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COMPRESSOR SHORT CYCLING AN UNRECONGIZED PROBLEM

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

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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 fairly 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 insure 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. Copelaweld 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 Copelametic 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 Corporation 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.

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