

Application Engineering

Single Phase Motors Frequent Causes of Failure

BULLETIN NO: AE9-1209 R3

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Safety

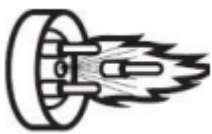
Important Safety Information

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

Air Cycle Testing of reciprocating compressors

An analysis of compressors returned during the warranty period consistently indicates that a large percentage of single phase motor failures need not have occurred, the most common causes of failure being miswiring or loss of refrigerant charge.

Production and service personnel often do not realize how quickly fatal damage to the motor can occur, particularly to the start winding, should the motor be miswired. Because of the fine wire used in the start winding, and the resulting high resistance, line voltage connected directly across the start winding can result in extremely high temperatures almost instantly. A motor energized with the wiring connections reversed can fail within a minute or less, and even though the wiring error is discovered and corrected after a few seconds, the start winding may be sufficiently damaged so that early field failure results. One of the most frequent sources of this type of failure is the improper installation of supplementary starting kits in the field.

In order to obtain a better understanding of how quickly a failure can occur, and the pattern of the resulting motor burn, frequently encountered types of failure have been duplicated in our engineering laboratory.

The illustrations that follow show the wiring connections schematically so that the basic wiring connections may be easily visualized. However, the wiring error need not necessarily occur at the compressor terminals, and quite probably the connections at switches, terminal boards, and contactors are more apt to be a problem.

Figure 1 illustrates first the correct wiring connection to a PSC motor with an internal protector, and shown by the broken line the connection when the "Common" and "Start" wires are interchanged. Note that when miswired, the line connections are across both the run and start windings in series, and that the protector is in the capacitor circuit and no longer senses the full line current.

When the leads were energized, the start winding failed from uniform overheating in 80 seconds but the protector did not trip. The main winding was undamaged.

Figure 2 illustrates a miswiring connection when the "Run" and "Start" wires are interchanged. Note that the line connections are directly across the start winding, and the run winding is out of the circuit.

When the leads were energized, the start winding failed in 25 seconds. The start winding was uniformly burned, while the run winding was undamaged.

Run capacitors with identified terminals are no longer used in new equipment, however, there are still some on older equipment in the field. If you have such a capacitor it must be connected as described below.

The terminal connected to the outer foil of a run capacitor is the one most likely to short to the can and be grounded. It is identified and marked by most manufacturers of run capacitors.

If the run capacitor is connected with the identified terminal on the line side, a grounded capacitor will result in a direct short to ground from the line. A compressor connected in this fashion as shown in Figure 3 blew a line fuse and no motor failure resulted.

If the capacitor is connected incorrectly, and the ground occurs on the start winding side of the capacitor, a short to ground exists through the start winding from either line wire. When the leads were energized, the protector tripped after 21 seconds. However a ground still existed from L1 to ground through both run and start windings. The start winding failed after 30 minutes in a stalled rotor condition.

If you have such a capacitor on a compressor it should be connected as described.

Loss of Refrigerant Charge

Even though the motor may be wired correctly, a motor failure can still result from a loss of charge. An external protector normally does not protect against such a condition. Since the current drawn by the motor is abnormally low, the compressor housing temperature may control the protector, either preventing a protector trip or causing a short cycling condition because of quick

Summary

cooling of the protector. In either case, a motor failure can occur in a relatively short time.

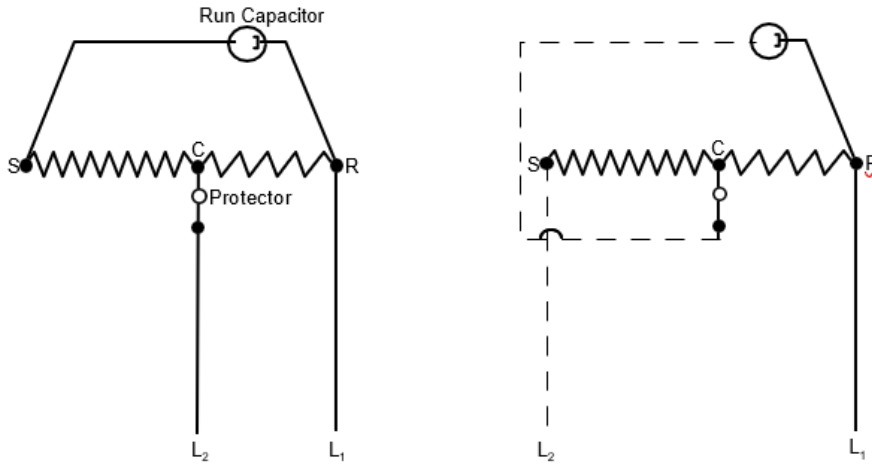
An internal protector is more directly responsive to motor heat, and once the protector trips, the "off" cycle is much longer, and the motor life can be greatly prolonged under the same loss of charge condition.

A compressor with an external protector was run with the suction tube closed and discharging to atmosphere to simulate a high side leak. The motor failed in 15 hours with severe overall heating.

A large percentage of single phase motor burns can be prevented if human error can be minimized. A convenient and dependable check of wiring connections can be easily made either on the production line or in the field by the simple ohmmeter test described in AE- 1183. Practically all run capacitors have the terminal connected to the outer foil identified so that proper connection is made easy. Internal protectors can extend the life of the compressor motor under loss of charge conditions so that hopefully the loss of charge condition can be discovered and corrected before failure occurs.

Figures

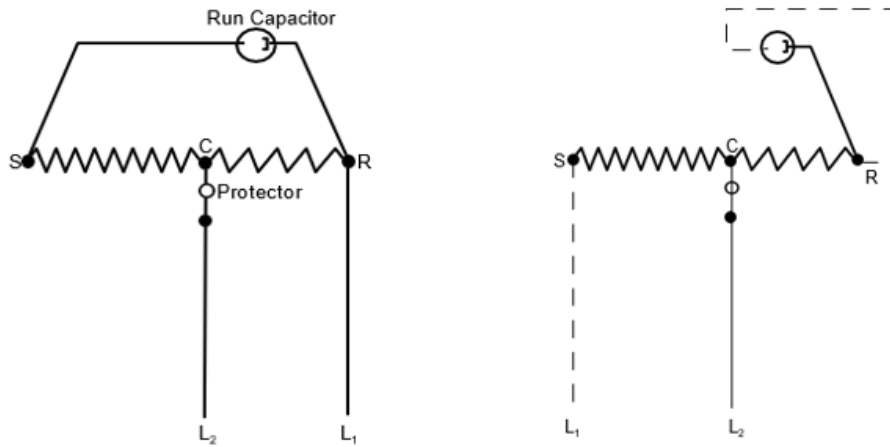
Figure 1 Interchanging "COMMON" And "START" Connections.



Correct Wiring Connection

Incorrect Wiring Connection "C" & "S" Interchanged.

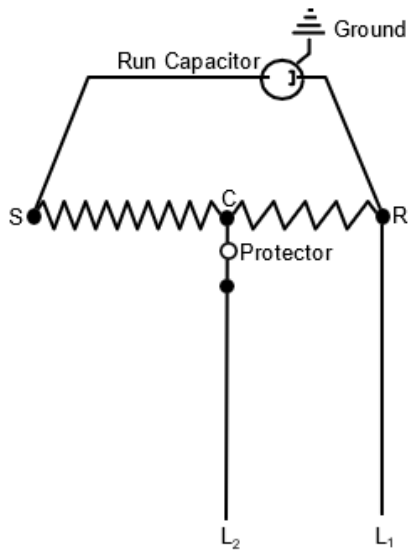
Figure 2 Interchanging "COMMON" And "START" Connections



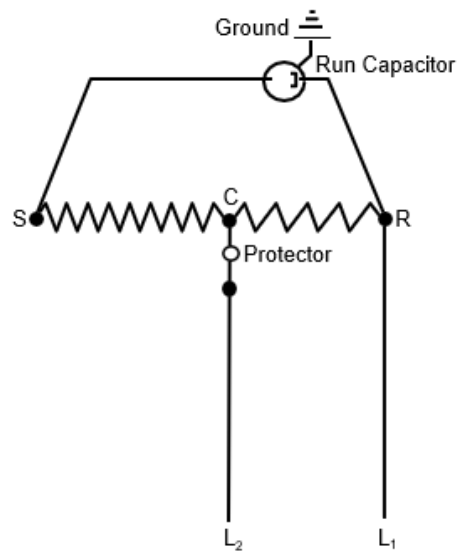
Correct Wiring Connection

Incorrect Wiring Connection "C" & "S" Interchanged.

Figure 3 Shorted Run Capacitor



Run Capacitor Shorted To Ground
Line Side Of Capacitor



Run Capacitor Shorted To Ground
Start Winding Side Of Capacitor

Revision Tracking R3

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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