Parallel Compressor Oil Management in Supermarkets

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The main purpose of oil in a refrigeration system is to lubricate the moving parts of the compressor. The oil management system on a supermarket compressor "rack" is one of the least understood parts of the refrigeration system. Most service engineers believe that the oil separator, reservoir and compressor oil level controls are the system components that will determine the compressor oil level. This is incorrect.

The addition of an oil separator, reservoir and oil level controls **will not** reduce the oil charge of a *properly designed, installed and operating refrigeration system*. The oil separator serves to minimize the amount of oil that enters the system. Once equilibrium is reached between the amount of oil entering the system and the amount returning to the compressors, the oil reservoir and oil level controls act as storage containers for the surplus oil.

Any change in operating conditions that disrupts the equilibrium (oil leaving vs. oil returning) will be corrected by the oil control system. Under many conditions, however, the oil control system will be unable to manage. It is the later condition that leads to the incorrect condemnation of oil level controls.

Oil separator efficiency has little effect on a refrigeration system that has *incorrectly sized piping* or is *poorly maintained*. When this occurs, there will be excessive oil in the system piping due to insufficient refrigerant velocities. It is on "problem" applications that an oil management system will yield a surplus of oil. The oil system acts as a time delay and limits the amount of oil circulated into the refrigerant piping between defrost cycles (refrigerant velocities are much greater after defrost termination and will sweep oil that was trapped in piping back to the compressors.)

Oil levels in compressors that drastically rise after a refrigeration circuit defrost termination are an indicator of a system problem. Excess oil decreases heat transfer in the evaporator. Oil slugs damage compressors.

Compressors on common piping do not recirculate the same amount of oil, nor do they have identical wear patterns or run times. The oil system's purpose is to compensate for *moderate* differences between the individual compressors oil recirculation rates due to <u>size</u>, <u>run time</u>, or <u>wear</u>. There are *moderate differences in the* amount of oil returning to each of the compressors through the suction line relative to the amount of oil leaving through the individual discharge lines.

Properly functioning reciprocating compressors typically recirculate somewhere between one and three percent oil per pound of refrigerant. Many rack manufacturers "multiplex" compressors to selectively operate the appropriate compressor based on system load. As an example, if the load is high, the controller would select a 15 HP compressor to operate rather than a 5 HP compressor on the same rack.

A typical 15 HP compressor operating at 110°F condensing temperature and a 15°F evaporator recirculates approximately 1,790 lb. of refrigerant an hour, or at 1% oil recirculation rate, 17.9 lb. of oil per hour. A typical 5 HP compressor operating at the same conditions recirculates approximately 445 lb. of refrigerant per hour, or at a 1% oil recirculation rate, 4.5 lb. of oil per hour. Assuming the two compressors are in parallel and are operating 100% of the time, the oil in the recirculation is 22.4 lb. per hour. With both compressors *maintaining peak efficiency*, there would be as much oil returning to each compressor through the suction lines as was leaving each compressors discharge line. With this <u>ideal</u> but unlikely scenario, the oil levels would remain constant with no need for an oil control system.

Using as an example the above compressor rack, cycle the 15 HP compressor off for fifteen minutes during a one hour period due to a light load. The average amount of oil in recirculation has been decreased by 4.5 lb. of oil per hour. However, with the 15 HP cycling, the average rate of oil in recirculation returning temporarily through the suction line is 17.9 lb. per hour. When the 15 HP compressor is not running, the 5 HP compressor could be receiving 2 times more oil per hour through the suction line than it is circulating out of its discharge line.

Installing an oil separator, reservoir and level control on the example system would not reduce the system oil charge. Actually, oil would need to be added to the system to fill the separator, reservoir and level controls. Externally equalized oil level controls would permit excess oil in the 5 HP compressor crankcase to flow to the 15 HP compressor when both are running. The separator, reservoir and oil level control would prevent the 15 HP compressor from a "too low" oil level.

Refrigerant recirculation rates for a typical medium temperature rack may be 8,000 to 10,000 pounds of refrigerant per hour at design conditions. Eighty to 100 lb. of oil will be moving through the (combined) compressor's crankcases per hour at a 1 percent rate. (240 to 300 lb. at 3%) A worn compressor could reach higher oil pumping rates.

All compressors wear. It is common to see several older compressors in parallel with a new compressor, i.e., a worn 5 HP compressor pumping at a 5% rate will circulate 22 lb. of oil an hour, while a less worn 15 HP compressor in parallel is circulating 17 lb. an hour. Reciprocating compressors that are typically used in supermarket refrigeration racks incorporate a flow control between the returned vapor motor compartment and the crankcase. The purpose of the control is to prevent oil in the crankcase from being forced into the motor compartment during the compressor start. The referenced 5 HP compressor will eventually wear to a point that the piston rings permit blow by to the crankcase. When the wear leading to blow by reaches the point where

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the crankcase pressure is **greater** than the return vapor motor compartment, oil return to the compressor crankcase from the system suction piping ceases. The 5 HP compressor now relies on the oil management system reservoir to replenish the 22 lb. (3.5 gal.) of oil it is discharging every hour. There is a point in time when the wear pattern on this compressor will be severe enough that it will deplete the reservoir oil supply. As more oil is added to the system to compensate for the worn compressor(s), less worn compressors overfill with the additional oil in recirculation. It is not uncommon to see several compressors on the same rack with oil levels over the top of the sight glass.

The Oil Charge

The total oil charge of a system is equal to the sum of:

* The oil charge in the compressor crankcases.

* The oil charge in the separator and reservoir.

* The oil necessary to charge the piping and heat exchangers.

When a supermarket rack is started and has stabilized, the oil system is a direct indicator of:

1) Correctly sized and correctly installed field piping.

2) Correctly sized rack piping and component selection by the system designer.

The correctly designed, installed, and balanced system will have compressors with the correct oil level in the compressor and oil reservoir 24 hours a day.

The Oil Separator

Oil separators can be purchased in varying stated efficiencies. The more efficient the separator, the less oil will enter the system. However, in a system it is a matter of time before oil accumulates in the same quantities, and at the same places as the less efficient separator.

The Oil Reservoir

The purpose of the reservoir is to store the amount of oil needed for a system in the "steady state" condition of oil recirculation. It is impossible to size an oil reservoir to compensate for a system that is incorrectly piped or is improperly maintained. There are supermarket systems in operation today that would fall short of oil *regardless* of the reservoir size.

The Oil Check Valve

The purpose of the oil check valve is to hold the oil reservoir at the correct pressure necessary to feed the oil level control if the oil level in the compressor drops below the set point. Referencing the attached diagram, the separator will begin to fill the reservoir with high pressure oil and vapor when the oil level in the separator float opens a "dump" valve. The spring loaded oil check valve is in a line between the top of the reservoir and the "rack" suction manifold and will bleed off excess vapor pressure.

The Oil Level Control

The purpose of an oil level control is the same as any other type of "make up valve". The only time the level control will feed is to "make up" for oil that is not returning through the suction manifold. The level control will make up for moderate differences in:

1) Compressor oil pumping rates due to size or wear.

2) Different oil return rates due to turbulence in the suction manifold.

Diagnosing An Oil System That Is Out Of Control

There should never be sudden fluctuations in the oil level. Oil levels that change quickly are a direct indication of oil logging caused by low velocities. Oil logging can be caused by any number of problems that limit heat transfer and slow gas velocities. Some of the more common are:

1) High store humidity levels that insulate evaporators with frost above design limits.

2) Iced coils from plugged drains.

3) TEV's out of adjustment

4) Incorrect defrost cycle times

All refrigeration racks have compressors that will wear out. There will be a time during each compressor operating life that piston ring "blow by" will reach a critical point. This "critical" point is when the ring blow down causes the crankcase pressure to exceed the suction pressure. The slightly positive pressure closes an oil flow control found in the crankcase of most supermarket compressors. It is at this point that two things happen:

1) The compressor's oil pumping rate is much higher than normal because of piston ring wear. In some severe cases oil pumping rates will surpass a gallon a minute.

2) The compressor can no longer return oil to the crankcase through the suction line because the oil flow control in the compressor crankcase inlet is closed. The oil reservoir will empty in a matter of minutes regardless of the oil separators degree of efficiency. If the compressor crankcases are equalized, the pressurization may be enough to prevent oil return in the surrounding "healthy" compressors.

When the oil reservoir and one or more compressors on a rack are low on oil, and compressors on the same rack are over filled with oil, proceed with the following checks:

Disconnect all compressor body equalization lines and install a 1/4” soft copper tube from above the oil level of the compressor crankcase to the suction service valve. Open the suction service valve and operate the compressor.

* If the copper tube remains cool, the compressor does not have “blow down” and is healthy.

* If the copper tube goes to discharge temperature, repair or replace the compressor.

If a rack is diagnosed as having a compressor that is an “oil pumper” and the problem corrected, be prepared to drain substantial amounts of oil from the rack system over a several day period.

NOTE: A compressor with damaged discharge valves or otherwise operating at higher than design discharge temperatures will accelerate piston ring wear. This may lead to crankcase pressurization in a matter of hours.

The single most expensive component in the refrigeration system is the compressor. Properly maintained oil levels unquestionably add years to the life of the compressors. Additional information regarding oil management systems and their operation can be found in Sporlan bulletins 110-10, 110-20, and 110-30.

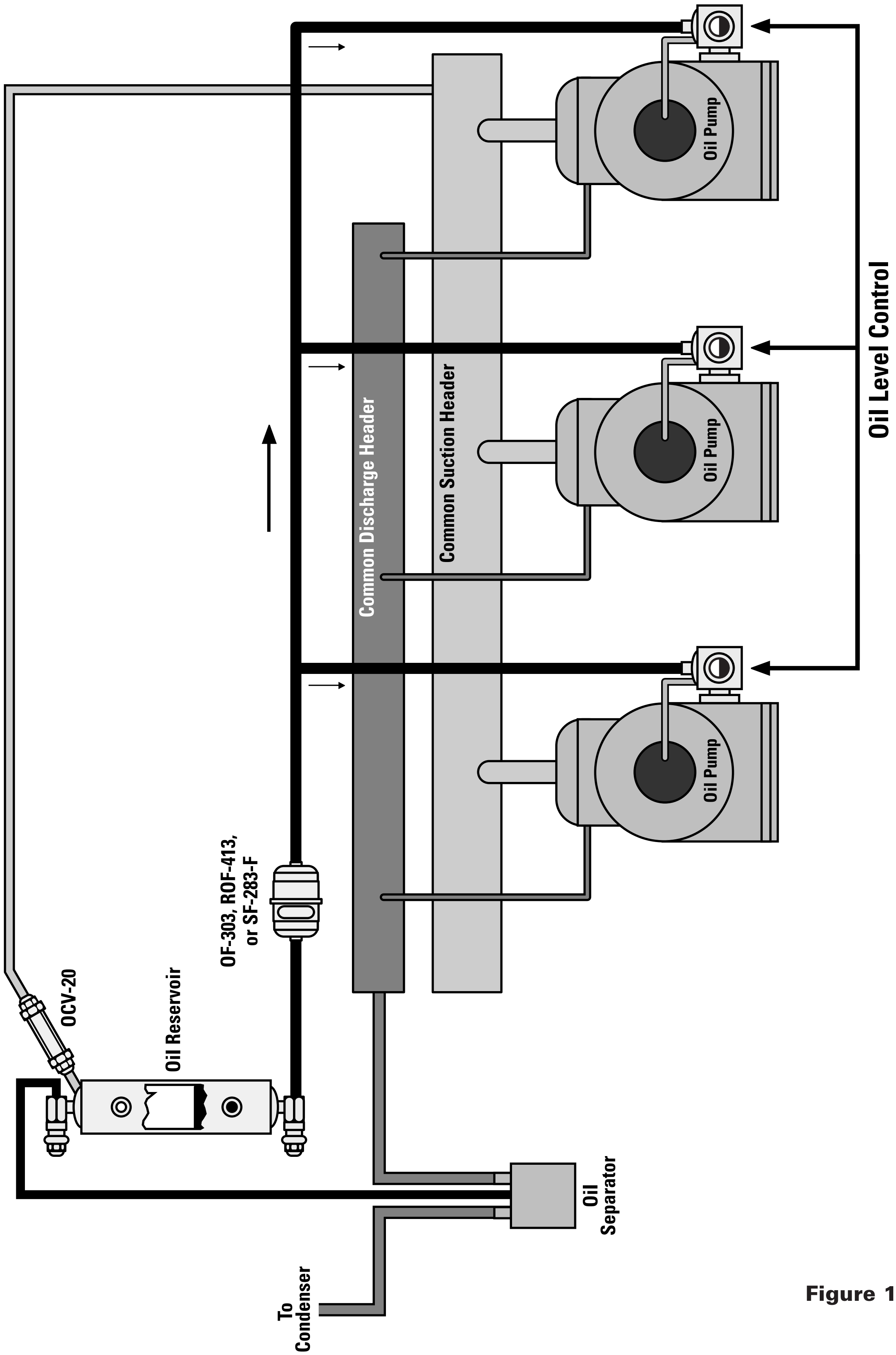
Oil Level Control
Oil Pump
Oil Pump
Oil Pump
Common Discharge Header
Common Suction Header
OF-303, ROF-413,
or SF-283-F
OCV-20
Oil Reservoir
Oil
Separator
To
Condenser

Figure 1