Pressure-Temperature (P/T) Ports – Correct Placement and Use

Most commercial WSHP systems utilize pressure-temperature ports on circuit-setter hose kits to verify water flow, usually determined from the pressure differential measurements (ΔP). However, this only validates flow at one point in the system – the circuit-setter or other in-line flex hose components. This does not necessarily confirm what the coaxial water-to-refrigerant heat exchanger is seeing with regards to actual flow performance within the heat pump, as the hose kit in-line components may show a different pressure reading that differs from that actually going through the heat pump. Further, many of these components only measure pressure through one leg of the hose kit.

P/T diagnostic ports must be installed as close to the water ports on the heat pump cabinet as possible, typically on the threaded fittings where the hose kit is connected to the heat pump.

Until the actual ΔP within the heat pump is known, a true functional performance test (FPT) validation cannot be achieved. This is necessary to compare to the manufacturer’s submittal data to confirm actual flow rate through the equipment.

The other key part of a FPT test is to accurately measure the temperature differential (ΔT) of the coaxial heat pump to verify correct heat of absorption/rejection. This data is necessary to complete the performance calculations. Measuring temperature differential at a point not directly reflecting entering and return water flow through the heat pump unit is rarely accurate.

The measured data is used to prove actual performance using the following calculation:

\[ \text{Btuh capacity} = \Delta T \times FR \times FC \]

Where:

\[ \Delta T = \text{temperature differential, °F} \]
\[ FR = \text{flow rate, determined from } \Delta P, \text{ using the manufacturer’s performance tables to interpolate actual flow, usually in gallons per minute (gpm)} \]
\[ FC = \text{flow constant, which is usually 500 for pure water, or adjusted to inhibitor and/or antifreeze type, typically ranging from 490 to 499} \]

In addition to confirming fluid temperature and pressure values, functional performance testing requires the concurrent measurement of voltage and amperage to calculate actual wattage. Electrical power values are utilized to determine full heating capacity (electrical contribution from the compressor) as expressed by Coefficient Of Performance (COP) and net cooling capacity, by subtracting compressor energy to determine actual load cooling performance and
Energy Efficient Ratio (EER). These values are critical to confirm the heat pump manufacturer’s performance requirements for the conditions tested.

COP and EER calculations are expressed as follows:

\[
\text{COP} = \frac{\text{HA} + \text{EH}}{\text{EH}}
\]

Where:

\[
\text{HA} = \text{Heat absorbed from fluid through the coaxial heat exchanger of the heat pump, determined from } \Delta T \times FR \times FC
\]

\[
\text{EH} = \text{Electrical energy converted to heat, watts } \times 3.412 \text{ to convert to btuh, direct measurement from heat pump electrical contactor on control board}
\]

\[
\text{EER} = \frac{\text{HR}}{\text{watts}}
\]

Where:

\[
\text{HR} = \text{Heat rejected to fluid through the coaxial heat exchanger of the heat pump, determined from } \Delta T \times FR \times FC
\]

watts = Electrical energy, direct measurement from heat pump electrical contactor on control board

In addition to validating the equipment performance for as-built documentation, validation of any applicable manufacturer’s warranty requirements, LEED commissioning, etc., functional performance testing adds further value to the advantage of the end-user client, design team and contractor:

1. Validates expected performance as required to meet building needs and confirm design criteria or specifications
2. Identifies any potential problems before they become a situation with the end-user, allowing the contractor to isolate and resolve potential problems before they occur
3. Confirms controls and peripheral component integrity with heat pump operation
4. Establishes a performance benchmark for any potential future service issues, providing a technician with valuable baseline data to more quickly trouble-shoot operational problems
5. Provides a baseline for simple, more streamlined preventive maintenance (PM) programs

In addition to heat pump testing, the ability to measure true \( \Delta T \) and \( \Delta P \) can provide similar validation tests for the following:

1. Hydronic fan coils
2. Thermal energy storage tanks (i.e., ice brine, etc.)
3. Plate and Frame heat exchangers
4. Any mechanical device that relies on water, water-brine solutions, or other fluid to transfer energy
General configuration for installing pressure/temperature (P/T) plugs for source or loadside water-to-refrigerant coils to obtain the most accurate $\Delta T$ and $\Delta P$ data possible.

The correct installation of P/T ports is critical for commissioning, tuning or servicing a GSHP system. P/T ports allow for direct measurement of fluid temperature and pressure data without loss of loop pressure or admission of air when a temperature or pressure probe is inserted through a synthetic rubber membrane. They are similar to the membranes used on inflatable sports equipment where a hollow needle is used to penetrate the device and allow compressed air to be injected into the ball, mattress or other equipment. In the same manner, P/T ports also allow access for injecting water to a loop system to achieve the required static pressure, minimizing the potential for pump cavitation and poor heat transfer in the water-to-refrigerant coil. Without reasonably precise temperature and pressure differential data, the system cannot be properly commissioned for the correct COP or EER performance, and will be more difficult to diagnose if service is ever required. The correct suction and discharge parameters on the refrigeration circuit may not be properly evaluated without knowing the source and load fluid flow activity. The sketch below is conceptual only. The use of the term water-to-refrigerant coil is generic in this context. Water-to-refrigerant coils may take the form of coaxial coil-in-coil designs, tube-in-shell heat exchangers, plate heat exchangers, etc.

Correct placement of pressure-temperature (P/T or “Pete’s plugs”) ports. P/T ports must be installed as close as possible to the entering and return water ports on the GSHP cabinet to obtain the most accurate temperature and pressure data across the water-to-refrigerant heat exchanger coil. The common industry standard is to use brass or copper couplings or elbows that are tapped for mpt P/T ports, and do not allow for air entrapment. The P/T ports must also be installed in the correct manner to allow either a pressure or temperature probe to sample data from direct fluid flow.
General configuration for installing P/T plugs for source or loadside water-to-refrigerant coils to obtain the most accurate $\Delta T$ and $\Delta P$ data possible.

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This configuration illustrates the **incorrect** placement of P/T ports. The ports are installed in a nipple that prohibits direct measurement of pressure and temperature parameters when the unit is operating with active fluid flow. This type of installation also encourages air entrapment during the purging procedure and may continually be responsible for service calls to refill the system. If not properly flushed, poor thermal transfer performance may result, the system operating cost will be higher and damage to circulation pump(s) may occur.

The use of brass or copper elbows or straight couplings designed for this purpose that are pre-tapped for $\frac{1}{4}''$ or $\frac{1}{2}''$ mpt P/T ports is recommended. Use thread **sealant** compounds, such as Loc-Tite products designed for severe piping applications to contain high pressure and/or aggressive fluid constituents, not Teflon based tapes or dressings which are thread lubricants, on all mechanically threaded joints to avoid seepage or more intense leaks.

T. R. Proffer, 4/23/01
FYI – make certain P/T ports are installed to allow access for instrumentation to determine pressure and temperature. The lower diagnostic port in this photograph is pointing straight up where a probe instrument cannot be used as the upper water line will block access to hand-held instruments. Install like you are going to use it – because you will!

Test instrument penetration cannot be achieved without P/T port access:

In this photo, either the probe is going to be damaged trying to force the probe into a P/T port at an angle it was not designed for, and/or fluid values cannot be acquired.
Correct installation for access:

Lower P/T port is correctly angled to allow full instrumentation access.
Below is a photo describing how **NOT** to install a P/T port:
P/T ports on ground loop header pairs below – incorrectly installed, will not permit instrument access, and ports are installed on an excessively long neck.

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