Application Engineering

Compressor Short Cycling - An Unrecognized Problem

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COPELAND

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

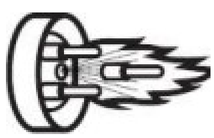
• OEMs are responsible for system design, selection of appropriate components, integration of this component into the system, and testing the system. OEMs must ensure that staff involved in these activities are competent and qualified.

• 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	**DANGER** indicates a hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	**WARNING** indicates a hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	**CAUTION**, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

Introduction

A frequent cause of compressor failure that is seldom recognized or understood is short cycling. If a compressor failure results, it will either be a motor burn or a lubrication failure, and in both cases, it is a near certainty that the cause of failure will be misdiagnosed.

Each time a compressor starts, there is a quick reduction in the suction pressure and therefore the crankcase pressure. The pressure drop causes a reduction in the saturation temperature, resulting in the oil-refrigerant mixture flashing into foam and vapor with the frequent result that a large percentage of the crankcase oil is pumped out of the compressor. If the compressor operates for sufficient time to stabilize the system, the oil will return to the compressor, but if the running period is very short, the oil may still be trapped in the system when the compressor cycles off.

If this cycle is repeated, the compressor will progressively pump oil from the crankcase, and the entire oil charge can be lost from the crankcase. If the running cycle is short, an oil pressure safety control may not be actuated since it requires at least two minutes run time to trip the heat actuated safety element. Under such conditions the compressor can operate without lubrication to the bearings, with the obvious potential for damage.

A second source of damage can result from liquid refrigerant flooding and loss of refrigerant control. Most expansion valve are quite sluggish in their control characteristics and tend to react slowly to any sudden change in system operating conditions. Under short cycling conditions, the expansion valve may be unable to reach a stable control condition and uncontrolled liquid refrigerant flooding can occur, again posing a threat to the compressor.

Every time the motor cycles on or off, the stator windings try to flex and move. Under prolonged cycling or short cycling conditions, this flexing may eventually create sufficient movement in the windings to scuff the insulation and cause a short. The larger the motor, the more vulnerable it is to winding flexing. With modern motor insulation and varnishes in a properly wound motor, this failure mode is rare, but the potential threat is present in any system subjected to excessive cycling, since the probability is that any motor has a finite life in terms of the number of cycles it can endure.

Short cycling can originate from many sources, and most such problems can be prevented if we understand the reasons behind them.

Discharge Air Thermostat

On larger roof top package air conditioning equipment, short cycling is probably the most common cause of early maintenance problems and compressor failure, to a considerable extent because the specifying engineer fails to specify an operating time delay.

If the controlling thermostat is in the return air stream, the flywheel effect of the conditioned space prevents rapid changes in the return air temperature and short cycling seldom becomes a problem. Unfortunately, it is becoming common practice to mount the control thermostat in the discharge air stream. Particularly with large compressors, the abrupt change in cooling capacity as the compressor cycles on and off can create wide swings in discharge air temperature. Compressors equipped with capacity control unloaders can minimize the temperature swing, but factors such as air flow, thermostat setting, and the cooling load may affect the compressor response.

Most manufacturers recognize the problem, but because of competitive pricing an operational time delay is often priced as an optional accessory. Unless the specification clearly requires a time delay, the salesman may be reluctant to push an option which will increase the price, the purchasing agent is frequently interested only in the low bid, and the operating and service engineer are seldom consulted.

In too many cases, after several thousand dollars of maintenance and service expense, the time of delay is eventually added to the system. Obviously, there is a need for better communication between specifying engineers and the service and operating personnel who must deal with the practical aspects of everyday operation.

Multizone Hot and Cold Deck Control

A similar problem was frequently encountered when multizone air conditioning units were first introduced with hot and cold deck control. The compressor was controlled by the cold deck thermostat, and obviously the system designer wanted to maintain close temperature control in the cold deck. The problem became acute as a greater portion of the cooling load was satisfied, and the majority of the air flow was shifted to the hot deck. Under light load conditions, compressor cycling could cause tremendous swings in cold deck temperature, with resulting compressor cycling. Time delays in a cold deck system are not conducive to acceptable comfort conditions, and the best solution is hot gas bypass with continuous compressor operation as long as a cooling demand exists.

Automatic Reset High Pressure Control

One of the most frequent types of short cycling failure occurs on systems with air-cooled condensers and automatic reset high pressure controls. If the condenser design is such that the loss of one condenser fan can cause a trip of the high-pressure control, on unattended systems it is quite possible that a loss of lubrication failure can occur within a relatively short period of time should a fan motor or fan belt failure occur. The oil is typically pumped from the compressor, the oil pressure safety control is inoperative due to the short operating cycle, and bearing damage can result.

Wherever possible, manual reset high pressure controls are recommended.

Close Differential Control

On any system, air conditioning or commercial refrigeration, where the compressor is controlled by a close differential control, short cycling can be a problem. There really is no magic answer as to an acceptable cycling rate. An adequate run time to stabilize the operating conditions and ensure oil return is more important than a long off cycle. The probability is that cycles at three-minute intervals will not cause a temperature problem in either the compressor or the contactor.

But the tremendous number of cycles over a period of time that accumulate from short cycling must shorten the life expectancy of both the contactor and the motor, and the benefits of close differential control versus short compressor life must be evaluated on a judgment basis.

The design of the compressor to considerable extent affects its cycle life expectancy. Copeland Hermetic air conditioning and heat pump compressors are spring mounted, with relatively soft mounts for good noise suppression. Spring life of 200,000 cycles would normally be adequate for a 10-year heat pump life. Commercial applications undoubtedly would see more frequent cycling, and 300,000 cycles would be a typical design goal for spring life on commercial welded compressors. In Copeland Semi-Hermetic compressors the mounting is external to the compressor, and cycle life would be related to the motor. 500,000 to 1,000,000 cycles might be a typical average life span, with longer life for smaller lower horsepower motors and shorter life for larger horsepower equipment.

Compressor Motor Plug Reversal Tests

In order to validate a three-phase motor’s capability of surviving under short cycling conditions, Copeland performs extensive plug reversal tests. The direction of rotation of the motor is reversed at three second intervals on a test stand, putting tremendous stress on the motor windings. This has proven to be a reliable standard to judge a motor’s capability of withstanding short cycling stresses.

Summary

Regardless of the motor design, excessive short cycling can shorten compressor life, and the service engineer must be alert to malfunctions in system controls which can create short cycling conditions.

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