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INSIDE SCIENCE AND TECHNOLOGY WITH KEEPRITE REFRIGERATION

ALTERNATIVE METHODS OF HEAD PRESSURE CONTROL

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Refrigeration systems operating under various seasonal conditions must employ some method of low ambient head pressure control (HPC). Unlike air-conditioning, refrigeration systems must continue to operate when temperatures drop below the conditioned space, below freezing or even below 0° F. These conditions present unique challenges that must be addressed in order for the system to perform effectively and efficiently. For years, the only practical method of head pressure control has been the flooded condenser method. However, advances in condenser fan technology have uncovered alternatives that result in huge energy and refrigerant savings.

First, we must take a look at why head pressure control is necessary during winter conditions. A simple look at the pressure / temperature (PT) chart shows that condensing pressures follow the ambient temperature as temperatures rise and fall.

A conventional R-404A system will see a head pressure of 270 psi in a 95° F ambient and the condenser sized for a 15° F TD. That same system would see condensing pressures reduce to 135 psi on a 50° F day and only 50 psi on a 0° F day. As liquid line pressures drop, the issue becomes a function of the thermostatic expansion valve (TXV) sizing. All expansion valves have a BTU rating that is dependent on the pressure drop across the port inside the valve. (See Table 1) As head pressure drops, valve capacity will similarly drop, resulting in a starved evaporator and high superheat. A drop in ambient from 95° F to 50° F can result in a 50% TXV capacity loss - therefore some method of elevating the head pressure must be used to keep the system online.

Why has the industry relied on flooded head pressure controls for so many years? The simple answer is, because it worked. The flooding valve uses a two pronged approach to sense and maintain head pressure while keeping the receiver and liquid line pressurized. Since the root problem is the condenser, the HPC valve senses condenser pressure and begins to hold back refrigerant as the pressure drops. The physical stacking of refrigerant reduces the effective heat transfer surface and artificially raises the head pressure. However, the reduced refrigerant flow into the receiver (as the TXV continues to feed) causes a drop in receiver and liquid line pressure. The HPC valve again steps in to maintain pressure as it bypasses high pressure discharge gas to the receiver. That injection acts as a warm blanket, pressurizing the liquid line and ensuring proper TXV performance. The reliability of this system has made it a staple of refrigeration systems for decades.

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The main disadvantage to using flooded head pressure controls comes when additional refrigerant is required to flood the condenser in a colder ambient. This will result in higher installation costs and system operating costs. Depending on the size of the system, flooding the condenser coil can result in an increased refrigerant charge anywhere from a few pounds to several hundred pounds. Coupled with the increased system charge, the condenser fans continue to run full speed (and full amp draw) even when the condenser doesn't require full heat transfer. Finally, most of smaller head pressure controls are non-adjustable and pre-set at a level that ensures system performance regardless of installation location.

EVAPORATOR TEMPERATURE °F	PRESSURE DROP ACROSS TXV (PSI)										
	30	50	75	100	125	150	175	200	225	250	275
	CORRECTION FACTOR, CF PRESSURE DROP										
40°	0.55	0.71	0.87	1.00	1.12	1.22	1.32	1.41	1.50	1.58	1.66
20° & 0°	0.49	0.63	0.77	0.89	1.00	1.10	1.18	1.26	1.34	1.41	1.48
-10° & -20°	0.45	0.58	0.71	0.82	0.91	1.00	1.08	1.15	1.22	1.29	1.35
-40°	0.41	0.53	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.25

Table 1

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The use of pre-set head pressure settings has always been a source of contention among different installation locations. In a colder climate, the higher settings are welcomed as the lower ambient temperatures are quite common. Typically, pre-set flooding valves are set for a 90° F condensing temperature or 75-80° F ambient. This setting ensures proper refrigerant flow through the TXV, but requires the system to operate as it would have during the spring and summer even during the dead of winter.

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In warm ambient conditions, many view the flooded HPC valve as almost unnecessary when the ambient rarely drops below 30° F. In these instances, many have relied on fan cycling to artificially raise the condensing pressure. As the ambient temperature drops, a pressure or ambient control will cycle the fan(s) off, reducing the airflow across the condenser, increase the condenser TD and elevating the head pressure. The results can be effective, but not without its own drawbacks. High pressure differential settings of fan cycling controls can result in head pressure fluctuations of 75 psi or more, affecting the overall performance of the system. As stated earlier, changes in head pressure effect the TXV operation and can result in intermittent refrigerant starving or flood back.

Changes in technology have resulted in a perfect solution of elevated yet adjustable and efficient head pressure control. Electrically Commutated (EC) motors have resulted in infinitely variable condenser fan motors that can adjust to the ever changing ambient of any environment. EC motors consistently vary their speed to mimic the environment thus eliminating the swing in pressure differentials caused by cycling conventional motors off. This gradual change in speed results in a smooth and more consistent head pressure regardless of ambient.

The EC motor speed responds to a simple 0-10V signal, so a controller is required to modulate the RPM. As the ambient drops, the motor slows in speed to reduce airflow and maintain head pressure. The fan speed controller is adjustable, so it is easy to change the pressure setting for any given application. Taking a quick look at TXV sizing, it is easy to adjust the head pressure setting lower to optimize system pressure, and the resulting reduction in compressor compression ratio that can result in some of the largest efficiency gains.

The EC motor's greatest energy benefit comes from reduced energy consumption at partial speed. Even at full speed, an EC motor can be as much as 40% more efficient than a conventional permanent split capacitor (PSC) motor. That alone can pay for any added cost. One look at the energy curve vs. RPM in Chart 1 is enough to confirm its place as a viable and reliable method of head pressure control of the future. As the speed reduces 10% (only 90° F ambient), energy consumption reduces an additional 30%. As the ambient drops 20% (75° F ambient), fan energy consumption drops 50%. You can see how great the savings are during the dead of winter. Looking at seasonal ambient data across the country, annual fan energy can be reduced by as much as 80%.

In addition to the tremendous energy saving afforded when utilizing EC motor technology, there is a significant reduction in the amount of refrigerant required to operate the system efficiently over an expansive range of ambient conditions. When using EC motors, the reduced airflows across the condenser coil eliminates the need to have an excessive amount of refrigerant in the system in order to flood the condenser. Given the endless variations in control, EC motors can easily reduce the total system charge by as much as 30%. These savings in refrigerant alone will reduce upfront costs and future liability.

When a flooded head pressure control valve is busy hoarding system refrigerant, EC motors are efficiently varying fan speed to maintain head pressures. Flooded head pressure controls and EC motors are both effective in maintaining head pressure while EC motors offer reduced energy consumption and refrigerant charges. With this, one must ask, why is anyone still using condenser flooding valves?

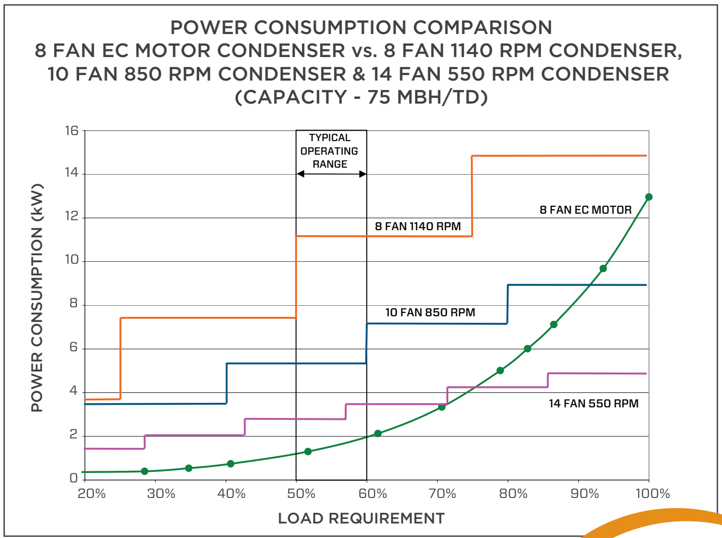

Chart 1