dec	1.4-1.7
Oil Access Fitting (Threads into Oil Rotalock)	16.7-18.3	200-220	22.6-24.9
Crankcase Heater	1.7-2.1	20-25	2.3-2.8
M6 Terminal Box Mounting Stud Nuts	3.5-3.9	42-47	4.7-5.3

Revision Tracking R3

Removed the compressor and drive parameter tables.

Update the 575 volt drive selection for Table 1.

Revision Tracking R4

Removed the hour restriction for the YAV0961E compressor.

Update drive model number for 575 volt YAV0661E-7X9 compressor in Table 1.

Add Oil Boost note to Figure 8.

Revision Tracking R5

Added note on selecting a compressor with a smaller drive.

Update drive model number for 575 volt YAV1601E-7X9 compressor in Table 1.

Revision Tracking R6

Updated part number EVM-355018 to AVM-355027

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