One-pipe: 1x4-Pipe Water Source Heat Pump Systems

Throughout the development of Hydronic HVAC Systems major advancements come in two primary forms:

Component improvements: Efficiency or function of everything from pumps to boilers and cooling towers to Water Source Heat Pumps and even GeoExchange.

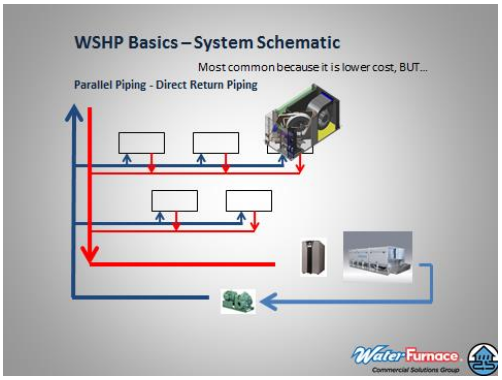
Reduction in pipe installed cost: The WSHP package being able to heat and cool on demand when served by a 2-pipe system and the use of alternate piping materials with the reduction in required insulation is a major reason for the growth of the WSHP system. Prior to WSHP's 2-pipe hydronic systems could only heat or cool, 4-pipe systems heat and cool but can be expensive to install, 2-pipe with auxiliary electric heat offered savings, but it was the simultaneous heating and cooling capability combined with the ability to "NET" heating and cooling loads either simultaneously or cyclically with a 2-pipe system to WSHP's that delivers at the energy bill affordably.

It is well established that water-cooled equipment is more efficient than air-cooled equipment because with a water-cooled system the compressor operates against a controlled moderate temperature range dampening the effect of utility rate structures that follow outdoor ambient temperatures. As a result, while designers work to reduce internal loads the other half of the battle against peak energy use suggests a water-cooled system approach. Additionally, hydronic systems use approximately 10% of the horsepower to move BTU's in the building versus ducted systems.

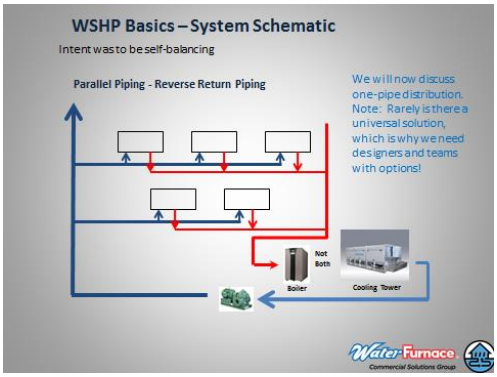
A major advantage with WSHP Systems is that when modeling the building and selecting WSHP equipment the individual units are evaluated at the limits of their operational performance, BUT spend the majority of their operation inside the limits even at peak conditions. Whereas, air-cooled equipment is rated at SEER and IEER at conditions that are inside the extremes of any given outdoor conditions and applied with factors that avoid reduced efficiency and capacity losses at Peak.

Cost is an issue, and based on the building and function the 1x4-pipe WSHP will reduce the cost of installing pipe. This is not a "silver bullet" but when applicable the savings in coordination, insulation, hangers, fittings, and labor, even core drilling while being self-balancing and continuously commissioning are substantial.

Parallel Piping Direct Return:



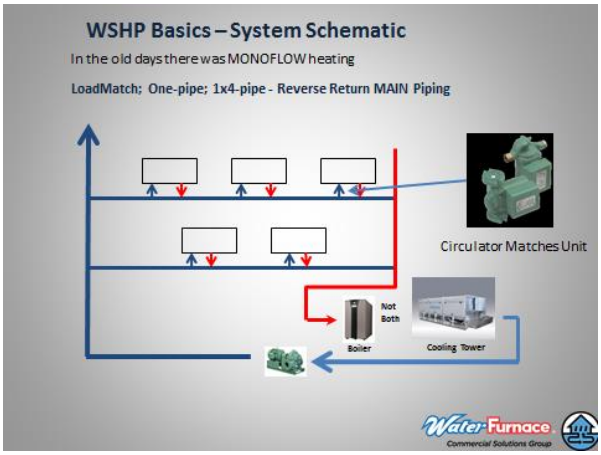
Parallel Piping Reverse Return:



Direct-return piping has its popularity in cost savings and it's penalties in forcing water to go where it does not want go. Aggravated by the use of VFD's on pumps to save operating cost the equipment applied to this system require balancing fittings, pressure capable control valves, and strainers to protect the flow control valve. Referred to as the valve package or hose kit the required hydronic specialties actually add pressure drop and maintenance points to the system in the name of energy efficiency.

Reverse-return piping has the advantage of being more self-balancing but the cost and the building shape have to be such that it is a solution. The advantage both have is that every unit on the supply gets exactly the same temperature of water. Critical when applied to hydronic coils selected at an exact EWT (Entering Water Temperature). WSHP's operate over a range of EWT's.

Reverse return mains to One-Pipe distribution, or a 1x4-pipe WSHP design:



Note the difference above. The mains remained the same as reverse-return and can be horizontal or vertical mains. The One-Pipe distribution pipe (LOOP) is sized like a coil for the load served. The pipe is sized at a design Delta-T. The result is that the units will all heat or cool on demand, and at relatively the same efficiency for multiple reasons when applied with Water Source Heat Pumps:

Typically the water temperature in the loop will be increasing if all units are in the cooling mode for example, but what if units are OFF, what if units are not at full load, what if units are HEATING?

Instead of each unit having a valve package each unit has a factional HP circulator that is activated by the same control signal that would open a control valve. By being sized to match the unit the flow to the unit is always as designed and typically at a lower Delta-T than a building system would be designed.

In fact, an advantage of WSHP systems in 1x4-pipe is that they do not have low Delta-T syndrome, 0^{o}F Delta-T is perfect.

How many units can be applied to a LOOP?

The number of units applied is actually based on connected tons. The pipe is sized for the load and a Delta-T. Load Btuh/500/ΔT = GPM

The pipe size is now selected based on allowable velocity of FPS. At 2 gpm per ton (12ΔT) the pipe is now equated to a total tonnage.

Pipe size	Flow - GPM	Rated tons
1"	12.5	6+
1 ¼"	22.5	11+
1 ½"	33	16+
2"	60	30
2 ½"	90	45
3"	130	65 maybe +

The choice is a financial one as to loop size. If 2½" pipe is the most economical then the

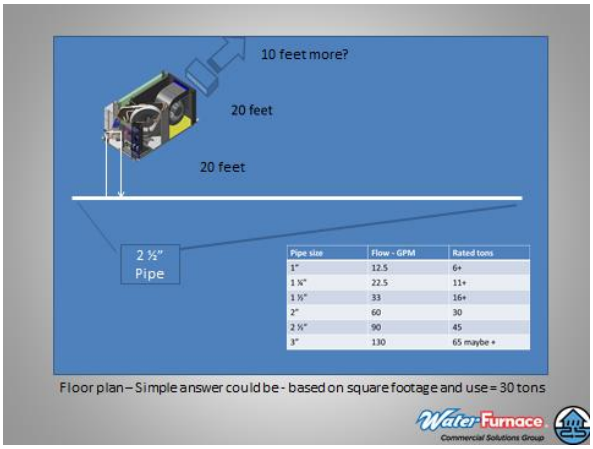
maximum connected tonnage per LOOP is 45 tons per the above chart. Each designer will create their own rules and preferences, but the basics do not change. The building is divided into 45 ton or less "LOOPS", multiple units is best.

Layout in the Building

The examples shown are vertical mains to horizontal distribution, but they can be horizontal at the top or bottom of the building to vertical riser LOOPS to the opposite top or bottom main. Creativity will be dictated by the designer and the shape of the building. A plan view of a rectangle could have supply and return vertical in each corner opposite of each other with LOOPS on the perimeter or middle of the floors. A vertical building could have a vertical riser LOOP and units in varying radius distances around the main feeding each unit.

How far from the main can units be located?

Typically the units are from 5-20 feet from the LOOP. Combining that distance with 20 feet of ductwork and 10 feet of throw a single LOOP can serve 100 feet of building or more.

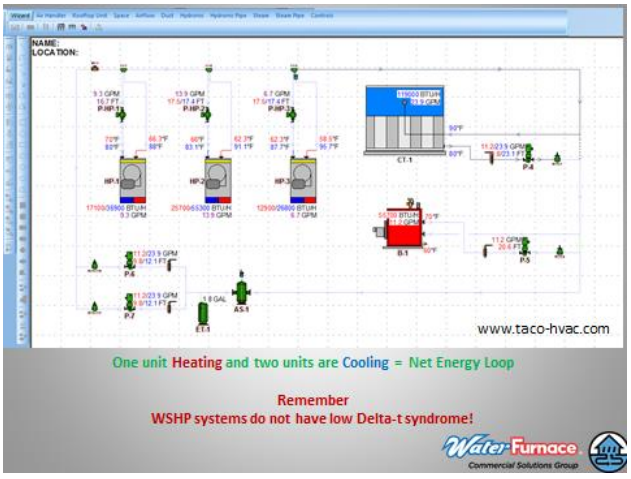


The limitation is the size of pipe selected and the equated tonnage as sized to the load served; not the equipment. This points to a very important advantage of 1x4-pipe WSHP's in that if the use of the space is not defined or even changed in the future; as long as the main was sized for the worst case tonnage the design is substantially unchanged, a flexible solution.

The Net Energy Loop

WSHP loops have been referred to as "condenser loops", but in actuality it is much more because both cooling and heating result in substantial energy transfer not only in the HVAC system but now to service hot water as well with the application of "water-to-water or reversible chiller" units.

In traditional parallel piping systems this "Net Effect" occurs as the returns blend together. With the 1x4-pipe WSHP design the Net Effect is both immediate and in the return mains. Boilers, cooling towers, or GeoExchange can be added to the loop with the same logic of primary-secondary series flow piping.



The One-pipe GeoExchange System has been applied repeatedly in Schools where the ground loop is parallel piped to 1x4-pipe WSHP's.

The concept means that much of the Compressor, Blower, and pump horsepower are Demand Controlled to the Net Energy Loop.