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SYSTEM DESIGN FOR CONTAINER REFRIGERATION

Container refrigeration, because of its inherent operating characteristics, presents unique problems in system design. To achieve an acceptable reliability level, special modifications may be necessary in compressor design, and additional protective components may be necessary for the system.

Aboard ship at sea, the container unit is subject to the roll of the ship, and the compressor, unlike a typical commercial application, does not have a stable level base. In rough weather, depending on the orientation of the compressor, it is possible the oil level in the crankcase may fall below the oil pump intake and the compressor may be subjected to repeated loss of oil pressure with each roll. To compensate for this, Copeland has developed a modified deep oil sump for compressors to be applied on containers, with a centrally located oil pick-up so that the oil pump will retain its prime in the roughest weather.

When the container is sitting on the dock, either awaiting loading aboard ship, or awaiting ground transportation, the unit may be without power for long periods. When power is applied, there may be a period of excessive liquid refrigerant floodback before the expansion valve can regain control. The best protection for this condition is a suction line accumulator to intercept the floodback and meter it to the compressor at an acceptable rate.

During long idle periods, liquid refrigerant migration to the compressor crankcase is a major threat to the compressor. This may occur when the container is loaded, but is more probable when the container is empty and disconnected from power awaiting its next period of usage. Pumping the refrigerant into the high pressure side of the system prior to shutdown is helpful, but over a period of days, refrigerant will leak back through the compressor valves. On start up, the mixture of oil and refrigerant in the crankcase will foam violently, causing a loss in oil pressure, and quite possibly all of the oil will be pumped out of the crankcase. Because container systems are close coupled, oil will start to return rather quickly but there may be a period of several minutes when the compressor is developing very little oil pressure.

There really is no way to prevent migration from occurring, since the lack of connected power makes a crankcase heater or a pumpdown control inoperative. An oil pressure safety control is frequently applied but it provides no real protection, and in itself becomes a nuisance. The major value of an oil pressure safety control on commercial systems is to provide a warning that something in the system design or operation is causing a loss of oil pressure, alerting the service engineer to the need for remedial action. On a container system, the problem is clearly migration resulting from long “off” periods without power, but there is no way the service engineer can remedy the situation. The oil pressure safety control becomes meaningless, and undoubtedly the service engineer bypasses it to get the unit back in operation.

The only real defense against refrigerant migration is to design a compressor and system that can live through this type of exposure without damage. From a system standpoint this means minimizing the refrigerant charge and providing an efficient suction accumulator. From a compressor standpoint this means maximizing the oil charge in the compressor. This not only improves the oil to refrigerant ratio in the compressor, a critical factor in foaming, but it also provides a greater reservoir of oil so that in periods when oil is pumped out of the compressor, oil return from the system is accelerated. The deep sump on the compressor obviously is the best remedial action that can be taken. One other compressor modification that has been helpful is the use of an oversized oil pump, which allows the compressor to restore oil pressure much more quickly on start up after periods of migration. It is difficult to prove or disprove the benefits of the larger oil pump, but actual experience has proven that the combination of the deep oil sump and large oil pump have been very effective in reducing liquid refrigerant related failures.

One other major potential problem area that may be seriously underestimated is the fact that the compressor must operate from many power sources, some of which may have a different phase sequence. On three phase motors, a change in phase sequence results in a change of direction of the motor rotation. The Copeland oil pump is reversible and is checked for its capability to pump in either direction at the time of original manufacture. After a period of operation however, the reversing plate may be slightly scored, particularly if it has been exposed to large amounts of liquid refrigerant, which is unavoidable on a container unit. The minor scoring or any slight accumulation of oil residue can prevent the reversing plate in the oil pump from working, even though the oil pump may be working perfectly in its original position. What this means is that if the compressor is connected to a power supply with a different phase sequence, the oil pump may fail to reverse, and no oil will be pumped. If an oil pressure safety control is in use, it may trip, but the operator being accustomed to trips from migration, will merely reset or bypass the control and eventual failure is almost certain. The only protection against this threat is the use of a phase sequence control to insure the same electrical phasing to the motor regardless of the phase sequencing of the power source.

In summary, container refrigeration presents unique operating problems, and both the system and compressor must be designed to meet those problems. When the container is in transit it is extremely difficult o repair or service the refrigeration system, and the design goal of every container unit should be to maximum reliability. Probably the greatest error the shipping companies can make is to purchase container equipment on a price basis, unless the equipment is specified down to the last detail. There is obviously a need for a better educational effort on the part of the equipment manufacturers, and a better understanding of the nature of the application on the part of the shipping companies, since many of the items critical to compressor survival are offered on an optional basis, and unfortunately many units are purchased without them.

To insure maximum reliability on container refrigeration units, Copeland recommends the following.

1. Use a compressor with a deep oil sump.
2. Use an efficient suction line accumulator. Experience in heat pump design has revealed that many commercially available suction accumulators perform very poorly in trapping liquid, and testing should be done to insure selection of an efficient design.
3. Use a phase sequence control.
4. Minimize the system refrigerant charge.
5. Provide continuous pumpdown control for operation, and a means of manual pumpdown for those operators conscientious enough to take advantage of this feature.
6. An oversized oil pump is mandatory on all compressors with deep oil sumps because of the additional pressure drop.
7. An oil pressure safety control is of questionable value on a container unit, and may be a nuisance. Copeland's standard warranty will apply on compressors applied on container units without oil pressure safety controls provided a deep sump, phase sequence control, suction accumulator, and an oversized oil pump are applied.

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