INTRODUCTION

It is assumed that the reader has sufficient knowledge of the heat pump refrigeration cycle, and electrical knowledge, to understand heat pumps and their refrigeration and electrical circuits. Those areas will not be covered in this material.

Additionally, the following information is representative only, and may not apply to equipment manufactured by others. Always refer to the manufacturer’s information and directions.

BASIC PRINCIPLES OF APPLICATION

The water source heat pump uses basic refrigeration principles to extract heat from a water source and reject the heat to the conditioned space in the heating mode. Conversely, in the cooling mode, heat is extracted from the conditioned space and rejected to the water source. This water could come from one of several sources; either an earth coupled closed loop, where a water/antifreeze solution is continuously circulated in a closed loop of plastic pipe located in the ground, or a pond. Or, the water could come from an open loop, where water is drawn from a well, used in the heat pump, and then sent back to a re-injection well or dumped into a river, stream, or pond located close by. Or, in more traditional commercial installations, where several units are connected in a closed loop fashion, a boiler and cooling tower may be used to maintain loop temperatures between 60 and 90 degrees Fahrenheit. Earth or pond loops and well water systems are also used commercially.

UNIT SELECTION

Water-To-Air Package Units

Water source equipment differs from its air source counterpart in a few important ways:

- No defrost cycle, therefore controls are greatly simplified.
- Most units are packaged units; therefore accumulators, service valves, etc. are not needed.

Water source equipment can be divided into these applications and entering water temperature ranges.

<table>
<thead>
<tr>
<th>Application</th>
<th>EWT Range</th>
<th>Expansion Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard-range Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boiler/cooler</td>
<td>50°-110°F</td>
<td>cap tube</td>
</tr>
<tr>
<td>Well water-South</td>
<td>70°F</td>
<td>cap tube or TXV</td>
</tr>
<tr>
<td>Earth coupled-South</td>
<td>45°-100°F</td>
<td>cap tube or TXV</td>
</tr>
<tr>
<td>Extended-range Units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth coupled-North</td>
<td>20°-110°F</td>
<td>TXV</td>
</tr>
<tr>
<td>Well water-North</td>
<td>50°F</td>
<td>TXV</td>
</tr>
</tbody>
</table>

Small tonnage (3/4- through 5-ton) water source equipment has traditionally employed capillary tubes as the metering device. The majority of these units built are still being installed in cooling tower/boiler systems. However, the "cap tube" usually requires entering water temperatures in the 50°-110°F range. These units would have problems in an earth loop in the north. When entering water temperatures are below 50°F, the unit capacity is much lower than the capacity for which the cap tube was designed. Therefore, entering water temperatures lower than 50 degrees, or even low flow-rates at 50°F, will allow
refrigerant flood-back to the compressor and eventual compressor failure. These are termed standard range units.

It is imperative that a unit be rated for the particular application's temperature constraints. Many manufacturers have designed extended range units that are specifically designed for the 20°-110°F temperature range needed for earth loops in the north. Condensation on the water coil and suction lines, due to the low temperatures, also warrants insulation for both earth coupled and well water units in the north. Manufacturers often include this insulation as part of the extended range package.

Split Systems

Split systems are also available. These are roughly the equivalent of an air source outdoor section, with the exception that they are mounted indoors and mated to a remote air handler. Refrigerant lines are run between the split condensing unit and the air handler.

Water-To-Water Units

Some manufacturers even offer water-to-water units. These units use water as a heat source/heat sink, and water is then used on the other side of the refrigerant circuit as a distribution medium.

Desuperheater Option

Desuperheaters are used in water-to-air heat pump systems as a domestic hot water preheating device. In the cooling mode, all heat gathered by the desuperheater is waste heat and hot water is produced free. The EER of the unit is enhanced because the desuperheater and source heat exchangers are effectively in series, simulating a larger water-to-refrigerant heat exchanger. In a typical family of four, desuperheaters can provide 30-50% of the total hot water load, with most of this hot water being generated in the Winter and Summer seasons, when the unit has long running times.

In the heating mode, since most of the heat is derived from actually condensing hot gas (changing a gas to a liquid) in the air coil, desuperheaters are limited in performance to extracting only enough heat from the hot gas until the superheat going into the coil is 10°-25°F, thus leaving most of the heat still available for use by the condensing coil. If desuperheaters are unrestrained in their extraction of heat, air heating capacity will be reduced drastically, and occupants will notice very low supply-register temperatures. Therefore, desuperheater coil capacities are restrained by a low flow rate (0.4 gram per nominal ton) and relatively warm (90°F) entering water temperature, with a 10°F rise through the desuperheater heat exchanger. Maintaining a stratified tank (bottom at 90°F and top at 140°F) enhances the desuperheater's performance by providing a good compromise between a lower entering water temperature to the desuperheater and conveniently high domestic water temperature.

On-Demand Hot Water Units

Triple Function units provide heating, cooling and 100% of the hot water needs on demand. When hot water is needed, the unit is engaged to generate hot water as priority. These types of units can also reject 100% of the water heat of cooling directly to the water heater. Here are the four modes of operation:

1. Space cooling from source liquid
2. Space heating from source liquid
3. Water heating from source liquid
4. Space cooling to water heating
These units are, as expected, more complex, both in the refrigeration circuit and electrical controls design, than other water source heat pumps.

THEORY OF OPERATION

Refer to TYPICAL WIRING SCHEMATIC, Figure 00.
INSTALLATION AND SERVICE OF WATER-SOURCE AND GEOTHERMAL HEAT PUMPS

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TYPICAL WirING SCHEMATIC

Legend

- Field Connector
- Field Wiring
- Factory Wiring
C1, C2 Capacitors
HT, HTR Heater
M1 Contactor
HP High Pressure Control
LP Low Pressure Control
T1 Transformer
TB Terminal Board
RV Reversing Valve
WN Wire Connector
M Reset Relay
RB Fan Relay
RS Random Start (Optional)
FS Fasestart (Optional)
NS Night setback Relay (Optional)
CS Condensate Overflow Switch (Optional)

Notes:

1. All field wiring to unit must comply with NEC and local codes.
2. Minimum voltage on 208-230 volt units is 197 volts.
3. All 208-230 volt units are factory wired for 230 volt operation. For 208 volt operation, move the wire from the 230 volt terminal to the 208 volt terminal on the transformer.
4. Wire not used if optional random start is used.
5. Remove this wire if optional setback is used.
6. Only units sizes 041, 049 and 059 have compressor crankcase heaters.
7. All fan motors are wired for high speed operation.
OPERATING SEQUENCE IN COOLING MODE

When the thermostat is set to the cool position, terminals #6 and #2 are connected to energize the reversing valve, RV. To call for cooling, the thermostat then closes a circuit between terminal #6 and terminal #4 on the low voltage terminal board, located in the heat pump.

This applies 24 volts from the control transformer to the coil of M1, provided the safety circuit comprised of HP, LP, and, if so equipped, CS and FX, is complete. When M1 is energized, its two switches (located in the line voltage circuit) close, applying power to the compressor windings, and the compressors starts. The thermostat also applies 24 volt power to terminal #3 on the low voltage terminal board, which energizes RB coil.

This closes the RB switch in the line voltage circuit, bringing on the indoor fan. The unit is now running in the cooling mode.

OPERATING SEQUENCE IN THE HEATING MODE

When the thermostat mode switch is set to the heat position, the thermostat calls for heat by closing the first-stage mercury bulb. This closes the circuit between terminals #6 and #4 on the low voltage terminal board and applies 24 volts from the control transformer to the coil of M1, provided the safety circuit is complete. When M1 is energized, its two switches (located in the line voltage circuit) close, applying power to the compressor windings, and the compressor starts. The thermostat also applies 24 volt power to terminal #3 on the low voltage terminal board, which energizes RB coil, turning on the indoor fan. The unit is now running in the heating mode. If the heat output of the heat pump cannot meet space demands, the second stage mercury bulb in the thermostat will close, turning on the optional emergency backup heat.

LOCK OUT SEQUENCE

If, for some reason, the safety circuit should open, the current from terminal #4 will be led through the coil in RL, from terminal #4 to terminal #3. This will cause the coil in the RL (lock out relay) to be energized, and the M1 coil to de-energize. The single-pole, double-throw switches in the RL will change from their normal position. That is to say, the switch on terminal #5 of the RL will open and the switch on terminal #2 of the RL will close. The open switch on terminal #5 will prevent the unit from restarting, should the safety circuit close. The switch on terminal #2 of the RL is provided to energize terminal #5 on the low voltage board, bringing on the Emergency Light on the thermostat, alerting the homeowner that there is a malfunction with the heat pump.

If the unit locks out again after resetting, the cause of the lock out should be determined and corrective measures taken by qualified service personnel. (See Troubleshooting section for corrective measures.)

These units use a 4-way or reversing valve to change the mode of operation, namely heating to cooling, and vice versa. The reversing valve is energized only in the cooling mode.
SIZING GEOTHERMAL HEAT PUMPS

When sizing geothermal heat pumps, the two primary parameters are cooling run-time in the highest temperature bin (hourly analyses are usually divided into 5°F outdoor temperature groupings, called temperature "bins"), and heating balance point. The heating balance point will occur when the unit output matches the heat loss of the home (100% run time). If this temperature occurs often (greater than 200 hours per year), the auxiliary heater will probably cost more than 10% of the annual heating bill. Lengthening the loop or choosing a larger unit would reduce this balance point. However, oversizing is unnecessary and will cause problems with good dehumidification, lost efficiency through cycling, and extra cost to the price of the installed system.

Loop temperatures should be kept in the 25°F to 110°F range for extended-range units, and between 45°F and 110°F for standard-range units. For the most part, lengthening loops beyond the recommended loop temperature range to obtain warmer loop temperatures in the Winter and cooler temperatures in the Summer will not be cost effective. The economics in earth-coupled systems point toward using equipment with the greatest inlet temperature range capability, rather than using longer loops to handle a smaller range of loop temperatures.

Many parameters must be taken into consideration when actually finding the proper geothermal system for a structure. Geothermal heat pumps should not be sized in the same manner that conventional heating/cooling systems are sized, as there are several interdependent aspects of this type of system. For instance, the capacity is dependent on the loop temperature, and the loop temperature is dependent on the capacity. Both are dependent on the loop length and the unit size. Calculating such a system involves an iterative process, which must include soil types, weather data, design temperatures, earth temperature swings, and thermostat settings, among other very important factors. This type of calculation would take practically all day to do by hand. Fortunately, many equipment manufacturers offer computer software packages, like the WaterFurnace® Energy Analysis.

The WaterFurnace® Energy Analysis takes standard heat loss/gain calculations and creates a building loads profile to tailor the system to actual living and location conditions. Once a loads profile has been calculated, a simulation of the geothermal system can be obtained. When the program has performed its calculations, system parameters and predicted annual operating costs can be obtained. It is recommended that a computer simulation be done to arrive at a properly sized and most cost-effective system.

Other benefits of an analysis include the ability to compare the benefits of alternate heating/cooling/domestic hot water systems. This particular software allows for comparison of air source heat pumps, electric furnaces, fossil-fuel furnaces, (gas, oil, or propane), and includes an economic analysis for determining which system is most cost effective for a particular location and structure.

INSTALLATION

Unit Location

Locate the unit in an indoor area that allows easy removal of the filter and access panels, and has enough space for service personnel to perform maintenance or repair. Provide sufficient room to make water, electrical, and duct connections. If the unit is located in a confined space, such as a closet, provisions must be made for return air to freely enter the space by means of a louvered door, etc. On horizontal units, allow adequate room below the unit for a condensate drain trap, and do not locate the unit above supply piping. These units are not approved for outdoor installation and therefore must be installed inside the structure being conditioned. Do not locate in areas subject to freezing.
Mounting Horizontal Units

Horizontal units are available with side or end discharge and may be field-converted from one to the other. Horizontal units are normally suspended from a ceiling by four 3/8" diameter threaded rods. The rods are usually attached to the unit corners by hanger bracket kits furnished with each unit.

⚠️ **CAUTION:**

Do not use rods smaller than 3/8” diameter, since they may not be strong enough to support the unit. The rods must be securely anchored to the ceiling.

Lay out the threaded rods per the dimensions in Figures 1A and 1B. Assemble the hangers to the unit, as shown in Figure 1C or 1D. Securely tighten the brackets to the unit. When attaching the hanger rods to the bracket, a double nut is recommended, since vibration could loosen a single nut. The unit should be pitched approximately 1/4” towards the drain in both directions, to facilitate condensate removal. See Figure 2.

![Figure 1A](image)
INSTALLATION AND SERVICE OF WATER-SOURCE AND GEOTHERMAL HEAT PUMPS
WaterFurnace International

WXH 009, 012, 041, 049, 059

Figure 1B

WXH 019 thru 036
Figure 1C

WXH 009,012
Figure 1D

WXH 019 thru 059
Some residential applications require an attic floor installation of horizontal units. In this case, the unit is set in a full-size secondary drain pan on top of a vibration absorbing mesh. The secondary drain pan prevents possible condensate overflow or water leakage damage to the ceiling. The secondary drain pan is usually placed on a plywood base isolated from the ceiling joists by additional layers of vibration absorbing mesh.

**Mounting Vertical Units**

Vertical units are available in left or front air return configurations. The front configuration can usually be used for right return applications. Vertical units should be mounted level on a vibration absorbing pad slightly larger than the base (Figure 3) to provide isolation between the unit and the floor. It is not necessary to anchor the unit to the floor.
If the side control box access panel will be difficult to service, remove the two side control box mounting screws before installing the duct work and setting the unit (leave the two front mounting screws intact). This will allow the control box to be removed with only the two front mounting screws. Control boxes on vertical units can also be rotated to face the adjacent access panel.

Duct System

An air outlet collar is provided on all units to facilitate a duct connection. A flexible connector is recommended for discharge and return air duct connections on metal duct systems. Leave access for the removal of the blower housing mounting screws on the discharge air duct flange (Figures 5, 6, 7). This will allow internal removal of the blower assembly in case the blower housing or the blower motor should need replacement. In the supply plenum connection, two holes at these locations should allow removal of the mounting screws; however, the flexible connector can also allow access if it is mounted directly on the discharge duct flange. Shipping filters should be left on units with open return ducting. The shipping filter is to be removed when using a return air duct collar.
Closed Loop: Cooler / Boiler Tower Typical Application.

Figure 5
Figure 6

Open System: Well Water Typical Application.
Uninsulated duct should be insulated with a minimum of one-inch duct insulation. Application of the unit to uninsulated ductwork in an unconditioned space is not recommended, as the unit's performance will be adversely affected.

If the unit is connected to existing ductwork, a previous check should have been made to assure that the duct has the capacity to handle the air required for the unit application. If ducting is too small, as in the replacement of heating-only systems, larger ductwork should be installed. All existing ductwork should be checked for leaks, and repairs should be made accordingly.
The duct system and diffusers should be sized to handle the design airflow quietly. To maximize sound attenuation of the unit blower, the supply and return plenums should include internal duct liner of 1" thick glass fiber or be of ductboard construction. If air noise or excessive air flow are a problem, the blower speed can be changed down to low speed (red) to reduce air flow.

Piping

Supply and return piping must be a least as large as the unit connections on the heat pump (larger on long runs). Unit may be furnished with either a copper or optional cupro-nickel coil. Copper is adequate for closed loop systems and ground water that is not high in mineral content. In conditions where moderate scale formation is likely or in brackish water, a cupro-nickel heat exchanger is recommended. In situations where scaling could be heavy, or where biological growth will be present, a closed loop system is recommended. Ground water unit heat exchanger coils may, over a period of time, lose heat exchange capability due to a buildup of mineral deposits inside. These can be cleaned, but only by a qualified service mechanic, as acid and special pumping equipment are required. Never use flexible hoses of a smaller inside diameter than that of the water connection on the unit, and limit hose length to 10 ft. per connection. Check carefully for water leaks.

Condensate Drain

Connect the drain through the trap to the condensate drain system in conformance to local plumbing codes. The condensate line must be trapped a minimum of 1.5" as shown in Figure 4. The condensate line should also be pitched away from the unit a minimum of 1/8" per foot. The top of the trap must be below unit's drain connection. Horizontal units must be positioned to cant towards the drain outlet for good condensate drainage.

Closed Loop - Cooler/Boiler Systems

The water loop is usually maintained between 60°F and 90°F for proper heating and cooling operation. This is done with a cooling tower and a boiler.
To reject excess heat from the water loop, the use of a closed circuit evaporative cooler or an open-type cooling tower, with a secondary heat exchanger between the tower and the water loop, is recommended. If an open-type cooling tower is used without a secondary heat exchanger, continuous chemical treatment and filtering of the water must be performed to ensure the water is free from damaging materials.

⚠️ CAUTION:

Water piping exposed to outside temperature may be subject to freezing.

Each unit is equipped with FPT fittings for the water supply and return lines. When making the water connections to the unit, a Teflon-tape thread sealant is recommended to minimize internal fouling of the piping. Do not over-tighten connections. The water lines should be routed so as not to interfere with access to the unit. The use of a short length of high pressure hose with a swivel type fitting may simplify the connections and prevent vibration transfer. (Figure 5).

Before final connection to the unit, the supply and return hose kits must be connected together and the system flushed to remove dirt, piping chips, and other foreign material. Normally a combination balancing and close-off (ball) valve is installed at the return, and a rated gate or ball valve is installed at the supply. The return valve can be adjusted to obtain the proper water flow. The valves allow the unit to be removed for servicing.

The proper water flow must be assured to each unit whenever the unit heats or cools. To assure proper flow rate, use the pressure/temperature ports. These ports should be located adjacent to the supply and return connections on the unit. The proper flow rate cannot be accurately set without measuring the water pressure drop through the refrigerant-to-water heat exchanger. See Table 3A for water flow and pressure drop information.

### Table 3A

<table>
<thead>
<tr>
<th>Model Number</th>
<th>WX009</th>
<th>WX012</th>
<th>WX019</th>
<th>WX025</th>
<th>WX031</th>
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<tbody>
<tr>
<td>Flow Rate (gpm)</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>1.5</td>
<td>2.5</td>
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<tr>
<td>Press Drop (ft hd)</td>
<td>3.8</td>
<td>6.2</td>
<td>9.1</td>
<td>5.8</td>
<td>13.3</td>
</tr>
<tr>
<td>Press Drop (psi)</td>
<td>1.6</td>
<td>2.7</td>
<td>3.9</td>
<td>2.5</td>
<td>5.8</td>
</tr>
</tbody>
</table>

### Table 3B

<table>
<thead>
<tr>
<th>Model Number</th>
<th>WX033</th>
<th>WX036</th>
<th>WX041</th>
<th>WX049</th>
<th>WX059</th>
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<tbody>
<tr>
<td>Flow Rate (gpm)</td>
<td>4.5</td>
<td>7.0</td>
<td>9.0</td>
<td>4.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Press Drop (ft hd)</td>
<td>3.0</td>
<td>7.1</td>
<td>11.4</td>
<td>3.0</td>
<td>7.1</td>
</tr>
<tr>
<td>Press Drop (psi)</td>
<td>1.3</td>
<td>3.1</td>
<td>4.9</td>
<td>1.3</td>
<td>3.1</td>
</tr>
</tbody>
</table>
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WaterFurnace International

Table 3C

<table>
<thead>
<tr>
<th>Pressure Drop Correction Factor</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EWT(Deg F)</td>
<td>Factor</td>
</tr>
<tr>
<td>30</td>
<td>0.93</td>
</tr>
<tr>
<td>50</td>
<td>1.00</td>
</tr>
<tr>
<td>70</td>
<td>1.08</td>
</tr>
<tr>
<td>90</td>
<td>1.14</td>
</tr>
<tr>
<td>110</td>
<td>1.20</td>
</tr>
</tbody>
</table>

Open Loop - Well Water Systems

Typical open loop piping is shown in Figure 6. If water quality is in question, use a closed loop. Always maintain water pressure in the heat exchanger by placing water control valves at the outlet of the unit to minimize mineral deposits. Use a closed bladder-type expansion tank, with a draw down capacity of 2 times the unit flow rate. Insure proper water flow through the unit by checking pressure drop across the heat exchanger and comparing it to the figures in Table 3. Since the pressure is always changing, two gauges will be needed for an accurate pressure drop. Measuring the temperature change through the unit is an alternative method for measuring flow; see Table 2.

Table 2 Temperature Change Thru Heat Exchanger

<table>
<thead>
<tr>
<th>Water Flow Rate (GPM)</th>
<th>Water Temperature Change (Deg F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rise (Clg)</td>
</tr>
<tr>
<td>For closed Loop: Earth Coupled or Cooler/Boiler systems use 3 gpm/ton</td>
<td>9 - 12</td>
</tr>
<tr>
<td>For Open Loop: Well systems use 1.5 gpm/ton</td>
<td>20 - 26</td>
</tr>
</tbody>
</table>

Normally about 2 gpm flow rate per ton of cooling capacity is needed in open loop systems. Greater flow rates tend to offset the increased performance by the higher pumping costs. Flow regulating valves can be used to restrict flow to a specific flow rate. These valves are purchased with a specific flow rating and can be mounted on the outlet of the water solenoid valve. Pressure regulating flow valves are not recommended on units employing TXV's. Since both systems modulate, they could tend to fight each other. If velocity noise is a problem, the ball valve on the outlet of the unit can be used to apply back pressure on the water solenoid valve and water regulating valve to reduce noise. P/T plugs can be installed in pvc using a bushing with 1/4" threads. If water hammer is a problem, a mini expansion tank (8 oz. capacity) can be installed on the bottom of the water solenoid valve to absorb some of the shock.

Some water control valves draw their power directly from the unit's 24V transformer and can overload and possibly burn out the transformer. Check total VA draw of the water valve and insure that it is under 15 VA or capable of being driven by the unit transformer. Connect 24V solenoid valve between pins 1&9 on the terminal strip. This allows the solenoid to operate whenever the compressor contactor is energized. If the unit should "lock out," the solenoid valve would be disengaged as well, preventing the wasting of water (see wiring diagram, Figure 00).
Discharge water from a heat pump is not contaminated in any manner and can be disposed of in various ways depending on local building codes (e.g., recharge well, storm sewer, drain field, adjacent stream or pond, etc.). Recharge wells have been difficult to predict in the past and should be avoided, if possible. Most local codes forbid use of sanitary sewer for disposal. Consult your local building and zoning department to assure compliance in your area.

**Closed Loop - Earth Coupled Systems**

Many manufacturers can supply pump kits that provide all flushing and fill connections, as well as housings for the circulating pumps. These kits are typically mounted within 10 ft. of the unit. Using rubber hose to connect between the unit and the pump kit can make a flexible installation. Usually hose kits also contain pressure/temperature ports which are used in start-up and service of the unit. All inside piping should be insulated if loop temperatures below 50°F are expected. Once piping is completed between the unit, the pump kit, and the earth loop, (Figure 7), final purging and charging of the loop can be completed. A WaterFurnace® flush cart (at least a 1.5 hp pump) is needed to provide adequate flow velocity in the loop in order to purge air and dirt particles. Flush velocity is usually set at 2 feet per second in earth loop piping.

Antifreeze solution is used in most areas to prevent freezing. Freeze protection needs to be adjusted to 10°F lower than the minimum exiting fluid temperature of the unit (15°F in the Midwest). Antifreeze protection levels are usually measured using hydrometers and specific gravity tables, similar to those used to check car batteries. Some common antifreezes used in the industry are calcium chloride, methanol, ethylene glycol, and propylene glycol. Maintain the pH in the 7.6-8.2 range for final charging. Flush the system adequately to remove as much air as possible, then pressurize the loop to a static pressure of 20-30 psi. This is normally adequate for good system operation year round. Circulating pumps of this type usually require 3 psi minimum static pressure for reliable operation. A loop pressure drop calculation should have been performed with antifreeze included before selection of the circulating pump(s). Insure the loop pump kit provides adequate flow through the unit by checking pressure drop across the heat exchanger and comparing it to the figures shown in Table 3. Usually 3 gpm of flow per ton of cooling capacity is needed in earth loop applications.

**Desuperheater**

Small bronze pumps (2 gpm @ 7 ft. of head) are used for circulators. At least family sized electric water heaters (>52 gal.) should be used. A second water heater can also be used as a storage tank to enhance performance by supplying extra preheat storage and allowing adaptation to existing gas water heaters. Desuperheater coils are required to be double walled (vented) to insure that in the event of a refrigerant leak, the domestic water supply will not be contaminated.

**START-UP**

BEFORE POWERING UNIT, check the following:

- High voltage correct and matches nameplate
- Fuses, breakers and wire size correct
- Low voltage wiring complete
- Piping completed and water system cleaned and flushed
- Air is purged from closed loop system
INSTALLATION AND SERVICE OF WATER-SOURCE AND GEOTHERMAL HEAT PUMPS

Isolation valves are open, water control valves wired or loop pumps wired

Condensate line open, trapped and correctly pitched

Blower rotates freely

Blower speed correct

Compressor mounting bolts are loosened to reduce vibration noise

Air filter is clean and in position

Service/access panels are in place

Thermostat is in "OFF" position

Return air temperature is between 50°-80°F in heating and 60°-95°F in cooling. Restricting air flow in low ambient conditions in heating can be used.

UNIT START UP

1. Turn thermostat fan position to "ON". Blower should operate.

2. Balance air flow at registers. Adjust fan speed if necessary.

3. Set thermostat to highest temperature.

4. Set thermostat operation switch to "COOL" position. Compressor should NOT come on.

5. Slowly reduce the thermostat setting until both the compressor and water control valve/loop pumps are activated. Verify that the compressor is on and that the water flow rate is correct by measuring pressure drop through the heat exchanger, using the P/T plugs and comparing to Table 3. For other temperatures, multiply the gauge pressure drop times the correction factor in Table 3.

6. Check the temperature of both the supply and discharge water. See Table 2.

7. If temperature rise is within range of Table 2, then proceed to step 8; otherwise, check the cooling refrigerant pressures and compare to Table 4.

### Table 4

<table>
<thead>
<tr>
<th>Entering Air Deg F</th>
<th>Leaving Water Temperature Deg F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Suction</td>
</tr>
<tr>
<td>75</td>
<td>61-66</td>
</tr>
<tr>
<td>80</td>
<td>63-68</td>
</tr>
<tr>
<td>85</td>
<td>65-70</td>
</tr>
</tbody>
</table>
8. Check for air temperature drop of 15°F to 20°F across the air coil.

9. Turn thermostat switch to "OFF" position. A hissing should indicate proper functioning of reversing valve.

10. Leave unit "OFF" for approximately five (5) minutes to allow pressure to equalize.

11. Turn thermostat to lowest setting.

12. Set thermostat switch to "HEAT" position.

13. Turn thermostat operation to higher temperatures until both compressor and water control valve/loop pumps are activated.

14. If temperature drop is within range of Table 2, then proceed to step 15; otherwise, check the heating refrigerant pressures and compare to Table 5.

<table>
<thead>
<tr>
<th>Entering Air (Deg F)</th>
<th>Entering Liquid (Deg F)</th>
<th>Suction Pressure</th>
<th>Discharge Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>34-44</td>
<td>180-200</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>42-52</td>
<td>200-220</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>50-63</td>
<td>220-240</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>59-72</td>
<td>240-275</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>68-82</td>
<td>255-290</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>77-92</td>
<td>275-315</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>82-102</td>
<td>295-330</td>
<td></td>
</tr>
</tbody>
</table>

15. Check for air temperature rise of 20°F to 35°F across the air coil.

16. To make certain that the first stage of auxiliary heat is operating properly (assuming an aux heater is installed and the mode switch is set correctly), turn the thermostat to a higher setting and check for the required temperature rise across the heater.

17. Confirm that all stages of the auxiliary heat come on when the thermostat is in "EMERGENCY HEAT" mode.

18. Check for vibrations, noise, and water leaks.

19. Set system to maintain desired comfort level.

20. Instruct the owner/operator about correct thermostat and system operation.

21. BE CERTAIN TO FILL OUT AND FORWARD ALL WARRANTY PAPERS.
PERFORMANCE EVALUATION

Determining Water Flow Rate Through Coax (Coaxial Heat Exchanger)

Proper water flow rate is essential to assure proper unit operation and maximum efficiency. All units require 3 gallons per minute/ton of cooling when connected to a closed loop. Closed loop systems are either earth-coupled or boiler/cooling tower applications. When connected to an open loop, such as a well water application, 2 gallons per minute/ton of cooling are required.

To determine the amount of water flow through the coax, measure the water pressure going into the unit and the water pressure coming out of the unit and subtract the out pressure from the in pressure. The difference is the Pressure Drop. Compare the pressure drop of the unit to the Pressure Drop, Table 3.

Example:

A WaterFurnace® WX049 was found to have a pressure drop of 8.1 psig. Referring to the pressure drop, Table 3, we find that a pressure drop of 8.1 psig will result in a flow rate of 12 gpm.

Heat of Extraction/Rejection

A great deal can be learned about how a unit is performing by checking the Heat of Extraction (heating mode) or the Heat of Rejection (cooling mode).

Heat of Extraction refers to the amount of heat extracted from the water source. By comparing the actual amount of heat extracted from the source to the catalog data (found in the Specifications Catalog), unit performance can be determined. The actual heat of extraction should be ±10% of the catalog data. It should be understood that too many variables exist—for example, pressure gauge/thermometer accuracy—to pinpoint in the field the exact rate of heat extraction or rejection (in Btu/hr). However, by determining roughly the amount of heat extracted/rejected per unit of time, the service tech can better judge the performance of the unit, and verify whether or not the unit is in the "ball park."

To find the Heat of Extraction/Rejection, use the following formula:

\[
\text{HEAT OF EXTRACTION/REJECTION: CRQ} = \text{FLOW} \times 500 \ (485) \times \Delta T \ (°F)
\]

- Q represents the heat of extraction/rejection in Btu/hr
- FLOW represents the flow rate measured in gallons per minute (gpm)
- 500 is a constant that represents the thermal capacity factors for water (use 485 for most antifreeze)
- \(\Delta T\) represents the temperature difference between the water going into the coax and the water coming out of the coax. (Measure with a single thermometer at the pressure/temperature ports provided at the unit).

Example

WXV036 Model, entering water temperature 30°F; entering air temperature 70°F; flow rate = 9 gpm; well water (500);

\(\Delta T = 4.2°F\)
Next, go to the specification manual and find the data on the WX036 Model (see Table 6). Match the entering water temperature, and gpm. Now move over to the right, to the column marked "heating." Find the entering air temperature and move to the right; read the number under the "HE" (heat of extraction), which is indicated in thousand or Btu/hr. You should find 19,100 Btu/hr. Compare this expected capacity with the actual performance calculation, 18,900 Btu/hr.

Model WX036 Desuperheater

<table>
<thead>
<tr>
<th>EWT</th>
<th>GPM</th>
<th>WPD</th>
<th>COOLING</th>
<th>HEATING</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EA</td>
<td>TC</td>
</tr>
<tr>
<td>30</td>
<td>4.5</td>
<td>30</td>
<td>75/63</td>
<td>40.7</td>
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<tr>
<td>30</td>
<td>4.5</td>
<td>3.5</td>
<td>80/67</td>
<td>44.2</td>
</tr>
<tr>
<td>30</td>
<td>4.5</td>
<td>3.0</td>
<td>85/71</td>
<td>47.7</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
<td>30</td>
<td>75/63</td>
<td>41.9</td>
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<tr>
<td>30</td>
<td>7</td>
<td>8.4</td>
<td>80/67</td>
<td>45.5</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
<td>3.0</td>
<td>85/71</td>
<td>49.1</td>
</tr>
<tr>
<td>30</td>
<td>9</td>
<td>30</td>
<td>75/63</td>
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<td>46.9</td>
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<td>75/63</td>
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<td>3.0</td>
<td>85/71</td>
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<td>75/63</td>
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<td>85/71</td>
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<td>7</td>
<td>70</td>
<td>75/63</td>
<td>36.2</td>
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<td>6.6</td>
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<td>3.0</td>
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<tr>
<td>90</td>
<td>4.5</td>
<td>90</td>
<td>75/63</td>
<td>30.9</td>
</tr>
</tbody>
</table>
The actual heat of extraction should be within 10% of the catalog data. If the actual heat of extraction is less than 10% of the catalog data, a further refrigeration check of the unit will be necessary to determine if the unit is short of charge, has a faulty component, or otherwise needs adjustment.

### START-UP TROUBLESHOOTING

Should a major problem develop, refer to the following information for possible causes and corrective steps:

**If neither fan nor compressor runs:**

1. The fuse may be blown or the circuit breaker is open. Check electrical circuits and motor windings for shorts or grounds. Investigate for possible overloading. Replace fuse or reset circuit breakers after fault is corrected.
2. Supply voltage may be too low. Check it with a VOM.
3. Control system may be faulty. Check thermostat for correct wiring and check 24-volt transformer for burnout.
4. Wires may be loose or broken. Replace or tighten.

**If fan operates and the compressor doesn’t:**

1. The low pressure switch may have tripped due to:
   a. fouled or plugged condenser
   b. lack of or no condenser water
INSTALLATION AND SERVICE OF WATER-SOURCE AND GEOTHERMAL HEAT PUMPS

WaterFurnace International

c. condenser water too cold
d. not enough air over the coil due to dirty filters
e. coil or fan motor failure
f. lack of refrigerant

2. The high pressure may have tripped due to:
   a. fouled or plugged condenser
   b. lack of or no condenser water
c. condenser water too warm
d. not enough airflow over the coil due to dirty filters
e. coil or fan motor failure

3. Check Capacitor.
4. Wires may be loose or broken. Replace or tighten.
5. The compressor overload protection may be open. If the compressor dome is extremely hot, the overload will not reset until cooled down. If the overload does not reset when cool, it may be defective. Replace the compressor.
6. The internal winding of the compressor motor may be grounded to the compressor shell. If so, replace the compressor.
7. The compressor winding may be open. Check continuity with ohmmeter. If the winding is open, replace the compressor.
8. Check thermostat setting, calibration, and wiring.

If sufficient cooling or heating is not obtained:
1. Check thermostat for improper location.
2. Airflow may be insufficient. Check and clean the filter.
3. Check for restriction in water flow.
4. Check subcooling for low refrigerant charge.
5. The reversing valve may be defective and creating a bypass of refrigerant. If the unit will not cool, check the reversing valve coil.
6. Check capillary tubes for possible restriction of refrigerant flow.

If the unit operation is noisy:
1. Check for fan wheel hitting the housing. Adjust for clearance.
2. Check for bent fan wheel. Replace if damaged.
3. Check for loose fan wheel on the shaft. Tighten it.
4. Check compressor for loosened mounting bolts. Make sure compressor is floating free on its isolator mounts.
5. Check for tubing touching the compressor or other surfaces. Readjust it by bending slightly.
6. Check screws on all panels.
7. Check for clattering or humming in the contactor or relays due to low voltage or a defective holding coil. Replace the component.
8. Check for proper installation of vibration absorbing material under the unit. Unit must be fully supported, not just on corners.
9. Check for abnormally high discharge pressures.

TROUBLESHOOTING

Before starting troubleshooting procedures, all desuperheater, hot water generation, free cooling coils, etc., should be disengaged to insure the system is functioning in a basic heating or cooling mode to ensure efficient and accurate diagnosis.

Here are some special troubleshooting notes for the three applications:

COOLING TOWER/BOILER SYSTEMS

• Open systems need continuous chemical treatment; sediment and fouling are commonplace. Closed systems are always recommended.
• Low-pressure switches are typically set in the 38-40 psi range for standard range units. A short burst of cold water from an exposed pipe, or return air that is too cold, can trip these switches.

WELL WATER SYSTEMS

Low-pressure switches are typically set in the 38-40 psi range for standard range units. A short burst of cold water from an exposed pipe, or return air that is too cold, can trip these switches. Low pressure switches on extended-range units are usually set in the 25-26 psi range and won't be plagued by this problem.

EARTH-COPUPLED CLOSED LOOP

Since earth loops in the north utilize loop temperatures down to 25°F, suction and loop temperatures will be below freezing and, therefore, frost can appear on suction and loop piping.

Since troubleshooting many of the common heat pump components is covered elsewhere, only those topics needing further clarification or that are specific to water-source equipment will be discussed here.

TROUBLESHOOTING – WATER AND AIR

The troubleshooting process should always start with a check for water flow and air flow problems, because these checks are easy and they frequently reveal the root cause of the system failure without
having to look further. Check for water or air problems before installing service gauges on the refrigerant circuit, for example.

Here is a list of items to check to determine if system malfunction might be due to an air flow problem:

dirty filter, debris in the coil, supply/return duct leakage, fan motor speed, and entering and leaving air temperatures at the unit should all be checked.
Here is a list of items to check for water flow problems:

- pressure drop through heat exchanger (use Table 3), static pressure of fluid in closed loops, entering and leaving water temperatures, circulating pump operation, and antifreeze level in northern earth loops.

**TROUBLESHOOTING – THERMOSTATIC EXPANSION VALVES (TXV’S)**

The most common reason for TXV failure is loss of charge in the sensing bulb. In normal operation, the pressure within the sealed TXV sensing bulb increases when suction line temperature increases, thus opening the valve. Therefore, if the bulb has lost its charge, the valve will not open and a high superheat condition will exist. TXV's can be checked for operation as follows:

- Look for cycling (hunting) in suction line temperature of 3-10°F and suction line pressure (1-4 psig).
- Artificially warm the bulb by placing it in your hand or in warm water to force it to open. Look for rise in suction pressure and drop in suction temperature.
- Artificially cool the bulb by applying an ice pack to it to force the valve to close. Look for drop in suction pressure and rise in suction temperature. If all three of these tests fail, then replace the valve.

**TROUBLESHOOTING – LOW-VOLTAGE ELECTRICAL THERMOSTAT**

The water source heat pump's simple low-voltage system is usually divided into two basic components: the unit itself and the thermostat. These can be isolated for further diagnosis by jumpering on the low-voltage board to verify major component operation. This is an easy method and can save considerable troubleshooting time.

- Disconnect thermostat wiring from low voltage terminal strip or turn thermostat "off"
- Jumper from 24VAC to compressor run, and verify compressor operation
- Jumper from 24VAC to fan signal, and verify blower operation
- Jumper from 24VAC to reversing valve signal, and verify reversing valve solenoid click. If all components function properly, then the thermostat and its associated wiring should be suspected.

**TROUBLESHOOTING – REFRIGERATION**

Typical operating conditions are shown in the refrigeration circuit schematic for cooling mode at 85°F and heating mode at 30°F. Figure 8 should be consulted throughout this discussion.
Anytime vacuum/recharging is performed, the nameplate charge should be used for replacing the refrigerant. However, in certain instances, field charging is required (split systems) or if system is still not performing as intended, superheat and subcooling should be used as guidelines in unit performance and troubleshooting. Table 7 is intended as an example of superheat/subcooling values for extended-range and standard-range units. Here WaterFurnace WX Series (extended) and WS Series (standard) range systems are shown. Superheat/subcooling varies little with air flow and water flow variation, and
temperature probe accuracy does not greatly affect results, either. Therefore, analyzing the refrigerant system in this manner is the most accurate means of assessing operation. Subcooling is an excellent measure of refrigerant charge.

Table 7 Typical Superheat And Subcooling Values At Different Entering Water Temperatures

<table>
<thead>
<tr>
<th>Entering Water Temp</th>
<th>Extended Range Unit with TXV</th>
<th>Standard Range Unit with Capillary Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heating</td>
<td>Cooling</td>
</tr>
<tr>
<td>110° F</td>
<td>*</td>
<td>10-20</td>
</tr>
<tr>
<td>90° F</td>
<td>*</td>
<td>10-20</td>
</tr>
<tr>
<td>70° F</td>
<td>10-14</td>
<td>6-10</td>
</tr>
<tr>
<td>50° F</td>
<td>9-12</td>
<td>8-12</td>
</tr>
<tr>
<td>30° F</td>
<td>5-10</td>
<td>8-12</td>
</tr>
</tbody>
</table>

*Operation at these EWT is not recommended*

Typically, charge is set with 50°F EWT in the heating mode and then verified while operating in the cooling mode. The numbers shown in the table should be used as a guide.

**DETERMINING SUPERHEAT:**

1. Measure the temperature of the suction line at the point where the TXV bulb is clamped.
2. Determine the suction pressure in the suction line by attaching refrigeration gauges to the Schrader connection on the side of the compressor.
3. Convert the pressure obtained in Step 2 above to the saturated evaporator temperature by using Table 8.
4. Subtract the temperature obtained in Step 3 from Step 1, the difference will be the superheat of the unit. Refer to the superheat Table 7 for recommended superheat ranges at specific entering water temperatures.

Figure 9 illustrates a typical example of how to measure superheat on a Water Furnace Liquid Source Heat Pump, using R-22. The temperature of the suction line at the sensing bulb is read at 50°F. The suction pressure at the compressor is 65 psig, which is the equivalent to 38°F saturation temperature.
Checking Superheat

38°F subtracted from 50°F = 12°F Superheat
NOTE:

Because of the limited amount of refrigeration piping inside the WaterFurnace® unit, it is not necessary to add an estimated line set pressure drop to the 65 psig. Use true pressure values shown on the gauges to convert to saturated temperature.

DETERMINING SUBCOOLING:

1. Measure the temperature of the liquid line at the point where the refrigerant leaves the condensing coil. In the heating mode, the measurement should be taken between the air coil and the expansion valve (liquid line). In the cooling mode, it should be taken between the water coil and expansion valve.

2. Determine the compressor discharge pressure (high side) by attaching refrigerant gauges to the Schrader connection on the hot gas discharge line of the compressor.

3. Convert the pressure obtained in Step 2 to temperature.

4. Subtract the temperature of Step 1 from the temperature of Step 3. The difference will be the subcooling. Compare with Table 7 values at specific entering water temperatures.

Figure 10 illustrates a typical example of measuring refrigeration subcooling in the heating mode, using R-22. The temperature of the liquid line after leaving the condensing coil is 100°F.
Checking Subcooling

100°F subtracted from 110°F = 10°F subcooling
NOTE:
If expansion device is suspected as faulty, test by placing the sensing bulb in your hand. This will drive open the valve and lower the superheat reading. Wrapping the bulb with an ice pack will close the valve and raise the readings. Expansion valves always fail with high superheat.

PREVENTIVE MAINTENANCE

Water Coil Maintenance

1. Keep all air out of the water. An open loop system should be checked to insure that the well head is not allowing air to infiltrate the water line. Lines should always be air-tight.

2. Keep the system under pressure at all times. It is recommended in open loop systems that a water control valve be placed in the discharge line to prevent loss of pressure during off cycles. Closed loop systems must have positive static pressure, or else air vents may draw air into the system.

NOTE:
If the unit is installed in an area with a known high mineral content in the water, it is best to establish with the owner a periodic maintenance schedule, wherein the coil can be checked on a regular basis. Should coil cleaning be necessary periodically, use standard coil cleaning procedures that are compatible with either the cupro-nickel or pure copper water lines. Generally, the more water flowing through the unit, the lower the chances for scaling. But to avoid excessive pressure drop and the possibility of copper erosion, do not exceed gpm flow rate shown in the specification sheets for each unit.

Other Maintenance

Filters must be clean to obtain maximum performance. They should be inspected every two to three months under normal operating conditions and be replaced when necessary. Units should never be operated without a filter.

In areas where airborne bacteria produce a slime in the drain pan, it may be necessary to treat the pan chemically to minimize the problem. The condensate drain can pick up lint and dirt, especially with dirty filters. Inspect twice a year to avoid the possibility of overflow.

When operating under normal conditions, additional fan motor lubrication is recommended every two years. Use 1/2 teaspoonful of SAE-20 non-detergent automotive oil or electric oil in each oiler in the end shields. DO NOT OVER OIL. If the discharge air arrangement is changed, or if the fan motor is replaced, be sure that the motor is arranged with its oilers above the horizontal. The air coil must be cleaned to obtain maximum performance. Check once a year under normal operating conditions and, if dirty, brush or vacuum clean. Care must be taken not to damage the aluminum fins while cleaning.
CAUTION:

- Fin edges are sharp.

STANDARD THERMOSTAT OPERATION

TM11 H02

STANDARD MANUAL CHANGEOVER. Install as shown in Figure 11.

Fan Switch

- ON: Fan runs continuously.
- AUTO: Fan cycles on a call for heat or cooling.

System Switch

- OFF: Heating and cooling functions are inoperative.
- COOL: Reversing valve is energized. On a call for cooling, the thermostat cycles the compressor to maintain the cooling set-point.
- HEAT: Reversing valve is de-energized. On a call for heating, the thermostat cycles the compressor to maintain the heating set-point.

TM21 G01 OR TM21 H01

MANUAL CHANGEOVER, AUXILIARY HEAT. Install as illustrated in Figure 12 for Thermostat TM21 G01 or TM21 H01. Stage the duct heater, using jumpers as per the diagram inside the duct heater door.

---

THERMOSTAT WIRING DIAGRAMS

**Figure 11**

**Figure 12**
Fan Switch

- ON: Fan runs continuously.
- AUTO: Fan cycles on a call for heat or cooling.

System Switch

- OFF: Compressor and duct heater are inoperative.
- HEAT: Compressor and/or duct heater is cycled (depending on mode switch) on a call for heat from the thermostat.
- COOL: Reversing valve is energized. On a call for cooling, the thermostat cycles the compressor to maintain the cooling set-point.

Mode Switch

- HEAT PUMP: First stage of heat cycles the compressor to satisfy a call for heat. Duct heater is inoperative.
- NORMAL: First stage of heat cycles the compressor to satisfy a call for heat. If the room temperature drops 3°F below the thermostat set-point, the first stage of the auxiliary duct heater is cycled, as needed, to meet the heating requirement. Auxiliary operation is indicated by a blue light.
- EMERGENCY The compressor is disabled and the auxiliary duct heater is cycled in two stages to satisfy a call for heat by the thermostat. The blue auxiliary light will indicate duct heater operation. In the emergency mode, the red emergency light is lit at all times. The emergency light (red) will be illuminated and will thus function as a fault indicator if the compressor lockout relay has been engaged due to low or high pressure safety switch activation, in either the heat pump or normal mode.

**NOTE:**

For all thermostats, on a trip of the high- or low-pressure safety switch, the compressor is locked out to prevent short cycling. To reset the unit, turn the system switch to the OFF position, then back to the desired heat or cool function.