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Another Solution To Oversized Systems

Try Head Pressure Control For Residential A/C And Heat Pumps.

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SHELTON, Conn. — John Staber used to work in HVAC contracting. Now he is in sales at EDC International Inc. The company manufactures and markets HVAC electronic measurement and control devices.

"I dove headfirst into the new position by trying to understand the products this company manufactures," he recalled.

Having come from the contracting side of the HVAC world, mostly residential and light commercial, Staber had a good understanding of condensate pumps, condensate overflow switches, temperature sensors, and most of the products in the line.

"I tried to educate myself by reading the cut sheets and the brochures — pretty dry reading, but this was new, challenging, and held my interest," he said. "The head pressure controller (HPC) brochure totally confused me."

Sure there were claims of energy savings, but how exactly was the energy saved?

According to Staber, "I had a rough idea what the control was designed to do but wasn't exactly sure where it would be used." He found an opportunity to "corner the designer of the HPC and get a better understanding of this very unique product."

Here is his translation.

How It Works

According to Staber, while the HPC reduces the speed of the condenser fan, this is not its primary energy-saving mechanism, "though this does contribute to energy savings," he said. "The real savings a head pressure controller provides comes from the optimization of the refrigeration system working under the correct pressures. Correct operating pressures allow for system efficiency and lowered run times.

"Almost all air conditioners are designed to work most efficiently at 80˚F ambient outdoor temperature," he continued. "This means the fan has to be big enough to remove sufficient heat from the condenser to provide optimal head or discharge gas pressure when it is blowing 80˚ air over the condenser coil.

"It is the difference between this discharge pressure and the low pressure in the evaporator that determines the refrigerant flow through the capillary tubes and into the evaporator cooling coil," explained Staber. "If there is a higher pressure on the condenser side of the capillary, the refrigerant flow is increased and vice versa."

Without an HPC, Staber said, and with the condenser fan running at full speed all the time, "this discharge gas pressure will drop as the ambient temperature falls be-cause the condenser fan is blowing colder air over the coil and this takes more heat out of the refrigerant flowing through the system."

In the condenser coil, where the refrigerant is condensing, pressure and temperature are related by the gas laws.

"As soon as this discharge pressure falls, the amount of refrigerant flowing through the capillary also falls," Staber pointed out. "Therefore, the compressor has to run for longer periods and work unnecessarily harder to take the same amount of heat out of the

Top: Ron Eastwood of Eastwood Electric prepares the condenser for the installation of a head pressure controller. Safety first: switch off the disconnect. **Above:** Some models need to have the fan removed to access the coil and the wiring.

indoor unit and satisfy the thermostat."

With an HPC retrofitted on a condenser — the sensor being positioned at the point of condensing on the condenser coil — the sensor continuously monitors the condensing temperature. If the temperature falls (say, because the temperature of the ambient air blowing over the condenser coil has dropped), the head pressure control slows down the fan to pull the temperature and the refrigerant pressure back up.

"The system is now back running at its design conditions and the cooling effect on the indoor unit is the same as it was designed for," Staber said. In order to fully understand it, Staber had one installed at his home.

Why Use One?

Staber described a few circumstances "where optimum design goes out the window despite the best attempts of engineers and equipment sales specialists." He outlined a few situations when a head pressure controller would come in handy, as in areas where outdoor temperatures fall below the design, 80˚, in spring, fall, and summer evenings.

HPCs could also be useful on hazy, hot, and humid days, and in restaurants, office buildings, and gyms. The cooling systems are often designed for full occupancy with different latent heat gain for people at work and people at rest.

"The condenser fans are still running at full for every cooling call from the thermostat," Staber said. For example, say the restaurant has a maximum occupancy of 150 people.

"Latent gain for this, at 300 Btuh per person, equals 4 tons or roughly 48,000 Btuh. It is 4 p.m. and there are only four tables filled for the dinner hour. That condenser fan is running full tilt to satisfy a larger cooling load than exists at that time," said Staber.

Head pressure controls could also be a remedy for problems caused by "Joe 'without a clue' Salesguy," according to Staber. "Joe has been bombarded with no-cooling calls and customers wanting quotes on air conditioning. What does he do to make life easier? He looks at the existing equipment and replaces the unit.

"Joe doesn't do a comprehensive cooling load calculation, doesn't ask the homeowner if there have been any upgrades to windows, doors, or insulation, and bingo, one oversized unit coming up. Joe sometimes even makes it worse. He may just want to make sure the customer gets enough cooling and gives them a half-ton extra, at no charge.

"Even when a proper cooling load has been done, and the sales engineer has painstakingly inspected the windows for low-E glass, checked insulation values, added for window shading, overhangs, color of the roof, duct sizing and any other conditions that make a difference, he looks at the load sheet and doesn't believe his own work and adds a little extra. 'Go big or go home.' He thinks the winning quote is going to have the biggest output for the lowest price."

Can the situation be worse than just an oversized system using too much electricity keeping the business or home cool? It sure can, said Staber.

"That oversized unit will turn the evaporator into a block of ice until the temperature changes. This blocks the airflow over the evaporator coil and more and more ice will build up from the condensate freezing on the coil and block airflow to the point where there will be no cooling."

When the design temperature changes, the ice starts to melt, the condensate drain can't keep up — pans overflow, moisture gets blown downstream from the evaporator, and/or overflows the evaporator trays, "and you start a nice little mold factory in the ducts or wherever the condensate drains or leaks."

Fixing The Problem

Sizing the system right in the first place would have been the best of all possible solutions. However, without time travel to stop these poor sales, it's not practical. Neither is trying to sell the homeowner a completely new system.

Installing a head pressure controller is practical. It helps maintain the correct refrigerant pressures for as long as possible, Staber said.

"Of course, if the ambient temperature drops too far, and the fan has slowed all it can, 30 to 35 percent of full speed, it will continue running at the minimum speed set on the controller and the temperature continues to drop," he said. "The pressures will fall along with it. By this point, however, we have already saved electricity and are way ahead."

One more thing that Staber needed to clear up for himself is why, when you are measuring pressure, do you use a temperature sensor? Would it be better to use a pressure transducer? Staber found that the answer is no, and for a number of reasons.

"First, there are a number of different refrigerants in use today, and they all have different characteristics and work at different pressures. So a pressure transducer would have to be able to be adjusted for all these different refrigerants, and here, there is too much room for error.

"But whatever the pressure-temperature relationship of the refrigerant gas itself, they all work at the same condensing temperatures. So a temperature sensor can be used with all existing and any new refrigerants without external modification or cali-

Top: A quick review of the installation instructions and the wiring diagram is always a good idea. **Above:** The sensor can be used to correct problems with oversized systems or older, lower-efficiency unitary systems.

bration. The calibration performed internally by the factory makes it completely universal."

There have been manufacturers of head pressure controls using pressure sensors, Staber added, but these products "haven't been capable of withstanding the very high pressures of [some] new refrigerants and have developed leaks."

In addition, a temperature sensor "is completely separate from the condensing unit itself, and is strapped around one of the return bends — an easy job to fit, and if it ever needs to be replaced, it's also an easy job."

How It Works, Electrically

The controller itself is a phase controller, Staber said. It does not control the frequency of the electrical power feeding the fan. "In effect, it controls the voltage to the fan motor by 'chopping' the waveform.

"Most condensing unit fans are the centrifugal types; that is, they have four or six blades. The power requirements of this type of fan are particularly suited to speed control by varying the voltage, because the power required varies as the cube of the speed. That is, for example, at half speed they only take one-eighth of the power. So the characteristic of the HPC is designed to vary the speed of the fan by varying the voltage supplied to it.

"Whenever the sensor detects the condensing temperature is falling, the controller reduces the voltage to the motor, and the fan slows down until the temperature goes back to where it should be."

This happens automatically. Moreover, because the temperature is being measured continuously, the fan speed is continuously modulated up and down, "and the actual temperature of the condenser hardly varies at all," Staber said.

It's important to know that when the condensing unit is first switched on, either by the homeowner or by the room thermostat, the HPC produces a hard start. "No matter what temperature the sensor is measuring when the unit turns on, the fan runs at full speed for about 10 seconds," Staber said. "This is to make certain that the fan starts properly, and in the right direction, and provides maximum cooling of the condenser during those first few seconds until the sensor has time to respond."

It also allows for the thermal delay in transferring the heat from the refrigerant into the sensor itself, he explained. As soon as the hard start is completed, the HPC takes control of the fan speed, depending on the refrigerant temperature.

"The place it really should be used is on minimum-SEER units," Staber said, as well as on oversized systems. Head pressure controls have been more common in re-frigeration systems than in residential A/C and heat pump applications — but that might change.

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