**ENGINEERING WHITE PAPER**

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**November 11, 2021**

# Air to Water Heat Pumps

**Air to Water Heat Pumps have become a dominant technology used to provide building heating and cooling. Since AWHP's utilize the refrigerant cycle, they can provide building heating with a COP between 2.0 - 4.0. For comparison, Electric heat has a COP of 1 and gas heat has a COP of 0.8 – 1.1 (standard vs. condensing furnace).**

**AWHP's move heat from the outdoor air to the system water loop and vice versa. They do not create heat.**

**Boilers burn fuel to generate heat. AWHP's and Boilers are fundamentally different and require different design considerations.**

**To understand how AWHP's work, it is important to understand the following definitions:**

## Definitions

***Refrigerant reversible heat pump*** has a reversing valve and the evaporator and condenser switch duties during heating and cooling modes.

***System*** is the building side CW and/or HW distribution

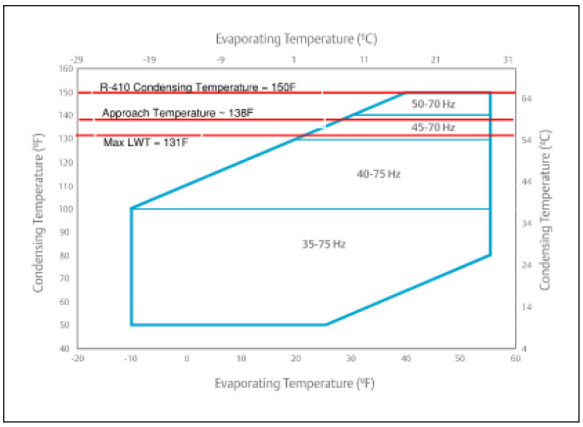
***Source*** is the air or water that the machine pulls energy from.

***Sink*** is the air or water that can accept energy.

***Effective System Volume*** is the water volume in the piping, storage tanks and coils that will always be available to the AWHP. Zones with control valves should not be counted in the effective system volume if they are expected to close at any time while the AWHP is operating.

***Lift*** is the compressor work required to achieve the desired LWT at the design ambient air conditions. For AWHP's, heating lift = (LWT – ambient air temperature). Typical AWHP's are capable of approximately 100F lift without vapor injection. Example: 130F LWT at 30F ambient = 100F Lift

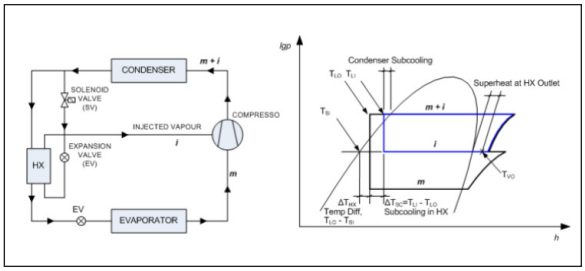
***Approach*** is the difference between the refrigerant temperature and water temperature. R-410a condenses at 150F.




The ***approach*** is determined by the plate heat exchanger sizing, which must maximize heat transfer and ensure oil return to the compressors. For R-410a machines, the ***approach*** is typically 10.8F - 12.6F degrees.

Aermec adds 5F - 6F degrees for reliability. Approach is why the max LWT = 131F for machines without **vapor injection.**

***Vapor Injection*** is a method utilized to expand the compression operating envelope & increase lift. An additional expansion device and HX (economizer) loop bypasses the evaporator and sends hot gas directly to compressors vapor injection port. This technology is used to deliver higher LWT's, up to 149F for AWHP (Aermec NRK).




***Heat Recovery*** is a separate refrigerant to water HX used to provide heating when there is a cooling load.

***Partial Heat Recovery*** is a separate HX in series with the condenser. The HX is located after the compressor, prior to the condenser. Whenever the machine is on, you will get heat recovery. The available heat recovery is dependent on cooling load and is limited to about 1/3 of total cooling load, depending on conditions.



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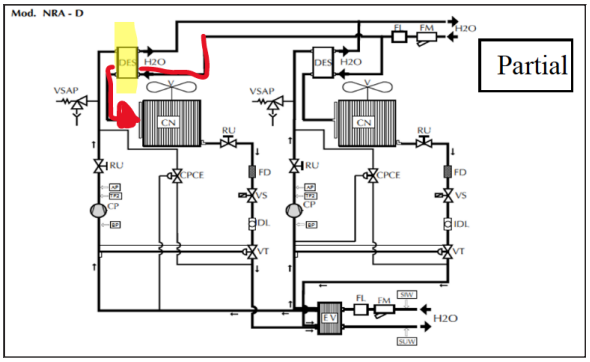
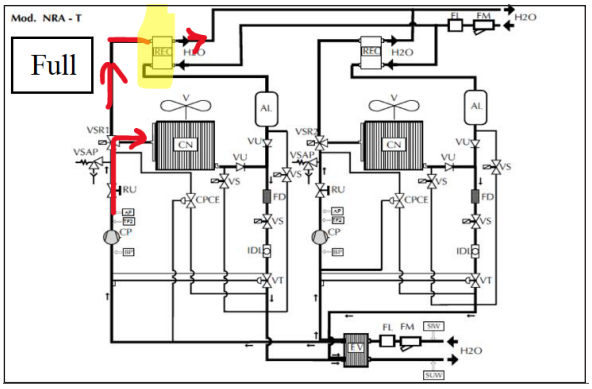
***Full Heat Recovery*** is a separate HX in parallel with the condenser. A 3-way valve controls the refrigerant path based on HR LWT setpoint. Heat recovery is only available when there is a cooling load, and the minimum run time is 10 minutes.




## AWHP Configurations:

***2 Pipe AWHP's*** have one Supply and one Return connection. They utilize a reversing valve to switch from cooling to heating mode based on a mode enable signal and HW or CW setpoint.

Aermec Models ANK, ANL, NLC, NRK, NRB, NRL

***4 Pipe AWHP's*** have two supply and two return connections (CW & HW). These units are referred to as simultaneous units and can produce cooling only, heating only, or both heating and cooling simultaneously. They include a refrigerant reversing valve and can control to HW & CW setpoints simultaneously.

Aermec Model NRP
Aermec Model CPS – 4 pipe + Domestic HW Booster for up to 164F LWT

## AWHP Design Considerations

### Defrost

- Defrost occurs most frequently between 25F – 40F OA temperature.
- Above 40F, the surface of the coil is at or above 32F so frost will not form.
  - Below 25F, the air does not have enough grains of moisture for frost to occur.
  - Defrost derate is significant for both efficiency and capacity. Therefore, defrost derate must be considered when designing a system.
- Aermec, like all certified European manufactures, includes defrost derate in their selections as required by Eurovent standards.
- **Intelligent Defrost Sequence:**
  Defrost Initiation: the refrigerant pressure sensor in the outdoor coil must read 61 PSI or less for 10 minutes to initiate defrost.
  - Once initiated, defrost runs for 5 minutes and records the refrigerant pressure at the end of the 5 minute cycle, recorded as reference pressure A.
  - The unit controller monitors the refrigerant pressure. If the pressure drops 8.7 PSI below the reference pressure A, **AND** it has been a minimum of 30 minutes since the last defrost cycle, then defrost is initiated.
  - In all cases, defrost cannot occur more frequently than once every thirty minutes.
  - In all cases, defrost cannot be shorter than 1.5 minutes or longer then 6 minutes.
  - The defrost sequence is terminated if the refrigerant temp sensor on the liquid line, prior to the expansion device reaches 68F or higher.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## System Volume

Designing with adequate system volume is critical for AWHP success. ***Effective System Volume*** must be used to ensure that the AWHP will always have the required volume available.

Minimum System volume is required for these reasons:

- Compressor run time & max allowed compressor starts/hour
- Defrost
- Minimum run times (simultaneous units)

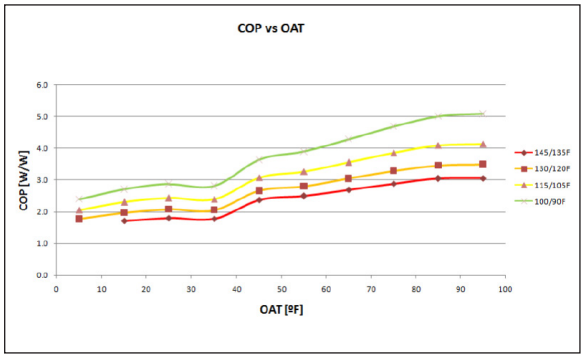
Aermec provides two minimum gallons/ton options, depending on application. The following situations require higher gallons/ton requirements.

- Low ambient temperatures
- Low load
- Process cooling applications
- Requirement to maintain LWT
- AWHP is serving as a source for another heat pump (booster for example)

For designs in Washington and Oregon with 0F-23F ambient conditions, the higher volume requirement should be seriously considered.

Aermec water volume calculator

## Temperature & Delta T limitations




Max/Min LWT and lift are a function of the compressor operating map and ambient conditions.

Higher LWT in heating = Lower Efficiency
Lower OAT = Lower Efficiency

Aermec's deltaT range during certain conditions can be 6F to 18F. Avoid designing at the limits. The recommended delta T is 8F to 14F.

Constant flow through the AWHP is required to ensure stable operation. Primary/secondary is allowed, so long as the AWHP has constant flow and the effective system volume complies with Aermec's requirements. Code requires variable flow through distribution piping in many cases.

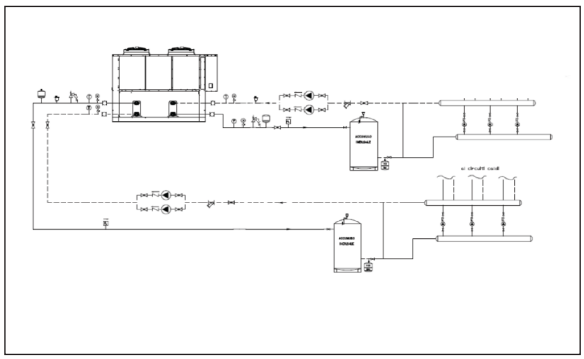
## 2-pipe mode changeover

Caution must be taken when switching between heating and cooling modes in a 2-pipe system.

- Standard water temp ranges that the AWHP can accept is 39F-64F in cooling, 68F-131F in heating.
  - If heating EWT below 68F is required, the DCPX kit must be installed.
- If the system volume is large or if rapid mode change is required, a bypass is recommended.

## Closing Thoughts

Designing AWHP systems requires many thoughtful considerations. The systems can be applied successfully if the best practices are followed. If you have further questions regarding operation or unit specifics, please contact the Engineering Dept.

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