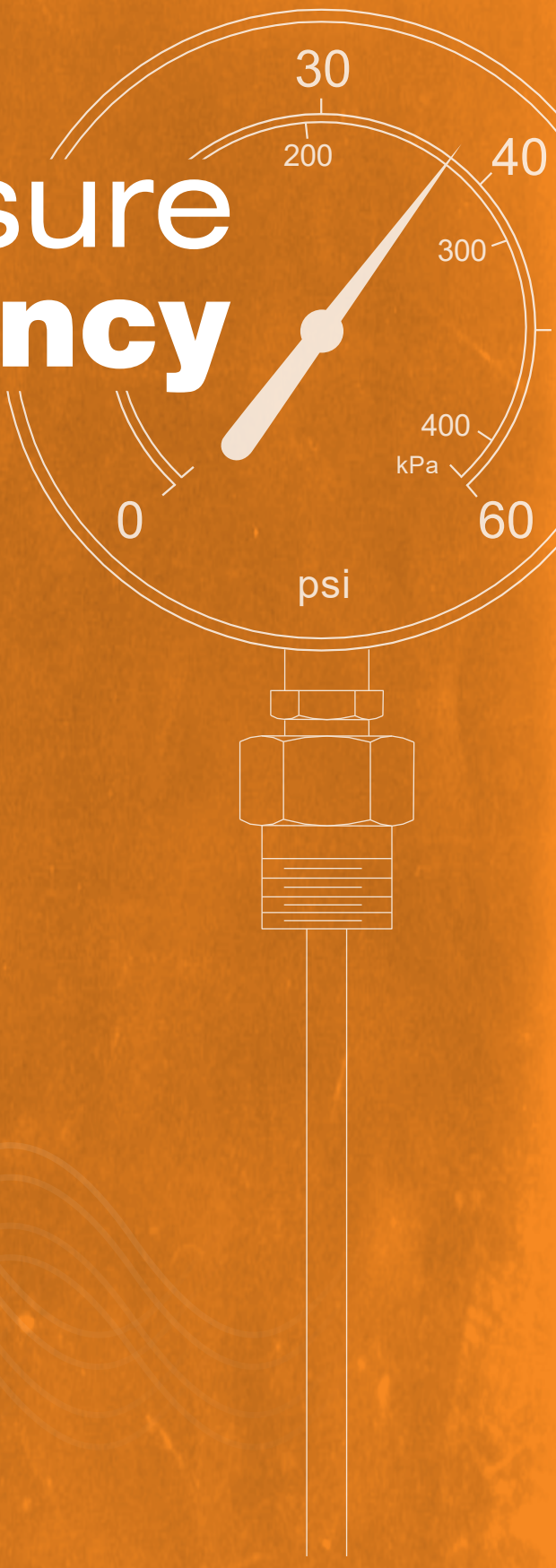
How to Measure **GSHP Efficiency**

For Forced Air Units



GEO CONNECTIONS
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GSHP Heating Efficiency

Measuring COP

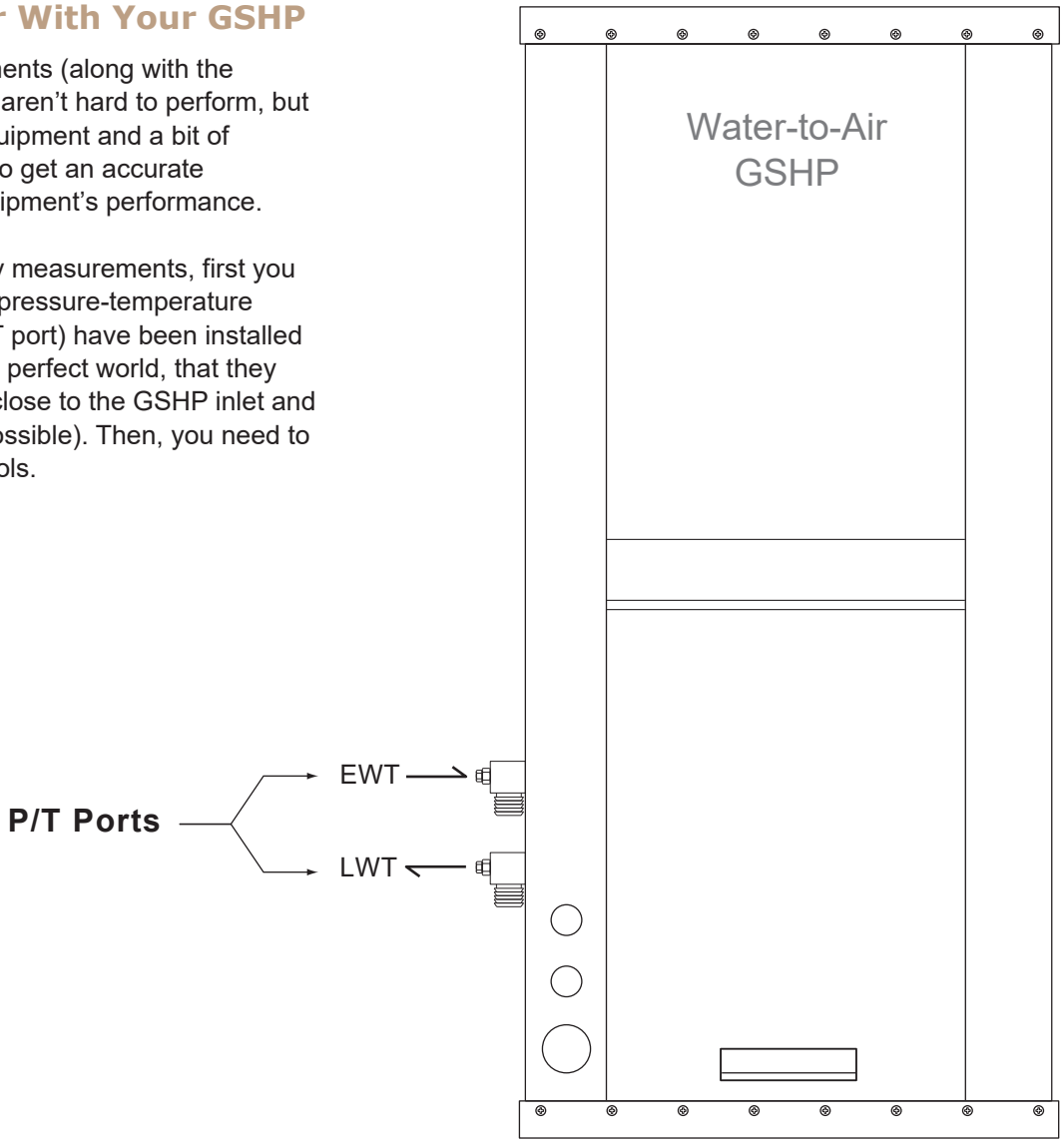
Ground source heat pump (GSHP) systems are one of the best ways a homeowner can reduce their heating and cooling bills while also reducing environmental pollution and overall energy consumption in the home. But in order to deliver on those savings, the GSHP itself must deliver and perform as advertised.

Have you ever gone into your mechanical room while your geothermal heat pump is running and asked yourself, “I wonder how this thing is actually performing right now”? Without taking a few measurements, it’s pretty hard to tell. Most heat pumps don‘t have a “How I’m Performing Today” gauge mounted on the side of the cabinet, at least not yet.

Getting Familiar With Your GSHP

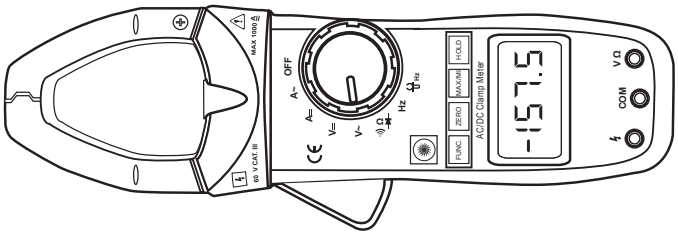
Performance measurements (along with the necessary calculations) aren’t hard to perform, but they do take specific equipment and a bit of understanding in order to get an accurate assessment of your equipment’s performance.

Before you can take any measurements, first you need to make sure that pressure-temperature measurement ports (P/T port) have been installed in your system (and in a perfect world, that they have been installed as close to the GSHP inlet and outlet connections as possible). Then, you need to gather the necessary tools.



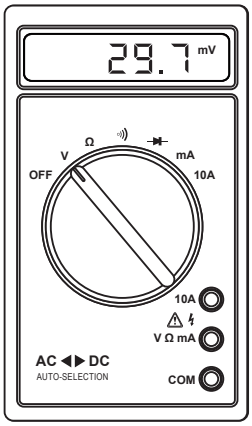
Preparing To Measure

What You Need



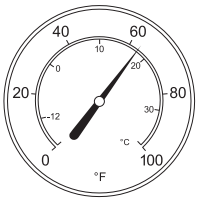
▲ Clamp Meter

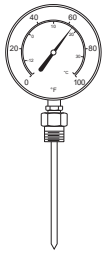
Used to measure amp draw through the system by clamping tongs around each of the wires connected to the hot leads.



Multimeter ▶

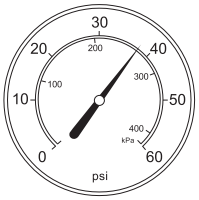
Used to measure voltage through the system by holding the two hot leads on the power input terminal of the GSHP.

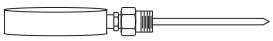




Thermometer ▲

Temperature gauge with 1/8” probe to measure temperature drop through water-refrigerant Heat Exchanger.





Pressure Gauge ▲

Pressure gauge with 1/8” probe to measure system flow.

Preparing To Take Measurements

Now that you have everything you need, it’s time to prepare the system for measurement. At this point, you need to completely disable the backup resistance heat (if used) by turning it off at the circuit breaker.

Note: The GSHP unit and the electric resistance backup heat should always be wired on separate circuits.

With the backup resistance heat disabled, set the thermostat well above the room temperature. This will ensure that your GSHP runs in heating mode and immediately into full-load operation (for dual capacity equipment). Since the backup heat is disabled, the GSHP will operate all by itself.

THINGS TO REMEMBER

- The pressure gauge should be capable of reading up to 60 psi.
- The temperature gauge should be capable of reading to the nearest 0.1°F.
- The multi-meter should be capable of reading voltages up to 480 volts.
- The clamp meter should be capable of reading amperages up to 50 amps.

Measure The Temp Drop

The system needs to reach “steady-state” operation before you can take any measurements. Otherwise, it will be hard to get a good, accurate reading. Because of this, you need to allow the system to operate non-stop for about 10 minutes before using any of your gauges.

Once “steady-state” has been reached (after 10 minutes or so), you will need to measure these things:

- Temperature drop (ΔT) through the GSHP unit.
- Pressure drop (ΔP) through the GSHP unit.
- Electricity consumption by measuring voltage and current.

The first measurement you’ll take is the temperature drop through the GSHP. When you’re ready to measure the temperature drop, remove the service cap and insert the probe into the P/T port for the water entering the unit (EWT=Entering Water Temperature). The temperature will take some time to stabilize. Wait for the dial to stop moving or for the digital thermometer to give a constant reading. Record temps, remove probe and repeat in other port (LWT=Leaving Water Temperature).

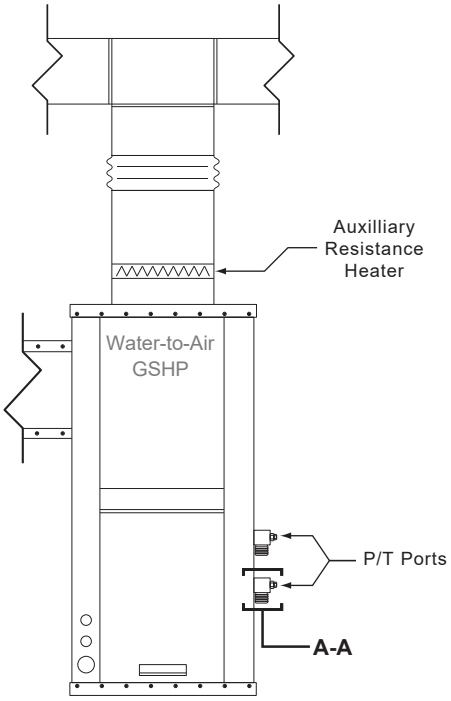
EWT should be the greater of the two when in heating mode. Temperature drop (ΔT) is simply the difference between the entering and the leaving water temperature:

ΔT=EWT-LWT (°F)

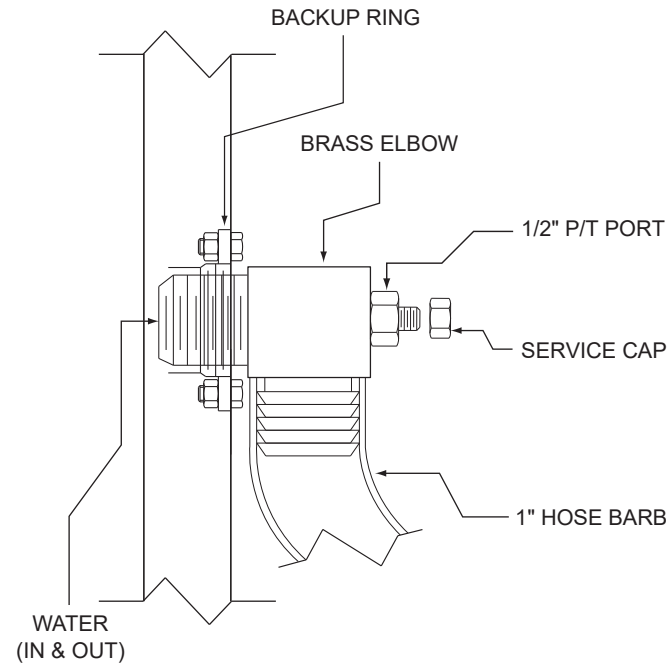
Note: Use the same thermometer for both readings to eliminate error due to instrument calibration.

Refer to the illustration to view where EWT/LWT measurements should be taken:

Pressure and Temperature Sensing Adapter & Components



Water -To-Air GSHP



Section A-A

Measure The Flow Rate

The next thing you'll need to know is how much flow (gpm, gallons per minute) you're getting through your system. You can measure flow directly with a flowmeter, but they typically have to be installed or inserted in the circulation path of the water in the system.

Because direct flow measurement with a flowmeter isn't usually an option, the next best thing is to estimate flow through pressure drop readings. If you know the pressure drop due to fluid flow, you can estimate how much flow you're actually getting through your heat pump.

To take pressure drop readings, insert your pressure gauge into the same P/T ports where the temperature drop readings were taken. Pressure readings will not stabilize in operation. it is normal for the indicator needle to jump during measurement. Use the average pressure reading that you observe.

First, measure the pressure of the water as it enters the unit (P_{in}) and then measure the pressure of the water as it leaves the unit (P_{out}). The inlet pressure (P_{in}) will always be greater than the outlet pressure (P_{out}).

Pressure drop (ΔP) is simply the difference between the two:

$$\Delta P = P_{in} - P_{out} \quad \text{(psi)}$$

Note: Use the same pressure gauge for both readings to eliminate error due to instrument calibration.

EWT °F	GPM	WPD	
		PSI	FT
20	8.0	5.6	12.9
	8.0	5.6	12.9
30	4.0	1.5	3.5
	4.0	1.5	3.5
	6.0	3.1	7.2
	6.0	3.1	7.2
	8.0	5.1	11.8
	8.0	5.1	11.8
40	4.0	1.3	3.0
	4.0	1.3	3.0
	6.0	2.8	6.5
	6.0	2.8	6.5
	8.0	4.5	10.4
	8.0	4.5	10.4

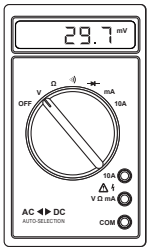
Source: ClimateMaster Tranquility TS024 Performance Data Catalog

Once you know the pressure drop through your unit, refer to the manufacturer's performance data tables to determine the flow:

For example, if the water is entering your heat pump at around 40°F (and it happens to be the TS024 shown on the left) and the pressure drop (ΔP) that you measured is around 4.5 psi, you can estimate the system flow to be around 8 gpm (gallons per minute).

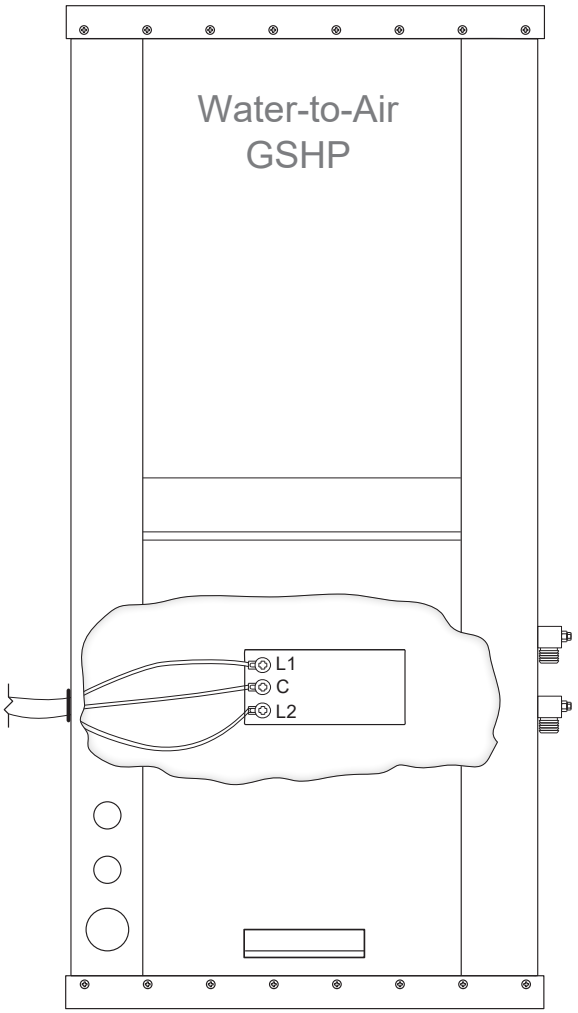
Measure The Electrical Demand

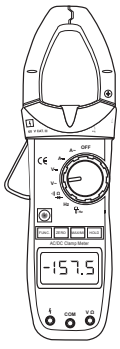
The last measurement to take to determine how well your equipment is performing is electrical demand (i.e. – how much electricity your heat pump is consuming during operation). Measure the electrical demand (DMD) of your GSHP by measuring the amperage through the unit and the total voltage supplied.



Voltage measurement (for single-phase power): Before attempting to take any voltage measurements, set the multimeter to take A/C voltage readings and ensure that the leads are plugged into the COM and Voltage inputs. Hold the leads of the multimeter tool across the two hot leads on the power input terminal of the GSHP (across L1 and L2 in the figure on the right) and record the measurement.

Voltage measurement (for three-phase power): Before attempting to take any voltage measurements, set the multimeter to take A/C voltage readings and ensure that the leads are plugged into the COM and Voltage inputs. Hold the leads across all three possible electrical lead combinations (across L1 and L2, across L1 and C, and across L2 and C in Figure 11.3). Two of the three possible combinations will yield the same measurement, and that reading will be the phase voltage that will need to be recorded.





Current measurement: Ensure that the clamp meter is set to take A/C current readings before attempting any measurements. The method of measuring amp draw is the same regardless of whether single-phase or three-phase electrical power is supplied to the equipment, but the calculation of electrical power consumption will differ as will be discussed later. To properly measure GSHP unit amperage, two individual readings will be made by placing the tongs of the clamp meter around each of the wires connected to the hot leads (around the wire connected to L1 to measure the current through L1 and around the wire connected to L2 to measure the current through L2. Record the higher of the two amperage measurements for use in electrical power calculations.

Performing The Calculations

After all of the proper measurements have been taken and recorded (EWT, LWT, GPM, Voltage & Amperage), the equations to calculate heat of extraction (HE), heating capacity (HC), and system efficiency (COP) are as follows:

Please keep in mind that differences between the measured and calculated values for HE, HC, and COP and the manufacturer's published values don't necessarily indicate that a problem exists. Contact a professional if you suspect that a system evaluation is necessary.

HEAT OF EXTRACTION (BTU/HR)

The portion of a GSHP's heating capacity that is extracted from the earth in heating mode.

$$HE = 500 \cdot (GPM) \cdot (EWT–LWT)$$

ELECTRICAL DEMAND (W)

The electrical input required to operate a GSHP unit for space conditioning.

$$\text{Single Phase DMD} = 0.85 \cdot \text{Voltage} \cdot \text{Amperage}$$

$$\text{Three Phase DMD} = 1.472 \cdot \text{Voltage} \cdot \text{Amperage}$$

HEATING CAPACITY (BTU/HR)

The amount of heat energy the GSHP is capable of delivering per unit time.

$$HC = HE + (3.412 \cdot DMD)$$

COEFFICIENT OF PERFORMANCE

A measure of heating efficiency for heat pump equipment, expressed as the heating energy provided to the space (Btu) divided by the electric energy consumed to provide that heating (Btu).

$$COP = HC / (3.412 \cdot DMD)$$

THINGS TO REMEMBER

- System voltage is measured in volts.
- System demand (DMD) is measured in Watts.
- System amperage draw is measured in amps.
- System flow (GPM) is measured in gpm (gallons per minute).
- System heat of extraction and heating capacity are measured in Btu/hr.
- Temperature drop through the water-refrigerant heat exchanger (EWT - LWT) is measured in °F.

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