

Application Engineering

3-15 Ton YAD*K1 and YPD*K1 Copeland Scroll Compressors

BULLETIN NO: AE4-1491 R2

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Safety

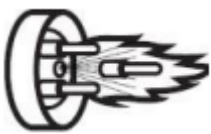
Important Safety Information

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

The 3-to-15-ton YAD (R454B) & YPD (R32) Copeland Scroll Digital are variable capacity compressors that can mechanically modulate. Digital scrolls are suitable for a variety of applications where a variable capacity compressor is needed. This bulletin describes the operating and application differences with respect to the equivalent fixed capacity Copeland Scroll™ compressors. For compressor accessories and service parts, please refer to Copeland Mobile.

Reference the AE4-1430 Compressor Multiples bulletin for multiple compressor applications. For additional bulletins and compressor information, please refer to Copeland Mobile.

Nomenclature

The model number of the Copeland Scroll Digital compressors includes the approximate nominal 60 Hz capacity at the AHRI high temperature full load air conditioning rating point. An example is the YAD174K1E-TFD, which has approximately 174,000 Btu/hr cooling capacity at the air conditioning rating point when operated on 60 Hz. Note that the same compressor will have approximately 5/6 of this capacity or 100,000 Btu/hr when operated on 50 Hz power. Please refer to Figure 20 for a breakdown of Copeland Digital Nomenclature.

Digital Compressor Operation

The digital scroll is capable of seamlessly modulating its capacity from 10% to 100%. A normally closed (deenergized) solenoid valve is a key component for achieving modulation. When the solenoid valve is in its normally closed position, the compressor operates at full capacity, or loaded state. When the solenoid valve is energized, the two scroll elements move apart axially, or into the unloaded state. During the unloaded state, the compressor motor continues running, but since the scrolls are separated, there is no compression. During the loaded state, the compressor delivers 100% capacity and during the unloaded state, the compressor

delivers 0% capacity. A cycle consists of one loaded state and one unloaded state. By varying the time of the loaded state and the unloaded state, an average capacity is obtained. The lowest achievable capacity is 10% which equates to 1.5 seconds of pumping during one 15 second cycle.

An example for the 15 second controller cycle: In any 15 second cycle, if the loaded time is 10 seconds and the unloaded time is 5 seconds, the average capacity is 66% or if the loaded time is 5 seconds and the unloaded time is 10 seconds the capacity during that 15 second period is 33%. See Figure 2 for a graphical representation of the digital cycle, and Figure 3 for a graph showing solenoid on-time vs. compressor capacity.

It's important to test at minimum modulation rates to verify proper motor cooling and oil return. The compressor can operate at 10% modulation, but testing is needed to determine how long this is acceptable in the system. Operating conditions, superheat levels and system designs will affect the acceptable minimum modulation rate in the system. It's common to set the minimum modulation rate at a higher percentage to verify proper motor cooling and oil return.

How it Works

The digital scroll compressor unloads by taking advantage of the Copeland Scroll compressor's axial compliance. All Copeland Scroll compressors are designed so that the compression elements can separate axially a few thousands of an inch. The YAD32-115 and YPD76-129 compressors described in this bulletin use a lift piston mechanism to separate the scrolls during the unloaded state. When the solenoid is energized the volume on top of the piston is vented to the low side allowing the piston and fixed scroll assembly to move axial away from the orbiting scroll. When the solenoid is de-energized the piston is forced down and the scrolls are loaded axially.

The YAD130-174 and YPD145-192 compressors employ a solenoid valve that is mounted on the side of the compressor that vents the intermediate cavity to the low side of the compressor during the unloaded state.

During the loaded state the solenoid valve is deenergized, and the intermediate cavity is pressurized to load the floating seal and scrolls axially.

Please refer to **Figures 4** and **5** for cross sectional pictures of the two digital modulation mechanisms.

Application Considerations

Operating Envelope

Figures 6 through 12 illustrate the operating envelopes for the YA & YP digital scroll compressors. The operating envelopes represent operating conditions with 20°F (11K) superheat in the return gas unless otherwise shown. The steady-state operating condition of the compressor must remain inside the prescribed operating envelope. Excursions outside of the envelope should be brief and infrequent.

The discharge temperature should be monitored to prevent the compressor from overheating. The compressor must not operate above maximum discharge line temperature. The system can potentially decrease the discharge line temperature by increasing the modulation rate, reducing the superheat, decreasing the condensing temperature and/or increasing the evaporating temperature. The operating conditions, modulation rate, amount of time at a low modulation rate and ambient temperature will impact the discharge line temperature. Low modulation rates for periods of time may result in insufficient motor cooling. Testing is required to determine the acceptable minimum modulation rate to ensure proper discharge line temperatures, motor cooling and oil return.

Scroll Temperature Protection

A discharge line thermistor should be used with the compressors for discharge temperature protection. 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 275F (144C) within the operating envelope unless otherwise noted in the operating envelope. For

enhanced protection, a lower discharge line temperature limit may be used.

For the Copeland Digital Controller to operate properly an NTC sensor must be attached to the compressor discharge within 6" (15cm) of the compressor discharge fitting. For best response the sensor should be insulated. See **Table 7** of **AE8-1328** for thermistor temperature vs. resistance values. Refer to Copeland Mobile for part numbers of discharge line thermistors.

Shell Temperature



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.

Compressors requiring certification to the Pressure Equipment Directive (PED): The nameplate will be marked with a TS min which is defined as the minimum allowable temperature. The nameplate will also be marked with a TS max which is defined as the maximum allowable temperature (max design temperature, highest temp that can occur during operation or standstill of the refrigeration system or during test under test conditions, specified by the manufacturer). Please refer to Copeland Mobile for more details.

Pressure Fluctuations

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

Long Pipe Lengths / High Refrigerant Charge

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

Some systems may contain higher than normal refrigerant charges. Systems with large reheat coils, low ambient condenser flooding, or systems with multiple heat exchangers are among some system configurations that may require additional lubricant. If the compressors have a sight glass for oil level viewing, the oil level should always be checked during OEM assembly, field commissioning, and field servicing. An estimation of the amount of additional lubricant to add to the compressor(s) when the circuit charge exceeds 20 pounds of refrigerant is as follows:

Single compressor application: 0.5 fluid ounce of oil per pound of refrigerant.

For multiple compressor applications, refer to AE4-1430 for additional oil estimate for tandems and trios.

The oil level must be carefully monitored during system development, and corrective action should be taken if the compressor oil level falls below the minimum oil level. The compressor oil level should be checked with the compressor "off" to avoid the sump turbulence when the compressor is running.

Some of 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. Some of 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.

Suction and Discharge Fittings

The compressors have copper plated steel suction and discharge or threaded rotalock fittings. See **Figure 1** for assembly line and field brazing recommendations and **Table 1** for rotalock torque requirements.

System Tubing Stress

System tubing should be designed to keep tubing stresses under the endurance limit of the copper tubing type used (i.e., Type K, L, etc.). Start, stop and running (resonance) cases should be evaluated to ensure long term reliability.

Solenoid Valve and Coil

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

Accumulators

The use of accumulators is very dependent on the application. The Copeland scroll compressor's inherent ability to handle liquid refrigerant during occasional operating flood back situations make the use of an accumulator unnecessary in most applications. The OEM is responsible for determining if an accumulator is

needed and the selection of the accumulator. Consideration for additional oil needed for the accumulator should be taken

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

A crankcase heater is required when the system charge exceeds the values listed in **Table 3**. This requirement is independent of system type and configuration. 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 Figures 13-16. 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 1 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 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. If pump out cycle is employed, a crankcase heater must be used if the circuit charge amount exceeds the values listed in **Table 3**.

Reversing Valves

Since Copeland scroll compressors have very high **WARNING** © 2023 Copeland LP 8 AE4-1491 volumetric efficiency, their displacements are lower than those of comparable capacity reciprocating compressors

Since Copeland scroll compressors have very high volumetric efficiency, their displacements are lower than those of comparable capacity reciprocating compressors.

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. Low ambient heating conditions with 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 pressures). 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 normal operating 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 temperature, and system charge level. The preferred method of mitigating defrost sound is to shut down the compressor for 20 to 30 seconds when the reversing valve changes position going into and coming out of the defrost cycle. This

technique allows the system pressures to reach equilibrium without the compressor running. The additional start-stop cycles do not exceed the compressor design limits, but suction and discharge tubing design should be evaluated.

The reversing valve solenoid should be wired so that the valve does not reverse when the system is shut off by the operating thermostat in the heating or cooling mode. If the valve is allowed to reverse at system shutoff, suction and discharge pressures are reversed to the compressor. This results in pressures equalizing through the compressor which can cause the compressor to slowly rotate backwards until the pressures equalize. This condition does not affect compressor durability but can cause unexpected sound after the compressor is turned off.

Start Up and Shut Down

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

Since Copeland scroll compressors are also excellent gas expanders, they may run backwards for a brief period after shutdown as the internal pressures equalize.

Discharge Check Valve

The YAD32-115 and YPD76-129 compressors include a low mass, disk type check valve in the discharge fitting of the compressor. The YAD130-174 and YPD145-192 compressors include a spring assist, disk-type check valve in the discharge fitting of the compressor. The check valve prevents the high pressure gas in the condenser from rapidly flowing back through the compressor after shutdown. The check valve is not leakproof. Performance of the check valves for recycling pump down applications hasn't been evaluated at all pressure differentials. Low pressure differentials may result in unacceptable leak-back rates.

Compressor Cycling

There is no set answer to how often scroll compressors can be started and stopped in an hour, since it is highly dependent on system configuration. There is no minimum off time because Copeland scroll compressors start unloaded, even if the system has unbalanced pressures. The most critical consideration is the minimum run time required to return oil to the compressor after startup.

To establish the minimum run time, obtain a sample compressor equipped with a sight tube (available from Copeland) and install it in a system with the longest connecting lines and highest internal volume that the system may have. The minimum on time becomes the time required for oil lost during compressor startup to return to the compressor sump and restore a minimal oil level that will assure oil pick up through the crankshaft. The minimum oil level required in the YAD32-50 compressors is 1.6" (40 mm) below the center of the compressor sight-glass. The minimum oil level required in the YAD57-86 and YPD76 compressors is 1.4" (35 mm) below the center of the compressor sight-glass. YAD98-115 and YPD110-129 compressors is 2.4" (60 mm) below the center of the compressor sight-glass. The minimum oil level required in the YAD130-174 and YPD145-192 compressors is 1.5" (40 mm) below the center of the compressor sight-glass. The oil level should be checked with the compressor "off" to avoid the sump turbulence when the compressor is running. Cycling the compressor for a shorter period than this, for instance to maintain very tight temperature control, will result in progressive loss of oil and damage to the compressor.

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

Sound Characteristics

The sound spectrum of the loaded state and the unloaded state are different. **Special consideration should be given to the transition sound between the loaded and unloaded states. If the transition sound is unacceptable, a heavy sound blanket should be applied to the compressor.** Fabricating Services (www.fabsrv.com) is one source for scroll compressor sound blankets.

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

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

Internal Pressure Relief (IPR) Valve

High Pressure Control



A high-pressure control must be used in all YAD130-174 and YPD145-192 applications because these compressors do not have internal pressure relief (IPR) valves.

The YAD130-174 and YPD145-192 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. The high pressure control should have a manual reset feature for the highest level of system protection.

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. Compressors with rotalock discharge fittings have a connection on the rotalock fitting for the high pressure cut-out switch connection. Refer to Table 2 for compressor features.

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.

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.

Oil Type

Polyol ester oil (POE) is used in YA*K1, YA*K2 and YP*K1 compressors. Please refer to Copeland publication 93-11 available at Copeland Mobile for specific POE oil grade in centistokes for each refrigerant.

See the compressor nameplate for the original oil charge. A complete recharge should be approximately four to six fluid ounces (118-177ml) less than the nameplate value. Please refer to Copeland Mobile for model specific oil charge and recharge values. If additional oil is needed in the field, there are multiple POE brands available at your local distributor and wholesalers

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

Power Factor

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

Manifolded Compressor Replacement



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

A crankcase into a tandem configuration in their manufacturing plant. Drawings of the tandem manifolds are available by contacting your application engineer. Figure 18 illustrates a typical tandem compressor assembly using YAD32-115 and YPD76-129 scroll compressors. Note that only one compressor in the tandem assembly is a digital scroll compressor. **Customers that choose to design and build their own manifolds for tandem and trio compressor assemblies are ultimately responsible for the reliability of those manifold sets.**

For more information, reference the AE4-1430 Compressor Multiples bulletin for multiple compressor applications.

Modulation Control

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

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

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

Application Tests

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.

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 should review the system design and operation to identify the critical conditions and to check oil return, oil balancing and liquid floodback. Typically, the following situations should be considered:

- **In single compressor systems:** to check oil return, testing conditions shall be at minimum mass flow condition, minimum modulation rate 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 the 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 17**. The oil dilution chart should be used if operating below 9F superheat. Liquid level and superheat at compressor suction should be checked.

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

Performance Modeling

Copeland Climate Technologies, Inc. is not responsible or liable for incorrect energy use predictions.

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

Refrigerant Flow Control

In the system with a digital compressor, the refrigerant flow control valve is required to control flow across a wide range of flow rates and varying pressure differentials. Expansion valves have varying turndown limitations based on their rated capacity. Excessive hunting and loss of superheat control can result when asking an expansion valve to operate outside of its design range. For this reason, the expansion device needs to be evaluated to ensure reliable operation over the expected operating range. Limiting the minimum compressor modulation rate to a value that the expansion valve can tolerate should be considered. Proper testing is required to verify the expansion valve is properly controlling the superheat at various modulation rates throughout the envelope.

Assembly Line Procedures

Assembly Line Brazing Procedure

The external modulation valve is purchased and shipped separately from the YAD32-115 and YPD76-129 compressors. The YAD130-174 and YPD145-192 compressors don't require an external modulation valve. Therefore, assembly is required in the OEM manufacturing plant. Figure 5 illustrates the correct position and orientation of the modulation valve. Please note the direction of the arrow on the valve, it must point to suction.

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

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 evacuating the high side only, it is possible for the scrolls to seal, preventing pressure equalization through the compressor. This may leave the low side shell and suction line tubing pressurized.

Removing Compressors



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

Instructions should be provided in appropriate product literature and assembly (line repair) areas. If a compressor removal is required, the compressor should be cut out of system rather than unbrazed.

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 U.L. 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, bottom cover distortion and/or shell rupture.

Assembly Line System Charging Procedure

Systems should be charged with liquid on the high side to the extent possible. Most of the charge should be pumped in the high side of the system to prevent low voltage starting difficulties, hipot motor test 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.



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) Motor Testing



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 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.

Service Procedures

Field Replacement



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

Removing Oil

If the oil level is higher than the oil Schrader fitting on the sump of the compressor oil can be drained from this fitting until the oil level reaches the level of the Schrader fitting. To remove oil from the compressor when the oil level is below the oil Schrader fitting one of two different procedures can be used. The first procedure is to remove the compressor from the system and drain the oil from the compressor suction connection. This method ensures complete removal of the oil from the compressor. The second procedure is to remove the compressor sight-glass and insert a hose into the sump of the compressor and draw the oil out with a hand-held pump.

Electrical

When replacing a compressor, especially one that has been in the field for several years, it is always a good idea to replace the contactor.

Note: See the locked rotor on the nameplate of the new compressor and make sure the contactor exceeds this locked rotor rating.

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 clean up 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.

Manifolded Compressor Replacement



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

Should a compressor fail in a manifolded set, only the failed compressor should be replaced and not both compressors. The oil from the failed compressor will stay mostly in the failed compressor. Any contaminated oil that does enter the tandem circuit will be cleaned by the liquid line filter drier, and when used, the suction line filter drier.

The suction and discharge manifolds can be reused if the failed compressor is carefully removed, and the manifolds are cut in such a way that a coupling and short piece of copper can reconnect the new compressor. Reference the **AE4-1430** Compressor Multiples Bulletin for more information on installing a new oil equalization line.

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 cut-out 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.

Modulation Troubleshooting

The modulation valve and solenoid coil are engineered for specific use with the digital scroll. Don't attempt to substitute replacement solenoid coils that are not of the correct part number. The YAD32-115 and YPD76-129 modulation valves must be installed in the correct orientation and with the arrow on the valve pointing to suction. Installing a modulation valve in a horizontal position, or with the suction and discharge connections reversed, can result in sporadic operation of the modulation valve. See Figure 4 for an illustration of the correct valve location and orientation.

Figure 19 is a troubleshooting flow chart to help with simple modulation problems. For more information on troubleshooting the Copeland Digital Compressor Controller please refer to **AE8-1328**.

Refrigerant Retrofits



Only use approved refrigerants, lubricants, and parts in accordance with the system and compressor specifications. Recover all the refrigerant from the system including the high and low side. Use a tubing cutter to remove the compressor.

These compressors are UL recognized and use with any other refrigerant than originally intended for use will void the compressor UL recognition. For a list of Copeland approved refrigerants please refer to Form 93-11, Refrigerants and Lubricants Approved for Use in Copeland Compressors.

Modulation Valve Replacement Procedure

The YAD32-115 and YPD76-129 compressors employ a modulation valve that is mounted external to the compressor in the modulation tubing. To replace the modulation valve, follow these recommended steps:

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

12. Evacuate the compressor/system and put the system back into operation.

Modulation Valve Replacement Procedure

The YAD130-174 and YPD145-192 compressors have a modulation valve that is replaceable in the event the valve stops functioning. The modulation valve threads into a receptacle that is inside the small terminal box on the compressor. To replace the modulation valve, follow these recommended steps:

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



9. Use care when handling the replacement valve - don't drop the valve or impact the solenoid stem. If the valve is dropped or damaged, discard it and obtain a new valve for replacement.
10. Lightly oil the gaskets with refrigeration oil and hand tighten the new modulation valve into the valve receptacle on the compressor.
11. Using a 7/8" deep well socket and a torque wrench, torque the modulation valve to 310-332 in-lbs.
11. Check for leaks using nitrogen with a properly sized regulating and relief valve.
12. Install the solenoid coil and torque the retaining screw to 25 in-lbs.
13. Install the terminal box cover, evacuate the compressor/system, and put the system back into operation.

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

Copeland Scroll Compressor Functional Check

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

1. Proper voltage to the unit should be verified.
2. The normal checks of motor winding continuity and short to ground should be made to determine if the inherent overload motor protector has opened or if an internal motor short or ground fault has developed. If the protector has opened, the compressor must be allowed to cool sufficiently to allow it to reset.
3. Proper indoor and outdoor blower/fan operation should be verified.
4. Remove power from the unloader solenoid to load the compressor 100%. With service

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

5. If suction pressure does not drop and discharge pressure does not rise to normal levels, reverse any two of the compressor power leads (this procedure is for 3-phase compressors only) and reapply power to make sure compressor was not wired to run in reverse direction. If pressures still do not move to normal values, either the reversing valve (if so equipped) or the compressor is faulty. Reconnect the compressor leads as originally configured and use normal diagnostic procedures to check operation of the reversing valve.

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

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

6. To test if the compressor is pumping properly, the compressor current draw must be compared to published compressor performance curves using the operating pressures and voltage of the system. If the measured average current deviates more than $\pm 15\%$ from published values, a faulty compressor may be indicated. A current imbalance exceeding 15% of the average on the three phases should be investigated further.
7. Before replacing or returning a compressor: Be certain that the compressor is actually inoperable. As a minimum, recheck a compressor returned from the field in the shop or depot for Hipot, winding resistance, and ability to start before returning. More than one-third of compressors returned to Copeland for warranty analysis are determined to have

nothing found wrong. They were misdiagnosed in the field as being inoperable. Replacing working compressors unnecessarily costs everyone.

Figures & Tables

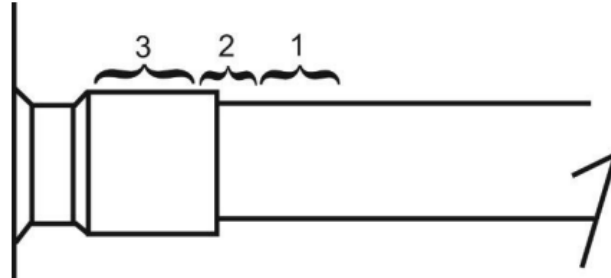


Figure 1 - Scroll Tube Fitting Brazing

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 tube approaches brazing temperature, move torch flame to Area 2.
- Heat Area 2 until braze temperature is attained, moving torch up and down and rotating around tube as necessary to heat tube evenly. Add braze material to the joint while moving torch around joint to flow braze material around circumference.
- After braze material flows around joint, move torch to heat Area 3. This will draw the braze material down into the joint. The time spent heating Area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the 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 **New Installation** brazing instructions above.

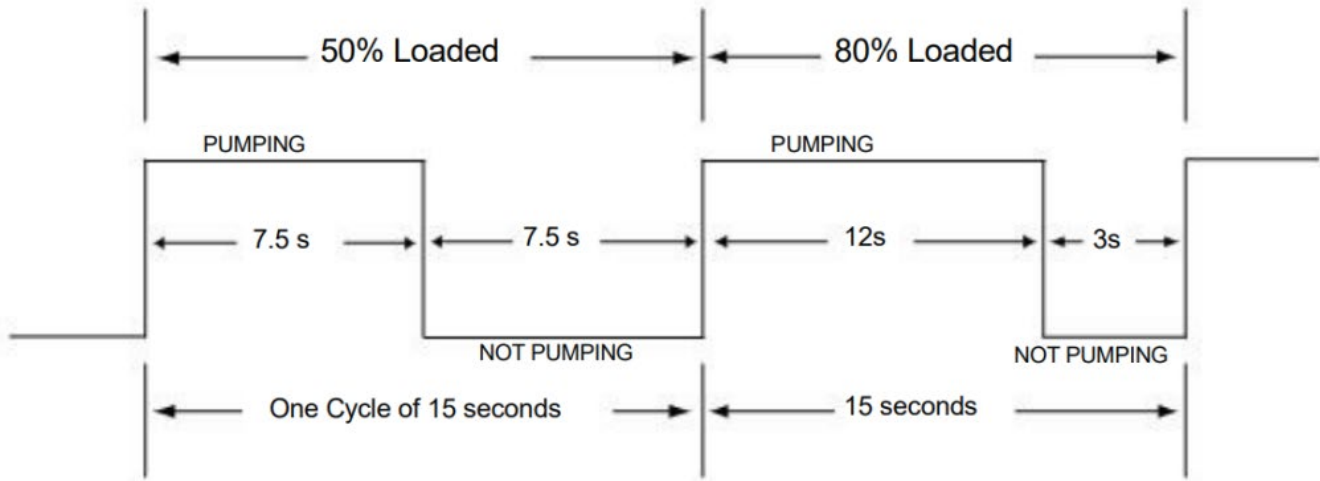


Figure 2 - Digital Modulation Cycle

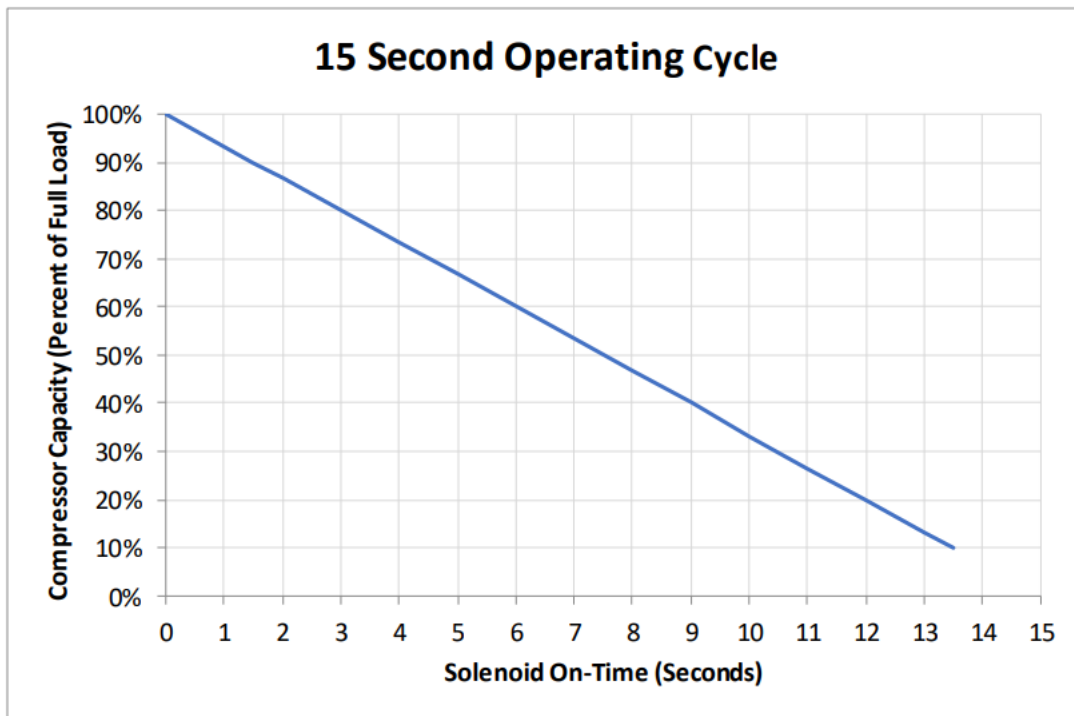


Figure 3 - Compressor Capacity Graph

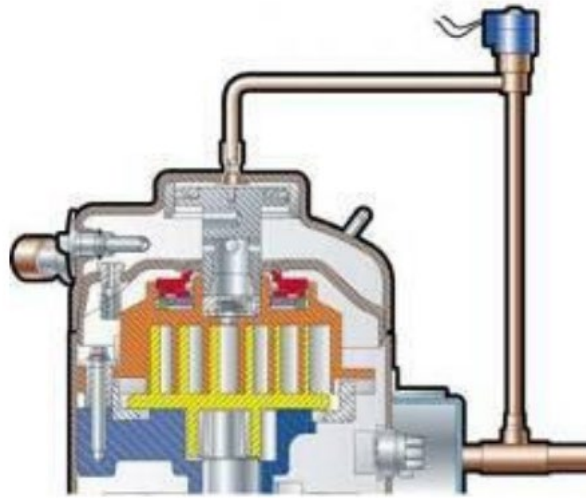


Figure 4 - Digital Scroll Cross Section: YAD32-115 & YPD76-129

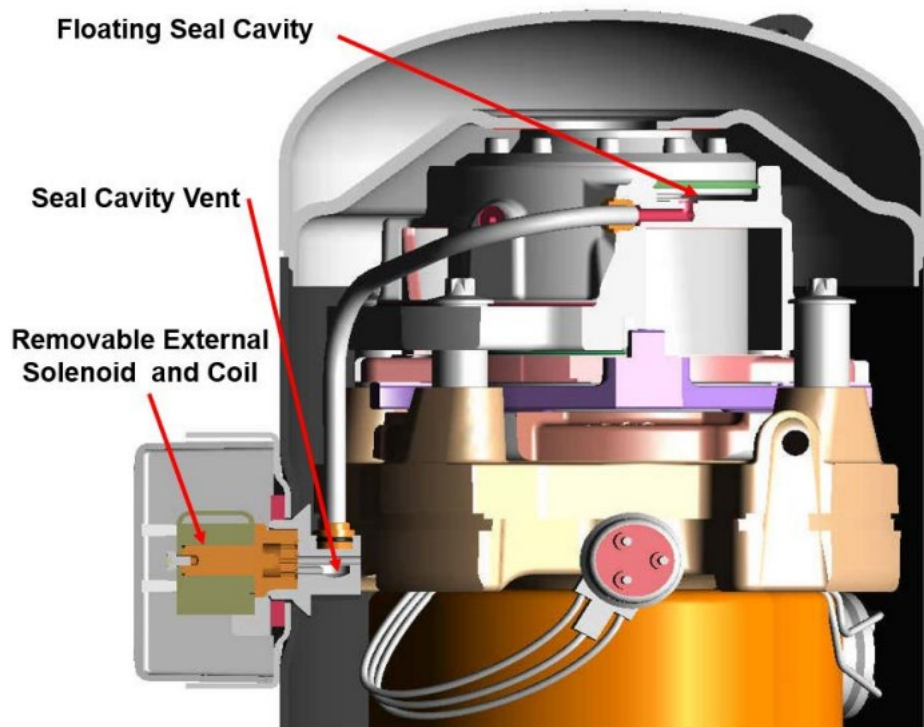


Figure 5 - Digital Scroll Cross Section: YAD130-174 & YPD145-192

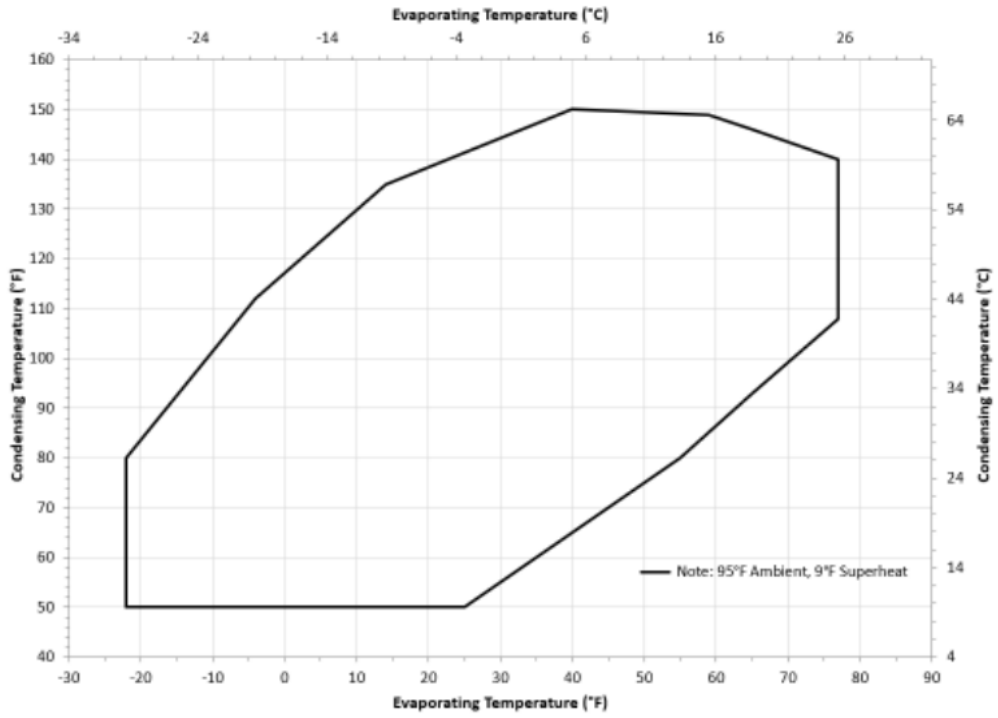


Figure 6 - Operating Envelope: YAD32-50

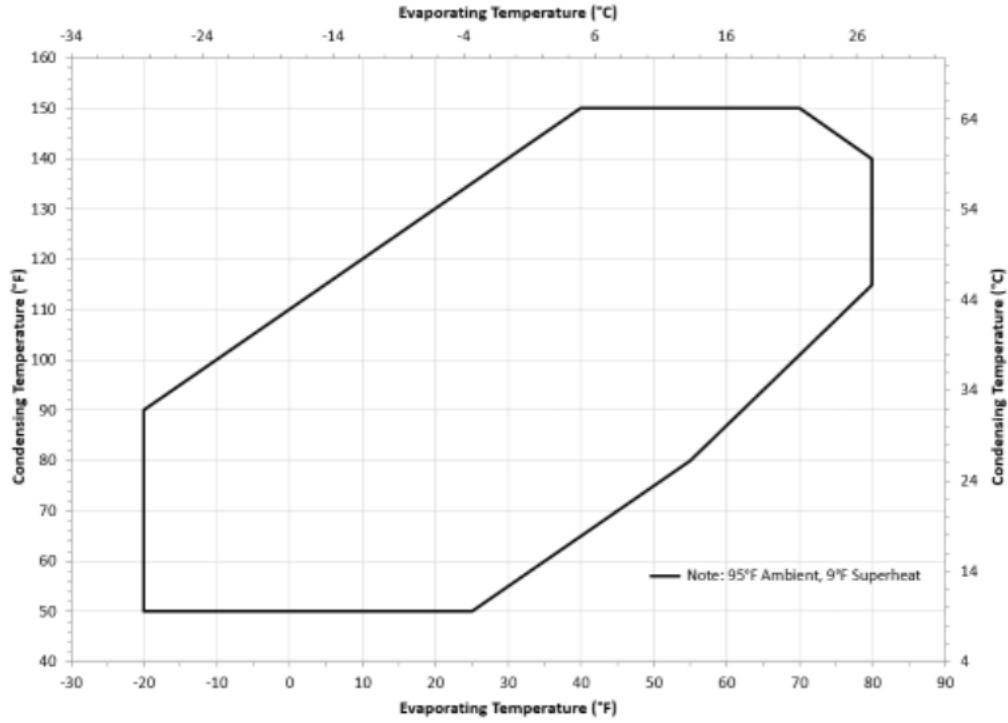


Figure 7 - Operating Envelope: YAD57-86

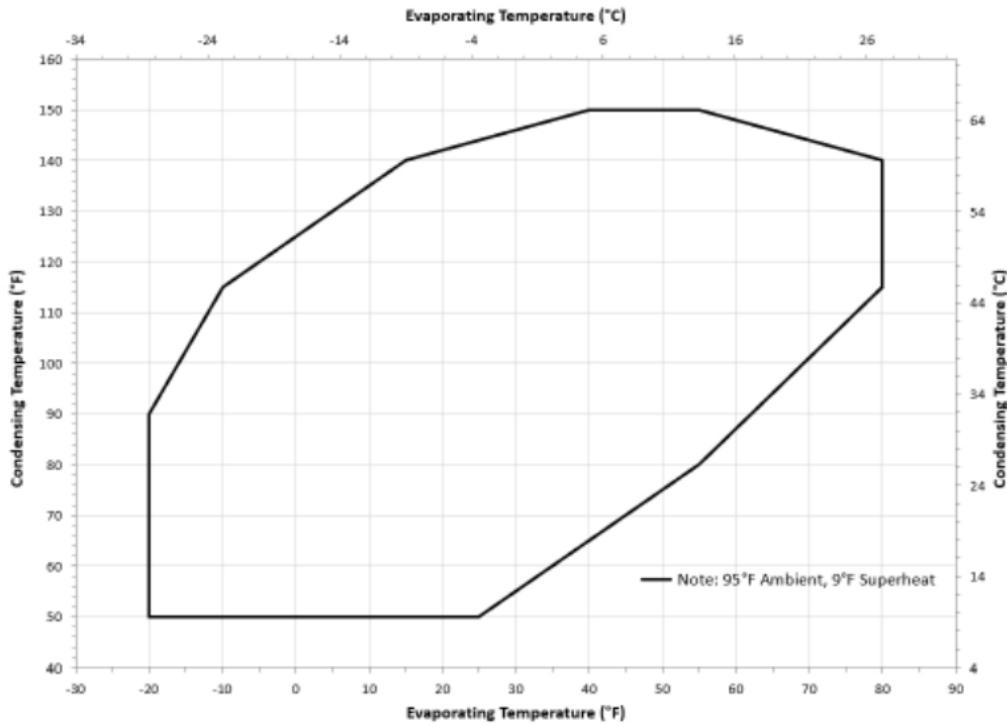


Figure 8 - Operating Envelope: YAD98-115

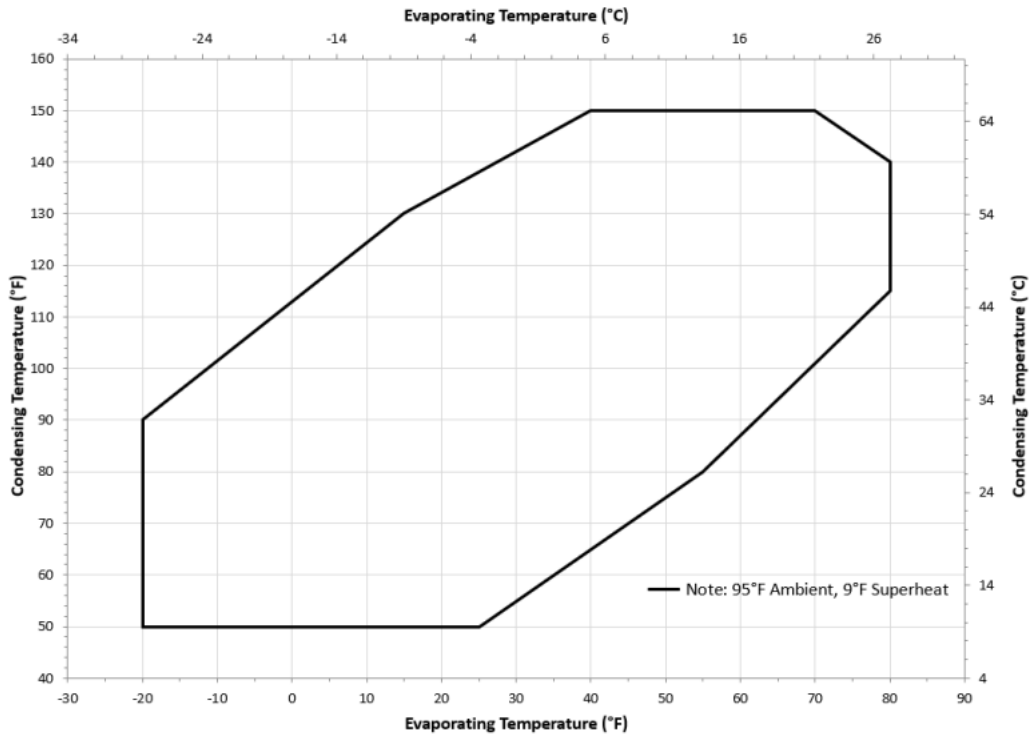


Figure 9 - Operating Envelope: YAD130-174

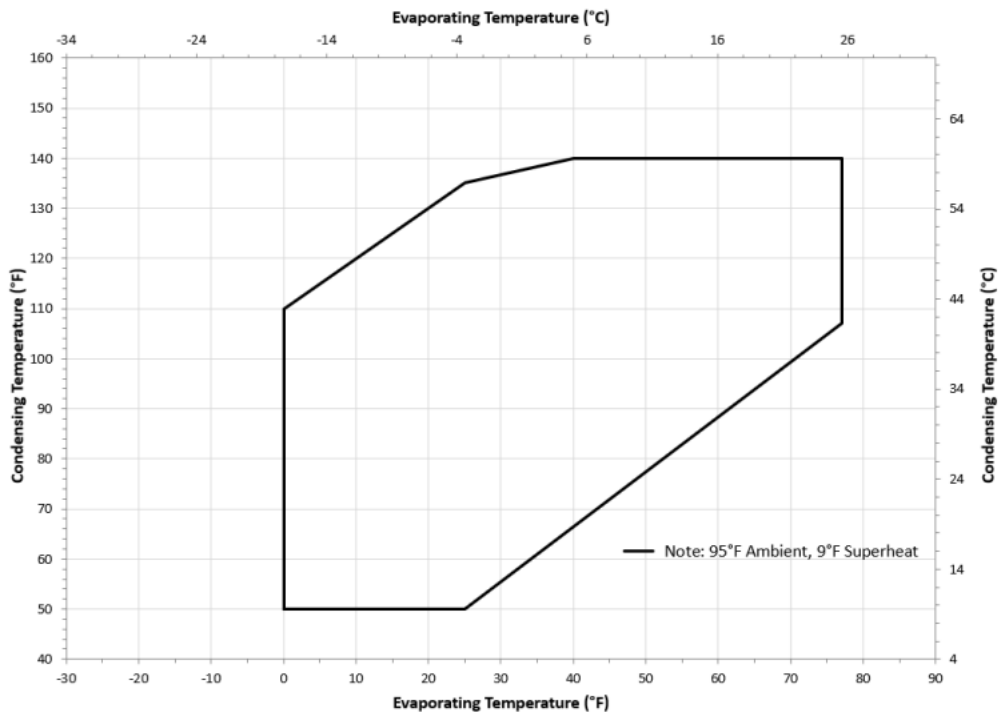


Figure 10 - Operating Envelope: YPD76

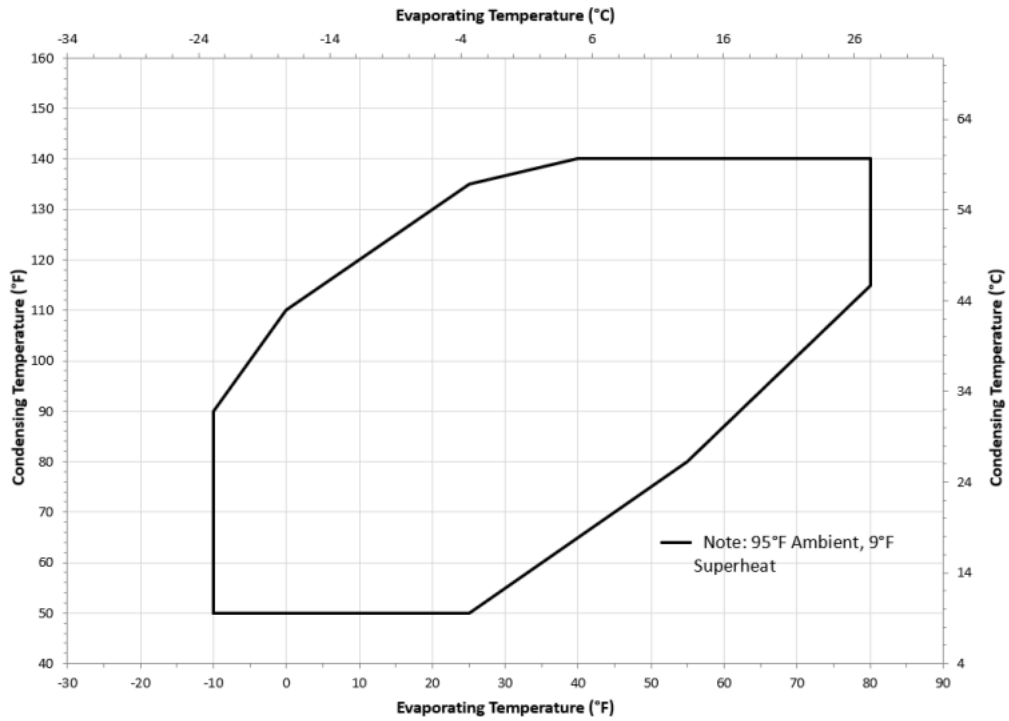


Figure 11 - Operating Envelope: YPD110-145

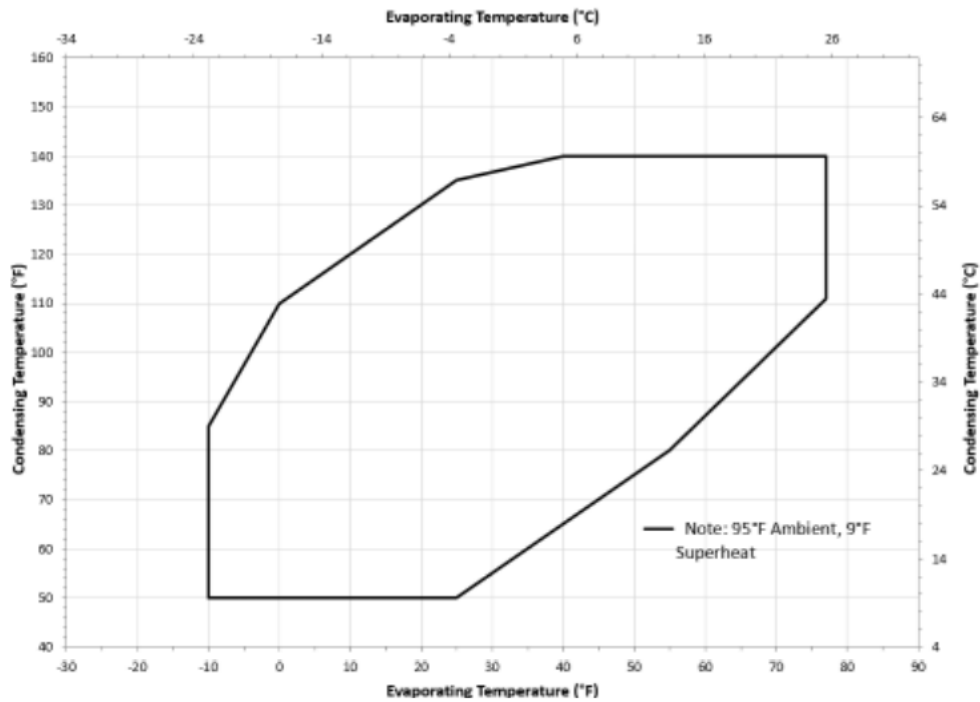


Figure 12 - Operating Envelope: YPD163-192

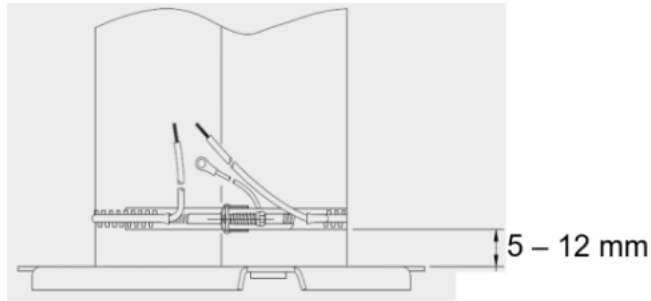


Figure 13 - Crankcase Heater Location: YAD32-50

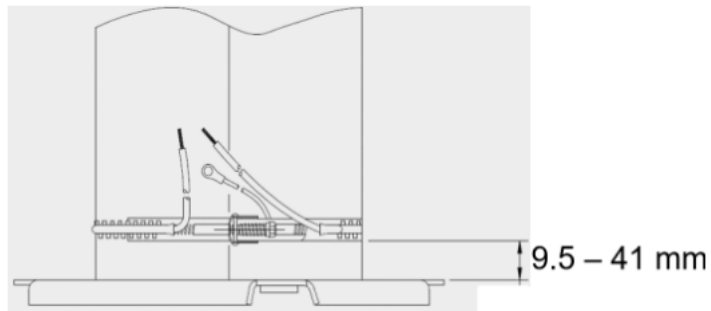


Figure 14 - Crankcase Heater Location: YAD57-115 & YPD76-129

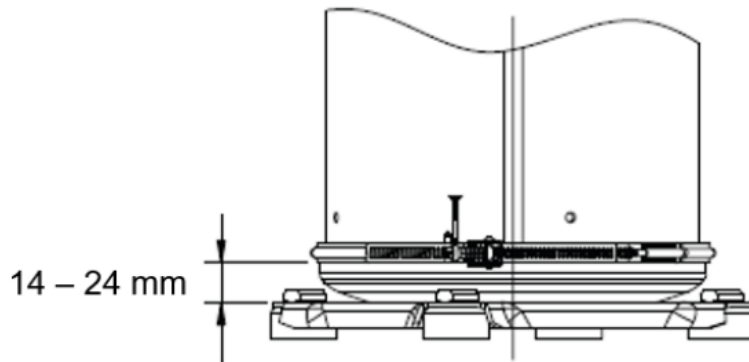


Figure 15 - Crankcase Heater Location: YAD130 & YPD145

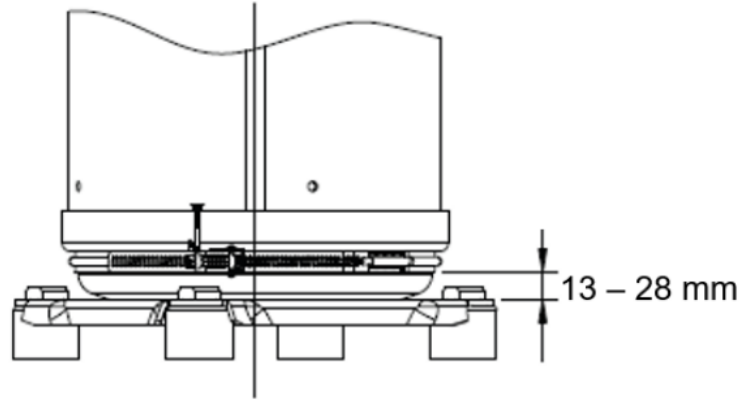


Figure 16 - Crankcase Heater Location: YAD147-174 & YPD163-192

Figure 17: Oil Dilution Chart

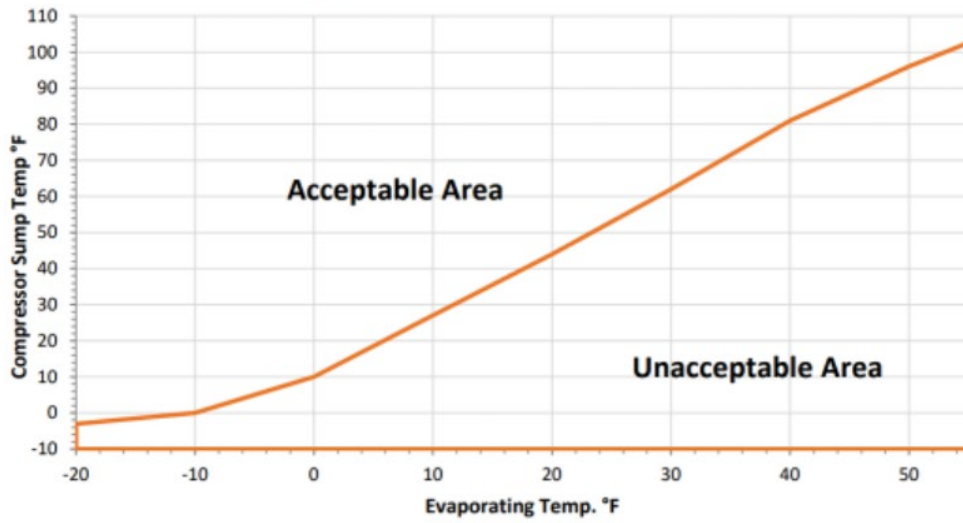


Figure 17 - Oil Dilution Chart

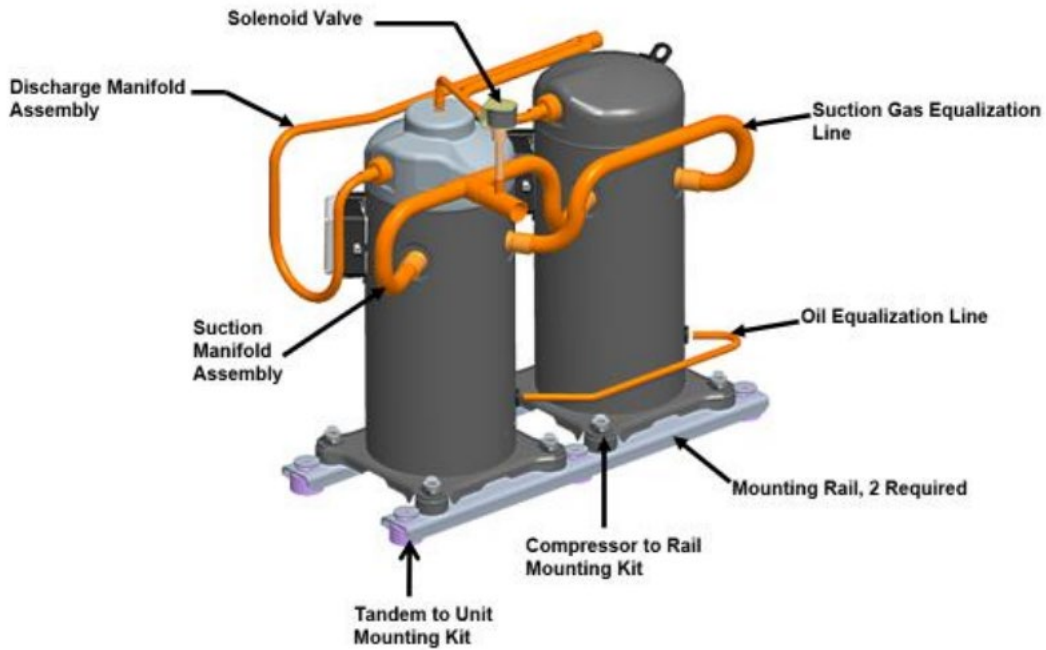


Figure 18 - Tandem Piping Example: YAD32-115 & YPD76-129

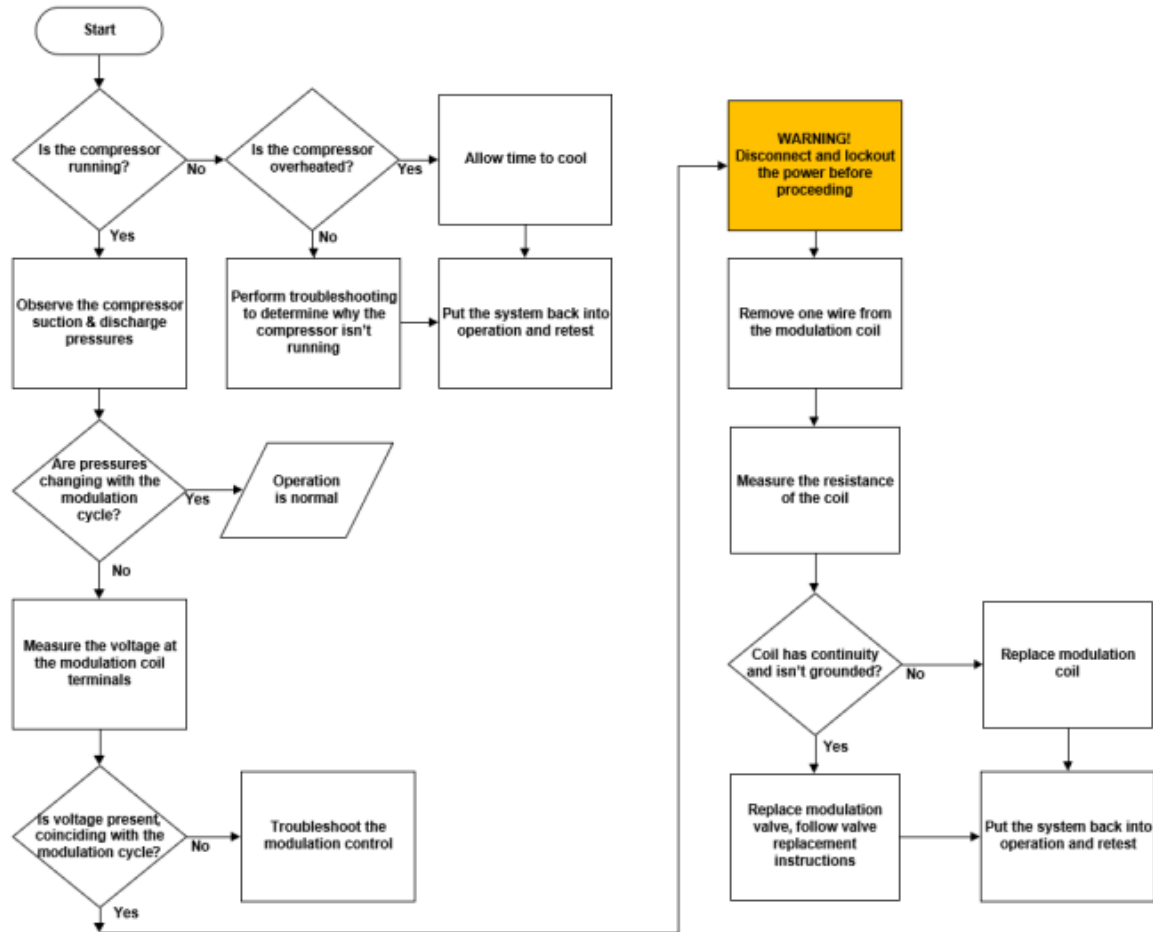


Figure 19 - Modulation Troubleshooting

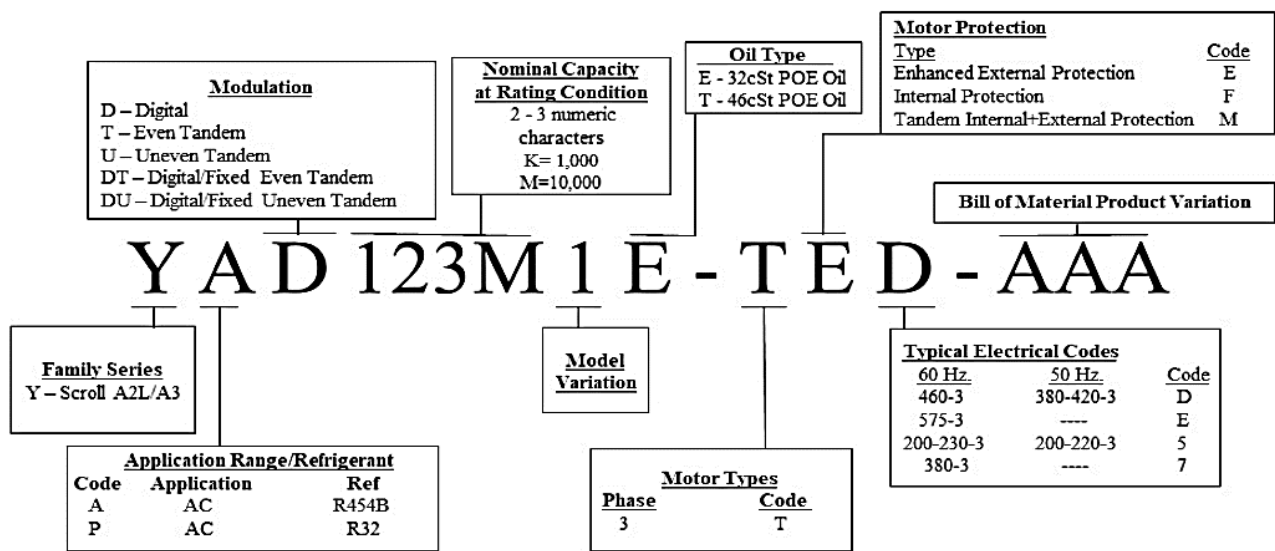


Figure 20 - Digital Nomenclature

Table 1 - Torque Values

Model	Torque		
	ft-lb	in-lb	N-M
Modulation Valve (YAD130-174 & YPD145-192)	25.8-27.7	310-332	35.0-37.5
Solenoid Screw	2	25	2.8
Schrader Valve	3.3-5.0	40-60	4.5-6.8
Terminal Block Screws	2	25	2.8
10-32 Green Ground Screw	2	25	2.8
Sight Glass	74-81	885-975	100-110

Table 2 - Compressor Features

Model	Digital Modulation Valve	Discharge Line Temperature External Sensor Required?	Discharge Check Valve	Internal Pressure Relief Valve (IPRV)
YAD32-50	Required Accessory	Yes	No	Yes
YAD57-86 YPD76	Required Accessory	Yes	No	Yes
YAD98-115 YPD110-129	Required Accessory	Yes	No	No
YAD130-174 YPD145-192	Installed On Compressor	Yes	Yes	No

Table 3 - Refrigerant Charge Limits

Model	Compressor Charge Limit	
	Pounds	kg
YAD32-50	8	3.6
YAD57-86 YPD76	10	4.5
YAD98-115 YPD110-129	11	5.0
YAD130 YPD145	16	7.3
YAD147-174 YPD163-192	18	8.2

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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