BOILER FACTS

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TOOLS AND TECHNIQUES FOR TECHNICIANS

# Air to Water Heat Pumps

As the New Year will be upon us when you read this, I wanted to share with you a new technology (at least new to the US market) that will be gaining in prominence in the hydronic market. The reason is this product fits perfectly with hot water heating, domestic hot water production as well as chilled water cooling. The product I am describing is an "Air-to-Water" heat pump.

As you know, heat pumps have been around for a long time in the comfort business. When you talk about heat pumps, historically there have been three categories:

- Air-to-Air heat pumps
- Water-to-Air heat pumps
- Water-to-Water heat pumps

In general, heat pumps are devices that can convert low temperature heat into higher temperature heat. The low temperature medium is referred to as the source. This is where the energy comes from to heat the building. The "source" can be the outdoor air or water from lakes and ponds, but most commonly, it's from tubing buried in the ground. This is where the "free" heat comes from—the renewable energy source.

The converted "higher temperature" energy is then released into the sink—the place that can absorb this energy. It is much like an air handler unit that is moving cooler return air across a coil (the heat exchanger) and delivering the warmer air into the living space.

Most are familiar with the Air-to-Air heat pumps, which extract heat from outside air; they have become fairly common throughout the US. They deliver the high temperature heat through a forced air network of ductwork throughout a home. This type of heat pump is classified as an Air-Source heat pump.

There are other heat pumps that extract heat by using water that is circulated through tubing (high density polyethylene or HDP pipe) which is buried in the ground. The earth heats the water circulating through a "field" of tubing and this heat is then converted by the heat pump into a higher temperature medium. If that medium is air, as in buildings with ductwork, they are known as Water-to-Air heat pumps and if the high temperature medium is water then they are referred to as Water-to-Water heat pumps.

The newest heat pumps to enter the marketplace are called Air-to-Water. They are a hydronic system that produces heat loop water temperatures of 85°F up to 130°F. They extract heat from a renewable energy source, (the outside air) and transfer it through refrigerant piping to a module. This module contains a refrigerant to water brazed plate heat exchanger that heats water, which is then circulated through floor heating systems, fan coils and low temperature radiators. It can also provide domestic hot water (DHW) through an indirect water heater. Because it is a heat pump, the whole cycle can be reversed to provide chilled water (41°F-70°F) for cooling. They have been in Europe for the last five to ten years and continue to grow in popularity.

## Why A Heat Pump?

Heat pumps are considered the most energy efficient, electrically operated heating and cooling systems on the market. These modern Air-to-Water heat pumps can deliver between 3-5kWh of usable heat for every 1kWh of electricity they use. This equates to a Coefficient of Performance (COP) of 3 to 5, or 300% to 500% more efficient than resistance electric heat. The heat pump uses a renewable energy source (air) and therefore has no localized $CO_2$ emissions. The same system can be used for heating in the winter, cooling in the summer

*Daikin Altherma is the commercial name given to the brand of air source air-to-water heat pump system shown here. At left, the outdoor unit, at right, the indoor system.*


as well as providing DHW.

Another benefit to this new style heat pump is they use an inverter technology to operate the compressor. They can vary the speed of the compressor to match the actual load the system is currently experiencing. This can provide more comfort by matching the output to the load. Cycle losses are reduced which increases the compressor's efficiency and reduces "wear and tear" on the compressor, thus extending its life cycle.

Using air instead of geothermal, you eliminate all of the expenses associated with drilling a well field and installing the HDP tubing (which can cost anywhere from $10,000—$30,000), consuming the necessary footprint to support the well field and the operating costs of pumping the well field all year long.

## Where Does the Heat Come From?

Generally speaking, the heat contained in the soil, ground water and air ALL started as solar energy. So basically we are taking energy from the sun and using it to heat the water for the hydronic systems. During warmer weather, the ground and the air absorb this heat and as the weather gets colder, some of this heat dissipates to the outside air. However the heat absorbed into the soil can take a long time to transfer back to the atmosphere, so even in the middle of dead winter, the soil temperature in the earth is much warmer than the outside air temperature. This condition generally favors water source heat pumps; their efficiency or thermal performance remains high because of the warmer source water temperature, whereas the Air-to-Water heat pumps' efficiency dips as the outside air temperature gets real cold ( -4°F to15°F). However, manufacturers are continuing to improve the efficiency of the refrigerant cycle, enabling them to extract more heat from these very cold temperatures while maintaining their rated efficiencies and capacities.

## How the Heat Pump Does What It Does…

Refrigerant plays a major role in the successful transfer of energy from one place where it is available to another place that needs or wants it. The refrigerant is a chemical that has unique properties that allow it to absorb heat from low temperatures and transfer that energy to a medium operating at higher temperatures. For this to happen, the refrigerant has to change its state from liquid to vapor and then back to liquid and in doing so, undergo some pressure changes. This whole process can be referred to as the "Refrigeration Cycle" and is the starting point for the operation of all vapor-compression heat pumps. There are four components that play a major role in this cycle. Their respective names indicate their function and how they play their part in the process.

- Evaporator
- Compressor
- Condenser
- Thermal expansion valve

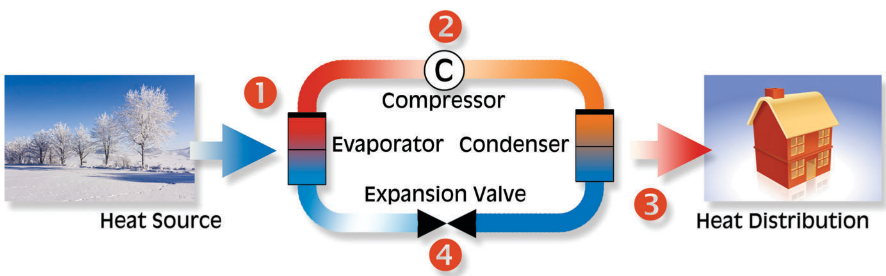
If you reference the figure below and start at position 1—the evaporator—here we have cold liquid refrigerant entering into the evaporator. At this point, the pressure of this cold liquid 410A refrigerant is low… and there is a direct relationship between the pressure of that refrigerant and what its corresponding temperature is, so the lower the pressure, the lower the refrigerant's temperature. And the refrigerant's pressure/temperature will adjust as the "SOURCE" (air) temperature changes. As it gets colder outside, the temperature of the liquid has to become colder so that it can absorb heat from the relatively cold air outside.

The key is, as it absorbs heat from the air outside, the refrigerant evaporates, changing its state into a vapor or gas. Its temperature is still low but warmer than when it was a liquid. This is important because the next component in line is the compressor. Because liquids aren't compressible, if the refrigerant didn't evaporate into a vapor, the liquid entering the compressor would severely damage it.

The compressor's (position 2) job is just as it sounds; it compresses the low temperature vapor. This creates a large increase in both its pressure as well as its corresponding temperature as the refrigerant leaves the compressor. Another factor to consider is the electrical energy used to compress the refrigerant by the compressor; that is added to the refrigerant. Now we have a high temperature vapor that contains a lot of energy ready to be utilized.

This high pressure, high temperature vapor then enters the condenser… (position 3) where a brazed plate refrigerant to water heat exchanger is located) and the cooler return water from the hydronic system is pumped across the exchanger. The refrigerant, being hotter than the water, transfers its energy to the cooler water, elevating the temperature of the water going back out to the heating system. This transfer of energy causes the refrigerant to again change its state and condense back to a high pressure liquid.

The last step in this process is for the high pressure/high temperature liquid refrigerant to flow through an expansion valve (either thermal or electronic) at position 4. The expansion valve controls the flow of the liquid refrigerant through its orifice, drastically reducing its pressure and thus its temperature so that the refrigerant is back to the cold temperature it was at the beginning of this process.




Air-to-Water Heat Pumps are going to play a major role in renewable energy applications in the very near future. For anyone in the business of delivering comfort and energy to their customers, they should become familiar with this new technology.

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