Demystifying HVAC

HVAC Systems and the Change of Season

It has to be one of the ten most beautiful days of the year. Fall has arrived. The air is cool and crisp, the sun is bright, and in weather like this you can even deal with the motorcade to work in the Chicago suburbs. At least, now that the heat and humidity of summer are gone you won't be plagued by HVAC problems, right? Wrong! While you are enjoying Mother Nature's gift day, events are conspiring to make your existence as a facility manager miserable via your HVAC systems.

Now that fall has arrived, the requirements and operating conditions for your HVAC systems have changed. These "fall" operating conditions will continue into outdoor temperatures of 35ºF. After closing time, when your stores are unlit and unoccupied, the indoor temperatures cool down to somewhere between 50ºF and 60ºF. Around 6:00 AM your thermostats will call for first stage heating to be energized in your rooftop air conditioning units. The thermostats are set for an occupied time of 7:30 Am, however like most high quality commercial programmable thermostats, these have a feature called "intelligent recovery". Intelligent recovery allows the thermostats to bring on the units at a time calculated to obtain the desired space temperature at the specified time the store will be occupied.

All over the northern United States, thermostats are calling for heat in an attempt to make your stores warm and toasty for the arrival of employees and customers. However, the fact that the thermostat calls for heat doesn't necessarily mean that the equipment it controls is actually providing that heat. In your Troy, Michigan Store, years of use and condensation have caused the heat exchanger in one of the gas fired rooftop units to rust through. When this unit calls for heat, the draft inducer (small fan which draws air and flue gases through the unit) comes on, the pilot gas valve opens, the spark igniter lights the pilot, the pilot flame is proved and the main gas valve opens allowing gas to flow to the burners. The burning gas inside the heat exchanger warms the heat exchanger and a temperature-actuated switch brings on the unit fan.

Now things start to go wrong. The air produced by the unit fan, which is supposed to flow around the exterior of the heat exchanger, is forced into the heat exchanger through the rotted hole and hot gases and flame are blown backwards out of the burners. Luckily, the unit manufacturer has provided a safety control called a roll-out-switch which shuts down and locks out heating operation before the flames have burned up all of the components in the heating section. This unit won't be providing any heat in the near future, but since the store is served by several units, no one will notice the malfunction until outdoor temperatures are extremely low, or until a technician discovers the problem during a maintenance visit.

In your store in Cincinnati, an insect has chosen to make the inlet tube of one of the gas burners in rooftop unit #1 (RTU1) his home during the spring and summer. To that end he has spun a white fluffy substance that looks like a web or cocoon. Unfortunately this substance is partially obstructing the inlet tube. When the burner comes on there is

insufficient air for complete combustion and this burner produces a yellow flame causing soot to be deposited in the heat exchanger and causing the flue gases to contain carbon monoxide. Owners of gas barbecues often experience a similar situation when a spider or other crawly friend takes up residence in a burner tube turning the nice blue flame orange, and coating the T-Bones with black soot. As with the heat exchanger situation described above, no one will be aware of this malfunction until outdoor temperatures are extremely low or until it's discovered during a maintenance inspection.

At your store in Union, New Jersey all but one of the units is heating just fine, but the burners on that one unit never came on because the draft inducer motor seized up and rusted solid during the cooling season.

In Raleigh, North Carolina your store uses rooftop heat pumps. One of the heat pumps is running in the cooling mode even though the thermostat is calling for heat. This is due to the fact that the reversing valve is stuck in the cooling position. Of course the stuck reversing valve had no adverse effect during the cooling season.

All of these malfunctions have occurred and gone unnoticed, and you haven't even arrived at your office yet.

The heating malfunctions described above are typical of those found at retail stores, and their occurrence explains the need for a good scheduled inspection program. However they only represent the problems during the heating cycle. The real problems won't begin until you're ready for lunch. As you head for your favorite restaurant, the lights and people within your stores have joined forces with the sun to warm the stores to the point that they now require cooling. It's 50°F outside but it will soon be 90°F in the stores unless the HVAC systems provide adequate cooling.

Remember that store in Troy, Michigan? Now it requires cooling. It's a good thing your chain uses auto-changeover thermostats that will allow the units to automatically switch from heating operation to cooling operation. As your driving to lunch each of the units in Troy is calling for cooling. These units have been installed with outdoor air economizers, which should allow them to cool the store without bringing on the unit compressors. Once again Murphy’s Law enters into the picture, and the outdoor air damper on one of the units fails to open due to a burned out damper actuator. The temperature at the thermostat that controls this unit rises another degree and the thermostat calls for second stage cooling. Now the compressor comes on because the economizer was not able to cool the space with outdoor air. This compressor is now operating at an outdoor ambient temperature of 50°F. Since the unit has an economizer, it lacks the controls that would allow the compressor to operate at such a low outdoor temperature. The compressor is now operating at lower pressures and temperatures than it was designed for. The evaporator (indoor coil) temperature drops below 32°F and ice begins to form on the coil. Eventually, the entire coil becomes covered with ice and the pressure within the coil drops low enough to trip a safety control which shuts down the compressor before it is destroyed. On units that are not equipped with this safety control, called a low-pressure switch, the compressor may be destroyed as it attempts to pump refrigerant in its liquid state rather than in its gaseous state. Now that the compressor has

shut down, the ice on the coil begins to melt, and since the ice is blocking the unit drain fitting, water begins to leak into the store. This prompts the store manager to call in a roof leak because it never occurs to him that the air conditioning might be running during this time of the year.

At your store in Evanston, Illinois the same situation is occurring due to a defective enthalpy changeover control. The enthalpy control is supposed to determine when it is appropriate for the unit to utilize outdoor air for economizer operation, rather than utilizing mechanical refrigeration. It does this by measuring both the temperature and the humidity content of the outdoor air. The temperature and humidity content of the air determine the enthalpy, or heat energy content of the outdoor air. The enthalpy control measures this enthalpy level and compares it with a predetermined set point or with the enthalpy content of the return air. If the enthalpy of the outdoor air is low enough, the unit will operate in economizer mode on a call for cooling. If the enthalpy is too high, the unit will bring on compressors on a call for cooling. The control on the unit in Evanston has failed in the mechanical cooling mode. Therefore whenever the unit calls for cooling, the compressor operates. Due to the fact that this unit does not have a low ambient control that would allow the compressors to operate at reduced outdoor temperatures, it will soon begin to ice up with the same consequences as the store in Troy.

In Kansas City, your store is located on the first floor of a two-story building, so it is cooled with split systems. The condensing units (outdoor unit which contains the compressor) were originally installed with low ambient operating controls which allows them to operate at reduced outdoor temperatures by reducing the speed of the outdoor fan motors. One of these controls failed during the cooling season and the technician, who discovered the failed control on an emergency service call, bypassed the control to give the store temporary cooling. Unfortunately, you never received a proposal to install a new control. This store has no economizers and so this condensing unit must run in order to cool the store. This unit is set up to decrease its capacity by unloading (shutting off) cylinders within the compressor. Operating without a low ambient control and at reduced capacity, not only are the temperatures and pressures below design levels, but the compressor is no longer getting adequate lubrication. This is due to the fact that when the capacity and pressures are reduced, the velocity of the gas and liquids within the refrigerant piping is reduced, and the lubricating oil that is normally carried along with the refrigerant is left to pool in the air handler. Eventually this compressor will fail mechanically due to a lack of lubrication.

One of the units which cools your store in Rochester, New York has been operating slightly low on refrigerant charge throughout the cooling season. No one noticed the slight decrease in capacity that resulted from this situation. Now that outdoor temperatures have dropped and the operating temperatures and pressures within the unit have dropped, this unit is also building up ice on the cooling coil and will soon be dripping into the store.

All of the scenarios above are real. They have happened in the past and they will reoccur in the future at different locations operated by different retailers.

These scenarios explain what areas of your HVAC systems are affected by the fall change of season and how malfunctions in these areas will manifest themselves. Your best defense against the problems described above, as well as most HVAC problems in general, is a thorough inspection by a competent technician on a regular basis. The fall inspection should include inspection of all heating components and an operational check of the heating systems and safety controls. In addition, particular attention should be paid to the operation of economizers, power exhaust accessories and low ambient controls. Older style enthalpy changeover controls that contain an acetate element should be checked and replaced if they are not operating properly. These elements are subject to premature failure due to degradation by airborne pollutants.

All of the component failures discussed can cause annoyance, discomfort, and loss of revenue. However, the most important failures during the fall change of season, are those which can cause a possible risk to health and life.

You are at home eating dinner when you receive a page from your chain's emergency center. The fire department has responded to a call from your store in Falls Church, Virginia. The store complained of smelling a noxious odor and someone thought it might be smoke. The Firemen have shut down the HVAC systems at this location because they measured significant quantities of Carbon Monoxide on the sales floor. You dispatch your HVAC service contractor to the store. The technician finds that the draft inducer on a neighboring unit lost its blower wheel, but the unit continued to operate because the safety control which proves inducer operation was of a type which senses motor rotation rather than induced draft flow. The neighboring unit was operating with incomplete combustion, producing soot, yellow flame and carbon monoxide. The outdoor air intake on one of your units was located near the neighboring unit and since the unit was operating in economizer mode, the products of combustion were drawn into the store.

The most important items to inspect during the fall season are the air to fuel mixture, condition of flue components including draft inducers, operation of heating safety controls, and measurements of the flue gas components. Carbon monoxide is a product of the incomplete combustion of natural gas. It is deadly in that it is poisonous, odorless, and colorless. If it is generated within a heating unit it can find its way into the occupied space through the unit producing the gas, through the outdoor air intake of another unit, or through any opening in the shell of a building. Your HVAC service company should know the signs that lead one to suspect the presence of Carbon Monoxide, and should be equipped to measure Carbon Monoxide levels in the occupied space and in the flue gases. It might also be a wise investment to mount at least one of the residential type Carbon Monoxide Detectors in an inconspicuous place in each store served by gas fired equipment.

We made it all the way through dinner without a real catastrophe, but who knows what your HVAC systems will be doing while you're sleeping; and then there is always tomorrow and the spring.