Monday, August 15, 2022

Heat Pump Water Heaters: Refrigerants and Weather (Part 3)

Monday Morning Minutes | by Norm Hall, August 15, 2022

Heat pump water heaters use the heat pulled from the water or air source to heat the domestic water. Most of the time the commercial heat pumps will use air as the heat source. This assumes there is no geothermal water source or central chilled water loop designed into the building. Can heat pump water heaters work reliably in the northern climates such as Michigan and Ohio? Can a refrigerant be safe to use and still play a role in producing hot water in the winter months? These concerns are answered in today's R. L. Deppmann Monday Morning Minutes.

Refrigerants Commonly Used in Commercial Heat Pumps?

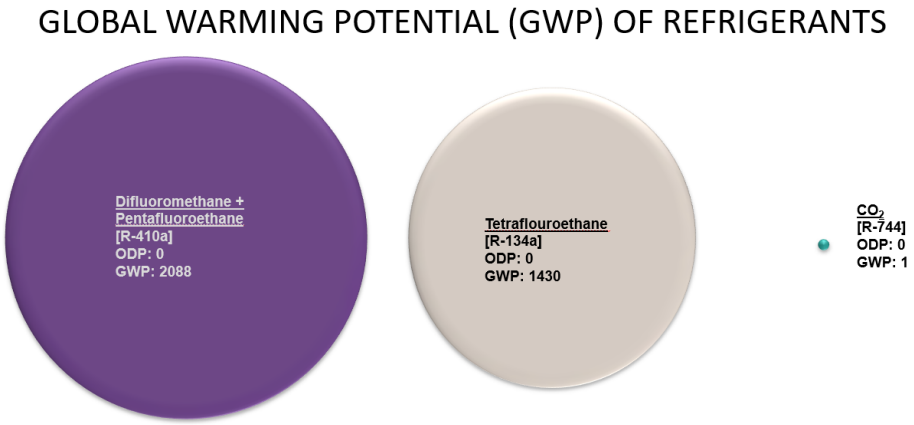
Which refrigerant should be used in a commercial heat pump water heater? This question can be answered by looking at three areas of concern by the engineer.

1. Is the refrigerant safe to use in building applications?
2. The goal of decarbonization is to protect the planet. Does the refrigerant used cause issues in the atmosphere? Will the refrigerant be around and for how long?
3. Does the refrigerant allow the heat pump water heater to produce hot water in the winter months?

Today, most heat pumps use either R-134a or tetrafluoroethene, R-410a or Difluoromethane + Pentafluoroethane, and R-744 or CO2 or common carbon dioxide.

R-134a, R-410a, R-744 and the Environment

CFC and HCFC refrigerants were phased out per the Montreal Protocol due to their ozone depletion potential (ODP). All three of the refrigerants shown above have an Ozone Depletion Potential of zero. Another measurement of environmental concern is Global Warming Potential or GWP. GWP is the relative measurement heat being absorbed by the atmosphere, as referenced to a baseline of CO2 as 1.0. Click the link above for more detail. For the refrigerants mentioned here, there is a stark difference.



The graphic above, provided by Lync, a Watts brand, clearly shows the difference. R-410a and R-134a have a GWP of 2000% and 1400% greater threat than carbon dioxide. If the purpose of reducing the use of gas-fired appliances is to save the planet, carbon dioxide is the answer.

There is always a concern for the safety of our loved ones when designing a building. Refrigerants used inside and outside of buildings have seen a lot of changes in recent years. Two measurements of concern are toxicity and flammability.

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standard 34 addresses these concerns. The standard indicates that all three of these refrigerants are rated A1. The "A" designation denotes lower toxicity. The "1" designation denotes no flame propagation. All three, from a toxicity and flammability standpoint, are safe in buildings.

There are also safety issues with refrigerants in piping systems and some equipment in occupied buildings. *Most notable is the regulation banning the use of hydrofluorocarbons such as R-410A in new chillers (air-cooled, water-cooled, scroll, screw, and centrifugal), rooftop units, and VRF systems beginning in 2024."*

The question of future availability is also a good one. Both R-134a and R-410a are slated for less availability soon due to GWP. Here are a couple of articles for a quick review. R-410A phasedown, are you ready? | US Air Conditioning Distributors (us-ac.com) and Refrigerant Transition & Environmental Impacts | US EPA

Once again, R-744 may be the choice to review for heat pump water heaters.

Heat Pump Water Heaters and Air Temperature

A heat pumps' ability to heat water in the winter is always a key question in northern and Midwest states. At what outdoor temperature does the heat pump fail to provide adequate hot water?

Part 2 of this series mentioned that frigid air contains heat, it is just a matter of using the equipment to capture that heat. The refrigerant has a lot to do with the equipment's ability to heat in winter weather.

First, I offer a statement. To get the full BTUH capacity of the heat pump water heater and provide 140°F without supplemental means, the ambient air temperature must be at or above: 35°F for R-134a and R-410a and -4°F for R-744.

Professionally designed and manufactured commercial heat pump water heaters can indeed provide the required hot water in cold climates. When it gets cold outside, the COP drops. See part 2 of this series for more on COP. Meanwhile, let's look at some typical weather data and the effects on a heat pump water heater.

Example System: Ann Arbor, Michigan

We recently engaged in a Lync by Watts heat pump water heater request in Ann Arbor, Michigan. The engineer wanted a realistic budget including an operating cost analysis, as well as a comparison to an R-410a system. This gave us an opportunity to look at the effect of outdoor temperature on the COP. When the outdoor temperature was between -15°F and -4°F, the COP was 1.0, assuming that during these times the system is relying on a resistance electric coil in the tank. This temperature range was predicted to be only 8 hours per year (About 0.1%). The engineer would discuss this with the owner and determine if storage capacity could suffice with a small coil.

Annual seasonal coefficient of performance (SCOP) can be calculated using ASHRAE bin values and a performance chart of the specified equipment. An example chart can be seen below. Using this data, the SCOP for an R-744 system in Ann Arbor can be expected to be approximately 3.5, whereas the R-410a system would be approximately 2.7. This means the R-744 system will use significantly less energy.

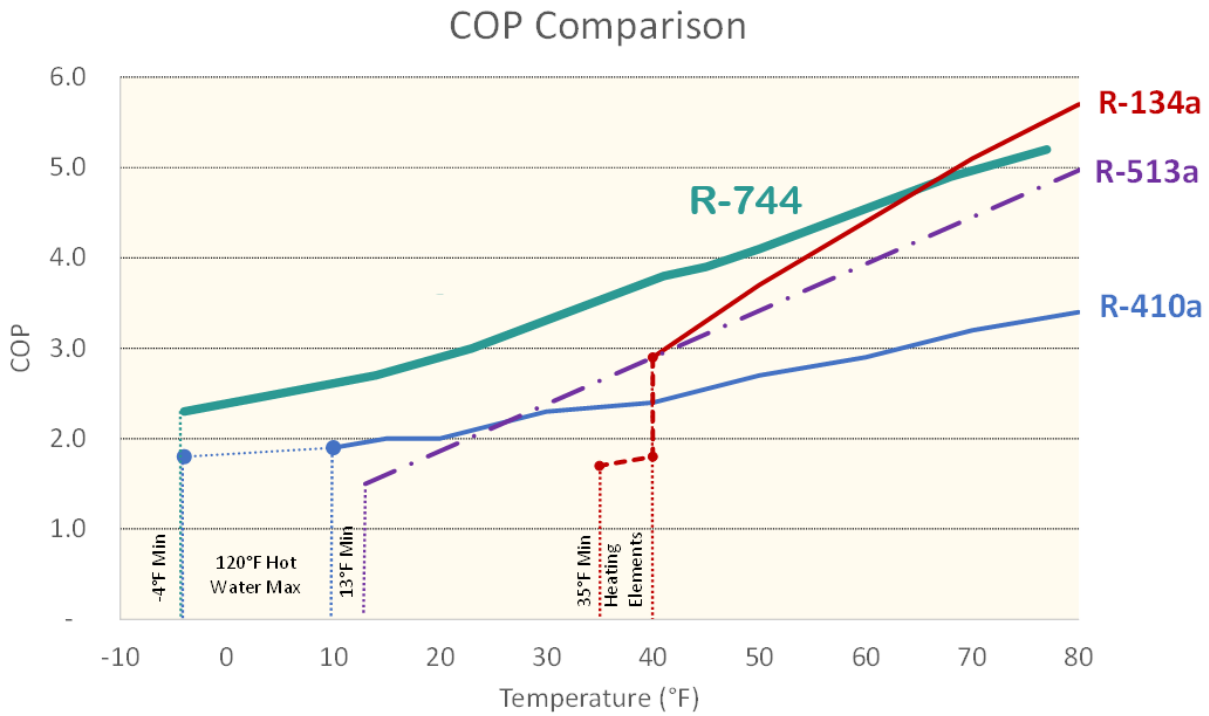


Chart provided by Lync, a Watts Inc. brand

It was interesting to learn that the heat pump water heater's annual utility charges would be the same as a gas-fired water heater AND ¼ of the electric water heater's yearly utility cost. That was before any increases caused by electric utility production limitations.

It is also important to note here that while some R-410a systems will operate near 0°F, the outlet temperature may be limited to a temperature below what is considered a safe storage temperature. This opens a system to potential waterborne pathogen proliferation, and as such is not a recommended application for R-410a systems.

The refrigerant of choice is clearly the CO2 (R-744) for heat pump water heater applications. Next week we will look at some of the parts and pieces of an air source water heater including storage.

Part 1: Heat Pump Water Heaters: The Road to Decarbonization

Part 2: Heat Pump Water Heaters: How They Work