Application Engineering

*Application Guidelines for ZB*KAU Copeland R-290 Scroll Compressors*

BULLETIN NO: AE4-1431 R2

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COPELAND

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Safety

Important Safety Information

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

Responsibilities, Qualifications and Training

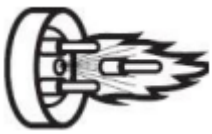
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

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

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

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

Terminal Venting and Other Pressurized System Hazards



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

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

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

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

Flammable Refrigerant Hazards

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

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

Electrical Hazards

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

Hot Surface and Fire Hazards

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

Lifting Hazards

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

POE Oil Hazards

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

Precautions

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

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

• Keep clear of the compressor when power is applied.

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

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

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

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

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

- Discharge capacitors for a minimum of two minutes

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

• Allow time for the compressor to cool before servicing.

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

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

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

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

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

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

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

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

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

• Before energizing the system:

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

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

Signal Word Definitions

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

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

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

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

Introduction

The purpose of these application guidelines is to provide guidance in the application of Copeland Scroll™ ZB*KAU compressors.

See **Table 1** for a summary of mechanical specifications.

Besides the support they provide, the instructions listed herein are also critical for the proper and safe functioning of the compressors. Copeland will not guarantee the performance and reliability of the product if it is misused in regard of these guidelines.

ZB*KAU compressors are released only for R290 stationary applications with refrigerant charges below 150 grams (5.29 oz.). For mobile applications, contact Application Engineering as other considerations may apply.

General Instructions

- During service make sure that:
- the area is well ventilated.
- the materials and equipment used are suitable for use under explosive conditions.
- only non-sparking tools are used.
- antistatic gloves and clothes are used.
- build-up of electrostatic charges is avoided.
- In case of explosive atmosphere: Immediately stop the compressor and/or de-energize the power supply of the compressor and any other electrical component / Equipment
- no unshielded flame is allowed.

Furthermore, before opening the refrigeration system or working on it with an unshielded flame:

- continuously check if the ambient atmosphere is non-explosive and ensure proper ventilation of the room before creating any naked flame; no naked flame is allowed in an explosive atmosphere
- if the atmosphere reaches a dangerous concentration of flammable gas, avoid any ignition source and ventilate the room further.

If an explosive atmosphere is detected, immediately stop the compressor and ventilate the room. No open flame is allowed.

Electrical shock hazard! Serious personal injuries and/or system breakdown! Allow drive components to electrically discharge for a minimum of two minutes before servicing. Use compressor with grounded system only. Refer to original equipment wiring diagrams. Electrical connections must be made by qualified electrical personnel.

System breakdown! Personal injuries! Only approved refrigerants and refrigeration oils must be used.

Overheating! Bearing damage! Do not operate compressor without refrigerant charge or without it being connected to the system.

Contact with POE!

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

Product Description

These application guidelines deal with vertical single Copeland Scroll compressor models ZB07KAU, ZB09KAU, ZB10KAU and ZB11KAU.

Nomenclature

The model designation contains the following technical information about the standard compressors:

Z B 09K A U - PFJ - BOM
1 2 3 4 5 6 7

1 Z= Compressor Family: Z=Scroll
2 B= MT / HT
3 Nominal Capacity [BTU/h] @ 60 Hz and ARI conditions using multiplier "K" for 1000.
4 Model Variation
5 Refrigerant R-290
6 Motor Version
7 Bill of material number

Application

Compressors	ZB07KAU, ZB09KAU, ZB10KAU
Qualified Refrigerants	R-290
Low, Medium Temp Oil	POE68B (Hatcol 4467)

Refer to Copeland Accepted Refrigerant List 93-11 for more options or details.

Maximum Allowable Operation Pressures

The Maximum Allowable Operation Pressure are the pressure values at the high- and low-pressure sides up to which it is safe to operate the compressor. Safety is established in compliance with the relevant standards applicable to the given product temperatures do not come into contact with these potentially hot areas.

Compressor	Maximum Allowable Operation Pressure	
	High-Pressure Side	Low-Pressure Side
ZB07KAU to ZB11KAU	406 PSIG (28 bar)	247 PSIG (17 bar)

Application limits

CAUTION

Inadequate lubrication! Compressor breakdown! The superheat at the compressor suction inlet must always be sufficient to ensure that no refrigerant droplets enter the compressor. **For a typical evaporator-expansion valve configuration a minimum stable superheat of at least 20°F (10 °K) is required measured 6" (152 mm) from the compressor suction inlet.**

Refer to **Figure 1** for application envelopes.

Oil Levels

ZB*KAU compressors have no oil sight glass which ensures maximum hermeticity to allow operation with flammable refrigerant, Consequently, it is difficult to get an indication of the actual oil level in the compressor during operation. For new applications, OEMs are required to order a sample compressor equipped with an external site tube for lab testing to confirm operating oil levels (see **Figure 19 and Figure 20**). Refer to Appendix B for details about Oil Filling Test for new applications.

The factory oil filling for all ZB*KAU compressor models has been optimized to a value of 16 oz (473 mL). This is a reduced oil filling which makes the compressor applicable to run in systems with refrigerant charges below 150 grams. This reduced oil filling is close to the minimum oil required; Oil Filling Test of Appendix B is required for application approval. See **Figure 2** for reference.

Superheat Requirements

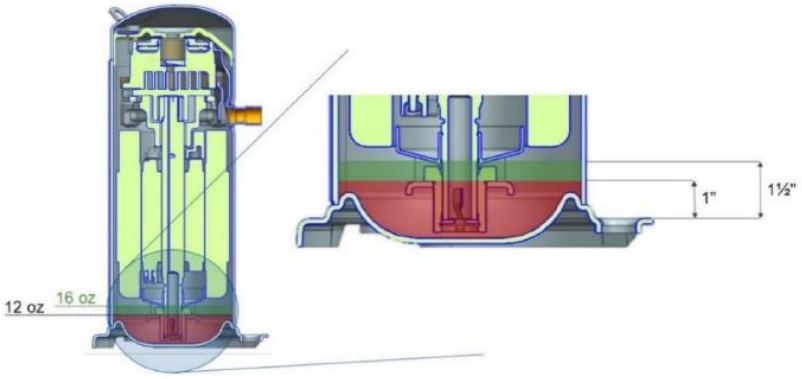
To determine if liquid refrigerant is returning to the compressor is recommended to accurately measure the temperature difference between the compressor oil crankcase and the suction line. During continuous operation we recommend that this difference be a minimum of 50°F (27°K). This “crankcase differential temperature” requirement supersedes the minimum suction superheat requirement in **Application Limits**. To measure oil temperature through the compressor shell, place a thermocouple on the bottom center (not the side) of the compressor shell and insulate from the Deep Vacuum Operation ambient.

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

Contact your Copeland representative regarding any exceptions to the above requirements.

*Figure 1 Extended Medium Temp operating envelope for ZB*KAU compressors*

Figure 2 Oil Filling and minimum acceptable oil level



Installation

CAUTION

High pressure! Injury to skin and eyes possible! Compressors are delivered pre-charged with pressurized dry air. Be careful when opening connections.

Transport and storage

CAUTION

Risk of collapse! Personal injuries! Move compressors only with appropriate mechanical or handling equipment according to weight. Keep in the upright position. Respect stacking loads according to Figure 3. Check the tilting stability and if needed take action to ensure the stability of the stacked loads. Do not stack single boxes on top of each other. Keep the packaging dry at all times

Respect the maximum number of identical packages which may be stacked on one another, where "n" is the limiting number:

- **Transport: n = 1**
- **Storage: n = 2**

Figure 3 - Maximum stacking loads for transport and storage

The compressor tilt angle should not be more than 30° during transport and handling. This will prevent oil from exiting through the suction stub. A tilt angle of maximum 45° is allowed for a very short time. Tilting the compressor more than 45° might affect its lubrication at start-up.

NOTE: The compressor is pre-charged with dry air to avoid any moisture contamination.

Positioning and securing

CAUTION

Handling damage! Compressor malfunction! Only use the lifting eyes whenever the compressor requires positioning. Using discharge or suction connections for lifting may cause damage or leaks

The compressor should be kept vertical during handling.

The discharge connection plug should be removed first before pulling the suction connection plug to allow the dry air pressure inside the compressor to escape. Pulling the plugs in this sequence prevents oil mist from coating the suction tube making brazing difficult. The copper-coated steel suction tube should be cleaned before brazing.

The plugs must be removed as late as possible before brazing so that the air humidity does not affect the oil characteristics.

As oil might spill out of the suction connection located low on the shell, the suction connection plug must be left in place until the compressor is set into the unit.

No object, e.g., a swaging tool should be inserted into the suction tube or it might damage the suction screen and motor.

Installation location

These compressors shall be installed only in a non-explosive atmosphere.

Scroll compressors are capable of operating correctly in ambient humidity from 30% to 95% and at altitudes up to 6562 feet (2000 meters). For correct operation, the ambient air temperature must range from -31°F to 122°F (-35°C to 50°C) and the compressor Maximum Allowable Operation Pressure shall be respected at all times during operation and at standstill.

Ensure the compressors are installed on a solid level base. For multiple-compressor parallel configurations, the compressors must be positioned completely vertically on a totally horizontal surface or rail.

Compressor mounting parts

The compressors are designed to be mounted on vibration absorber grommets. The grommets dampen the start-up surge of the compressor and minimize sound and vibration transmission to the compressor base during operation. The metal sleeve inside is a guide designed to hold the grommet in place. It is not designed as a load-bearing member, and application of excessive torque to the bolts can crush the sleeve. Its inner diameter is approximately 0.335 inches (8.5 mm) to fit, e.g., an M8 screw. The mounting torque should be 9.588 ± 0.738 ft. lb (13 ± 1 Nm). It is critically important that the grommet is not compressed.

See **Figure 4** for reference.

Figure 4 - Soft mounting parts for single compressors ZB07KAU to ZB11KAU

Brazing Procedures

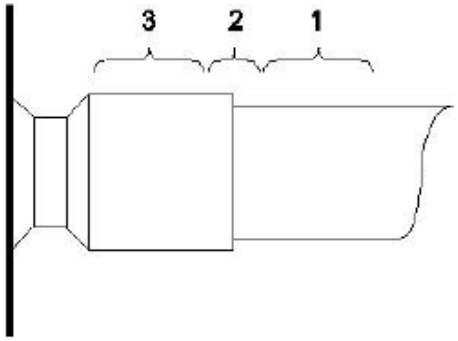


Figure 5 - Suction tube connecting areas

WARNING

High temperature! Burning! Proceed with caution when brazing system components. Do not touch the compressor until it has cooled down. Ensure that other materials in the area of the compressor do not make contact

CAUTION

Blockage! Compressor breakdown! Maintain a flow of oxygen-free nitrogen through the system at very low-pressure during brazing (1.5 to 2 PSI). Nitrogen displaces the air and prevents the formation of copper oxides in the system. If allowed to form, the copper oxide material can later be swept through the system and block screens such as those protecting capillary tubes, thermal expansion valves, and accumulator oil return orifices.

CAUTION

Contamination or moisture! Bearing failure! Do not remove the connection plugs until the compressor is set into the unit. This minimizes any entry of contaminants and moisture.

Refer to **Figure 5** and procedure below for the brazing of the suction and discharge lines to a Scroll compressor.

The copper-coated steel tubes on Scroll compressors can be brazed in approximately the same manner as any copper tube.

- Recommended brazing material: Any SIL-FOS® material is recommended, preferably with a minimum of 5% silver. However, 0% silver is acceptable.
- Be sure tube fitting inner diameter and tube outer diameter are clean prior to assembly.
- Using a double-tipped torch, apply heat in area 1.
- As the tube approaches brazing temperature, move the torch flame to area 2.
- Heat area 2 until braze temperature is attained, moving the torch up and down and rotating around the tube as necessary to heat the tube evenly. Add braze material to the joint while moving the torch around the joint to flow braze material around the circumference.
- After the braze material flows around the joint, move the torch to heat area 3. This will draw the braze material down into the joint. The time spent heating area 3 should be minimal.
- As with any brazed joint, overheating may be detrimental to the final result.

NOTE: Since the discharge stub contains a check valve, care must be taken not to overheat it to prevent brazing material from flowing into it.

Filter screens

CAUTION

Screen blocking! Compressor breakdown! Use filter screens with at least 0.024" openings.

The use of filter screens finer than 30 x 30 mesh (0.024" openings) anywhere in the system should be avoided with these compressors. Field experience has shown that finer mesh screens used to protect thermal expansion valves, capillary tubes or accumulators can become temporarily or permanently plugged with normal system debris and block the flow of either oil or refrigerant to the compressor. Such blockage can result in compressor failure.

Sounds and vibration

FLAMMABLE

Vibrations during compressor operation can cause cracks which could lead to refrigerant leakage. This situation must be avoided by the system manufacturer/installer. Therefore, proper pipe design must be taken into consideration when connecting a scroll compressor to a system.

A scroll compressor makes both a rocking and twisting motion and enough flexibility must be provided in the pipelines to allow starting, stopping and steady state running of the compressor without transmitting excessive stress into any line attached to the unit.

Under some conditions, the Copeland Scroll has a normal starting rotational motion that can transmit a transient noise along the lines. This may be particularly pronounced in compressors using a three-phase motor due to their inherently higher starting torque. This phenomenon, like the one described previously, can easily be avoided by using standard line isolation techniques.

The sound level of a system is the result of design, quality and application. Scroll compressors sound power levels generally increase with the compressor model capacity and the condition pressure ratio.

Electrical Connections

Units Electrical connections per BOM 634

ZB*KAU compressors for applications in US market are delivered with electrical pin connections ready for molded plug connection. Its protection class is IP65. R290 qualified and dedicated molded plug cables must be used. The R290 dedicated kit includes a special O-ring, a grounding connection and a retainer, see figures below.

Copeland recommends that the electrical installation be executed considering the recommendations of NEC-NFPA and/or other standards and national regulations that may apply.

Assembly of the molded plug cable

- Make sure to apply only R290 qualified and dedicated molded plug power cables with grounding and retainer.
- Check, that the O-ring on the molded plug connector is in place and not damaged.
- Shut off power supply.
- Check, that the circle fence is clean and dry, before connecting the molded plug power cable.
- Connect the grounding of the molded plug power cable to the compressor circle fence.
- Install the molded plug connector properly to the motor terminals. Push the molded plug connector smoothly as far as possible towards the terminals. Don`t use any tool to knock on the molded plug connector, because this could damage the glass inserts of the Fusite terminal pins.
- Secure the connection with the retainer.

Refer to **Figure 6** to **Figure 8** for more details

Figure 6 - Power Cable molded plug IP65, USA

Figure 7 - Circle fence with motor terminals, USA

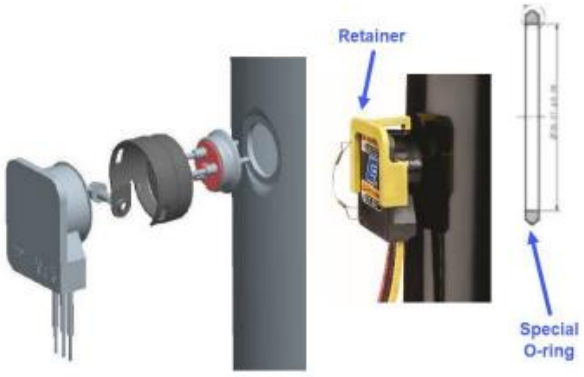


Figure 8 - Principle of connecting the molded plug power cable to the connection pins

Removing the molded plug power cable

- Shut off power supply.
- Remove the retainer from the connection.
- Remove the molded plug connector from the connection pins.
- Disconnect the grounding from the compressor circle fence.

Models with 634 BOM will be single and three phases. For 3 phase units, pay special attention to appropriate phase rotation to avoid reverse rotation of the scroll motor.

Electrical Installation

WARNING

Conductor cables! Electrical shock! Shut off power supply before and between each test

FLAMMABLE

The system capacitor may remain charged for a few minutes after shutdown. Before starting to work on the electrical installation make sure accidental sparking is not possible.

FLAMMABLE

Shut off power supply before and between each test. Continuously check if the ambient atmosphere is non-explosive and ensure proper ventilation before and when working on the electrical installation.

With flammable or explosive atmosphere no work on the electrical installation is allowed. If the atmosphere reaches a dangerous concentration of flammable gas immediately stop any work on the electrical installation, avoid any source of ignition and ensure proper ventilation of the room.

US Units

A motor soft starter can also be used to temporarily reduce the load, the torque and the electric current surge of the compressor motor at start-up. For more information, please contact Application Engineering.

Figure 10 shows electrical connections schematic.

NOTE: Copeland recommends the use of a Residual Current Device (RCD) as an additional safety measure.

NOTE: Copeland recommends the use of a second contactor K2 for the safety chain of the compressor. This protection must be considered it in conjunction with the mentioned RCD.

European Units

European Units Electrical connections

In EU compressors electrical connection is only available using a terminal dome cover. Due to the IP11 certification of the terminal box, the compressor must be protected by a cover, which can only be opened with a tool.

The compressor terminal box has a wiring diagram on its cover. Before connecting the compressor, ensure the supply voltage, the phases and the frequency match the nameplate data.

When installing these compressors in the system, the following steps must be taken:

- Add the foam gasket and the plastic terminal cover.
- To connect the power leads, use suitable 90° insulated female crimp connector terminals from "250 series" suitable for 0.250-inch (6.35 mm) male tab width. See **Figure 9**.
- To ensure the wires are properly terminated, the correct terminal and clamping tool for the selected wire size must be used.
- The ground wiring must conform to local regulations and codes of practice (only the provided parts must be used).
- Add a cable strain relief device.
- Protect cable and wires against sharp edges

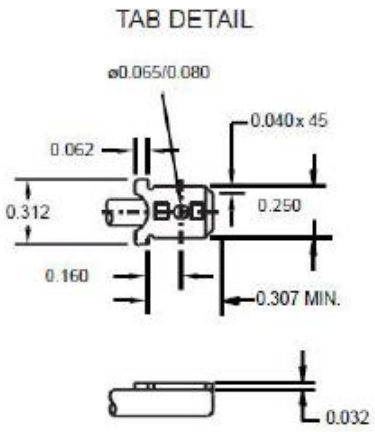


Figure 9 - Connections dimensions in inches

Terminal box

CAUTION

Mechanical stress or shock! Terminal box damage! Mechanical stress and shocks to the terminal box must be avoided as they might result in tightness failure or loss of terminal box performance.

CAUTION

Mechanical stress or shock! Terminal Fusite damage! Mechanical stress and shocks to the Fusite must be avoided as they could damage the glass and/or ceramic. This might result in hermetic failure or loss of terminal performance. Precautions are required to prevent striking or bending of pins. Bent or damaged pins may result in loss of hermeticity and/or terminal performance.

CAUTION

Overheating! Terminal Fusite damage! Ensure correct connection of cables to the compressor terminal Fusite to avoid local overheating of Fusite pins which might lead to refrigerant leaks.

Special attention shall be paid to the electrical connections owing to possible local overheating.

Figure 11 and **Figure 12** show Terminal dome cover and correct electrical connection. This connection is only detailed for services propose.

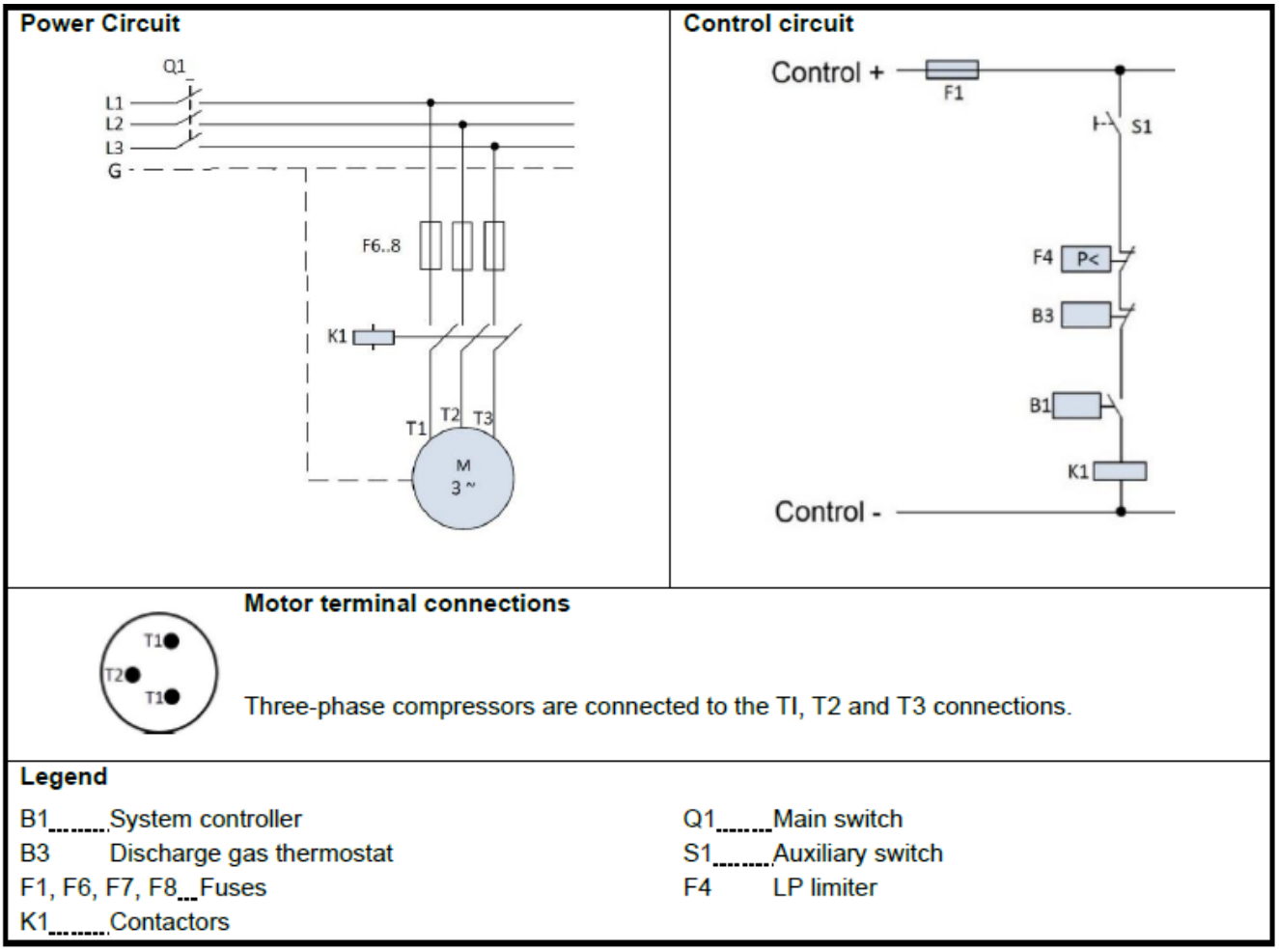


Figure 10 - Three phase compressor (TF) with internal motor protection, USA*

Figure 11 - Terminal dome cover and correct installation, European Electrical

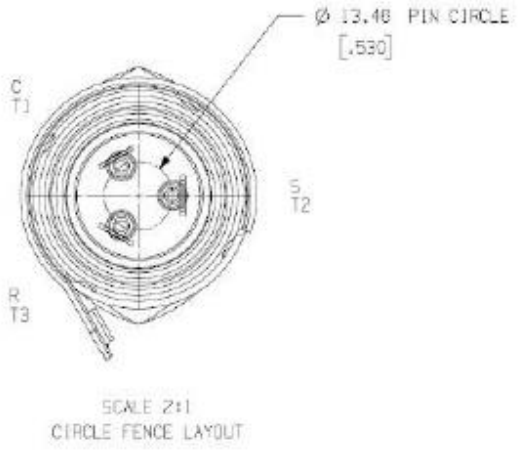


Figure 12 - European Electrical connections

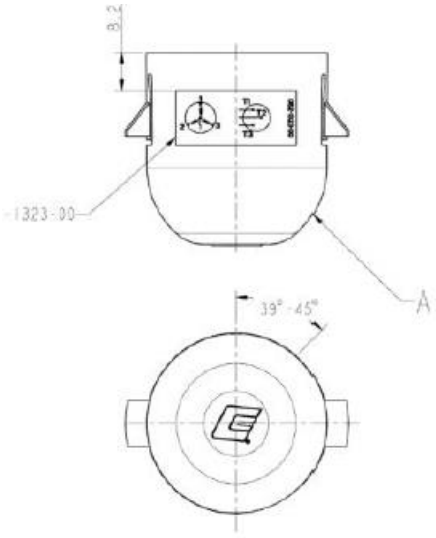


Figure 13 - Cover Equations

Protection devices

Independently from the internal motor protection, fuses must be installed before the compressor. The selection of fuses should be carried out according to UL standards, RLA and LRA. Failing to install fuses before the compressor or selecting inappropriate fuses may result in compressor failure.

Crankcase heaters

Crankcase heaters are not released for ZB*KAU compressors.

Pressure protection devices

High Pressure protection

For systems conforming to, IEC 60335-2-89, UL 60335-2-89 and EN 60335-2-89 no high-pressure switch is required.

Low Pressure protection

FLAMMABLE

Operation under ambient pressure! During operation under ambient pressure an explosive mixture can form inside the system. Make sure that the pressure never falls below atmospheric pressure

CAUTION

Operation outside the application envelope! A low-pressure protection shall be fitted in the suction line to stop the compressor when it operates outside the envelope limits.

CAUTION

Loss of system charge! Loss of lubrication! Bearing malfunction and compressor breakdown! A low-pressure limiter protection must be installed and set above the atmospheric pressure. Do not bridge or by-pass the low-pressure limiter. Do not operate under atmospheric pressure.

In some instances, systems must operate at low evaporating pressure because of the low ambient temperatures, sometimes combined with a high level of relative humidity. Proper evaporator sizing and adequate defrost strategy control will prevent the system from operating outside the operating envelope published by Copeland, whatever the climatic conditions and the capacity demand.

However, in some extreme cases – such as loss of system charge, extreme heat transfer restriction at the evaporator, any defect or blocked flow control component (expansion valve, screens, etc.) – the evaporating conditions may be such that the compressor will operate outside the published operating envelope limits. These conditions may result in compressor failure.

Therefore, Copeland requires that all ZB*KAU compressors without exception be fitted with a low-pressure protection in the suction line. The mandatory inclusion of a low-pressure switch will stop the compressor operating outside the published envelope limits or below atmospheric pressure.

Discharge gas temperature protection

CAUTION

Inadequate lubrication! Scroll set damage! All ZB*KAU compressors must be equipped with an external discharge gas temperature protection.

A good system control shall prevent the system from operating outside the published operating envelope and acceptable superheat range, whatever the climatic conditions and the capacity demand. However, under some extreme operating conditions (such as loss of charge or improper control operation), the internal discharge gas temperature reached can cause compressor damage.

To guarantee positive compressor protection, it's required that discharge gas temperature protection be used for any application with Copeland brand compressors. This protection must not be used as an operating envelope controller. If not used, the warranty of the compressor will be lost.

The maximum discharge gas temperature is 275°F (135°C) for Internal limitation. The external DLT is set for 250°F (121°C) for all ZB*KAU models. These compressors have no internal discharge gas temperature protection. Therefore, an external protector is required.

Excessive discharge gas temperature

A few of the possible consequences are listed below:

- Since the oil circulates in the system with the refrigerant, it is subjected to high discharge gas temperatures. If the discharge gas temperature becomes too high, the so-called "coking" effect will occur (heating of oil under exclusion of air). Carbon deposits can form at points of high temperature, for example on the valves, oil channels, oil filters, etc. The oil lubricity will be reduced, and a progressive wear process will occur which will prematurely damage the compressor.
- The stability of the refrigerant can also be affected, particularly if traces of contaminant are present.
- The problems listed under the first 2 points frequently occur simultaneously, particularly since the chemical reaction time approximately doubles at every 20°F (10°C) temperature rise. This directly leads to chemical reactions of the oil with the refrigerant and the compounds extracted from sealants and insulation material. Therefore, contaminants of various types, among them acids, will form inside the system.

Discharge gas temperature protection

Discharge gas temperature protection is the "fallback" for failure of the system control. It is essential that proper control of the evaporating and condensing pressures and the superheat is maintained and has the ability to cope with all likely conditions and high loads. Reliance on protectors will cause inadequate system performance and short cycling. Copeland offers a discharge line thermostat, which complies with the ATEX1 requirements. This thermostat is marked with a special ATEX label, see **Figure 14**.

Figure 14 - ATEX discharge line thermostat and ATEX label

NOTE: Please make sure to select a discharge line thermostat that complies with the ATEX requirements. Other discharge thermostat devices might not comply with the ATEX requirements and could be a potential ignition source, and therefore they could only be installed in a non-explosive atmosphere.

NOTE: For correct discharge line thermostat (DLT) selection, please refer to the Copeland.com/OPI.

To be ATEX compliant, the cable ends of the thermostat must be connected with suitable cable glands and electrical enclosure to achieve a minimum protection degree of IP54 according to UL471 SB5 (IEC60079-15, clause 6.3).

When connecting the cable ends, a creepage distance of minimum 0.16 inches (4 mm) and a clearance distance of 0.1 inches (2.5 mm) between the conductive parts at different potentials must be maintained.

Maximal Voltage and Amps values for the thermostat and a protection against electrical shock must be respected during the installation.

Additionally, the ATEX compliance requires a protection of the thermostat body against mechanical damage, according to UL471 SB5 (IEC 60079-0, clause 26.4.2, table 13). There is no need for an additional housing around the thermostat body. Protection against mechanical damage to the thermostat can be achieved with an overall cover or box placed around the compressor or refrigerant system.

See **Table 2** for technical data of the discharge line thermostat.

For installation, please follow recommendations detailed on **Table 3.**

Motor Protection

Conventional inherent internal line break motor protection is provided for the ZB*KAU range of compressors.

High Potential Testing

High potential testing on R290 compressor! Special attention should be paid when performing high-potential testing.

Conductor cables! Electrical shock! Shut off power supply before high-potential testing.

Internal arcing! Motor destruction! Do not carry out high-voltage or insulation tests if the compressor housing is under vacuum.

Copeland subjects all Scroll compressors to a high-voltage test after final assembly. Each motor phase winding is tested according to EN60335-2-34, IEC 60335-2-34 and UL 60335-2-34 at a differential voltage of 1000V plus twice the nominal voltage.

Since high-voltage tests lead to premature ageing of the winding insulation, further additional tests of this nature are not recommended. However, if it must be done for any reason, a lower voltage must be used. Disconnect all electronic devices, e.g., motor protection module, fan speed control, etc. prior to testing.

The high-potential and/or Megohm resistance testing must not be done with the compressor charged with R-290. These tests can induce an electrical arc and cause a potential fire/explosion hazard.

For the same reason, compressors removed from an R290 system will need to have the oil drained and a nitrogen purge introduced to flush any remaining refrigerant from the compressor prior to high-potential testing and Megohm resistance reading.

Starting up & operation

Compressor tightness test

High pressure! Personal injuries! Consider personal safety requirements and refer to test pressures prior to test.

System explosion! Personal injuries! Use only dry nitrogen for leak testing. DO NOT USE other industrial gases.

System contamination! Bearing malfunction! Use only dry nitrogen for leak testing. DO NOT USE other industrial gases.

The compressor has been leak-pressure tested in the Copeland factory according to standards EN 14276-1, EN 60335-2-34, IEC 60335-2-34 and UL60335-2-34. Therefore, it is not necessary for the system manufacturer/installer to leak-pressure test the compressor on the assembly/system.

Never add refrigerant to the test gas (as leak indicator).

Leak checking at a pressure not to exceed 175 PSIG should be Ok to verify connections.

System Evacuation

Before the installation is put into commission, it must be evacuated with a vacuum pump. The vacuum pump and all tools must be approved for R290/air mixture. The installation should be evacuated down to 225 microns. Proper evacuation reduces residual moisture to 50 ppm.

Evacuating the system only on the suction side of a Scroll compressor can occasionally result in a temporary no-start condition for the compressor. The reason for this is that the floating seal could axially seal with the scroll set, with the higher pressure on the floating seal. Consequently, until the pressures equalize, the floating seal and scroll set can be held tightly together.

Charging procedure

In any case avoid air/R290 mixture in the refrigeration system. Make sure that the system is filled with pure R290.

Low suction pressure operation! Compressor damage! Do not operate compressor with a restricted suction. Do not operate with the low-pressure limiter bridged. Do not operate at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

For this dedicated system with refrigerant charges below 150 grams, the entire refrigerant quantity can be charged from the bottle by means of pressure difference. The charging point is typically on high pressure side, in the proximity of the filter drier.

Preliminary checks – Pre-starting

- Visual check of the electrics, wiring, fuses etc.
- Cable glands in good state, all electrical connections well connected and terminal dome cover closed to ensure corresponding IP protection for European units and compressor molded plug fully seated and clipped in place for US units.
- Visual check of the plant for leaks, loose component parts such as TXV bulbs or solenoid valve coil, loose wires in electrical installation, etc.
- Functional test of LP switch
- Check setting and operation of all safety features and protection devices
- All valves in the correct running position
- Correctly charged with refrigerant
- Compressor electrical auxiliary switch location and position

Rotation Direction

Scroll compressors are directional dependent, i.e. they will compress in one rotational direction only. Three phase scrolls will rotate in either direction depending on power phasing. Since there is a 50/50 chance of connected power being “backwards”, contractors should be warned of this. Appropriate instructions or notices should be provided by the OEM.

Verification of proper rotation can be made by observing that the suction pressure drops and the discharge pressure rises when the compressor is energized.

There is no negative impact on durability caused by operating three-phase Scroll compressors in the reversed direction for a short period of time (under one hour) but oil may be lost. Oil loss can be prevented during reverse rotation if the tubing is routed at least 6” above the compressor. After several minutes of operation in reverse, the compressor protection system will trip due to high motor temperature. The operator will notice a lack of cooling or heating. However, if allowed to repeatedly restart and run in reverse without correcting the situation, the compressor will be permanently damaged.

All three-phase scroll compressors are identically wired internally. Therefore, once the correct phasing is determined for a specific system or installation, connecting properly phased power leads to the identified compressor terminals will ensure proper rotation direction.

Starting Sound

During the very brief start-up, a clicking sound is audible, resulting from initial contacting of the spirals and is normal. Due to the design of the Copeland Scroll compressors, the internal compression components always start unloaded even if system pressures are not balanced. In addition, since internal compressor pressures are always balanced at start-up, low voltage starting characteristics are excellent for Copeland Scroll compressors.

Deep Vacuum operation

CAUTION

Vacuum operation! Compressor damage! Copeland Scroll compressors should never be used to evacuate refrigeration or air-conditioning systems

Shell temperature

The top shell and discharge line can briefly but repeatedly reach temperatures above 300°F (150°C) if the compressor cycles on its internal protection devices. This only happens under rare circumstances and can be caused by the failure of system components such as the condenser or evaporator fan or loss of charge and depends upon the type of expansion control. Care must be taken to ensure that wiring or other materials that could be damaged by these temperatures do not contact the shell.

Minimum Run Time

Copeland recommends a maximum of 10 starts per hour. Recommend stating minimum 2-3 minutes run time is required for adequate oil return. There is no minimum off time because scroll compressors start unloaded, even if the system has unbalanced pressures.

Shut-off sound

Scroll compressors incorporate a device that minimizes reverse rotation. The residual momentary reversal of the scrolls at shut off will cause a clicking sound, but it is entirely normal and has no effect on compressor durability.

Maintenance & Repair

CAUTION

Conductor cables! Electrical shock! Follow the lockout/tag out procedure and the national regulations before carrying out any maintenance or service work on the system.

When opening the refrigeration equipment or working on it avoid explosive atmosphere and ignition sources in any case.

To maximize efficiency in controlling leaks when opening the refrigeration equipment or working on it, it is recommended to use a leak detector designed for use with R290 refrigerant.

Continuously check if the ambient atmosphere is non-explosive.

In case of explosive atmosphere:

- do not energize any electrical component in the system.
- fire and smoking are strictly forbidden.
- no unshielded flame is allowed.
- power tools shall not be used.

Furthermore, before opening the refrigeration system or working on it with an unshielded flame:

- continuously check if the ambient atmosphere is non-explosive and ensure proper ventilation of the room.
- if the atmosphere reaches a dangerous concentration of flammable gas, avoid any ignition source and ventilate the room further.
- if parts of the refrigeration system are charged with flammable refrigerant, be sure that all the valves are tightly closed and that the open pipes after the valves are free of refrigerant and oil.

Disassembling system components

Continuously check if the ambient atmosphere is non-explosive.

- During service make sure that:
- the area is well ventilated.
- the materials and equipment used are suitable for use under explosive conditions.
- only non-sparking tools are used.
- antistatic gloves and clothes are used.
- build-up of electrostatic charges is avoided.

In case of explosive atmosphere:

- do not energize any electrical component in the system.
- no unshielded flame is allowed.

Unshielded flame! Fire hazard! Oil-refrigerant mixtures are highly flammable. Remove all refrigerant before opening the system. Avoid working with an unshielded flame in a refrigerant charged system. Use a pipe cutting tool to disassemble the compressor from the system.

When disassembling system components please follow the main steps described hereunder:

1. Recover refrigerant and evacuate system using a hydrocarbons-dedicated recovery unit and vacuum pump.
2. Flush system with dry nitrogen.
3. Disassemble components with a cutting tool.
4. Drain, recover and dispose of compressor oil as appropriate.

To disconnect:

- Using a pipe cutting tool, cut off the suction and discharge lines in such a manner that the new compressor can easily be re-connected into the system.
- Heat joint areas 2 and 3 slowly and uniformly until the braze material softens and the tube end can be pulled out from the fitting. See Figure 15

To reconnect:

- Recommended brazing material: SIL-FOS® with minimum 5% silver or silver braze used on other compressors.
- Due to the different thermal properties of steel and copper, brazing procedures may have to be changed from those commonly used.

NOTE: Since the discharge stub contains a check valve, care must be taken not to overheat it to prevent brazing material from flowing into it.

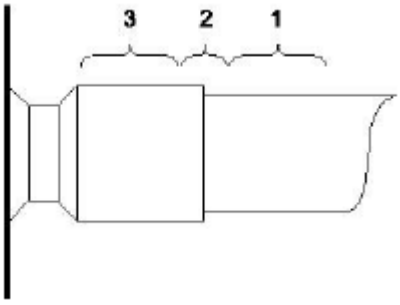


Figure 15 - Suction Tube connecting areas

Exchanging the refrigerant

FLAMMABLE

In any case avoid air/R290 mixture in the refrigeration system. Make sure that the system is filled with pure R290. In the event that the refrigerant needs replacing, the charge should be recovered using a R290 recovery unit and dedicated cylinders.

CAUTION

Low suction pressure operation! Compressor damage! Do not operate with a restricted suction. Do not operate with the low-pressure limiter bridged. Do not operate compressor at pressures that are not allowed by the operating envelope. Allowing the suction pressure to drop below the envelope limit for more than a few seconds may overheat scrolls and cause early drive bearing and moving parts damage.

See “Qualified refrigerant and oil

section for a list of approved refrigerants and oils.

It is not necessary to replace the refrigerant with new unless contamination due to an error such as topping up the system with an incorrect refrigerant is suspected. To verify correct refrigerant composition, a sample can be taken for chemical analysis. A check can be made during shut down by comparing the refrigerant temperature and pressure using precision measurements at a location in the system where liquid and vapor phases are present and when the temperatures have stabilized. If the refrigerant needs replacing, the charge should be recovered using a R290 recovery unit and dedicated cylinders.

Replacing the compressor

Before beginning to work on R-290 systems read and follow Safety Statements on page **5**.

FLAMMABLE

When opening the refrigeration system or working on it avoid explosive atmosphere and ignition sources in any case. When replacing the compressor avoid explosive mixture (air/R290). Use a pipe cutting tool to disassemble the compressor from the system.

Compressor Replacement

Use a suitable cylinder for oil disposal as R290 may still be solved in the oil.

In the case of an R290 compressor replacement the oil must be drained out of the compressor and the compressor should be flushed with dry nitrogen. DO NOT close the stubs with plugs.

In the case of a motor burnout, most of contaminated oil will be removed with the compressor. The rest of the oil is cleaned using suction and liquid line filter driers. A 100% activated alumina suction line filter drier is recommended but it must be removed after 72 hours.

Start-up of a new or replacement compressor

Rapid charging only on the suction side of a scroll-equipped system can occasionally result in a temporary no-start condition for the compressor. The reason for this is that, if the flanks of the scrolls happen to be in a sealed position, rapid pressurization of the low side without opposing high-side pressure can cause the scrolls to seal axially. As a result, until the pressures eventually equalize, the scrolls can be held tightly together preventing rotation. **The charge should be done on the high-pressure side of the system. Before system start-up, allow the pressures to equalize.**

Follow instructions detailed about tagging and locking out on Safety Statements section on Pg. **5.**

Do not start the compressor while the system is in a deep vacuum. Internal arcing may occur when a Scroll compressor is started in a vacuum causing burnout of the internal lead connections.

Compressor return procedure

To return a compressor to Copeland for analysis, the procedure below shall be followed:

- During the entire working procedure continuously check if the ambient atmosphere is explosive. If explosive atmosphere is detected ensure proper ventilation of the working space and immediately cut-off the power supply.
- Resume working after the atmosphere is no longer dangerous.
- Recover the refrigerant from the system using a
- suitable recovery unit.
- Do not allow the recovery unit to recover below atmospheric pressure. Make sure the low-pressure switch that stops the recovery process is not set below 7 PSIG.
- At this pressure, some refrigerant will still be in the system. Therefore, before opening the system, pressurize to 15 PSIG with dry nitrogen.
- Open the system with a cutting tool and flush the entire system with dry nitrogen.
- Disassemble the compressor with a cutting tool. Drain and recover compressor oil properly. Flush the compressor with dry nitrogen for a few minutes.
- The compressor should be returned free of oil and with connections open - do not close connections with plugs.
- Properly collect and secure the oil. Provide information about the quantity of oil drained from the compressor and its color. Ideally, send a good picture.
- Dispose of the oil according to local rules and regulations.
- Use a proper cardboard box package when preparing the compressor for shipment. Place warning icons on each side and on the top of the box:

Mention the following message on the box: **"Warning! Hydrocarbon compressor for analysis".**

- The compressor shipment must be kept in the upright position – mark it accordingly.
- If more than one compressor is returned, each compressor has to be packed individually.

NOTE: Check with your transport company to ensure compliance with all requirements for such a shipment.

Lubrication and oil removal

FLAMMABLE

Use a suitable cylinder for oil disposal as R290 may still be solved in the oil.

CAUTION

Chemical reaction! Compressor destruction! Do not mix ester oils with mineral oil and/or alkyl benzene.

The compressor is supplied with an initial oil charge. The standard oil charge for use with refrigerant R290 is a polyolester (POE) lubricant. See nameplate for original oil charge shown in liters.

One disadvantage of POE is that it is far more hygroscopic than mineral oil (see **Figure 16**). Only brief exposure to ambient air is needed for POE to absorb sufficient moisture to make it unacceptable for use in a refrigeration system. Since POE holds moisture more readily than mineral oil it is more difficult to remove the moisture through the use of a vacuum. Compressors supplied by Copeland contain oil with low moisture content, and it may rise during the system assembling process. Therefore, it is recommended that a properly sized filter-drier is installed in all POE systems. This will maintain the moisture level in the oil to less than 50 ppm

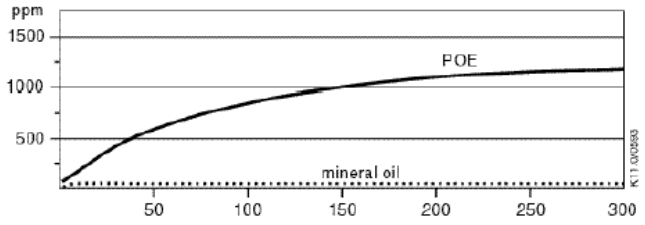


Figure 16 Absorption of moisture in ester oil in comparison to mineral oil in ppm by weight at 77 °F and 50% relative humidity (h=hours)

If the moisture content of the oil in a refrigeration system reaches unacceptably high levels, corrosion and copper plating may occur. The system should be evacuated down to 225 microns or lower before charging with refrigerant. If there is uncertainty as to the moisture content in the system, an oil sample should be taken and tested for moisture. Sight glass/moisture indicators currently available can be used with the R290 refrigerant and lubricants; however, the moisture indicator will only show the moisture content of the refrigerant. The actual moisture level of POE would be higher than the sight glass indicates due to the high hygroscopicity of the POE oil. To determine the actual moisture content of the lubricant, samples must be taken from the system and analyzed.

Oil additives

Although Copeland cannot comment on any specific product, from our own testing and experience, we do not recommend the use of any additives to reduce compressor bearing losses or for any other purpose. Furthermore, the long-term chemical stability of any additive in the presence of refrigerant, low and high temperatures, and materials commonly found in refrigeration systems is complex and difficult to evaluate without rigorously controlled chemical laboratory testing. The use of additives without adequate testing may result in malfunction or premature failure of components in the system and, in specific cases, voiding of the warranty on the component.

Troubleshooting

Most in-warranty electrical failures are a result of mechanical problems (particles in the oil, liquid refrigerant in the oil, etc.) and most mechanical problems are a result of system problems. Unless the reason for the failure is found, replacing the compressor will probably lead to another compressor failure.

If the compressor fails to start and run properly, it is important that the compressor be tested to determine its condition. It is possible that electrical components may be defective, the protector may be open, or a safety device may have tripped. Appendix A lists the most common compressor problems encountered in the field.

Electrical cables! Electrical shock! Before attempting any electrical troubleshooting, make sure all grounds are connected and secure and there is ground continuity throughout the compressor system. Also ensure the compressor system is correctly grounded to the power supply. If you are not a qualified service person familiar with electrical troubleshooting techniques, DO NOT PROCEED until a qualified service person is available.

Diesel effect! The mixture of air and oil at high temperature can lead to an explosion. Avoid operating with air.

Check the concentration of refrigerant in the atmosphere before starting the compressor and ensure proper ventilation of the room. If the level is explosive no compressor starting is allowed. In any case be sure that the system contains only refrigerant and no explosive mixture.

Dismantling & disposal

Removing oil and refrigerant:

- Do not disperse in the environment.
- Use the correct equipment and method of removal.
- Dispose of oil and refrigerant according to national legislation and regulations.
- Dispose of compressor according to national legislation and regulations

General Guidelines and More Information

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

93-11 R36	Refrigerants and lubricants approved for use in Copeland compressors
AE4-1380	Guide for the Use of R-290 Refrigerant in Copeland Refrigeration Compressors
AE4-1305	Application Guidelines for Copeland AF, AR & AS Refrigeration Hermetic Compressors
AE4-1344	Application Guidelines for Copeland RFT, RRT, RST Compressors

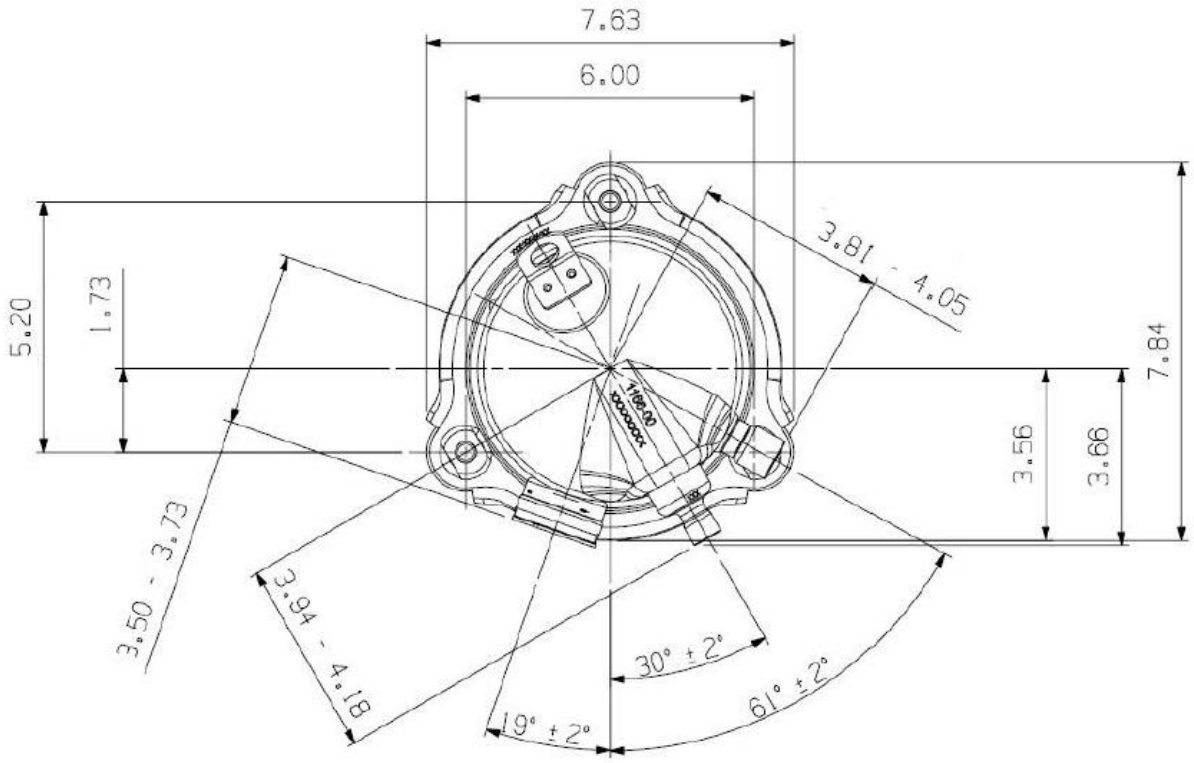


*Figure 17 Dimensions of ZB*KAU compressors , upper view*

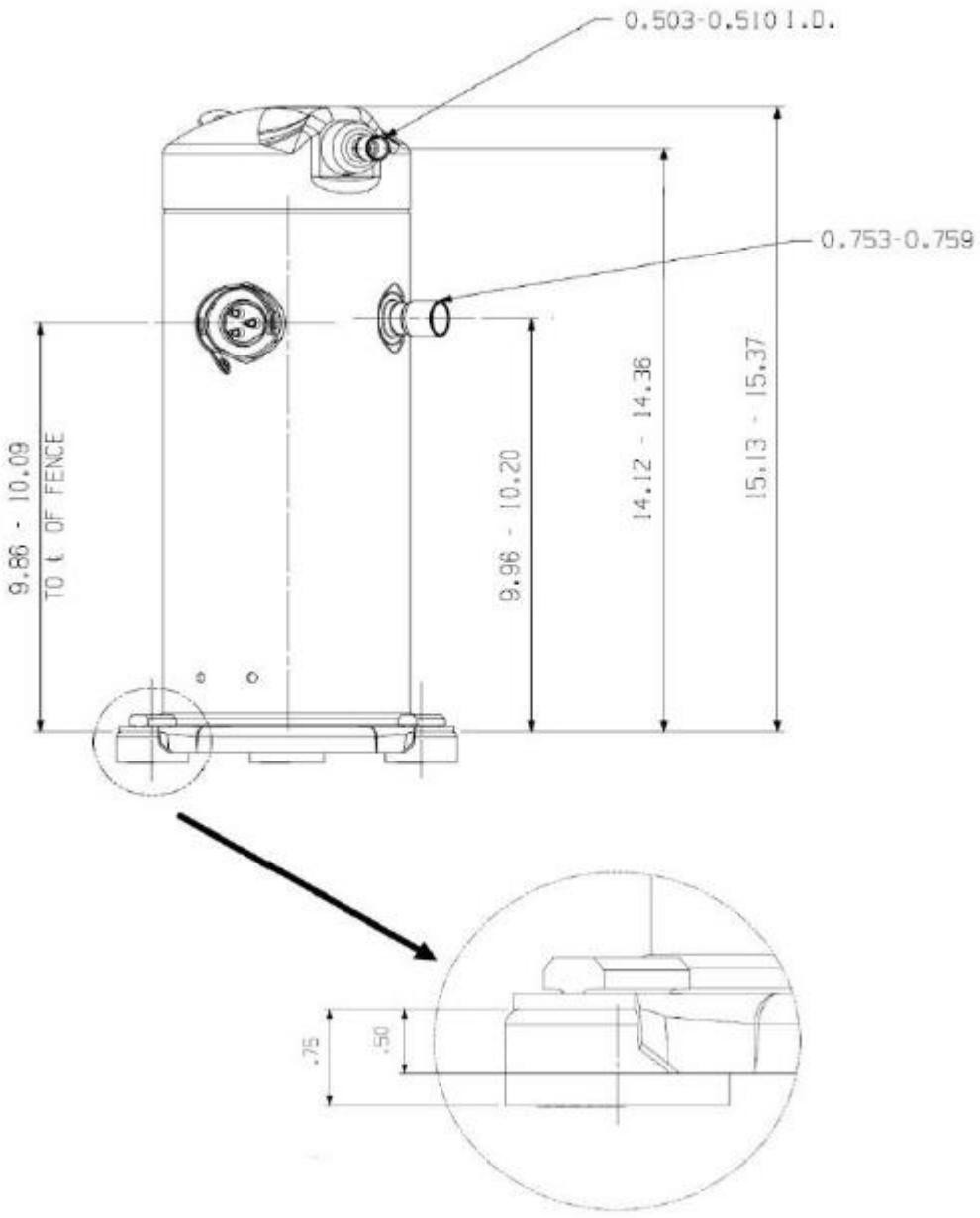


*Figure 18 - Dimensions of ZB*KAU compressors*

Appendix A Common Scroll problems encountered in the field.

Condition	Cause	Corrective action
The Scroll compressor does not run, instead a buzz sound can be heard	Wired incorrectly	Check the power supply on the compressor terminals if there is voltage measured. Trace the wiring diagram to see where the circuit is interrupted.
	Low supply voltage	If the voltage falls below 90% of the nameplate voltage, the motor may develop insufficient torque. Make sure the compressor is supplied with rated nominal voltage.
	Shorted or grounded motor windings	Check the motor for ground by means of a continuity check between the terminals. If grounded replace compressor.
	Internal compressor mechanical damage	Refrigeration migration: When the compressor is switched off for a long period refrigerant can condense in the crankcase. If the compressor body is colder than the evaporator, refrigerant will move from the evaporator to the compressor crankcase. Refrigerant migration normally occurs when the compressor is installed in a cold area. A pump down cycle provides good protection against refrigerant migration. Acid formation: Acid forms in the presence of moisture, oxygen, metal, salts, metal oxides and/or high discharge temperatures. The chemical reactions are accelerated at higher temperatures. Oil and acid react with each other. Acid formation leads to damage of the moving parts and in extreme cases to motor burnout. Several different test methods can be used to test for acid formation. If acid is present a complete oil change (including the oil in the oil separator) will help. A suction filter which removes acid should also be fitted. Check filter-drier condition.
The Scroll compressor does not run, no buzz sound can be heard	Compressor motor protector open	Check if there is continuity on the compressor external protector. If the compressor is warm, it may require considerable time to cool down.
	Defective system control components	Check if the pressure control or thermostat works properly or if the controls are open.
	Power circuit open	Check the fuse for a tripped circuit breaker or for an open disconnected switch.
	Burned motor winding	If motor burned is due to undersized contactors, this is observed when the contacts welded together. Complete motor burnout on all three phases despite the presence of a functioning protection system can be the result. For sizing information please consult with Contactor manufacturer data sheet. If the application of the compressor is changed the contactor sizing should be rechecked. Check for unbalanced voltage.

Condition	Cause	Corrective action
The Scroll compressor trips on motor protection	High discharge pressure / suction pressure	For high discharge pressure: Check for system leaks. With system leaks at the low-pressure side, air as non-condensable gas could enter the system and create high pressure. Check the system design. Make sure the discharge line is correctly sized: undersized discharge line can increase discharge pressure. This is also true for an undersized condenser. Correct the component selection as needed. Check the fan motor, make sure it is running properly in the right direction. Check the condenser: if dirt has been accumulated it will clog the airflow; clean as necessary. High discharge pressure is also caused by an overcharged system and high ambient temperature surrounding the condenser. For high suction pressure, check the “evaporator superheat” first to diagnose the problem: High superheat at the evaporator outlet: this is likely in case of excessive pressure-drop in the liquid line or too much vertical lift on the pipe work. Low superheat at the evaporator outlet is usually the consequence of oversized selection of the expansion valve or incorrect bulb sensor mounting. The valve may freeze up in the open position due to accumulation of debris in the system. For a system with very short refrigeration lines an accumulator is recommended.
	Compressor operating outside the design limits	Check the compressor suction and discharge pressures while it is running. Make sure they are within the operating envelope.
	Defective motor protector	If all operating conditions are normal, the voltage supply at the compressor terminals are balanced and within limits, the compressor crankcase temperature is within normal limits, and the amperage drawn is within the specified range, the motor protector may be defective.
Excessive discharge temperature	Too high compressor superheat	Make sure the compressor operates within the acceptable operates superheat range published by Copeland.within
The Scroll compressor runs continuously	Excessive cooling / heating load or inadequate insulation	Check the load design; make sure that proper insulation is applied. Correct it as necessary.
	Control circuit inoperative	Check the thermostat, measure the temperature of the room and compare with the thermostat; replace or re-calibrate the thermostat. Check the LP control switch and replace it if it is found defective.

Condition	Cause	Corrective action
Compressor lubrication problem	Oil trap due to incorrect piping layout / sizing	Check the piping layout design. Installations of pipe being routed over or around obstacles can inadvertently create unwanted traps for the oil return. As much as possible the refrigerant line should travel a direct and straight course between the evaporator and compressor. It should also be remembered that the entire system will be coated in oil to some extent. Oil viscosity changes with temperature. More oil stays in the system than was originally expected. Make sure the line is correctly sized.
	Oil pump out due to high cycling rate	A high cycling rate will pump oil into the system and lead to lubrication failure. Oil leaves the compressor at start-up and the short running time is insufficient to return the oil to the compressor via the suction side. Try to limit the number of cycles to maximum 10 per hour.
	Low gas velocity	System gas velocity changes depending on temperature and load (capacity control). In low load conditions gas velocity may not be high enough to return oil to the compressor.
Low discharge pressure	Low ambient temperature	Fit a fan cycling control system.
	Refrigerant undercharge	Check the system for leaks. Observe sight glass for bubbles if fitted. Add refrigerant until the sight glass is clear. If no sight glass is fitted, check the evaporator superheat and fill in with refrigerant.
Low suction pressure	System design load too small	If the compressor is running in a tandem or in parallel, modulate the running process.
	Inadequate refrigerant going to the evaporator	Lower normal discharge pressure values can lead to insufficient refrigerant flow to the system. This can also be verified by checking the evaporator outlet superheat, if it is found unusually high. Check the selection of the expansion valve (likely undersized).
Noise during shut-off	Anti-reverse device	This does not have any effect on the durability of the compressor, no action is necessary.

Appendix B: Oil Filling Test for new applications

For all new systems with ZB*KAU compressors and a reduced oil filling, it is mandatory to check and test the oil distribution and compressor oil filling using a dedicated sample compressor equipped with an external oil sight tube.

The oil tests for compressors with an external oil sight tube must be carried out by the system designer in the lab. This will allow to investigate the oil return behavior to the compressor. In case some oil remains in the system, e.g., in the tubes, heat exchangers or other components, oil top-up is required. A sufficient oil level must be present in the compressor at all times to ensure proper compressor reliability.

Test procedure

- Before first compressor start, mark the 12oz (355 mL) minimum filling level and the 16oz (473 mL) filling level on the external oil sight tube. The distance to the markings can be measured from the top of the compressor footplate
-

*Figure 19 - ZB*KAU with external oil sight tube*

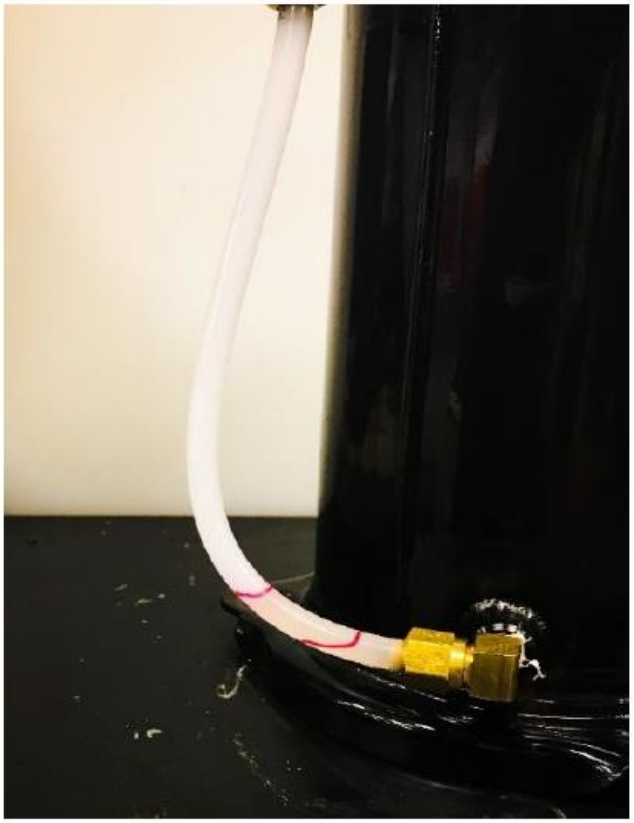


Figure 20 - Markings on the external oil sight tube

- Start and run the system until it reaches stable conditions, then run at stable conditions for a minimum of 15 minutes. Stop the compressor and read the oil level during standstill. Any oil level between 12oz (355 mL) and 16oz (473 mL) is in the nominal range and is acceptable.
- Always check the level in the external oil sight tube. Once the level falls below the 12oz (355 mL) marking, stop the compressor immediately. Re-check the oil level after stopping. Any oil level below the 12oz (355 mL) marking is not acceptable.
- Top-up some oil if necessary and record the amount of topped-up oil. This could be the reference for all future systems with the same design. Perform the test anew to check the oil return behavior again, as described above.
- Repeat the test at different operating conditions, starting with the main operating point. Test different

operating points in the corners of the operating envelope as well. Refer to Figure 21 for main operating point, high load HL, maximum differential

- Also perform tests for different system operations, e.g., part load, defrost, bypass etc. Make sure the tests cover all possible different system conditions.

- Another method to determine if liquid refrigerant is returning to the compressor is to accurately measure the temperature difference between the compressor oil crankcase and the suction line. During continuous operation we recommend that this difference be a minimum of 50°F (27°C). This “crankcase differential temperature” requirement supersedes the minimum suction superheat requirement detailed in section “Applications limits”. To measure oil temperature through the compressor shell, place a thermocouple on the bottom center (not the side) of the compressor shell and insulate from the ambient.

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

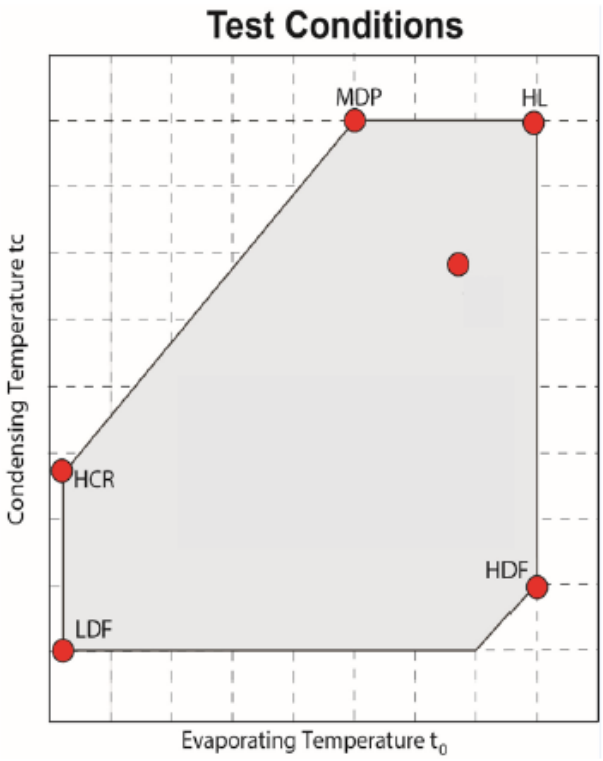


Figure 21 - Testing points for oil return behavior investigation

Figures & Tables

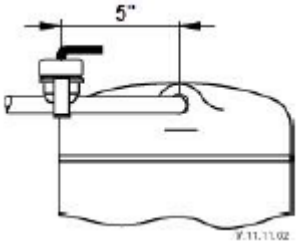
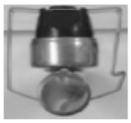
*Table 1 - ZB*KAU available compressors models*

Compressor	Motor	Application	Cooling Capacity BTU/hr	Disp./ Rev. (in³)	CFH (60 Hz)
ZB07KAU	TFD/TF5	EM*	8060	1.31	158.84
ZB09KAU	TFD/TF5	EM *	9690	1.54	186.91
ZB10KAU	TFD/TF5	EM*	11000	1.77	214.86
ZB11KAU	TF5	EM*	13450	2.076	252.3

Table 2 - Technical data of the discharge line thermostat

Ident number / Part number		971-0034-00
Voltage		230V (± 10%)
Maximum amperage		5A/240V
Operating temperatures	Open	273°F (± 7°F); 134°C (± 4K)
	Close	222°F (±14°F); 106°C (± 8K)
Wire insulation maximum temperature		302°F (150°C)
Clips for tube		Ø 0.5 inch (12.7 mm)

Table 3 - Recommendations for assembling the discharge line thermostat

Install the discharge line thermostat on the discharge tube 5” (127 mm) from top cap.	
Snap the retainer clip over the tube and onto the thermostat. The thermostat should be placed on the discharge tube so that its body is in upward position on a horizontal tube installation. Ensure that the thermostat is not tilted.	
The wire must not be in contact with the top cap of the compressor or the discharge tube. Care should be taken to route wires so that they do not come into contact with sharp objects.	

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