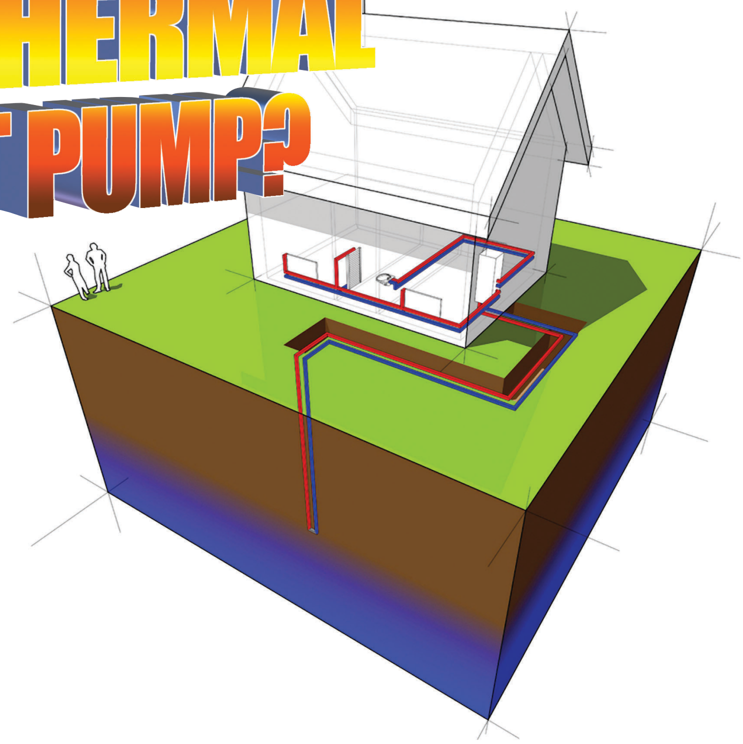
INDOOR COMFORT MARKETING

BOILER FACTS

BY GEORGE CAREY
GCAREY@FIAINC.COM

TOOLS AND TECHNIQUES FOR TECHNICIANS

What is a GEOTHERMAL HEAT PUMP?



Heat pumps are devices that are designed to take heat from one area where it is available and move it to another area that can accept this heat. The channel that can provide this heat is referred to as the "source" while the area receiving this heat is called the "sink."

Most people are familiar with the popular "air to air" heat pump. This device absorbs heat from the outside air and delivers it through a forced air duct work system throughout the house.

To collect this available heat from outdoors, we have to use refrigeration…more specifically, the vapor-compression refrigeration cycle. The cycle consists of the following sequence: cold liquid refrigerant is evaporated in the outside heat exchanger, which contains a fan that blows air across the refrigerant coil (known as the evaporator in the heating mode). The refrigerant, now in a low pressure gaseous state, has "picked up" heat from the outside air. It is piped to the compressor where it is compressed into a high pressure/high temperature gas. This hot gas is routed inside to a refrigerant-to-air heat exchanger (known as the *condenser* in the heating mode).

Return air from inside the building flows across this heat exchanger/coil and causes the high pressure/high temperature gas to condense. In doing so, the air temperature is raised as it flows across the coil and out to the system through the duct system.

The refrigerant condenses back into a high pressure liquid where it is "throttled" by a thermal expansion valve. The valve's job in the heating mode is to lower the pressure and temperature of the refrigerant so that it can now travel back out to the evaporator as a cold liquid refrigerant.

Heat pumps have a device known as a reversing valve, which makes them unique. By reversing the direction of flow of the refrigerant, the heat pump now becomes an air conditioner. In cooling mode, we want the cold liquid refrigerant to flow across our inside air coil. By absorbing heat from the air flowing across the coil (now called the *evaporator* in the cooling mode), the air is cooled and dehumidified and the liquid becomes a low pressure gas. This gas then flows through the reversing valve and back to the suction side of the compressor, where it is compressed into a high pressure/high temperature gas. It then flows out to the refrigerant-to-air heat exchanger where a fan blows air across the coil, condensing the gas into a high pressure liquid.

Lastly, the thermal expansion valve throttles this high pressure liquid, dropping its pressure so that it again becomes a cold liquid refrigerant.

Of course, air-to-air heat pumps have their limitations, especially during the heating season. As the outdoor temperature drops, the ability of the refrigerant to pick up heat is reduced. The heating system's capacity—as well as efficiency—decreases as it gets colder outside. To offset this lack of capacity/performance, air source heat pumps need supplemental heat to handle design loads, especially in northern climates such as the New York and New England climates. Often, this supplemental heat takes the form of electric resistance elements, which can substantially reduce the heat pump's overall efficiency. This is due to the ever increasing costs for electricity.

Instead of air, what about water?

Water-to-refrigerant heat exchangers (instead of air-to-refrigerant exchangers) allow the possibility of creating water-to-water and/or water-to-air heat pumps. These heat pumps can extract heat from a source of

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lower water temperature and deliver it to a higher temperature flow of water.

If we were to look at the same refrigeration cycle as before, everything is the same except instead of using air, we are using water to extract or remove heat from the refrigerant side of the process. Also, in addition to heating air in a water-to-air heat pump where heat is delivered through a duct system, we can heat water for low temperature applications such as radiant floor heating through a water-to-water heat pump.

Water-source heat pumps collect heat from the ground. This is because the temperature of the soil four to five feet below the surface is very stable and also much higher than the outside temperature during the majority of the winter. Even though the outdoor temperature may be as low as 5-15°F during the winter, the earth's temperature five feet below the surface will be 45-50°F. This higher temperature, compared to the outside air temperature, increases the capacity as well as the efficiency of water-to-air/water-to-water heat pumps and is what makes them more attractive, especially in the northern climates.

There are several methods of gathering this geothermal heat source. Open loop systems from lakes, ponds or wells are examples, but for purposes of this discussion, we will describe the more common closed loop method. In a closed loop system, a piping manifold is installed either in one or more vertical bore holes or (see illustration, facing page) they are buried horizontally in trenches 5-7 feet below the earth's surface. A mixture of water and glycol is circulated through this piping field. By chilling the water, the heat from the soil migrates through the pipe walls and warms the circulated water. This water is then pumped back to the heat pump where the heat is removed through the refrigeration cycle; the water is chilled again and heads back down to the earth to extract more heat.

Typically the ground loop piping material is high-density polyethylene. One important technique to be aware of is that all the joints below ground should be heat fused. The amount of tubing used will depend upon the location, the type of soil, and of course, the building load.

One of the main differences between designing a hydronic system with a geothermal heat pump versus a traditional oil/gas boiler is the operating temperatures of the water flowing through the terminal units (radiation). Because most water-to-water heat pumps operate with R410-A refrigerant, they can't heat the water any hotter than 120-125°F. Any higher and they run the risk of tripping high-pressure switches in the refrigerant circuit. Those temperatures are appropriate for most slab-style radiant floor systems, which are typically designed for 95-120°F. They can also operate in properly designed fan coil/air handler systems where the coils are selected at this lower water temperature.

Another area of concern is flow rates. Water-to-water heat pumps need a certain minimum flow rate pumping through them—if not, they quickly shut down due to refrigerant pressure issues. This can happen when a heat pump(s) is supplying heat to several heating zones and only one or two are calling. The problem is that the heat pump is adding energy to the water faster than the zone can remove it from the water. The result is the system water temperature rises quickly, hitting the high limit and shutting down the heat pump. This type of operation leads to rapid short-cycling of the heat pump and premature failure of the compressor.

The solution is to hydraulically separate the heating zones from the heat pump (not unlike piping low mass/high pressure drop mod/con boilers). The best way to isolate each other is through a buffer tank. These storage tanks are well insulated and provide the necessary thermal mass that the small individual heating zones can't provide. Whenever a zone calls for heat, it can pull whatever necessary BTUs it needs to satisfy its call and when the tank's temperature drops by whatever the differential; the heat pump will turn on to satisfy the tank's stored temperature. This larger mass will extend the heat pump's run cycle as well as protect the compressor from short-cycling, thus extending its life cycle.

One last point that really makes geothermal heat pumps intriguing is that they always produce more heat output than the electrical energy required to operate them. And that source of energy is the stable soil temperatures the earth provides. The ratio of a heat pump's heating capacity to the required electrical requirements to run it is called the coefficient of performance or COP. It is calculated by dividing the heating capacity in Btu/h by the amount of kW x 3413. (3413 Btu/h per kW and kW is the electrical input to the heat pump in kilowatts). Naturally, the higher the COP of the heat pump, the higher the amount of "free" heat in the heat pump's total output. The higher the source temperature is and/or the lower the temperature of the heating load, the higher the capacity and greater the efficiency for a given heat pump.

If you have any questions or comments call me at FIA at 1-800-423-7187 or email me at gcarey@fiainc.com