Heat Pump Operating Concepts - TXV

The heat pump system is comprised of a 3.5HP electric motor powered vapor compressor (i.e. the compressor), a coil-in-coil water-to-refrigerant heat exchanger, a finned coil air-to-refrigerant heat exchanger, a 4-way refrigerant valve, and a TXV (Thermostatic eXpansion Valve). Refrigerant flows in the inner coil and the ground loop water flows in the outer coil of the water-to-refrigerant heat exchanger. Refrigerant flows in the coil of the air-to-refrigerant heat exchanger and air is blown past the fins on the coil. To switch between heating and cooling, the 4-way refrigerant valve reverses the flow of refrigerant through the system. The valve position is controlled by a solenoid. The valve has a default position (typically heating in a heat pump system) and the other position is activated by supplying 24VAC to the solenoid coil of the 4-way refrigerant valve. The compressor must be operating and generating pressure to complete the transition of the gas switching elements inside the valve. The coil is usually connected to the "O" thermostat wire.

In heating mode, "O" is not energized and the default-position of the 4-way refrigerant valve is "Heating Mode".

- In heating mode, the 4-way refrigerant valve routes hot high-pressure refrigerant gas from the compressor output to the refrigerant-to-air heat-exchanger. The air heat-exchanger operates as a refrigerant condenser and air heater (cooling and condensing the refrigerant gas into a liquid and adding heat to the air).
- The 4-way refrigerant valve also routes cool low-pressure refrigerant gas to the compressor suction input from the refrigerant-to-water heat-exchanger. The water heat-exchanger operates as a refrigerant evaporator and water cooler (heating and boiling the refrigerant liquid into a gas and extracting heat from the ground loop water).

In cooling mode, "O" is energized (24VAC) and the powers the solenoid coil of the 4-way refrigerant valve. The valve moves to the "Cooling Mode" position as soon as the compressor generates gas pressure.

- In cooling mode, the 4-way refrigerant valve routes hot high-pressure refrigerant gas from the compressor output to the water-to-air heat-exchanger. The water heat-exchanger operates as a refrigerant condenser and water heater (cooling and condensing the refrigerant gas into a liquid and adding heat to the ground loop water).
- The 4-way refrigerant valve also routes cool low-pressure refrigerant gas to compressor suction input from the refrigerant-to-air heat-exchanger. The air heat-exchanger operates as a refrigerant evaporator and air cooler (heating and boiling the refrigerant liquid into a gas and extracting heat from the air – i.e. cooling the air and condensing water out of the air).

The vapor ⍰ liquid phase change of the R-410A refrigerant is a potent heat source and heat sink. A large amount of energy is required to force a liquid to change phase (i.e. condense from a gas or boil to a gas). Some insight into how much energy a phase change requires can be gotten from looking at the behavior of water. For example, it takes 4.186 joules of heat to warm 1 gram of water 1 °C, or 418.6 joules to heat 1 gram of water from just above freezing to just below boiling. However, it takes 2261.11 joules to boil that 1 gram of water into a gas, starting with the water already heated to just below boiling. In other words, 5.4 times more energy is needed to boil the water (without any appreciable temperature change) than to heat the water from freezing to boiling. A phase change is a powerful mechanism to source or sink heat with very small temperature differences.